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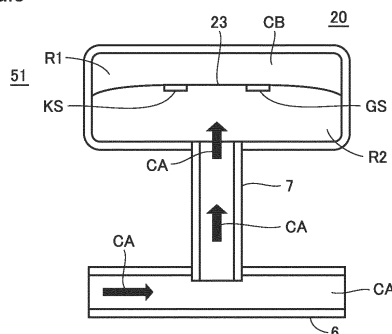
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(54) **AIR CONDITIONING DEVICE**

(57) A detection case (20) is arranged between an outdoor heat exchanger (2) and an expansion valve (3). A diaphragm (23) divides an internal space of the detection case (20) into a first space (R1) and a second space (R2). The first space (R1) is sealed, and a second refrigerant (CB) of the same type as a first refrigerant (CA) is sealed in the first space (R1). The second space (R2) is connected to a refrigerant circuit (100), and the first re-

frigerant (CA) flows into the second space (R2). A strain sensor (GS) is arranged on the diaphragm (23) and detects a difference between a pressure of the first refrigerant (CA) in the second space (R2) and a pressure of the second refrigerant (CB) in the first space (R1). A temperature detector (51) detects a temperature of the first refrigerant (CA) between the outdoor heat exchanger (2) and the detection case (20).

FIG.5



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Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioner.

BACKGROUND ART

[0002] An air conditioner capable of calculating a degree of supercooling as an operation state amount has conventionally been known. For example, the apparatus disclosed in PTL 1 includes a temperature sensor configured to detect an outside air temperature and a temperature sensor configured to detect a temperature of air subjected to heat exchange at a use-side heat exchanger. This apparatus calculates a degree of supercooling based on a difference between the temperatures detected by the two temperature sensors.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2016-99059

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the refrigeration cycle apparatus disclosed in PTL 1, however, the accuracy of the degree of supercooling calculated deteriorates if there is a difference between the temperatures detected by the two temperature sensors. In particular, when the degree of supercooling has a small value, the accuracy of the degree of supercooling calculated deteriorates considerably due to the difference between the temperatures detected by the two temperature sensors.

[0005] An object of the present invention is therefore to provide an air conditioner capable of determining an operation state with high accuracy.

SOLUTION TO PROBLEM

[0006] An air conditioner of the present invention includes a refrigerant circuit in which a first refrigerant circulates and which has a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger annularly connected by a refrigerant pipe, a detection case arranged between the outdoor heat exchanger and the expansion valve, and a diaphragm configured to divide an internal space of the detection case into a first space and a second space. The first space is sealed, and a second refrigerant of the same type as the first refrigerant is sealed in the first space. The second space is connected to the refrigerant circuit, and the first

refrigerant flows into the second space. The air conditioner further includes a strain sensor arranged on the diaphragm and configured to detect a difference between a pressure of the first refrigerant in the second space and a pressure of the second refrigerant in the first space, and a temperature detector configured to detect a temperature of the first refrigerant between the outdoor heat exchanger and the detection case.

[0007] An air conditioner of the present invention includes a refrigerant circuit in which a first refrigerant circulates and which has a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger annularly connected by a refrigerant pipe, a detection case arranged between the outdoor heat exchanger and the expansion valve, and a diaphragm configured to divide an internal space of the detection case into a first space and a second space. The first space is sealed, and a second refrigerant of the same type as the first refrigerant is sealed in the first space. The second space is connected to the refrigerant circuit, and the first refrigerant flows into the second space. The air conditioner further includes a strain sensor arranged on the diaphragm and configured to detect a difference between a pressure of the first refrigerant in the second space and a pressure of the second refrigerant in the first space, and a temperature detector configured to detect a temperature of the first refrigerant between the indoor heat exchanger and the detection case.

30 ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present invention, the air conditioner includes the strain sensor and the temperature detector, and thus, can determine an operation state with high accuracy.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 shows a refrigerant circuit 100 of an air conditioner of a reference example and a refrigerant flow in refrigerant circuit 100 during a cooling operation of the air conditioner.

Fig. 2 shows temperature sensors arranged in the vicinity of an outdoor heat exchanger 2 of Fig. 1.

Fig. 3 shows a configuration of the air conditioner of Embodiment 1 and a refrigerant flow in refrigerant circuit 100 during the cooling operation of the air conditioner.

Fig. 4 shows an arrangement of a detection case 20 of Embodiment 1.

Fig. 5 shows a configuration of detection case 20 of Embodiment 1.

Fig. 6 is a p-h diagram of refrigerant circuit 100.

Fig. 7 shows a relation between a differential pressure ΔP and a degree of supercooling SC at every temperature T_q in Embodiment 1.

Fig. 8 is a flowchart showing a control procedure of the air conditioner of Embodiment 1.

Fig. 9 shows a configuration of the air conditioner of Embodiment 1 and a refrigerant flow in refrigerant circuit 100 during a heating operation of the air conditioner.

Fig. 10 shows a temperature sensor arranged in the vicinity of an outdoor heat exchanger 2 and an arrangement of a detection case 20 in Embodiment 2. Fig. 11 shows a configuration of detection case 20 of Embodiment 2.

Fig. 12 shows a relation between a differential pressure ΔP and a degree of supercooling SC at every temperature T_q in Embodiment 2.

Fig. 13 shows a configuration of an air conditioner of Embodiment 3 and a refrigerant flow of a refrigerant circuit 100 during a heating operation of the air conditioner.

Fig. 14 shows an arrangement and a configuration of a detection case 20 of Embodiment 3.

Fig. 15 shows a configuration of the air conditioner of Embodiment 3 and a refrigerant flow in refrigerant circuit 100 during a cooling operation of the air conditioner.

Fig. 16 shows an arrangement and a configuration of a detection case 20 of Embodiment 4.

DESCRIPTION OF EMBODIMENTS

[0010] Embodiments will now be described with reference to the drawings.

(Reference Example)

[0011] First, a configuration of, and a problem with, an air conditioner of a reference example will be described.

[0012] Fig. 1 shows the configuration of the air conditioner of the reference example and a refrigerant flow in a refrigerant circuit 100 during a cooling operation of the air conditioner.

[0013] Refrigerant circuit 100 includes a compressor 1, a four-way valve 5, an outdoor heat exchanger 2, an expansion valve 3, and an indoor heat exchanger 4 annularly connected by a refrigerant pipe 6. A first refrigerant CA circulates in refrigerant circuit 100.

[0014] Compressor 1 compresses first refrigerant CA and discharges the compressed first refrigerant CA.

[0015] Four-way valve 5 switches a flow path of first refrigerant CA. During the cooling operation of the air conditioner, first refrigerant CA discharged from compressor 1 flows to outdoor heat exchanger 2. During a heating operation of the air conditioner, first refrigerant CA discharged from compressor 1 flows to indoor heat exchanger 4.

[0016] Outdoor heat exchanger 2 performs heat exchange between the air (hereinafter, referred to as outside air as appropriate) supplied by an outdoor blower, such as a fan, and first refrigerant CA. Outdoor heat ex-

changer 2 functions as a condenser during the cooling operation of the air conditioner. Outdoor heat exchanger 2 functions as an evaporator during the heating operation of the air conditioner.

[0017] Expansion valve 3 decompresses and thus expands first refrigerant CA. Expansion valve 3 is, for example, a valve with a controllable degree of opening, such as an electronic expansion valve.

[0018] Indoor heat exchanger 4 performs heat exchange between the air supplied by an indoor blower, such as a fan, and first refrigerant CA. Indoor heat exchanger 4 functions as an evaporator during the cooling operation of the air conditioner. Indoor heat exchanger 4 functions as a condenser during the heating operation of the air conditioner.

[0019] Fig. 2 shows temperature sensors arranged in the vicinity of outdoor heat exchanger 2 of Fig. 1.

[0020] Outdoor heat exchanger 2 includes a sub-heat exchanger 2a and a sub-heat exchanger 2b. Temperature sensor 11 is arranged in the vicinity of the middle of sub-heat exchanger 2a. Temperature sensor 11 detects a condensation temperature CT of first refrigerant CA flowing through outdoor heat exchanger 2 during the cooling operation of the air conditioner. Temperature sensor 12 is arranged at the outlet for first refrigerant CA in outdoor heat exchanger 2 during the cooling operation of the air conditioner. Temperature sensor 12 detects a temperature TA of first refrigerant CA at the outlet of outdoor heat exchanger 2 during the cooling operation of the air conditioner.

[0021] In the reference example, during the cooling operation of the air conditioner, a degree of supercooling SC of first refrigerant CA at the outlet of outdoor heat exchanger 2 can be determined based on a difference between condensation temperature CT of first refrigerant CA which is detected by temperature sensor 11 and temperature TA of first refrigerant CA at the outlet of outdoor heat exchanger 2 which is detected by temperature sensor 12.

[0022] Thus, measurement errors of two temperature sensors 11, 12 exert effects in the reference example. In particular, when degree of supercooling SC has a small value, degree of supercooling SC cannot be calculated accurately. When not only a temperature detected by temperature sensor 11 but also a temperature detected by temperature sensor 12 is a temperature of first refrigerant CA in a liquid phase, temperature sensor 12 fails to measure condensation temperature CT of first refrigerant CA. As a result, the operation state of the air conditioner cannot be grasped accurately.

Embodiment 1

[0023] Fig. 3 shows a configuration of an air conditioner of Embodiment 1 and a refrigerant flow in a refrigerant circuit 100 during a cooling operation of the air conditioner. Fig. 4 shows an arrangement of a detection case 20 of Embodiment 1.

[0024] The air conditioner includes refrigerant circuit 100, detection case 20 connected to refrigerant circuit 100, and a controller 80. Refrigerant circuit 100 of Embodiment 1 is similar to refrigerant circuit 100 of the reference example, and accordingly, description thereof will not be repeated. Detection case 20 is arranged between outdoor heat exchanger 2 and expansion valve 3.

[0025] Fig. 5 shows a configuration of detection case 20 of Embodiment 1.

[0026] An internal space of detection case 20 is divided into a first space R1 and a second space R2 by a diaphragm 23. Diaphragm 23 is a displaceable thin-film member.

[0027] First space R1 is a sealed space. A second refrigerant CB is sealed in first space R1. Second refrigerant CB is of the same type as first refrigerant CA that circulates in refrigerant circuit 100.

[0028] Second space R2 is connected to refrigerant circuit 100 by a refrigerant pipe 7. First refrigerant CA that circulates in refrigerant circuit 100 flows into second space R2.

[0029] A strain sensor GS is arranged on diaphragm 23. Although strain sensor GS is arranged within second space R2 in Fig. 5, it may be arranged in first space R1.

[0030] A temperature sensor KS is arranged on diaphragm 23. In Embodiment 1, temperature sensor KS constitutes temperature detector 51. Temperature sensor KS detects a temperature Tq of first refrigerant CA between outdoor heat exchanger 2 and detection case 20.

(Operation during Cooling Operation)

[0031] During the cooling operation of the air conditioner, first refrigerant CA cooled by outdoor heat exchanger 2 functioning as the condenser flows into second space R2 of detection case 20.

[0032] Fig. 6 is a p-h diagram of refrigerant circuit 100.

[0033] LA represents an isotherm at the outside air temperature. LB represents an isotherm of a temperature at the outlet in outdoor heat exchanger 2 (condenser). LC represents an isotherm at a discharge pressure Pd of outdoor heat exchanger 2.

[0034] The temperature of second refrigerant CB sealed in first space R1 is higher than the outside air temperature and lower than or is equal to the temperature of first refrigerant CA discharged from outdoor heat exchanger 2. Among a saturation pressure P1s at the outside air temperature, a saturation pressure P2s at the temperature of first refrigerant CA discharged from outdoor heat exchanger 2, and a pressure Pv of second refrigerant CB sealed in first space R1, the following equation is established.

$$P1s < Pv < P2s \dots (1)$$

[0035] The pressure of first refrigerant CA that flows into second space R2 becomes equal to a pressure Pd of first refrigerant CA discharged from outdoor heat exchanger 2. Thus, the following relation is established.

$$Pd > Pv \dots (2)$$

[0036] Thus, a differential pressure ΔP between pressure Pd of first refrigerant CA in second space R2 and pressure Pv of second refrigerant CB in first space R1 occurs in diaphragm 23.

$$\Delta P = Pd - Pv \dots (3)$$

[0037] Strain sensor GS measures differential pressure ΔP .

[0038] Differential pressure ΔP changes in accordance with degree of supercooling SC. When degree of supercooling SC decreases, second refrigerant CB in first space R1 is heated by first refrigerant CA of high temperature which is discharged from outdoor heat exchanger 2, leading to increased Pv. As a result, ΔP decreases. When degree of supercooling SC increases, second refrigerant CB in first space R1 is cooled by first refrigerant CA of low temperature which is discharged from outdoor heat exchanger 2, leading to decreased Pv. As a result, ΔP increases.

[0039] Fig. 7 shows a relation between differential pressure ΔP and degree of supercooling SC at every temperature Tq in Embodiment 1.

[0040] As shown in Fig. 7, the relation between differential pressure ΔP and degree of supercooling SC changes in accordance with temperature Tq of first refrigerant CA between outdoor heat exchanger 2 and detection case 20.

[0041] Controller 80 determines degree of supercooling SC of first refrigerant CA at the outlet of outdoor heat exchanger 2 based on temperature Tq of first refrigerant CA which is detected by temperature sensor KS, differential pressure ΔP detected by strain sensor GS, and the predetermined relation between differential pressure ΔP and degree of supercooling SC which corresponds to refrigerant temperature Tq.

[0042] For example, controller 80 identifies a table of temperature Tq of the refrigerant which is detected by temperature sensor KS from among tables showing a relation between differential pressure ΔP and degree of supercooling SC at every temperature Tq of the refrigerant. Controller 80 determines degree of supercooling SC corresponding to differential pressure ΔP detected by strain sensor GS, with reference to the identified table.

[0043] Alternatively, controller 80 identifies a characteristic equation of temperature Tq of the refrigerant which is detected by temperature sensor KS from among

characteristic equations showing a relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 substitutes differential pressure ΔP detected by strain sensor GS into the determined characteristic equation, thereby calculating degree of supercooling SC. The characteristic equation may be, for example, a quadratic equation, or more simply, a linear equation.

[0044] Further, controller 80 calculates condensation temperature CT of first refrigerant CA in outdoor heat exchanger 2 according to the following equation.

$$CT = T_q + SC \dots (4)$$

[0045] Controller 80 controls refrigerant circuit 100 based on the calculated degree of supercooling SC and condensation temperature CT.

[0046] Controller 80 controls a degree of opening of expansion valve 3 based on condensation temperature CT of first refrigerant CA.

[0047] Controller 80 determines whether first refrigerant CA has leaked from refrigerant circuit 100 based on degree of supercooling SC of first refrigerant CA. For example, when degree of supercooling SC of first refrigerant CA is zero, controller 80 can determine that first refrigerant CA has leaked from refrigerant circuit 100.

[0048] Fig. 8 is a flowchart showing a control procedure of the air conditioner of Embodiment 1.

[0049] At step S101, temperature sensor KS detects temperature T_q of first refrigerant CA between outdoor heat exchanger 2 and detection case 20.

[0050] At step S102, strain sensor GS detects differential pressure ΔP between pressure Pd of first refrigerant CA in second space R2 of detection case 20 and pressure Pv of second refrigerant CB in first space R1 of detection case 20.

[0051] At step S103, controller 80 determines degree of supercooling SC of first refrigerant CA at the outlet of outdoor heat exchanger 2 based on temperature T_q of first refrigerant CA and differential pressure ΔP .

[0052] At step S104, controller 80 calculates condensation temperature CT of first refrigerant CA in outdoor heat exchanger 2 based on temperature T_q and degree of supercooling SC of first refrigerant CA.

[0053] At step S105, controller 80 determines whether first refrigerant CA has leaked from refrigerant circuit 100 based on degree of supercooling SC of first refrigerant CA.

[0054] At step S106, controller 80 controls the degree of opening of expansion valve 3 based on condensation temperature CT of first refrigerant CA.

(Operation during Heating Operation)

[0055] Fig. 9 shows a configuration of the air conditioner of Embodiment 1 and a refrigerant flow in refrigerant

circuit 100 during the heating operation of the air conditioner.

[0056] During the heating operation of the air conditioner, controller 80 operates as follows.

5 **[0057]** Controller 80 does not calculate degree of supercooling SC of the refrigerant. Accordingly, differential pressure ΔP detected by strain sensor GS is not used by controller 80.

10 **[0058]** Controller 80 obtains, as an evaporation temperature of first refrigerant CA in outdoor heat exchanger 2, temperature T_q of first refrigerant CA between outdoor heat exchanger 2 and detection case 20 which is detected by temperature sensor KS.

15 **[0059]** As described above, the present embodiment calculates degree of supercooling SC using differential pressure ΔP applied to diaphragm 23 in detection case 20, and accordingly, can measure degree of supercooling SC with higher accuracy than when calculating a degree of supercooling using a difference between the temperatures detected by two temperature sensors 11, 12 as in the reference example. In the reference example, particularly, an error may become larger when the detected temperature has a smaller value.

25 **[0060]** The present embodiment can detect a degree of supercooling accurately even during the operation in which an operation with a lower degree of supercooling is performed with a reduced amount of refrigerant sealed in refrigerant circuit 100.

30 **[0061]** The present embodiment can measure degree of supercooling SC accurately, and accordingly, can detect a refrigerant leakage from the refrigerant circuit accurately.

35 **[0062]** The present embodiment can determine an accurate degree of supercooling SC of first refrigerant CA by arranging temperature sensor KS and strain sensor GS in detection case 20. Accordingly, compared with the case when the pressure sensor for detecting a pressure of the refrigerant is arranged in the vicinity of outdoor heat exchanger 2, the present embodiment can save more space for the air conditioner in order to determine an accurate degree of supercooling SC of first refrigerant CA.

45 **[0063]** Further, the present embodiment can detect condensation temperature CT of first refrigerant CA even without temperature sensor 11 for measuring condensation temperature CT of first refrigerant CA as in the reference example.

Embodiment 2

50 **[0064]** Fig. 10 shows a temperature sensor arranged in the vicinity of outdoor heat exchanger 2 and an arrangement of detection case 20 in Embodiment 2. Fig. 11 shows a configuration of detection case 20 of Embodiment 2.

55 **[0065]** Temperature sensor 10 is arranged in the vicinity of outdoor heat exchanger 2. Temperature sensor 10 detects an outside air temperature T_a . In Embodiment

2, temperature sensor KS is not arranged on diaphragm 23.

(Operation during Cooling Operation)

[0066] In Embodiment 2, a computation unit 19 calculates temperature T_q of first refrigerant CA between outdoor heat exchanger 2 and detection case 20 according to the following equation from outside air temperature T_a detected by temperature sensor 10.

$$T_q = T_a + \alpha \dots (5)$$

[0067] In the equation, α depends on the specifications of outdoor heat exchanger 2, and can be determined as appropriate by a designer. Alternatively, α may change in accordance with a rotational speed of compressor 1. For example, α may be larger as the rotational speed of compressor 1 is higher.

[0068] In Embodiment 2, temperature sensor 10 and computation unit 19 constitute a temperature detector 52.

[0069] Fig. 12 shows a relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q in Embodiment 2.

[0070] As shown in Fig. 12, the relation between differential pressure ΔP and degree of supercooling SC changes in accordance with temperature T_q of first refrigerant CA between outdoor heat exchanger 2 and detection case 20.

[0071] Controller 80 determines degree of supercooling SC of first refrigerant CA at the outlet of outdoor heat exchanger 2 based on temperature T_q detected by temperature detector 52, differential pressure ΔP detected by strain sensor GS, and the predetermined relation between differential pressure ΔP and degree of supercooling SC which corresponds to refrigerant temperature T_q .

[0072] For example, controller 80 identifies a table of temperature T_q of the refrigerant which is detected by temperature detector 52 from among tables showing a relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 determines degree of supercooling SC corresponding to differential pressure ΔP detected by strain sensor GS, with reference to the identified table.

[0073] Alternatively, controller 80 identifies a characteristic equation of temperature T_q of the refrigerant which is detected by temperature detector 52 from among the characteristic equations showing the relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 substitutes differential pressure ΔP detected by strain sensor GS into the identified characteristic equation, thereby calculating degree of supercooling SC. The characteristic equation may be, for example, a quadratic equation, or more simply, a primary equation.

[0074] Further, controller 80 calculates condensation

temperature CT of first refrigerant CA in outdoor heat exchanger 2 according to the following equation.

$$CT = T_q + SC \dots (6)$$

[0075] As in Embodiment 1, controller 80 controls refrigerant circuit 100 based on the calculated degree of supercooling SC and condensation temperature CT , and controls a degree of opening of expansion valve 3 based on condensation temperature CT of first refrigerant CA.

Embodiment 3

[0076] Fig. 13 shows a configuration of an air conditioner of Embodiment 3 and a refrigerant flow in refrigerant circuit 100 during a heating operation of the air conditioner. Fig. 14 shows an arrangement and a configuration of detection case 20 of Embodiment 3.

[0077] The air conditioner includes refrigerant circuit 100, detection case 20 connected to refrigerant circuit 100, and controller 80, as in Embodiment 1. Indoor heat exchanger 4 includes a sub-heat exchanger 4a and a sub-heat exchanger 4b.

[0078] Detection case 20 is arranged between indoor heat exchanger 4 and expansion valve 3. An internal space of detection case 20 is divided into first space R1 and second space R2 by diaphragm 23. First space R1 is a sealed space. Second refrigerant CB is sealed in first space R1. A second refrigerant CB is of the same type as first refrigerant CA that circulates in refrigerant circuit 100. Second space R2 is connected to refrigerant circuit 100 by refrigerant pipe 7. First refrigerant CA that circulates in refrigerant circuit 100 flows into second space R2.

[0079] Strain sensor GS is arranged on diaphragm 23.

[0080] Temperature sensor KS is arranged on diaphragm 23. In Embodiment 3, temperature sensor KS constitutes temperature detector 51. Temperature sensor KS detects temperature T_q of first refrigerant CA between indoor heat exchanger 4 and detection case 20.

(Operation during Heating Operation)

[0081] During the heating operation of the air conditioner, first refrigerant CA cooled by indoor heat exchanger 4 functioning as the condenser flows into second space R2 of detection case 20.

[0082] In diaphragm 23, differential pressure ΔP between pressure P_d of first refrigerant CA in second space R2 and pressure P_v of second refrigerant CB in first space R1 occurs.

[0083] As in Embodiment 1, strain sensor GS measures differential pressure ΔP .

[0084] Controller 80 determines degree of supercooling SC of first refrigerant CA at the outlet of indoor heat exchanger 4 based on temperature T_q of first refrigerant CA which is detected by temperature sensor KS, differ-

ential pressure ΔP detected by strain sensor GS, and the predetermined relation between differential pressure ΔP and degree of supercooling SC which corresponds to refrigerant temperature T_q .

[0085] For example, controller 80 identifies a table of temperature T_q of the refrigerant which is detected by temperature sensor KS from among tables showing a relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 determines degree of supercooling SC corresponding to differential pressure ΔP detected by strain sensor GS, with reference to the identified table.

[0086] Alternatively, controller 80 identifies a characteristic equation of temperature T_q of the refrigerant which is detected by temperature sensor KS from the characteristic equations showing the relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 substitutes differential pressure ΔP detected by strain sensor GS into the identified characteristic equation, thereby calculating degree of supercooling SC. The characteristic equation may be, for example, a quadratic equation, or more simply, a primary equation.

[0087] Controller 80 calculates condensation temperature CT of first refrigerant CA in indoor heat exchanger 4 according to the following equation, as in Embodiment 1.

$$CT = T_q + SC \dots (7)$$

[0088] As in Embodiment 1, controller 80 controls refrigerant circuit 100 based on the calculated degree of supercooling SC and condensation temperature CT, and controls a degree of opening of expansion valve 3 based on condensation temperature CT of first refrigerant CA.

(Operation during Cooling Operation)

[0089] Fig. 15 shows a configuration of an air conditioner of Embodiment 3 and a refrigerant flow in refrigerant circuit 100 during a cooling operation of the air conditioner.

[0090] During the cooling operation of the air conditioner, controller 80 operates as follows.

[0091] Controller 80 does not calculate degree of supercooling SC of the refrigerant. Thus, differential pressure ΔP detected by strain sensor GS is not used by controller 80.

[0092] Controller 80 obtains, as an evaporation temperature of first refrigerant CA in indoor heat exchanger 4, temperature T_q of first refrigerant CA between indoor heat exchanger 4 and detection case 20 which is detected by temperature sensor KS.

Embodiment 4

[0093] Fig. 16 shows an arrangement and a configuration of detection case 20 of Embodiment 4. In Embodiment 4, temperature sensor KS is not arranged on diaphragm 23.

(Operation during Heating Operation)

[0094] In Embodiment 4, a computation unit 39 calculates temperature T_q of first refrigerant CA between indoor heat exchanger 4 and detection case 20 according to the following equation from outside air temperature T_a detected by temperature sensor 10 in the vicinity of outdoor heat exchanger 2.

$$T_q = T_a + \alpha \dots (8)$$

[0095] In the equation, α depends on the specifications of indoor heat exchanger 4, or may be determined as appropriate by a designer. Alternatively, α may change in accordance with a rotational speed of compressor 1. For example, α may be larger as the rotational speed of compressor 1 is higher.

[0096] In Embodiment 4, temperature sensor 10 and computation unit 39 constitute temperature detector 52.

[0097] Controller 80 determines degree of supercooling SC of first refrigerant CA at the outlet of indoor heat exchanger 4 based on temperature T_q detected by temperature detector 52, differential pressure ΔP detected by strain sensor GS, and the predetermined relation between differential pressure ΔP and degree of supercooling SC which corresponds to refrigerant temperature T_q .

[0098] For example, controller 80 identifies a table of temperature T_q of the refrigerant which is detected by temperature detector 52 from among tables showing a relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 determines degree of supercooling SC corresponding to differential pressure ΔP detected by strain sensor GS, with reference to the identified table.

[0099] Alternatively, controller 80 identifies a characteristic equation of temperature T_q of the refrigerant which is detected by temperature detector 52 from among characteristic equations showing the relation between differential pressure ΔP and degree of supercooling SC at every temperature T_q of the refrigerant. Controller 80 substitutes differential pressure ΔP determined by strain sensor GS into the identified characteristic equation, thereby calculating degree of supercooling SC. The characteristic equation may be, for example, a quadratic equation, or more simply, a primary equation.

[0100] Further, controller 80 calculates condensation temperature CT of first refrigerant CA in indoor heat exchanger 4 according to the following equation.

CT = Tq + SC ... (9)

[0101] As in Embodiment 1, controller 80 controls re- frigerant circuit 100 based on the calculated degree of supercooling SC and condensation temperature CT, and controls a degree of opening of expansion valve 3 based on condensation temperature CT of first refrigerant CA.

Variations

[0102] The present invention is not limited to the em- bodiments described above.

(1) Detection case 20 is arranged between outdoor heat exchanger 2 and expansion valve 3 in Embod- iments 1 and 2, and detection case 20 is arranged between indoor heat exchanger 4 and expansion valve 3 in Embodiments 3 and 4, but the present invention is not limited thereto. A detection case 20A may be arranged between outdoor heat exchanger 2 and expansion valve 3, and a detection case 20B may be arranged between indoor heat exchanger 4 and expansion valve 3.

[0103] It is to be understood that the embodiments dis- closed herein are presented for the purpose of illustration and non-restrictive in every respect. It is therefore intend- ed that the scope of the present invention is defined by claims, not only by the embodiments described above, and encompasses all modifications and variations equiv- alent in meaning and scope to the claims.

REFERENCE SIGNS LIST

[0104] 1 compressor; 2 outdoor heat exchanger; 2a, 2b, 4a, 4b sub-heat exchanger; 3 expansion valve; 4 in- door heat exchanger; 6, 7 refrigerant pipe; 10, 11, 12, KS temperature sensor; 19 computation unit; 20 detec- tion case; 23 diaphragm; 51, 52 temperature detector; R1 first space; R2 second space; GS strain sensor; CA first refrigerant; CB second refrigerant.

Claims

1. An air conditioner comprising:

- a refrigerant circuit in which a first refrigerant circulates, the refrigerant circuit having a com- pressor, an outdoor heat exchanger, an expan- sion valve, and an indoor heat exchanger annu- larly connected by a refrigerant pipe;
- a detection case arranged between the outdoor heat exchanger and the expansion valve;
- a diaphragm configured to divide an internal space of the detection case into a first space and a second space, the first space being

sealed, a second refrigerant of a same type as the first refrigerant being sealed in the first space, the second space being connected to the refrigerant circuit, the first refrigerant flowing into the second space;

a strain sensor arranged on the diaphragm and configured to detect a difference between a pressure of the first refrigerant in the second space and a pressure of the second refrigerant in the first space; and

a temperature detector configured to detect a temperature of the first refrigerant between the outdoor heat exchanger and the detection case.

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2. The air conditioner according to claim 1, wherein the temperature detector has a temperature sensor ar- ranged on the diaphragm and configured to detect a temperature of the first refrigerant between the out- door heat exchanger and the detection case.

3. The air conditioner according to claim 1, wherein the temperature detector has

a temperature sensor configured to detect an outside air temperature, and

a computation unit configured to add a prede- termined value to the outside air temperature detected by the temperature sensor to detect a temperature of the first refrigerant between the outdoor heat exchanger and the detection case.

4. The air conditioner according to claim 3, wherein the predetermined value changes in accordance with a frequency of the compressor.

5. The air conditioner according to any one of claims 1 to 4, comprising a controller configured to, during a cooling operation of the air conditioner, determine a degree of supercooling of the first refrigerant at an outlet of the outdoor heat exchanger based on the difference between the pressures detected by the strain sensor and the detected temperature of the first refrigerant.

6. The air conditioner according to claim 5, wherein the controller is configured to select an equation showing a relation between the difference between the pres- sures and the degree of supercooling in accordance with the detected temperature of the first refrigerant, and substitute the detected difference between the pressures into the selected equation to determine the degree of supercooling.

7. The air conditioner according to claim 5 or 6, wherein the controller is configured to determine a conden- sation temperature of the first refrigerant in the out- door heat exchanger based on the detected temper- ature of the first refrigerant and the degree of super-

cooling.

8. The air conditioner according to any one of claims 5 to 7, wherein the controller is configured to, during a heating operation of the air conditioner, obtain the detected temperature of the first refrigerant as an evaporation temperature of the first refrigerant in the outdoor heat exchanger. 5
9. An air conditioner comprising: 10
- a refrigerant circuit in which a first refrigerant circulates, the refrigerant circuit having a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger annularly connected by a refrigerant pipe; 15
 - a detection case arranged between the indoor heat exchanger and the expansion valve; and
 - a diaphragm configured to divide an internal space of the detection case into a first space and a second space, the first space being sealed, a second refrigerant of a same type as the first refrigerant being sealed in the first space, the second space being connected to the refrigerant circuit, the first refrigerant flowing into the second space; 20
 - a strain sensor arranged on the diaphragm and configured to detect a difference between a pressure of the first refrigerant in the second space and a pressure of the second refrigerant in the first space; and 25
 - a temperature detector configured to detect a temperature of the first refrigerant between the indoor heat exchanger and the detection case. 30
10. The air conditioner according to claim 9, wherein the temperature detector is arranged on the diaphragm and has a temperature sensor configured to detect a temperature of the first refrigerant between the indoor heat exchanger and the detection case. 35 40
11. The air conditioner according to claim 9, wherein the temperature detector has 45
- a temperature sensor configured to detect an outside air temperature, and
 - a computation unit configured to add a predetermined value to the outside air temperature detected by the temperature sensor to detect a temperature of the first refrigerant between the indoor heat exchanger and the detection case. 50
12. The air conditioner according to claim 11, wherein the predetermined value changes in accordance with a frequency of the compressor. 55
13. The air conditioner according to any one of claims 9 to 12, comprising a controller to, during a heating operation of the air conditioner, determine a degree of supercooling of the first refrigerant at an outlet of the indoor heat exchanger based on the difference between the pressures detected by the strain sensor and the detected temperature of the first refrigerant.
14. The air conditioner according to claim 13, wherein the controller is configured to select an equation showing a relation between the difference between the pressures and the degree of supercooling in accordance with the detected temperature of the first refrigerant, and substitute the detected difference between the pressures into the selected equation to determine the degree of supercooling.
15. The air conditioner according to claim 13 or 14, wherein the controller is configured to determine a condensation temperature of the first refrigerant in the indoor heat exchanger based on the detected temperature of the first refrigerant and the degree of supercooling.
16. The air conditioner according to any one of claims 13 to 15, wherein the controller is configured to, during a cooling operation of the air conditioner, obtain the detected temperature of the first refrigerant as an evaporation temperature of the first refrigerant in the outdoor heat exchanger.
17. The air conditioner according to any one of claims 5 to 7 and 13 to 15, wherein the controller is configured to determine that the first refrigerant has leaked in the refrigerant circuit when the degree of supercooling is zero.

FIG.1

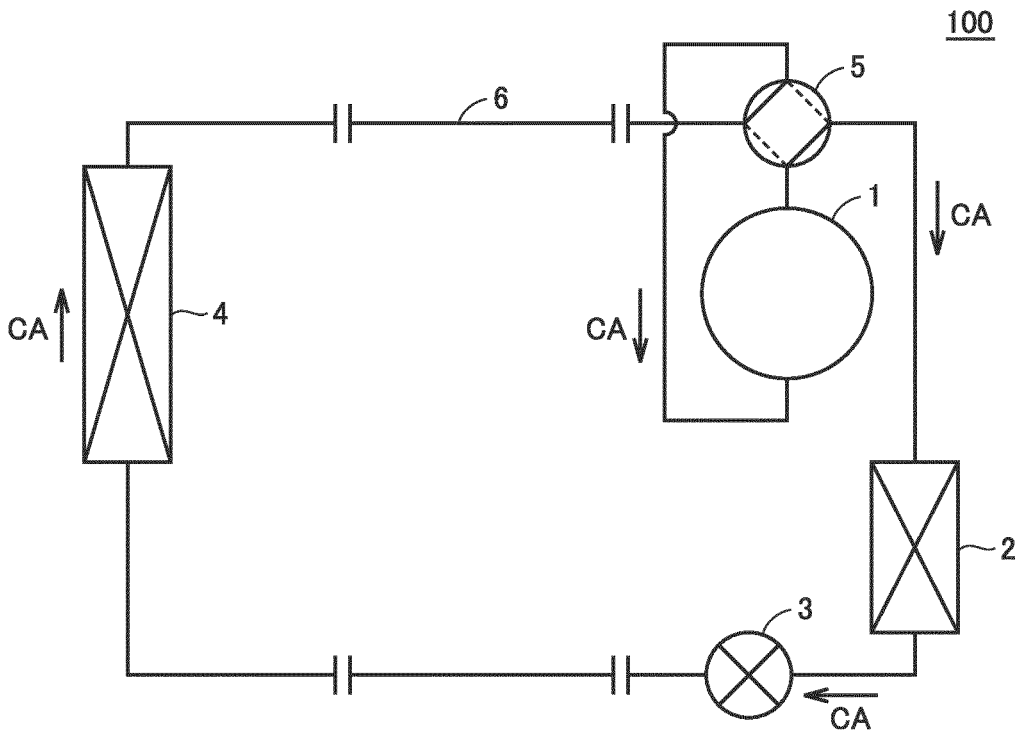


FIG.2

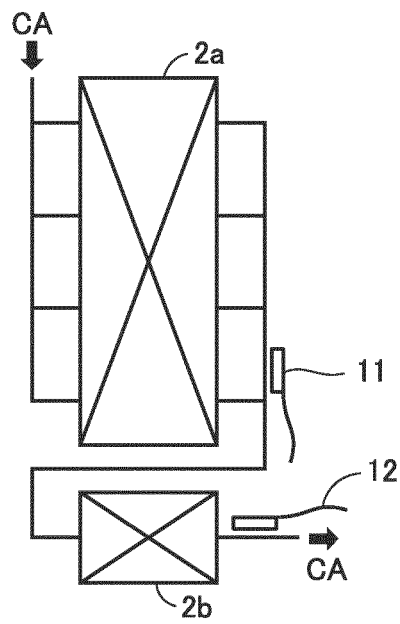


FIG.3

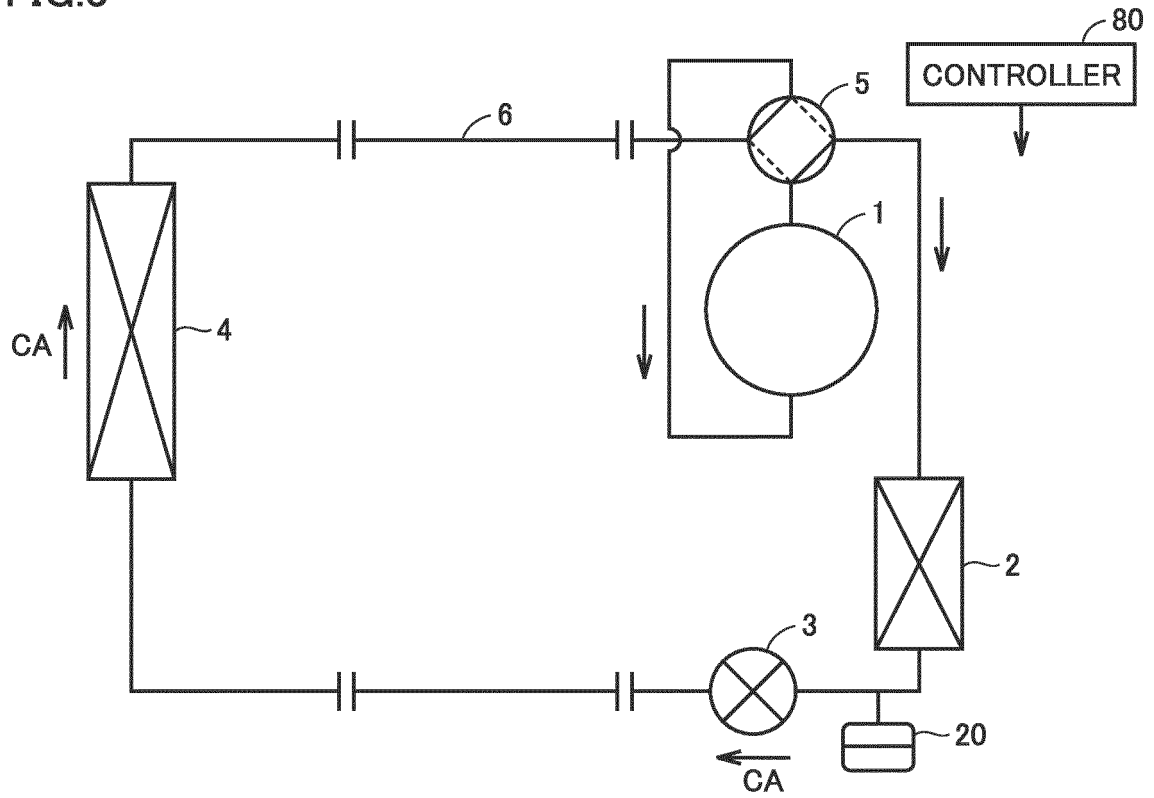


FIG.4

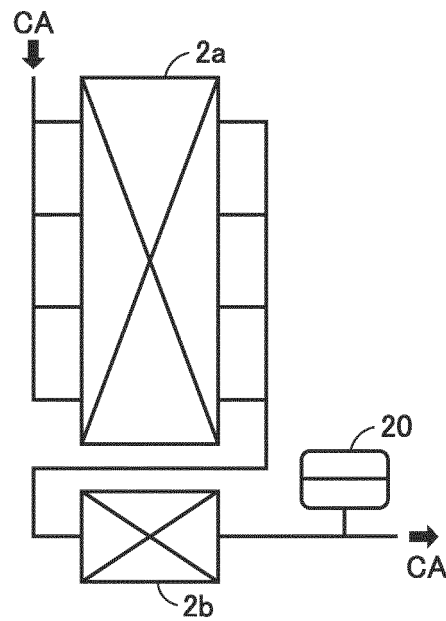


FIG.5

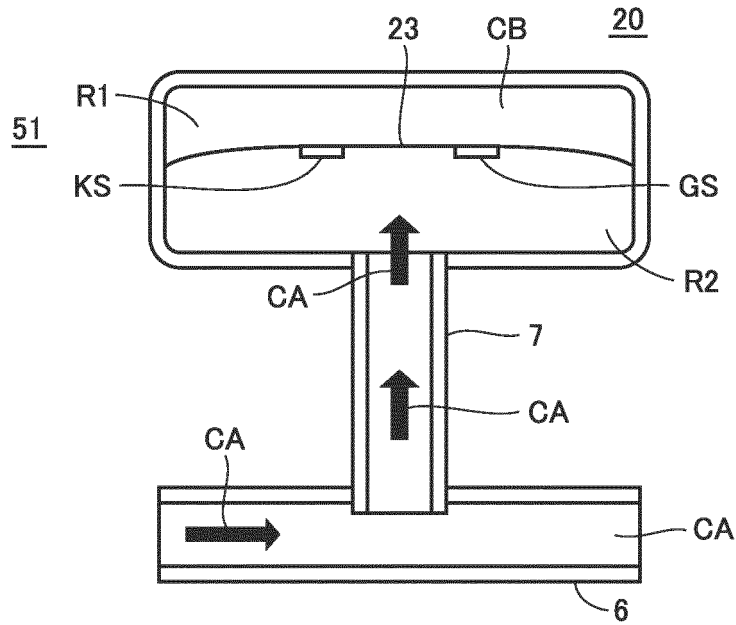


FIG.6

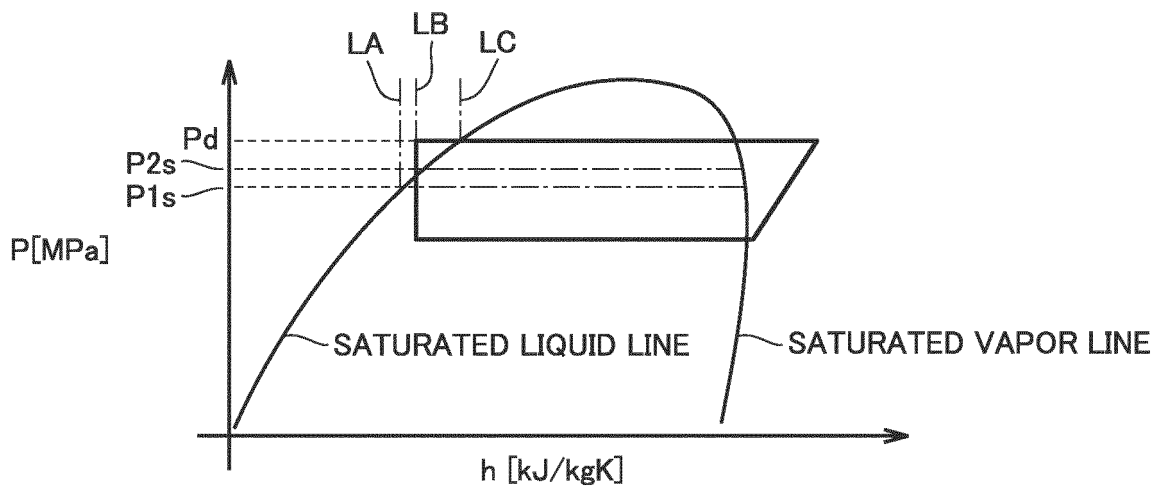


FIG.7

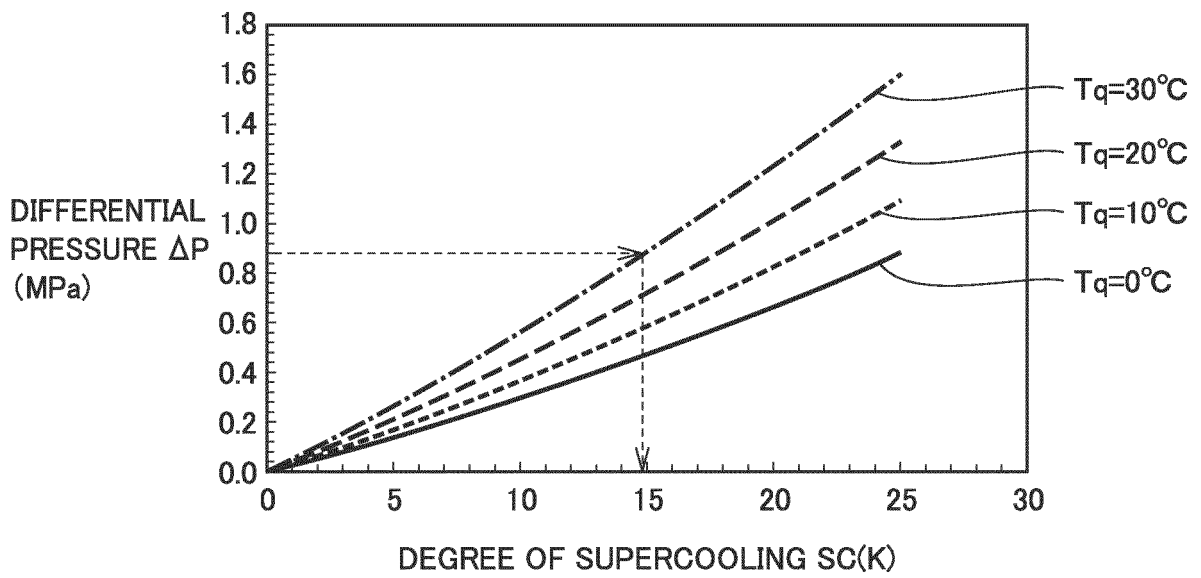


FIG.8

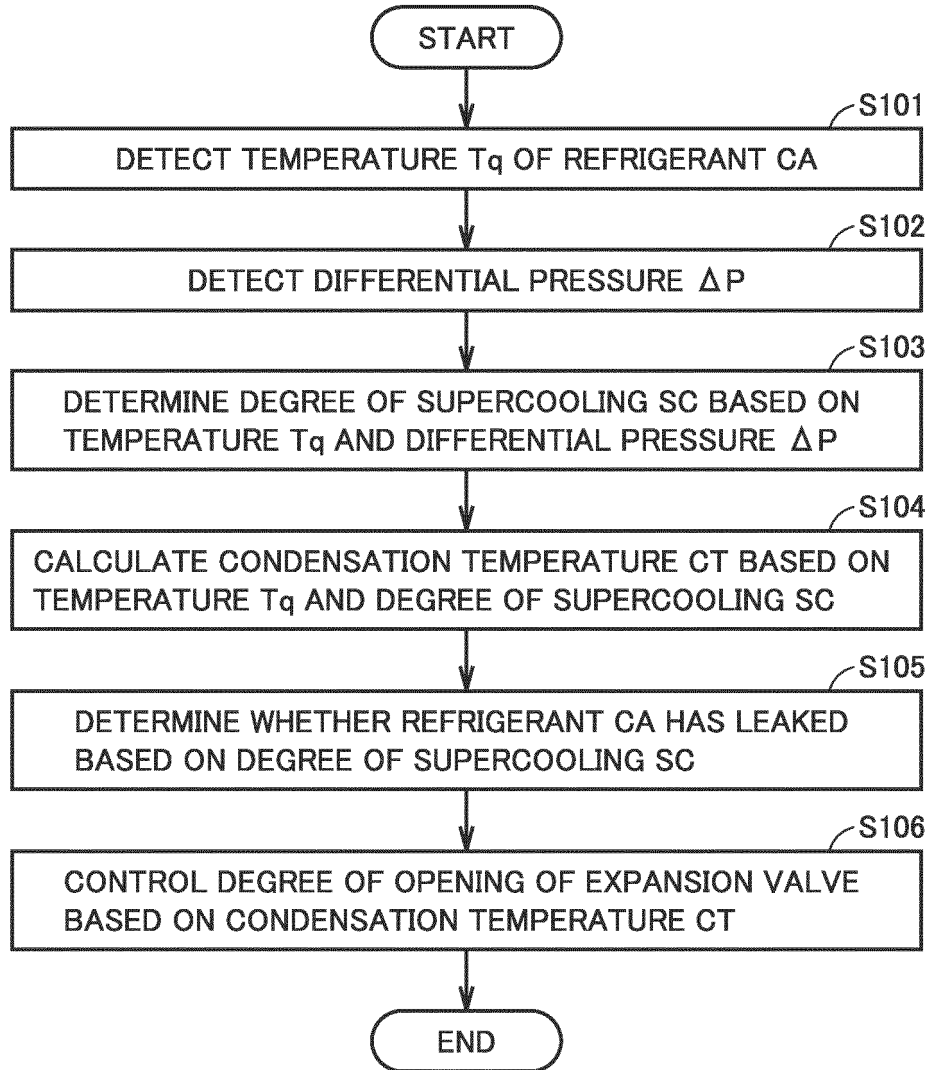


FIG.9

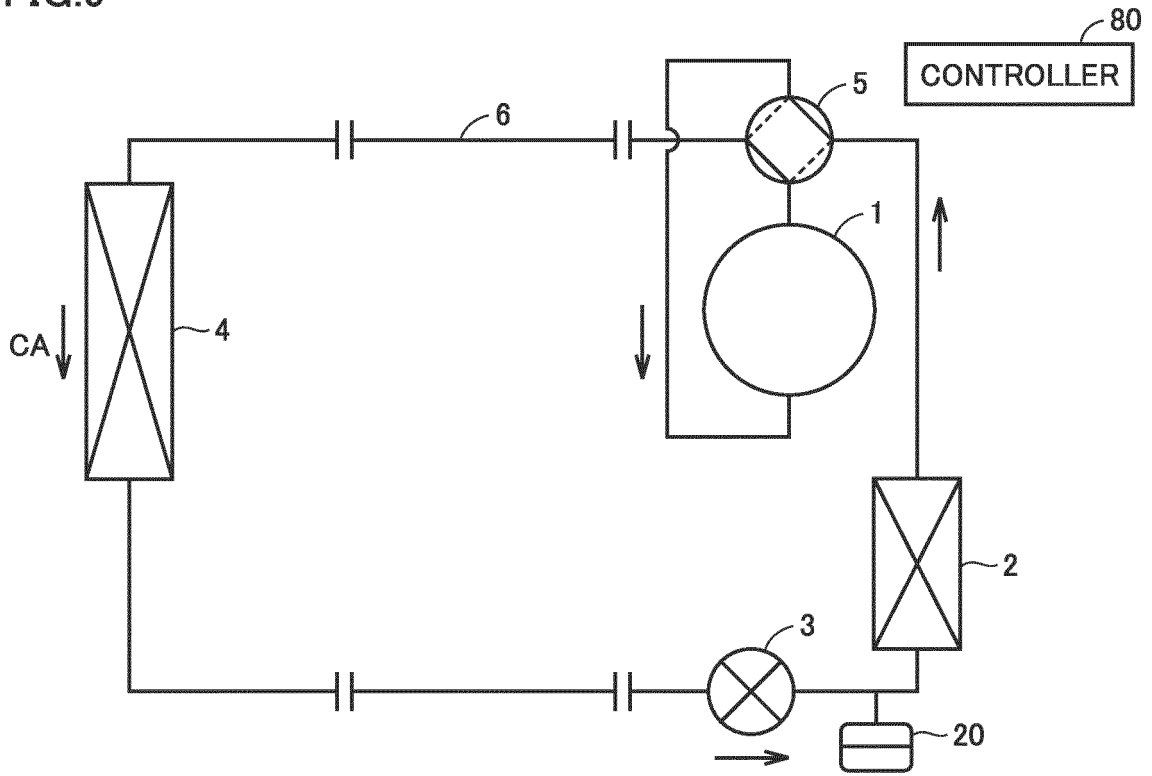


FIG.10

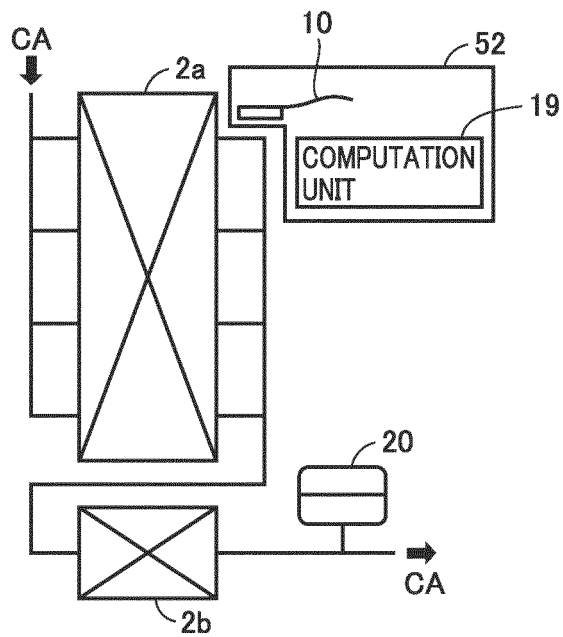


FIG.11

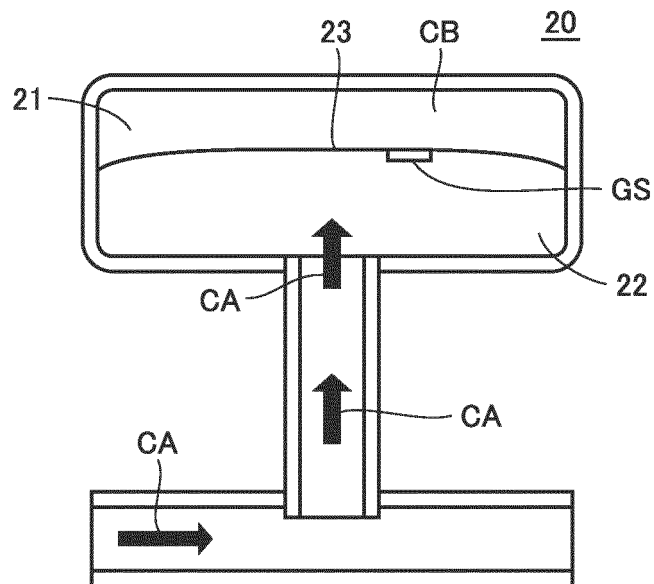


FIG.12

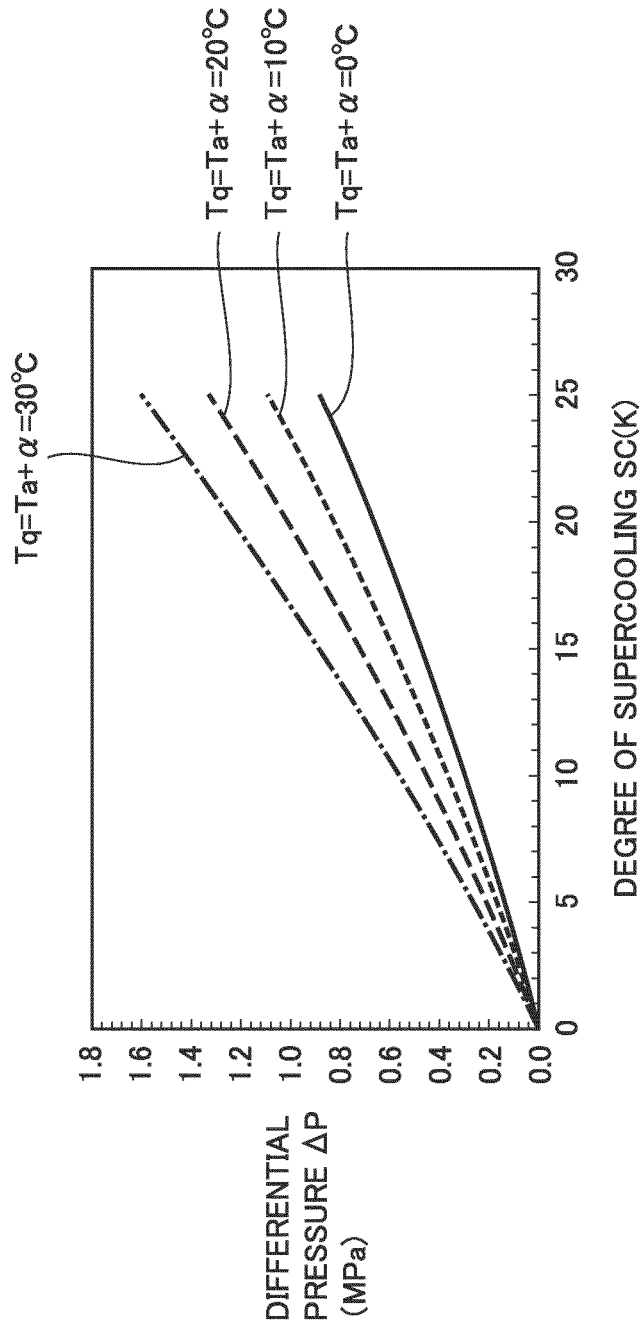


FIG.13

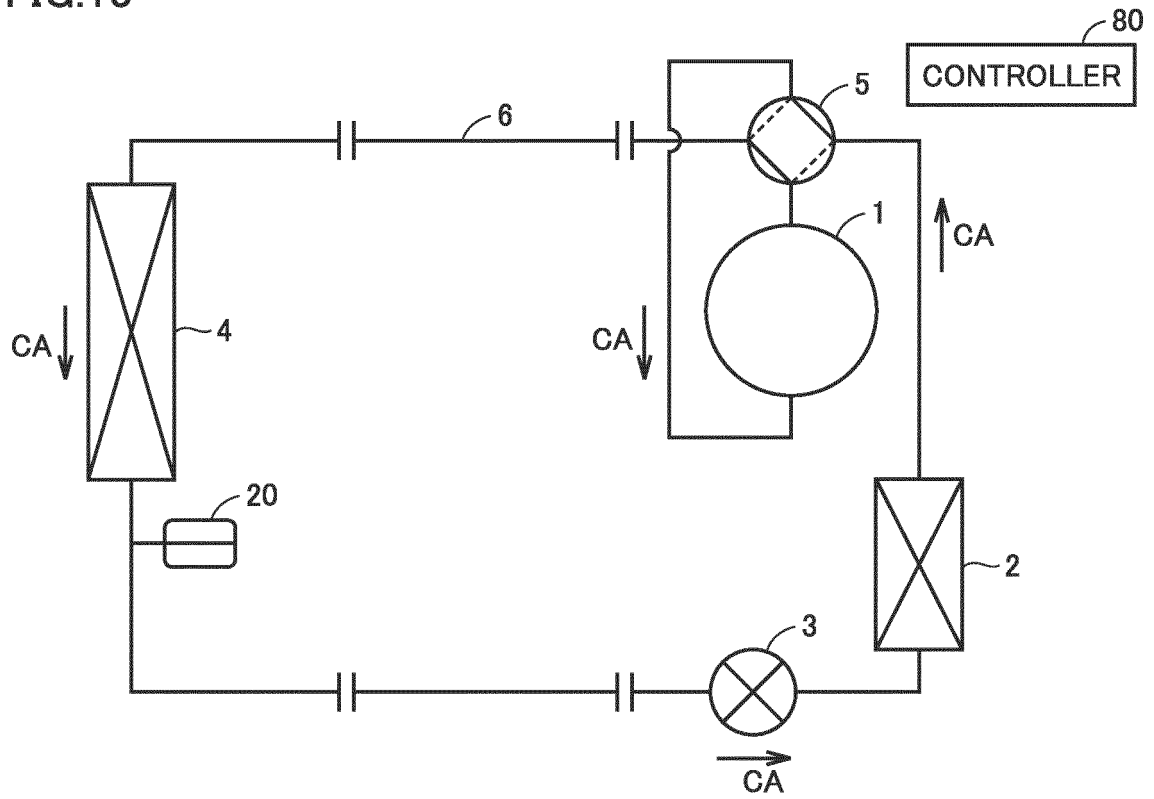


FIG.14

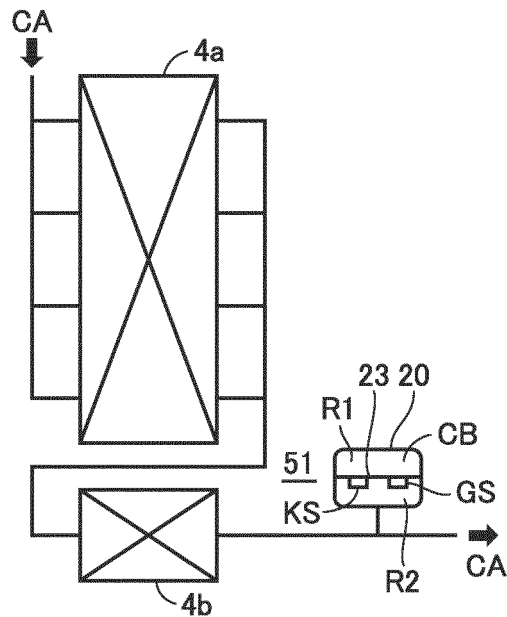


FIG.15

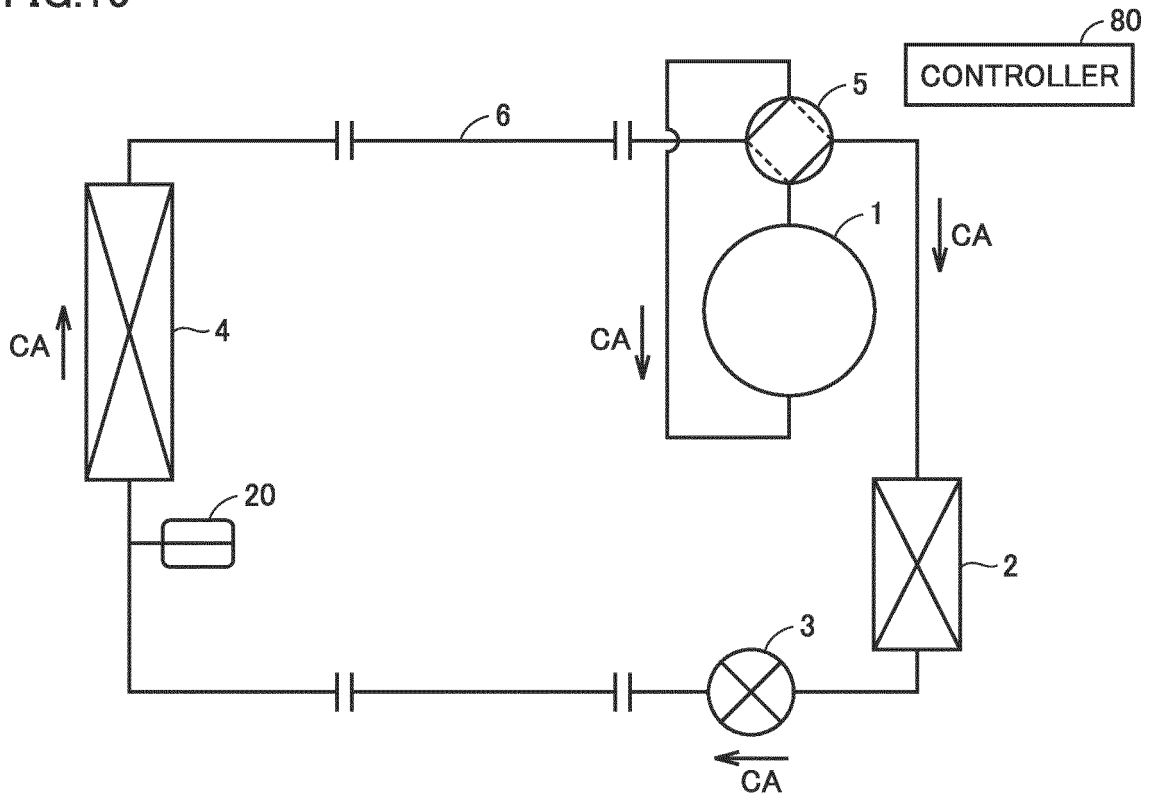
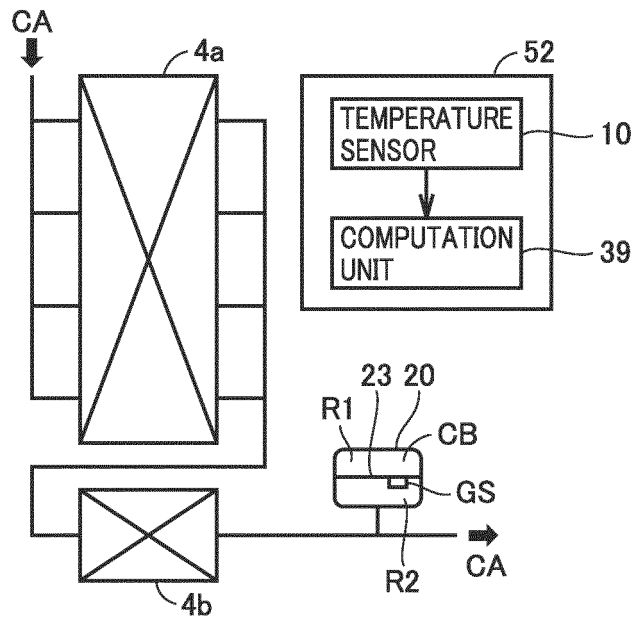


FIG.16



5	INTERNATIONAL SEARCH REPORT	International application No. PCT/JP2019/044892
	A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. F25B49/02 (2006.01) i FI: F25B49/02 510C, F25B49/02 510F	
10	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. F25B49/02	
15	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 1971-2020 Registered utility model specifications of Japan 1996-2020 Published registered utility model applications of Japan 1994-2020	
20	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
25	A	JP 2010-7994 A (DAIKIN INDUSTRIES, LTD.) 14 January 2010, paragraphs [0038]-[0107], fig. 1-8
30	A	JP 2012-211723 A (NAKANO REFRIGERATORS CO., LTD.) 01 November 2012, abstract
35	A	JP 9-105567 A (DENSO CORP.) 22 April 1997, abstract
40	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.	
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
50	Date of the actual completion of the international search 06.01.2020	Date of mailing of the international search report 21.01.2020
55	Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No. PCT/JP2019/044892
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Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2010-7994 A	14.01.2010	US 2011/0107780 A1 paragraphs [0044]- [0111], fig. 1-8 WO 2009/157191 A1 EP 2320169 A1 CN 102077041 A	
JP 2012-211723 A	01.11.2012	(Family: none)	
JP 9-105567 A	22.04.1997	(Family: none)	

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/044892

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The description does not make it possible to understand the method for implementing "finding the degree of supercooling of the first refrigerant at the exit of the outdoor heat exchanger on the basis of the difference in the pressure detected by the strain sensor and the temperature of the first refrigerant that has been detected" recited in claim 5. According to the description of the present application (paragraphs [0029] and [0030]), the temperature of the second refrigerant CB enclosed in the first space R1 is also affected by the outside air temperature. As such, the outside air temperature also has an effect on the differential pressure ΔP , and thus the degree of supercooling cannot be determined by the differential pressure ΔP and the temperature T_q alone.

The same is also true of "finding the degree of supercooling" recited in claim 13.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016099059 A [0003]