(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 885 676 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.09.2021 Bulletin 2021/39

(21) Application number: **19887164.2**

(22) Date of filing: **12.11.2019**

(51) Int Cl.:
F25B 49/02 *(2006.01)*

(86) International application number:
PCT/JP2019/044420

(87) International publication number:
WO 2020/105515 (28.05.2020 Gazette 2020/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **19.11.2018 JP 2018216841**

(71) Applicant: **DAIKIN INDUSTRIES, LTD.**
Osaka-shi, Osaka 530-8323 (JP)

(72) Inventors:
- **OKUDA, Noriyuki**
Osaka-shi
Osaka 530-8323 (JP)
- **NISHIKAWA, Tooru**
Osaka-shi
Osaka 530-8323 (JP)
- **HONDA, Masahiro**
Osaka-shi
Osaka 530-8323 (JP)
- **YOH, Hiroshi**
Osaka-shi
Osaka 530-8323 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) REFRIGERANT CYCLE DEVICE, REFRIGERANT AMOUNT DETERMINATION SYSTEM, AND REFRIGERANT AMOUNT DETERMINATION METHOD

(57) The technique in PTL 1 is incapable of grasping a decrease in the amount of a refrigerant from an initial amount of the refrigerant, and the determination of the amount of the refrigerant is insufficient for the purpose other than protection of a compressor. A refrigeration cycle apparatus (100) includes an air temperature sensor (36), a condensation temperature sensor (37), an acquisition unit (38), and a determination unit (34). The air temperature sensor (36) detects an air temperature, which is a temperature of air that flows into a condenser. The condensation temperature sensor (37) detects a condensation temperature of the refrigerant that flows through the condenser. The acquisition unit (38) acquires a temperature difference between the air temperature and the condensation temperature. The determination unit (34) determines an amount of the refrigerant included in the refrigerant circuit by comparing a first temperature difference and a second temperature difference with each other. The first temperature difference is a temperature difference acquired by the acquisition unit (38) at a first timing. The second temperature difference is a temperature difference acquired by the acquisition unit (38) at a second timing.

EP 3 885 676 A1

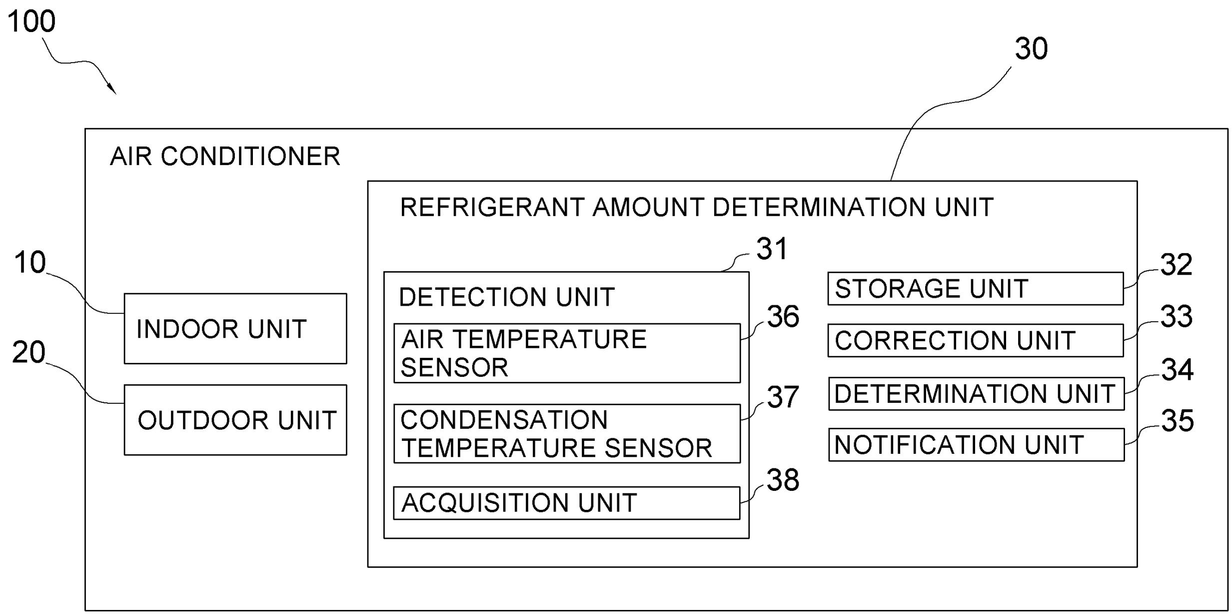
100
30
AIR CONDITIONER
REFRIGERANT AMOUNT DETERMINATION UNIT
10
INDOOR UNIT
20
OUTDOOR UNIT
31
DETECTION UNIT
AIR TEMPERATURE SENSOR
36
CONDENSATION TEMPERATURE SENSOR
37
ACQUISITION UNIT
38
STORAGE UNIT
32
CORRECTION UNIT
33
DETERMINATION UNIT
34
NOTIFICATION UNIT
35

FIG. 2

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus, a refrigerant amount determination system, and a refrigerant amount determination method.

BACKGROUND ART

[0002] Conventionally, a refrigeration cycle apparatus that determines the amount of a refrigerant included in a refrigerant circuit has been known. For example, PTL 1 (Japanese Unexamined Patent Application Publication No. H6-159869) determines the amount of the refrigerant on the basis of a difference between a refrigerant temperature and an inlet air temperature and a preset compressor protection-limit temperature difference and stops operation of the compressor.

SUMMARY OF INVENTION

<Technical Problem>

[0003] The technique in PTL 1 is incapable of grasping a decrease in the amount of the refrigerant from an initial amount of the refrigerant, and the determination of the amount of the refrigerant is insufficient for the purpose other than protection of the compressor.

<Solution to Problem>

[0004] In a refrigeration cycle apparatus according to a first aspect, a refrigerant circulates in a refrigerant circuit constituted by a compressor, a condenser, an expansion mechanism, and an evaporator being connected. The refrigeration cycle apparatus includes an air temperature sensor, a condensation temperature sensor, an acquisition unit, and a determination unit. The air temperature sensor detects an air temperature, which is a temperature of air that flows into the condenser. The condensation temperature sensor detects a condensation temperature of the refrigerant that flows through the condenser. The acquisition unit acquires a temperature difference between the air temperature and the condensation temperature. The determination unit determines an amount of the refrigerant included in the refrigerant circuit by comparing a first temperature difference and a second temperature difference with each other. The first temperature difference is a temperature difference acquired by the acquisition unit at a first timing. The second temperature difference is a temperature difference acquired by the acquisition unit at a second timing.

[0005] The refrigeration cycle apparatus herein compares the first temperature difference and the second temperature difference with each other and determines the amount of the refrigerant included in the refrigerant circuit. Thus, it can be determined whether the refrigerant leaks from the refrigerant circuit to the outside by accidental means.

[0006] A refrigeration cycle apparatus according to a second aspect is the refrigeration cycle apparatus according to the first aspect further including a storage unit. The storage unit stores at least one of the first temperature difference or the air temperature and the condensation temperature acquired at the first timing.

[0007] A refrigeration cycle apparatus according to a third aspect is the refrigeration cycle apparatus according to the first or second aspect, in which the first timing is any of a time at which the refrigeration cycle apparatus is installed, at a time of initial operation of the refrigeration cycle apparatus, or a time of maintenance of the refrigeration cycle apparatus.

[0008] A refrigeration cycle apparatus according to a fourth aspect is the refrigeration cycle apparatus according to any of the first to third aspects, in which, if a difference between the first temperature difference and the second temperature difference is greater than or equal to a threshold that is any value from 2°C to 4°C, the determination unit determines that the amount of the refrigerant included in the refrigerant circuit is insufficient.

[0009] A refrigeration cycle apparatus according to a fifth aspect is the refrigeration cycle apparatus according to any of the first to fourth aspects, further including a notification unit that notifies insufficiency of the amount of the refrigerant if the determination unit determines that the amount of the refrigerant is insufficient.

[0010] A refrigeration cycle apparatus according to a sixth aspect is the refrigeration cycle apparatus according to any of the first to fifth aspects, further including a correction unit that corrects the first temperature difference and the second temperature difference by using at least either one of the air temperature or an evaporation temperature of the refrigerant.

[0011] A refrigerant amount determination system according to a seventh aspect is a refrigerant amount determination system that determines an amount of a refrigerant included in a refrigeration cycle apparatus. In the refrigeration cycle apparatus, the refrigerant circulates in a refrigerant circuit constituted by a compressor, a condenser, an expansion mechanism, and an evaporator being connected. The refrigerant amount determination system includes an air temperature sensor, a condensation temperature sensor, an acquisition unit, and a determination unit. The air temperature sensor detects an air temperature, which is a temperature of air that flows into the condenser. The condensation temperature sensor detects a condensation temperature of the refrigerant that flows through the condenser. The acquisition unit acquires a temperature difference between the air temperature and the condensation temperature. The determination unit determines the amount of the refrigerant included in the refrigerant circuit by comparing a first temperature difference and a second temperature difference with each other. The first temperature difference is a temperature difference acquired by the acquisition unit at a first timing. The second temperature difference is a temperature difference acquired by the acquisition unit at a second timing.

[0012] The refrigeration cycle apparatus herein compares the first temperature difference and the second temperature difference with each other and determines the amount of the refrigerant included in the refrigerant circuit. Thus, it can be determined whether the refrigerant leaks from the refrigerant circuit to the outside by accidental means.

[0013] A refrigerant amount determination system according to an eighth aspect is the refrigerant amount determination system according to the seventh aspect further including a storage unit. The storage unit stores at least one of the first temperature difference or the air temperature and the condensation temperature acquired at the first timing.

[0014] A refrigerant amount determination system according to a ninth aspect is the refrigerant amount determination system according to the seventh or eighth aspect, in which the first timing is any of a time at which the refrigeration cycle apparatus is installed, at a time of initial operation of the refrigeration cycle apparatus, or a time of maintenance of the refrigeration cycle apparatus.

[0015] A refrigerant amount determination system according to a tenth aspect is the refrigerant amount determination system according to any of the seventh to ninth aspects, in which, if a difference between the first temperature difference and the second temperature difference is greater than or equal to a threshold that is any value from 2°C to 4°C, the determination unit determines that the amount of the refrigerant included in the refrigerant circuit is insufficient.

[0016] A refrigerant amount determination system according to an eleventh aspect is the refrigerant amount determination system according to any of the seventh to tenth aspects further including a notification unit that notifies insufficiency of the amount of the refrigerant if the determination unit determines that the amount of the refrigerant is insufficient.

[0017] A refrigerant amount determination system according to a twelfth aspect is the refrigerant amount determination system according to any of the seventh to eleventh aspects further including a correction unit that corrects the first temperature difference and the second temperature difference by using the air temperature or an evaporation temperature of the refrigerant.

[0018] A refrigerant amount determination method according to a thirteenth aspect is a refrigerant amount determination method for determining an amount of a refrigerant included in a refrigeration cycle apparatus. In the refrigeration cycle apparatus, the refrigerant circulates in a refrigerant circuit constituted by a compressor, a condenser, an expansion mechanism, and an evaporator being connected. The refrigerant amount determination method includes a first step, a second step, and a third step. In the first step, a first temperature difference is acquired. The first temperature difference is a temperature difference detected at a first timing, between an air temperature and a condensation temperature, the air temperature being a temperature of air that flows into the condenser, the condensation temperature being a condensation temperature of the refrigerant that flows through the condenser. In the second step, a second temperature difference is acquired. The second temperature difference is a temperature difference detected at a second timing, between the air temperature and the condensation temperature, the air temperature being a temperature of air that flows into the condenser, the condensation temperature being a condensation temperature of the refrigerant that flows through the condenser. In the third step, a change in the amount of the refrigerant included in the refrigerant circuit is determined by comparing the first temperature difference and the second temperature difference with each other.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

<Fig. 1> Fig. 1 schematically illustrates an air conditioner according to a first embodiment.
<Fig. 2> Fig. 2 is a block diagram of a refrigeration cycle apparatus according to the first embodiment.
<Fig. 3> Fig. 3 is a flowchart illustrating operations of the refrigeration cycle apparatus in a first step.
<Fig. 4> Fig. 4 is a flowchart illustrating operations of the refrigeration cycle apparatus in a second step and a third step.
<Fig. 5> Fig. 5 is a P-H chart regarding a relationship between the amount of a refrigerant and an air temperature.
<Fig. 6> Fig. 6 is a block diagram of Modification 6 according to the first embodiment.
<Fig. 7> Fig. 7 is a block diagram of a refrigeration cycle apparatus according to a second embodiment.
<Fig. 8> Fig. 8 is a flowchart illustrating operations of the refrigeration cycle apparatus and a refrigerant amount determination system in a first step.
<Fig. 9> Fig. 9 is a flowchart illustrating operations of the air conditioner and the refrigerant amount determination system in a second step and a third step.

DESCRIPTION OF EMBODIMENTS

(1) First Embodiment

[0020] Now, an embodiment of an air conditioner 100 as a refrigeration cycle apparatus according to a first embodiment will be described.

(1-1) Overall Configuration

[0021] Fig. 1 schematically illustrates the air conditioner 100 according to this embodiment. The air conditioner 100 performs indoor cooling and heating for buildings or the like by performing a vapor compression refrigeration cycle. The air conditioner 100 mainly includes an indoor unit 10, an outdoor unit 20, a refrigerant connection pipe 15 that connects the indoor unit 10 and the outdoor unit 20, and a refrigerant amount determination unit 30 that determines the amount of a refrigerant that flows through a refrigerant circuit 16. The refrigerant circuit 16 of the air conditioner 100 is constituted by the indoor unit 10 and the outdoor unit 20 being connected via the refrigerant connection pipe 15. As the refrigerant that circulates in the refrigerant circuit 16, R410A, R32, R407C, R22, R134a, carbon dioxide, or the like is used.

[0022] The indoor unit 10 of the air conditioner 100 is installed, for example, by being hooked to a wall surface in a room or by being embedded in or hung from the ceiling in a room. The indoor unit 10 is connected to the outdoor unit 20 via the refrigerant connection pipe 15 and constitutes part of the refrigerant circuit 16. The indoor unit 10 includes an indoor fan 11 and an indoor heat exchanger 12.

[0023] The outdoor unit 20 is installed outside. The outdoor unit 20 is connected to the indoor unit 10 via the refrigerant connection pipe 15 and constitutes part of the refrigerant circuit 16. The outdoor unit 20 includes an outdoor fan 21, an outdoor heat exchanger 22, a compressor 23, a four-way switching valve 24, and an outdoor expansion valve 25 as an expansion mechanism.

[0024] The refrigerant connection pipe 15 is a refrigerant pipe that is constructed on site when the air conditioner 100 is installed at an installation site. The refrigerant connection pipe 15 is connected to the indoor unit 10 and the outdoor unit 20 and constitutes the refrigerant circuit 16.

[0025] The refrigerant amount determination unit 30 determines the amount of the refrigerant included in the refrigerant circuit 16. Details of the refrigerant amount determination unit 30 will be described later.

[0026] When the air conditioner 100 according to this embodiment is installed on site, the outdoor unit 20 filled with a predetermined amount of the refrigerant in advance and the indoor unit 10 are installed, and the refrigerant connection pipe 15 is connected to constitute the refrigerant circuit 16, and then, the refrigerant circuit 16 is additionally filled with the refrigerant that has been insufficient, in accordance with the length of the refrigerant connection pipe 15, to set a state in which a prescribed amount of the refrigerant is included.

(1-2) Operations of Air Conditioner

[0027] Next, operations of the air conditioner 100 will be described. The air conditioner 100 performs a cooling operation in which the refrigerant sequentially flows in the compressor 23, the outdoor heat exchanger 22, the outdoor expansion valve 25, and the indoor heat exchanger 12 or performs a heating operation in which refrigerant sequentially flows in the compressor 23, the indoor heat exchanger 12, the outdoor expansion valve 25, and the outdoor heat exchanger 22.

[0028] During a cooling operation, the four-way switching valve 24 is switched to an outdoor heat release state (state indicated by the solid line in Fig. 1). In the refrigerant circuit 16, a gaseous refrigerant at a low pressure in the refrigeration cycle is sucked into the compressor 23 and is compressed to a high pressure in the refrigeration cycle before being discharged. The high-pressure gaseous refrigerant is discharged from the compressor 23 and is sent through the four-way switching valve 24 to the outdoor heat exchanger 22. The high-pressure gaseous refrigerant sent to the outdoor heat exchanger 22 is subjected to heat exchange with outdoor air supplied from the outdoor fan 21 and becomes a high-pressure liquid refrigerant. At this time, the outdoor heat exchanger 22 functions as a condenser. The high-pressure liquid refrigerant releases heat in the outdoor heat exchanger 22 and is decompressed by the outdoor expansion valve 25 to the low pressure in the refrigeration cycle to become a low-pressure refrigerant in a gas-liquid two-phase state. The low-pressure refrigerant in a gas-liquid two-phase state decompressed by the outdoor expansion valve 25 is sent to the indoor heat exchanger 12. The low-pressure refrigerant in a gas-liquid two-phase state sent to the indoor heat exchanger 12 is subjected to heat exchange in the indoor heat exchanger 12 with indoor air supplied from the indoor fan 11 to be evaporated. Thus, indoor air is cooled, and indoor cooling is performed. At this time, the indoor heat exchanger 12 functions as an evaporator. The low-pressure gaseous refrigerant evaporated in the indoor heat exchanger 12 passes through the four-way switching valve 24 and is sucked into the compressor 23 again.

[0029] During a heating operation, the four-way switching valve 24 is switched to an outdoor evaporation state (state indicated by the broken line in Fig. 1). In the refrigerant circuit 16, a gaseous refrigerant at a low pressure in the refrigeration cycle is sucked into the compressor 23 and is compressed to a high pressure in the refrigeration cycle before being discharged. The high-pressure gaseous refrigerant is discharged from the compressor 23 and is sent through the four-way switching valve 24 to the indoor heat exchanger 12. The high-pressure gaseous refrigerant sent to the indoor heat exchanger 12 is subjected to heat exchange in the indoor heat exchanger 12 with indoor air supplied from the indoor fan 11 and become a high-pressure liquid refrigerant. Thus, indoor air is heated, and indoor heating is performed. At this time, the indoor heat exchanger 12 functions as a condenser. The high-pressure liquid refrigerant releases heat in the indoor heat exchanger 12 and is sent to the outdoor expansion valve 25. The refrigerant sent to the outdoor expansion valve 25 is decompressed by the outdoor expansion valve 25 to the low pressure in the refrigeration cycle to become a low-pressure refrigerant in a gas-liquid two-phase state. The low-pressure refrigerant in a gas-liquid two-phase state decompressed by the outdoor expansion valve 25 is sent to the outdoor heat exchanger 22. The low-pressure refrigerant in a gas-liquid two-phase state sent to the outdoor heat exchanger 22 is subjected to heat exchange in the outdoor heat exchanger 22 functioning as an evaporator for the refrigerant with outdoor air supplied from the outdoor fan 21 to be evaporated and becomes a low-pressure gaseous refrigerant. The low-pressure gaseous refrigerant evaporated in the outdoor heat exchanger 22 passes through the four-way switching valve 24 and is sucked into the compressor 23 again.

(1-3) Detailed Configuration of Refrigerant Amount Determination Unit

[0030] A detailed configuration of the refrigerant amount determination unit 30 illustrated in Fig. 2 will be described. The refrigerant amount determination unit 30 includes a detection unit 31, a storage unit 32, a correction unit 33, a determination unit 34, and a notification unit 35.

[0031] The detection unit 31 includes an air temperature sensor 36, a condensation temperature sensor 37, and an acquisition unit 38. The air temperature sensor 36 detects an air temperature that is the temperature of outdoor air that flows into the outdoor heat exchanger 22. The condensation temperature sensor 37 detects the condensation temperature of the refrigerant. For example, the condensation temperature sensor 37 is provided so as to be in contact with a heat exchanger tube (not illustrated) included in the outdoor heat exchanger 22. The acquisition unit 38 acquires a temperature difference between the air temperature detected by the air temperature sensor 36 and the condensation temperature detected by the condensation temperature sensor 37.

[0032] The storage unit 32 stores the air temperature detected by the air temperature sensor 36, the condensation temperature detected by the condensation temperature sensor 37, and the temperature difference acquired by the acquisition unit 38.

[0033] The correction unit 33 corrects the temperature difference by using the air temperature stored in the storage unit 32.

[0034] The determination unit 34 compares a plurality of temperature differences acquired by the acquisition unit 38 and determines a change in the amount of the refrigerant included in the refrigerant circuit 16.

[0035] If the determination unit 34 determines that the amount of the refrigerant is insufficient, the notification unit 35 notifies insufficiency of the amount of the refrigerant. The notification unit 35 notifies insufficiency of the amount of the refrigerant by using, for example, an LED or the like.

(1-4) Refrigerant Amount Determination Method

[0036] Next, a method for determining the amount of the refrigerant will be described with reference to Fig. 3 and Fig. 4. Note that, in a case described below, for example, regular inspection is performed for determining whether the refrigerant leaks from the refrigerant circuit 16 to the outside by accidental means.

[0037] The amount of the refrigerant is determined in a first step ST1, a second step ST2, and a third step ST3 in this order. In the first step ST1, step S101 to step S104 are performed. In the second step ST2, step S105 to step S109 are performed. In the third step ST3, step S110 and step S111 are performed. Each step will be described below.

[0038] Fig. 3 is a flowchart illustrating operations of the air conditioner 100 in the first step ST1. The air conditioner 100 is installed on site in a state in which a prescribed amount of the refrigerant is included. The time at which the air conditioner 100 is installed is a first timing T1. In step S101, the air conditioner 100 starts a test run for detecting the air temperature and the condensation temperature. In step S102, the air conditioner 100 performs control such that the frequency of the compressor 23 becomes a predetermined value so as to set a state in which the frequency of the compressor 23 is stabilized. In step S103, the air temperature sensor 36 of the detection unit 31 detects a first air temperature Ta1, and the condensation temperature sensor 37 detects a first condensation temperature Tc1. The first air temperature Ta1 is the air temperature at the first timing T1, and the first condensation temperature Tc1 is the condensation temperature at the first timing T1. The storage unit 32 stores the first air temperature Ta1 and the first condensation temperature Tc1 that are detected. In step S104, the acquisition unit 38 compares the first air temperature Ta1 and the first condensation temperature Tc1 with each other, thereby acquiring a first temperature difference $\Delta T1$, which is a temperature difference at the first timing T1. The acquired first temperature difference $\Delta T1$ is stored in the storage unit 32.

[0039] Next, the second step ST2 and the third step ST3, which are illustrated in Fig. 4, will be described. The second step ST2 and the third step ST3 are performed after a certain period has elapsed from the first timing T1. Herein, the second step ST2 and the third step ST3 are performed at the time of maintenance after a period of about one year has elapsed from the first timing T1. This time of maintenance is a second timing T2. In step S105, the air conditioner 100 starts a test run as in step S101. In step S106, control is performed such that the frequency of the compressor 23 becomes a predetermined value so as to set a state in which the frequency of the compressor 23 is stabilized. In step S107, the air temperature sensor 36 of the detection unit 31 detects a second air temperature Ta2, and the condensation temperature sensor 37 detects a second condensation temperature Tc2. The second air temperature Ta2 is the air temperature at the second timing T2, and the second condensation temperature Tc2 is the condensation temperature at the second timing T2. The storage unit 32 stores the second air temperature Ta2 and the second condensation temperature Tc2 that are detected. In step

S108, the acquisition unit 38 compares the second air temperature Ta2 and the second condensation temperature Tc2 with each other and acquires a second temperature difference ΔT2, which is a temperature difference at the second timing T2. The acquired second temperature difference ΔT2 is stored in the storage unit 32.

[0040] Subsequently, in step S109, the correction unit 33 corrects the first temperature difference ΔT1 and the second temperature difference ΔT2 by using a difference between the first air temperature Ta1 and the second air temperature Ta2 stored in the storage unit 32. The method for correction performed by the correction unit 33 will be described later. In step S110, the determination unit 34 compares the corrected first temperature difference ΔT1 and the corrected second temperature difference ΔT2 with each other, and, if the temperature difference is 3°C or more, determines that the refrigerant leaks to the outside and that the amount of the refrigerant is insufficient. In step Sill, the notification unit 35 notifies to an operator that the amount of the refrigerant is insufficient.

(1-5) Correction Method

[0041] Fig. 5 is a P-H chart obtained by experiment in which the amount of the refrigerant to be included in the air conditioner 100 is changed in a case in which the first air temperature Ta1 and the second air temperature Ta2 are at 35°C. It is found that the condensation temperature is lower in the air conditioner 100 in which the amount of the refrigerant is insufficient compared with the air conditioner 100 filled with a prescribed amount of the refrigerant. If the refrigerant included in the air conditioner 100 leaks by 20% from the prescribed amount, the first temperature difference ΔT1 and the second temperature difference ΔT2 diverges from each other by 3°C, and the performance efficiency of the air conditioner 100 decreases by 10%. From the experimental results, the present inventors have found that, if the first temperature difference ΔT1 and the second temperature difference ΔT2 are compared with each other, and if the temperature difference diverges by 2°C to 4°C or more, it can be determined that the refrigerant leaks to the outside and that the amount of the refrigerant is insufficient.

[0042] In addition, if the first air temperature Ta1 and the second air temperature Ta2 are at 25°C, and if the refrigerant included in the air conditioner 100 leaks by 20% from the prescribed amount, the performance efficiency of the air conditioner 100 decreases by 9.4%. Furthermore, if the first air temperature Ta1 and the second air temperature Ta2 are at 45°C, and if the refrigerant included in the air conditioner 100 leaks by 20% from the prescribed amount, the performance efficiency of the air conditioner 100 decreases by 10.6%.

[0043] From these experimental results, for example, if the first air temperature Ta1 is 35°C, and if the second air temperature Ta2 is 25°C, the correction unit 33 corrects the first temperature difference ΔTa1 by +0.4°C by using an air temperature of 25 °C as a reference temperature. If the difference between the first air temperature Ta1 and the second air temperature Ta2 corrected by the correction unit 33 diverges by 3°C or more, the determination unit 34 determines that the amount of the refrigerant is insufficient.

[0044] Herein, the correction unit 33 may correct either one of the first temperature difference ΔT1 or the second temperature difference ΔT2 or may correct each of the first temperature difference ΔT1 and the second temperature difference ΔT2. In addition, in accordance with the difference between the first temperature difference ΔTa1 and the second temperature difference ΔTa2, the threshold used as a reference for determining the amount of the refrigerant may be corrected. Furthermore, a correction may also be made in accordance with a difference between the air temperature as a reference and each of the first air temperature Ta1 and the second air temperature Ta2.

(1-6) Characteristics

(1-6-1)

[0045] The air conditioner 100 as a refrigeration cycle apparatus according to the first embodiment includes the indoor unit 10, the outdoor unit 20, the refrigerant connection pipe 15 that connects the indoor unit 10 and the outdoor unit 20, and the refrigerant amount determination unit 30 that determines the amount of the refrigerant that flows in the refrigerant circuit 16. The refrigerant circuit 16 of the air conditioner 100 is constituted by the indoor unit 10 and the outdoor unit 20 being connected via the refrigerant connection pipe 15. The refrigerant amount determination unit 30 includes the detection unit 31, the storage unit 32, the correction unit 33, the determination unit 34, and the notification unit 35. The detection unit 31 includes the air temperature sensor 36, the condensation temperature sensor 37, and the acquisition unit 38. The air temperature sensor 36 detects the air temperature that is the temperature of air that flows into the outdoor heat exchanger 22 as a condenser. The condensation temperature sensor 37 detects the condensation temperature of the refrigerant that flows in the outdoor heat exchanger 22. The acquisition unit 38 acquires a temperature difference between the air temperature and the condensation temperature. The determination unit 34 compares the first temperature difference ΔT1 and the second temperature difference ΔT2 with each other, thereby determining the amount of the refrigerant included in the refrigerant circuit 16. The first temperature difference ΔT1 is a temperature difference acquired by the acquisition unit 38 at the first timing T1 when the air conditioner 100 is installed. The second temperature difference ΔT2 is a temperature difference acquired by the acquisition unit 38 at the second timing T2 after a certain period has elapsed from the first timing T1.

[0046] In the air conditioner 100 in which the amount of the refrigerant is insufficient, compared with the air conditioner 100 filled with a prescribed amount of the refrigerant, the condensation temperature decreases. Thus, by comparing the first temperature difference ΔT1 and the second temperature difference ΔT2 with each other, the amount of the refrigerant included in the refrigerant circuit 16 can be determined, and it can be determined whether the refrigerant leaks from the refrigerant circuit 16 to the outside by accidental means.

[0047] In addition, by comparing the second temperature difference ΔT2 with the first temperature difference ΔT1, it is possible to grasp the amount of the refrigerant in comparison with an initial amount of the refrigerant filled with a prescribed amount of the refrigerant and to protect the air conditioner 100.

(1-6-2)

[0048] From the experimental knowledge in Fig. 5, the present inventors have found that the threshold used by the determination unit 34 to determine that the amount of the refrigerant is insufficient is 2°C to 4°C. If the difference between the first temperature difference ΔT1 and the second temperature difference ΔT2 is from 2°C to 4°C or more, by determining that the amount of the refrigerant is insufficient, the determination unit 34 can determine whether the refrigerant leaks from the refrigerant circuit 16 to the outside by accidental means.

(1-6-3)

[0049] If the determination unit 34 determines that the amount of the refrigerant is insufficient, the notification unit 35 notifies the insufficiency of the amount of the refrigerant. Thus, an operator who determines the amount of the refrigerant can notice the insufficiency of the amount of the refrigerant.

(1-6-4)

[0050] The correction unit 33 corrects the temperature differences by using the air temperature stored in the storage unit 32. By the correction made by the correction unit 33, the amount of the refrigerant is not necessarily determined under the same conditions as those at the first timing T1. This enables the operator to determine the amount of the refrigerant at any time.

(1-7) Modifications

(1-7-1) Modification 1

[0051] In the air conditioner 100 that is a refrigeration cycle apparatus according to the first embodiment, the first timing T1 may be the time of initial operation of the air conditioner 100 or the time of maintenance of the air conditioner 100. The second timing T2 is a maintenance timing at or after the maintenance performed at the first timing T1.

(1-7-2) Modification 2

[0052] In the air conditioner 100 according to the first embodiment, the correction unit 33 may make a correction by using the evaporation temperature of the refrigerant. In this case, the air conditioner 100 includes an evaporation temperature sensor that detects the evaporation temperature of the refrigerant.

[0053] If the evaporation temperature decreases by 5°C, the performance efficiency decreases by 9.4%. If the evaporation temperature increases by 5°C, the performance efficiency decreases by 10.6%. Thus, for example, when the evaporation temperature decreases by 5°C, the difference between the first temperature difference ΔT1 and the second temperature difference ΔT2 is corrected by +0.2°C. In contrast, when the evaporation temperature increases by 5°C, the temperature between the first temperature difference ΔT1 and the second temperature difference ΔT2 is corrected by -0.2°C.

[0054] When the outdoor air temperature is 25°C with respect to the reference value that is an outdoor air temperature of 35°C and the evaporation temperature decreases by 5°C, the difference between the first temperature difference ΔT1 and the second temperature difference ΔT2 is corrected by +0.4°C. When the outdoor air temperature is 45°C and the evaporation temperature increases by 5°C, the difference between the first temperature difference ΔT1 and the second temperature difference ΔT2 is corrected by -0.4°C.

(1-7-3) Modification 3

[0055] In the air conditioner 100 according to the first embodiment, in the determination of the amount of the refrigerant, the correction unit 33 does not necessarily make a correction. The air conditioner 100 can determine the amount of the refrigerant without correction.

(1-7-4) Modification 4

[0056] In the air conditioner 100 according to the first embodiment, the storage unit 32 does not necessarily store the first temperature difference ΔT1 and the second temperature difference ΔT2. The air conditioner 100 may acquire the first temperature difference ΔT1 as necessary from the first air temperature Ta1 and the first condensation temperature Tc1 stored in the storage unit 32, and the determination unit 34 may compare the acquired first temperature difference ΔT1 and the second temperature difference ΔT2 with each other.

(1-7-5) Modification 5

[0057] In the air conditioner 100 according to the first embodiment, the air temperature detected by the air temperature sensor 36 may be the temperature of outdoor air around installation site of the outdoor unit 20. The air temperature sensor 36 may be a sensor that detects the air temperature around the outdoor unit 20.

(1-7-6) Modification 6

[0058] As illustrated in Fig. 6, in the air conditioner 100 according to the first embodiment, the storage unit 32, the correction unit 33, the determination unit 34, and the acquisition unit 38 may alternatively be included in a server 150 connected to the air conditioner 100 via the Internet 39.

[0059] At this time, the detected air temperature and condensation temperature are transmitted to the server 150. The storage unit 32, the correction unit 33, the determination unit 34, and the acquisition unit 38 in the server 150 performs substantially the same operations as those in the refrigerant amount determination method according to the first embodiment.

(2) Second Embodiment

[0060] Hereinafter, an embodiment of a refrigerant amount determination system 200 according to a second embodiment will be described.

[0061] The refrigerant amount determination system 200 according to this embodiment is a system that determines the amount of a refrigerant included in a refrigeration cycle apparatus. In this embodiment, as the refrigeration cycle apparatus, an air conditioner 300 is used.

(2-1) Air Conditioner

[0062] Fig. 7 schematically illustrates the air conditioner 300 according to this embodiment. The air conditioner 300 performs indoor cooling and heating for buildings or the like by performing a vapor compression refrigeration cycle. The air conditioner 300 mainly includes an indoor unit 310, an outdoor unit 320, and a refrigerant connection pipe that connects the indoor unit 310 and the outdoor unit 320. A refrigerant circuit of the air conditioner 300 is constituted by the indoor unit 310 and the outdoor unit 320 being connected via the refrigerant connection pipe.

[0063] The indoor unit 310 of the air conditioner 300 is installed, for example, by being hooked to a wall surface in a room or by being embedded in or hung from the ceiling in a room. The indoor unit 310 is connected to the outdoor unit 320 via the refrigerant connection pipe and constitutes part of the refrigerant circuit. The indoor unit 310 includes an indoor fan 311 and an indoor heat exchanger 312.

[0064] The outdoor unit 320 is installed outside. The outdoor unit 320 is connected to the indoor unit 310 via the refrigerant connection pipe and constitutes part of the refrigerant circuit. The outdoor unit 320 includes an outdoor fan 321, an outdoor heat exchanger 322, a compressor 323, a four-way switching valve 324, and an outdoor expansion valve 325 as an expansion mechanism.

[0065] The refrigerant connection pipe is a refrigerant pipe that is constructed on site when the air conditioner 300 is installed at an installation site. The refrigerant connection pipe is connected to the indoor unit 310 and the outdoor unit 320 and constitutes the refrigerant circuit. Operations of the air conditioner 300 are substantially the same as those of the air conditioner 100 according to the first embodiment and thus will be omitted.

(2-2) Refrigerant Amount Determination System

[0066] The refrigerant amount determination system 200 is a retrofitted unit that is placed separately from the air conditioner 300. The refrigerant amount determination system 200 includes a detection unit 231, a storage unit 232, a correction unit 233, a determination unit 234, and a notification unit 235.

[0067] The detection unit 231 includes an air temperature sensor 236, a condensation temperature sensor 237, and an acquisition unit 238. The air temperature sensor 236 detects an air temperature that is the temperature of outdoor air that flows into the outdoor heat exchanger 322. The condensation temperature sensor 237 detects the condensation temperature of the refrigerant. For example, the condensation temperature sensor 237 is provided so as to be in contact with a heat exchanger tube (not illustrated) included in the outdoor heat exchanger 322 of the air conditioner 300. The acquisition unit 238 acquires a temperature difference between the air temperature detected by the air temperature sensor 236 and the condensation temperature detected by the condensation temperature sensor 237.

[0068] The storage unit 232 stores the air temperature detected by the air temperature sensor 236 and the temperature difference acquired by the acquisition unit 238.

[0069] The correction unit 233 corrects the temperature difference by using the air temperature stored in the storage unit 232.

[0070] The determination unit 234 compares a plurality of temperature differences acquired by the acquisition unit 238 and determines a change in the amount of the refrigerant included in the refrigerant circuit.

[0071] If the determination unit 234 determines that the amount of the refrigerant is insufficient, the notification unit 235 notifies insufficiency of the amount of the refrigerant. The notification unit 235 notifies insufficiency of the amount of the refrigerant by using, for example, an LED or the like.

(2-3) Refrigerant Amount Determination Method

[0072] Next, a method for determining the amount of the refrigerant will be described with reference to Fig. 8 and Fig. 9.

[0073] The amount of the refrigerant is determined in a first step ST1, a second step ST2, and a third step ST3 in this order. In the first step ST1, step S201 to step S204 are performed. In the second step ST2, step S205 to step S209 are performed. In the third step ST3, step S210 and step S211 are performed. Each step will be described below. Note that substantially the same operations as those of the air conditioner 100 according to the first embodiment will be omitted from the description.

[0074] Fig. 8 is a flowchart illustrating operations of the air conditioner 300 and the refrigerant amount determination system 200 in the first step ST1. The air conditioner 300 is installed on site in a state in which a prescribed amount of the refrigerant is included. The time at which the air conditioner 300 is installed is a first timing T1. Operations in step S201 to step S204 are substantially the same as operations in step S101 to step S104 in the first embodiment.

[0075] Next, the second step ST2 and the third step ST3, which are illustrated in Fig. 9, will be described. The second step ST2 is performed at the time of maintenance after a certain period has elapsed from the first timing T1. Step S205 is performed at the time of maintenance after a certain period has elapsed from the first timing T1. This time of maintenance is a second timing T2. Step S205 to step S211 are substantially the same as operations in step S205 to step S211 in the first embodiment below.

[0076] The basis for determining the insufficiency of the amount of the refrigerant is substantially the same as that in the first embodiment and thus will be omitted.

(2-4) Characteristics

(2-4-1)

[0077] The refrigerant amount determination system 200 according to the second embodiment includes the detection unit 231, the storage unit 232, the correction unit 233, the determination unit 234, and the notification unit 235. The detection unit 231 includes the air temperature sensor 236, the condensation temperature sensor 237, and the acquisition unit 238. The air temperature sensor 236 detects the air temperature that is the temperature of air that flows into the outdoor heat exchanger 322 as a condenser. The condensation temperature sensor 237 detects the condensation temperature of the refrigerant that flows in the outdoor heat exchanger 322. The acquisition unit 238 acquires a temperature difference between the air temperature and the condensation temperature. The determination unit 234 compares a first temperature difference ΔT1 and a second temperature difference ΔT2 with each other, thereby determining the amount of the refrigerant included in the refrigerant circuit. The first temperature difference ΔT1 is a temperature difference acquired by the acquisition unit 238 at the first timing T1 when the air conditioner 300 is installed. The second temperature difference ΔT2 is a temperature difference acquired by the acquisition unit 238 at the second timing T2 after a certain period has elapsed from the first timing T1.

[0078] In the air conditioner 300 in which the amount of the refrigerant is insufficient, compared with the air conditioner 300 filled with a prescribed amount of refrigerant, the condensation temperature decreases. Thus, by comparing the first temperature difference ΔT1 and the second temperature difference ΔT2 with each other, the amount of the refrigerant included in the refrigerant circuit can be determined, and it can be determined whether the refrigerant leaks from the refrigerant circuit to the outside by accidental means.

[0079] In addition, by comparing the second temperature difference ΔT2 with the first temperature difference ΔT1, it is possible to grasp the amount of the refrigerant in comparison with an initial amount of the refrigerant filled with a prescribed amount of the refrigerant and to protect the air conditioner 300.

(2-4-2)

[0080] From the experimental knowledge in Fig. 5, the present inventors have found that the threshold used by the determination unit 234 to determine that the amount of the refrigerant is insufficient is 2°C to 4°C. If the difference between the first temperature difference ΔT1 and the second temperature difference ΔT2 is from 2°C to 4°C or more, by determining that the amount of the refrigerant is insufficient, the determination unit 234 can determine whether the refrigerant leaks from the refrigerant circuit to the outside by accidental means.

(2-4-3)

[0081] If the determination unit 234 determines that the amount of the refrigerant is insufficient, the notification unit 235 notifies the insufficiency of the amount of the refrigerant. Thus, an operator who determines the amount of the refrigerant can notice the insufficiency of the amount of the refrigerant.

(2-4-4)

[0082] The correction unit 233 corrects the temperature differences by using the air temperature stored in the storage unit 232. By the correction made by the correction unit 233, the amount of the refrigerant is not necessarily determined under the same conditions as those at the first timing T1. This enables the operator to determine the amount of the refrigerant at any time.

(2-5) Modifications

[0083] The modifications in the first embodiment are applicable to the second embodiment.

[0084] Although the embodiments of the present disclosure have been described above, it should be understood that various changes can be made on the forms and details without departing from the spirit and scope of the present disclosure described in the scope of claims.

REFERENCE SIGNS LIST

[0085]

12	evaporator
16	refrigerant circuit
22	condenser
23	compressor
25	expansion mechanism
32	storage unit
33	correction unit
34	determination unit
35	notification unit
36	air temperature sensor
37	condensation temperature sensor
38	acquisition unit
100	refrigeration cycle apparatus
200	refrigerant amount determination system
232	storage unit
233	correction unit
234	determination unit
235	notification unit
236	air temperature sensor
237	condensation temperature sensor
238	acquisition unit
300	refrigeration cycle apparatus
312	evaporator
322	condenser
323	compressor
325	expansion mechanism
T1	first timing
T2	second timing
ΔT1	first temperature difference
ΔT2	second temperature difference
Ta1, Ta2	air temperature
Tc1, Tc2	condensation temperature

CITATION LIST

PATENT LITERATURE

[0086] PTL 1: Japanese Unexamined Patent Application Publication No. H6-159869

Claims

1. A refrigeration cycle apparatus (100) in which a refrigerant circulates in a refrigerant circuit (16) constituted by a compressor (23), a condenser (22), an expansion mechanism (25), and an evaporator (12) being connected, the refrigeration cycle apparatus comprising:

    an air temperature sensor (36) that detects an air temperature (Tal, Ta2), which is a temperature of air that flows into the condenser (22);
    a condensation temperature sensor (37) that detects a condensation temperature (Tc1, Tc2) of the refrigerant that flows through the condenser (22);
    an acquisition unit (38) that acquires a temperature difference between the air temperature (Tal, Ta2) and the condensation temperature (Tc1, Tc2); and
    a determination unit (34) that determines an amount of the refrigerant included in the refrigerant circuit (16) by comparing a first temperature difference (ΔT1) and a second temperature difference (ΔT2) with each other, the first temperature difference (ΔT1) being a temperature difference acquired by the acquisition unit (38) at a first timing (T1), the second temperature difference (ΔT2) being a temperature difference acquired by the acquisition unit (38) at a second timing (T2).

2. The refrigeration cycle apparatus according to Claim 1, further comprising:
a storage unit (32) that stores at least one of the first temperature difference (ΔT1) or the air temperature (Tal, Ta2) and the condensation temperature (Tc1, Tc2) acquired at the first timing (T1).

3. The refrigeration cycle apparatus according to Claim 1 or 2,
wherein the first timing (T1) is any of a time at which the refrigeration cycle apparatus (100) is installed, at a time of initial operation of the refrigeration cycle apparatus (100), or a time of maintenance of the refrigeration cycle apparatus (100).

4. The refrigeration cycle apparatus according to any of Claims 1 to 3,
wherein, if a difference between the first temperature difference (ΔT1) and the second temperature difference (ΔT2) is greater than or equal to a threshold that is any value from 2°C to 4°C, the determination unit (34) determines that the amount of the refrigerant included in the refrigerant circuit (16) is insufficient.

5. The refrigeration cycle apparatus according to any of Claims 1 to 4, further comprising:
a notification unit (35) that notifies insufficiency of the amount of the refrigerant if the determination unit (34) determines that the amount of the refrigerant is insufficient.

6. The refrigeration cycle apparatus according to any of Claims 1 to 5, further comprising:
a correction unit (33) that corrects the first temperature difference (ΔT1) and the second temperature difference (ΔT2) by using at least either one of the

air temperature (Tal, Ta2) or an evaporation temperature of the refrigerant.

7. A refrigerant amount determination system (200) that determines an amount of a refrigerant included in a refrigeration cycle apparatus (300) in which the refrigerant circulates in a refrigerant circuit constituted by a compressor (323), a condenser (322), an expansion mechanism (325), and an evaporator (312) being connected, the refrigerant amount determination system comprising:

an air temperature sensor (236) that detects an air temperature (Tal, Ta2), which is a temperature of air that flows into the condenser (322);
a condensation temperature sensor (237) that detects a condensation temperature (Tc1, Tc2) of the refrigerant that flows through the condenser (322);
an acquisition unit (238) that acquires a temperature difference between the air temperature (Tal, Ta2) and the condensation temperature (Tc1, Tc2); and
a determination unit (234) that determines a change in the amount of the refrigerant included in the refrigerant circuit by comparing a first temperature difference (ΔT1) and a second temperature difference (ΔT2) with each other, the first temperature difference (ΔT1) being a temperature difference acquired by the acquisition unit (238) at a first timing (T1), the second temperature difference (ΔT2) being a temperature difference acquired by the acquisition unit (238) at a second timing (T2).

8. The refrigerant amount determination system according to Claim 7, further comprising:
a storage unit (232) that stores at least one of the first temperature difference (ΔT1) or the air temperature (Tal, Ta2) and the condensation temperature (Tc1, Tc2) acquired at the first timing (T1).

9. The refrigerant amount determination system according to Claim 7 or 8,
wherein the first timing (T1) is any of a time at which the refrigeration cycle apparatus (300) is installed, at a time of initial operation of the refrigeration cycle apparatus (300), or a time of maintenance of the refrigeration cycle apparatus (300).

10. The refrigerant amount determination system according to any of Claims 7 to 9,
wherein, if a difference between the first temperature difference (ΔT1) and the second temperature difference (ΔT2) is greater than or equal to a threshold that is any value from 2°C to 4°C, the determination unit (234) determines that the amount of the refrigerant included in the refrigerant circuit is insufficient.

11. The refrigerant amount determination system according to any of Claims 7 to 10, further comprising:
a notification unit (235) that notifies insufficiency of the amount of the refrigerant if the determination unit (234) determines that the amount of the refrigerant is insufficient.

12. The refrigerant amount determination system according to any of Claims 7 to 11, further comprising:
a correction unit (233) that corrects the first temperature difference (ΔT1) and the second temperature difference (ΔT2) by using at least either one of the air temperature (Tal, Ta2) or an evaporation temperature of the refrigerant.

13. A refrigerant amount determination method for determining an amount of a refrigerant included in a refrigeration cycle apparatus (100, 300) in which the refrigerant circulates in a refrigerant circuit (16) constituted by a compressor (23, 323), a condenser (22, 322), an expansion mechanism (25, 325), and an evaporator (12, 312) being connected, the refrigerant amount determination method comprising:

a first step (ST1) of acquiring a first temperature difference (ΔT1), which is a temperature difference detected at a first timing (T1), between an air temperature (Tal, Ta2) and a condensation temperature (Tc1, Tc2), the air temperature (Ta1, Ta2) being a temperature of air that flows into the condenser (22, 322), the condensation temperature (Tc1, Tc2) being a condensation temperature of the refrigerant that flows through the condenser (22, 322);
a second step (ST2) of acquiring a second temperature difference (ΔT2), which is a temperature difference detected at a second timing (T2), between the air temperature (Tal, Ta2) and the condensation temperature (Tc1, Tc2), the air temperature (Tal, Ta2) being a temperature of air that flows into the condenser (22, 322), the condensation temperature (Tc1, Tc2) being a condensation temperature of the refrigerant that flows through the condenser (22, 322); and
a third step (ST3) of determining a change in the amount of the refrigerant included in the refrigerant circuit (16) by comparing the first temperature difference (ΔT1) and the second temperature difference (ΔT2) with each other.

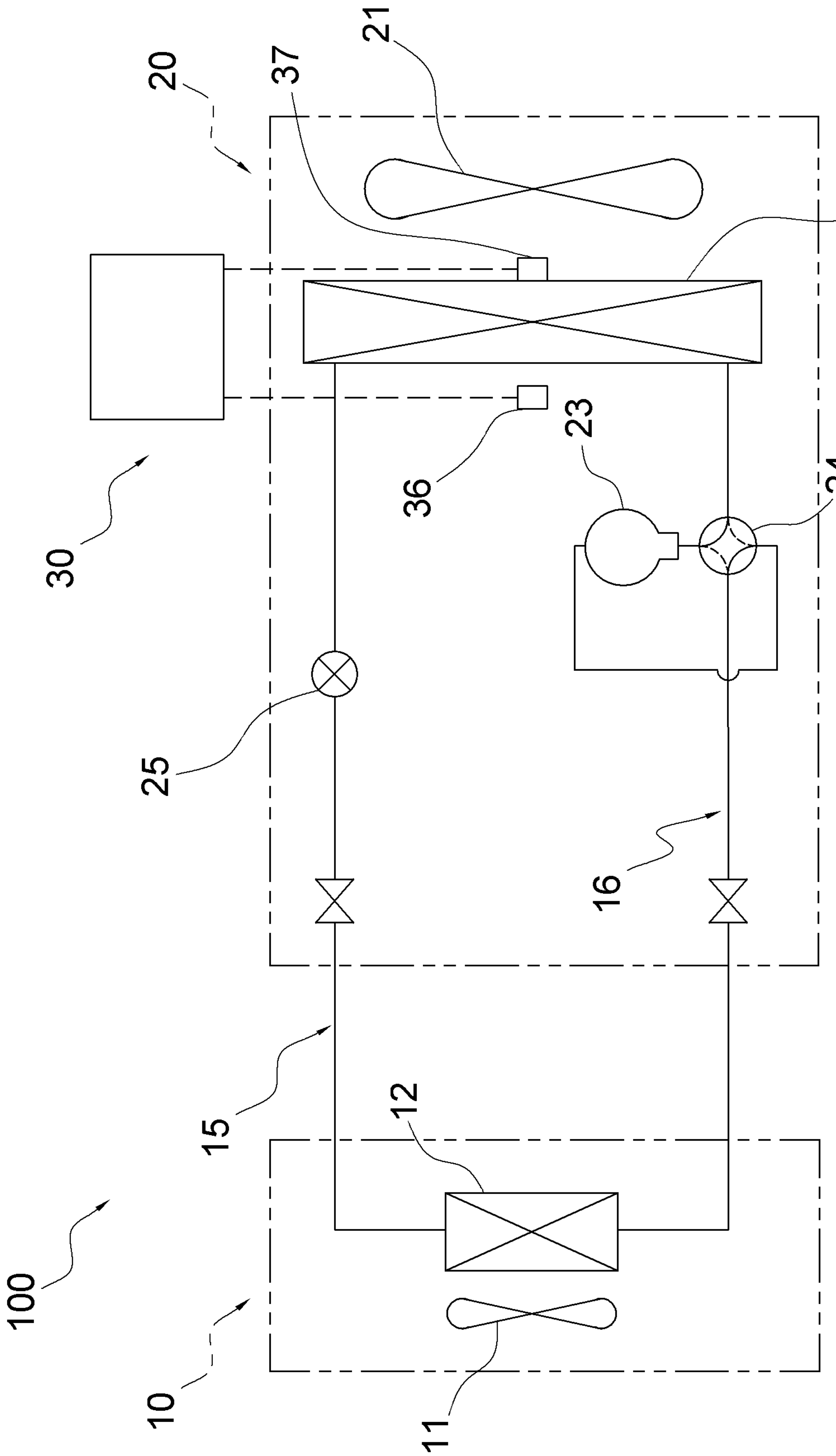

FIG. 1

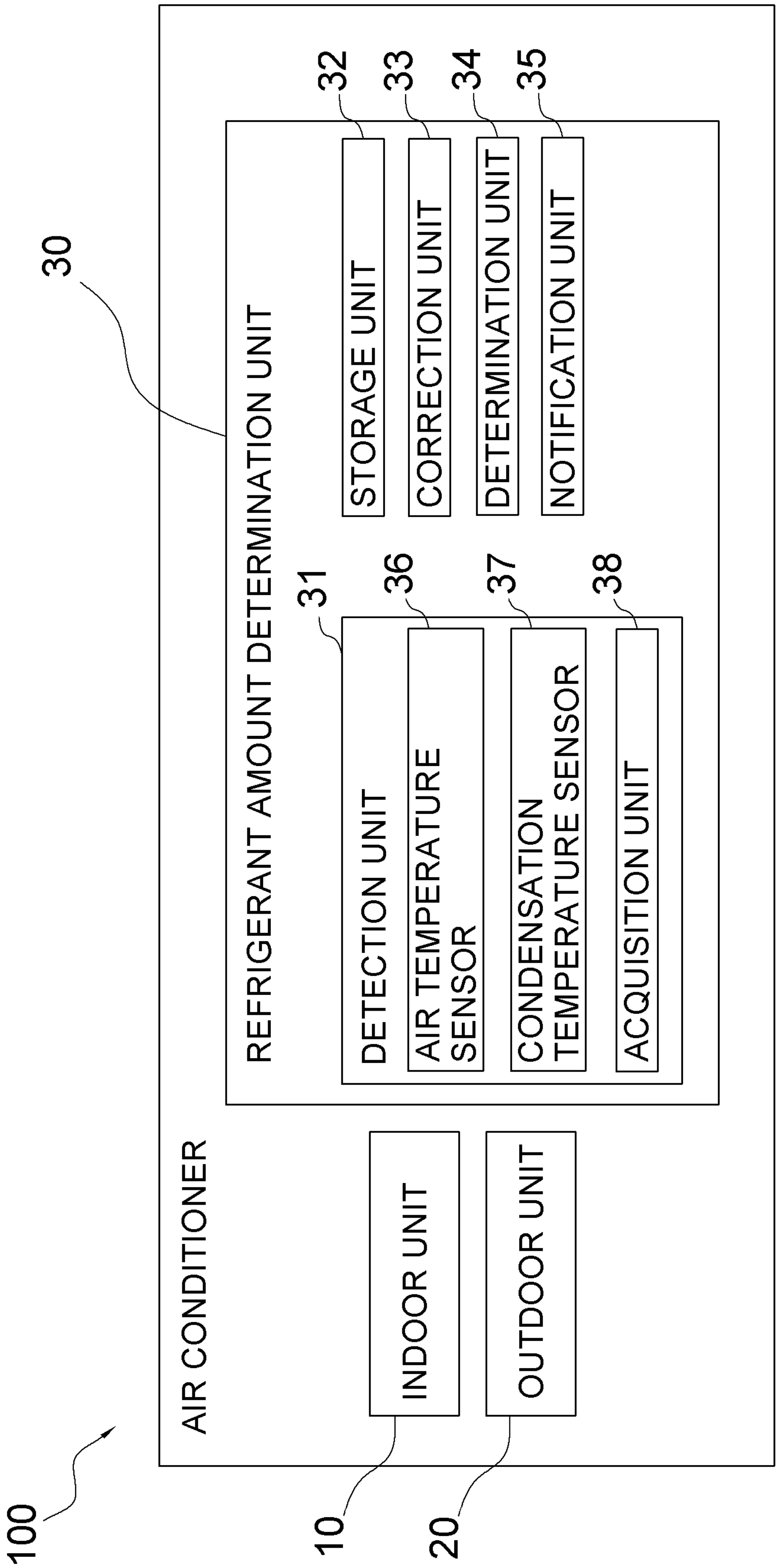
100
AIR CONDITIONER
INDOOR UNIT
10
OUTDOOR UNIT
20
30
REFRIGERANT AMOUNT DETERMINATION UNIT
31
DETECTION UNIT
36
AIR TEMPERATURE SENSOR
37
CONDENSATION TEMPERATURE SENSOR
38
ACQUISITION UNIT
32
STORAGE UNIT
33
CORRECTION UNIT
34
DETERMINATION UNIT
35
NOTIFICATION UNIT

FIG. 2

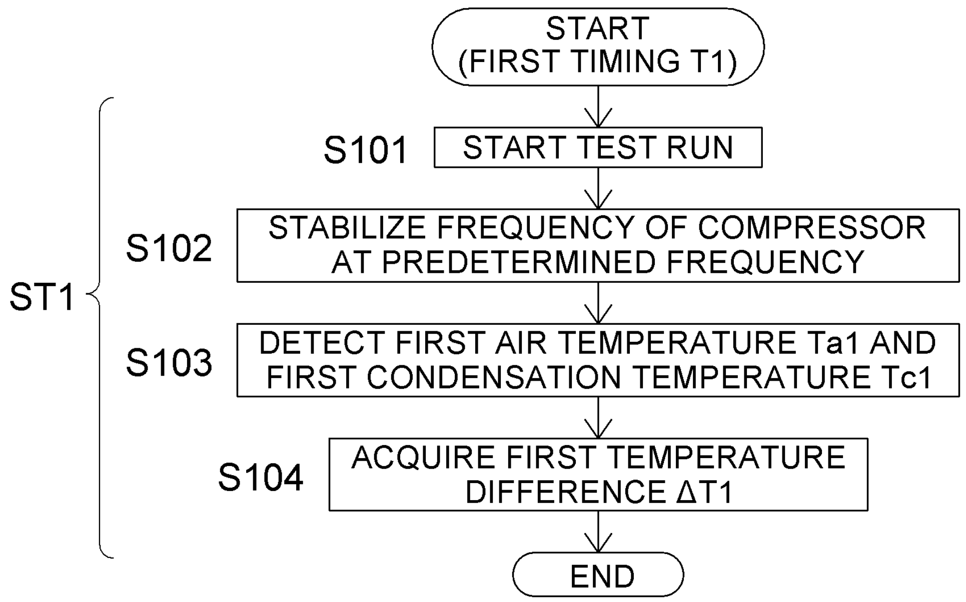
START
(FIRST TIMING T1)
ST1
S101
START TEST RUN
S102
STABILIZE FREQUENCY OF COMPRESSOR AT PREDETERMINED FREQUENCY
S103
DETECT FIRST AIR TEMPERATURE Ta1 AND FIRST CONDENSATION TEMPERATURE Tc1
S104
ACQUIRE FIRST TEMPERATURE DIFFERENCE ΔT1
END

FIG. 3

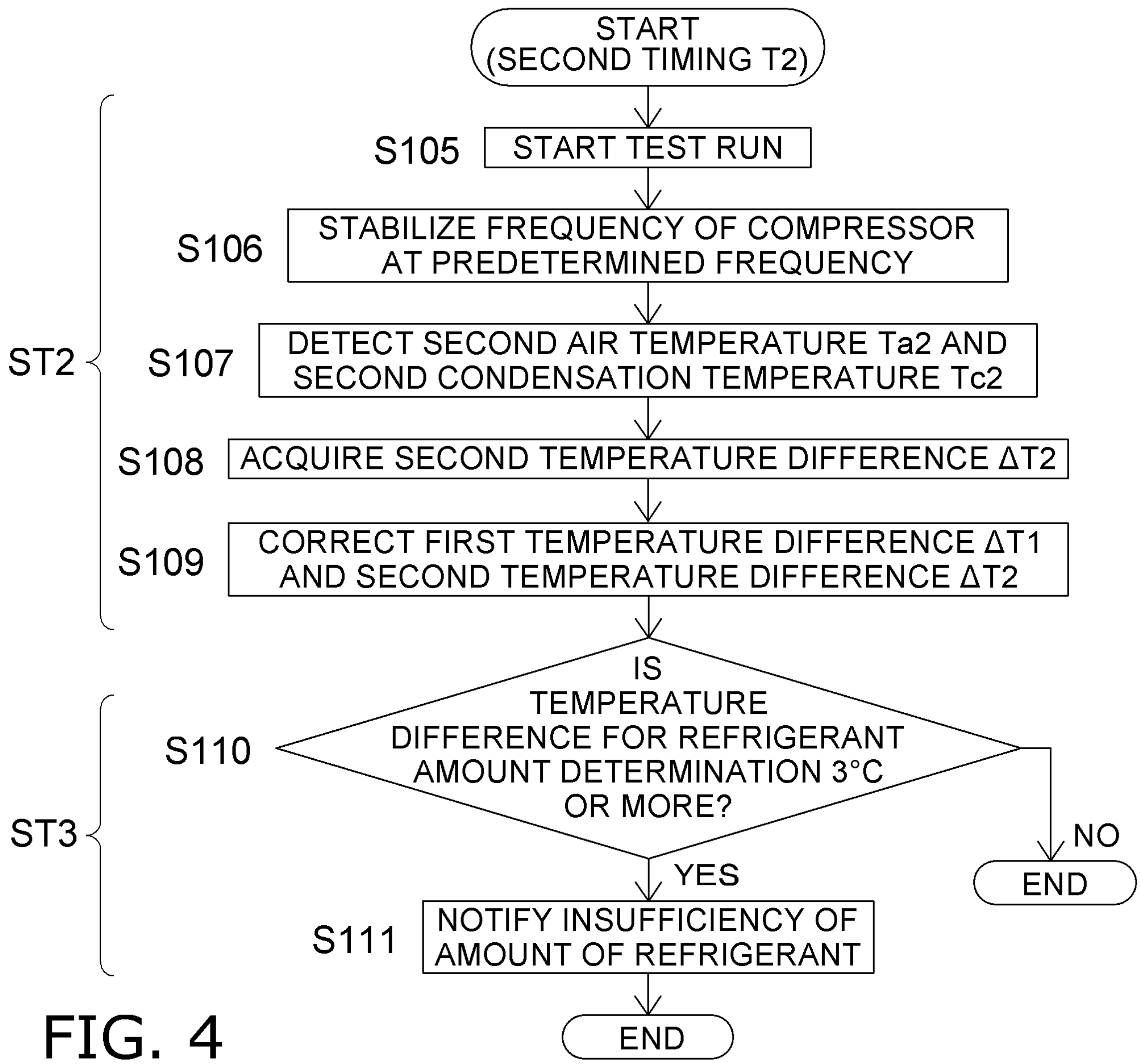
START
(SECOND TIMING T2)
ST2
S105
START TEST RUN
S106
STABILIZE FREQUENCY OF COMPRESSOR AT PREDETERMINED FREQUENCY
S107
DETECT SECOND AIR TEMPERATURE Ta2 AND SECOND CONDENSATION TEMPERATURE Tc2
S108
ACQUIRE SECOND TEMPERATURE DIFFERENCE ΔT2
S109
CORRECT FIRST TEMPERATURE DIFFERENCE ΔT1 AND SECOND TEMPERATURE DIFFERENCE ΔT2
ST3
S110
IS TEMPERATURE DIFFERENCE FOR REFRIGERANT AMOUNT DETERMINATION 3°C OR MORE?
NO
END
YES
S111
NOTIFY INSUFFICIENCY OF AMOUNT OF REFRIGERANT
END

FIG. 4

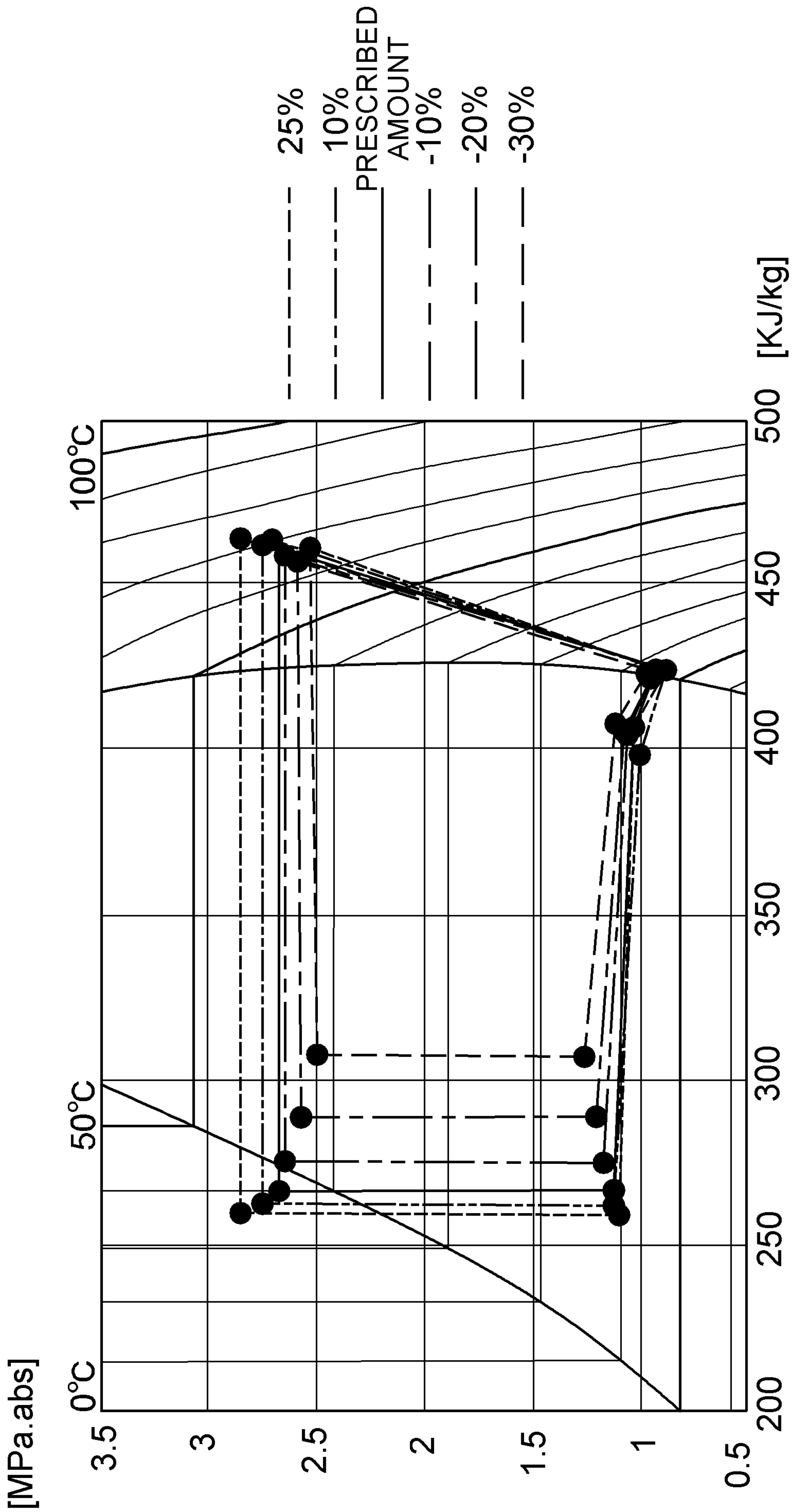
[MPa.abs]
3.5
3
2.5
2
1.5
1
0.5
0°C
50°C
100°C
200
250
300
350
400
450
500
[KJ/kg]
25%
10%
PRESCRIBED AMOUNT
-10%
-20%
-30%

FIG. 5

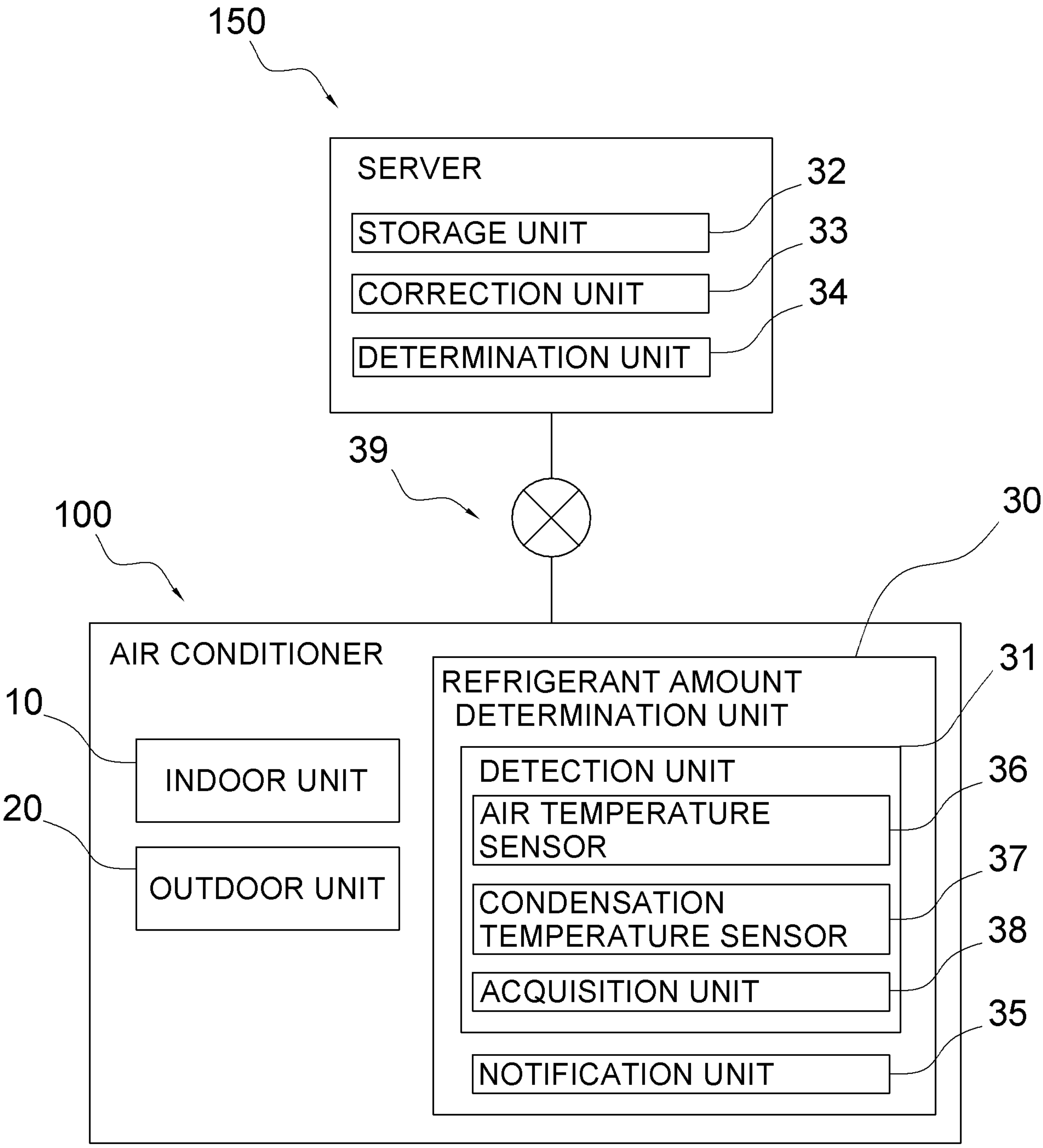
150
SERVER
STORAGE UNIT
CORRECTION UNIT
DETERMINATION UNIT
32
33
34
39
100
30
AIR CONDITIONER
REFRIGERANT AMOUNT DETERMINATION UNIT
31
10
INDOOR UNIT
20
OUTDOOR UNIT
DETECTION UNIT
AIR TEMPERATURE SENSOR
36
CONDENSATION TEMPERATURE SENSOR
37
ACQUISITION UNIT
38
NOTIFICATION UNIT
35

FIG. 6

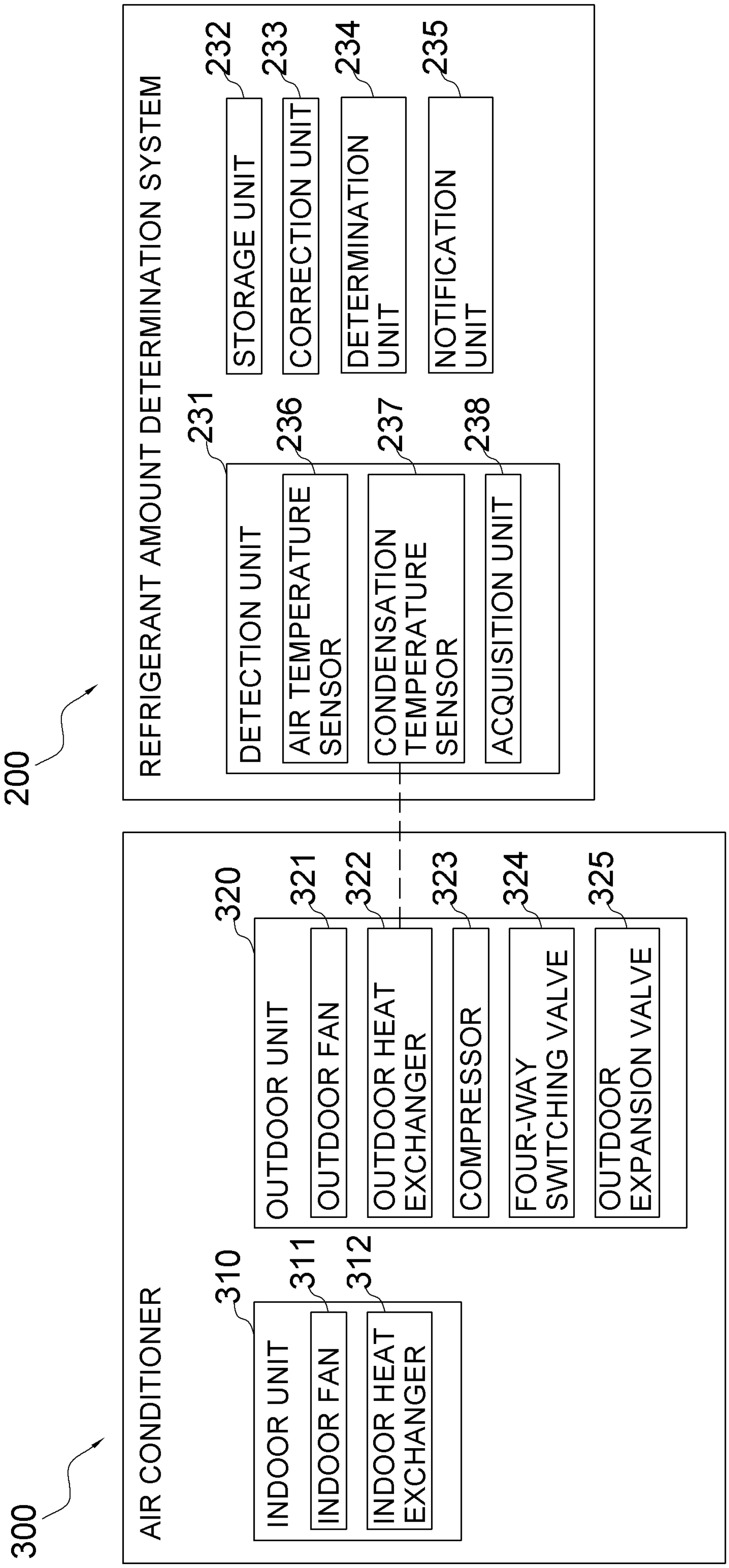
200
REFRIGERANT AMOUNT DETERMINATION SYSTEM
231
DETECTION UNIT
236
AIR TEMPERATURE SENSOR
237
CONDENSATION TEMPERATURE SENSOR
238
ACQUISITION UNIT
232
STORAGE UNIT
233
CORRECTION UNIT
234
DETERMINATION UNIT
235
NOTIFICATION UNIT
300
AIR CONDITIONER
310
INDOOR UNIT
311
INDOOR FAN
312
INDOOR HEAT EXCHANGER
320
OUTDOOR UNIT
321
OUTDOOR FAN
322
OUTDOOR HEAT EXCHANGER
323
COMPRESSOR
324
FOUR-WAY SWITCHING VALVE
325
OUTDOOR EXPANSION VALVE

FIG. 7

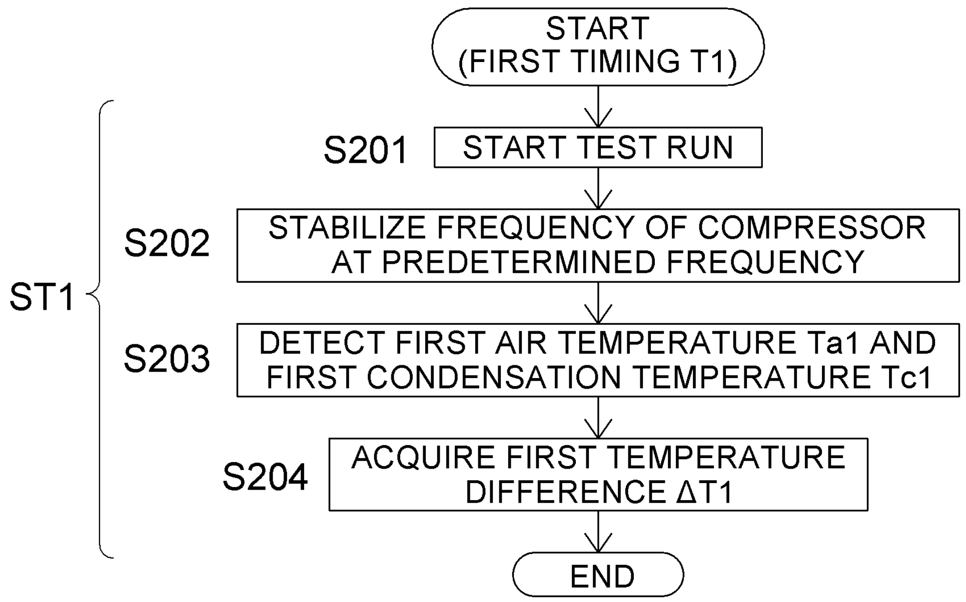
START
(FIRST TIMING T1)
S201
START TEST RUN
S202
STABILIZE FREQUENCY OF COMPRESSOR AT PREDETERMINED FREQUENCY
ST1
S203
DETECT FIRST AIR TEMPERATURE Ta1 AND FIRST CONDENSATION TEMPERATURE Tc1
S204
ACQUIRE FIRST TEMPERATURE DIFFERENCE ΔT1
END

FIG. 8

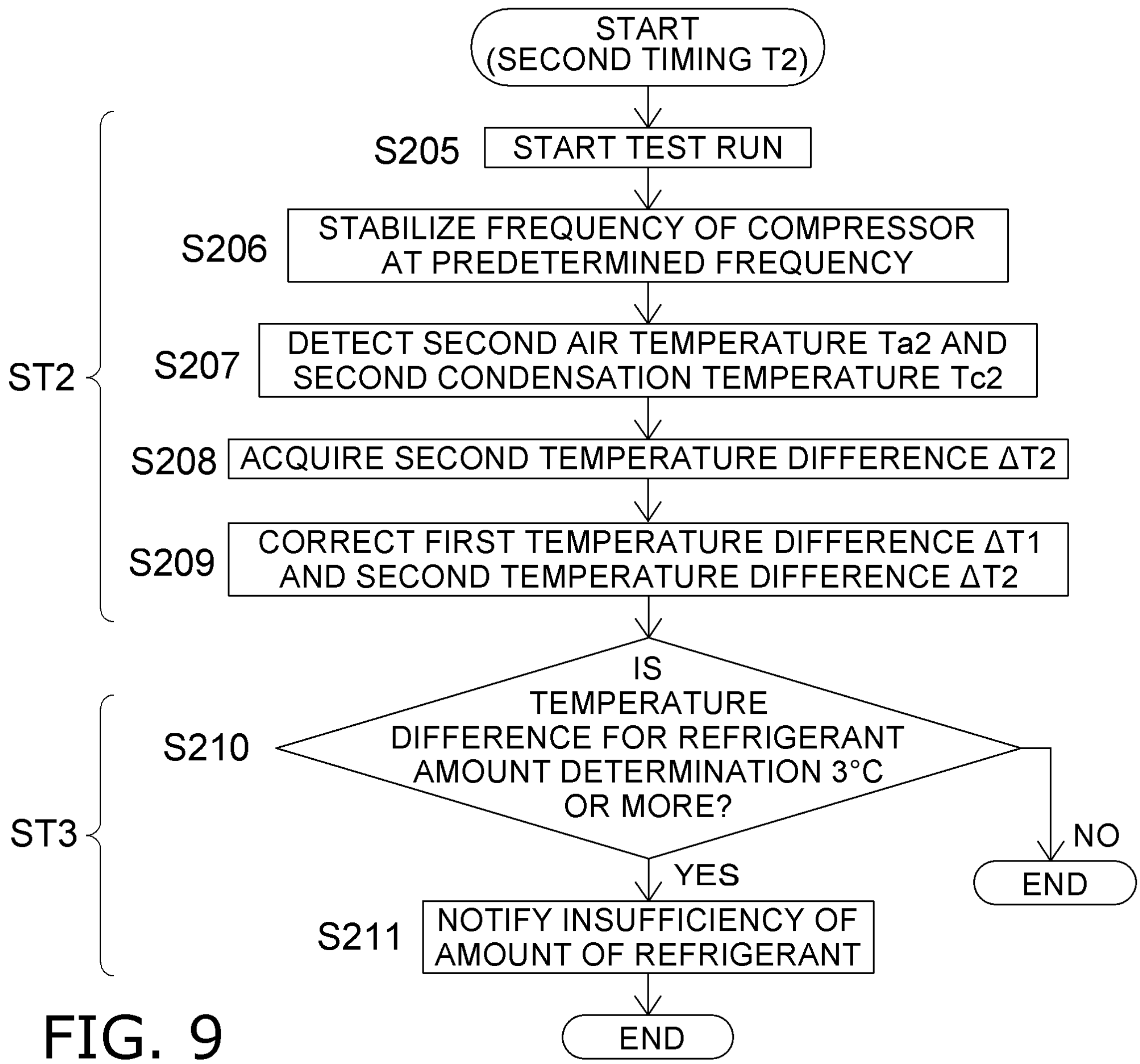
START
(SECOND TIMING T2)
S205
START TEST RUN
S206
STABILIZE FREQUENCY OF COMPRESSOR AT PREDETERMINED FREQUENCY
ST2
S207
DETECT SECOND AIR TEMPERATURE Ta2 AND SECOND CONDENSATION TEMPERATURE Tc2
S208
ACQUIRE SECOND TEMPERATURE DIFFERENCE ΔT2
S209
CORRECT FIRST TEMPERATURE DIFFERENCE ΔT1 AND SECOND TEMPERATURE DIFFERENCE ΔT2
S210
IS TEMPERATURE DIFFERENCE FOR REFRIGERANT AMOUNT DETERMINATION 3°C OR MORE?
ST3
NO
END
YES
S211
NOTIFY INSUFFICIENCY OF AMOUNT OF REFRIGERANT
END

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/044420

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B49/02(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. F25B49/02

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
X Y	WO 2016/159152 A1 (DAIKIN INDUSTRIES, LTD.) 06 October 2016, paragraphs [0054]-[0123], fig. 1-11 & US 2018/0283719 A1, paragraphs [0082]-[0152], fig. 1-11 & EP 3279591 A1 & CN 107407514 A & JP 2016-191531 A	1-2, 5, 7-8, 11, 13 3-4, 6, 9-10, 12
Y	WO 2008/035418 A1 (MITSUBISHI ELECTRIC CORP.) 27 March 2008, paragraphs [0016]-[0020] & EP 1970651 A1, paragraphs [0016]-[0020]	3-4, 6, 9-10, 12

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

* 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

Date of the actual completion of the international search	Date of mailing of the international search report
17 December 2019 (17.12.2019)	07 January 2020 (07.01.2020)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP H6159869 A **[0002] [0086]**