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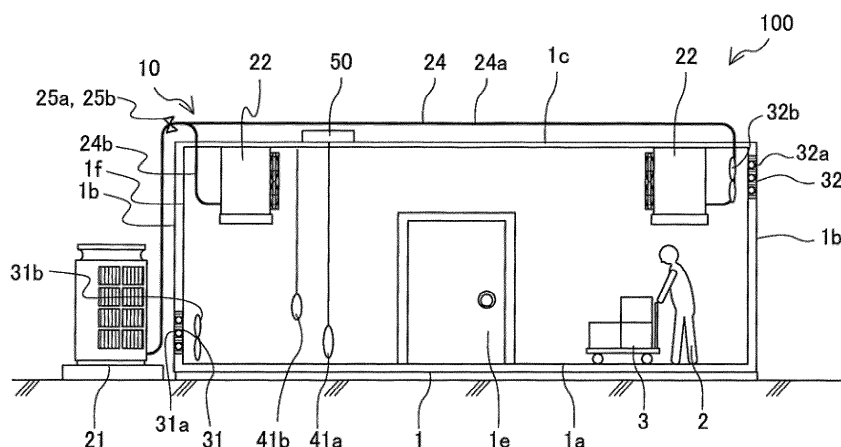
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(54) **REFRIGERATED WAREHOUSE**

(57) A cooling warehouse includes a warehouse main body in which an introduction port through which air outside the cooling warehouse is introduced and a discharge port through which air inside the cooling warehouse is discharged are formed, an air-sending device that introduces air outside the cooling warehouse to an inside of the cooling warehouse and discharges air inside the cooling warehouse to an outside of the cooling warehouse, a plurality of leakage detectors that are provided

at different heights in the cooling warehouse and each detect refrigerant, and a controller that controls the air-sending device depending on whether or not one of the plurality of leakage detectors detects refrigerant, whether or not another of the plurality of leakage detectors detects refrigerant, and a time during which refrigerant has been detected by each of the plurality of leakage detectors.

FIG. 1



Description

Technical Field

5 **[0001]** The present invention relates to a cooling warehouse that discharges refrigerant that has leaked inside the warehouse to the outside of the warehouse.

Background Art

10 **[0002]** Prefabricated refrigerators or prefabricated freezers have been known as cooling warehouses, and people, forklifts, and other objects may go in and out of the cooling warehouses. Furthermore, an indoor unit called a unit cooler included in a refrigeration cycle apparatus that uses refrigerant is provided inside a cooling warehouse, so that the inside of the cooling warehouse is cooled by the indoor unit.

15 **[0003]** As refrigerant for refrigeration cycle apparatuses, fluorocarbon-based refrigerant, which has low flammability and low toxicity, has been often used. In the recent years, however, from the viewpoint of global environmental conservation, a refrigerant having low GWP, that is, global warming potential, has been paid attention to, and more products using fluorocarbon-based refrigerant containing slightly flammable refrigerant have been available as refrigeration cycle apparatuses for cooling warehouses.

20 **[0004]** Furthermore, the housing of a cooling warehouse is made of insulating panels, and joints of the insulating panels are sealed. Consequently, extremely high airtightness of such a cooling warehouse is achieved. In addition, the specific gravity of fluorocarbon-based refrigerant containing slightly flammable refrigerant is greater than the specific gravity of air. Consequently, if refrigerant leaks out of an indoor unit, the refrigerant may disadvantageously stagnate inside the cooling warehouse.

25 **[0005]** To solve this problem, a cooling apparatus using flammable refrigerant that includes a fan and a refrigerant sensor provided at an indoor unit is suggested in which in a case where the refrigerant sensor detects leaking refrigerant, the fan is driven to rotate so that the refrigerant can be discharged outside through an air supply-exhaust port that communicates the inside of the indoor unit with the outside (for example, see Patent Literature 1).

Citation List

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Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 8-200904

35 Summary of Invention

Technical Problem

40 **[0007]** However, the cooling apparatus disclosed in Patent Literature 1 detects refrigerant only using one refrigerant sensor that is provided at one portion of the indoor unit, and is thus not able to determine the degree of leakage of refrigerant. Consequently, a problem has present in that a cooling operation is stopped even when the degree of leakage of refrigerant is low and an accommodated object that needs to be cooled down may thus be damaged.

[0008] The present invention has been designed to solve the problem mentioned above, and an object of the present invention is to provide a cooling warehouse that is able to determine the degree of leakage of refrigerant.

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Solution to Problem

50 **[0009]** A cooling warehouse according to an embodiment of the present invention includes a warehouse main body in which an introduction port through which air outside the cooling warehouse is introduced and a discharge port through which air inside the cooling warehouse is discharged are formed, an air-sending device that introduces air outside the cooling warehouse to an inside of the cooling warehouse and discharges air inside the cooling warehouse to an outside of the cooling warehouse, a plurality of leakage detectors that are provided at different heights in the cooling warehouse and each detect refrigerant, and a controller that controls the air-sending device depending on whether or not one of the plurality of leakage detectors detects refrigerant, whether or not another of the plurality of leakage detectors detects refrigerant, and a time during which refrigerant has been detected by each of the plurality of leakage detectors.

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Advantageous Effects of Invention

[0010] A cooling warehouse according to an embodiment of the present invention includes a plurality of leakage detectors that are provided at different heights in the cooling warehouse and each detect refrigerant and a controller that controls an air-sending device depending on whether or not one of the plurality of leakage detectors detects refrigerant, whether or not another of the plurality of leakage detectors detects refrigerant, and a time during which refrigerant has been detected by each of the plurality of leakage detectors. Consequently, the cooling warehouse is able to determine the degree of leakage of refrigerant.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a cross-sectional view illustrating a cooling warehouse according to Embodiment of the present invention.

[Fig. 2] Fig. 2 is a circuit diagram illustrating a refrigeration cycle apparatus according to Embodiment of the present invention.

[Fig. 3] Fig. 3 is a functional block diagram of the cooling warehouse according to Embodiment of the present invention.

[Fig. 4] Fig. 4 is a flowchart illustrating the flow of a control process by a controller of the cooling warehouse according to Embodiment of the present invention.

[Fig. 5] Fig. 5 is a diagram for explaining the flow of air in a case where refrigerant leaks inside the cooling warehouse according to Embodiment of the present invention.

Description of Embodiment

[0012] Hereinafter, Embodiment of the present invention will be explained with reference to drawings. The present invention is not intended to be limited to Embodiment described below. Furthermore, the relationship of sizes of components in the drawings may be different from the actual relationship.

Embodiment

[0013] Fig. 1 is a cross-sectional view illustrating a cooling warehouse 100 according to Embodiment of the present invention.

[0014] As illustrated in Fig. 1, the cooling warehouse 100 according to Embodiment includes a warehouse main body 1, an introduction lid 32a, an introduction port air-sending device 32b, a discharge lid 31a, a discharge port air-sending device 31b, an outdoor unit 21, indoor units 22, a lower-position leakage detector 41a, a higher-position leakage detector 41b, and a controller 50. Furthermore, a refrigeration cycle apparatus 10 is provided in the cooling warehouse 100.

[0015] The warehouse main body 1 is, for example, a housing of a box type serving as the outer shell of the cooling warehouse 100, and a floor face 1a, wall faces 1b, and a ceiling face 1c each include an insulating panel 1f. Furthermore, the warehouse main body 1 is provided with an introduction port 32 and a discharge port 31. The warehouse main body 1 also has a doorway (not illustrated in the drawing) through which a person 2, a load 3, and other objects enter or exit, and a door 1e is provided at the doorway. The cooling warehouse 100 is, for example, a prefabricated refrigerator, and joints of the insulating panels 1f around the warehouse main body 1 are sealed. Hereinafter, the inside of the warehouse main body 1 may be referred to as "inside the warehouse", and the outside of the warehouse main body 1 may be referred to as "outside the warehouse".

[0016] The introduction port 32 is an opening port through which air outside the warehouse is introduced into the warehouse. The introduction port 32 is formed, for example, at the wall face 1b positioned on the right when Fig. 1 is viewed from front. The introduction port 32 is formed, for example, between a position corresponding to two-thirds of the height of the warehouse main body 1 and the ceiling face 1c, that is, formed at a position corresponding to two-thirds or more of the height of the warehouse main body 1. The introduction port 32 may be formed at the ceiling face 1c of the warehouse main body 1.

[0017] Furthermore, the discharge port 31 is an opening port through which air inside the warehouse is discharged out of the warehouse. The discharge port 31 is formed, for example, at the wall face 1b positioned on the left when Fig. 1 is viewed from front. The discharge port 31 is formed, for example, between the floor face 1a and a position corresponding to one-third of the height of the warehouse main body 1, that is, formed at a position corresponding to one-third or less of the height of the warehouse main body 1. The introduction port 32 may be formed at the floor face 1a of the warehouse main body 1.

[0018] The introduction lid 32a is provided at the introduction port 32 to open and close the introduction port 32. The

introduction port air-sending device 32b is provided inside the warehouse and in the vicinity of the introduction port 32 and the introduction lid 32a. The introduction port air-sending device 32b allows air outside the warehouse to be introduced when the introduction lid 32a is opened. The introduction port air-sending device 32b allows air inside the warehouse to be stirred when the introduction lid 32a is closed. The discharge lid 31a is provided at the discharge port 31 to open and close the discharge port 31. The discharge port air-sending device 31b is provided inside the warehouse and in the vicinity of the discharge port 31 and the discharge lid 31a. The discharge port air-sending device 31b allows air inside the warehouse to be discharged when the discharge lid 31a is opened. The discharge port air-sending device 31b allows air inside the warehouse to be stirred when the discharge lid 31a is closed. Each of the introduction port air-sending device 32b and the discharge port air-sending device 31b may be provided outside the warehouse, not inside the warehouse.

[0019] The discharge port air-sending device 31b and the introduction port air-sending device 32b each have a capability of generating an air volume that is equal to or more than the amount of ventilation multiplied by the number of ventilation times calculated by a mathematical formula 1 shown below.

[Math. 1]

Number of ventilation times $n = 400/\text{warehouse internal volume } V \text{ (m}^3\text{)}$

[0020] Furthermore, the discharge port air-sending device 31b and the introduction port air-sending device 32b each have a capability of generating a wind velocity of 1.8 meters or more per second.

[0021] In the case where flammable refrigerant is used for the refrigeration cycle apparatus 10, if refrigerant leaks inside the warehouse, the refrigerant will need to be stirred or ventilation will need to be performed before the refrigerant stagnates inside the warehouse to an extent that refrigerant-air mixture has the lowest density that can propagate flame, and the above-mentioned air volume and wind velocity are necessary for this case. In addition, the above-mentioned air volume and wind velocity are values for the case where flammable refrigerant that is available at the present time is used for the refrigeration cycle apparatus 10.

[0022] The outdoor unit 21 is installed outside the warehouse. For example, a compressor 11 and an outdoor heat exchanger 12, which will be described later, are installed inside the outdoor unit 21. The indoor units 22 are installed inside the warehouse. For example, an expansion unit 13 and an indoor heat exchanger 14, which will be described later, are installed inside each of the indoor units 22. Furthermore, as illustrated in Fig. 1, the indoor units 22 are installed in such a manner that the indoor units 22 are suspended from the ceiling face 1c. The indoor units 22 may not be suspended from the ceiling and may be installed on the floor or wall. Furthermore, although the case where two indoor units 22 are installed is described, the number of indoor units installed may be one or three or more.

[0023] The lower-position leakage detector 41a and the higher-position leakage detector 41b are provided at different heights inside the warehouse and each detect refrigerant leaking inside the warehouse. In the case where the indoor unit 22 of the refrigeration cycle apparatus 10 is installed in such a manner that the indoor unit 22 is suspended from the ceiling, the lower-position leakage detector 41a is provided, for example, in a space inside the warehouse between the floor face 1a and a position 20 centimeters above the floor face 1a. In the case where the width or depth of the warehouse main body 1 is 8 meters or more, one or more lower-position leakage detectors 41a are provided within a horizontal distance of 8 meters from an end part of the indoor unit 22 of the refrigeration cycle apparatus 10. Furthermore, in the case where the indoor unit 22 of the refrigeration cycle apparatus 10 is installed on the floor, the lower-position leakage detector 41a is provided, for example, in a space inside the warehouse between the floor face 1a and a position 5 centimeters above the floor face 1a.

[0024] Furthermore, the higher-position leakage detector 41b is provided, for example, in a space inside the warehouse between the floor face 1a and a position corresponding to one-third of the height of the warehouse main body 1.

[0025] In the case where the specific gravity of refrigerant is greater than the specific gravity of air, refrigerant that has leaked stagnates in the vicinity of the floor face 1a inside the warehouse. As the amount of leaking refrigerant increases, the refrigerant accumulates up to a portion above the floor face 1a. Consequently, as the flow rate of leaking refrigerant increases, the time shortens that is needed for the higher-position leakage detector 41b to detect refrigerant after the lower-position leakage detector 41a detects refrigerant.

[0026] The cooling warehouse 100 according to Embodiment is able to determine the degree of leakage of refrigerant on the basis of whether or not the lower-position leakage detector 41a detects refrigerant, whether or not the higher-position leakage detector 41b detects refrigerant, and the time during which refrigerant has been detected by each of the lower-position leakage detector 41a and the higher-position leakage detector 41b, or the time needed for the higher-position leakage detector 41b to detect leaking refrigerant after the lower-position leakage detector 41a detects leaking refrigerant. The time during which refrigerant has been detected mentioned above represents the length of time during which refrigerant has been detected.

[0027] For example, in the case where the flow rate of refrigerant leaking inside the warehouse is substantially high, the lower-position leakage detector 41a and the higher-position leakage detector 41b detect leaking refrigerant within a short time or at the same time.

[0028] In the configuration mentioned above, the case is described where the specific gravity of refrigerant is greater than the specific gravity of air. However, in the case where the specific gravity of refrigerant is lower than the specific gravity of air, the higher-position leakage detector 41b is provided, for example, in a space inside the warehouse between the ceiling face 1c and a position 5 centimeters below the ceiling face 1c. Furthermore, in the case where the specific gravity of refrigerant is lower than the specific gravity of air, the lower-position leakage detector 41a is provided in a space between a position corresponding to two-thirds of the height of the warehouse main body 1 and the ceiling face 1c, that is, in a space corresponding to two-thirds or more of the height of the warehouse main body 1.

[0029] The controller 50 includes, for example, dedicated hardware or a Central Processing Unit (also referred as a CPU, a central processing device, a processing device, a computing device, a microprocessor, a microcomputer, or a processor) that executes a program stored in a memory 52 (see Fig. 3, which will be described later). Furthermore, the controller 50 controls the discharge port air-sending device 31b, the introduction port air-sending device 32b, and other devices depending on results of detection by the lower-position leakage detector 41a and the higher-position leakage detector 41b.

[0030] Fig. 2 is a circuit diagram illustrating the refrigeration cycle apparatus 10 according to Embodiment of the present invention.

[0031] As illustrated in Fig. 2, the refrigeration cycle apparatus 10 according to Embodiment includes, for example, a refrigerant circuit in which the compressor 11, the outdoor heat exchanger 12, the expansion units 13, and the indoor heat exchangers 14 are connected by a pipe 24 and through which refrigerant circulates. Furthermore, the refrigeration cycle apparatus 10 includes the outdoor unit 21 and the indoor units 22, and the outdoor unit 21 and the indoor units 22 are connected by the pipe 24.

[0032] The pipe 24 includes, as illustrated in Fig. 1, an outside pipe 24a that is positioned outside the warehouse in a region from the outdoor unit 21 to the warehouse main body 1 and an inside pipe 24b that is positioned inside the warehouse in a region from the warehouse main body 1 to the indoor units 22. A set of the outside pipe 24a and the inside pipe 24b corresponds to, as illustrated in Fig. 2, a set of a high-pressure pipe 24c that extends from the outdoor unit 21 to the indoor units 22 and a low-pressure pipe 24d that returns from the indoor units 22 to the outdoor unit 21. Furthermore, a high-pressure pipe isolation valve 25a is provided at the high-pressure pipe 24c, and a low-pressure pipe isolation valve 25b is provided at the low-pressure pipe 24d.

[0033] The high-pressure pipe isolation valve 25a and the low-pressure pipe isolation valve 25b, which are opened or closed at desired timing by the controller 50, may be replaced with solenoid valves that each are opened when the solenoid valve is electrically connected and closed when the solenoid valve is not electrically connected.

[0034] The compressor 11 compresses refrigerant. The outdoor heat exchanger 12 exchanges heat between air outside the warehouse and refrigerant to condense the refrigerant. The expansion units 13 each expand and decompress refrigerant. The indoor heat exchangers 14 each exchange heat between air inside the warehouse and refrigerant to evaporate the refrigerant.

[0035] Refrigerant to be used for the refrigeration cycle apparatus 10 is, for example, slightly flammable refrigerant.

[0036] Next, a cooling operation of the refrigeration cycle apparatus 10 according to Embodiment will be explained.

[0037] Refrigerant is sucked into the compressor 11 of the outdoor unit 21, compressed by the compressor 11, and discharged as refrigerant in a high-temperature, high-pressure gas state. The discharged refrigerant flows into the outdoor heat exchanger 12. The refrigerant that has flowed into the outdoor heat exchanger 12 is subjected to heat exchange with air outside the warehouse and condensed. The condensed refrigerant flows into the expansion unit 13 of each of the indoor units 22, and is expanded and decompressed by the expansion unit 13. The expanded and decompressed refrigerant flows into the indoor heat exchanger 14. The refrigerant that has flowed into the indoor heat exchanger 14 is subjected to heat exchange with air inside the warehouse and is evaporated. At this time, the air inside the warehouse is cooled down, so that the inside of the warehouse is cooled down. Subsequently, the evaporated refrigerant is sucked into the compressor 11.

[0038] A flow switching device may be provided in the refrigeration cycle apparatus 10. With the provision of a flow switching device, a heating operation can be performed by switching flows of the flow switching device.

[0039] Fig. 3 is a functional block diagram of the cooling warehouse 100 according to Embodiment of the present invention.

[0040] As illustrated in Fig. 3, the controller 50 includes a measuring unit 51, the memory 52, a determination unit 53, and a driving unit 54. The controller 50 is configured to receive signals from the lower-position leakage detector 41a and the higher-position leakage detector 41b. Furthermore, the controller 50 is configured to output signals to the compressor 11, the high-pressure pipe isolation valve 25a, the low-pressure pipe isolation valve 25b, the discharge lid 31a, the discharge port air-sending device 31b, the introduction lid 32a, the introduction port air-sending device 32b, and a notification unit 43. The notification unit 43 is, for example, a sound output unit such as a speaker, a display unit such

as an LED, a contact point with a remote centralized control panel or a controller, or all the sound output unit, display unit, and contact point.

[0041] The measuring unit 51 acquires signals detected by the lower-position leakage detector 41a and the higher-position leakage detector 41b. The memory 52 stores various types of information. The determination unit 53 performs various types of determination on the basis of a signal acquired by the measuring unit 51 and information stored in the memory 52. For example, a reference value is stored in the memory 52, and the determination unit 53 determines that the lower-position leakage detector 41a has detected refrigerant in the case where the value of a signal that the measuring unit 51 has acquired from the lower-position leakage detector 41a is equal to or more than the reference value stored in the memory 52. The driving unit 54 outputs driving signals to the compressor 11, the high-pressure pipe isolation valve 25a, the low-pressure pipe isolation valve 25b, the discharge lid 31a, the discharge port air-sending device 31b, the introduction lid 32a, the introduction port air-sending device 32b, and the notification unit 43 on the basis of a result of a determination by the determination unit 53, so that the compressor 11, the high-pressure pipe isolation valve 25a, the low-pressure pipe isolation valve 25b, the discharge lid 31a, the discharge port air-sending device 31b, the introduction lid 32a, the introduction port air-sending device 32b, and the notification unit 43 can be driven.

[0042] Fig. 4 is a flowchart illustrating the flow of a control process by the controller 50 of the cooling warehouse 100 according to Embodiment of the present invention.

[0043] The control process by the controller 50 according to Embodiment will be explained below with reference to Fig. 4.

[0044] The controller 50 according to Embodiment determines the degree of leakage of refrigerant on the basis of whether or not the lower-position leakage detector 41a detects refrigerant, whether or not the higher-position leakage detector 41b detects refrigerant, and the time during which refrigerant has been detected by each of the lower-position leakage detector 41a and the higher-position leakage detector 41b, or the time needed for the higher-position leakage detector 41b to detect leaking refrigerant after the lower-position leakage detector 41a detects leaking refrigerant, and performs control for reducing stagnation of refrigerant that has leaked depending on the degree of leakage of refrigerant.

[0045] The relationship of a first time, a second time, and a third time, which will be described later, is represented by an inequation of the second time < the first time < the third time. The first time, the second time, and the third time are stored in the memory 52. The first time, the second time, and the third time each represent the length of a predetermined time. Furthermore, the first time, the second time, and the third time are determined on the basis of the type of refrigerant for the refrigeration cycle apparatus 10 and the internal volume of the cooling warehouse 100. The first time, the second time, and the third time may be set long for a refrigerant having high flammability and short for a refrigerant having low flammability.

[0046] After a cooling operation starts, the determination unit 53 of the controller 50 determines, on the basis of a signal input to the measuring unit 51 from the lower-position leakage detector 41a, whether or not the lower-position leakage detector 41a has detected refrigerant (step S1).

[0047] In the case where the determination unit 53 of the controller 50 determines that the lower-position leakage detector 41a has not detected refrigerant (NO in step S1), a normal cooling operation continues (step S8).

[0048] In contrast, in the case where the determination unit 53 of the controller 50 determines that the lower-position leakage detector 41a has detected refrigerant (YES in step S1), the driving unit 54 of the controller 50 operates the notification unit 43 to notify an external administrator that refrigerant has leaked inside the warehouse, drives the introduction port air-sending device 32b and the discharge port air-sending device 31b to stir the refrigerant that has leaked inside the warehouse, causes the compressor 11 to continue driving, and causes the refrigeration cycle apparatus 10 to continue operating (step S2), that is, the cooling operation continues running, and the process proceeds to step S3.

[0049] In step S3, the determination unit 53 of the controller 50 determines, on the basis of signals input to the measuring unit 51 from the lower-position leakage detector 41a and the higher-position leakage detector 41b, whether or not the lower-position leakage detector 41a detects refrigerant and whether or not the higher-position leakage detector 41b detects refrigerant.

[0050] In the case where the determination unit 53 of the controller 50 determines that the lower-position leakage detector 41a has not detected refrigerant for a time equal to or longer than the first time and the higher-position leakage detector 41b has not detected refrigerant (NO in step S3), the driving unit 54 of the controller 50 operates the notification unit 43 to send to the external administrator a notification prompting to move an object accommodated in the warehouse and repair a position where the refrigerant has leaked (step S7).

[0051] In contrast, in the case where the determination unit 53 of the controller 50 determines that the lower-position leakage detector 41a has detected refrigerant for a time equal to or longer than the first time or the higher-position leakage detector 41b has detected refrigerant (YES in step S3), the driving unit 54 of the controller 50 closes the high-pressure pipe isolation valve 25a and the low-pressure pipe isolation valve 25b to stop driving of the compressor 11, so that the operation of the refrigeration cycle apparatus 10 is stopped, that is, the cooling operation is stopped. Furthermore, after the driving unit 54 of the controller 50 operates the notification unit 43 to notify the external administrator that entry to the warehouse is not allowed (step S4), the process proceeds to step S5.

[0052] In step S5, the determination unit 53 of the controller 50 determines, on the basis of signals input to the measuring

unit 51 from the lower-position leakage detector 41a and the higher-position leakage detector 41b, whether or not the lower-position leakage detector 41a detects refrigerant and whether or not the higher-position leakage detector 41b detects refrigerant.

[0053] In the case where the determination unit 53 of the controller 50 determines that the higher-position leakage detector 41b has not detected refrigerant within the second time after the lower-position leakage detector 41a detects refrigerant and a time equal to or longer than the third time has not passed after the lower-position leakage detector 41a detects refrigerant (NO in step S5), the driving unit 54 of the controller 50 operates the notification unit 43 to send to the external administrator a notification prompting to move an object accommodated in the warehouse and repair a position where the refrigerant has leaked (step S7).

[0054] In contrast, in the case where the determination unit 53 of the controller 50 determines that the higher-position leakage detector 41b has detected refrigerant within the second time after the lower-position leakage detector 41a detects refrigerant or a time equal to or longer than the third time has passed after the lower-position leakage detector 41a detects refrigerant (YES in step S5), the driving unit 54 of the controller 50 operates the notification unit 43 to notify the external administrator that the temperature inside the warehouse has increased, and opens the discharge lid 31a and the introduction lid 32a to open the discharge port 31 and the introduction port 32 (step S6).

[0055] With the control process described above, even in the cooling warehouse 100 that includes the refrigeration cycle apparatus 10 using flammable refrigerant, refrigerant stagnating inside the warehouse is stirred before the combustion concentration is reached. Consequently, outbreak of fire can be prevented. Furthermore, with notification by the notification unit 43, the external administrator is able to move an object accommodated in the warehouse and then repair a position where refrigerant has leaked. Consequently, damage to the object accommodated inside the warehouse can be reduced toward the minimum.

[0056] As described above, in the cooling warehouse 100 according to Embodiment, the lower-position leakage detector 41a and the higher-position leakage detector 41b are a plurality of leakage detectors provided within an appropriate range from the position where refrigerant may leak, and the controller 50 is able to determine the degree of leakage of refrigerant on the basis of whether or not the lower-position leakage detector 41a detects refrigerant, whether or not the higher-position leakage detector 41b detects refrigerant, and the time during which refrigerant has been detected by each of the lower-position leakage detector 41a and the higher-position leakage detector 41b, or the time needed for the higher-position leakage detector 41b to detect leaking refrigerant after the lower-position leakage detector 41a detects refrigerant, that is, the refrigerant detection timing. By performing each of the control operations mentioned above depending on the degree of leakage of refrigerant, stagnation of refrigerant inside the warehouse can be reduced, and notification can be sent to an external administrator. Consequently, prevention of outbreak of fire and reduction toward the minimum of damage to an object accommodated inside the warehouse can be achieved at the same time.

[0057] Specifically, in the case where the lower-position leakage detector 41a detects refrigerant, the controller 50 drives the introduction port air-sending device 32b and the discharge port air-sending device 31b. That is, in the case where the degree of leakage of refrigerant is low, the refrigerant that has leaked inside the warehouse is stirred while a cooling operation is continued. Consequently, damage to an object accommodated inside the warehouse that needs to be cooled down can be reduced while stagnation of refrigerant inside the warehouse is reduced.

[0058] Furthermore, in the case where the lower-position leakage detector 41a has detected refrigerant for a time equal to or longer than the first time or in the case where the higher-position leakage detector 41b has detected refrigerant, the controller 50 closes the high-pressure pipe isolation valve 25a and the low-pressure pipe isolation valve 25b. That is, in the case where the degree of leakage of refrigerant is medium, the external administrator may be prompted to move an object accommodated inside the warehouse and repair a position where the refrigerant has leaked, while the cooling operation is stopped to block leakage of refrigerant.

[0059] Furthermore, in the case where the higher-position leakage detector 41b detects refrigerant within the second time after the lower-position leakage detector 41a detects refrigerant or in the case where a time equal to or longer than the third time passes after the lower-position leakage detector 41a detects refrigerant, the controller 50 opens the discharge lid 31a and the introduction lid 32a. That is, in the case where the degree of leakage of refrigerant is high, stagnation of refrigerant inside the warehouse can be reduced more reliably by discharging the refrigerant that has leaked inside the warehouse to the outside of the warehouse.

[0060] Furthermore, the high-pressure pipe isolation valve 25a and the low-pressure pipe isolation valve 25b may be replaced with solenoid valves that each open only when the solenoid valve is electrically connected. With this configuration, leakage of refrigerant to the inside of the warehouse can be blocked reliably even in an emergency such as power outage, and outbreak of fire can be prevented.

[0061] As mentioned above, the discharge port 31 is formed between the floor face 1a and a position corresponding to one-third of the height of the warehouse main body 1, that is, formed at a position corresponding to one-third or less of the height of the warehouse main body 1. Furthermore, the introduction port 32 is formed between a position corresponding to two-thirds of the height of the warehouse main body 1 and the ceiling face 1c, that is, formed at a position corresponding to two-thirds or more of the height of the warehouse main body 1.

[0062] Fig. 5 is a diagram for explaining the flow of air in a case where refrigerant leaks inside the cooling warehouse 100 according to Embodiment of the present invention.

[0063] The discharge port 31 and the introduction port 32 are formed at the positions mentioned above. Consequently, as illustrated in Fig. 5, air outside the warehouse introduced into the warehouse via the introduction port 32 and through an introduction path 71 is discharged, together with refrigerant 6, which has a specific gravity greater than the specific gravity of air, leaking inside the warehouse and stagnating in the vicinity of the floor face 1a, to the outside of the warehouse through a discharge path 72 via the discharge port 31. For this reason, the refrigerant 6, which has a specific gravity greater than the specific gravity of air, can be discharged out of the warehouse effectively. That is, the refrigerant 6, which has a specific gravity greater than the specific gravity of air, can be discharged out of the warehouse easily and quickly. Furthermore, by setting the air volume of the discharge port air-sending device 31b and the introduction port air-sending device 32b to a value obtained by the mathematical formula 1 mentioned above, ventilation can be completed within a short time.

Reference Signs List

[0064] 1 warehouse main body, 1a floor face, 1b wall face, 1c ceiling face, 1e door, 1f insulating panel, 2 person, 3 load, 6 refrigerant having a specific gravity greater than a specific gravity of air, 10 refrigeration cycle apparatus, 11 compressor, 12 outdoor heat exchanger, 13 expansion unit, 14 indoor heat exchanger, 21 outdoor unit, 22 indoor unit, 24 pipe, 24a outside pipe, 24b inside pipe, 24c high-pressure pipe, 24d low-pressure pipe, 25a high-pressure pipe isolation valve, 25b low-pressure pipe isolation valve, 31 discharge port, 31a discharge lid, 31b discharge port air-sending device, 32 introduction port, 32a introduction lid, 32b introduction port air-sending device, 41a lower-position leakage detector, 41b higher-position leakage detector, 43 notification unit, 50 controller, 51 measuring unit, 52 memory, 53 determination unit, 54 driving unit, 71 introduction path, 72 discharge path, 100 cooling warehouse

Claims

1. A cooling warehouse, comprising:

a warehouse main body in which an introduction port through which air outside the cooling warehouse is introduced and a discharge port through which air inside the cooling warehouse is discharged are formed;
an air-sending device configured to introduce air outside the cooling warehouse to an inside of the cooling warehouse and discharge air inside the cooling warehouse to an outside of the cooling warehouse;
a plurality of leakage detectors provided at different heights in the cooling warehouse and each configured to detect refrigerant; and
a controller configured to control the air-sending device depending on whether or not one of the plurality of leakage detectors detects refrigerant, whether or not another of the plurality of leakage detectors detects refrigerant, and a time during which refrigerant has been detected by each of the plurality of leakage detectors.

2. The cooling warehouse of claim 1, wherein the air-sending device is provided to each of the introduction port and the discharge port.

3. The cooling warehouse of claim 1 or 2, wherein the plurality of leakage detectors include a lower-position leakage detector provided at a lowest position among positions of the plurality of leakage detectors, and
in a case where the lower-position leakage detector detects refrigerant, the controller is configured to drive the air-sending device.

4. The cooling warehouse of claim 3, further comprising
a refrigeration cycle apparatus including an outdoor unit and an indoor unit connected by a high-pressure pipe and a low-pressure pipe, a high-pressure pipe isolation valve being provided at the high-pressure pipe, a low-pressure pipe isolation valve being provided at the low-pressure pipe,
wherein the plurality of leakage detectors include a higher-position leakage detector provided at a position higher than the lower-position leakage detector, and
in a case where the lower-position leakage detector has detected refrigerant for a time equal to or longer than a first time or in a case where the higher-position leakage detector detects refrigerant, the controller is configured to close the high-pressure pipe isolation valve and the low-pressure pipe isolation valve.

5. The cooling warehouse of claim 4, further comprising:

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an introduction lid provided at the introduction port to open and close the introduction port; and
a discharge lid provided at the discharge port to open and close the discharge port,
wherein in a case where a second time is shorter than the first time and the higher-position leakage detector
detects refrigerant within the second time after the lower-position leakage detector detects refrigerant or in a
case where a third time is longer than the first time and a time equal to or longer than the third time passes after
the lower-position leakage detector detects refrigerant, the controller is configured to open the discharge lid
and the introduction lid.

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FIG. 1

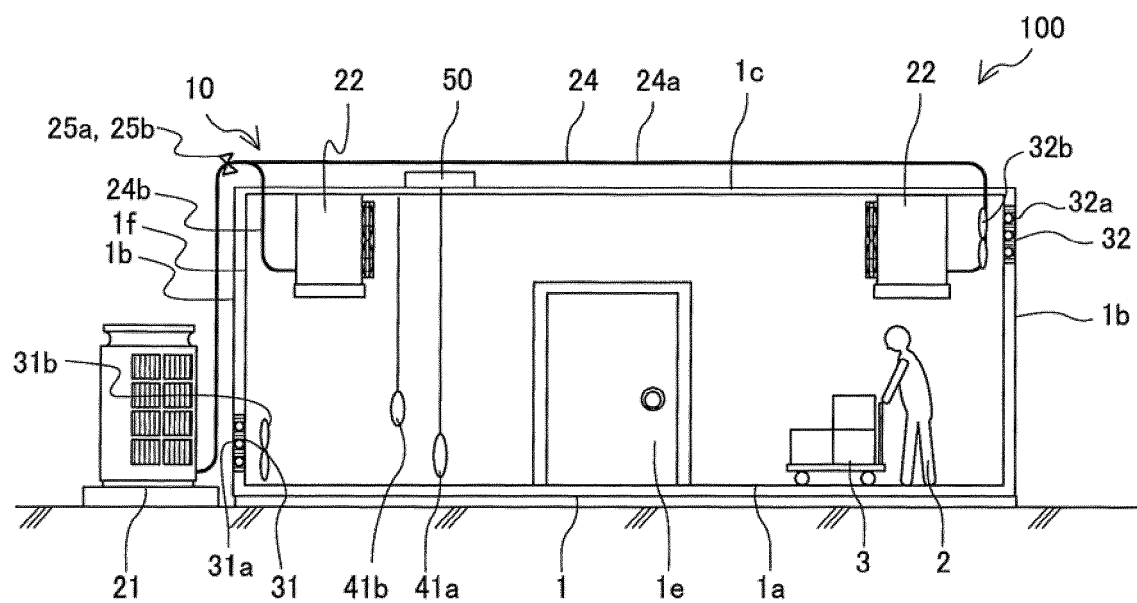


FIG. 2

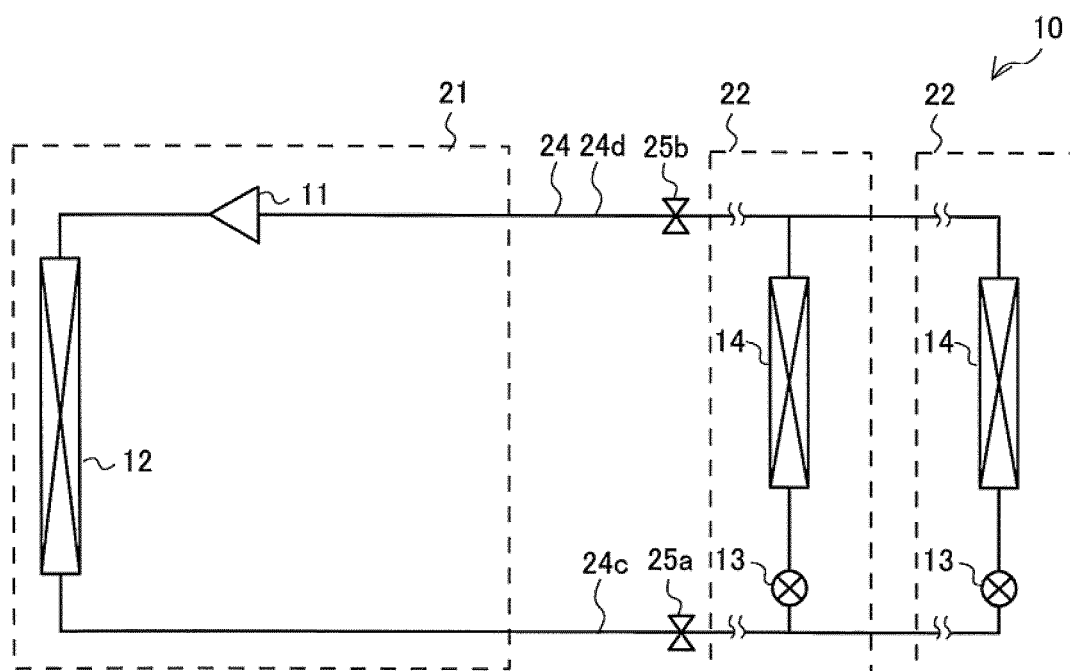


FIG. 3

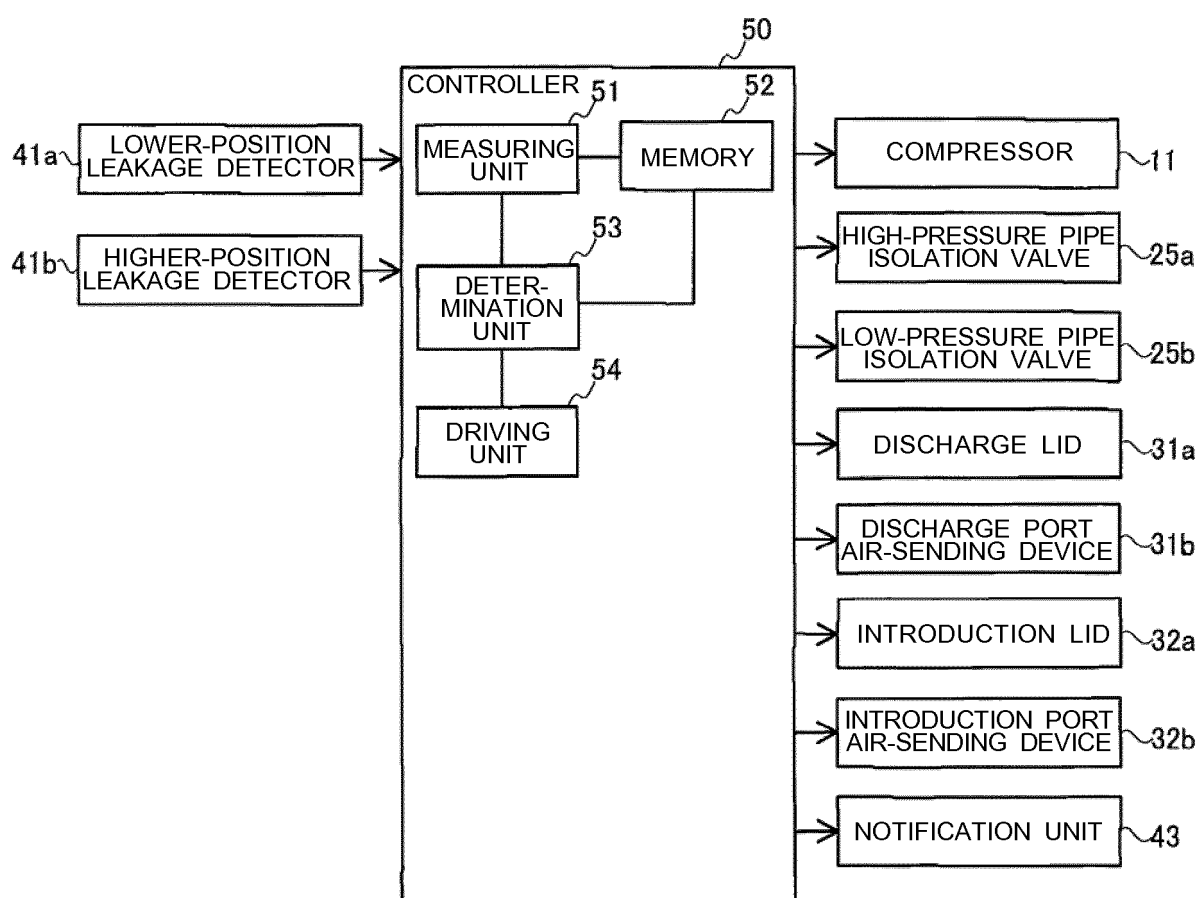


FIG. 4

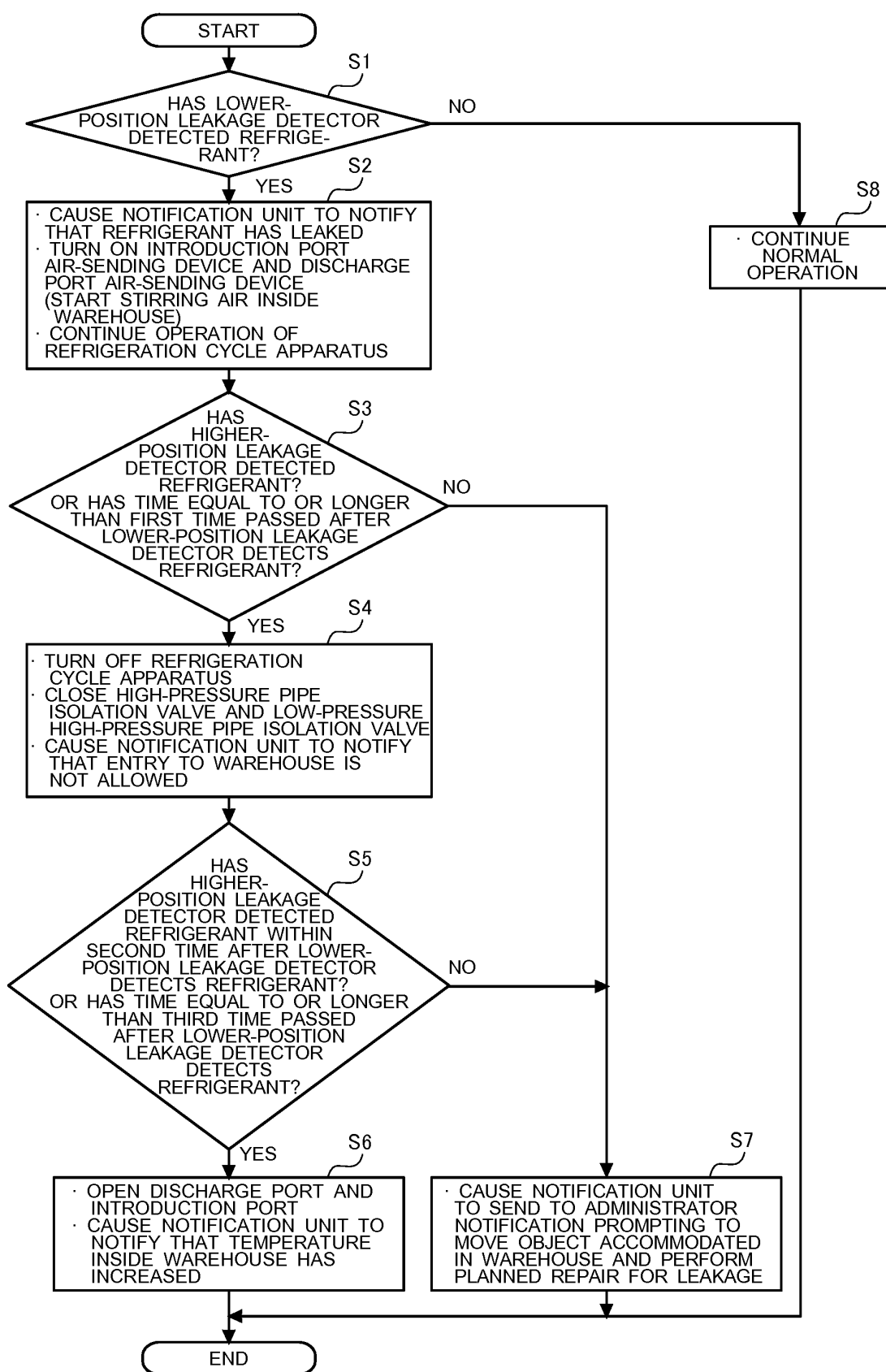
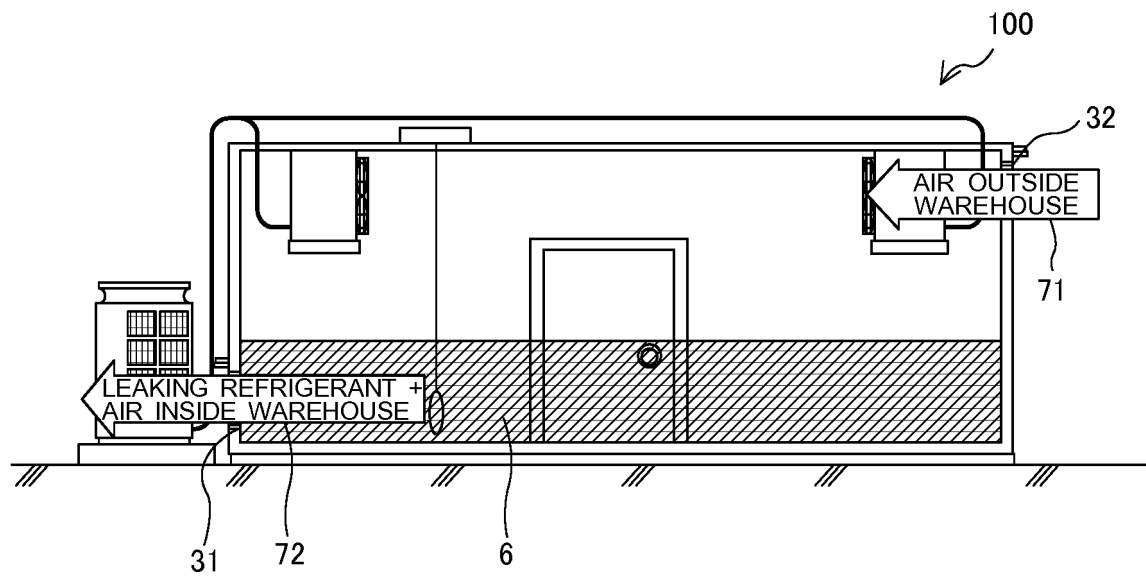


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/000593

A. CLASSIFICATION OF SUBJECT MATTER

F25B49/02(2006.01)i, F25B41/04(2006.01)i, F25D17/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B49/02, F25B41/04, F25D17/06, F25B1/00, F24F11/02

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 8-200904 A (Sanyo Electric Co., Ltd.), 09 August 1996 (09.08.1996), paragraphs [0009] to [0022], [0026]; fig. 1 to 2, 5 (Family: none)	1-3 4-5
Y A	JP 2008-249239 A (Mitsubishi Electric Corp.), 16 October 2008 (16.10.2008), paragraphs [0008] to [0011]; fig. 1 to 2 (Family: none)	1-3 4-5
Y A	WO 2017/002216 A1 (Mitsubishi Electric Corp.), 05 January 2017 (05.01.2017), paragraph [0031]; fig. 5 (Family: none)	1-3 4-5

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

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Date of the actual completion of the international search
23 March 2017 (23.03.17)Date of mailing of the international search report
11 April 2017 (11.04.17)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

International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2015-90240 A (Daikin Industries, Ltd.), 11 May 2015 (11.05.2015), paragraphs [0006], [0045] to [0082]; fig. 1 to 8 & WO 2015/068638 A1	1-3 4-5
Y A	JP 2005-16822 A (Toshiba Carrier Corp.), 20 January 2005 (20.01.2005), paragraphs [0011] to [0021]; fig. 1 (Family: none)	1-3 4-5
A	JP 11-37619 A (Daikin Industries, Ltd.), 12 February 1999 (12.02.1999), paragraphs [0039] to [0040]; fig. 1 to 3 (Family: none)	4-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8200904 A [0006]