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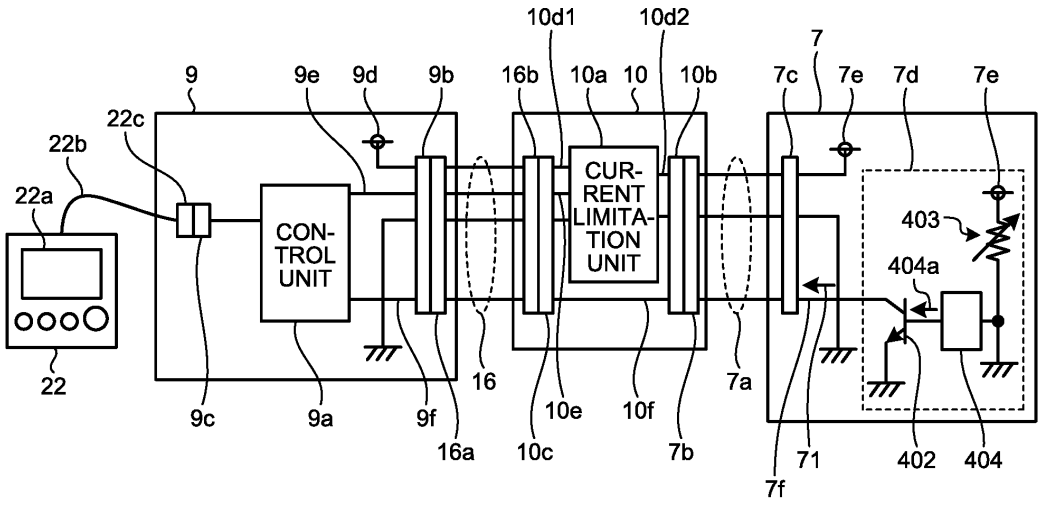
(54) **AIR CONDITIONER**

(57) An air conditioner includes: a floor-mounted type indoor unit; a control board (9) that is placed in the floor-mounted type indoor unit and controls the floor-mounted type indoor unit; a refrigerant sensor (7) that is placed in the floor-mounted type indoor unit and outputs a detection signal (71) that has on-duty varied in accordance with a detected refrigerant concentration; and a current limitation unit (10a) that is placed in the floor-mounted type indoor unit and limits a current supplied to the refrigerant sensor (7) when a short-circuit failure occurs in the refrigerant sensor (7), and thereby can detect a refrigerant leak and reduce costs for preventing spread of fire.

FIG.3



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Description

Field

[0001] The present invention relates to an air conditioner that includes a floor-mounted type indoor unit and a refrigerant sensor that detects a refrigerant leak occurring on a floor-mounted type indoor unit side.

Background

[0002] Fluorocarbon-based refrigerants are stable and easy to handle but have high global warming potentials, adversely affecting the global environment; thus, hydrocarbon-based refrigerants such as propane and propylene, which are natural refrigerants having low warming potentials, have become a focus of attention as a replacement of the fluorocarbon-based refrigerants. When the hydrocarbon-based refrigerants, which are flammable, are used in an air conditioner, however, a refrigerant leak from the air conditioner may achieve a flammable concentration. It is thus desirable that an air conditioner have a measure to detect a refrigerant leak at an early stage and prevent the refrigerant leak from achieving the flammable concentration.

[0003] A floor-mounted type indoor unit disclosed in Patent Literature 1 includes a control board that provides centralized control over devices such as an air fan, a fan motor, and a compressor, and a remote controller, for a user to operate an air conditioner, that monitors an operation state and an anomaly description. A refrigerant sensor is connected to the control board via wiring including a signal wire.

[0004] The refrigerant sensor is placed below a machine chamber in the floor-mounted type indoor unit disclosed in Patent Literature 1. The refrigerant sensor is placed in this manner for the following reasons.

(1) Hydrocarbon-based refrigerants have greater specific gravity than that of air, allowing the refrigerant sensor, which is placed below the machine chamber, to effectively measure the concentration of a refrigerant leak.
(2) The control board is placed inside a metal housing or covered in flame-retardant resin to prevent spread of fire. If the refrigerant sensor and the control board are placed in an identical space, that is, if the refrigerant sensor is placed inside the metal housing or is covered in the flame-retardant resin, a refrigerant leak is not likely to enter the metal housing or the flame-retardant resin. The refrigerant sensor is thus not placed in the same space with the control board but placed away from the control board.

[0005] The refrigerant sensor, which is placed in this manner, detects a refrigerant leak from a component that configures a refrigeration cycle, such as a heat exchanger and a union joint, and, when the concentration of the leak reaches a certain value or greater, the floor-mounted type indoor unit operates the air fan to diffuse the refrigerant leak, thereby preventing the concentration of the refrigerant leak from achieving a flammable concentration.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Patent Application Laid-open No. 2015-94566

Summary

Technical Problem

[0007] A refrigerant sensor placed in a location away from a control board, as in the floor-mounted type indoor unit disclosed in Patent Literature 1, needs to be covered in a metal housing or flame-retardant resin, similar to that used for the control board, to prevent the refrigerant sensor from undergoing anomalous heating due to a short-circuit failure and affecting nearby devices. As described above, the floor-mounted type indoor unit disclosed in Patent Literature 1 needs a measure on the refrigerant sensor to prevent spread of fire, posing a problem of costs incurred for the prevention of spread of fire.

[0008] The present invention has been achieved in view of the above, and an object of the present invention is to provide an air conditioner that can detect a refrigerant leak and reduce costs for preventing spread of fire.

Solution to Problem

[0009] In order to solve the foregoing problem, and to achieve the object, an air conditioner according to the present invention includes: a floor-mounted type indoor unit; a control board, placed in the floor-mounted type indoor unit, that controls the floor-mounted type indoor unit; a refrigerant sensor, placed in the floor-mounted type indoor unit, that outputs a detection signal that has on-duty varied in accordance with a detected refrigerant concentration; and a current limitation unit, placed in the floor-mounted type indoor unit, that limits a current supplied to the refrigerant sensor when a short-circuit failure occurs in the refrigerant sensor.

Advantageous Effects of Invention

[0010] An air conditioner according to the present invention produces effects of enabling detection of a refrigerant leak and reduction of costs for preventing spread of fire.

Brief Description of Drawings

[0011]

FIG. 1 is an exterior view of an air conditioner according to an embodiment of the present invention.
FIG. 2 is an interior view of a floor-mounted type indoor unit illustrated in FIG. 1.
FIG. 3 is a diagram illustrating a remote controller, a control board, a relay board, and a refrigerant sensor included in the air conditioner according to the embodiment of the present invention in a connected state.
FIG. 4 is a configuration diagram of a current limitation unit illustrated in FIG. 3.
FIG. 5 is a diagram illustrating an example pulse-width modulating signal output by a control unit of the refrigerant sensor illustrated in FIG. 3.
FIG. 6 is a diagram illustrating modifications of the control board and the relay board illustrated in FIG. 3.

Description of Embodiments

[0012] An exemplary embodiment of an air conditioner according to the present invention is described in detail below with reference to the drawings. The present invention is not limited to the embodiment.

Embodiment.

[0013] FIG. 1 is an exterior view of an air conditioner according to an embodiment of the present invention. An air conditioner 100 includes an outdoor unit 1, a floor-mounted type indoor unit 2 connected to the outdoor unit 1, and piping 3 connecting the outdoor unit 1 to the floor-mounted type indoor unit 2 and allowing a refrigerant to flow therethrough. The air conditioner 100 according to the present embodiment uses a flammable hydrocarbon-based refrigerant.

[0014] The floor-mounted type indoor unit 2 includes a housing 20, a front panel 21 placed on a front of the housing 20, and a remote controller 22. The remote controller 22 may be simply referred to as "remote controller 22" below. The housing 20 is a hollow box body and has a front opening portion in a front face of the housing 20. The front panel 21 is detachably attached to the front opening portion of the housing 20. The front panel 21 has an air inlet port 21a formed in a lower side of the front panel 21 and an air outlet port 21b formed in an upper side of the front panel 21. The front panel 21 includes the remote controller 22 between the air inlet port 21a and the air outlet port 21b.

[0015] The remote controller 22 is a user interface that allows a user to operate the air conditioner 100 and monitor an operation state and an anomaly description of the air conditioner 100. Examples of operating can include an operation to start the air conditioner 100, an operation to stop the air conditioner 100, and an operation to switch operation modes. Examples of anomaly descriptions can include refrigerant leak information indicating a refrigerant leak from a component configuring a refrigeration cycle of the air conditioner 100, communication anomaly information indicating an anomaly in communication between the floor-mounted type indoor unit 2 and the outdoor unit 1, and disconnection anomaly information indicating a disconnection in a signal wire connected to a refrigerant sensor. The remote controller 22 includes a display unit 22a that displays the operation state and the anomaly descriptions. In the air conditioner 100, the refrigerant leak information, which has higher priority over other information such as the communication anomaly information and the disconnection anomaly information, is displayed on the display unit 22a of the remote controller 22. This notifies a user of a refrigerant leak before the refrigerant leak achieves the flammable concentration, thereby encouraging the user to ventilate a room in which the air conditioner 100 is installed or to operate the air conditioner 100 to force the refrigerant leak to diffuse.

[0016] FIG. 2 is an interior view of the floor-mounted type indoor unit illustrated in FIG. 1. The housing 20 of the floor-mounted type indoor unit 2 illustrated in FIG. 2 has a lower space 200 that configures an air intake portion and an upper space 201 that is located above the lower space 200 and configures a heat exchange portion. The lower space 200 and the upper space 201 are divided by a partition portion 4. The partition portion 4 has a flat plate shape and placed in the middle of the housing 20 in an up-and-down direction. The partition portion 4 has an air-path opening portion 4a that provides an air path between the lower space 200 and the upper space 201.

[0017] The lower space 200 is placed on a back face side of the air inlet port 21a illustrated in FIG. 1 and exposed to a front face side when the air inlet port 21a is removed from the front panel 21. The upper space 201 is placed on a back face side of the air outlet port 21b illustrated in FIG. 1 and exposed to a front face side when the air outlet port 21b is removed from the front panel 21.

[0018] An indoor air fan 5 that generates an air flow from the air inlet port 21a toward the air outlet port 21b illustrated in FIG. 1 is placed in the lower space 200. The indoor air fan 5 is a sirocco fan that is connected to an output shaft 5b of a motor 5a and has an impeller 5c having a plurality of blades placed in a circumferential direction at regular intervals. The indoor air fan 5 is covered by a fan casing 6 having a scroll shape. The fan casing 6 is placed in a location facing the air inlet port 21a illustrated in FIG. 1. Since the fan casing 6 is placed below the partition portion 4, the inside of the fan casing 6 is a part of the lower space 200.

[0019] A refrigerant sensor 7 that detects a refrigerant leak and an electrical-item box 8 having a cuboid shape are also placed in the lower space 200. The electrical-item box 8 is placed above the indoor air fan 5 and houses a control board 9 that controls the floor-mounted type indoor unit 2, and a relay board 10 internally. The control board 9 has a drive control function with which centralized control is provided over units to be controlled that configure the air conditioner 100 and an anomaly display function with which an anomaly description for an anom-

aly that has occurred in the air conditioner 100 is displayed on the display unit 22a of the remote controller 22 illustrated in FIG. 1. The units to be controlled include undepicted devices such as fan motors, air direction plates, compressors, and propeller fans mounted in the floor-mounted type indoor unit 2 and in the outdoor unit 1. Examples of the anomaly description on the anomaly display function can include the refrigerant leak information, which indicates a refrigerant leak, the communication anomaly information, which indicates an anomaly in the communication between the floor-mounted type indoor unit 2 and the outdoor unit 1, the disconnection anomaly information, which indicates a disconnection in wiring 7a, and short-circuit failure information that indicates a short circuit in the refrigerant sensor 7.

[0020] The refrigerant sensor 7 includes the wiring 7a for transmitting, to the control board 9, a detection signal 71 that is output by the refrigerant sensor 7, and the wiring 7a is connected to the relay board 10. The refrigerant sensor 7 is placed below the indoor air fan 5 and detects the concentration of the refrigerant in the air surrounding the refrigerant sensor 7. The refrigerant sensor 7 outputs the detection signal 71, which has on-duty varied in accordance with the detected refrigerant concentration. A configuration of the refrigerant sensor 7 is described in detail below.

[0021] The upper space 201 is located downstream of the lower space 200 in terms of the air flow generated by the indoor air fan 5. An indoor heat exchanger 11 is placed in the upper space 201. The indoor heat exchanger 11 is connected to one end of an indoor piping 11a that allows the refrigerant to pass therethrough, and a joint unit 12a is connected to the other end of the indoor piping 11a. The indoor piping 11a passes through the partition portion 4, and the joint unit 12a is placed in the lower space 200. A joint unit 12b is placed on one end of the piping 3, which is extended piping. The piping 3 and the indoor piping 11a are connected together by connecting the joint unit 12b to the joint unit 12a.

[0022] Possible refrigerant leak locations in the floor-mounted type indoor unit 2, which is configured as described above, are a brazed portion 13 between the indoor heat exchanger 11 and the indoor piping 11a and a connected portion 14 between the joint unit 12a and the joint unit 12b. The refrigerant used in the air conditioner 100 according to the present embodiment is a flammable refrigerant having specific gravity greater than that of air. A refrigerant leak from at least one of the brazed portion 13 and the connected portion 14 thus leads to an increased concentration of the refrigerant in the lower space 200. Locating the refrigerant sensor 7 in a lower portion of the lower space 200 enables accurate measurement of the concentration of the refrigerant that is collected on a bottom surface of the lower space 200.

[0023] The detection signal 71, which is output by the refrigerant sensor 7, is received by the control board 9 via the wiring 7a and the relay board 10. The control board 9 operates the indoor air fan 5 to diffuse a refrigerant leak when the concentration of the leaking refrigerant reaches a certain value or greater on the basis of the detection signal 71, which is output by the refrigerant sensor 7, thus preventing the concentration of the refrigerant leak from reaching the flammable concentration.

[0024] In the case of the floor-mounted type indoor unit disclosed in Patent Literature 1 described above, the refrigerant sensor needs to be covered in a metal housing similar to that used for the control board or in flame-retardant resin as a measure taken on the refrigerant sensor to prevent spread of fire. In contrast, the air conditioner 100 according to the present embodiment does not have such measures taken on the refrigerant sensor 7 and includes a current limitation unit for limiting a current supplied to the refrigerant sensor 7 when a short-circuit failure occurs in the refrigerant sensor 7, thereby preventing spread of fire. A configuration that achieves prevention of spread of fire as described above is described below in detail.

[0025] FIG. 3 is a diagram illustrating the remote controller, the control board, the relay board, and the refrigerant sensor included in the air conditioner according to the embodiment of the present invention in a connected state. The remote controller 22 is connected to wiring 22b that includes a connector 22c.

[0026] The control board 9 includes a control unit 9a, a connecting terminal 9b, a connecting terminal 9c, and a power source 9d for supplying power to the relay board 10 and the refrigerant sensor 7. The control board 9 includes a communication line 9e for transmitting, to the control unit 9a, a feedback signal output by a current limitation unit 10a included in the relay board 10, and a signal wire 9f for transmitting, to the control unit 9a, the detection signal 71, which is output by the refrigerant sensor 7.

[0027] The control unit 9a has the drive control function and the anomaly display function described above. The remote controller 22 is connected to the control unit 9a by connecting the connecting terminal 9c to the connector 22c of the remote controller 22. The power source 9d is connected to the connecting terminal 9b. The communication line 9e has one end connected to the control unit 9a and the other end connected to the connecting terminal 9b. The signal wire 9f has one end connected to the control unit 9a and the other end connected to the connecting terminal 9b.

[0028] The relay board 10 includes the current limitation unit 10a, which limits a current supplied to the refrigerant sensor 7 to inhibit an excessive current from flowing through the refrigerant sensor 7 when a short-circuit failure occurs in the refrigerant sensor 7. The relay board 10 also includes a connecting terminal 10b, a connecting terminal 10c, a power line 10d1 connected to the connecting terminal 10c, a power line 10d2 connected to the connecting terminal 10b, a communication line 10e connected to the connecting terminal 10c, and a signal wire 10f for transmitting the detection signal 71, which is output by the refrigerant sensor 7, to the control unit 9a.

[0029] The control board 9 is connected to the relay board 10 by wiring 16. The wiring 16 includes a power line, a communication line, and a signal wire, and a connector 16a placed on one end side of the wiring 16 is connected to the connecting terminal 9b of the control board 9. A connector 16b placed on the other end side of the wiring 16 is connected to the connecting terminal 10c of the relay board 10. The power source 9d of the control board 9 is supplied to the current limitation unit 10a via the power line 10d1 by connecting the connector 16a of the wiring 16 to the connecting terminal 9b.

[0030] The refrigerant sensor 7 includes the wiring 7a, a connector 7b connected to one end of the wiring 7a, a connector 7c connected to the other end of the wiring 7a, a refrigerant detection circuit 7d, a power source 7e having the same electric potential as the power source 9d, and a signal wire 7f. The wiring 7a includes a power line, a communication line, and a signal wire. The power source 9d of the control board 9 is supplied to the refrigerant sensor 7 via the current limitation unit 10a by connecting the connector 7b to the connecting terminal 10b of the relay board 10 and connecting the connector 7b to the connecting terminal 10b. The detection signal 71, which is output by the refrigerant detection circuit 7d, is transmitted to the control unit 9a via the signal wire 7f, the signal wire 10f of the relay board 10, and the signal wire 9f of the control board 9.

[0031] The refrigerant detection circuit 7d includes a transistor 402 for varying electric potentials of the signal wire 7f, the signal wire 10f, and the signal wire 9f, a sensor element 403 for detecting a refrigerant, and a control unit 404 that controls on/off timing of the transistor 402 in accordance with the concentration of the refrigerant detected by the sensor element 403. The power source 7e, which is needed for operations of the transistor 402 and the refrigerant detection circuit 7d, is supplied from the control board 9. While the transistor 402 is used in the refrigerant detection circuit 7d, a switch element, such as an operational amplifier or a relay, may be used in place of the transistor 402.

[0032] FIG. 4 is a configuration diagram of the current limitation unit illustrated in FIG. 3. The current limitation unit 10a illustrated in FIG. 4 includes a resistor 302 having one end connected to a power source 301, and a transistor 303 having a drain connected to the other end of the resistor 302. The current limitation unit 10a also includes a comparator 304 that compares an electric potential at an end connection between the resistor 302 and the transistor 303 to an electric potential of the power source 301 and outputs a comparison result in a digital value of one or zero. The current limitation unit 10a also includes a power source terminal 305 connected to an end connection between the resistor 302 and the drain of the transistor 303 and connected to the power line 10d2, and a communication terminal 306 connected to an output end of the comparator 304 and connected to the communication line 10e.

[0033] Operations of the control board 9, the relay board 10, and the refrigerant sensor 7 are described below.

[0034] When the operation of the refrigerant sensor 7 is in a normal state, the current limitation unit 10a operates in such a manner that a current loss is very small; thus, a current of the power source 9d is supplied to the refrigerant sensor 7 with a voltage of the power source 9d unvaried. Additionally, when the operation of the refrigerant sensor 7 is in the normal state, the feedback signal, which is output by the current limitation unit 10a, is transmitted to the control unit 9a of the control board 9. The feedback signal that is output by the current limitation unit 10a in this case is a signal at an L level output by the comparator 304.

[0035] A case in which a short-circuit failure occurs in the refrigerant sensor 7 and causes an overcurrent to flow is described next. When a short-circuit failure occurs in the sensor element 403 or the control unit 404, which configure the refrigerant sensor 7, and reduces impedance between the power source of the refrigerant sensor 7 and a GND so as to be smaller than that of the normal state, the control board 9 attempts to continue causing a current to flow until the supply capacity of the power source 9d is reached. A current having a value lower than a certain value, however, is supplied to the refrigerant sensor 7 because of the current limitation unit 10a. The current having a value lower than the certain value here is a current having a value lower than that of a current that can cause the refrigerant sensor 7 to undergo heating and spread fire due to the short-circuit failure; the current having a value lower than the certain value may be a current having a value that does not allow the refrigerant sensor 7 to continue operating.

[0036] An operation of the current limitation unit 10a performed when a short-circuit failure occurs is described in detail with reference to symbols (1) to (4) illustrated in FIG. 4, where (1) when an overcurrent flows through the resistor 302 due to a short-circuit failure in the current limitation unit 10a, (2) the comparator 304 compares electric potentials at two input ends. (3) When the electric potential at the end connection between the resistor 302 and the transistor 303 is lower than that of the power source 301 by a certain amount or more, the output of the comparator 304 changes from an H level to the L level. The signal at the L level is transmitted to the transistor 303 and the communication terminal 306. The signal at the L level that is transmitted to the communication terminal 306 is transmitted to the communication line 10e, which is connected to the communication terminal 306, and to the control unit 9a as the feedback signal. The feedback signal at the L level that is transmitted to the control unit 9a is a signal that indicates occurrence of the short-circuit failure in the refrigerant sensor 7. (4) A gate of the transistor 303 changes from on to off due to the change in the output of the comparator 304 from the H level to the L level. This limits a current supplied to the power source terminal 305 to a value lower than the certain value. The current limitation unit 10a may use

an operational amplifier in place of the comparator 304. When an operational amplifier is used in place of the comparator 304, a current flowing through the power line 10d2 can be varied linearly.

[0037] The sensor element 403 or the control unit 404 of the refrigerant detection circuit 7d can be prevented from being heated by an excessive current in this manner. Additionally, the control unit 9a of the control board 9 causes the remote controller 22 to display the short-circuit failure information described above when the control unit 9a detects the short-circuit failure in the refrigerant sensor 7 based on the feedback signal, which is output by the current limitation unit 10a. Examples of a method to display the short-circuit failure information on the remote controller 22 can include a method of displaying message information indicative of occurrence of the short-circuit failure on the display unit 22a of the remote controller 22 and a method of causing a light emitting diode (LED) that is an undepicted light emitting unit included in the remote controller 22 to turn on when the refrigerant sensor 7 is in the normal state and to flash when the short-circuit failure occurs in the refrigerant sensor 7.

[0038] FIG. 5 is a diagram illustrating an example pulse-width modulating signal output by the control unit of the refrigerant sensor illustrated in FIG. 3. In FIG. 5(1), a pulse-width modulating signal 404a that is output by the control unit 404 when the concentration of the refrigerant detected by the sensor element 403 is smaller than a certain value is illustrated. In FIG. 5(1), on-duty, which is a ratio of an on-time Ton to a cycle T of the pulse-width modulating signal 404a is 30%. In FIG. 5(2), the pulse-width modulating signal 404a that is output by the control unit 404 when the concentration of the refrigerant detected by the sensor element 403 is equal to or greater than the certain value is illustrated. In FIG. 5(2), the on-duty is 70%. The control unit 404 generates the pulse-width modulating signal 404a, which increases the on-duty as the concentration of the refrigerant detected by the sensor element 403 increases as described above.

[0039] Examples of the sensor element 403 can include a thermistor that varies a resistance value using cooling effect of the refrigerant. Specifically, the resistance value of the thermistor decreases as the concentration of the refrigerant increases, increasing a current value input to the control unit 404 from the power source 7e. The control unit 404 varies the on-duty of the pulse-width modulating signal 404a as illustrated in FIG. 5 on the basis of the magnitude of the value of the current.

[0040] As described above, the power source 7e, which is needed for the operations of the transistor 402 and the refrigerant detection circuit 7d of the refrigerant sensor 7, is supplied from the control board 9, and the on-duty of the pulse-width modulating signal 404a is varied in accordance with the concentration of the refrigerant detected by the sensor element 403. The transistor 402 is controlled in this manner, changing an electric potential applied to the signal wire 7f, which is connected to a collector of the transistor 402. That is, the on-duty of the detection signal 71 varies with the concentration of the refrigerant.

[0041] The control unit 9a of the control board 9 can determine whether the concentration of the refrigerant is equal to or greater than the certain value or smaller than the certain value by measuring the on-duty of the detection signal 71. That is, the control unit 9a determines that there is no refrigerant leak when receiving the detection signal 71 that has short on-duty as illustrated in FIG. 5(1) and does not cause the remote controller 22 to display the refrigerant leak information; the control unit 9a determines that there is a refrigerant leak when receiving the detection signal 71 that has long on-duty illustrated in FIG. 5(2) and causes the remote controller 22 to display the refrigerant leak information, which has higher priority over other information such as communication anomaly and disconnection anomaly.

[0042] FIG. 6 is a diagram illustrating modifications of the control board and the relay board illustrated in FIG. 3. Differences between the control board 9 and the relay board 10 illustrated in FIG. 3 and a control board 9A and a relay board 10A illustrated in FIG. 6, respectively, are as follows.

(1) The control board 9A includes a resistor 9g that is a pull-down resistor for stabilizing an electric potential of a signal wire.

(2) The relay board 10A includes a current limitation unit 10a-1 in place of the current limitation unit 10a illustrated in FIG. 3; the current limitation unit 10a-1 includes a fuse 307 that melts when an overcurrent flows through the refrigerant sensor 7, and a resistor 308 that is a pull-down resistor for stabilizing an electric potential of a signal wire.

[0043] Use of the current limitation unit 10a-1 eliminates the need to receive the feedback signal, which indicates occurrence of a short-circuit failure in the refrigerant sensor 7. The communication line 9e and the communication line 10e illustrated in FIG. 3 are thus no longer necessary, which results in simplified structures of the control board 9A and the relay board 10A and thereby improves yield and reliability. Operations of the control board 9A, the relay board 10A, and the refrigerant sensor 7 are described below.

[0044] When the operation of the refrigerant sensor 7 is in the normal state, the control unit 9a of the control board 9A determines whether the concentration of a refrigerant is equal to or greater than a certain value or smaller than the certain value by measuring the on-duty of the detection signal 71. When the transistor 402 is turned on, a voltage output from the power source 9d is divided due to the resistor 9g, the resistor 308, and on-resistance of the transistor 402. A resultant divided voltage is applied to the control unit 9a of the control board 9A. Here, if the resistance value of the resistor 9g is sufficiently greater than that of the resistor 308, the control

unit 9a can clearly distinguish an electric potential of the signal wire observed when the transistor 402 is turned on from an electric potential of the signal wire observed when the transistor 402 is turned off. This allows the control unit 9a to determine whether the concentration of the refrigerant is equal to or greater than the certain value or smaller than the certain value by measuring the on-duty of the detection signal 71.

[0045] A case in which a short-circuit failure occurs in the refrigerant sensor 7 and causes an overcurrent to flow is described next. When a short-circuit failure occurs in the sensor element 403 or the control unit 404, which configure the refrigerant sensor 7, and reduces the impedance between the power source of the refrigerant sensor 7 and the GND so as to be smaller than that of the normal state, the control board 9A attempts to continue causing a current to flow until the supply capacity of the power source 9d is reached. If, however, a current having a value greater than a certain value flows, the fuse 307 in the current limitation unit 10a-1 melts, interrupting the flow of the current. This causes the refrigerant sensor 7 to lose a power source, with the source voltage reduced to a GND level. The control unit 404 and the transistor 402 are thus disabled from operating, causing the electric potentials of the signal wires 7f, 10f, and 9f to have values divided by the resistor 308 and the resistor 9g. The refrigerant sensor 7 outputs the detection signal 71 that has a similar form to that of the pulse-width modulating signal 404a described above, regardless of an excessive amount of the refrigerant. When, however, the control unit 404 and the transistor 402 are disabled from operating, the output of this detection signal 71 is stopped; thus, the electric potentials of the signal wires 7f, 10f, and 9f are reduced. This enables the control unit 9a of the control board 9A to detect the short-circuit failure in the refrigerant sensor 7 and to cause the remote controller 22 to display the short-circuit failure information. A method to display on the remote controller 22 is similar to those described above.

[0046] As described above, the air conditioner 100 according to the present embodiment uses the current limitation unit 10a or 10a-1 to thereby enable prevention of anomalous heating of the refrigerant sensor 7 and eliminate the need to cover the refrigerant sensor 7 in flame-retardant resin or in a metal housing. This eliminates the need for a process to cover the refrigerant sensor 7 in the flame-retardant resin or in the metal housing during the manufacturing of the refrigerant sensor 7. The air conditioner 100 according to the present embodiment thus enables detection of a refrigerant leak and reduction of costs for a measure taken on the refrigerant sensor 7 to prevent spread of fire. Additionally, the air conditioner 100 according to the present embodiment leads to a simplified structure of the refrigerant sensor 7, thereby improving yield and reliability.

[0047] Moreover, the control boards 9 and 9A according to the present embodiment can notify a user or service personnel of occurrence of a short-circuit failure in the refrigerant sensor 7 via the remote controller 22. The refrigerant sensor 7 having the short-circuit failure can be then replaced immediately; thus, risks due to a refrigerant leak can be reduced.

[0048] While examples in which the relay boards 10 and 10A include the current limitation units 10a and 10a-1, respectively, are described in the present embodiment, the current limitation units 10a or 10a-1 may be included in the control boards 9 and 9A, respectively. If the current limitation unit 10a or 10a-1 is included in the control board 9 or 9A, respectively, the connecting terminal 9b of the control board 9 or 9A is connected to the connector 7b of the refrigerant sensor 7. Including the current limitation unit 10a or 10a-1 in the control board 9 or 9A, respectively, reduces the space taken for the installation of devices in the electrical-item box 8, enabling prevention of anomalous heating of the refrigerant sensor 7 without placing the relay board 10 or 10A.

[0049] If the relay board 10 or 10A is used, the wiring 16 is connected to the control board 9 or 9A, and the wiring 7a of the refrigerant sensor 7 is connected to the relay board 10 or 10A. Using the relay board 10 or 10A enables prevention of anomalous heating of the refrigerant sensor 7 without adding an improvement to the control board 9 or 9A.

[0050] Configuration examples in which the control board 9 or 9A is electrically connected to the relay board 10 or 10A, respectively, and the relay board 10 or 10A is electrically connected to the refrigerant sensor 7 by connecting the respective connectors to the respective connecting terminals are described in the present embodiment. The air conditioner 100 according to the present embodiment, however, may be configured by directly connecting the wiring 7a, 16, and 22b to the connecting terminals without using the connectors; alternatively, the wiring 7a, 16, and 22b may be soldered to undepicted wiring patterns on the control board 9 or 9A and the relay board 10 or 10A.

[0051] The configurations in the embodiment described above represent some examples of the present invention, and they can be combined with another publicly known technique and partially omitted or modified without departing from the spirit of the present invention.

Reference Signs List

[0052] 1 outdoor unit: 2 floor-mounted type indoor unit; 3 piping; 4 partition portion; 4a air-path opening portion; 5 indoor air fan; 5a motor; 5b output shaft; 5c impeller; 6 fan casing; 7 refrigerant sensor; 7a, 16, 22b wiring; 7b, 7c, 16a, 16b, 22c connector; 7d refrigerant detection circuit; 7e, 9d, 301 power source; 7f, 9f, 10f signal wire; 8 electrical-item box; 9, 9A control board; 9a, 404 control unit; 9b, 9c, 10b, 10c connecting terminal; 9e, 10e communication line; 9g, 302, 308 resistor; 10, 10A relay board; 10a, 10a-1 current limitation unit; 10d1, 10d2 power line; 11 indoor heat exchanger; 11a indoor piping; 12a, 12b joint unit; 13 brazed portion; 14 connection unit; 20

housing; 21 front panel; 21a air inlet port; 21b air outlet port; 22 remote controller; 22a display unit; 71 detection signal; 100 air conditioner; 200 lower space; 201 upper space; 303, 402 transistor; 304 comparator; 305 power source terminal; 306 communication terminal; 307 fuse; 403 sensor element; 404a pulse-width modulating signal.

Claims

1. An air conditioner, comprising:

   a floor-mounted type indoor unit;
   a control board, placed in the floor-mounted type indoor unit, to control the floor-mounted type indoor unit;
   a refrigerant sensor, placed in the floor-mounted type indoor unit, to output a detection signal that has on-duty varied in accordance with a detected refrigerant concentration; and
   a current limitation unit, placed in the floor-mounted type indoor unit, to limit a current supplied to the refrigerant sensor when a short-circuit failure occurs in the refrigerant sensor.

2. The air conditioner according to claim 1, further comprising a relay board placed between the control board and the refrigerant sensor, the current limitation unit being placed in the relay board.

3. The air conditioner according to claim 1 or 2, further comprising a remote controller,
   wherein the control board causes the remote controller to display information indicative of occurrence of a short-circuit failure in the refrigerant sensor when the control board detects the occurrence of the short-circuit failure in the refrigerant sensor based on a signal output from the current limitation unit.

FIG.1

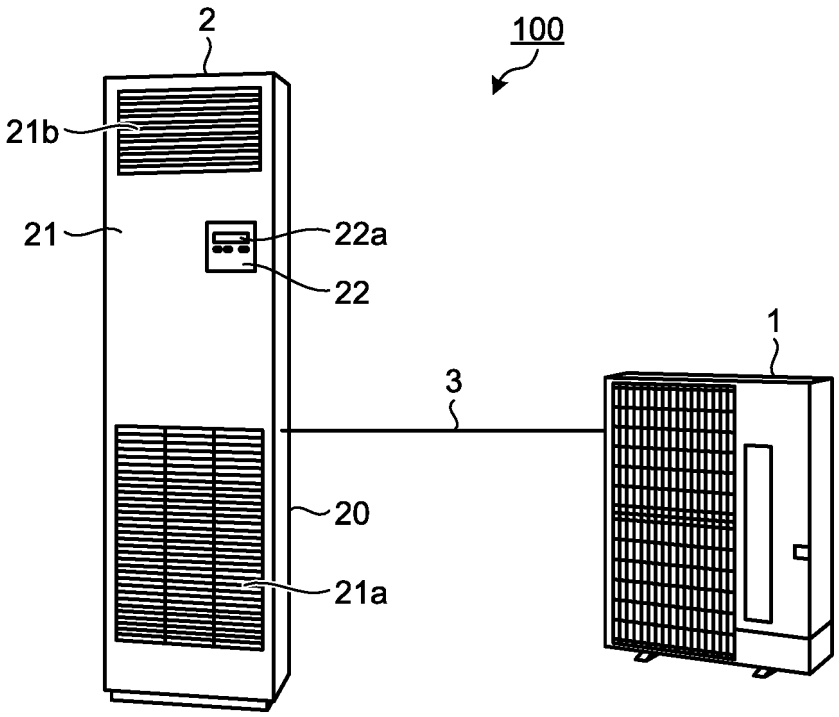


FIG.2

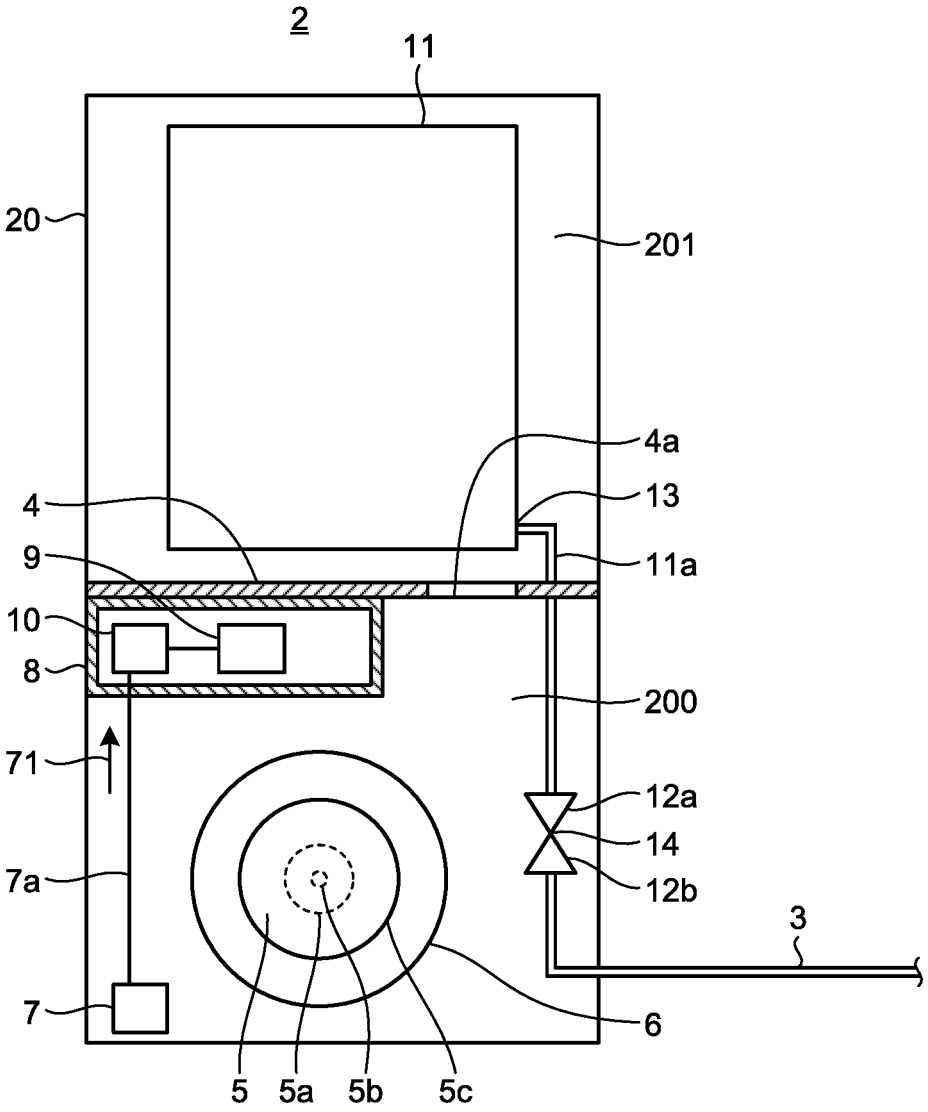


FIG.3

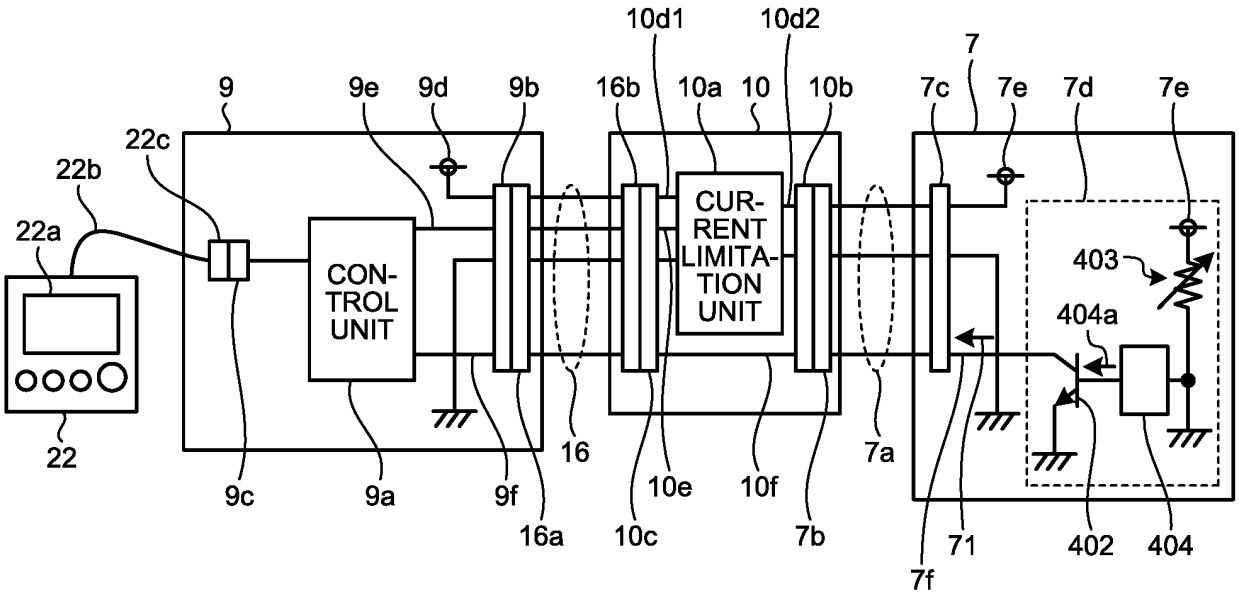

10d1
10d2
7
9
9e
9d
9b
16b
10a
10
10b
7c
7e
7d
7e
22c
22b
22a
CON-
TROL
UNIT
CUR-
RENT
LIMITA-
TION
UNIT
403
404a
22
9c
9a
9f
16
16a
10e
10c
10f
7b
7a
7f
71
402
404

FIG.4

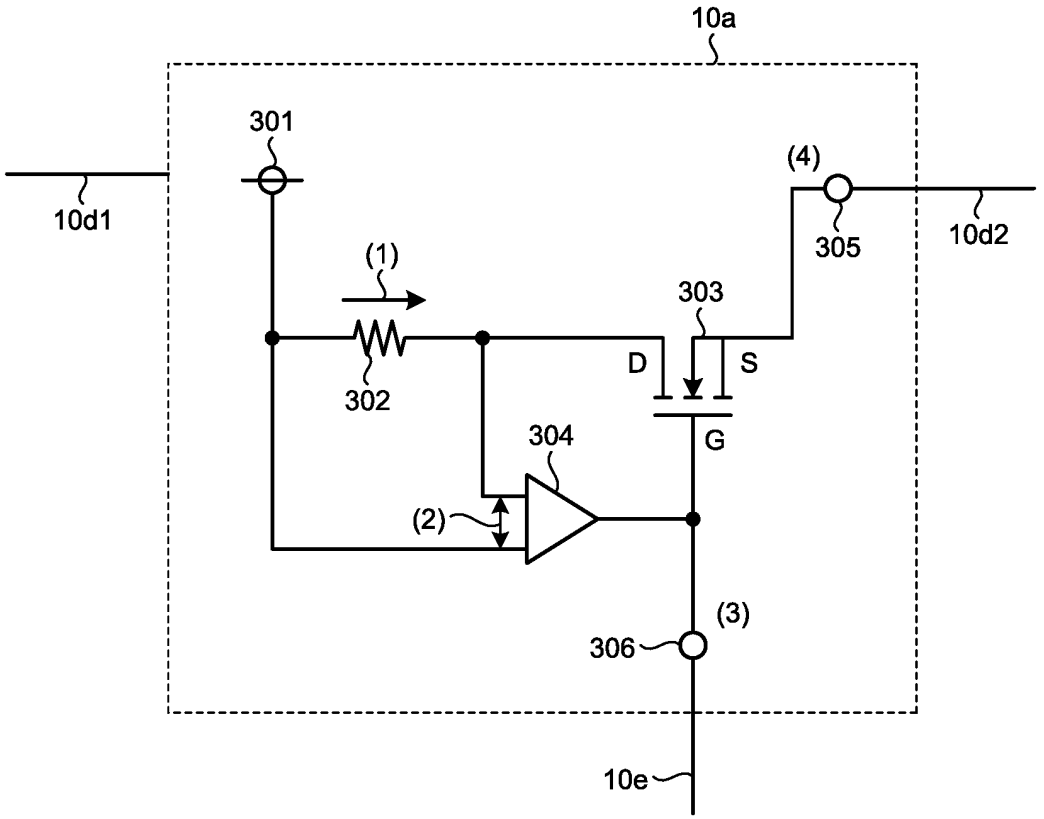

10a
301
10d1
(4)
305
10d2
(1)
303
302
D
S
G
304
(2)
(3)
306
10e

FIG.5

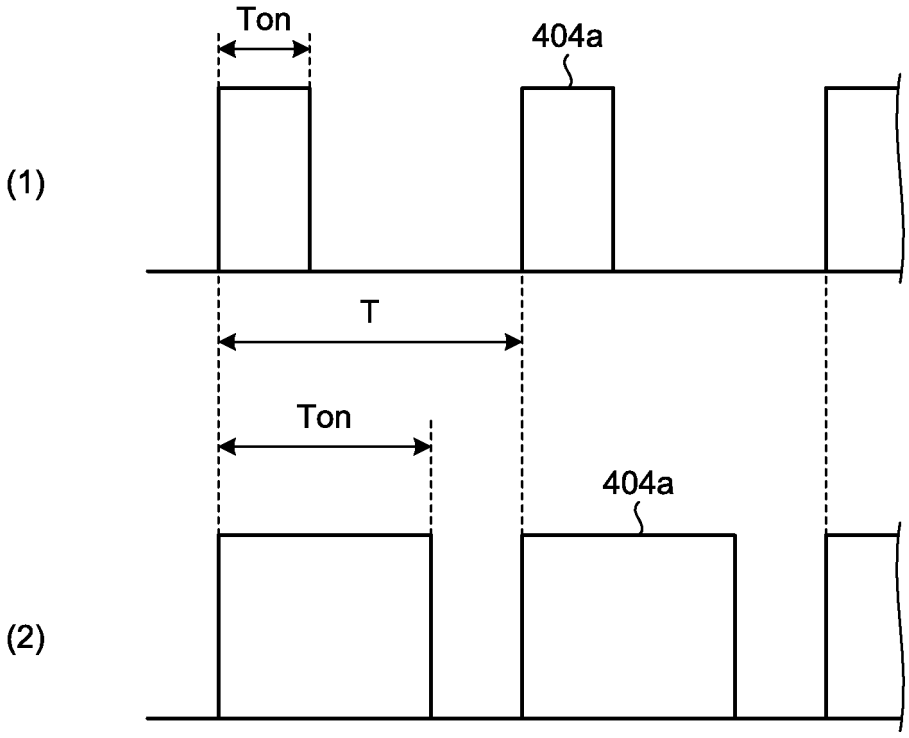
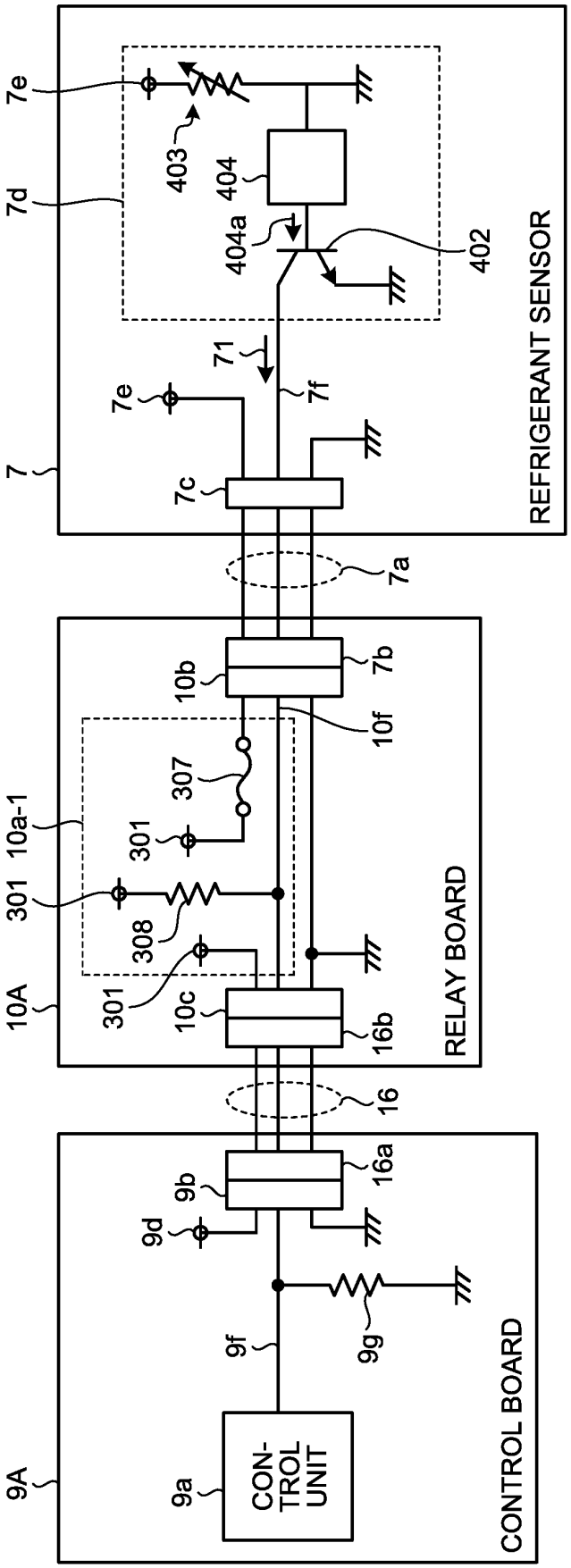


FIG.6


REFRIGERANT SENSOR
RELAY BOARD
CONTROL BOARD
CON-
TROL
UNIT
7
7a
7b
7c
7d
7e
7f
71
402
403
404
404a
10A
10a-1
10b
10c
10f
16
16a
16b
301
307
308
9A
9a
9b
9d
9f
9g

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/064623

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i, *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)
F24F11/02, F25B49/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2014-224612 A (Panasonic Corp.), 04 December 2014 (04.12.2014), paragraphs [0044] to [0059]; fig. 1 to 6 & WO 2013/038704 A1	1-3
Y	JP 2006-23256 A (FIS Inc.), 26 January 2006 (26.01.2006), paragraph [0051] (Family: none)	1-3

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2016 (26.07.16)	02 August 2016 (02.08.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2015094566 A **[0006]**