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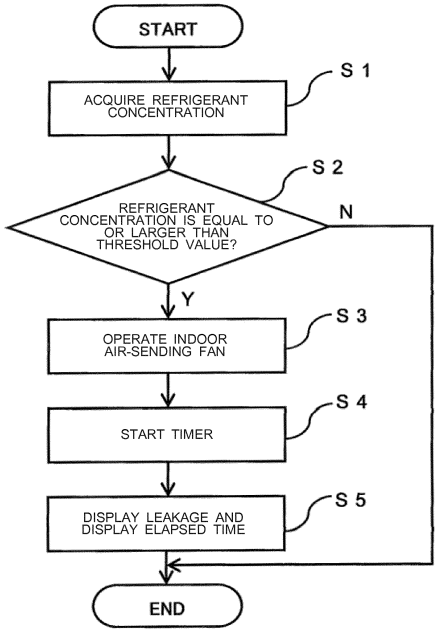
(54) REFRIGERATION CYCLE DEVICE

(57) Provided is a refrigeration cycle apparatus, in which, when refrigerant is detected by a refrigerant detector, an informing unit informs of occurrence of leakage of the refrigerant and countermeasure information for enabling determination of a procedure of coping with the refrigerant leakage.

FIG. 7



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Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus having a refrigerant detection function.

Background Art

[0002] In Patent Literature 1, there is described an air-conditioning apparatus using a flammable refrigerant, which includes a gas sensor provided on an outer surface of an indoor unit and configured to detect a flammable refrigerant gas. The indoor unit is of a floor type, and the gas sensor is provided to a lower part of the indoor unit. When a sensor detection voltage of the gas sensor is equal to or larger than a reference value, a controller of the air-conditioning apparatus determines that the flammable refrigerant has leaked. Thus, an alert is immediately issued by an alarm, and a fan provided inside the indoor unit is rotated. In this manner, a user is informed of the leakage of the flammable refrigerant, and can take measures of, for example, ventilating an indoor space and calling a serviceperson for repair.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 4599699

Summary of Invention

Technical Problem

[0004] An action to be first taken by the serviceperson, who has been informed of the refrigerant leakage and has arrived at a work site, differs depending on presence or absence of the refrigerant in a refrigerant circuit. When the refrigerant remains in refrigerant pipes, the serviceperson is required to deal with the refrigerant leakage by, for example, closing extension pipe connection valves of an outdoor unit so as to prevent further leakage of the refrigerant from a portion of the indoor unit at which the leakage occurs. Meanwhile, when no refrigerant remains in the refrigerant pipes, the serviceperson can start a series of steps of work, specifically, immediately checking the portion at which the leakage occurs and repairing the thus found portion at which the leakage occurs.

[0005] However, the controller of the air-conditioning apparatus disclosed in Patent Literature 1 informs of only the occurrence of leakage of the flammable refrigerant. Therefore, the serviceperson, who starts maintenance of the indoor unit, cannot immediately determine in which of the above-mentioned steps the work is to be started. As a result, there is a problem in that the serviceperson, who has been informed of the leakage of the refrigerant, cannot quickly take an appropriate countermeasure.

[0006] The present invention has been made to solve the problem described above, and has an object to provide a refrigeration cycle apparatus that enables an action be quickly taken after refrigerant leakage has occurred.

Solution to Problem

[0007] According to one embodiment of the present invention, there is provided a refrigeration cycle apparatus, including: an indoor unit including: a load-side heat exchanger forming a refrigeration cycle, through which refrigerant is circulated; a refrigerant detector configured to detect the refrigerant; and an air-sending fan, the indoor unit being installed indoors; a controller configured to control the indoor unit; an informing unit configured to present information about the refrigerant; and a timer configured to measure time, wherein, when the refrigerant is detected by the refrigerant detector, the controller controls the informing unit to present countermeasure information for enabling determination of a procedure of coping with refrigerant leakage and information about the time measured by the timer.

Advantageous Effects of Invention

[0008] According to the refrigeration cycle apparatus of one embodiment of the present invention, when the refrigerant is detected by the refrigerant detector, the countermeasure information for enabling determination of the procedure of coping with the refrigerant leakage is informed of. Therefore, a serviceperson, who copes with the refrigerant leakage, can quickly take an appropriate initial action.

Brief Description of Drawing

[0009]

Fig. 1 is a refrigerant circuit diagram for illustrating a schematic configuration of an air-conditioning apparatus in an embodiment of the present invention.
Fig. 2 is a front view for illustrating an external appearance of an indoor unit of the air-conditioning apparatus in the embodiment of the present invention.
Fig. 3 is a front view for schematically illustrating an internal structure of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention.
Fig. 4 is a side view for schematically illustrating the internal structure of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention.
Fig. 5 is a front view of a remote controller for the indoor unit of the air-conditioning apparatus in the embodiment of the present invention.
Fig. 6 is a control block diagram of the indoor unit of

the air-conditioning apparatus in the embodiment of the present invention.

Fig. 7 is a flowchart for illustrating an example of refrigerant leakage detection processing to be executed by the controller of the air-conditioning apparatus in the embodiment of the present invention.

Fig. 8 is a front view for illustrating the external appearance of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention together with a schematic view of a display device, which is additionally connected to the indoor unit.

Description of Embodiments

[0010] A refrigeration cycle apparatus according to an embodiment of the present invention is described in detail below with reference to the drawings. The present invention is not limited to the embodiment described below.

Embodiment

[0011] An air-conditioning apparatus in an embodiment of the present invention is described. Fig. 1 is a refrigerant circuit diagram for illustrating a schematic configuration of the air-conditioning apparatus in the embodiment of the present invention. In Fig. 1 and the subsequent drawings, a dimensional relationship and a shape of components may be different from actual ones.

[0012] As illustrated in Fig. 1, the air-conditioning apparatus 100 includes a refrigerant circuit 40 configured to circulate refrigerant. The refrigerant circuit 40 includes a compressor 3, a refrigerant flow switching device 4, a heat source-side heat exchanger 5 (for example, outdoor heat exchanger), a pressure reducing device 6, and a load-side heat exchanger 7 (for example, indoor heat exchanger), which are annularly connected through refrigerant pipes in the stated order. Further, the air-conditioning apparatus 100 includes, for example, an outdoor unit 2, which is installed outdoors as a heat source unit. Further, the air-conditioning apparatus 100 includes, for example, an indoor unit 1, which is installed indoors as a load unit. The indoor unit 1 and the outdoor unit 2 are connected to each other through extension pipes 10a and 10b forming parts of the refrigerant pipes.

[0013] Examples of refrigerant to be used as the refrigerant to be circulated in the refrigerant circuit 40 include a slightly flammable refrigerant, for example, HFO-1234yf or HFO-1234ze and a strongly flammable refrigerant, for example, R290 or R1270. Those refrigerants may be each used as a single refrigerant, or may be used as a mixed refrigerant obtained by mixing two or more kinds of the refrigerants with each other. In the following description, the refrigerant having a flammability equal to or higher than a slightly flammable level (for example, 2L or higher in category of ASHRAE34) is sometimes referred to as "flammable refrigerant". Further, as the refrigerant to be circulated in the refrigerant circuit 40, a nonflammable refrigerant, for example, R22 or R410A, having nonflammability (for example, 1 in category of ASHRAE34) can also be used. Those refrigerants have a density larger than that of air under, for example, an atmospheric pressure.

[0014] The compressor 3 is a fluid machine configured to compress a sucked low-pressure refrigerant and to discharge the low-pressure refrigerant as high-pressure refrigerant. The refrigerant flow switching device 4 is configured to switch a flow direction of the refrigerant in the refrigerant circuit 40 during a cooling operation and during a heating operation. As the refrigerant flow switching device 4, for example, a four-way valve is used. The heat source-side heat exchanger 5 is a heat exchanger configured to function as a radiator (for example, condenser) during the cooling operation and to function as an evaporator during the heating operation. In the heat source-side heat exchanger 5, heat is exchanged between the refrigerant circulated through an inside of the heat source-side heat exchanger 5 and outdoor air sent by an outdoor air-sending fan 5f described later. The pressure reducing device 6 is configured to reduce the pressure of the high-pressure refrigerant such that the high-pressure refrigerant becomes the low-pressure refrigerant. As the pressure reducing device 6, for example, an electronic expansion valve having an adjustable opening degree is used. The load-side heat exchanger 7 is a heat exchanger configured to function as an evaporator during the cooling operation and to function as a radiator (for example, condenser) during the heating operation. In the load-side heat exchanger 7, heat is exchanged between the refrigerant circulated through an inside of the load-side heat exchanger 7 and air sent by an indoor air-sending fan 7f described later. In this case, the cooling operation represents an operation of supplying low-temperature and low-pressure refrigerant to the load-side heat exchanger 7, and the heating operation represents an operation of supplying high-temperature and high-pressure refrigerant to the load-side heat exchanger 7.

[0015] The outdoor unit 2 accommodates the compressor 3, the refrigerant flow switching device 4, the heat source-side heat exchanger 5, and the pressure reducing device 6. Further, the outdoor unit 2 accommodates the outdoor air-sending fan 5f configured to supply outdoor air to the heat source-side heat exchanger 5. The outdoor air-sending fan 5f is installed so as to be opposed to the heat source-side heat exchanger 5. When the outdoor air-sending fan 5f is rotated, an airflow passing through the heat source-side heat exchanger 5 is generated. As the outdoor air-sending fan 5f, for example, a propeller fan is used. The outdoor air-sending fan 5f is arranged, for example, on downstream of the heat source-side heat exchanger 5 along the airflow generated by the outdoor air-sending fan 5f.

[0016] The refrigerant pipes arranged in the outdoor unit 2 include a refrigerant pipe configured to connect between an extension pipe connection valve 13a on the gas side during the cooling operation and the refrigerant

flow switching device 4, a suction pipe 11 connected to a suction side of the compressor 3, a discharge pipe 12 connected to a discharge side of the compressor 3, a refrigerant pipe configured to connect between the refrigerant flow switching device 4 and the heat source-side heat exchanger 5, a refrigerant pipe configured to connect between the heat source-side heat exchanger 5 and the pressure reducing device 6, and a refrigerant pipe configured to connect between an extension pipe connection valve 13b on the liquid side during the cooling operation and the pressure reducing device 6. The extension pipe connection valve 13a is formed of a two-way valve capable of switching between open and close, and has one end to which a flare joint is mounted. Further, the extension pipe connection valve 13b is formed of a three-way valve capable of switching between open and close. The extension pipe connection valve 13b has one end to which a service port 14a is mounted, which is used at a time of vacuuming being a preliminary work of filling the refrigerant circuit 40 with refrigerant, and an other end to which a flare joint is mounted.

[0017] During both the cooling operation and the heating operation, high-temperature and high-pressure gas refrigerant compressed by the compressor 3 flows through the discharge pipe 12. During both the cooling operation and the heating operation, low-temperature and low-pressure gas refrigerant or two-phase refrigerant subjected to an evaporation action flows through the suction pipe 11. The suction pipe 11 is connected to a low-pressure-side service port 14b with a flare joint, and the discharge pipe 12 is connected to a high-pressure-side service port 14c with a flare joint. The service ports 14b and 14c are used to connect a pressure gauge to measure the operating pressure at a time of installation of the air-conditioning apparatus 100 or at a time of a trial run for a repair.

[0018] The indoor unit 1 accommodates the load-side heat exchanger 7. Further, the indoor air-sending fan 7f configured to supply air to the load-side heat exchanger 7 is installed in the indoor unit 1. When the indoor air-sending fan 7f is rotated, an airflow passing through the load-side heat exchanger 7 is generated. As the indoor air-sending fan 7f, a centrifugal fan (for example, sirocco fan or turbofan), a cross flow fan, a mixed flow fan, an axial-flow fan (for example, propeller fan), or an other fan is used depending on a shape of the indoor unit 1. The indoor air-sending fan 7f in this embodiment is arranged on upstream of the load-side heat exchanger 7 along the airflow generated by the indoor air-sending fan 7f, but may be arranged on downstream of the load-side heat exchanger 7.

[0019] Of the refrigerant pipes of the indoor unit 1, a gas-side indoor pipe 9a is provided, in a connection portion to the gas-side extension pipe 10a, with a joint portion 15a (for example, flare joint) for connection to the extension pipe 10a. Further, of the refrigerant pipes of the indoor unit 1, a liquid-side indoor pipe 9b is provided, in a connection portion to the liquid-side extension pipe 10b, with a joint portion 15b (for example, flare joint) for connection to the extension pipe 10b.

[0020] Further, the indoor unit 1 includes, for example, a suction air temperature sensor 91 configured to detect a temperature of indoor air sucked from the indoors, a heat exchanger entrance temperature sensor 92 configured to detect a refrigerant temperature at an entrance portion of the load-side heat exchanger 7 during the cooling operation (exit portion during the heating operation), and a heat exchanger temperature sensor 93 configured to detect a refrigerant temperature (evaporating temperature or condensing temperature) of a two-phase portion of the load-side heat exchanger 7. In addition, the indoor unit 1 includes a refrigerant detector 99 (for example, a semiconductor gas sensor) described later. Those sensors are configured to output a detection signal to a controller 30 configured to control an entirety of the indoor unit 1 or the air-conditioning apparatus 100.

[0021] The controller 30 includes a microcomputer including, for example, a central processing unit (CPU), a read only memory (ROM), a random access memory (RAM), and an input/output (I/O) port. The controller 30 is capable of performing data communications to/from an operation unit of a remote controller described later. The operation unit is configured to receive an operation performed by a user and output an operation signal based on the operation to the controller 30. The controller 30 in this embodiment is configured to control the operation of the entirety of the indoor unit 1 or the air-conditioning apparatus 100 including an operation of the indoor air-sending fan 7f based on an operation signal received from the operation unit, the detection signal received from the sensors, or other signals. Further, the controller 30 in this embodiment is capable of switching between energization and deenergization of the refrigerant detector 99. The controller 30 may be provided inside a casing of the indoor unit 1, or may be provided inside a casing of the outdoor unit 2. Further, the controller 30 may include an outdoor unit controller provided to the outdoor unit 2 and an indoor unit controller provided to the indoor unit 1 and capable of performing data communications to/from the outdoor unit controller.

[0022] Next, description is made of the operation of the refrigerant circuit 40 of the air-conditioning apparatus 100. First, the operation during the cooling operation is described. In Fig. 1, the solid arrows indicate flow directions of the refrigerant during the cooling operation. The refrigerant circuit 40 is configured so that, during the cooling operation, a refrigerant flow passage is switched by the refrigerant flow switching device 4 as indicated by the solid line, and the low-temperature and low-pressure refrigerant flows into the load-side heat exchanger 7.

[0023] The high-temperature and high-pressure gas refrigerant discharged from the compressor 3 first flows into the heat source-side heat exchanger 5 after passing through the refrigerant flow switching device 4. During the cooling operation, the heat source-side heat exchanger 5 functions as a condenser. That is, in the heat

source-side heat exchanger 5, heat is exchanged between the refrigerant circulated through the inside and the outdoor air sent by the outdoor air-sending fan 5f, and heat of condensation of the refrigerant is transferred to the outdoor air. With this operation, the refrigerant that has flowed into the heat source-side heat exchanger 5 is condensed to become high-pressure liquid refrigerant. The high-pressure liquid refrigerant flows into the pressure reducing device 6, and is reduced in pressure to become low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant passes through the extension pipe 10b, and flows into the load-side heat exchanger 7 of the indoor unit 1. During the cooling operation, the load-side heat exchanger 7 functions as an evaporator. That is, in the load-side heat exchanger 7, heat is exchanged between the refrigerant circulated through the inside and the air (for example, indoor air) sent by the indoor air-sending fan 7f, and heat of evaporation of the refrigerant is received from the sent air. With this operation, the refrigerant that has flowed into the load-side heat exchanger 7 evaporates to become low-pressure gas refrigerant or two-phase refrigerant. Further, the air sent by the indoor air-sending fan 7f is cooled by a heat receiving action of the refrigerant. The low-pressure gas refrigerant or two-phase refrigerant evaporated by the load-side heat exchanger 7 passes through the extension pipe 10a and the refrigerant flow switching device 4, and is sucked by the compressor 3. The refrigerant sucked by the compressor 3 is compressed to become the high-temperature and high-pressure gas refrigerant. During the cooling operation, the above-mentioned cycle is repeated.

[0024] Next, the operation during the heating operation is described. In Fig. 1, the dotted arrows indicate flow directions of the refrigerant during the heating operation. The refrigerant circuit 40 is configured so that, during the heating operation, the refrigerant flow passage is switched by the refrigerant flow switching device 4 as indicated by the dotted line, and the high-temperature and high-pressure refrigerant flows into the load-side heat exchanger 7. During the heating operation, the refrigerant flows in a direction reverse to that of the refrigerant flow during the cooling operation, and the load-side heat exchanger 7 functions as a condenser. That is, in the load-side heat exchanger 7, heat is exchanged between the refrigerant circulated through the inside and the air sent by the indoor air-sending fan 7f, and the heat of condensation of the refrigerant is transferred to the sent air. With this operation, the air sent by the indoor air-sending fan 7f is heated by a heat transferring action of the refrigerant.

[0025] Fig. 2 is a front view for illustrating a configuration of an outer appearance of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention. Fig. 3 is a front view for schematically illustrating an internal structure of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention. Fig. 4 is a side view for schematically illustrating the internal structure of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention. The left side of Fig. 4 indicates a front surface side (that is, indoor space side) of the indoor unit 1. In this embodiment, as the indoor unit 1, the indoor unit 1 of a floor type, which is installed on a floor surface of an indoor space being an air-conditioned space, is described as an example. In the following description, positional relationships (for example, top-bottom relationship) of components are, in principle, exhibited when the indoor unit 1 is installed in a usable state.

[0026] As illustrated in Fig. 2 to Fig. 4, the indoor unit 1 includes a casing 111 having a vertically elongated rectangular parallelepiped shape. An air inlet 112 configured to suck air inside the indoor space is formed in a lower portion of a front surface of the casing 111. The air inlet 112 in this embodiment is provided at a position close to the floor surface below a center portion of the casing 111 along a vertical direction thereof. An air outlet 113 configured to blow off the air sucked from the air inlet 112 indoors is formed in the upper portion of the front surface of the casing 111, that is, at a position higher than the air inlet 112 (for example, above the center portion of the casing 111 along the vertical direction).

[0027] The casing 111 is a hollow box body, and a front opening part is formed in a front surface of the casing 111. The casing 111 includes a first front panel 114a, a second front panel 114b, and a third front panel 114c, which are removably mounted to the front opening part. The first front panel 114a, the second front panel 114b, and the third front panel 114c all have a substantially rectangular flat outer shape. The first front panel 114a is removably mounted to a lower part of the front opening part of the casing 111. In the first front panel 114a, the air inlet 112 described above is formed. The second front panel 114b is arranged immediately above the first front panel 114a, and is removably mounted to a center part of the front opening part of the casing 111 along the vertical direction. In the second front panel 114b, the operation unit described above is provided. The third front panel 114c is arranged immediately above the second front panel 114b, and is removably mounted to an upper part of the front opening part of the casing 111. In the third front panel 114c, the air outlet 113 described above is formed.

[0028] An internal space of the casing 111 is roughly divided into a space 115a being an air-sending part and a space 115b being a heat-exchanging part, which is located above the space 115a. The space 115a and the space 115b are partitioned by a partition portion 20. The partition portion 20 has, for example, a flat shape, and is arranged approximately horizontally. In the partition portion 20, at least an air passage opening part 20a is formed to serve as an air passage between the space 115a and the space 115b. The space 115a is defined to be exposed to the front surface side when the first front panel 114a is removed from the casing 111, and the space 115b is defined to be exposed to the front surface side when the

second front panel 114b and the third front panel 114c are removed from the casing 111. That is, the partition portion 20 is mounted at approximately the same height as a height of an upper edge of the first front panel 114a or a lower edge of the second front panel 114b. In this case, the partition portion 20 may be formed integrally with a fan casing 108 described later, may be formed integrally with a drain pan described later, or may be formed separately from the fan casing 108 or the drain pan.

[0029] In the space 115a, there is arranged the indoor air-sending fan 7f, which is configured to cause a flow of air from the air inlet 112 to the air outlet 113 in the air passage 81 of the casing 111. The indoor air-sending fan 7f in this embodiment is a sirocco fan including a motor (not shown) and an impeller 107. The impeller 107 is connected to an output shaft of the motor, and has a plurality of blades arranged, for example, at regular intervals along a circumferential direction of the impeller 107. A rotary shaft of the impeller 107 is arranged substantially in parallel with a depth direction of the casing 111. A rotation speed of the indoor air-sending fan 7f is set at multiple levels (for example, two or more levels) or set to be continuously variable by control of the controller 30 based on a preset air volume set by the user or other information.

[0030] The impeller 107 of the indoor air-sending fan 7f is covered with the fan casing 108 having a spiral shape. The fan casing 108 is formed, for example, separately from the casing 111. A suction opening part 108b for sucking the indoor air through the air inlet 112 into the fan casing 108 is formed near the center of a spiral of the fan casing 108. The suction opening part 108b is located so as to be opposed to the air inlet 112. Further, an air outlet opening part 108a for blowing off the sent air is formed along a direction of a tangential line of the spiral of the fan casing 108. The air outlet opening part 108a is arranged so as to be oriented upward, and is connected to the space 115b through the air passage opening part 20a of the partition portion 20. In other words, the air outlet opening part 108a communicates to the space 115b through the air passage opening part 20a. An opening end of the air outlet opening part 108a and an opening end of the air passage opening part 20a may be directly connected to each other, or may be indirectly connected to each other through a duct member or other members.

[0031] Further, in the space 115a, there is provided an electrical component box 25 accommodating, for example, a microcomputer included in the controller 30, various electrical components, and a board.

[0032] The load-side heat exchanger 7 is arranged in the air passage 81 within the space 115b. The drain pan (not shown) configured to receive condensed water that is condensed on a surface of the load-side heat exchanger 7 is provided below the load-side heat exchanger 7. The drain pan may be formed as a part of the partition portion 20, or may be formed separately from the partition portion 20 and arranged on the partition portion 20.

[0033] The refrigerant detector 99 is provided at a position near and below the space 115a. As the refrigerant detector 99, an energization-type refrigerant detector including an energization-type gas sensor such as a semiconductor gas sensor or a hot-wire type semiconductor gas sensor is used. The refrigerant detector 99 is configured to detect, for example, a refrigerant concentration in the air around the refrigerant detector 99 to output a detection signal to the controller 30. The controller 30 executes processing for the leakage of the refrigerant based on the detection signal received from the refrigerant detector 99.

[0034] In the indoor unit 1, leakage of refrigerant is liable to occur at a brazed portion of the load-side heat exchanger 7 and at the joint portions 15a and 15b. Further, the refrigerant used in this embodiment has a density larger than that of the air under the atmospheric pressure. Therefore, the refrigerant detector 99 in this embodiment is provided at a position lower in height than the load-side heat exchanger 7 and the joint portions 15a and 15b within the casing 111. With this arrangement, the refrigerant detector 99 can reliably detect the leaked refrigerant at least when the indoor air-sending fan 7f is stopped. In this embodiment, the refrigerant detector 99 is provided at the position below the space 115a, but an arrangement position of the refrigerant detector 99 may be another position.

[0035] As illustrated in Fig. 2, a remote controller 26 is provided on the front surface of the casing 111 above the air inlet 112 and below the air outlet 113. Specifically, the remote controller 26 is provided on a design surface of the casing 111. Fig. 5 is a front view of the remote controller for the indoor unit of the air-conditioning apparatus in the embodiment of the present invention. The remote controller 26 includes a display unit 26a and an operation unit 26b. When the user operates the operation unit 26b of the remote controller 26, an operation for starting the operation of the air-conditioning apparatus 100 and an operation for ending the operation of the air-conditioning apparatus 100, switching of an operation mode, setting of a set temperature and set air volume of the air-conditioning apparatus, and other operations are performed.

[0036] The display unit 26a of the remote controller 26 includes a state display region 261, an abnormality code display region 262, a current time display region 263, and a countermeasure information display region 264, on which information for enabling determination of a procedure of coping with the refrigerant leakage is to be displayed. When the controller 30 determines that the refrigerant is leaking, a character string indicating the refrigerant leakage is displayed on the state display region 261. In Fig. 5, a state in which characters "REFRIGERANT LEAKAGE" are displayed is illustrated as an example. When an abnormality occurs in the air-conditioning apparatus 100, a code that is specified in advance to correspond to details of the abnormality is displayed on

the abnormality code display region 262. In Fig. 5, a double-digit code is displayed as an example of the code. The code is found in, for example, a manual to be used by a serviceperson who is responsible for maintenance and repair of the air-conditioning apparatus 100. The serviceperson checks the code displayed on the abnormality code display region 262 in the manual to verify what kind of abnormality has occurred in the air-conditioning apparatus 100, to thereby determine how to cope with the abnormality. For example, under a situation in which the character string indicating the refrigerant leakage is displayed on the abnormality display region 261, a code indicating the refrigerant leakage is displayed on the abnormality code display region 262. Specifically, the information having the same content is displayed on the state display region 261 and the abnormality code display region 262.

[0037] Fig. 6 is a control block diagram of the indoor unit of the air-conditioning apparatus in the embodiment of the present invention. Information corresponding to the details of the operation on the operation unit 26b of the remote controller 26, which is performed by the user, and a result of detection by the refrigerant detector 99 are input to the controller 30. Control signals for controlling the display unit 26a of the remote controller 26 and the indoor air-sending fan 7f are output from the controller 30. An elapsed time measured by a timer 101 is input to the controller 30. The elapsed time is displayed on the countermeasure information display region 264 of the display unit 26a of the remote controller 26 by control of the controller 30. The timer 101 may be built into the controller 30 or into the remote controller 26.

[0038] Fig. 7 is a flowchart for illustrating an example of refrigerant leakage detection processing to be executed by the controller 30 of the air-conditioning apparatus 100 in the embodiment of the present invention. The refrigerant leakage detection processing is repeatedly executed at predetermined time intervals in a constant manner regardless of whether the air-conditioning apparatus 100 is in operation or stopped or only when the air-conditioning apparatus 100 is stopped.

[0039] In Step S1 of Fig. 7, the controller 30 acquires information on the refrigerant concentration around the refrigerant detector 99 based on the detection signal output from the refrigerant detector 99. Next, in Step S2, the controller 30 checks whether the refrigerant concentration around the refrigerant detector 99 is equal to or larger than a preset threshold value. After it is verified that the refrigerant concentration around the refrigerant detector 99 is equal to or larger than the threshold value, the processing proceeds to Step S3. For example, when the refrigerant enclosed in the refrigerant circuit 40 is flammable, the threshold value is set to, for example, one-fourth of a lower flammable limit (LFL).

[0040] Therefore, when the refrigerant concentration around the refrigerant detector 99 is equal to or larger than the threshold value, it is determined that the refrigerant is leaking from a brazed portion of the load-side heat exchanger 7 or the joint portions 15a and 15b. In Step S3, when the indoor air-sending fan 7f is stopped, the controller 30 starts the operation of the indoor air-sending fan 7f. When the indoor air-sending fan 7f is already in operation, the operation is continued. That is, the controller 30 forcedly brings the indoor air-sending fan 7f into the operation state so as to prevent an air concentration from becoming unsuitable for a working environment due to the leakage of the refrigerant. Further, when the leaking refrigerant is a flammable refrigerant, the controller 30 forcedly brings the indoor air-sending fan 7f into the operation state so as to prevent the refrigerant concentration from reaching a flammable concentration region.

[0041] Next, the processing proceeds to Step S4, and the controller 30 starts the timer 101 to start the measurement of the elapsed time. The order of Step S3 and Step S4 is interchangeable. Specifically, the controller 30 may start the operation of the indoor air-sending fan 7f after starting the timer 101 to start the measurement of the elapsed time. Then, in Step S5, the controller 30 displays the character string for informing of the leakage of the refrigerant on the state display region 261 of the display unit 26a of the remote controller 26. Further, the controller 30 displays the abnormality code indicating the refrigerant leakage on the abnormality code display region 262. Further, the controller 30 displays the elapsed time acquired from the timer 101 on the countermeasure information display region 264.

[0042] Meanwhile, in Step S2, when the refrigerant concentration around the refrigerant detector 99 has not reached the threshold value, it is determined that the refrigerant is not leaking. In this case, the processing is terminated without executing Step S3 to Step S5 described above.

[0043] As described above, according to this embodiment, when the refrigerant is leaking, on the display unit 26a of the remote controller 26, the character string indicating that the refrigerant is leaking is displayed on the state display region 261, the code indicating the condition of the leakage is displayed on the abnormality code display region 262, and the elapsed time from the start of the operation of the indoor air-sending fan 7f after the detection of the leakage of the refrigerant is displayed on the countermeasure information display region 264. That is, in addition to the information indicating that the refrigerant is leaking, the elapsed time from the start of the operation state of the indoor air-sending fan 7f after the detection of the leakage of the refrigerant is provided to the user. Therefore, when the user, who has checked the display of the character string indicating the refrigerant leakage on the state display region 261, informs the serviceperson of the code displayed on the abnormality code display region 262 and the elapsed time displayed on the countermeasure information display region 264 in advance, the serviceperson can precisely determine a condition of the refrigerant leakage in the air-conditioning apparatus 100. Information to be used for determination

of the details indicated by the abnormality code and the condition of the refrigerant leakage are found in the manual to be used by the serviceperson. For example, a time T from a time point at which the refrigerant starts leaking from the brazed portion of the load-side heat exchanger 7, the joint portions 15a and 15b, or other portions to a time point at which all the refrigerant enclosed in the refrigerant circuit 40 finishes leaking can be calculated by: T=m/v, where m represents an amount (kg) of the refrigerant enclosed in the refrigerant circuit 40 and v represents a predicted leakage speed (kg/h) of the refrigerant. The above-mentioned refrigerant amount m, predicted leakage speed v, and time T, and other parameters are also found in the manual for the serviceperson. Further, even when the serviceperson is informed by the user only of the leakage of the refrigerant, the serviceperson, who has arrived at the work site, can precisely determine the condition of the refrigerant leakage in the air-conditioning apparatus 100 by checking the above-mentioned information displayed on each of the display regions of the display unit 26a and the manual to be used by the serviceperson. As a result, the serviceperson can quickly make an appropriate initial response at the time of refrigerant leakage.

[0044] When the elapsed time is not equal to or larger than the above-mentioned time T, an elapsed time shorter than the time T is displayed on the countermeasure information display region 264. The serviceperson, who has obtained the information on the elapsed time from the user, can understand that the refrigerant remains and the flammable concentration region may be formed as a result of subsequently continued leakage when the refrigerant is flammable. Therefore, the serviceperson can determine that the serviceperson is required to instruct the user to ventilate the indoor space. Further, even when the serviceperson arrives at the work site without obtaining the above-mentioned information in advance, the serviceperson understands that it is required to immediately ventilate the indoor space due to the possibility that the refrigerant may remain and to close the extension pipe connection valves 13a and 13b of the outdoor unit 2 to prevent further leakage, for example. Therefore, an inappropriate action, for example, turning off a breaker to stop the operation of the indoor air-sending fan 7f even though the refrigerant remains and continues leaking, can be prevented.

[0045] When the elapsed time is equal to or longer than the above-mentioned time T, the character string indicating that the refrigerant is leaking is displayed on the state display region 261 and the elapsed time equal to or larger than the time T is displayed on the countermeasure information display region 264. The serviceperson, who has obtained the information described above, can make the following determination. Specifically, a full amount of the refrigerant having been enclosed in the refrigerant circuit 40 has been released, and therefore the refrigerant does not leak any more. Thus, in a case where the leaking refrigerant is flammable, even when the indoor air-sending fan 7f is stopped, the flammable concentration region is not formed. Therefore, the serviceperson turns off the breaker to stop the operation of the indoor air-sending fan 7f so as to start checking the portion at which the leakage occurs without complicated work, for example, closing the extension pipe connection valves 13a and 13b for prevention of further leakage.

[0046] In this embodiment, the remote controller 26 including the display unit 26a configured to present the information about the refrigerant leakage is provided on the design surface of the casing 111. Therefore, the user and the serviceperson can easily visibly check and acquire the information about the refrigerant leakage.

[0047] In this embodiment, the indoor unit 1 may include a battery. When the breaker is turned off to stop supply of a commercial power supply, the indoor air-sending fan 7f is stopped. When the indoor unit 1 includes the battery, however, the operation of the indoor air-sending fan 7f, the measurement of the elapsed time by the timer 101, and the display of the information about the refrigerant leakage on the display unit 26a can be continued with supply of power from the battery of the indoor unit 1 even after the supply of commercial power is stopped.

[0048] In this embodiment, the timer 101 is started after the leakage of the refrigerant is detected and the operation of the indoor air-sending fan 7f is started. However, the order of the operation of the timer 101 is not limited thereto. The control may be performed so that the timer 101 is first started based on the detection of the leakage of the refrigerant and the operation of the indoor air-sending fan 7f is then started.

[0049] Further, the indoor air-sending fan 7f, which is started to operate in Step S3 of Fig. 7, may be stopped after elapse of preset predetermined time. For example, a length of the predetermined time may be set so that the released refrigerant is prevented from being diffused by the indoor air-sending fan 7f so as not to form a flammable concentration. Through the control described above, the action of stopping the indoor air-sending fan 7f to be taken by the serviceperson can be omitted, and hence a burden of the serviceperson is reduced.

[0050] Although the elapsed time measured by the timer 101 is displayed on the countermeasure information display region 264 of the display unit 26a of the remote controller 26 in this embodiment, time to be displayed on the countermeasure information display region 264 is not limited thereto. For example, a remaining time to a preset predetermined time at which the refrigerant is entirely released, a remaining time to a preset predetermined time at which the above-mentioned indoor air-sending fan 7f is stopped, and other kinds of time may be displayed.

[0051] Although the information about the refrigerant leakage and the information that allows the serviceperson to determine the procedure of coping with the refrigerant leakage are displayed on the display unit 26a of the remote controller 26 in this embodiment, a portion on

which the above-mentioned information is to be displayed is not limited to the display unit 26a. The above-mentioned information may be displayed on a display device, a display, or other devices, which are to be additionally connected to the air-conditioning apparatus 100.

[0052] The display device to be additionally connected may be, for example, a centralized-management type system controller or personal computer, which can collectively manage a plurality of air-conditioning apparatus. Further, as illustrated in Fig. 8, the display device to be additionally connected may be a segment display 301, which is connected to the air-conditioning apparatus 100 by the serviceperson at the time of inspection to allow the operation state to be checked. The above-mentioned system controller, personal computer, and segment display may be wirelessly connectable.

[0053] Further, although the information about the refrigerant leakage and the information that allows the serviceperson to determine the procedure of coping with the refrigerant leakage are informed of as character display in this embodiment, a method of informing of the above-mentioned information is not limited to the character display. The above-mentioned information may be informed of by lighting and flashing of a lamp or may be informed of with voice.

[0054] Although the indoor unit 1 of the air-conditioning apparatus 100 has been described as an example in this embodiment, the location at which the display unit 26a is provided is not limited to the indoor unit 1. The above-mentioned display unit 26a may be provided to the outdoor unit 2. Further, although the air-conditioning apparatus 100 has been described as an example in this embodiment, the present invention is not limited to the air-conditioning apparatus 100. Other refrigeration cycle apparatus and refrigeration cycle systems such as a heat pump water heater, a chiller, and a showcase may be configured as described above so as to display the information about the refrigerant leakage.

Reference Signs List

[0055] 1 indoor unit 2 outdoor unit 3 compressor 4 refrigerant flow switching device 5 heat source-side heat exchanger 5f outdoor air-sending fan 6 pressure reducing device 7 load-side heat exchanger 7f indoor air-sending fan 9a, 9b indoor pipe 10a, 10b extension pipe 11 suction pipe 12 discharge pipe 13a, 13b extension pipe connecting valve 14a, 14b, 14c service port 15a, 15b joint portion 20 partition portion 20a air passage opening part 25 electrical component box 26 remote controller 26a display unit 26b operation unit 30 controller 40 refrigerant circuit 81 air passage 91 suction air temperature sensor 92 heat exchanger entrance temperature sensor 93 heat exchanger temperature sensor 99 refrigerant detector100 air-conditioning apparatus 101 timer 107 impeller 108 fan casing 108a air outlet opening part 108b suction opening part 111 casing 112 air inlet 113 air outlet 114a first front panel 114b second front panel 114c third front panel 115a, 115b space 261 state display region262 abnormality code display region 263 current time display region 264 countermeasure information display region 301 segment display

Claims

1. A refrigeration cycle apparatus, comprising:

   an indoor unit including:

   a load-side heat exchanger forming a refrigeration cycle, through which refrigerant is circulated;
   a refrigerant detector configured to detect the refrigerant; and
   an air-sending fan,
   the indoor unit being installed indoors;

   a controller configured to control the indoor unit;
   an informing unit configured to present information about the refrigerant; and
   a timer configured to measure time,
   wherein the controller is configured to, when the refrigerant is detected by the refrigerant detector, control the informing unit to present countermeasure information for enabling determination of a procedure of coping with refrigerant leakage.

2. The refrigeration cycle apparatus of claim 1, wherein the controller is configured to, when the refrigerant is detected by the refrigerant detector, first bring the air-sending fan into an operation state and then start the timer.

3. The refrigeration cycle apparatus of claim 1, wherein the controller is configured to, when the refrigerant is detected by the refrigerant detector, first start the timer and then bring the air-sending fan into an operation state.

4. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein the controller is configured to control the informing unit to present information representing occurrence of the refrigerant leakage.

5. The refrigeration cycle apparatus of any one of claims 1 to 4, wherein the controller is configured to, when the refrigerant is detected by the refrigerant detector, bring the air-sending fan into an operation state.

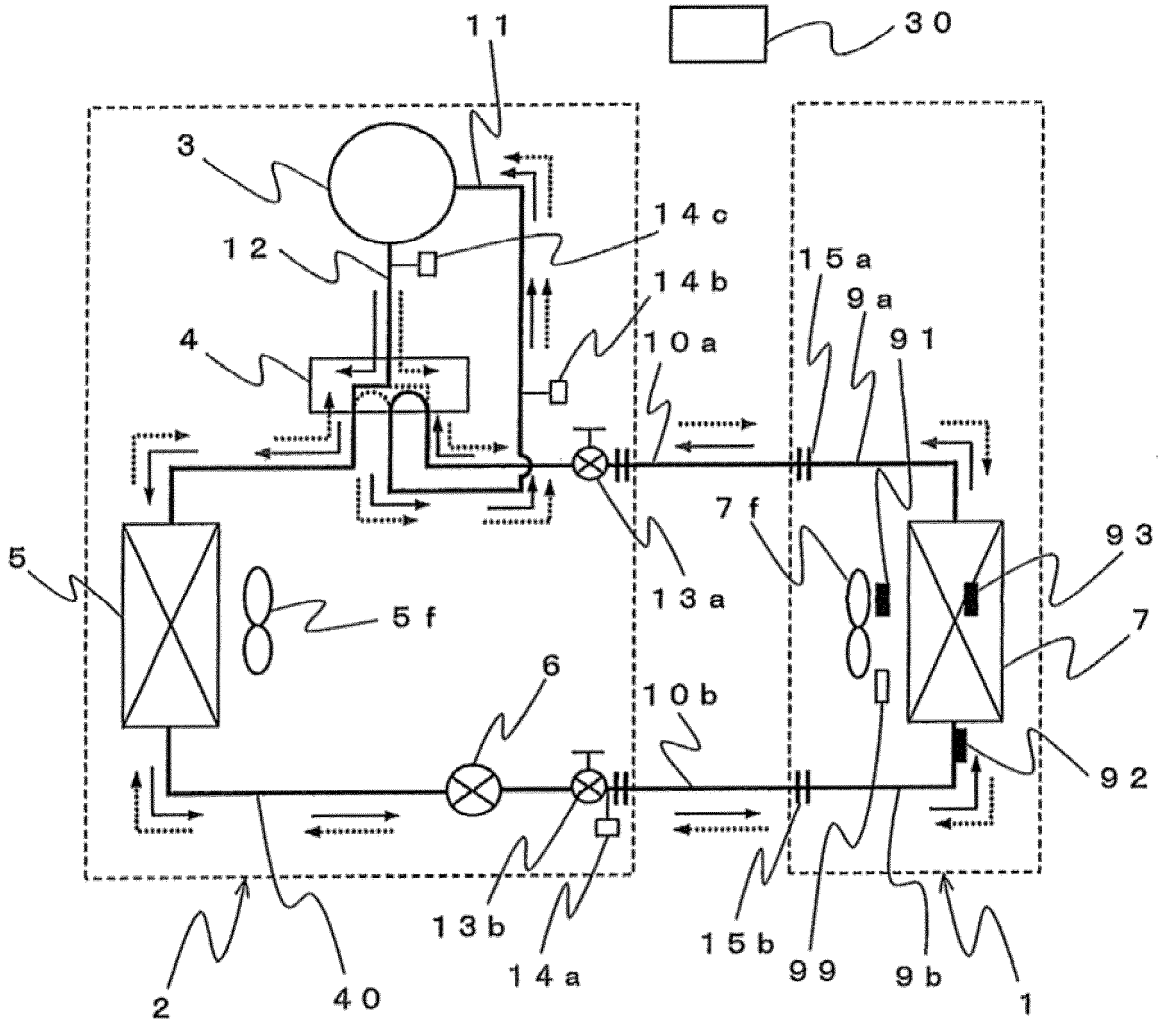
6. The refrigeration cycle apparatus of any one of claims 1 to 5, wherein the informing unit is provided on a design surface of a casing of the indoor unit.

7. The refrigeration cycle apparatus of any one of claims 1 to 6, wherein the informing unit includes a display device to be additionally connected to the indoor unit.

8. The refrigeration cycle apparatus of any one of claims 1 to 7, wherein the indoor unit includes a battery.

9. The refrigeration cycle apparatus of any one of claims 1 to 8, wherein the controller is configured to, when a preset time elapses after the refrigerant is detected by the refrigerant detector, stop the air-sending fan.

FIG. 1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14c
12
15a
14b
9a
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7f
93
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14a
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9b
2
40
1
100

FIG. 2

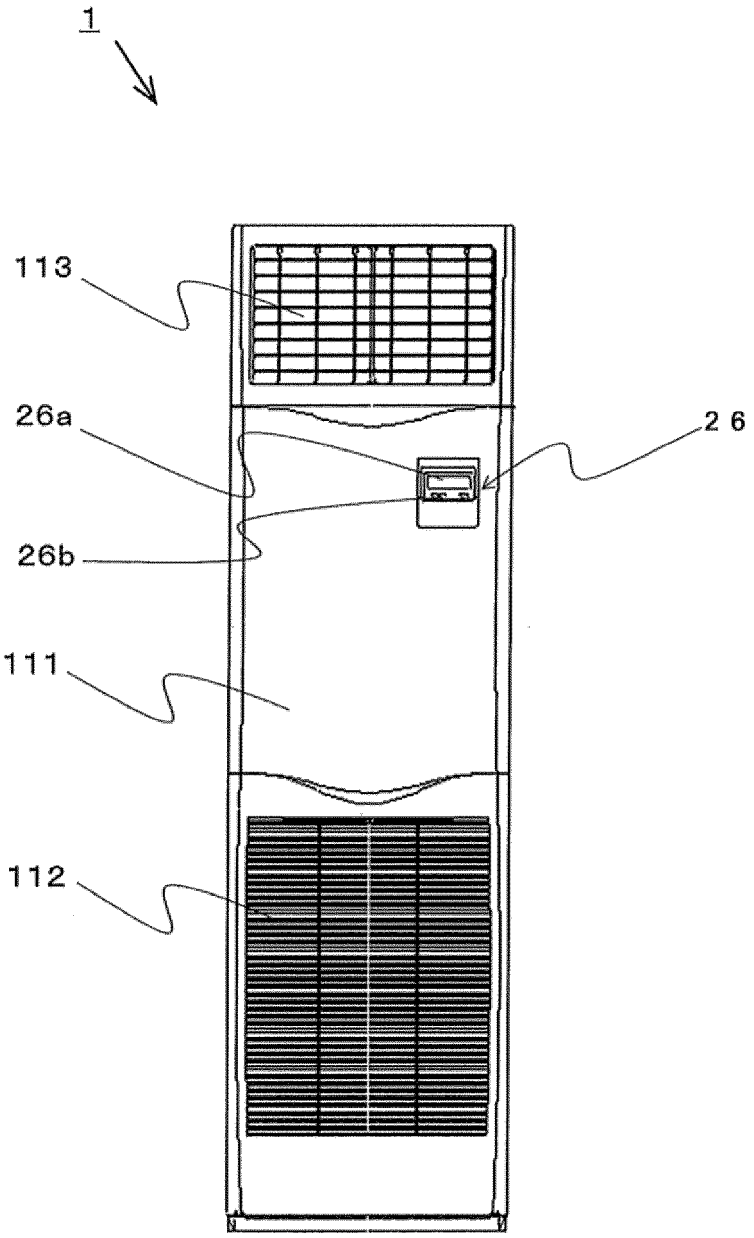
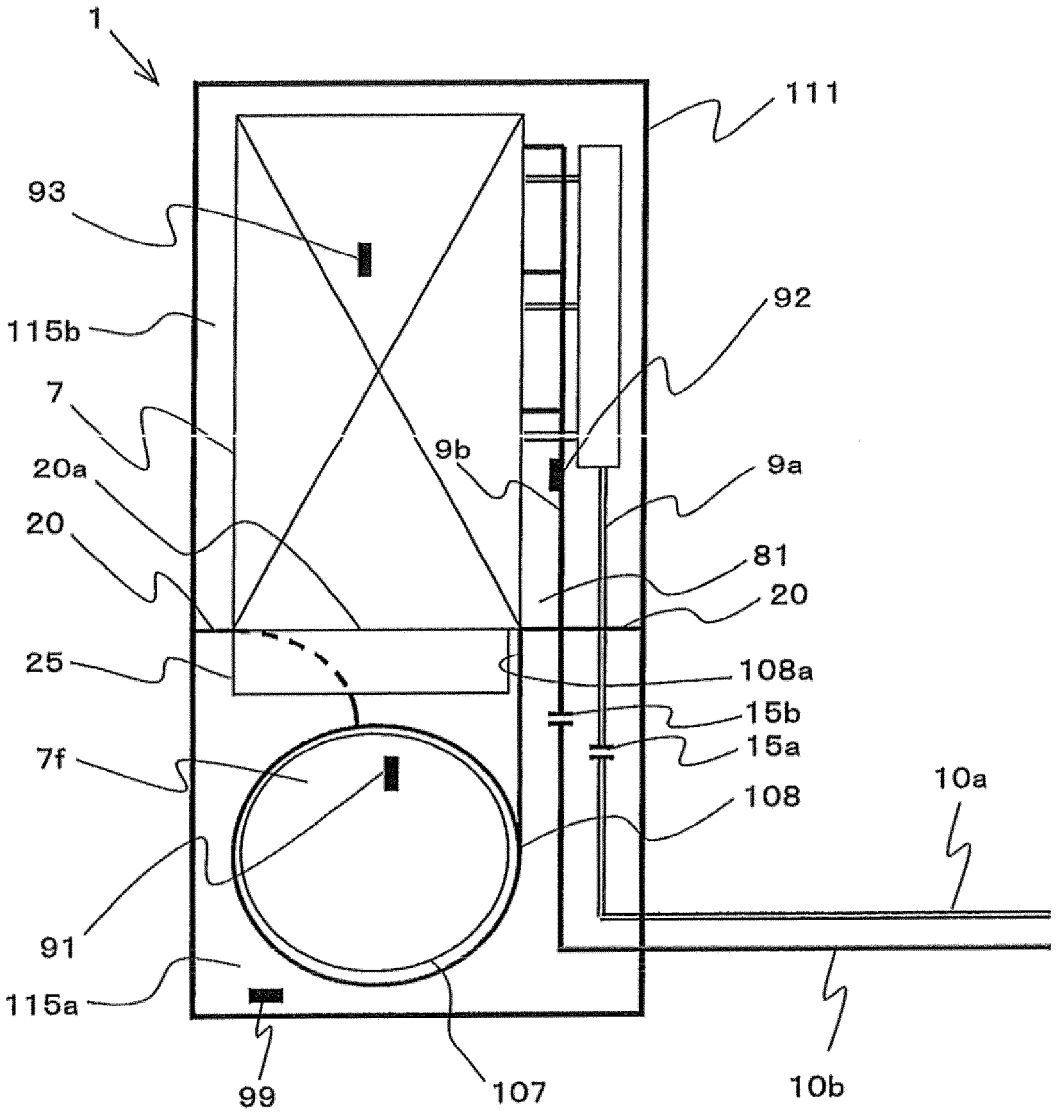


FIG. 3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115a
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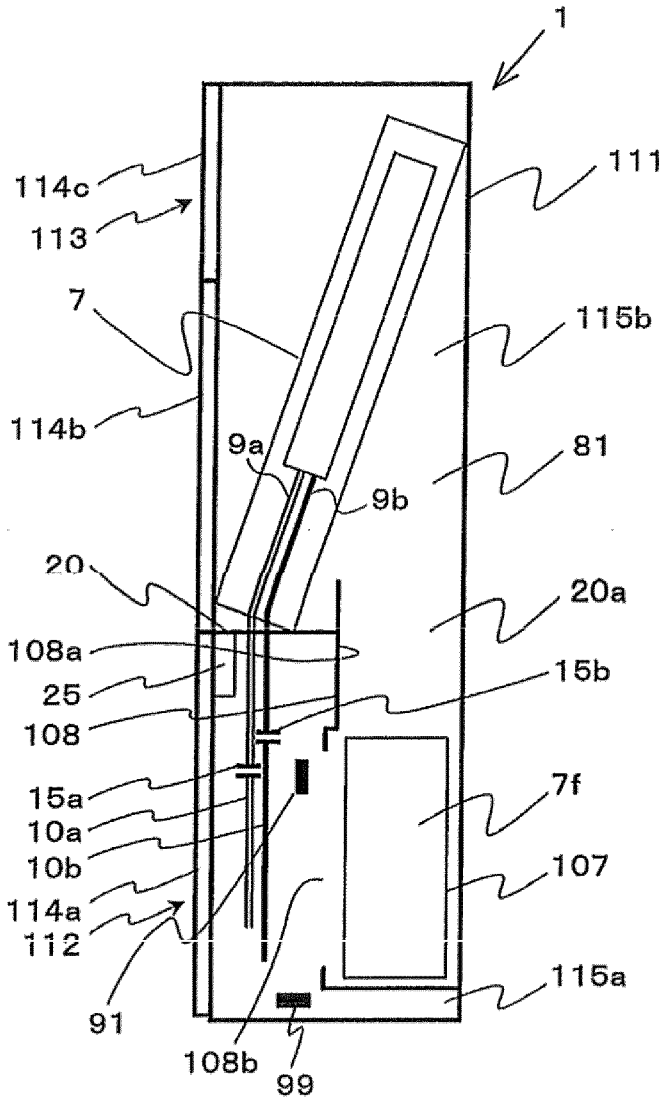
107
10b

FIG. 4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108b
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FIG. 5

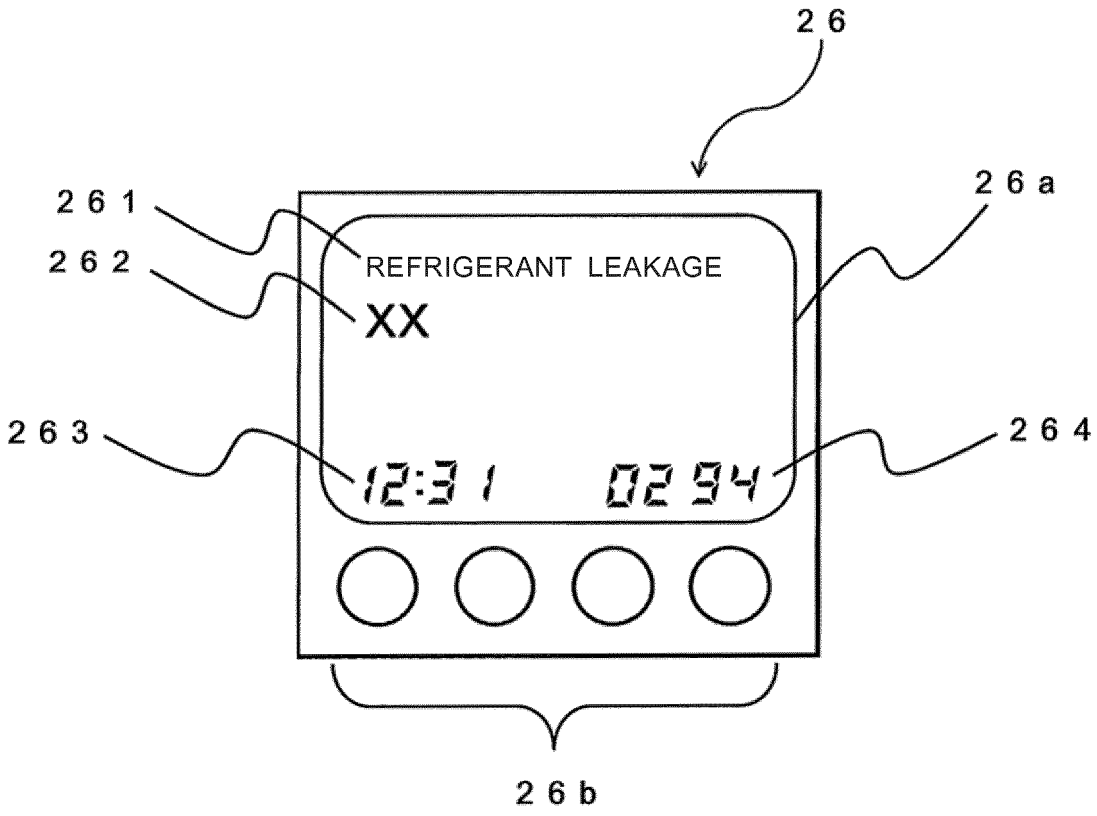


FIG. 6

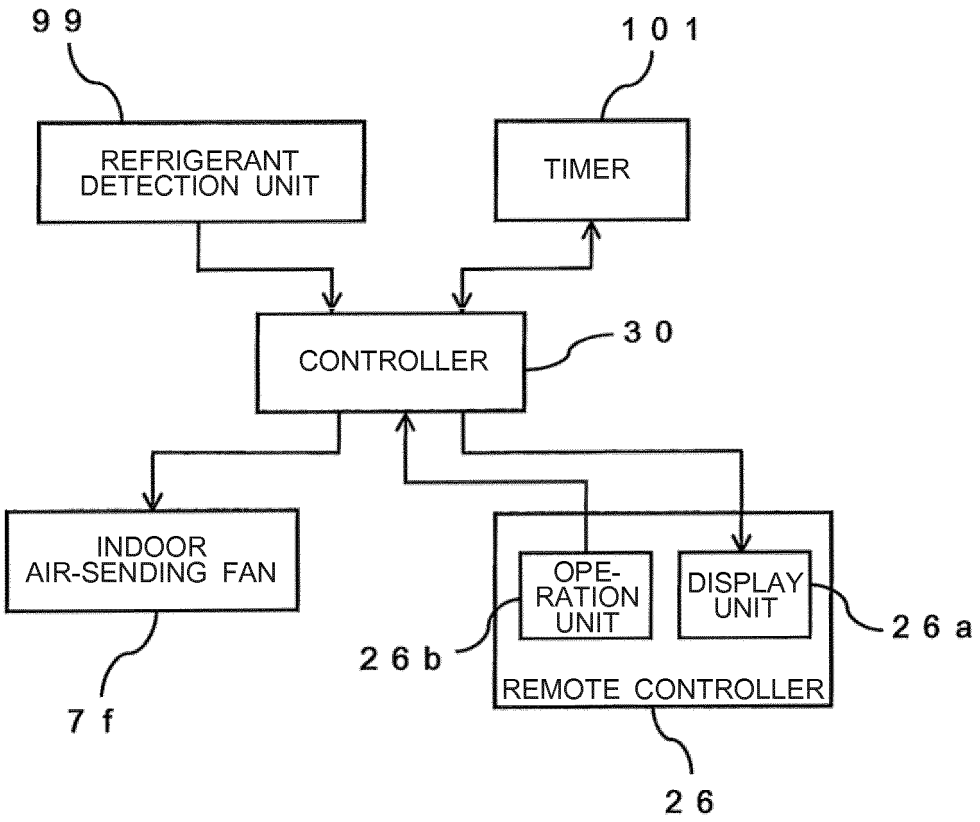

99
101
REFRIGERANT DETECTION UNIT
TIMER
CONTROLLER
30
INDOOR AIR-SENDING FAN
7f
OPE-RATION UNIT
DISPLAY UNIT
26a
26b
REMOTE CONTROLLER
26

FIG. 7

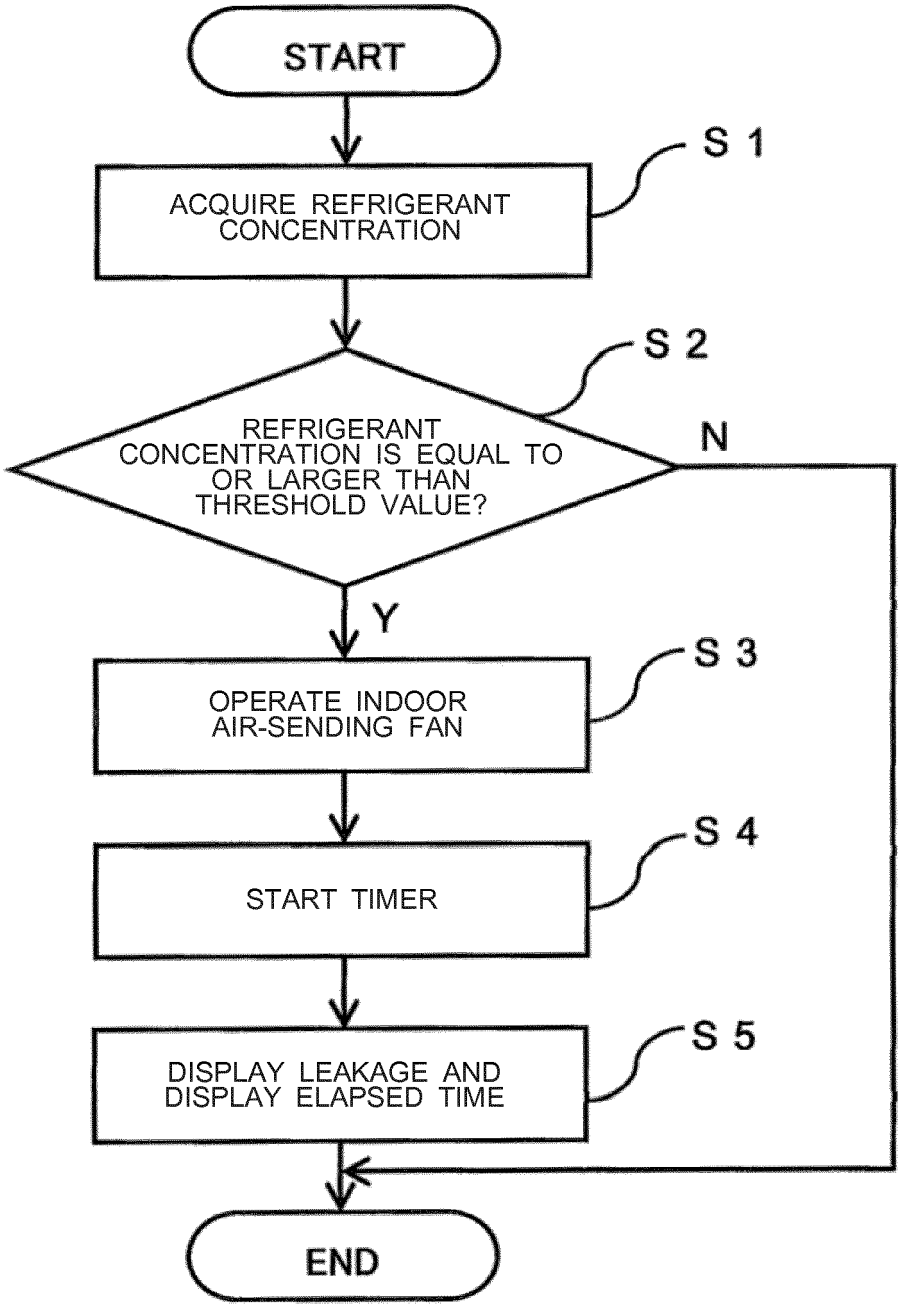
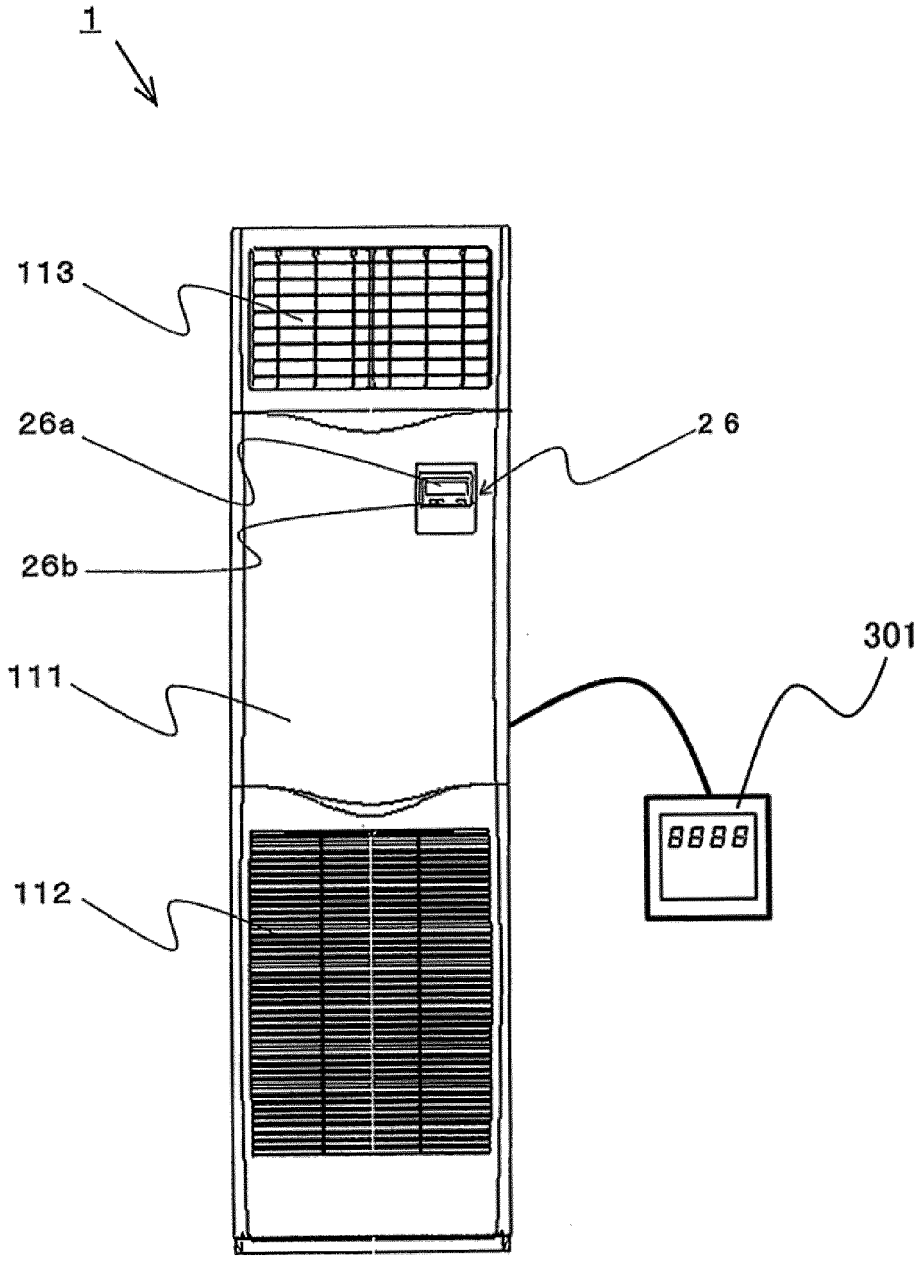

START
S 1
ACQUIRE REFRIGERANT CONCENTRATION
S 2
REFRIGERANT CONCENTRATION IS EQUAL TO OR LARGER THAN THRESHOLD VALUE?
N
Y
S 3
OPERATE INDOOR AIR-SENDING FAN
S 4
START TIMER
S 5
DISPLAY LEAKAGE AND DISPLAY ELAPSED TIME
END

FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/017661

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(2006.01)i, *F25B1/00*(2006.01)i, *F25B49/00*(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, F25B1/00, F25B49/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 11-230648 A (Matsushita Electric Industrial Co., Ltd.), 27 August 1999 (27.08.1999), paragraphs [0014] to [0022]; fig. 1 to 4 & US 6073455 A specification, column 4, line 24 to column 8, line 41; fig. 1 to 4 & EP 936417 A2 & CN 1226668 A	1,4,6-7 2-3,5,8-9
Y	JP 2003-207261 A (Toshiba Corp.), 25 July 2003 (25.07.2003), paragraphs [00094] to [0103]; fig. 3 & US 2005/0103029 A1 paragraphs [0191] to [0202]; fig. 29 & WO 2003/060400 A1 & EP 1475588 A1 & CN 1615420 A & KR 10-2004-0073565 A	2-3,5

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

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"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
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"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
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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
24 July 2017 (24.07.17)	01 August 2017 (01.08.17)
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.
PCT/JP2017/017661

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010-078285 A (Mitsubishi Electric Corp.), 08 April 2010 (08.04.2010), paragraphs [0026], [0029], [0031]; fig. 4 to 6 (Family: none)	2-3,5,8
Y	JP 2015-094515 A (Daikin Industries, Ltd.), 18 May 2015 (18.05.2015), paragraphs [0035], [0037]; fig. 4 & US 2016/0245566 A1 paragraphs [0050], [0052]; fig. 4 & WO 2015/072311 A1 & EP 3070420 A1 & CN 105705888 A	2-3,5,9
A	JP 2016-029322 A (Mitsubishi Electric Corp.), 03 March 2016 (03.03.2016), paragraphs [0017] to [0096]; fig. 1 to 16 & WO 2016/009667 A1 & CN 105318508 A	1-9
A	JP 2015-197279 A (Daikin Industries, Ltd.), 09 November 2015 (09.11.2015), paragraphs [0063] to [0097]; fig. 9 to 12 (Family: none)	1-9
A	JP 2016-065674 A (Mitsubishi Electric Corp.), 28 April 2016 (28.04.2016), paragraphs [0015] to [0080]; fig. 1 to 7 & WO 2016/047278 A1 & CN 105466013 A	1-9
P,A	JP 2017-053509 A (Johnson Controls-Hitachi Air Conditioning Technology (Hong Kong) Ltd.), 16 March 2017 (16.03.2017), paragraphs [0009] to [0034]; fig. 1 to 8 (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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