

(19)



(11)

EP 2 679 921 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

01.01.2014 Bulletin 2014/01

(51) Int Cl.:

F24F 1/06 (2011.01)**F25B 9/00** (2006.01)**F25B 13/00** (2006.01)**F24F 1/46** (2011.01)**F24F 3/14** (2006.01)(21) Application number: **13160066.0**(22) Date of filing: **19.03.2013**

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Designated Extension States:

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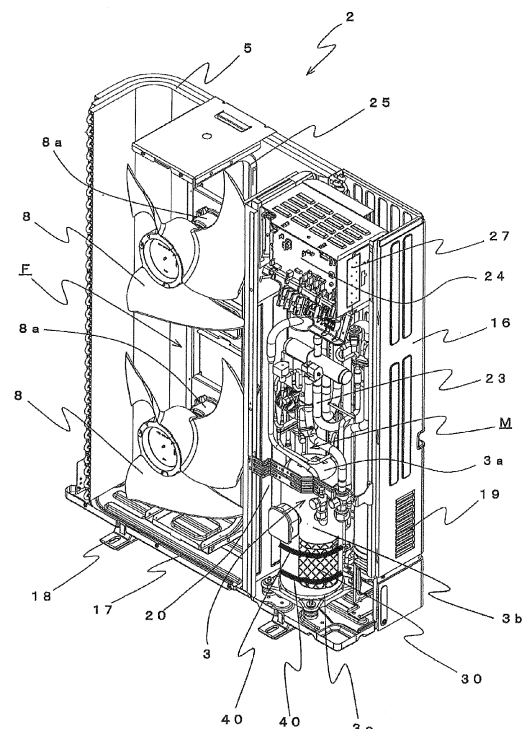
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(74) Representative: **Pfenning, Meinig & Partner GbR****Theresienhöhe 13****80339 München (DE)**(54) **Refrigeration cycle apparatus**

(57) From recent study of combustion of an HFC refrigerant that has a low GWP but is flammable, it has been found that the combustion scale tends to increase as the absolute humidity increases. In a refrigeration cycle apparatus using such a refrigerant, it is necessary to increase safety against unexpected refrigerant leakage in consideration of this tendency.

This refrigeration cycle apparatus includes a compressor having a compression mechanism section in an enclosed container and configured to compress and discharge a refrigerant so as to circulate the refrigerant in a refrigerant circuit, and an outdoor unit installed outdoors and having a housing divided by a partition plate into a fan chamber and a machine chamber including the compressor. The refrigerant is a flammable HFC refrigerant. The refrigeration cycle apparatus further includes a desiccant attached in thermal contact with a surface of the enclosed container of the compressor whose temperature is increased by a gas refrigerant compressed by the compression mechanism section during operation of the compressor so that the temperature becomes a high temperature near a temperature of the compressed gas refrigerant, and adsorbs water from air in the machine chamber during non-operation of the outdoor unit.

FIG. 3



Description

[Citation List]

[Technical Field]

[Patent Literature]

[0001] The present invention relates to a refrigeration cycle apparatus, such as an air-conditioning apparatus, which uses a flammable refrigerant, and more particularly, to an outdoor unit including a compressor that compresses and circulates a refrigerant in a refrigerant circuit.

5 **[0006]**

[Patent Literature 1] Japanese Unexamined Patent Application Publication No. 2000-105003 (columns 0011 to 0020, Fig. 3)

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[Background Art]

[Summary of Invention]

[0002] In current refrigeration cycle apparatuses represented by air-conditioning apparatuses, an HFC refrigerant, such as R410A, is used as a refrigerant. Unlike a conventional HCFC refrigerant such as R22, this R410A has an ozone depletion potential ODP of zero and does not destroy the ozone layer, but has a high global warming potential GWP. For this reason, it is currently being considered, as part of prevention of global warming, to change the refrigerant from a high-GWP HFC refrigerant, such as R410A, to a low-GWP HFC refrigerant.

[Technical Problem]

[0003] R32 (CH_2F_2 ; difluoromethane) is a candidate for such a low-GWP HFC refrigerant. Also, halogenated hydrocarbon having a double bond of carbon in a composition, such as HFO-1234yf ($\text{CF}_3\text{CF}=\text{CH}_2$; tetrafluoropropene) and HFO-1234ze ($\text{CF}_3\text{-CH=CHF}$), is a similar candidate refrigerant. While each of the HFC refrigerants is a kind of HFC refrigerant similar to R32, it is often referred to as HFO including O of olefin in order to distinguish it from an HFC refrigerant, such as R32, having no double bond of carbon in a composition, because unsaturated hydrocarbon having a double bond of carbon is referred to as olefin.

15 **[0007]** However, among the substances given as refrigerant adsorbing substances in Patent Literature 1, especially, silica gel and molecular sieve are commonly known as desiccants for adsorbing water (water vapor) in the air, and are widely used as desiccants. While the machine chamber of the outdoor unit is physically separated from the outside, new outside air is introduced into and passed through the machine chamber from a vent hole or the like by utilizing rotation of an air-sending fan in a fan chamber in order to cool electrical components set in the machine chamber during operation of the refrigeration cycle apparatus.

20 **[0008]** For this reason, the refrigerant adsorbing substance formed of silica gel or molecular sieve, although provided on the inner wall surface of the machine chamber, is frequently exposed to the flow of outside air, and positively adsorbs water from the outside air (outdoor air). Hence, after a predetermined time, which is not so long, elapses from installation of the outdoor unit, the refrigerant adsorbing substance is saturated with adsorbed water. Thus, even if the refrigerant leaks in the machine chamber, the refrigerant adsorbing substance cannot adsorb the refrigerant, and this makes it difficult to improve safety.

[0004] While such a low-GWP HFC refrigerant (including an HFO refrigerant) is not as highly flammable as an HC refrigerant such as R290 (C_3H_8 ; propane), it is slightly flammable unlike non-flammable R410A. For this reason, it is necessary to pay attention to refrigerant leakage. Hereinafter, a refrigerant having flammability is referred to as a flammable refrigerant.

25 **[0009]** If the volume concentration of the refrigerant in the air is within a flammable concentration range and the flammable refrigerant is ignited by some sort of ignition source, the refrigerant catches fire and combusts. The combustion scale differs according to the kind of refrigerant. Since the low-GWP HFC refrigerant is slightly flammable, the combustion scale thereof is smaller than that of the highly flammable HC refrigerant such as propane. Here, a large combustion scale means that the reciprocal of the combustion time is large, for example, that flames quickly propagate, the pressure greatly increases, and large flames are produced.

[0005] In conventional refrigeration cycle apparatuses, highly flammable refrigerants, such as propane, are considered as flammable refrigerants that may leak. There is a refrigeration cycle apparatus, in which at least one of activated carbon, gas adsorbing resin, clay, activated alumina, molecular sieve, bone char, white clay, silica gel, and a mixture of two or more of them is provided as a refrigerant adsorbing substance on an inner wall surface of a machine chamber in an outdoor unit, and a leakage refrigerant is adsorbed by the refrigerant adsorbing substance to suppress diffusion of the leakage refrigerant to the outside (for example, see Patent Literature 1).

30 **[0010]** In relation to flammability, from recent study and evaluation of a combustion phenomenon of a slightly flammable HFC refrigerant, whose combustion scale is smaller than that of a highly flammable refrigerant such as propane, it has been found that the combustion scale increases as the absolute humidity increases under the same conditions in combustion of R32 and the HFO refrigerant. For this reason, in a refrigeration cycle appa-

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ratus using, as a refrigerant, a low-GWP, but slightly flammable HFC refrigerant such as R32 or an HFO refrigerant, it is necessary to improve safety against unexpected leakage of the refrigerant in consideration of such a correlation between the combustion scale and the absolute humidity, although the refrigerant is slightly flammable.

[0011] The present invention has been made to overcome the above-described problems, and an object of the invention is to provide a refrigeration cycle apparatus that improves safety against unexpected refrigerant leakage when an HFC refrigerant that has a low GWP but is flammable, such as R32 or an HFO refrigerant, is used as a refrigerant.

[Solution to Problem]

[0012] A refrigeration cycle apparatus according to the present invention includes a refrigerant circuit, a compressor provided in the refrigerant circuit, having a compression mechanism section in an enclosed container, and configured to compress and discharge a refrigerant so as to circulate the refrigerant in the refrigerant circuit, and an outdoor unit installed outdoors and having a housing divided by a partition plate into a fan chamber including an outdoor air-sending fan and an outdoor heat exchanger and a machine chamber including the compressor. The refrigerant is a flammable HFC refrigerant. The refrigeration cycle apparatus further includes a desiccant attached in thermal contact with a surface of the enclosed container of the compressor whose temperature is increased by a gas refrigerant compressed by the compression mechanism section during operation of the compressor. The desiccant adsorbs water from air in the machine chamber during non-operation of the outdoor unit.

[Advantageous Effects of Invention]

[0013] According to the present invention, during non-operation, the desiccant adsorbs water from the air in the machine chamber and maintains a low absolute humidity in the machine chamber. Hence, even if a flammable HFC refrigerant leaks into the machine chamber and the leakage refrigerant is ignited by some sort of ignition source when the concentration of the leakage refrigerant is within a flammable range, the combustion scale can be kept down. Thus, it is possible to provide a refrigeration cycle apparatus having higher safety against unexpected refrigerant leakage.

[Brief Description of Drawings]

[0014]

[Fig. 1] Fig. 1 illustrates a configuration of a refrigeration cycle apparatus including a refrigerant circuit according to Embodiment 1 of the present invention.
[Fig. 2] Fig. 2 is an external perspective view of an outdoor unit in the refrigeration cycle apparatus ac-

cording to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a perspective view of the outdoor unit illustrated in Fig. 2, from which front and top panels are removed.

[Fig. 4] Fig. 4 is a perspective view of an electrical component unit and its surroundings in a machine chamber.

[Fig. 5] Fig. 5 schematically illustrates the flow of cooling air in the electrical component unit.

[Fig. 6] Fig. 6 schematically illustrates other flow of cooling air in the machine chamber different from that of Fig. 5.

[Fig. 7] Fig. 7 schematically illustrates a manner in which a desiccant is attached to a compressor with a fixing member different from a fixing member illustrated in Fig. 2.

[Fig. 8] Fig. 8 is a schematic vertical sectional view of the fixing member and its surroundings in Fig. 7.

[Fig. 9] Fig. 9 schematically illustrates a fixing member different from the fixing member of Fig. 7.

[Fig. 10] Fig. 10 schematically illustrates a manner in which the desiccant is attached to the compressor with a fixing member different from the fixing member of Fig. 7.

[Fig. 11] Fig. 11 is a schematic transverse sectional view of the fixing member and its surroundings in Fig. 10.

[Fig. 12] Fig. 12 schematically illustrates a manner in which the desiccant is attached to a position on a surface of the compressor different from the position of Fig. 3.

[Fig. 13] Fig. 13 illustrates a desiccant having a structure different from that of the desiccant of Fig. 3.

[Fig. 14] Fig. 14 illustrates a desiccant having a structure different from that of the desiccant of Fig. 13.

[Description of Embodiments]

Embodiment 1

[0015] Embodiment 1 of the present invention will be described below with reference to Figs. 1 to 14. Here, an air-conditioning apparatus that performs indoor cooling and heating will be described as a refrigeration cycle apparatus using a refrigeration cycle in which a refrigerant is compressed and circulated by a compressor and heat is removed from a low-temperature heat source and is discharged to a high-temperature heat source.

[0016] Fig. 1 is a configuration view schematically illustrating a configuration of an air-conditioning apparatus 100 serving as a refrigeration cycle apparatus according to Embodiment 1, and also illustrates a refrigerant circuit of a refrigeration cycle. The air-conditioning apparatus 100 is of a separate type composed of an indoor unit 1 installed indoors and an outdoor unit 2 installed outdoors. A refrigerant circuit is connected between the indoor unit 1 and the outdoor unit 2 by connecting pipes 10a and 10b. The connecting pipe 10a is a liquid-side connecting

pipe through which a liquid refrigerant flows, and the connecting pipe 10b is a gas-side connecting pipe through which a gas refrigerant flows.

[0017] In the outdoor unit 2, there are provided a compressor 3 that compresses and discharges a refrigerant, a refrigerant-channel switch valve 4 that changes the flow direction of the refrigerant in the refrigerant circuit between cooling operation and heating operation (hereinafter referred to as a four-way valve 4), an outdoor heat exchanger 5 serving as a heat-source side heat exchanger that exchanges heat between outdoor air and the refrigerant, and a decompression device 6, such as an electronically-controlled expansion valve, which can change the opening degree and decompresses the refrigerant from high pressure to low pressure (hereinafter referred to as an expansion valve 6). In the indoor unit 1, an indoor heat exchanger 7 is provided as a use-side heat exchanger that exchanges heat between indoor air and the refrigerant. These components are sequentially connected by metallic refrigerant pipes, including the connecting pipes 10a and 10b, to constitute a refrigerant circuit, that is, a compression heat pump cycle in which the refrigerant is circulated by the compressor 3.

[0018] Here, of the refrigerant pipes for connecting these components, a refrigerant pipe that connects the compressor 3 and an entrance of the four-way valve 4 on a discharge side of the compressor 3 is referred to as a discharge pipe 12, and a refrigerant pipe that connects the four-way valve 4 and the compressor 3 on a suction side of the compressor 3 is referred to as a suction pipe 11. In both cooling operation and heating operation, a high-temperature and high-pressure gas refrigerant compressed by the compressor 3 constantly flows through the discharge pipe 12, and a low-temperature and low-pressure refrigerant subjected to evaporation flows through the suction pipe 11. The low-temperature and low-pressure refrigerant flowing through the suction pipe 11 is sometimes a gas refrigerant or sometimes a biphasic refrigerant in which a small quantity of liquid refrigerant is mixed in a gas refrigerant.

[0019] In the outdoor unit 2, an outdoor air-sending fan 8 serving as an air-sending device is provided near the outdoor heat exchanger 5. By rotating the outdoor air-sending fan 8, an air flow that passes through the outdoor heat exchanger 5 is produced. In the outdoor unit 2, a propeller fan is used as the outdoor air-sending fan 8. The outdoor air-sending fan 8 is located downstream of the outdoor heat exchanger 5 in the air flow produced by the outdoor air-sending fan 8.

[0020] Similarly, an indoor air-sending fan 9 is provided near the indoor heat exchanger 7 in the indoor unit 1. An air flow that passes through the indoor heat exchanger 7 is produced by rotation of the indoor air-sending fan 9. As the indoor air-sending fan 9, various fans, such as a crossflow fan and a turbofan, are used according to the type of the indoor unit 1. The indoor air-sending fan 9 is sometimes located downstream or upstream of the indoor heat exchanger 7 in the air flow produced by the

indoor air-sending fan 9.

[0021] In Fig. 1, solid arrows indicate directions in which the refrigerant flows in cooling operation. In cooling operation, the four-way valve 4 is switched to a refrigerant circuit shown by solid lines. The high-temperature and high-pressure gas refrigerant discharged from the compressor 3 first flows into the outdoor heat exchanger 5 via the four-way valve 4, and the outdoor heat exchanger 5 functions as a condenser. When the air flow produced by the rotation of the outdoor air-sending fan 8 passes through the outdoor heat exchanger 5, the passing outdoor air and the refrigerant flowing in the outdoor heat exchanger 5 exchange heat, and condensation heat of the refrigerant is given to the outdoor air. In this way, the refrigerant is condensed into a high-pressure and low-temperature liquid refrigerant by the outdoor heat exchanger 5, and is then subjected to adiabatic expansion by the expansion valve 6 to become a low-temperature and low-pressure biphasic refrigerant (a mixture of a liquid refrigerant and a gas refrigerant).

[0022] Next, the refrigerant flows in the indoor heat exchanger 7 in the indoor unit 1, and the indoor heat exchanger 7 functions as an evaporator. When the air flow produced by rotation of the indoor air-sending fan 9 passes through the indoor heat exchanger 7, the passing indoor air and the refrigerant flowing in the indoor heat exchanger 7 exchange heat, the refrigerant is evaporated by removing evaporation heat from the indoor air, and the passing indoor air is cooled. The refrigerant is evaporated in the indoor heat exchanger 7, sucked in the compressor 3 as a low-temperature and low-pressure gas refrigerant or a biphasic refrigerant in which a small quantity of liquid refrigerant is mixed in a gas refrigerant, and is compressed into a high-temperature and high-pressure refrigerant again by the compressor 3. In cooling operation, this cycle is repeated.

[0023] In Fig. 1, dotted arrows indicate directions in which the refrigerant flows during heating operation. When the four-way valve 4 is switched to a refrigerant circuit shown by dotted lines, the refrigerant flows in a direction opposite the direction in cooling operation, and first flows into the indoor heat exchanger 7. The indoor heat exchanger 7 and the outdoor heat exchanger 5 are operated as a condenser and an evaporator, respectively, and indoor air passing through the indoor heat exchanger 7 is heated by heat of condensation to perform heating operation.

[0024] In the air-conditioning apparatus 100, R32 (CH_2F_2 ; difluoromethane) is used as the refrigerant flowing in the refrigerant circuit. R32 is an HFC refrigerant that has a global warming potential GWP lower than that of an HFC refrigerant R410A widely used in current air-conditioning apparatuses and that has a comparatively small influence on global warming.

[0025] The refrigerant is not limited to R32, and may be the above-described HFO refrigerant, such as HFO-1234yf (C_3F_7 ; tetrafluoropropane) or HFO-1234ze (C_3F_6 ; tetrafluoropropene), serving as a kind of HFC refrigerant,

which is halogenated hydrocarbon having a double bond of carbon in a composition and a global warming potential GWP even lower than that of the R32 refrigerant. Alternatively, the refrigerant may be a low-GWP HFC mixed refrigerant in which R32 having no double bond of carbon in a composition and one or a plurality of the above-described HFO refrigerants are mixed.

[0026] Fig. 2 is an external perspective view of the outdoor unit 2 in the air-conditioning apparatus 100, and Fig. 3 is a perspective view illustrating an internal structure of the outdoor unit 2 from which a part of a housing is removed. The housing that forms an outline of the outdoor unit 2 is formed by a combination of a plurality of platelike metallic parts. A partition plate 20 for separating the interior of the outdoor unit 2 (housing interior) into right and left parts is set upright on a bottom plate 17 (see Fig. 3) that forms a bottom portion of the housing. The partition plate 20 defines a fan chamber F including outdoor air-sending fans 8 and the outdoor heat exchanger 5 and a machine chamber M including the compressor 3, a group of refrigerant pipes 23, and an electrical component unit 24.

[0027] The group of refrigerant pipes 23 is the general name of a refrigerant pipe that connects the gas-side connecting pipe 10b and the four-way valve 4, the suction pipe 11, the discharge pipe 12, the four-way valve 4, a refrigerant pipe that connects the four-way valve 4 and the outdoor heat exchanger 5, a refrigerant pipe that connects the outdoor heat exchanger 5 and the expansion valve 6, the expansion valve 6, and a refrigerant pipe that connects the expansion valve 6 and the liquid-side connecting pipe 10a in Fig. 1.

[0028] Besides the bottom plate 17, the housing that forms the outline of the outdoor unit 2 includes a fan-chamber front panel 14 that covers a front side of the fan chamber F, an L-shaped machine-chamber front panel 15 that covers a front side of the machine chamber M and a front portion of a side opposite the partition plate 20, an L-shaped machine-chamber side panel 16 that covers a rear portion of the side and a rear side of the machine chamber M, and a top panel 13 that extends on the fan chamber F and the machine chamber M to cover an upper side of the outdoor unit 2. These panels are all formed by sheet-metal parts. The panels that constitute the housing may be more finely divided, or some of them may be molded integrally. Fig. 3 illustrates a state in which the top panel 13, the fan-chamber front panel 14, and the machine-chamber front panel 15 are removed from the housing. In Fig. 3, electric wires are not illustrated.

[0029] The fan-chamber front panel 14 has substantially circular air outlets 21 opposed to the outdoor air-sending fans 8. To prevent something from touching the outdoor air-sending fans 8 through the air outlets 21, the air outlets 21 are provided with fun guards 22 that ensure a ventilation area. Although described in detail below, an air inlet 19 is formed as a louver in a lower side portion of the machine-chamber side panel 16. The air inlet 19

serves as an inlet for an air flow for cooling the electrical component unit 24 during operation. The air inlet 19 may be provided in a rear surface of the machine-chamber side panel 16 or a side surface of the machine-chamber front panel 15, and may be provided at a plurality of positions. The air inlet 19 communicates between the outdoors and the interior of the machine chamber M.

[0030] The outdoor heat exchanger 5 is substantially L-shaped in transverse cross section, and is fixed on the bottom plate 17 such that a long side portion thereof is located in a rear face portion of the fan chamber F. A short side portion of the outdoor heat exchanger 5 is located in a side face portion of the fan chamber F opposite the partition plate 20. The outdoor air-sending fans 8 are located in front of the long side portion of the outdoor heat exchanger 5 in the fan chamber F. The outdoor heat exchanger 5 is located on an upstream side of an air flow produced by the rotation of the outdoor air-sending fans 8, and the outdoor air-sending fans 8 are located on a downstream side of the air flow.

[0031] Behind the outdoor air-sending fans 8, fan motors 8a are connected to the outdoor air-sending fans 8 via rotation shafts to rotate the outdoor air-sending fans 8. The fan motors 8a are fixed to a fan-motor support plate 25 that is fixed to the bottom plate 17 and stands upright. The fan-motor support plate 25 is located between the outdoor air-sending fans 8 and the long side portion of the outdoor heat exchanger 5 in the front-rear direction.

[0032] In contrast, the compressor 3, which is heavier than the other devices, is provided on the bottom plate 17 with vibration isolation rubber being disposed therebetween in a lower part of the machine chamber M. In an enclosed container defined by an upper lid 3a, a cylindrical container 3b, and a bottom lid 3c that are formed by steel sheets, the compressor 3 includes a compression mechanism section in which a compression element rotates to compress the refrigerant, and a motor section that rotates the compression element in the compression mechanism section. The compressor 3 is of a high-pressure shell type, in which a suction refrigerant from the suction pipe 11 directly flows into the compression element in the compression mechanism section, and a gas refrigerant compressed by the compression mechanism section is temporarily discharged from the compression mechanism section into the enclosed container and is then discharged to the discharge pipe 12 communicating with the enclosed container. In the compressor 3 of such a high-pressure shell type, a high-temperature and high-pressure refrigerant atmosphere compressed by the compression mechanism section is provided in the internal space of the enclosed container.

[0033] In the compression mechanism section of the compressor 3, a scroll type is adopted as the type of the compression element, in which one of combined scroll laps is fixed and the other is scrolled to compress the refrigerant by reducing the capacity of the compression chamber defined by the combined scroll laps. The type

of the compression element is not limited to the scroll type, and may be other types, for example, a rotary type in which a circular piston eccentrically rotates in an inner space of a cylindrical cylinder to compress the refrigerant by reducing the capacity of a compression chamber defined between an inner peripheral surface of the cylinder and an outer peripheral surface of the piston.

[0034] In at least an upper part of the machine chamber M above the compressor 3, an electrical component unit 24 containing an electric component board 26 is provided. On the electric component board 26, electric and electronic components for constituting a control device, which controls the operation of the air-conditioning apparatus 100 in operative cooperation with a control device in the indoor unit 1, are mounted. Fig. 4 is a perspective view of the electrical component unit 24 and its surroundings provided in the upper part of the machine chamber M. A right side wall of a housing of the electrical component unit 24 has a vent hole 27 formed by a plurality of small holes. A left side wall of the housing close to the partition plate 20 has a similar vent hole 28.

[0035] The vent hole 28 in the left side wall is opposed to a communication hole 29 provided in an upper part of the partition plate 20 to communicate between the machine chamber M and the fan chamber F. The communication hole 29 of the partition plate 20 is formed by one substantially rectangular through hole having a size such that the entire vent hole 28 of the left side wall of the housing of the electrical component unit 24 is fitted in the through hole. The left side wall of the housing of the electrical component unit 24 is in contact with the partition plate 20. The group of refrigerant pipes 23 is routed in an internal space of the machine chamber M except for the compressor 3 located in the lower part and the electrical component unit 24 located in the upper part.

[0036] Next, the basic operation of the outdoor unit 2 will be described. When an operation start command is transmitted from the user to the air-conditioning apparatus 100, the control device operates the four-way valve 4 to switch the flow passage of the refrigerant circuit according to an instructed operation mode (cooling operation or heating operation). Then, each of the fan motors 8a is energized to rotate the outdoor air-sending fan 8, and the compressor 3 is started to circulate a refrigerant in the refrigerant circuit.

[0037] The control device starts the compressor 3 at a predetermined low start rotation speed, and gradually increases the rotation speed of the compressor 3 toward a target rotation speed determined according to the air conditioning load. After the rotation speed reaches the target rotation speed, when the difference between the preset temperature and the room temperature decreases, the rotation speed of the compressor 3 is decreased. Basically, the rotation speed of the outdoor air-sending fan 8 is also changed in accordance with the rotation speed of the compressor 3.

[0038] By the rotation of the outdoor air-sending fan 8, outside air is sucked from the rear and side directions

of the outdoor air-sending fan 8 formed by the propeller fan, and an air flow to be blown out from the air outlet 21 opening in the fan-chamber front panel 14 and opposing the front side of the outdoor air-sending fan 8 is produced. When this air flow passes through the outdoor heat exchanger 5, it exchanges heat with the refrigerant flowing in the outdoor heat exchanger 5. The air that has passed through the outdoor heat exchanger 5 is heated by heat of condensation of the refrigerant in cooling operation and is cooled by evaporation heat removed by the refrigerant in heating operation. After heat exchange, the air is blown outdoors from the air outlet 21 again.

[0039] During operation of the air-conditioning apparatus 100, the electric and electronic components on the electric component board 26 set in the electrical component unit 24 need to be cooled because part of the flowing current is converted into heat energy and heat is generated to increase the temperature. For this reason, in the outdoor unit 2, an air flow for cooling the interior of the electrical component unit 24 is produced by the rotation of the outdoor air-sending fan 8, separately from the air flow that performs heat exchange in the outdoor heat exchanger 5. Fig. 5 is a schematic explanatory view illustrating the flow of cooling air in the electrical component unit 24, and arrows in Fig. 5 indicate the cooling air flow.

[0040] The suction operation with the outdoor air-sending fan 8 also acts on the interior of the electrical component unit 24 that communicates with the fan chamber F via the communication hole 29 of the partition plate 20 and the vent hole 28 in the left side wall of the housing of the electrical component unit 24. Air in the electrical component unit 24 flows through the vent hole 28 and the communication hole 29, and is sucked to the outdoor air-sending fan 8 in the fan chamber F.

[0041] To supplement air to be sucked in the fan chamber F, air flows from the machine chamber M into the electrical component unit 24 through the vent hole 27 provided in the right side wall of the housing of the electrical component unit 24. Further, the machine chamber M communicates with the outdoors via the air inlet 19 provided in the lower part of the machine-chamber side panel 16, and new outdoor air flows into the machine chamber M through the air inlet 19 to supplement the air flowing in the electrical component unit 24.

[0042] In this way, when the outdoor air-sending fan 8 rotates, the suction operation of the rotating outdoor air-sending fan 8 produces an air flow that flows in from the air inlet 19, rises in the machine chamber M, crosses the electrical component unit 24 in the right-left direction, and flows out to the fan chamber F (an air flow for cooling the interior of the electrical component unit 24), separately from the air flow passing through the outdoor heat exchanger 5.

[0043] The cooling air flow for the electrical component unit 24 originates from outside air introduced, by the rotation of the outdoor blower fan 8 in the fan chamber F, into the machine chamber M through the air inlet 19 pro-

vided in the lower part of the machine-chamber side panel 16. The cooling air flow flows from the machine chamber M into the electrical component unit 24 through the vent hole 27 provided in the right side wall of the housing to serve as an air inlet to the electrical component unit 24, crosses the electrical component unit 24 in the right-left direction, and is guided from the vent hole 28 of the left side wall into the fan chamber F via the communication hole 29 of the partition plate 20. While crossing the electrical component unit 24, the cooling air flow passes by the electric component board 26 in the right-left direction. For this reason, the cooling air flow diffuses heat generated by the electric and electronic components (for example, a smoothing condenser) on the electric component board 26 during operation, and cools the heat-generating electric and electronic components.

[0044] In this way, while the cooling air flow for the electrical component unit 24 crosses the electrical component unit 24 in the right-left direction and flows into the fan chamber F, it cools the electric and electronic components, including the electric component board 26, provided in the electrical component unit 24. The cooling air flow that has flowed in the fan chamber F is blown outdoors from the air outlet 21 together with the air (main air flow) that is sucked by the outdoor air-sending fan 8 and is subjected to heat exchange in the outdoor heat exchanger 5. Only the communication hole 29 through which the cooling air passes is a portion of the partition plate 20 that communicates between the machine chamber M and the fan chamber F, and only the cooling air flow is an air flow guided from the machine chamber M to the fan chamber F by the rotation of the outdoor blower fan 8.

[0045] The above is the basic structure and operation of the outdoor unit 2. As described above, the air-conditioning apparatus 100 uses, as the refrigerant flowing in the refrigerant circuit, a low-GWP HFC refrigerant (here, R32) which is effective in preventing global warming. Since such an HFC refrigerant is slightly flammable, the air-conditioning apparatus 100 is required to have high safety against unexpected leakage of the refrigerant.

[0046] As described above, recent study of HFC refrigerants (R32, HFO), which have a low GWP, but are slightly flammable, particularly, evaluation of the combustion scale has found that the combustion scale tends to increase as the absolute humidity under the same conditions (the same kind of refrigerant, the same gas refrigerant concentration, and ignition with the same ignition source) except for the absolute humidity. A gas refrigerant is sealed in an experimental box. At this time, a quantity of gas refrigerant such as the gas refrigerant concentration in the box becomes a specific value within a flammable range (14.4 to 29.3 vol% for R32, 6.2 to 12.3 vol% for HFO1234yf) is sealed, the gas refrigerant concentration distribution in the box is uniformized by an agitation fan set in the box.

[0047] Then, current is supplied to a nichrome wire heater set in the box, and the heater is heated until the

refrigerant in the experimental box is ignited. A process in which the refrigerant is ignited and combusted and naturally stops combustion is observed, and the combustion range, combustion time, and increase in pressure are evaluated. The combustion scale is determined from these results. The absolute humidity in the experimental box is measured with an absolute humidity sensor. To confirm that the gas refrigerant concentration is not changed, it is confirmed with an oximeter instead that the oxygen concentration in the box is not changed.

[0048] When such evaluation of the slightly flammable HFC refrigerant was conducted a plurality of times by using the absolute humidity in the experimental box as a parameter, it was found that the combustion scale tended to increase as the absolute humidity increased. The absolute humidity is changed according to the weather, season, time, etc. From the result obtained by this evaluation, it is conceivable that, when an R32 or HFO refrigerant, whose refrigerant concentration in the air is within the flammable range, is ignited by an ignition source supplied (provided) for some reason, the combustion scale can decrease and the safety against unexpected refrigerant leakage can increase as the absolute humidity decreases.

[0049] Accordingly, to increase the safety against unexpected leakage of the refrigerant from the group of refrigerant pipes 23 and so on in the machine chamber M, in the outdoor unit 2, a desiccant 30, such as silica gel, which adsorbs water from the air is provided in the machine chamber M so as to maintain a low absolute humidity in the machine chamber M. Further, as a characterizing structure of the outdoor unit 2, as illustrated in Fig. 3, the desiccant 30 is provided in contact with an outer side surface of the high-pressure shell compressor 3, more specifically, an outer side surface of the cylindrical container 3b that forms a part of the enclosed container of the compressor 3.

[0050] The desiccant 30 is obtained by storing granulated silica gel serving as a desiccating substance in a net bag made of a breathable metal or a heat-resistant resin. The mesh size of the net bag is large to an extent such that the granulated silica gel does not come out, and the inner silica gel can exchange air with the space in the machine chamber M.

[0051] Here, the desiccant 30 is attached in contact with the outer side surface (outer surface) of the cylindrical container 3b of the compressor 3 with metallic bands 40 that are formed by two coil springs wound on the cylindrical container 3b of the compressor 3 in the circumferential direction. In other words, the desiccant 30 is tied to the outer side surface of the cylindrical container 3b of the compressor 3 with the bands 40.

[0052] Both ends of each of the metallic bands 40 are shaped like hooks, and the band 40 is fixed around the cylindrical container 3b of the compressor 3 by engaging the hooks. The fixed bands 40 press the desiccant 30 against the outer side surface of the cylindrical container 3b with elastic force of the coil springs. The desiccant 30

is clamped between the bands 40 and the cylindrical container 3b by the elastic force of the bands 40. Since the desiccant 30 has a structure in which the granulated silica gel is contained in the net bag, it is deformed along a curved surface (outer shape) of the cylindrical container 3b by the pressing force of the bands 40, and is brought into contact on the outer side surface of the cylindrical container 3b in a wide area.

[0053] The bands 40 are not limited to the coil springs, and it is satisfactory as long as the bands 40 can press the desiccant 30 against the outer side surface of the cylindrical container 3b with a tightening force while being fixed around the cylindrical container 3b. Further, the bands 40 may be formed of a heat-resistant resin instead of metal.

[0054] While the operation of the outdoor unit 2 is stopped, suction is not performed by the rotation of the outdoor air-sending fan 8. Hence, air does not positively come in and out between the machine chamber M and the outdoors. The fact that air does not positively come in and out means that the outdoor unit 2 does not introduce and release air in and out of the machine chamber M, and substantially, little air comes in and out. In such a non-operation state, since the desiccant 30 is provided in the machine chamber M, it adsorbs water (water vapor) from the air in the machine chamber M. Since water is adsorbed from the air in the machine chamber M, where air does not positively come in and out during non-operation, by the desiccant 30, the absolute humidity in the machine chamber M can be kept down. Hence, the humidity in the machine chamber M of the stopped outdoor unit 2 is kept low.

[0055] For this reason, for example, if a flammable R32 refrigerant, although it is slightly flammable, leaks from the group of refrigerant pipes 23 into the machine chamber M and some kind of ignition source exists when the concentration of the leakage refrigerant in the air is within a flammable range, there may be a risk in igniting and combusting the refrigerant. However, since the desiccant 30 adsorbs water from the air in the stopped machine chamber M and the absolute humidity in the machine chamber M is kept low, even if the refrigerant is ignited in the above state, the combustion scale can be kept down, and the safety is increased.

[0056] The outdoor unit 2 is most **characterized in that** the desiccant 30 is attached in contact with the surface of the compressor 3 to maintain a low absolute humidity in the stopped machine chamber M in case of unexpected refrigerant leakage. The reason for that will now be described.

[0057] When the outdoor unit 2 is driven and the compressor 3 is also brought into operation, since the compressor 3 is of a high-pressure shell type and a high-temperature and high-pressure gas refrigerant atmosphere compressed by the compression mechanism section is provided in the enclosed container, the enclosed container formed by a steel sheet has a high temperature near the temperature of the high-temperature gas refrigerant

discharged from the compressor 3 to the discharge pipe 12 because of heat transfer of the high-temperature gas refrigerant after compression in a normal state except for a state immediately after startup.

5 [0058] For this reason, during operation of the outdoor unit 2, heat is supplied from the high-temperature cylindrical container 3b of the operating compressor 3 to the desiccant 30 that is fixed while being pressed against the surface of the cylindrical container 3b of the enclosed container by the bands 40, that is, the desiccant 30 is heated. A desiccating substance like silica gel has the properties of releasing adsorbed water when heated and becoming operable (capable of adsorbing water from the air) as a desiccating substance again. Therefore, the desiccant 30 is heated by the cylindrical container 3b of the compressor 3 during operation of the outdoor unit 2, and releases the water in the air in the machine chamber M that is adsorbed during non-operation. During operation, the desiccant 30 is heated by the compressor 3 and releases the water in the air in the machine chamber M, which is adsorbed during non-operation of the outdoor unit 2, into the machine chamber M again.

[0059] As a result, the water adsorbed by the desiccant 30 is released as water vapor into the machine chamber M again. This release of water is performed during operation of the compressor 3, that is, during operation of the outdoor unit 2. In the machine chamber M, the above-described cooling air flow for the electrical component unit 24 illustrated in Fig. 5 is produced by the rotation of the outdoor air-sending fan 8 during operation. For this reason, the water released as water vapor from the desiccant 30 is taken into this cooling air flow, is carried to the fan chamber F by the rotation of the outdoor air-sending fan 8, and is released outdoors from the air outlet 21, that is, is released to the atmosphere together with the air passing through the outdoor heat exchanger 5 and subjected to heat exchange.

[0060] Since the cooling air flow for the electrical component unit 24 exists in the machine chamber M, the water (water vapor) heated by the compressor 3 and released from the desiccant 30 during operation of the outdoor unit 2 does not stay in the machine chamber M, but comes outdoors from the air outlet 21 of the fan chamber F. Hence, even when the water is released from the desiccant 30 during operation, the absolute humidity in the machine chamber M is not increased by the released water.

[0061] In this way, the desiccant 30 is heated by the high-temperature enclosed container in the operating compressor 3 during operation of the outdoor unit 2 and releases water that is adsorbed during non-operation. Therefore, its function of adsorbing water is restored when the outdoor unit 2 is stopped again. Thus, the desiccant 30 adsorbs water (water vapor) from the air in the stopped machine chamber M again, and maintains a low absolute humidity in the stopped machine chamber M again.

[0062] The desiccant 30 can repeat the operations of

adsorbing water during non-operation of the outdoor unit 2 and releasing the adsorbed water during operation (during operation of the compressor 3) (the released water is discharged outdoors by the rotation of the outdoor air-sending fan 8). Even when the water adsorption capacity of the desiccant 30 is saturated by the water adsorbed during non-operation of the outdoor unit 2, it recovers during operation of the outdoor unit 2, and the desiccant 30 is returned to a reusable state. Hence, when the operation is stopped, the desiccant 30 can constantly adsorb water from the air in the machine chamber M, and can maintain a low absolute humidity in the stopped machine chamber M.

[0063] In this way, the desiccant 30 is attached in contact with the surface of the high-pressure shell compressor 3 so that it releases water, which is adsorbed during non-operation, by utilizing heat radiation from the compressor 3 during operation, and is restored to constantly adsorb water during non-operation. Heat radiation from the compressor 3 is utilized as a heat source for heating the desiccant 30 to release water adsorbed by the desiccant 30 during operation of the outdoor unit 2. Hence, waste energy is effectively utilized to dry the desiccant 30 (release water) without using any power of the air-conditioning apparatus 100.

[0064] Water (water vapor), which is heated by exhaust heat from the compressor 3 and released from the desiccant 30 during operation of the outdoor unit 2, is discharged outdoors from the air outlet 21 of the machine-chamber front panel 15 via the fan chamber F together with the cooling air flow for the electrical component unit 24 by the rotation of the outdoor air-sending fan 8, as described above, but does not stay in the machine chamber M. Further, if the flammable refrigerant leaks into the machine chamber M, it is discharged outdoors and diffused into the air from the air outlet 21 via the fan chamber F together with the cooling air flow for the electrical component unit 24 by the rotation of the outdoor air-sending fans 8 during operation. Hence, the gas refrigerant concentration is extremely low, and does not reach the flammable range.

[0065] In Fig. 5, an air flow caused to flow from the machine chamber M to the fan chamber F by the rotation of the outdoor air-sending fan 8 during operation of the outdoor unit 2 is only the cooling air flow for the electrical component unit 24. However, for example, as illustrated in Fig. 6, a vent hole 50 different from the communication hole 29, through which the cooling air flow for the electrical component unit 24 passes, may be provided in the partition plate 20 so that an air flow different from the cooling air flow for the electrical component unit 24 is also produced to flow from the machine chamber M to the fan chamber F.

[0066] Here, this air flow, which flows from the machine chamber M to the fan chamber F via the vent hole 50, is referred to as a sub-air flow. Water heated by the compressor 3 and released from the desiccant 30 during operation may be taken into the sub-air flow, carried from

the machine chamber M to the fan chamber F via the vent hole 50, and released outdoors from the air outlet 21 via the outdoor air-sending fan 8. For that purpose, the position of the vent hole 50 in the up-down direction is set above the desiccant 30 and below the electrical component unit 24. Similarly to the cooling air flow for the electrical component unit 24, the air flowing into the fan chamber F as the sub-air flow is introduced from the outdoors into the machine chamber M via the air inlet 19 provided in the lower part of the side panel 16.

[0067] During operation, water evaporated from the desiccant 30 is taken into both the cooling air flow for the electrical component unit 24 and the above-described sub-air flow and is then sent from the machine chamber M to the fan chamber F. The water may be mainly sent together with the cooling air flow or sent together with the sub-air flow. In the latter case, the position of the vent hole 50 in the front-rear direction in the outdoor unit 2 is preferably set to be the same as the position of the desiccant 30 in the front-rear direction. If the refrigerant leaks into the machine chamber M, it is released outdoors and diffused to the atmosphere from the air outlet 21 via the vent hole 50 and the fan chamber F together not only with the cooling air flow for the electrical component unit 24 but also with the sub-air flow by the rotation of the outdoor air-sending fan 8 during operation.

[0068] If refrigerant leakage occurs in the machine chamber M where little air flows during non-operation of the outdoor unit 2, the leaking HFC gas refrigerant flows down in the machine chamber M and accumulates at the bottom of the machine chamber M because the average molecular weight thereof is more than that of air, that is, the specific gravity with respect to air is more than 1. Further, since the compressor 3 is heavy, it is set in the lower part of the machine chamber M. For this reason, attachment of the desiccant 30 to the compressor 3 is also effective not only in releasing water utilizing heat radiation from the compressor 3 during operation, but also in actively making the absolute humidity low in the lower part of the machine chamber M where the leakage refrigerant is apt to accumulate, that is, the gas refrigerant concentration may fall within the flammable range.

[0069] Moreover, since the leakage refrigerant accumulates at the bottom of the stopped machine chamber M, the desiccant 30 attached in contact with the compressor 3 is preferably located at as a low position as possible on the compressor 3 shaped like a cylinder that extends long in the up-down direction.

[0070] As the heat source for releasing water from the desiccant 30 during operation, it is conceivable to utilize heat of the discharge pipe 12 through which the high-temperature and high-pressure gas refrigerant discharged from the compressor 3 flows. However, the discharge pipe 12 is a narrow pipe having an outer diameter of, for example, about 13 mm, and has a plurality of bent portions. For this reason, although the desiccant 30 can be attached to a surface of the discharge pipe 12, the quantity of desiccant 30 to be attached is limited because

the surface area of the discharge pipe 12 is small and the desiccant 30 is not easily pressed against and fixed to the bent portions. As a result, the amount of water that can be adsorbed during non-operation is reduced, and this method is less than effective.

[0071] Accordingly, even if the desiccant 30 is wound thick around the discharge pipe 12 to increase the quantity of desiccant 30 to be attached, there is a limitation to the space in the machine chamber M. Moreover, heat of the discharge pipe 12 becomes less likely to be transferred with increasing distance from the discharge pipe 12 in the radial direction, sufficient heating is not performed, and it may be impossible to sufficiently release water that is adsorbed during non-operation.

[0072] However, the high-pressure shell type compressor 3 includes the enclosed container that has a large surface area and has high temperature during operation, and the desiccant 30 can be attached in contact with the outer surface of the enclosed container in an area wider than that of the discharge pipe 12. Since a wide attachment area of the desiccant 30 can be ensured, there is no need to make the desiccant 30 thick. During operation, the desiccant 30 can be heated by sufficient heat transferred from the compressor 3.

[0073] Therefore, during non-operation of the outdoor unit 2, the desiccant 30 can maintain a low absolute humidity in the machine chamber M by adsorbing a sufficient amount of water from the air, and can increase the safety against unexpected refrigerant leakage. During operation, the desiccant 30 is sufficiently heated by heat radiated from the compressor 3, sufficiently releases the adsorbed water, and restores the adsorption ability. During the next non-operation time, the desiccant 30 can adsorb a sufficient amount of water again, and maintain a low absolute humidity in the machine chamber M. This cycle can be repeated.

[0074] The desiccant 30 is not limited to the above-described silica gel, and may be other desiccants, for example, synthetic zeolite such as molecular sieve, as long as it can adsorb water, release the adsorbed water when heated, and restore. Alternatively, the desiccant 30 may be a mixture of a plurality of desiccants.

[0075] While the desiccant 30 is attached to the compressor 3 by the method in which the desiccant 30 is tied to the cylindrical container 3b of the compressor 3 and pressed against the surface of the cylindrical container 3b with the metallic bands 40 formed by coil springs, as illustrated in Fig. 3, other methods can be adopted. Fixing with a fixing member different from the bands 40 will be described below with reference to Figs. 7 to 11.

[0076] Fig. 7 schematically illustrates fixing of the desiccant 30 to the compressor 3 with a fixing member different from the bands 40, and Fig. 8 is a schematic vertical sectional view of a pocket 41 serving as the fixing member and its surroundings illustrated in Fig. 7. A metallic pocket 41 is fixed to the surface of the cylindrical container 3b of the compressor 3 by welding or brazing, and the desiccant 30 is attached by being stored in the pocket

41.

[0077] As illustrated in Fig. 7, the depth of the pocket 41 is set to be large at both ends and small at the center in the circumferential direction of the compressor 3. A distance A between an inner wall of the pocket 41 and the cylindrical container 3b of the compressor 3 (a distance in the radial direction of the cylindrical container 3b) in Fig. 8 is set such that the desiccant 30 is located in contact with the cylindrical container 3b. Accordingly, an area of the desiccant 30 stored in the pocket 41 exposed to the machine chamber M can be increased, and the desiccant 30 is in contact with the surface of the cylindrical container 3b of the desiccant 30. Thus, the desiccant 30 adsorbs water from the air in the machine chamber M during non-operation of the outdoor unit 2, and is heated by heat released from the enclosed container of the compressor 3 during operation to release the water adsorbed during non-operation and to restore the water adsorption ability.

[0078] As illustrated in Fig. 9, as a fixing member for the desiccant 30, a net pocket 42 may be provided. The net pocket 42 is formed by a metallic net that is open in at least one direction (open in an upward direction here) and is fixed to the cylindrical container 3b by welding or brazing. The net pocket 42 ensures sufficient air permeability toward the desiccant 30. By setting the size of the net pocket 42 to be more than that of the desiccant 30, the desiccant 30 can be firmly fixed to the surface of the cylindrical container 3b.

[0079] Fig. 10 schematically illustrates fixing of the desiccant 30 to the compressor 3 with a fixing member different from the fixing member of Fig. 7, and Fig. 11 is a schematic transverse sectional view of holders 43 serving as the fixing member and their surroundings illustrated in Fig. 10. Each of the holders 43, formed by a long metal strip, is fixed at one longitudinal end to the cylindrical container 3b of the compressor 3 by welding or brazing, and is made free at the other end. The desiccant 30 is attached by being clamped between the holders 43 and the cylindrical container 3b with elastic force of the holders 43 (spring force of leaf springs).

[0080] As illustrated in Fig. 11, the open ends of the holder 43 are slightly lifted, and the desiccant 30 is put under the holders 43 and is pressed against the cylindrical container 3b by the spring force of the holders 43. Here, as illustrated in Fig. 10, upper and lower ends of the desiccant 30 are fixed by the holders 43 that extend long in the circumferential direction of the cylindrical container 3b. The holders 43 do not always need to extend long in the circumferential direction of the cylindrical container 3b, and, for example, may extend long in the up-down direction of the compressor 3.

[0081] While two holders 43 are provided and both ends of the desiccant 30 are clamped by the holders 43 here, the number of holders 43 may be appropriately set according to the size of the desiccant 30 (the contact area with the cylindrical container 3b). While the longitudinal length of the holders 43 is more than that of the

desiccant 30 in Figs. 10 and 11, it may be less than that of the desiccant 30 as long as it can fix the desiccant 30.

[0082] The number, longitudinal length, and lateral length (width) of the holders 43 are appropriately set such that the area of the desiccant 30 hidden by the holders 42 is minimized and the desiccant 30 can be fixed in a wide contact area with the cylindrical container 3b of the compressor 3 by the holders 43.

[0083] The holders 43 may be replaced with a holder that branches halfway to have one fixed end and a plurality of open ends. Further, the open ends may be bent toward the cylindrical container 3b to restrict the fixed desiccant 30 from moving to a side opposite the fixed side.

[0084] In the above, the desiccant 30 is fixed in contact with the outer side surface of the cylindrical container 3b of the compressor 3 that extends long in the up-down direction. Fig. 12 schematically illustrates another attachment position of the desiccant 30, and the desiccant 30 is attached to an upper surface of the upper lid 3a of the enclosed container in the compressor 3. In this case, it is difficult to fix the desiccant 30 with belts. Hence, the desiccant 30 is fixed by the holders 43, the pocket 41, or the net pocket 42 provided on the upper surface of the upper lid 3a.

[0085] Since the gas refrigerant is heavier than air, as described above, if it leaks in the machine chamber M, where air does not positively come in and out, during non-operation, the leakage gas refrigerant accumulates at the bottom of the machine chamber M. Hence, the desiccant 30 is preferably fixed to as a low position on the compressor 3 as possible so that the absolute humidity in the lower part of the machine chamber M is as low as possible. However, when the desiccant 30 is attached to the upper surface of the upper lid 3a, it is easily fixed because the upper lid 3a supports the gravity acting on the desiccant 30 and the gravity of the desiccant 30 allows the desiccant 30 to be in firm contact with the surface of the compressor 3.

[0086] The holders 43, the pocket 41, or the net pocket 42 provided to fix the desiccant 30 to the upper surface of the upper lid 3a serves to mainly restrict movement of the desiccant 30 rather than firmly press the desiccant 30 against the compressor 3. Hence, the dimensional management can be relaxed more than when the fixing member is provided on the outer side surface of the cylindrical container 3b.

[0087] The above-described compressor 3 is of a high-pressure shell type in which the enclosed container is filled with a high-temperature and high-pressure gas refrigerant compressed by the compression mechanism section. This is because, to heat the desiccant 30 and restore the function thereof, the surface of the high-temperature enclosed container serving as the heat source needs to be wide. However, in some low-temperature shell compressors, a space serving as a high-temperature and high-pressure gas refrigerant atmosphere compressed by the compression mechanism section is pro-

vided in a part of the enclosed container. For example, the above-described scroll compressor includes a low-pressure shell compressor, in which a compression mechanism section is provided in an upper part of an enclosed container, a motor section is provided in a lower part of the enclosed container, and an atmosphere of a low-pressure suction refrigerant to be sucked in the compressor is provided in the parts.

[0088] In some of such low-pressure shell scroll compressors, a space above the compressor mechanism section in the enclosed container is used as a muffler space for the gas refrigerant that is to be compressed by the compression mechanism section and discharged to the discharge pipe 12, and the space is filled with a high-temperature and high-pressure gas refrigerant. In such low-pressure shell compressors, a portion of the enclosed container corresponding to the space filled with the discharge gas refrigerant has a high temperature. The desiccant 30 can be attached to the surface of the portion of the enclosed container, for example, an upper surface of an upper lid covering the above-described muffler space so that water in the desiccant 30 (water adsorbed during non-operation) is evaporated by using heat radiated from the portion as a heat source during operation.

[0089] While the above-described desiccant 30 is formed by a breathable metallic or heat-resistant resin net bag containing the granulated desiccating substance (here, silica gel), when a desiccating substance that is shaped like fiber or a sheet, not like granules, is stored in the net bag, it tangles or is caught by the mesh, and therefore, is restricted from coming out of the net bag. Hence, the mesh size of the net bag can be increased to enhance air permeability toward the contained desiccating substance. When the net bag is formed of heat-resistant resin, it is preferably flame-retardant in case of unexpected ignition of leakage gas refrigerant.

[0090] Figs. 13 and 14 illustrate desiccants that are different in structure from the desiccant 30 contained in the net bag. A desiccant 31 illustrated in Fig. 13 is obtained by directly forming a desiccating substance in the necessary shape and size. The desiccant 31 is attached to the outer side surface of the cylindrical container 3b of the compressor 3, and an inner wall surface thereof, that is, a surface in contact with the outer side surface of the cylindrical container 3b is formed by a curved face having a radius such as to conform to the outer side surface of the cylindrical container 3b. This reliably ensures the contact area with the cylindrical container 3b.

[0091] The desiccant 31 obtained by directly forming the desiccating substance in the attachment shape does not need the net bag used for the above-described desiccant 30. Hence, there is no member that reduces air permeability of the desiccant 31 besides the fixing members for fixing the desiccant 31 to the outer side surface of the compressor 3 such as the bands 40 and the pocket 41. This further improves ventilation to the machine chamber M.

[0092] A desiccant 32 illustrated in Fig. 14 is obtained by bonding a desiccating substance, such as silica gel, to a metallic or heat-resistant resin mesh cloth member having a mesh size less than that of the net bag used in the desiccant 30. Desiccating substance powder or a desiccating substance shaped like granules or fiber may be directly bonded to a surface of the mesh cloth member, or a mixture of the desiccating substance and binder may be chemically attached to the mesh member, that is, the desiccating substance may be carried by the mesh member.

[0093] Since the desiccant 32 is shaped like cloth, it can be wound around the cylindrical container 3b of the compressor 3, and this can ensure a wide area exposed to the machine chamber M and a wide contact surface area with the cylindrical container 3b opposite the exposed surface. The desiccant 32 may be wound around the outer side surface of the cylindrical container 3b in the circumferential direction, and may then be fixed by the bands 40 from above. Alternatively, catches, such as hooks, to be engageable with each other may be provided at opposite ends of the desiccant 32 in the circumferential direction, and the desiccant 32 may be wound on the outer side surface of the cylindrical container 3b and fixed utilizing the elastic force of the mesh member while the catches are engaged with each other.

[0094] Of course, since the surface area of the desiccant 32 is not large enough to wind the desiccant 32 around the cylindrical container 3b, the desiccant 32 may be fixed to the outer side surface of the cylindrical container 3b or the upper surface of the upper lid 3a in the compressor 3, similarly to the desiccant 30 obtained by storing the desiccating substance in the net bag. At this time, the desiccant 32 can be fixed while being bent in a plurality of layers. This can relax the dimensional management of the fixing member such as the pocket 41.

[0095] The air-conditioning apparatus 100 uses, as the refrigerant, R32 serving as an HFC refrigerant that has a low GWP, but is flammable. Recent study and evaluation of flammability have found that the combustion scale of R32 tends to increase as the absolute humidity increases when the refrigerant concentration with respect to air is within the flammable range. For this reason, in the outdoor unit 2, the desiccants 30 to 32 (at least any one of the desiccants 30, 31, and 32, this also applies below) are exposed in the machine chamber M, and are attached in contact with the outer side surface of the enclosed container whose temperature becomes high during operation of the compressor 3 in the machine chamber M.

[0096] For this reason, the desiccants 30 to 32 can adsorb water from the air in the machine chamber M during non-operation of the outdoor unit 2, and maintain a low absolute humidity in the machine chamber M. Even if the refrigerant leaks in the machine chamber M and is ignited by some sort of ignition source when the concentration of the leakage refrigerant is within the flammable range, the combustion scale can be kept down, and safe-

ty against unexpected refrigerant leakage can be enhanced.

[0097] During operation of the outdoor unit 2, the desiccants 30 to 32 in contact with the surface of the enclosed container in the operating compressor 3 are heated by heat from the enclosed container of the operating compressor 3, and release water that is adsorbed during non-operation. Thus, the desiccants 30 to 32 restore their water adsorption function, and can adsorb water from the air in the machine chamber M again during the next non-operation time.

[0098] By the rotation of the outdoor air-sending fan 8, the water, which is heated by heat from the compressor 3 and is released as water vapor again from the desiccants 30 to 32 to the machine chamber M during operation, is introduced from the outdoors into the machine chamber M, is guided to the fan chamber F after passing through the electrical component unit 24 provided in the upper part of the machine chamber M, is taken into the cooling air for the electrical component unit 24 or the sub-air flow that is to be blown outdoors from the front air outlet 21 via the outdoor air-sending fan 8, and is released to the atmosphere from the air outlet 21 together with the air flow. Hence, the water does not stay in the machine chamber M, and does not increase the absolute humidity in the machine chamber M.

[0099] If the HFC gas refrigerant (here R32) leaks in the machine chamber M during non-operation, it accumulates near the bottom of the housing of the machine chamber M where air does not positively come in and out during non-operation, because it has a density more (heavier) than air. The compressor 3 is heavy, is installed on the upper surface of the bottom plate 17 of the housing of the outdoor unit 2, and is located in the lower part of the machine chamber M. Therefore, the desiccants 30 to 32 fixed in contact with the compressor 3 are also located in the lower part of the machine chamber M. For this reason, the desiccants 30 to 32 subjectively maintain a low absolute humidity in the lower space of the machine chamber M where the leakage refrigerant is apt to accumulate. This can enhance safety against unexpected refrigerant leakage. Even if the refrigerant leaks in the machine chamber M during operation, the leakage gas refrigerant is released to the atmosphere and is widely diffused together with the cooling air flow for the electrical component unit 24, similarly to water vapor released from the desiccants 30 to 32. Hence, the gas refrigerant concentration does not fall within the flammable range.

[0100] Since the enclosed container of the compressor 3 has a wide area whose temperature becomes high during operation, such as the outer side surface of the cylindrical container 3b and the upper surface of the upper lid 3a, the desiccants 30 to 32 can be attached thereto in a wider area than when they are attached in contact with the surface of the discharge pipe 12 through which the high-temperature gas refrigerant flows. For this reason, since both the exposed areas to the machine chamber M and the contact areas with the heat source (com-

pressor 3) of the attached desiccants 30 to 32 increase, the desiccants 30 to 32 can adsorb much water from the air in the machine chamber M and maintain a low absolute humidity in the machine chamber M during non-operation, and are heated by heat of the compressor 3 to reliably release much adsorbed water, and restore the water adsorption function during operation.

[0101] While R32 is used here as the HFC refrigerant that has a low GWP but is flammable, an HFO refrigerant (a kind of HFC refrigerant), such as HFO-1234yf, formed of halogenated hydrocarbon having a double bond of carbon in a composition, tends to have a relationship between the absolute humidity and the combustion scale similar to that of R32. Also, the HFO refrigerant has a density more than that of air, similarly to R32. Hence, when the HFO refrigerant is used as the refrigerant that circulates in the refrigerant circuit, or when a mixture of R32 and the HFO refrigerant is used, application of the present invention can obtain advantages similar to those of R32.

[0102] The desiccants 30 to 32 do not always need to be in direct contact with the outer surface of the enclosed container of the compressor 3. It is satisfactory as long as the desiccants 30 to 32 are in thermal contact therewith so that heat is transferred from the compressor 3 to the desiccants 30 to 32 and releases adsorbed water as the heat source. For example, the desiccant 30 to 32 may be heated by heat transferred from the compressor 3 via a metallic member that is provided between the compressor 3 and the desiccants 30 to 32 and is formed of a metallic material having high thermal conductivity.

[0103] Since the adsorption capacity (water adsorption ability) of the desiccants 30 to 32 may decrease owing to aging degradation, the desiccants 30 to 32 are preferably attached such as to be replaceable periodically. When the desiccants 30 to 32 are attached to the outer side surface of the cylindrical container 3b of the compressor 3, they are preferably provided on the front side of the compressor 3, that is, on the machine-chamber front panel 15 side. The desiccants 30 to 32 can be attached and detached without taken the compressor 3 out of the machine chamber M, by temporarily releasing the elastic force of the above-described bands 40 or holders 43 and giving elasticity thereto again, or by being simply put in and out from the pocket 41 or the net pocket 42. This allows new and old desiccants 30 to 32 to be exchanged easily.

[0104] While the embodiment of the present invention has been described above in conjunction with the outdoor unit 2 in the air-conditioning apparatus 100, the present invention is applicable not only to the air-conditioning apparatus 100 but also to other refrigeration cycle apparatuses, such as a heat-pump water heater and a refrigerator, as long as the refrigeration cycle apparatus includes an internal compressor having an enclosed container that at least partially increases in temperature during operation and an outdoor unit set outdoors, and uses R32, an HFO refrigerant, or a mixture thereof as a refrigerant to

circulate in the refrigerant circuit. In this case, similar operational advantages can be obtained, and safety against unexpected refrigerant leakage can be enhanced.

5 [Reference Signs List]

[0105] 2: outdoor unit, 3: compressor, 3a: upper lid (enclosed container), 3b: cylindrical container (enclosed container), 3c: bottom lid (enclosed container), 5: outdoor heat exchanger, 8: outdoor air-sending fan, 13: top panel (housing), 14: fan-chamber front panel (housing), 15: machine-chamber front panel (housing), 16: machine-chamber side panel (housing), 17: bottom plate (housing), 19: air inlet, 20: partition plate, 21: air outlet, 24: electrical component unit, 26: electric component board, 30: desiccant, 31: desiccant, 32: desiccant, 40: band, 41: pocket, 42: net pocket, 43: holder.

20 Claims

1.

A refrigeration cycle apparatus comprising:

a refrigerant circuit;
a compressor (3) provided in the refrigerant circuit, having a compression mechanism section in an enclosed container (3a,3b,3c) and configured to compress and discharge a refrigerant so as to circulate the refrigerant in the refrigerant circuit; and
an outdoor unit (2) installed outdoors and having a housing (13,14,14,16,17) divided by a partition plate (20) into a fan chamber (F) including an outdoor air-sending fan (8) and an outdoor heat exchanger(5) and a machine chamber (M) including the compressor (3),
wherein the refrigerant is a flammable HFC refrigerant, and
wherein the refrigeration cycle apparatus further includes a desiccant (30) attached in thermal contact with a surface of the enclosed container whose temperature is increased by a gas refrigerant compressed by the compression mechanism section during operation of the compressor (3), the desiccant (30) adsorbing water from air in the machine chamber (M) during non-operation of the outdoor unit (2).

2.

The refrigeration cycle apparatus of Claim 1, wherein the compressor (3) is located in a lower part of the machine chamber (M).

3.

The refrigeration cycle apparatus of Claim 1 or 2, wherein, during operation of the outdoor unit (2), the desiccant (30) is heated by the enclosed container

with the high temperature in the operating compressor to release the water adsorbed during non-operation of the outdoor unit (2).

4.

The refrigeration cycle apparatus of Claim 3, further comprising:

an air inlet (19) provided in the housing to communicate between the outdoors and the machine chamber (M); and
 an air outlet (21) from which an air flow produced by rotation of the outdoor air-sending fan (8) is blown outdoors, the air outlet (21) being provided in the housing to be opposed to the outdoor air-sending fan (8),
 wherein, during operation of the outdoor unit (2), an air flow is produced by the rotation of the outdoor air-sending fan (8) so as to be introduced from the outdoors into the machine chamber (M) via the air inlet (19), guided from the machine chamber (M) to the fan chamber (F), and blown out from the air outlet (21), and
 wherein the water released from the desiccant (30) during operation of the outdoor unit (2) is released outdoors from the air outlet (21) together with the air flow.

5.

The refrigeration cycle apparatus of Claim 3, further comprising:

an electrical component unit (24) provided above the compressor (3) in the machine chamber (M) and having an electric component board (26);
 an air inlet (19) provided in the housing to communicate between the outdoors and the machine chamber (M); and
 an air outlet (21) from which an air flow produced by rotation of the outdoor air-sending fan (8) is blown outdoors, the air outlet (21) being provided in the housing to be opposed to the outdoor air-sending fan (8),
 wherein, during operation of the outdoor unit (2), a cooling air flow for the electrical component unit (24) is produced by the rotation of the outdoor air-sending fan (8) so as to be introduced from the outdoors into the machine chamber (M) via the air inlet (19), guided to the fan chamber (F) through the electrical component unit (24), and blown out from the air outlet (21), and
 wherein the water released from the desiccant (30) during operation of the outdoor unit (2) is released outdoors from the air outlet (21) together with the cooling air flow.

6.

The refrigeration cycle apparatus of any of Claims 1 to 5,
 wherein the compressor (3) is of a high-pressure shell type in which a high-temperature and high-pressure gas refrigerant atmosphere compressed by the compression mechanism section is provided in the enclosed container, and
 wherein the desiccant (30) is attached in contact with an outer side surface of a cylindrical container (3b) that constitutes the enclosed container.

7.

The refrigeration cycle apparatus of any of Claims 1 to 5, wherein the desiccant (30) is attached in contact with an upper surface of an upper lid (3a) that constitutes the enclosed container, and gravity acting on the desiccant (30) is supported by the upper lid (3a).

8.

The refrigeration cycle apparatus of any of Claims 1 to 7, wherein the desiccant (30) is obtained by storing a desiccating substance in a net bag (42) formed of a breathable metal or a heat-resistant resin.

9.

The refrigeration cycle apparatus of Claim 6, wherein the desiccant (30) is attached in contact with the outer side surface of the cylindrical container while being tied with a band (40) wound on the cylindrical container.

FIG. 1

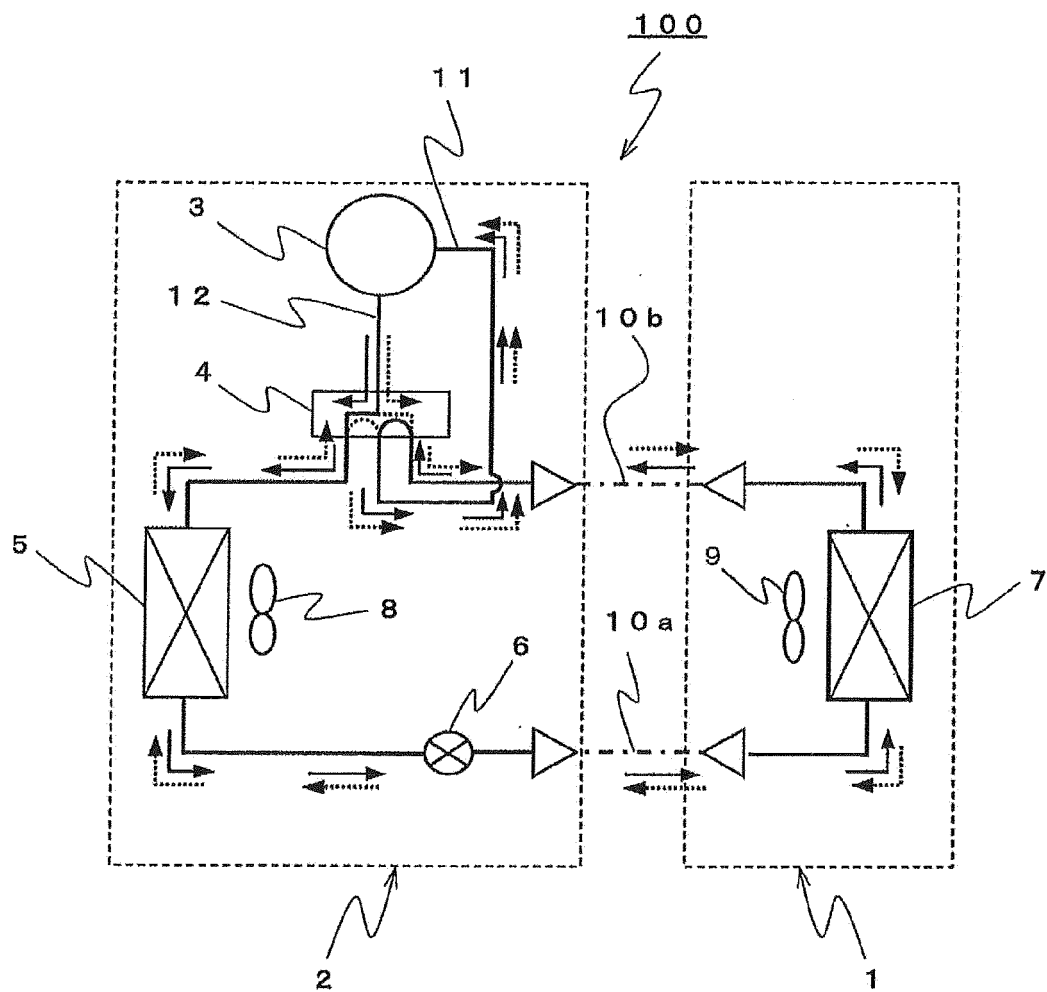


FIG. 2

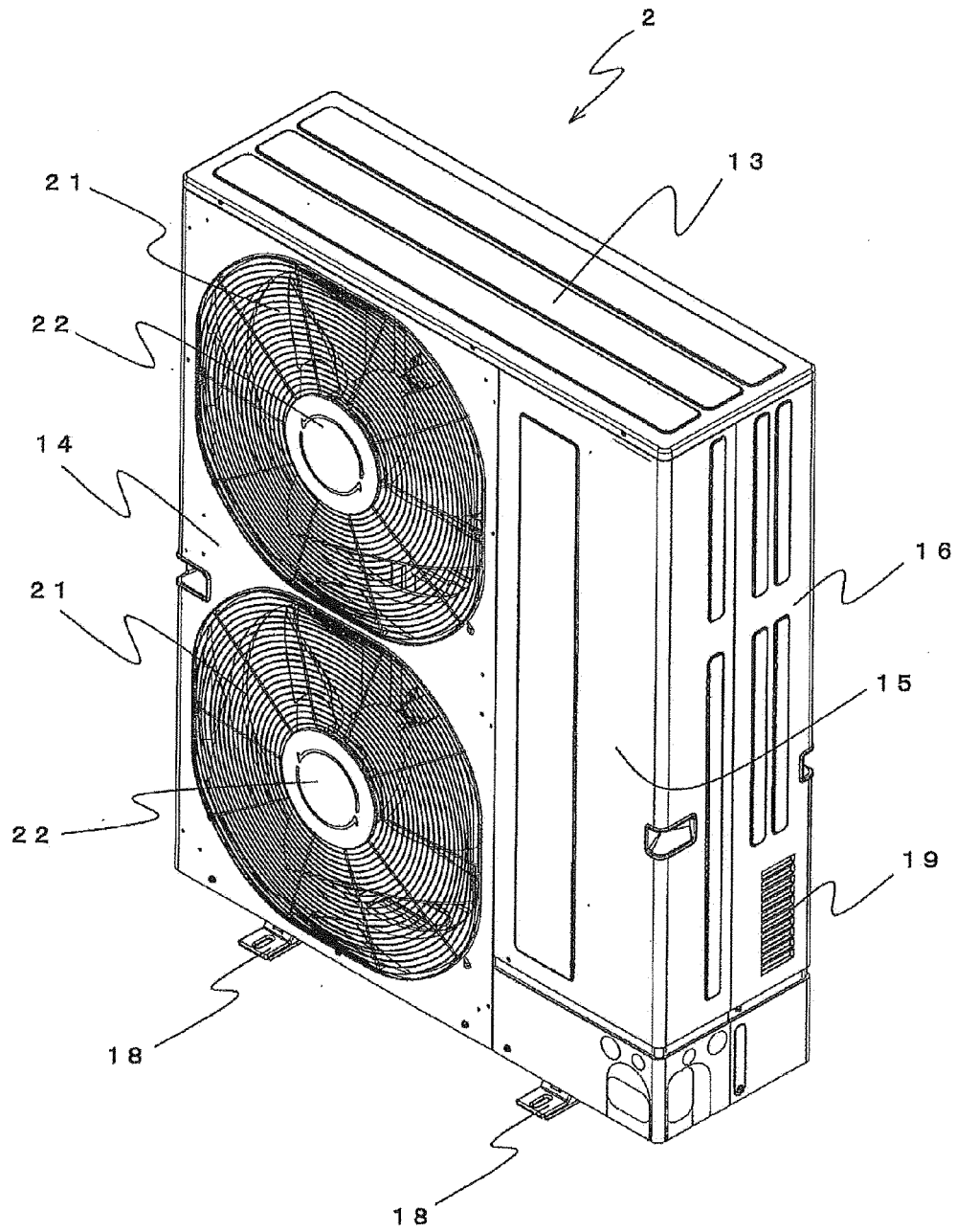


FIG. 3

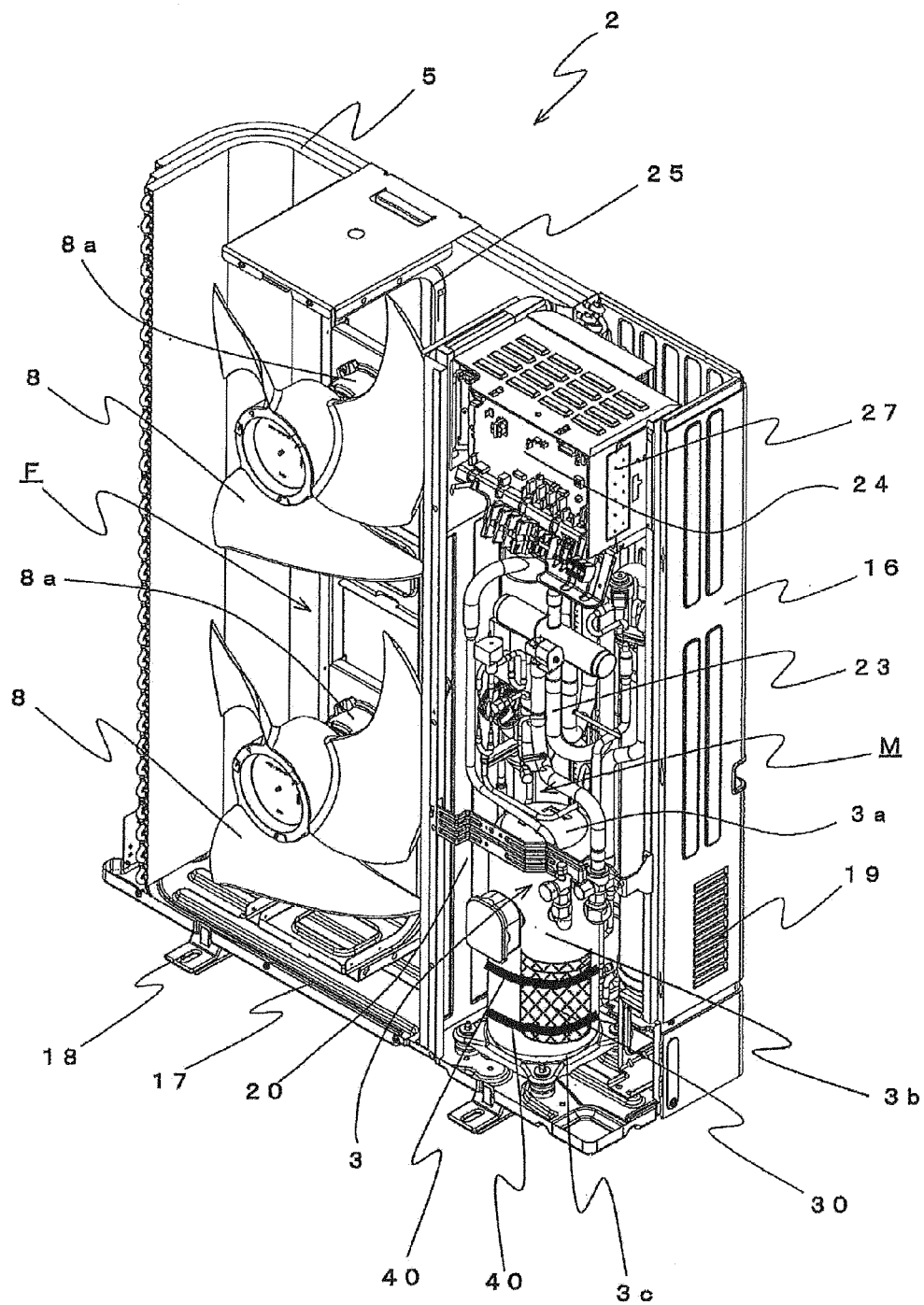


FIG. 4

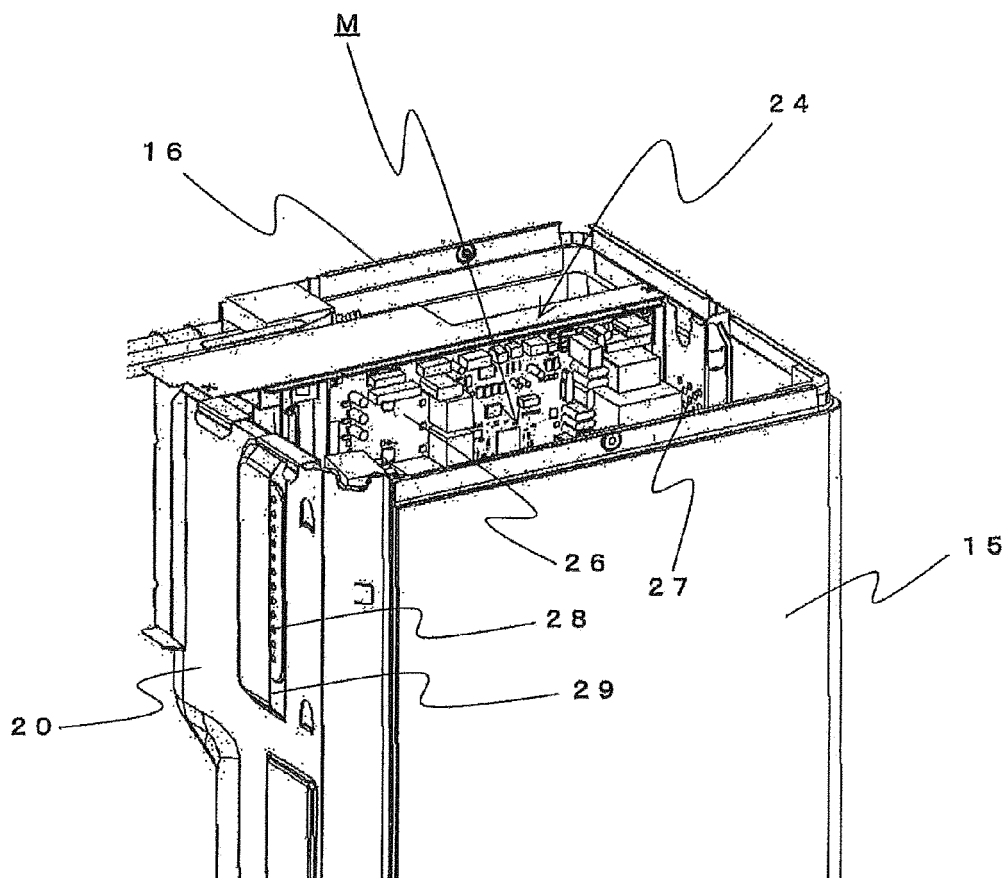


FIG. 5

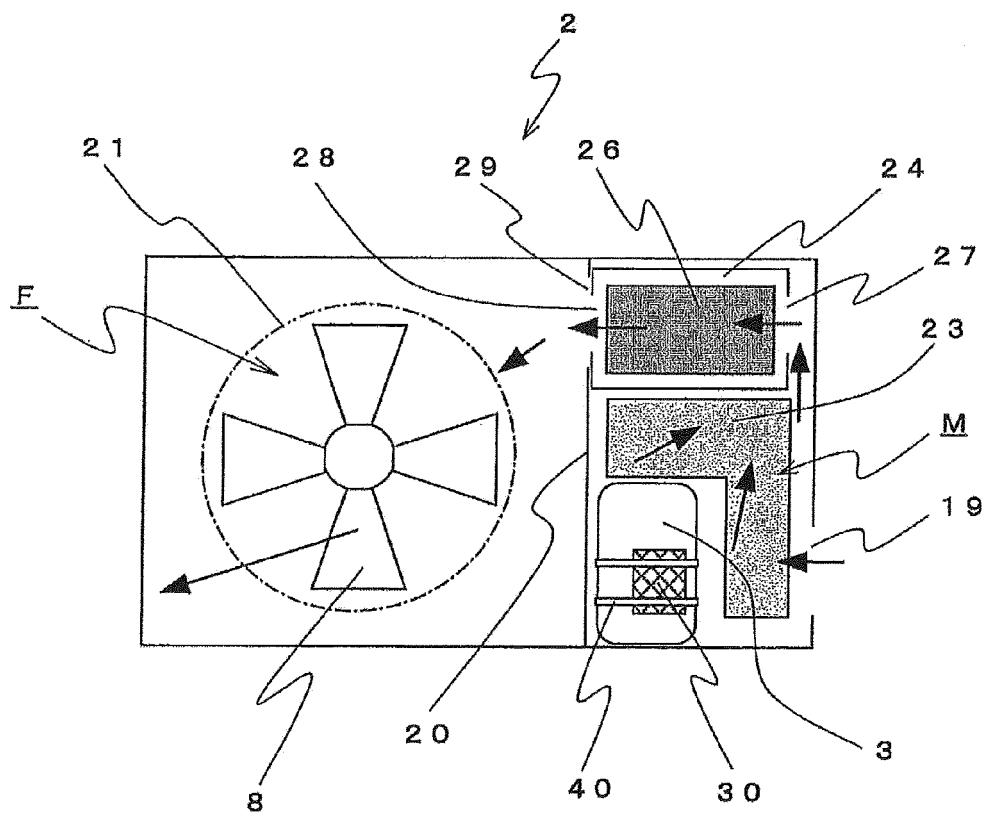


FIG. 6

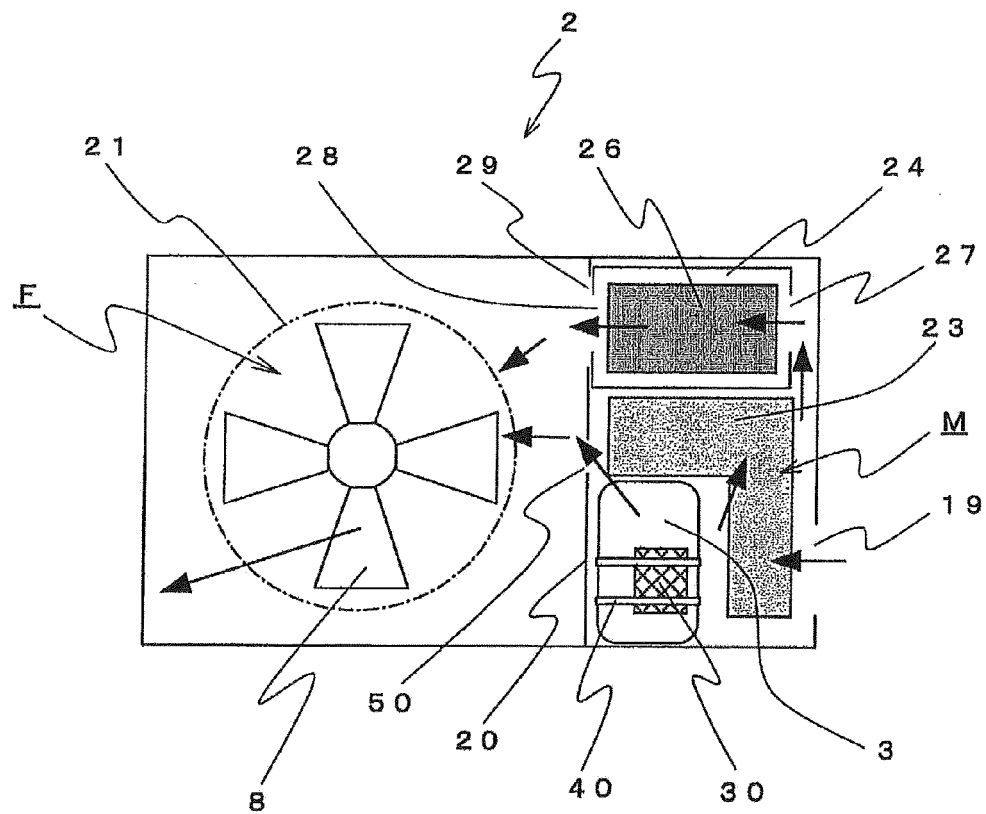


FIG. 7

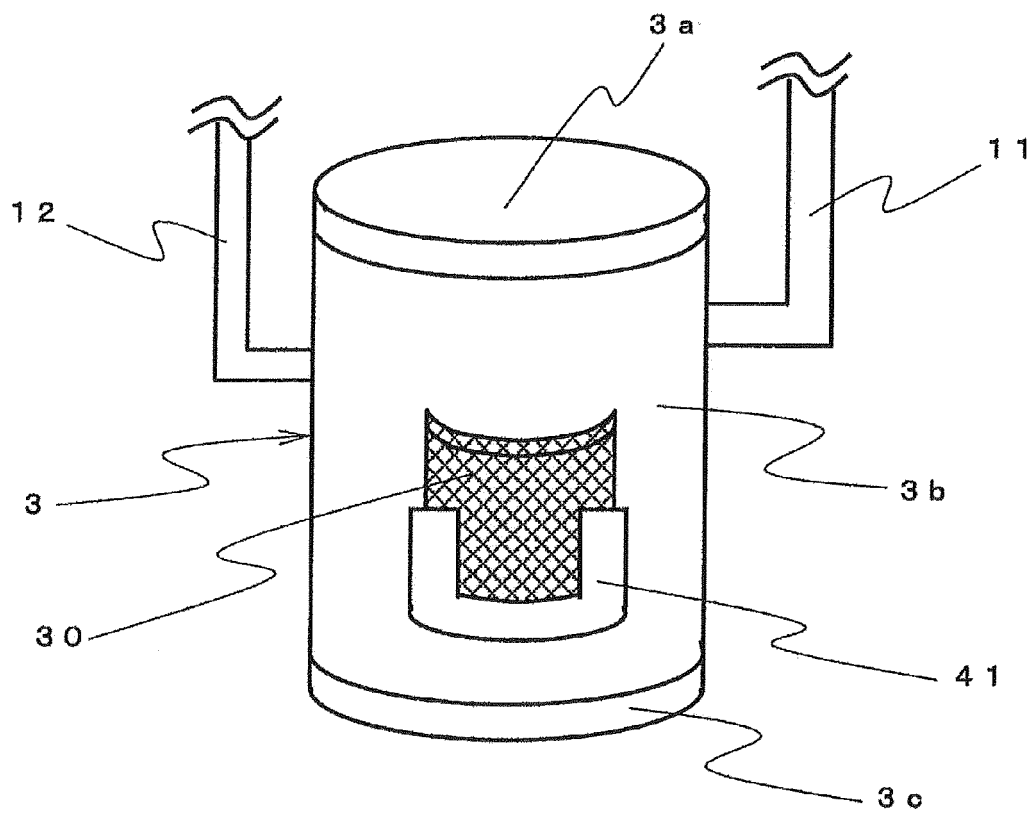


FIG. 8

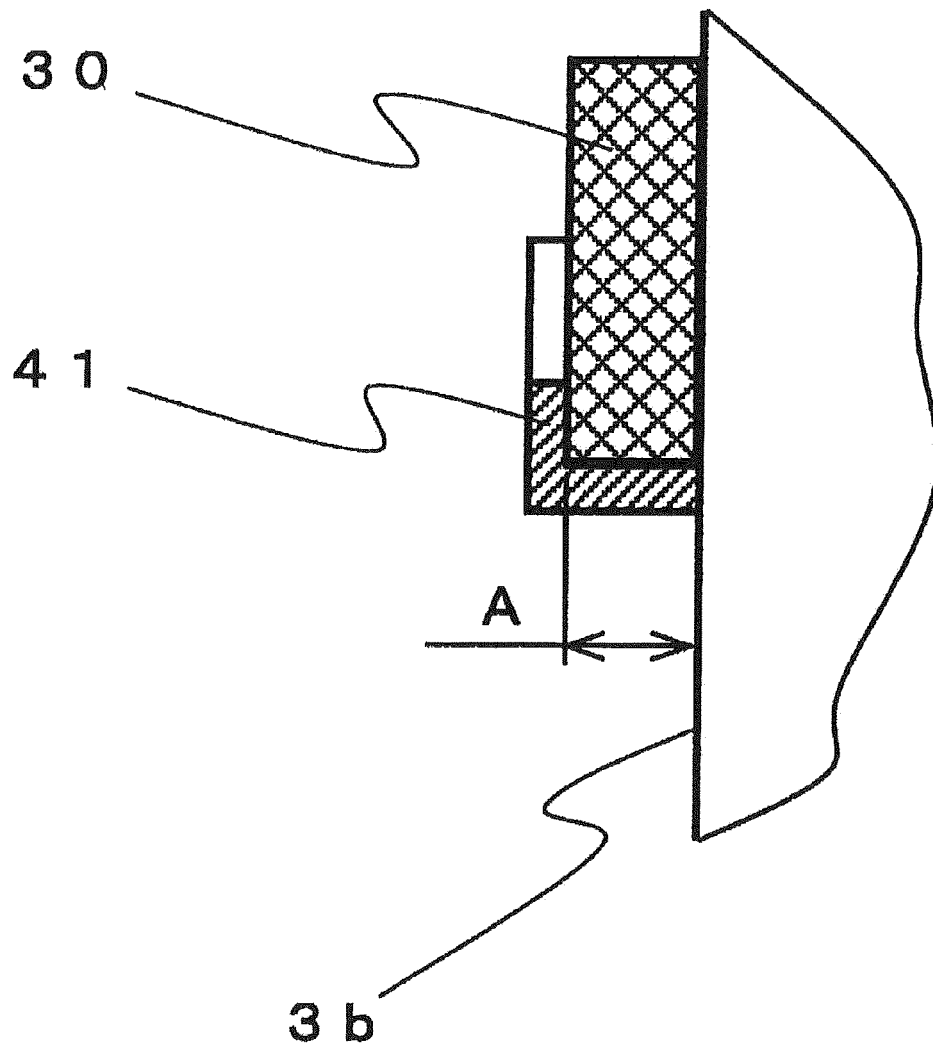


FIG. 9

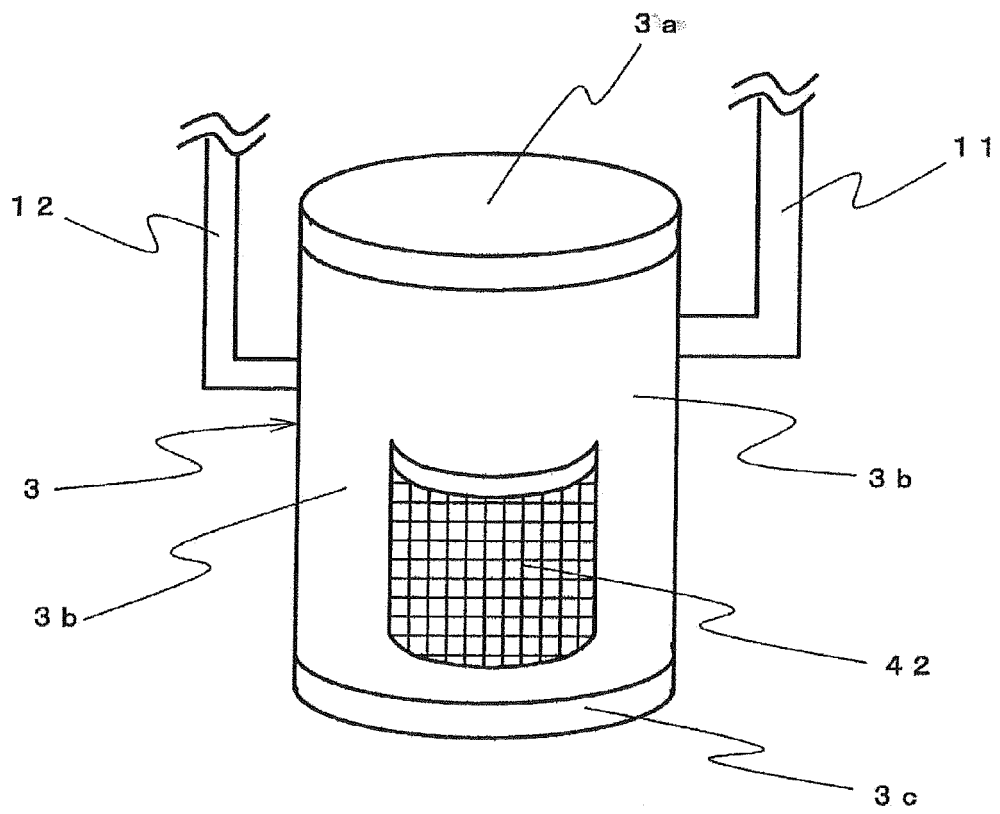


FIG. 10

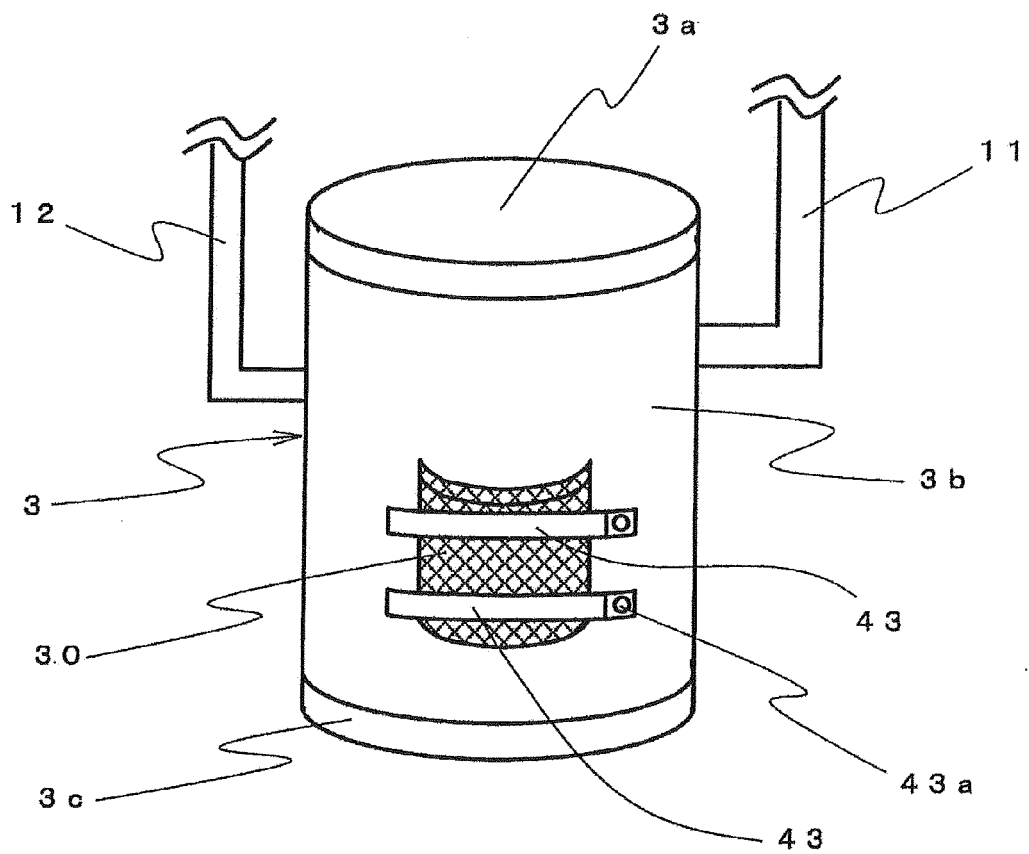


FIG. 11

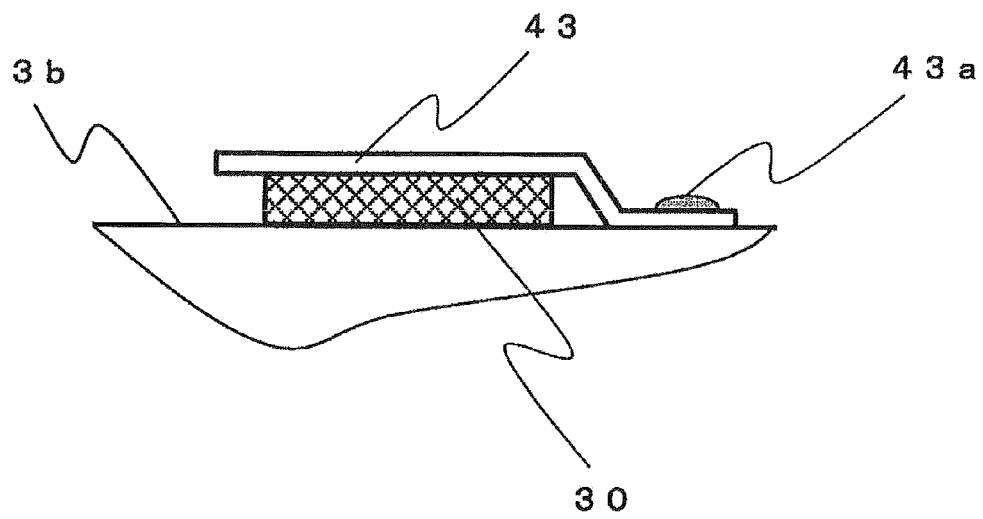


FIG. 12

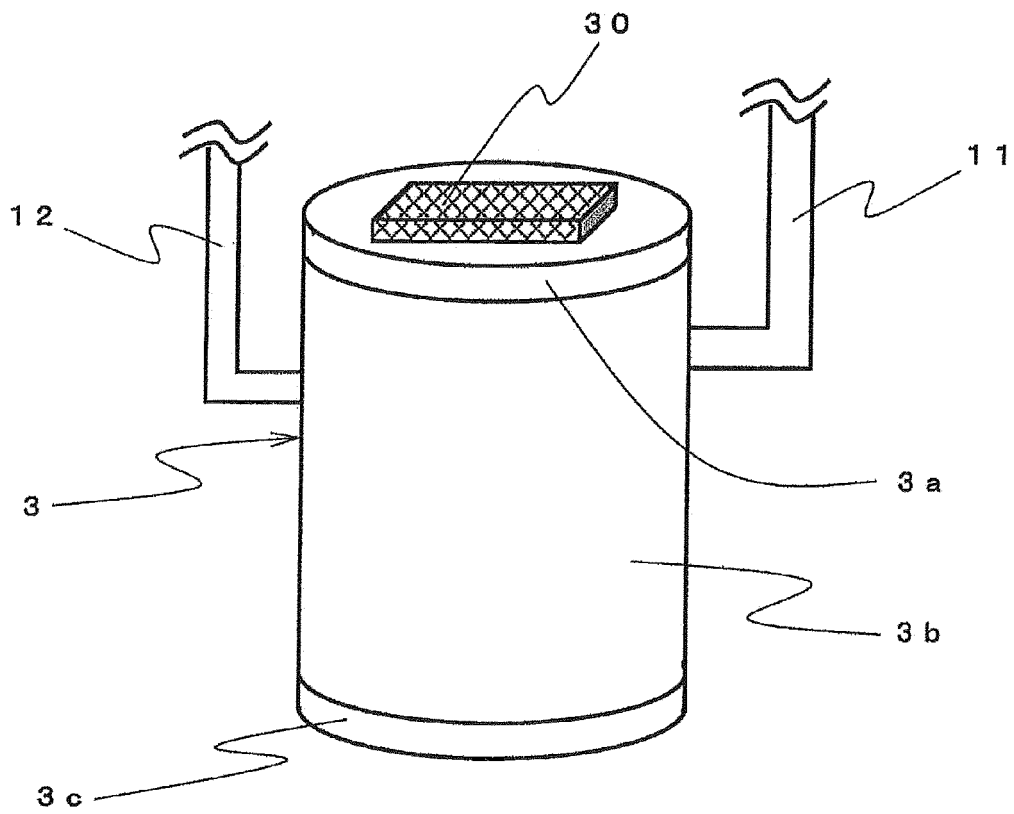


FIG. 13

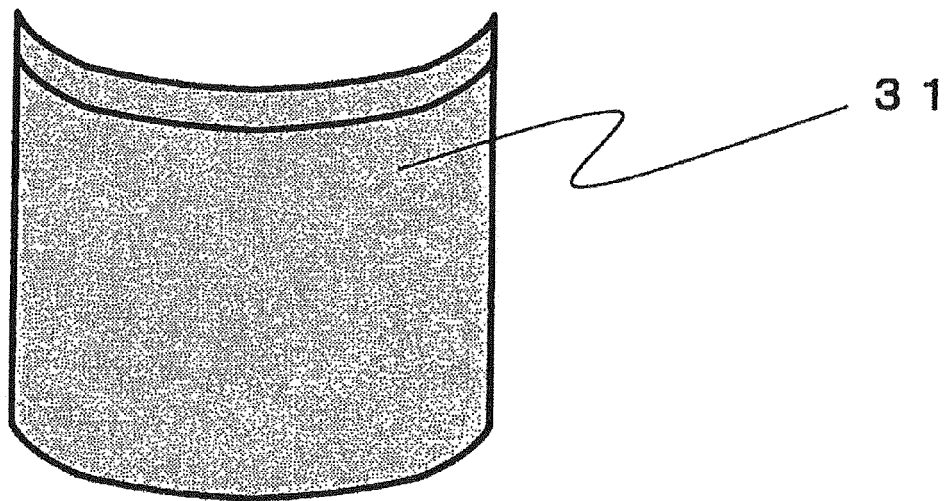
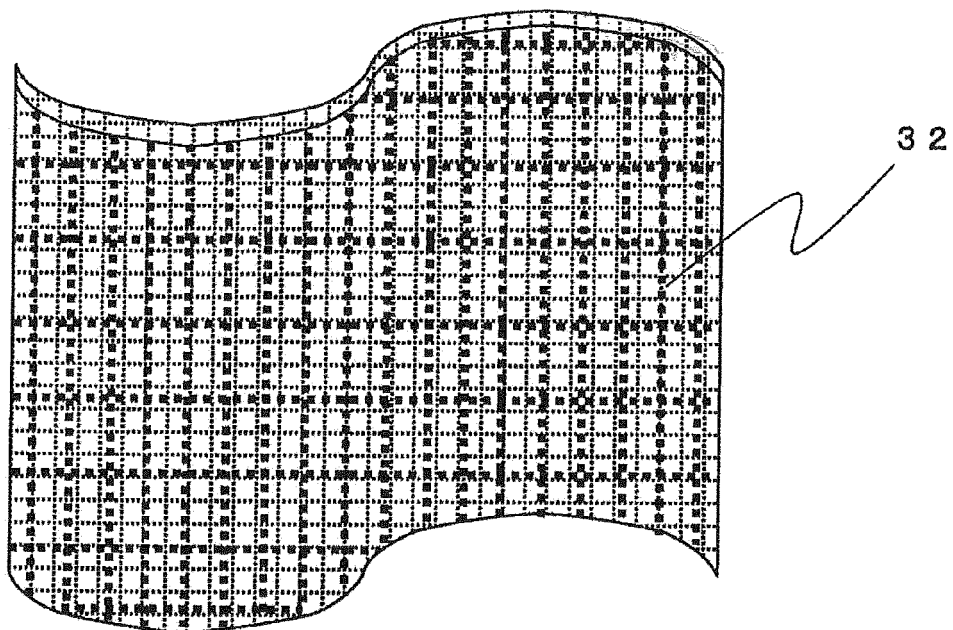


FIG. 14



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000105003 A [0006]