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(72) Inventors:
• **YAMATANI, Takahiro**
Tokyo 100-8310 (JP)
• **MORIMOTO, Hiroyuki**
Tokyo 100-8310 (JP)

(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner GbR**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(54) **INDOOR DEVICE AND AIR CONDITIONING DEVICE COMPRISING SAME**

(57) An electric component box 30 is disposed at a position such that a bottom surface E1 of the electric component box 30 is higher than a bottom surface E2 of a housing 10a by not less than one third of a height of the housing. A controller 50 and an electric component (relay) 33 are disposed at positions such that bottom surfaces E4 and E5 of the controller 50 and the electric component 33 are higher than a bottom surface E3 of the electric component box 30 by not less than one third of a height of the electric component box 30.

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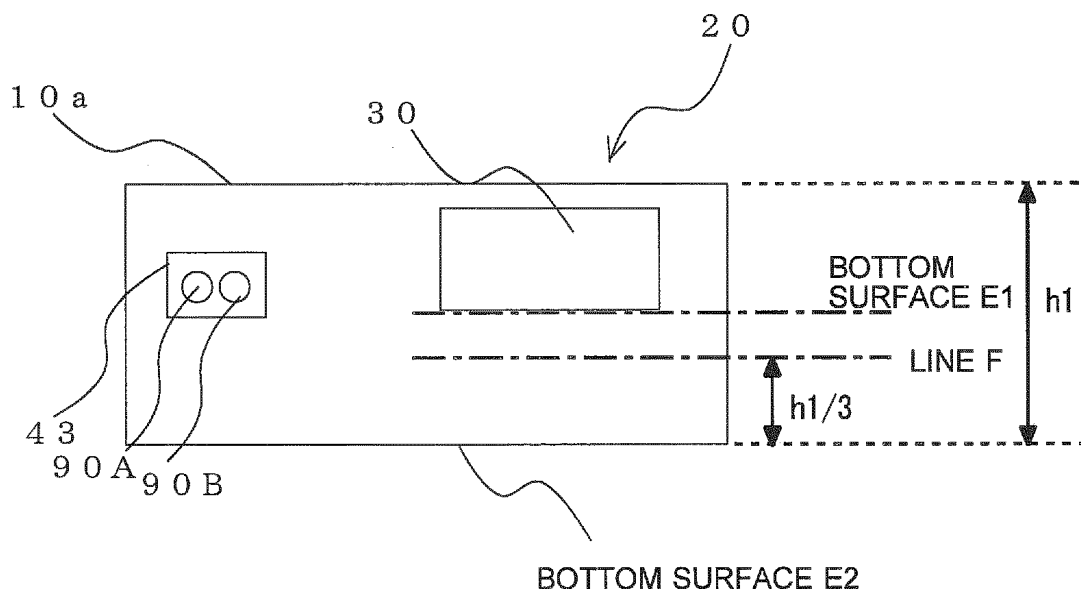
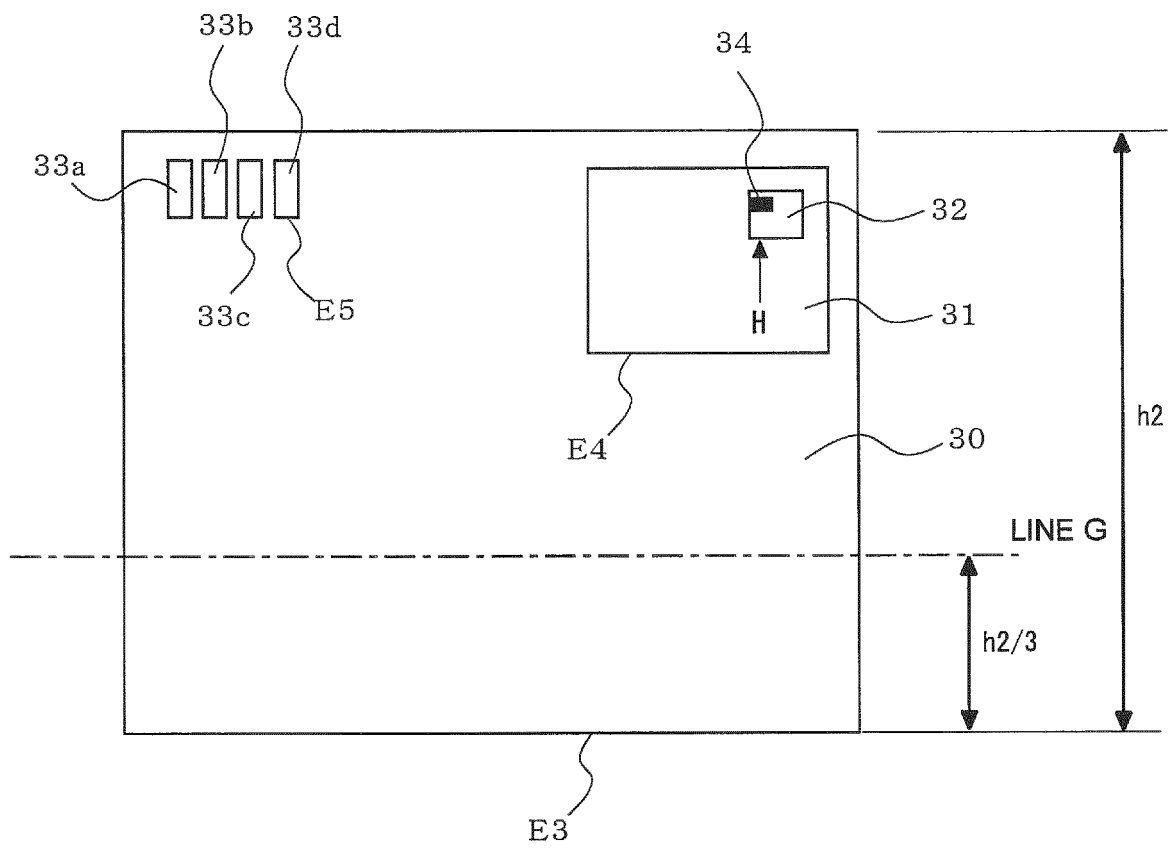


FIG. 8



Description

Technical Field

[0001] The present invention relates to an indoor unit applied to, for example, a multi-air-conditioning apparatus for a building and to an air-conditioning apparatus including the indoor unit.

Background Art

[0002] In a conventional air-conditioning apparatus such as a multi-air-conditioning apparatus for a building, for example, refrigerant is circulated between an outdoor unit serving as a heat source unit disposed outside the building and an indoor unit disposed inside the building. In such an air-conditioning apparatus, an air-conditioning target space is cooled or heated by air that is heated or cooled by heat transfer or heat receiving of the refrigerant.

[0003] In the indoor unit of such an air-conditioning apparatus, multiple electrical components, such as a motor of an indoor air-sending device, are mounted. In addition, to operate these electric components, an inverter device and a substrate are disposed in the indoor unit while being stored in an electric component box. The electric component box has a slit or a hole provided in an upper or lower surface, or includes a large heat sink. This provides a structure in which air flows into the electric components to suppress the temperature rise due to the electronic components in the electric component box.

[0004] In recent years, there has been a move to limit the use of HFC refrigerant having high global warming potential (for example, R410A, R404A, R407C, and R134a) in view of global warming. Accordingly, there has been proposed an air-conditioning apparatus that uses refrigerant having low global warming potential (for example, R32, HFO1234yf, HFO1234ze(E), and a mixture of these refrigerants). However, all of these refrigerants having low global warming potential are flammable, and may enter the electric component box upon leakage.

[0005] To prepare for such a situation, there has been disclosed a technique of using a non-contact switch in an electric component and providing an electric component box with a film that transmits only gas (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 6-101913 (for example, [0030]-[0033], [0045])

Summary of Invention

Technical Problem

[0007] However, when the non-contact switch is provided and the film that transmits only gas is used as in the technique described in Patent Literature 1, the cost significantly increases. Further, since the films are highly susceptible to aged deterioration, it is difficult to ensure long-term reliability. For this reason, films need to be periodically replaced, and the system requires much effort and high maintenance cost.

[0008] The present invention has been made to solve the above problems, and an object of the invention is to provide an indoor unit with improved safety, suppressed cost increase and an air-conditioning apparatus including the indoor unit. Solution to Problem

[0009] An indoor unit for an air-conditioning apparatus according to the present invention is an indoor unit that forms a part of the air-conditioning apparatus using a flammable refrigerant, and includes a housing, an indoor air-sending device that takes air into the housing, a use-side heat exchanger provided within the housing such that the air is supplied thereto from the indoor air-sending device, a controller that controls at least the indoor air-sending device, and an electric component box disposed in the housing to house at least the controller and an electric component used to control a driving component that constitutes the air-conditioning apparatus. The electric component box is disposed at a position such that a bottom surface of the electric component box is higher than a bottom surface of the housing by not less than one third of a height of the housing. The controller and the electric component are disposed at positions such that bottom surfaces of the controller and the electric component are higher than the bottom surface of the electric component box by not less than one third of a height of the electric component box.

Advantageous Effects of Invention

[0010] According to the indoor unit for the air-conditioning apparatus of the present invention, the mount positions of the electric component box, and the controller and the electric component (relay) housed in the electric component box are specified. Hence, even if flammable refrigerant leaks, not only the leakage refrigerant can be considerably restricted from entering the electric component box, but also the controller and the relay are not exposed to the leakage refrigerant even if the refrigerant enters the electric component box. Therefore, according to the indoor unit of the present invention, safety is greatly improved while suppressing cost increase.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a schematic circuit configuration view illustrating an exemplary circuit configuration of an air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 2] Fig. 2 is a refrigerant circuit diagram illustrating the flow of refrigerant in a cooling operation mode of the air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 3] Fig. 3 is a refrigerant circuit diagram illustrating the flow of refrigerant in a heating operation mode of the air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 4] Fig. 4 is a circuit configuration view schematically explaining an electrical connection state of the air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 5] Fig. 5 is a schematic perspective view illustrating an outward appearance image of an indoor unit according to Embodiment of the present invention.

[Fig. 6] Fig. 6 is a side view illustrating a side surface of the indoor unit illustrated in Fig. 5, where an electric component box is mounted.

[Fig. 7] Fig. 7(a) is a cross-sectional view of the indoor unit, taken along line X-X of Fig. 5, and Fig. 7(b) is a cross-sectional view of the indoor unit, taken along line Y-Y of Fig. 5.

[Fig. 8] Fig. 8 is a schematic view schematically illustrating the arrangement of electric components in the electric component box mounted on the indoor unit according to Embodiment of the present invention.

[Fig. 9] Fig. 9 includes schematic views schematically illustrating a mount example of a wide band-gap semiconductor for forming at least a part of an element that is included in a controller mounted in the indoor unit according to Embodiment of the present invention.

Description of Embodiments

[0012] Embodiment of the present invention will be described below with reference to the drawings.

[0013] Fig. 1 is a schematic circuit configuration view illustrating an exemplary circuit configuration of an air-conditioning apparatus 100 according to Embodiment of the present invention. A detailed circuit configuration of the air-conditioning apparatus 100 will be described with reference to Fig. 1. Fig. 1 illustrates an example in which four indoor units 20 are connected. In Fig. 1 and subsequent drawings, the dimensional relationships of components are sometimes different from the actual ones. Moreover, in Fig. 1 and the subsequent drawings, components denoted by the same reference numerals correspond to the same or equivalent components. This is common through the full text of the description. Further, forms of components described in the full text of the description are mere examples, and the components are

not limited to the described forms.

[0014] As illustrated in Fig. 1, the air-conditioning apparatus 100 is configured such that an outdoor unit (heat source unit) 10 and indoor units 20 (indoor units 20a to 20d) are connected by pipes. That is, in the air-conditioning apparatus 100, a plurality of indoor units 20 are connected in parallel with the outdoor unit 10.

[0015] It is assumed that, in the air-conditioning apparatus 100, for example, R32, HFO1234yf, HFO1234ze(E), a mixture of R32 and HFO1234yf, or a mixture of R32 and HFO1234ze(E) is sealed as refrigerant. Two geometric isomers of HFO1234yf exists in, that is, a trans-isomer in which F and CF₃ are positioned symmetrically with respect to a double bond and a cis-isomer in which F and CF₃ are positioned on the same side. In Embodiment, HFO1234ze(E) is a trans-isomer. According to IUPAC nomenclature, HFO1234ze(E) is trans-1,3,3,3-tetrafluoro-1-propene.

[Outdoor Unit 10]

[0016] The outdoor unit 10 has a function of offering heating or cooling to the indoor units 20. In this outdoor unit 10, a compressor 1, an oil separator 2 for separating refrigerant and refrigerating machine oil, a flow switching device 3 such as a four-way valve, a heat-source-side heat exchanger 4, a subcooling heat exchanger 6 for enhancing performance by increasing the degree of subcooling during cooling, an expansion device 7, an accumulator 5, and an oil returning circuit 8, where the oil separator 2 and a downstream pipe of the accumulator 5 are connected, are mounted while being connected by pipes. In the outdoor unit 10, an opening and closing valve 9 and an opening and closing valve 11 are set in a high-pressure pipe and a low-pressure valve, respectively. For example, the opening and closing valve 9 and the opening and closing valve 11 are used by a worker during service. The opening and closing valve 9 and the opening and closing valve 11 may each be formed by a solenoid valve, and may be turned on/off via below-described relays 33.

[0017] The compressor 1 sucks refrigerant, compresses the refrigerant into a high-temperature and high-pressure state, and conveys the refrigerant to a refrigerant circuit. For example, the compressor 1 is preferably formed by an inverter compressor capable of capacity control. The oil separator 2 is provided on a discharge side of the compressor 1, and separates, from the refrigerant, refrigerating machine oil discharged from the compressor 1 together with the refrigerant. The refrigerating machine oil separated by the oil separator 2 is guided via the oil returning circuit 8 to a downstream side of the accumulator 5, that is, to a suction side of the compressor 1. The flow switching device 3 is provided on a refrigerant passage on the downstream side of the oil separator 2, and switches between a flow of refrigerant in a heating operation mode and a flow of refrigerant in a cooling operation mode.

[0018] The heat-source-side heat exchanger (outdoor-side heat exchanger) 4 functions as an evaporator during heating operation, functions as a radiator (or a condenser) during cooling operation, and exchanges heat between air supplied from an outdoor air sending device such as a fan (not illustrated) and the refrigerant. The accumulator 5 is provided on the suction side of the compressor 1, and accumulates excess refrigerant due to a difference between the heating operation mode and the cooling operation mode or excess refrigerant due to a transient change of operation (for example, a change in number of indoor units 20 to be operated).

[0019] The subcooling heat exchanger 6 exchanges heat between refrigerant flowing between the heat-source-side heat exchanger 4 and the opening and closing valve 9 (hereinafter sometimes referred to as main refrigerant) and refrigerant branching off between the heat-source-side heat exchanger 4 and the opening and closing valve 9 and reduced in pressure by the expansion device 7 (hereinafter sometimes referred to as bypass refrigerant), and thereby increases the degree of subcooling during cooling. That is, the subcooling heat exchanger 6 exchanges heat between the refrigerants. The bypass refrigerant is a refrigerant that branches off between the heat-source-side heat exchanger 4 and the opening and closing valve 9 and flows through a bypass 12 connected to the expansion device 7, a bypass refrigerant side of the subcooling heat exchanger 6, and an upstream side of the accumulator 5. The subcooling heat exchanger 6 may be disposed at any position that allows heat exchange between the refrigerants.

[0020] The expansion device 7 is disposed in the bypass 12, through which the bypass refrigerant flows, on an upstream side of the subcooling heat exchanger 6. The expansion device 7 reduces the pressure of the refrigerant flowing through the bypass 12, and adjusts the flow rate of bypass refrigerant flowing into the subcooling heat exchanger 6. The expansion device 7 is preferably formed by an element capable of controlling the opening degree, for example, an electronic expansion valve.

[0021] The oil returning circuit 8 is disposed to connect a lower side of the oil separator 2 and the downstream pipe of the accumulator 5. In the oil returning circuit 8, a pressure reducing means 8a formed by, for example, a capillary tube, is disposed. That is, the refrigerating machine oil separated by the oil separator 2 flows through the oil returning circuit 8, is reduced in pressure by the pressure reducing means 8a, and is then guided to the downstream side of the accumulator 5.

[Indoor Units 20]

[0022] The indoor units 20 have a function of heating or cooling an air-conditioning target space, such as the inside of a room, by refrigerant supplied from the outdoor unit 10. Each of the indoor units 20 includes at least a use-side heat exchanger (indoor-side heat exchanger) 22 and an expansion device 21, which are mounted

therein while being connected in series. Specifically, the expansion device 21 and the use-side heat exchanger 22 are arranged in order and in series in a direction from the opening and closing valve 9 to the opening and closing valve 11. Each indoor unit 20 further includes an indoor air-sending device 44 for supplying air taken in the indoor unit 20 to the use-side heat exchanger 22 (see Fig. 7), and a controller 50 (controllers 50a to 50d) for controlling, for example, the rotation speed of the indoor air-sending device 44.

[0023] Relays 33 are mounted in the outdoor unit 10. These relays 33 turn on/off a solenoid valve that is not illustrated in Fig. 1, the opening and closing valve 9, the opening and closing valve 11, etc. The relays 33 will be described with reference to Fig. 8.

[0024] The use-side heat exchanger 22 functions as a radiator (or a condenser) during heating operation, functions as an evaporator during cooling operation, exchanges heat between air supplied from the indoor air-sending device 44 such as an unillustrated fan (see Figs. 7(a) and 7(b)) and the refrigerant, and thereby generates heating air or cooling air to be supplied to the air-conditioning target space.

[0025] The expansion device 21 functions as a pressure reducing valve and an expansion valve, and expands the refrigerant by pressure reduction. The expansion device 21 is preferably formed by an element capable of changing the opening degree, for example, an electronic expansion valve. The unillustrated indoor air-sending device and the expansion device 21 are controlled by the controller 50.

[0026] Each controller 50 is mounted in the corresponding indoor unit 20, and controls various devices provided in the indoor unit 20. Controllers 50a to 50d are communicatively connected by cable or wirelessly to be able to perform cooperation control. The controllers 50 totally control the entire system of the air-conditioning apparatus 100, for example, on the basis of detection information of unillustrated detection elements and instructions from a remote control. Specifically, the controllers 50 control the driving frequency of the compressor 1, switching of the flow switching device 3, the opening degrees of the expansion devices 7 and 22, the rotation speeds of the outdoor air-sending device, which is not illustrated in Fig. 1, and the indoor air-sending devices 44, etc. That is, the controllers 50 control actuators (driving components such as compressor 1, flow switching device 3, expansion devices 7 and 22, outdoor air-sending device, and indoor air-sending devices 44).

[0027] In Embodiment, four indoor units 20 are connected as an example, and are illustrated as an indoor unit 20a, an indoor unit 20b, an indoor unit 20c, and an indoor unit 20d in order from a left side (lower side) of the plane of the drawing. In correspondence with the indoor units 20a to 20d, use-side heat exchangers 22 are also illustrated as a use-side heat exchanger 22a, a use-side heat exchanger 22b, a use-side heat exchanger 22c, and a use-side heat exchanger 22d in order from the left

side (lower side) of the plane of the drawing. Similarly, expansion devices 21 are illustrated as an expansion device 21 a, an expansion device 21 b, an expansion device 21 c, and an expansion device 21 d in order from the left side (lower side) of the plane of the drawing. The number of indoor units 20 to be connected is not limited to four.

[0028] Operation modes to be executed by the air-conditioning apparatus 100 will be described.

[Cooling Operation Mode]

[0029] Fig. 2 is a refrigerant circuit diagram illustrating the flow of refrigerant in a cooling operation mode of the air-conditioning apparatus 100. Fig. 2 illustrates an example in which all of the indoor units 20 are driven. In the cooling operation mode, the flow switching device 3 is switched such that the heat-source-side heat exchanger 4 operates as a radiator and the use-side heat exchangers 22 operate as evaporators. Specifically, the flow switching device 3 is switched such that refrigerant discharged from the compressor 1 flows into the heat-source-side heat exchanger 4. In Fig. 2, a flowing direction of the refrigerant is shown by arrows.

[0030] A low-temperature and low-pressure refrigerant is compressed by the compressor 1, and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows into the heat-source-side heat exchanger 4 via the oil separator 2 and the flow switching device 3. In the oil separator 2, refrigerating machine oil discharged from the compressor 1 together with the refrigerant is separated from the refrigerant gas. The separated refrigerating machine oil flows through the oil returning circuit 8 and is returned to a pipe on a suction side of the compressor 1. In contrast, the refrigerant gas separated by the oil separator 2 flows into the flow switching device 3.

[0031] The high-temperature and high-pressure gas refrigerant flowing in the heat-source-side heat exchanger 4 is turned into a liquid state by heat exchange with air supplied from the outdoor air-sending device, and flows out from the heat-source-side heat exchanger 4. Part of the liquid refrigerant flows into the bypass 12, and the remaining part thereof flows into the indoor units 20. The liquid refrigerant (bypass refrigerant) flowing in the bypass 12 is reduced in pressure by the expansion device 7 to become a low-pressure two-phase gas-liquid refrigerant. This low-pressure two-phase gas-liquid refrigerant flows into the subcooling heat exchanger 6, is turned into a low-pressure gas refrigerant by heat exchange with a high-pressure liquid refrigerant (main refrigerant), and then flows out from the subcooling heat exchanger 6. The main refrigerant flowing in the subcooling heat exchanger 6 is cooled by the bypass refrigerant to lower the liquid temperature thereof (to increase the degree of subcooling).

[0032] Although not illustrated, a pressure sensor and a temperature sensor are provided at an outlet of the

subcooling heat exchanger 6 in the bypass 12, and the controllers 50 adjust the opening degree of the expansion device 7 on the basis of information from these sensors so that the degree of superheat at the outlet of the subcooling heat exchanger 6 becomes about 5 degrees C.

[0033] The part of the liquid refrigerant that does not flow in the bypass 12 passes through a pipe for connecting the indoor units 20 and the outdoor unit 10, and flows out from the outdoor unit 10. Then, the part of the liquid refrigerant flows into the indoor units 20a to 20d. The refrigerant flowing in the indoor units 20a to 20d is expanded (reduced in pressure) into a low-temperature and low-pressure two-phase gas-liquid state by the expansion devices 21 a to 21 d, respectively. The two-phase gas-liquid refrigerant flows into the use-side heat exchangers 22a to 22d. The two-phase gas-liquid refrigerant flowing in the use-side heat exchangers 22a to 22d removes heat from air (indoor air) supplied from unillustrated indoor air-sending devices by exchanging heat with the air, is thereby turned into a low-pressure gas refrigerant, and flows out from the use-side heat exchangers 22a to 22d.

[0034] Although not illustrated here, in general, temperature sensors are provided at a refrigerant entrance and a refrigerant outlet of each of the use-side heat exchangers 22. The amount of refrigerant to be supplied to the use-side heat exchanger 22 is adjusted by utilizing temperature information from the temperature sensor provided at the refrigerant entrance and the refrigerant outlet of the use-side heat exchanger 22. Specifically, each controller 50 calculates the degree of subheat (refrigerant temperature at the outlet - refrigerant temperature at the entrance) on the basis of the information from the temperature sensor, determines the opening degree of the expansion device 21 so that the degree of subheat becomes about 2 to 5 degrees C, and adjusts the amount of refrigerant to be supplied to the use-side heat exchanger 22.

[0035] The low-pressure gas refrigerant flowing out of the use-side heat exchangers 22a to 22d flows out from the indoor units 20a to 20d, and flows into the outdoor unit 10 through the pipe that connects the indoor units 20 and the outdoor unit 10. The refrigerant flowing in the outdoor unit 10 passes through the flow switching device 3, and flows into the accumulator 5. The refrigerant flowing in the accumulator 5 is separated into liquid refrigerant and gas refrigerant, and the gas refrigerant is sucked into the compressor 1 again.

[0036] In such a cooling operation mode, the liquid-state refrigerant does not flow into the accumulator 5 because the degree of subheat is controlled in each of the indoor units 20. However, in a transient state or when any of the indoor units 20 is stopped, a small amount of liquid-state (a quality of about 0.95) refrigerant sometimes flows into the accumulator 5. The liquid refrigerant flowing in the accumulator 5 is evaporated and sucked into the compressor 1, or is sucked into the compressor 1 via an oil return hole (not illustrated) provided in an

outlet pipe of the accumulator 5.

[Heating Operation Mode]

[0037] Fig. 3 is a refrigerant circuit diagram illustrating the flow of refrigerant in a heating operation mode of the air-conditioning apparatus 100. Fig. 3 illustrates an example in which all of the indoor units 20 are driven. In the heating operation mode, the flow switching device 3 is switched such that the heat-source-side heat exchanger 4 operates as an evaporator and the use-side heat exchangers 22 operate as radiators. Specifically, the flow switching device 3 is switched such that refrigerant discharged from the compressor 1 flows into the use-side heat exchangers 22. In Fig. 3, a flowing direction of the refrigerant is shown by arrows.

[0038] A low-temperature and low-pressure refrigerant is compressed by the compressor 1, and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 passes through the oil separator and the flow switching device 3, flows through the pipe that connects the indoor units 20 and the outdoor unit 10, flows out from the outdoor unit 10, and flows into the indoor units 20a to 20d. The operation of the oil separator 2 is as described in conjunction with the cooling operation mode.

[0039] The high-temperature and high-pressure gas refrigerant flowing in the indoor units 20a to 20d transfers heat to air (indoor air) supplied from the unillustrated indoor air-sending devices in the use-side heat exchangers 22a to 22d by exchanging heat with the air, is turned into a liquid state, and flows out from the use-side heat exchangers 22a to 22d. This high-pressure liquid refrigerant is expanded (reduced in pressure) by the expansion devices 21 a to 21 d, is turned into a low-temperature and low-pressure two-phase gas-liquid state, and flows out from the indoor units 20a to 20d.

[0040] Although not illustrated here, in general, a temperature sensor and a pressure sensor are provided at the refrigerant outlet of each of the use-side heat exchangers 22. The amount of refrigerant to be supplied to the use-side heat exchangers 22 is adjusted by utilizing information from the temperature sensor and the pressure sensor provided at the refrigerant outlet of each of the use-side heat exchangers 22. Specifically, each controller 50 calculates the degree of subcooling (saturation temperature converted from the detected pressure of the refrigerant at the outlet side - refrigerant temperature at the outlet side) on the basis of information from these sensors, determines the opening degrees of the expansion device 21 so that the degree of subcooling becomes about 2 to 5 degrees C, and adjusts the amount of refrigerant to be supplied to the use-side heat exchanger 22.

[0041] The low-temperature and low-pressure two-phase gas-liquid refrigerant flowing out of the indoor units 20a to 20d passes through the pipe that connects the indoor units 20 and the outdoor unit 10, and flows into

the outdoor unit 10. This refrigerant flows into the heat-source-side heat exchanger 4. The low-temperature and low-pressure two-phase gas-liquid refrigerant flowing in the heat-source-side heat exchanger 4 removes heat from air supplied from the outdoor air-sending device by exchanging heat with the air, and the quality thereof gradually increases. Then, the refrigerant becomes a two-phase gas-liquid refrigerant with high quality at the outlet of the heat-source-side heat exchanger 4, and flows out from the heat-source-side heat exchanger 4. The refrigerant flowing out of the heat-source-side heat exchanger 4 passes through the flow switching device 3, and flows into the accumulator 5. The refrigerant flowing in the accumulator 5 is separated into liquid refrigerant and gas refrigerant, and the gas refrigerant is sucked into the compressor 1 again.

[Electric Configuration of Air-Conditioning Apparatus 100]

[0042] Fig. 4 is a circuit configuration view schematically illustrating an electric connection state of the air-conditioning apparatus 100. The electric configuration of the air-conditioning apparatus 100 will be described with reference to Fig. 4. A mount position of an electric component box 30 will be described in detail with reference to Figs. 5 to 7.

[0043] Each of the controllers 50a to 50d serving as the controllers 50 includes an inverter board 31 on which a rectifier 52 for converting an alternating-current voltage of a three-phase alternating-current power supply 51 into a direct-current voltage, a reactor 53 for improving the power factor, a smoothing capacitor 54, an inverter main circuit 55, a control circuit 56 for controlling the inverter main circuit 55, etc. are mounted, and is connected to a motor 57A of an indoor air-sending device 44 (see Figs. 7(a) and 7(b)).

[0044] The inverter main circuit 55 converts a direct-current power smoothed by the smoothing capacitor 54 into an alternating-current power, and includes a plurality of switching elements, for example, formed by a silicon (Si) semiconductor or a wide band-gap semiconductor. The wide band-gap semiconductor is a general term for semiconductor elements having a band gap wider than that of a silicon (Si) element, and examples thereof are gallium nitride (GaN) and a diamond element as well as silicon carbide (SiC). Each switching element in the inverter main circuit 55 performs switching operation on the basis of actuating signals (PWM signal, gate signal) sent from the control circuit 56.

[0045] The control circuit 56 is formed by, for example, a microcomputer, actually controls driving of various actuators on the basis of detection information from unillustrated detectors (for example, temperature sensor and pressure sensor) and instructions from the remote control, and executes heating operation and cooling operation. In Fig. 4, only the motor 57A of the indoor air-sending device 44 is illustrated for convenience. Not only the

switching elements, but also a diode element can be formed by a wide band-gap semiconductor.

[Mount Position of Electric Component Box 30]

[0046] Fig. 5 is a schematic perspective view illustrating an outward appearance image of each indoor unit 20 according to Embodiment. Fig. 6 is a side view illustrating a side surface of the indoor unit 20 illustrated in Fig. 5, where the electric component box 30 is mounted. Fig. 7(a) is a cross-sectional view of the indoor unit 20, taken along line X-X of Fig. 5, and Fig. 7(b) is a cross-sectional view of the indoor unit 20, taken along line Y-Y of Fig. 5. A mount position of the electric component box 30 will be described in detail with reference to Figs. 5 to 7. In Figs. 7(a) and 7(b), flows of air are shown by arrows.

[0047] As described above, the indoor units 20 form a part of the air-conditioning apparatus 100, and are connected by refrigerant pipes. Cooling energy or heating energy is supplied thereto from the outdoor unit 10 to cool or heat the air-conditioning target space. In the following description, a surface viewed from a direction of arrow A in Fig. 5 is referred to as a front surface of each indoor unit 20.

[0048] As illustrated in Figs. 5 to 7, the indoor unit 20 includes a housing 10a shaped like a substantially rectangular parallelepiped to form an outline of the indoor unit 20, the use-side heat exchanger 22, a temperature detecting means 91 for detecting the temperature of the use-side heat exchanger 22, a drain pan 95 for storing dew condensation water dripping from the use-side heat exchanger 22 and the like, the indoor air-sending device 44 for supplying air taken in the housing 10a to the use-side heat exchanger 22, a partition plate 94 for partitioning an inner space of the housing 10a, a rubber bush 92A provided on a side surface at the electric component box 30, a rubber bush 92B provided on the partition plate 94, and the expansion device 21.

[0049] In the following description, a space on a front side of the partition plate 94 and a space on a rear side of the partition plate 94, of the inner space of the housing 10a partitioned by the partition plate 94, are referred to as a space S1 and a space S2, respectively. Further, an inner space of the electric component box 30 is referred to as a space S3.

[0050] While the indoor unit 100 is of a ceiling suspended type in Embodiment, as illustrated in Figs. 5 to 7, the type of the indoor unit 106 may be not limited thereto. For example, the indoor unit 100 may be of a wall hanging type or a ceiling concealed type.

[0051] The housing 10a forms an outline of the indoor unit 20, and is shaped like a substantially rectangular parallelepiped. A front surface of the housing 10a has an air outlet 93A from which air subjected to heat exchange in the use-side heat exchanger 22 is supplied to the air-conditioning target space, and a lower surface of the housing 10a has an air inlet 93B from which air is taken into the housing 10a.

[0052] To a side surface of the housing 10a on a right side of the front surface, the electric component box 30 housing the controller 50 and so on is attached to open and close on hinges. In the side surface of the housing 10a on the right side of the front surface, a pipe take-out port 43 is open at a position closer to the front side than the electric component box 30 such that refrigerant pipes 90a and 90B for connecting the indoor unit 20 and the outdoor unit 10 are taken out therefrom. Further, the side surface of the housing 10a on the right side of the front surface has an aperture that allows the space S2 and the space S3 to communicate with each other, and the rubber bush 92A is provided in the aperture.

[0053] The use-side heat exchanger 22 is disposed in the space S1. As illustrated in Fig. 7(a), the use-side heat exchanger 22 is set in a tilting state in the housing 10a such that a front side of the use-side heat exchanger 22 is located on an upper side and a rear side of the use-side heat exchanger 22 is located on a lower side.

[0054] The use-side heat exchanger 22 is connected to the refrigerant pipe 90A serving as a pipe connected to the opening and closing valve 11 and the refrigerant pipe 90B serving as a pipe connected to the opening and closing valve 9 and the expansion device 21. The temperature detecting means 91 is disposed on a side of the use-side heat exchanger 22, the side where the electric component box 30 is provided.

[0055] The temperature detecting means 91 detects the temperature of the use-side heat exchanger 22, and is formed by, for example, a thermistor. The temperature detecting means 91 is disposed in the space S1 and on the side of the use-side heat exchanger 22 where the electric component box 30 is provided.

[0056] The temperature detecting means 91 is connected to the controller 50 by a cable. More specifically, the cable of the temperature detecting means 91 extends from the space S1 to the space S2 via the rubber bush 92B, further extends from the space S2 to the space S3 in the electric component box 30 via the rubber bush 92A, and is connected to the controller 50.

[0057] The drain pan 95 stores dew condensation water dripping from the use-side heat exchanger 22 and so on. The drain pan 95 is disposed in the space S1 and below the use-side heat exchanger 22.

[0058] The indoor air-sending device 44 supplies, to the use-side heat exchanger 22, air taken into the housing 10a through the air inlet 93B. The indoor air-sending device 44 includes at least a motor 57A composed of a stator, a rotor, and so on and a fan 57B to be rotated by the motor 57A.

[0059] The motor 57A is provided in the space S2, and the fan 57B is provided in the space S1. The motor 57A is connected to the controller 50 by a cable. More specifically, the cable of the motor 57A extends from the space S2 to the space S3 in the electric component box 30 via the rubber bush 92A, and is connected to the controller 50.

[0060] The partition plate 94 partitions the inner space

of the housing 10a into front and rear parts. That is, the partition plate 94 partitions the inner space into the space S1 and the space S2. In the space S1, the use-side heat exchanger 22, the temperature detecting means 91, the expansion device 21, a part of the refrigerant pipe 90A, a part of the refrigerant pipe 90B, the drain pan 95, and the fan 57B of the indoor air-sending device 44 are provided. In the space S2, the motor 57A of the indoor air-sending device 44 is provided.

[0061] The partition plate 94 has an aperture that allows the space S1 and the space S2 to communicate with each other such that the expansion device 21 and the controller 50 by the cable and the temperature detecting means 91 and the controller 50 are connected by the cable. The partition plate 94 is provided with the rubber bush 92B that seals the aperture.

[0062] The rubber bush 92A restricts entry of the refrigerant from the space S1 into the space S2 while ensuring a space through which the cable passes. The rubber bush 92A is provided in the aperture of the partition plate 94 that allows the space S1 and the space S2 to communicate with each other.

[0063] The rubber bush 92B restricts entry of the refrigerant from the space S2 into the space S3 while ensuring a space through which the cable passes. The rubber bush 92B is provided in the aperture of the housing 10a that allows the space S1 and the space S2 to communicate with each other.

[0064] Owing to these rubber bushes 92A and 92B, even when flammable refrigerant leaks, it can be considerably restricted from entering from the space S1 and the space S2 of the housing 10a into the space S3 of the electric component box 30.

[0065] The expansion device 21 is disposed in the space S1. The expansion device 21 is connected to the controller 50 by a cable. More specifically, the cable of the expansion device 21 extends from the space S1 to the space S2 via the rubber bush 92B, further extends from the space S2 to the space S3 in the electric component box 30 via the rubber bush 92A, and is connected to the controller 50.

[0066] The flow of air in the indoor unit 20 will be described with reference to Figs. 7(a) and 7(b). When the indoor air-sending device 44 is driven, air is sucked into the housing 10a through the air inlet 93B. The air sucked in the housing 10a passes through the use-side heat exchanger 22 disposed in the housing 10a, and exchanges heat with the refrigerant supplied to the use-side heat exchanger 22. The air that has exchanged heat in the use-side heat exchanger 22 is discharged from the air outlet 93A of the housing 10a to the outside of the indoor unit 20 by the indoor air-sending device 44. This air flow is formed by the indoor air-sending device 44, and the air flows into the housing 10a from a lower side of the paper of Fig. 7(a), and is blown toward the front of the housing 10a.

[0067] Table 1 shows refrigerant gas densities at 25 degrees C and at the atmospheric pressure (101.3 kPa

abs) of next-generation refrigerants that are now regarded as promising. Physical properties are obtained from REFPROP Version 9.0 released by NIST (National Institute of Standards and Technology).

[0068] [Table 1]

Table 1 List of Refrigerant Gas Densities

Refrigerant	Density (kg/m ³)
R32	2.1526
HFO1234yf	4.7654
HFO1234ze(E)	4.7738

[0069] Table 1 shows that the gas densities of the next-generation refrigerants that are now regarded as promising are higher than an air density of 1.2 (kg/m³). The next-generation refrigerants that are now regarded as promising are R32, HFO1234yf, and HFO1234ze(E), as listed in Table 1. This means that the refrigerants listed in Table 1 are heavier than air and are likely to stagnate at the bottom of the indoor unit 20 upon leakage from the outdoor unit 10. This shows that the electric component box 30, which houses electric components that may become ignition sources, should be disposed at as high a position as possible on the housing 10a.

[0070] For example, when it is assumed that any refrigerant shown in Table 1 leaks in an indoor unit that is now widely spread, it is known that the leakage refrigerant stays at a height up to about 10 cm from the bottom surface of the indoor unit. This shows that the electric component box 30 should be disposed at a height of more than 10 cm from the bottom surface of the indoor unit.

[0071] Here, the height of the indoor unit 20 is more than 30 cm. For this reason, as illustrated in Fig. 6, the electric component box 30 is disposed on the indoor unit 20 such that a bottom surface E1 of the electric component box 30 is positioned higher than a bottom surface E2 of the housing 10a by not less than one third of a height h1 of the housing 10a (line F in Fig. 6). This can prevent the electric component box 30 from being exposed to an area, where the density is higher than the lower explosion limit density, by leakage of the refrigerant while suppressing deterioration of maintenance performance and operability for the user due to too low a mount position of the electric component box 30.

[Arrangement of Electric Components in Electric Component Box 30]

[0072] Fig. 8 is a schematic view schematically illustrating the arrangement of the electric components in the electric component box 30. The arrangement of the electric components in the electric component box 30 will be described with reference to Fig. 8. As described above, the electric component box 30 houses the controller 50 serving as an electric component. The controller 50 in-

cludes the inverter board 31. The electric component box 30 further houses electric components, such as relays 33a to 33d for turning on/off a solenoid valve that is not illustrated in Figs. 1 to 3, the opening and closing valve 9, and the opening and closing valve 11, as well as the controller 50. The controller 50 performs control to change the rotation speed of a motor of the compressor 1 from several hertz to several hundred hertz.

[0073] A wide band-gap semiconductor is used for a part of an electric component that constitutes the inverter board 31, as described above. In Fig. 8, a wide band-gap semiconductor mounted on the inverter board 31 is illustrated as a wide band-gap semiconductor 32 for convenience. As described above, the wide band-gap semiconductor 32 is formed by, for example, a gallium nitride (GaN) element or a diamond element as well as a silicon carbide (SiC) element.

[0074] A semiconductor element formed by the wide band-gap semiconductor 32 (for example, the inverter main circuit 55 illustrated in Fig. 4) can endure high temperature because it has high heat resistance. For this reason, a slit or a hole that conducts air for suppressing the temperature rise in the electric component box 30 is unnecessary, and a structure such that ambient air is unlikely to enter can be obtained.

[0075] Accordingly, the electric component box 30 is formed by a non-flammable material such as sheet metal, and adopts a structure in which a cover of the electric component box 30 can be removed with a screwdriver or the like from the right side of the housing 10a with respect to the front side in order to cope with service such as connection of wires and replacement of electric components. The aperture is provided to allow the space S3 in the electric component box 30 and the space S2 in the housing 10a to communicate with each other, and this aperture is sealed with the rubber bush 92A. That is, the electric component box 30 has a structure such that ambient air is unlikely to enter the space S3 in the electric component box 30.

[0076] By giving such a structure to the electric component box 30, even if the refrigerant leaks, it can be considerably restricted from entering the electric component box 30, and this can further enhance safety. That is, as described above, the electric component box 30 is disposed such that the bottom surface E1 of the electric component box 30 is positioned higher than the bottom surface E2 of the housing 10a by not less than one third of the height h1 of the housing 10a. This arrangement itself serves as measures against entry of the refrigerant. In addition thereto, the electric component box 30 adopts the structure such that ambient air is unlikely to enter, and thereby further strengthens the measures against entry of the refrigerant. Even when the electric component box 30 adopts such a structure where ambient air is unlikely to enter, since the wide band-gap semiconductor 32 with high heat resistance is used, the temperature rise in the electric component box 30 can be suppressed only by heat transfer from the electric component

box 30 to the surroundings.

[0077] Since the wide band-gap semiconductor 32 has high heat resistance and is operable at high temperature, a fanless structure or a structure without radiating-fins (or a structure having a downsized radiating fin) can be adopted. This allows the electric component box 30 to have a substantially sealed structure. Further, since the switching element or the diode element formed by the wide band-gap semiconductor 32 has high voltage resistance and high allowable current density, the switching element can be miniaturized, and the size of a semiconductor module in which these elements are incorporated can be reduced. Still further, since the wide band-gap semiconductor 32 has low power loss, efficiency of the switching element can be enhanced, and also efficiency of the semiconductor module can be enhanced.

[0078] As illustrated in Fig. 8, in the electric component box 30, electric components, such as the relays 33a to 33d that may become ignition sources and the wide band-gap semiconductor 32 whose temperature becomes high, are disposed at as high positions as possible. Accordingly, the electric components are disposed in the electric component box 30 such that bottom surfaces E4 and E5 of the electric components are higher than a bottom surface E3 of the electric component box 30 by not less than one third of a height h2 of the electric component box 30 (line G in Fig. 8). In this case, even if the refrigerant leaks, the electric components are not exposed to the area with a density higher than the lower explosion limit density. According to such arrangement, even if the leakage refrigerant enters from a clearance of the electric component box 30, it stays in the lower part of the electric component box 30. Hence, safety is enhanced further.

[0079] When it is assumed that any refrigerant shown in Table 1 enters an electric component box that is now widely spread, it is known that the entering refrigerant stays at a height up to about several ten centimeters from the bottom surface of the electric component box. According to this, it is only necessary that the electric components should be disposed at a height of more than several ten centimeters from the bottom surface of the electric component box. However, in the outdoor unit 10, the electric components are disposed, in consideration of not only safety but also maintenance performance and operability, such that the bottom surfaces E4 and E5 of the electric components are higher than the bottom surface E3 of the electric component box 30 by not less than one third of the height h2 of the electric component box 30.

[Suppression of Temperature Rise of Wide Band-Gap Semiconductor 32]

[0080] Fig. 9 includes schematic views schematically illustrating a setting example of the wide band-gap semiconductor 32. With reference to Fig. 9, a description will be given of a case in which safety is further enhanced by suppressing the temperature rise of the wide band-

gap semiconductor 32. Fig. 9(a) is a front transparent view of the wide band-gap semiconductor 32 and a temperature sensor 34, and Fig. 9(b) is a view of the wide band-gap semiconductor 32 and the temperature sensor 34, as viewed from a direction H in Fig. 8.

[0081] Table 2 shows ignition temperatures of the next-generation refrigerants that are now regarded as promising.

[Table 2]

Table 2 List of Ignition Temperatures of Refrigerants

Refrigerant	Ignition temperature (degrees C)
R32	648
HFO1234yf	405
HFO1234ze(E)	288-293

[0082] The ignition temperature shown in Table 2 is a temperature at which the refrigerant itself ignites. That is, when the temperature of the wide band-gap semiconductor 32 becomes not less than the temperature shown in Table 2 and the density of the refrigerant becomes not less than the lower explosion limit density, the refrigerant may ignite. This shows that the surface temperature of the wide band-gap semiconductor 32, whose temperature becomes the highest among the electric components in the electric component box 30, must be less than the ignition temperature of the refrigerant used in the air-conditioning apparatus 100.

[0083] Accordingly, the temperature sensor 34 is preferably in contact with the surface of the wide band-gap semiconductor 32 to appropriately detect the temperature of the wide band-gap semiconductor 32. As long as the temperature of the wide band-gap semiconductor 32 can be appropriately detected, the temperature rise of the wide band-gap semiconductor 32 can be suppressed efficiently. For example, the temperature sensor 34 can be stuck into contact with the surface of the wide band-gap semiconductor 32 with a thermally conductive adhesive. Alternatively, as illustrated in Fig. 9, the temperature sensor 34 and the wide band-gap semiconductor 32 can be made in contact with each other with an attachment 35 and stoppers 36.

[0084] A thermistor is preferably used as the temperature sensor 34. Alternatively, another temperature sensor, such as a thermocouple, may be used as the temperature sensor 34. The materials, shapes, sizes, numbers, etc. of the attachment 35 and the stoppers 36 are not limited to the illustrated ones, and it is only necessary that the attachment 35 and the stoppers 36 should be structured such that the wide band-gap semiconductor 32 and the temperature sensor 34 can be made in contact with each other.

[0085] A description will be given of an operation for suppressing the temperature rise of the wide band-gap

semiconductor 32. When the temperature sensor 34 detects that the surface temperature of the wide band-gap semiconductor 32 is a predetermined temperature, the controller 50 stops the operation of the air-conditioning apparatus 100. Alternatively, the controller 50 decreases the rotation speed of the compressor 1. This control can restrict the wide band-gap semiconductor 32 from further generating heat, and can suppress the temperature rise of the wide band-gap semiconductor 32.

[0086] If the heat generation temperature of the wide band-gap semiconductor 32 does not fall below the predetermined temperature even when this control is executed, the controller 50 completely stops the air-conditioning apparatus 100. That is, the controller 50 executes control to suppress the temperature rise of the wide band-gap semiconductor 32 when the temperature of the wide band-gap semiconductor 32 reaches a predetermined temperature (suppression control start temperature) used for a condition for starting the control for suppressing the temperature rise of the wide band-gap semiconductor 32. By executing such control, the risk at the time of leakage of the refrigerant can be further reduced, and the air-conditioning apparatus 100 with greatly improved safety can be provided. When such control is executed, it is better to inform the outside of the control by voice or display.

[0087] Next, the predetermined temperature (suppression control start temperature) will be described. The suppression control start temperature serves as the predetermined temperature used for the condition for starting the suppression control of the temperature rise of the wide band-gap semiconductor 32, and needs to be determined in consideration of, for example, variations of the thermistor and attachment variations of the thermistor and the wide band-gap semiconductor. Further, the ignition temperature of the refrigerant also changes according to the humidity and temperature around the refrigerant. That is, when the predetermined temperature is set to be equal to the ignition temperature, it can be supposed that the suppression control for the temperature rise of the wide band-gap semiconductor 32 is sometimes executed and is sometimes not executed depending on the conditions.

[0088] For this reason, the predetermined temperature needs to be set with a large margin. From such a background, in the air-conditioning apparatus 100, the predetermined temperature is set at "ignition temperature of used refrigerant - about 100 degrees C" in consideration of all environmental influences, age-related degradation, individual variations, etc. While the predetermined temperature can be changed according to the used refrigerant, it is preferably set on the basis of HFO1234ze(E), whose ignition temperature is the lowest among the refrigerants listed in Table 2, in consideration of versatility. In this case, the predetermined temperature is about 188 degrees C.

[0089] Although the wide band-gap semiconductor 32 surely has high heat resistance, the possibility that the

wide band-gap semiconductor 32 gets out of order increases at 200 degrees C or more. Accordingly, to ensure safety and to ensure reliability of the wide band-gap semiconductor 32, the predetermined temperature is set at about 150 degrees C. In this case, reliability of the wide band-gap semiconductor 32 as well as safety is ensured, and this greatly enhances reliability of the air-conditioning apparatus 100.

[Advantageous Effects of Indoor Units 20 and Air-Conditioning Apparatus 100]

[0090] Since the mount position of the electric component box 30 is specified in each indoor unit 20 of the air-conditioning apparatus 100 according to Embodiment, even if flammable refrigerant leaks, the leakage refrigerant can be considerably restricted from entering the electric component box 30. Therefore, according to the indoor unit 20 of the air-conditioning apparatus 100 of Embodiment, safety can be improved greatly.

[0091] Since the mount positions of the electric components provided in the electric component box 30 are specified in the indoor unit 20 of the air-conditioning apparatus 100 according to Embodiment, even if flammable refrigerant enters the electric component box 30, the electric components are not exposed to an area with a density exceeding the lower explosion limit density.

[0092] In the indoor unit 20 of the air-conditioning apparatus 100 according to Embodiment, the housing 10a is provided with the rubber bush 90A and the partition plate 94 is provided with the rubber bush 90B. For this reason, even if flammable refrigerant leaks, it can be considerably restricted from flowing from the space S1 and the space S2 of the housing 10a into the space S3 in the electric component box 30. Therefore, according to the indoor unit 20 of the air-conditioning apparatus 100 of Embodiment, safety can be improved greatly.

[0093] In the indoor unit 20 of the air-conditioning apparatus 100 according to Embodiment, the wide band-gap semiconductor 32 is used in a part of the inverter board 31, high heat resistance and high reliability can be ensured.

[0094] In the indoor unit 20 of the air-conditioning apparatus 100 according to Embodiment, since the wide band-gap semiconductor 32 is used in a part of the inverter board 31, a fanless structure or a structure without radiating-fins (or a structure having a downsized radiating fin) can be adopted, and the electric component box 30 can have a substantially sealed structure. Thus, even if an outside fire is caused for the indoor unit 20 in the ceiling by an electric component of, for example, an adjacent lighting device installed in the ceiling, the electric component box 30 with the sealed structure can prevent the fire from spreading owing to the catch of the fire.

[0095] Since the air-conditioning apparatus 100 according to Embodiment includes the indoor unit 20, it can have greatly improved safety and reliability, similarly to the indoor unit 20.

Reference Signs List

[0096] 1: compressor, 2: oil separator, 3: flow switching device, 4: heat-source-side heat exchanger, 5: accumulator, 6: subcooling heat exchanger, 7: expansion device, 8: oil returning circuit, 8a: pressure reducing means, 9: opening and closing valve, 10: outdoor unit, 10a: housing, 11: opening and closing valve, 12: bypass, 20: indoor unit, 20a to 20d: indoor unit, 21: expansion device, 21 a to 21 d: expansion device, 22: use-side heat exchanger, 22a to 22d: use-side heat exchanger, 30: electric component box, 31: inverter board, 32: wide band-gap semiconductor, 33: relay, 33a to 33d: relay, 34: temperature sensor, 35: attachment, 36: stopper, 43: pipe take-out port, 44: indoor air-sending device, 50: controller, 50a to 50d: controller, 51: three-phase alternating-current power supply, 52: rectifier, 53: reactor, 54: smoothing capacitor, 55: inverter main circuit, 56: control circuit, 57A: motor, 57B: fan, 90A, 90B: refrigerant pipe, 91: temperature detecting means, 92A: rubber bush (first rubber bush), 92B: rubber bush (second rubber bush), 93A: air outlet, 93B: air inlet, 94: partition plate, 95: drain pan, 100: air-conditioning apparatus, S1: space (first space), S2: space (second space), S3: space.

Claims

1. An indoor unit that forms a part of an air-conditioning apparatus using a flammable refrigerant, the indoor unit comprising:
 - a housing,
 - an indoor air-sending device that takes air into the housing,
 - a use-side heat exchanger provided within the housing such that the air is supplied thereto from the indoor air-sending device,
 - a controller that controls at least the indoor air-sending device, and
 - an electric component box disposed in the housing to house at least the controller and an electric component used to control a driving component that constitutes the air-conditioning apparatus, wherein the electric component box is disposed at a position such that a bottom surface of the electric component box is higher than a bottom surface of the housing by not less than one third of a height of the housing, and
 - wherein the controller and the electric component are disposed at positions such that bottom surfaces of the controller and the electric component are higher than the bottom surface of the electric component box by not less than one third of a height of the electric component box.
2. The indoor unit of claim 1, further comprising:

- temperature detecting means provided in the use-side heat exchanger to detect a temperature of the use-side heat exchanger; an expansion device provided within the housing; and a partition plate standing within the housing, wherein the indoor air-sending device includes a fan and a motor that rotates the fan, and wherein the partition plate separates a first space in which the use-side heat exchanger, the temperature detecting means, the expansion device, and the fan are provided, from a second space in which the motor is provided.
3. The indoor unit of claim 2, wherein a side surface of the housing where the electric component box is provided is provided with a first rubber bush that seals the second space and an inside of the electric component box, wherein the partition plate is provided with a second rubber bush that seals the first space and the second space, wherein the controller is connected to the temperature detecting means and the expansion device via the second rubber bush and the first rubber bush, and wherein the controller is connected to the indoor air-sending device via the first rubber bush.
 4. The indoor unit of claims 1 to 3, wherein at least a part of an element that constitutes the controller is formed by a wide band-gap semiconductor.
 5. The indoor unit of claim 4, further comprising:
 - another temperature detecting means that detects a temperature of the wide band-gap semiconductor, wherein the another temperature detecting means is disposed in contact with a surface of the wide band-gap semiconductor.
 6. The indoor unit of claim 5, wherein the controller stops operation of the air-conditioning apparatus when the another temperature detecting means detects a predetermined temperature set beforehand.
 7. The indoor unit of any one of claim 6, wherein the predetermined temperature is set to be not less than 150 degrees C.
 8. The indoor unit of any one of claims 4 to 7, wherein the wide gap semiconductor is formed by at least one of a silicon carbide element, a gallium nitride element, and a diamond element.
 9. The indoor unit of any one of claims 1 to 8, wherein R32 is used as the flammable refrigerant.
 10. The indoor unit of any one of claims 1 to 8, wherein HFO1234yf is used as the flammable refrigerant.
 11. The indoor unit of any one of claims 1 to 8, wherein HFO1234ze(E) is used as the flammable refrigerant.
 12. The indoor unit of any one of claims 1 to 8, wherein a mixed refrigerant of R32 and HFO1234yf is used as the flammable refrigerant.
 13. The indoor unit of any one of claims 1 to 8, wherein a mixed refrigerant of R32 and HFO1234ze(E) is used as the flammable refrigerant.
 14. An air-conditioning apparatus comprising:
 - the indoor unit of any one of claims 1 to 13; and
 - an outdoor unit including a compressor and a heat-source-side heat exchanger and connected to the indoor unit by a refrigerant pipe.
 15. The air-conditioning apparatus of claim 14 as dependent on claim 5, wherein the controller decreases a rotation speed of the compressor from a current rotation speed when the another temperature detecting means detects a predetermined temperature set beforehand.
 16. The air-conditioning apparatus of claim 15, wherein the controller stops operation of the air-conditioning apparatus when the temperature of the wide band-gap semiconductor does not become lower than the predetermined temperature after a predetermined time elapses.

FIG. 1

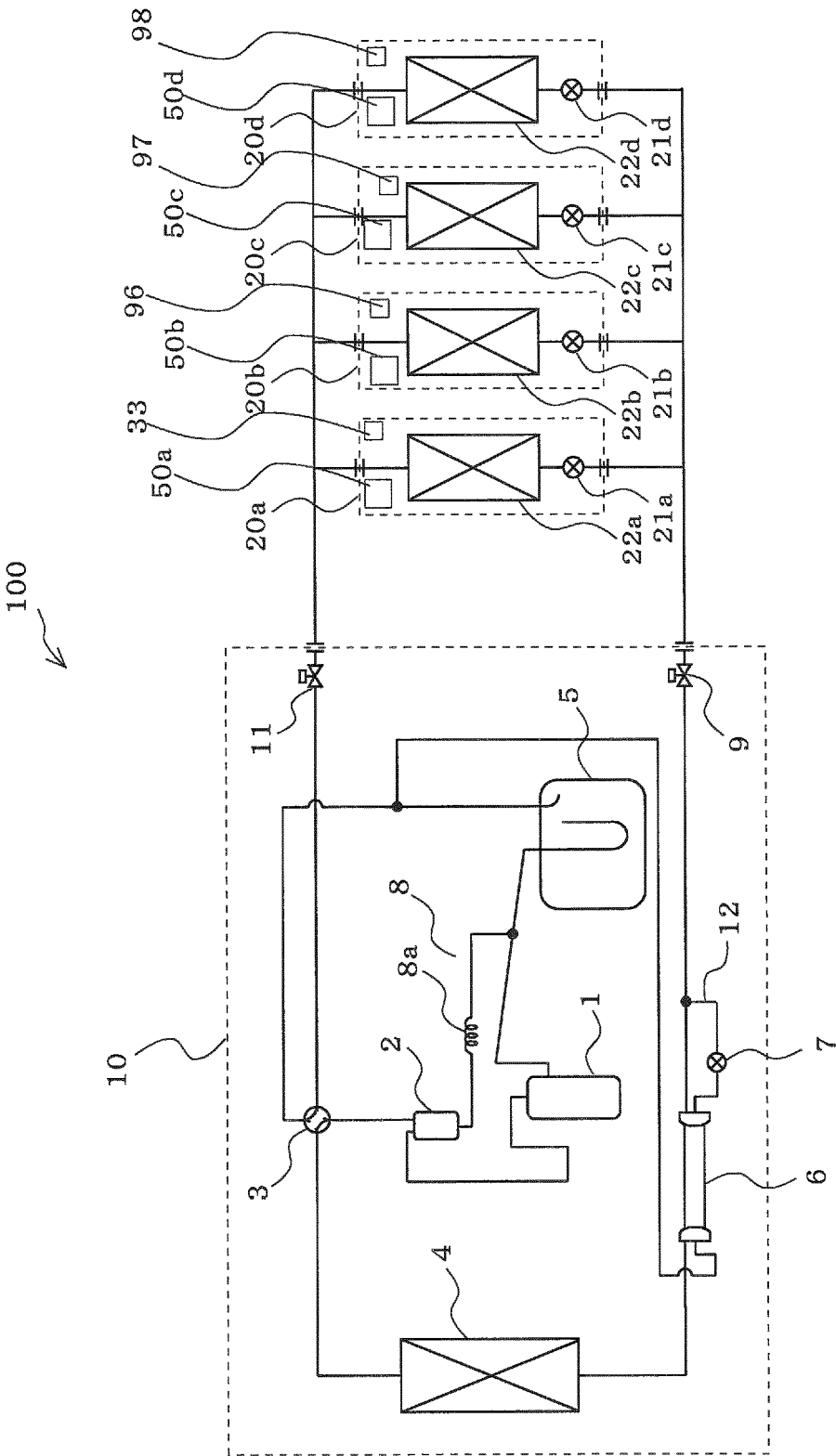


FIG. 2

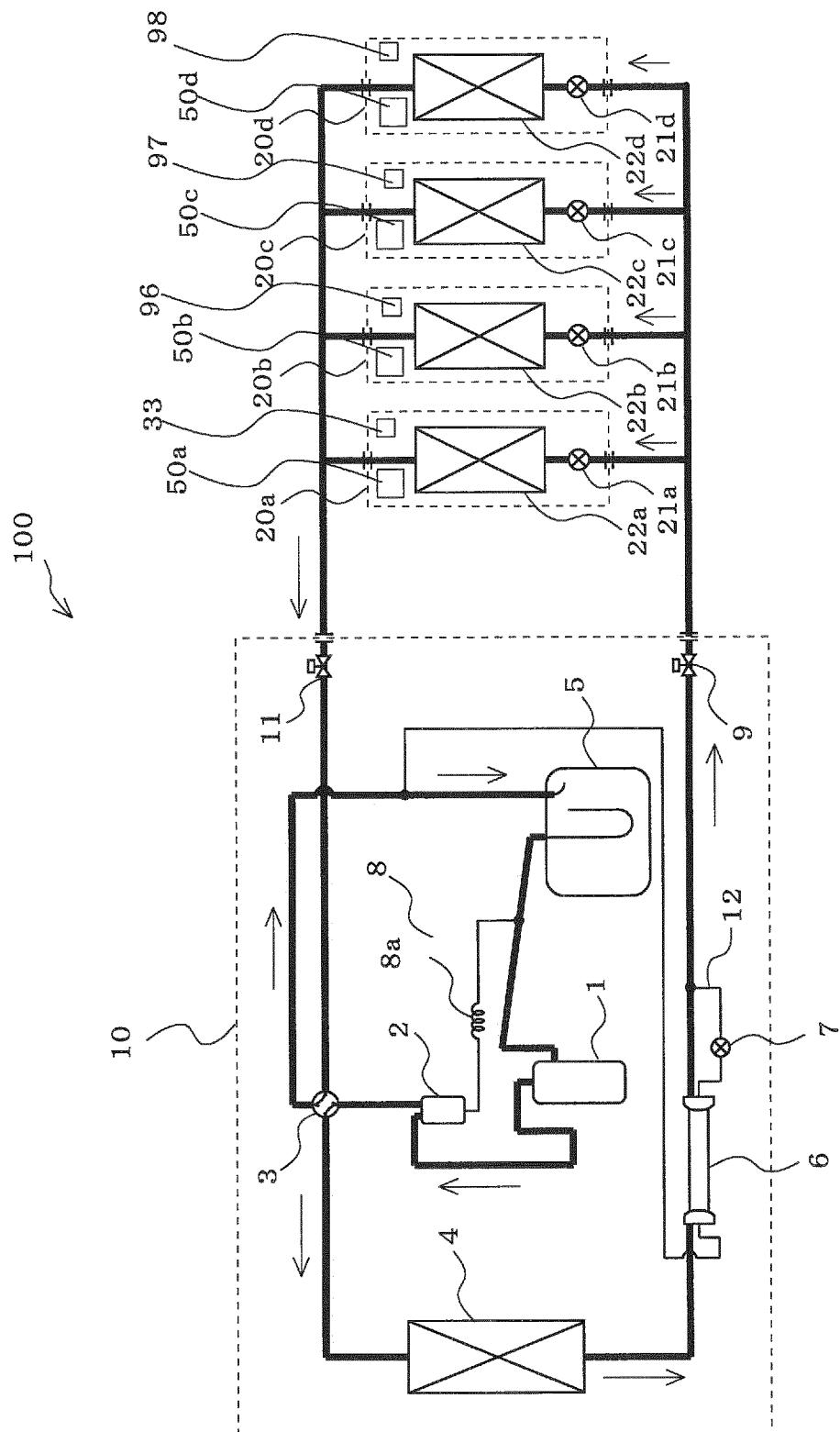


FIG. 3

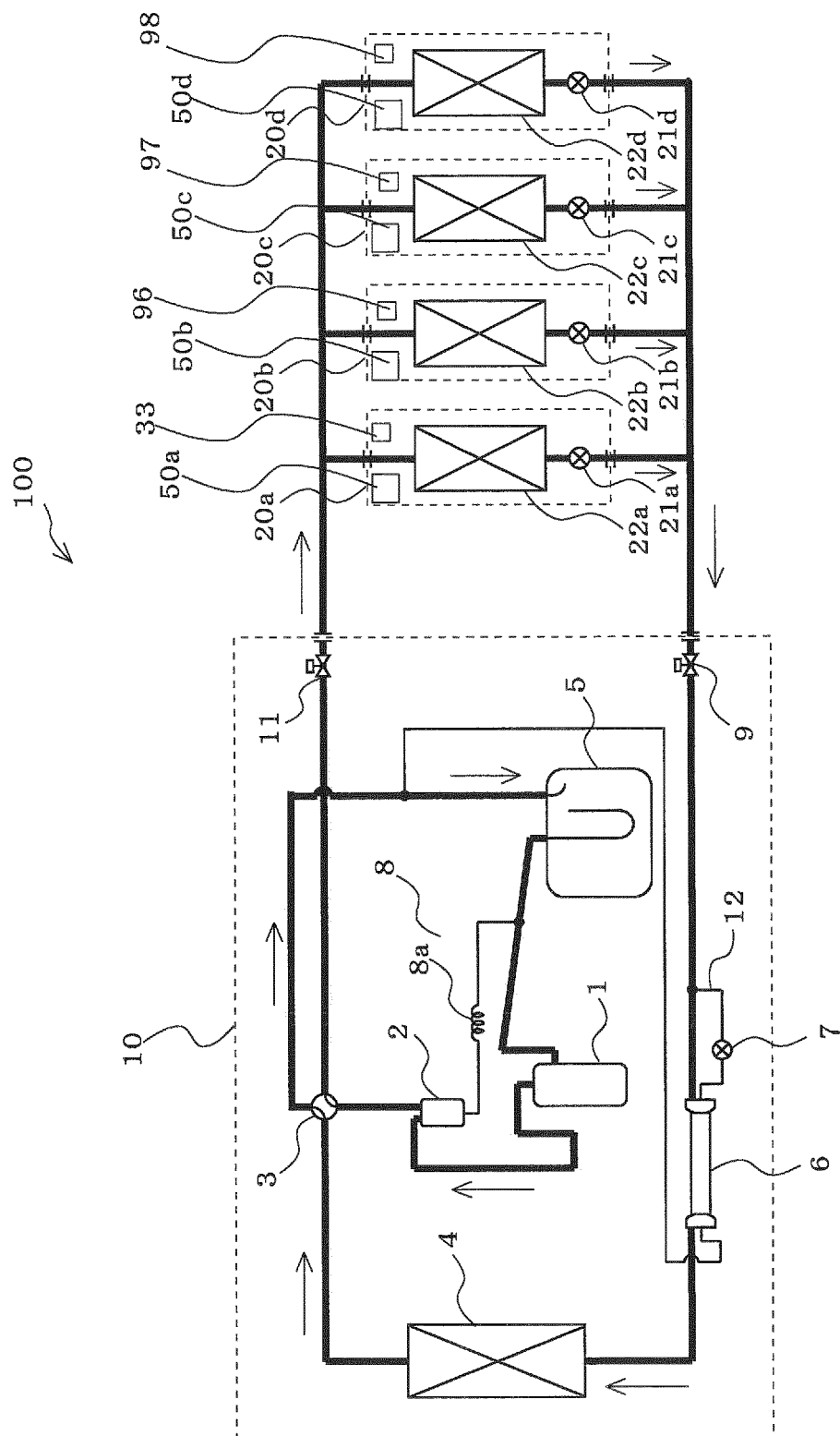


FIG. 4

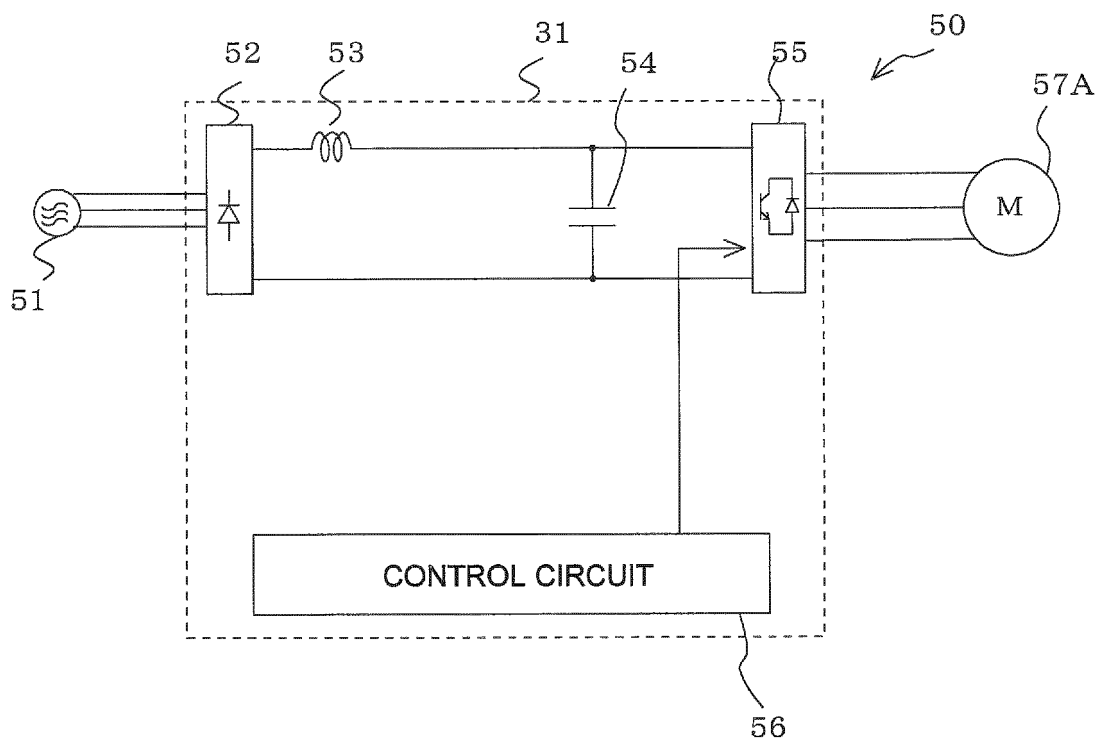


FIG. 5

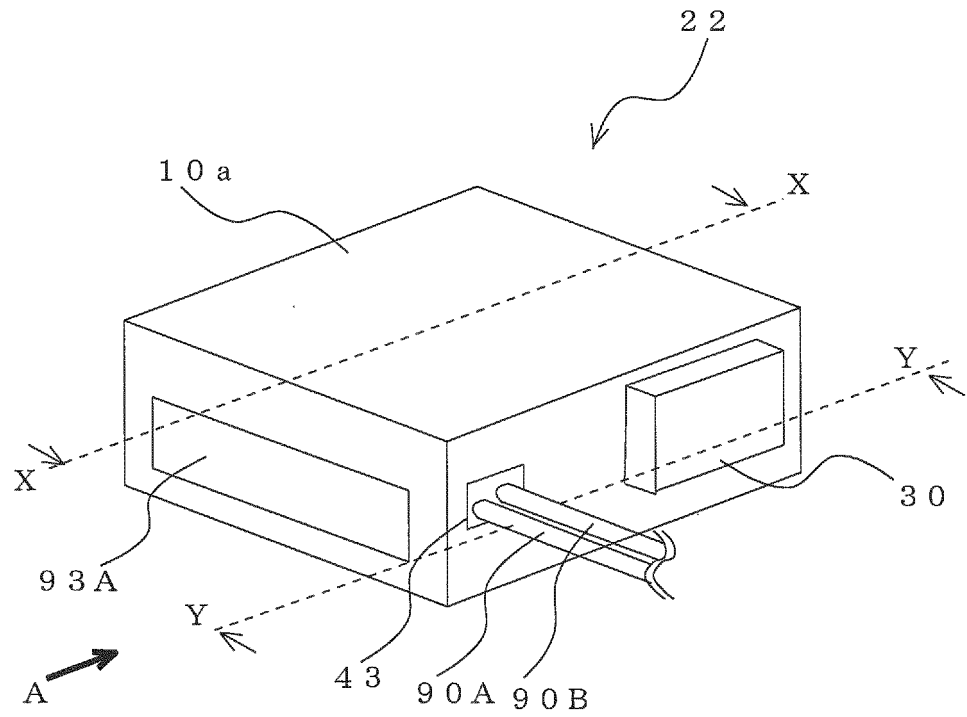


FIG. 6

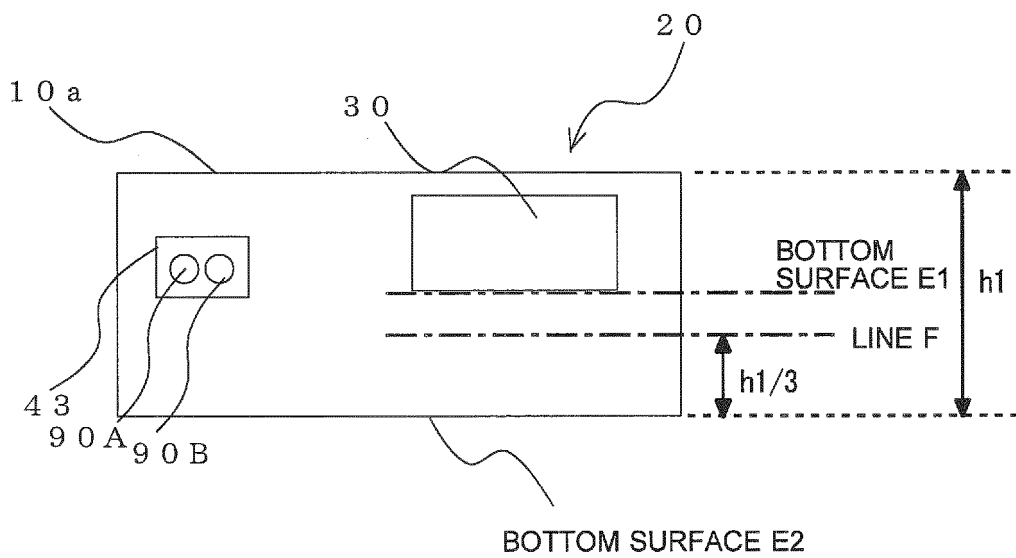


FIG. 7

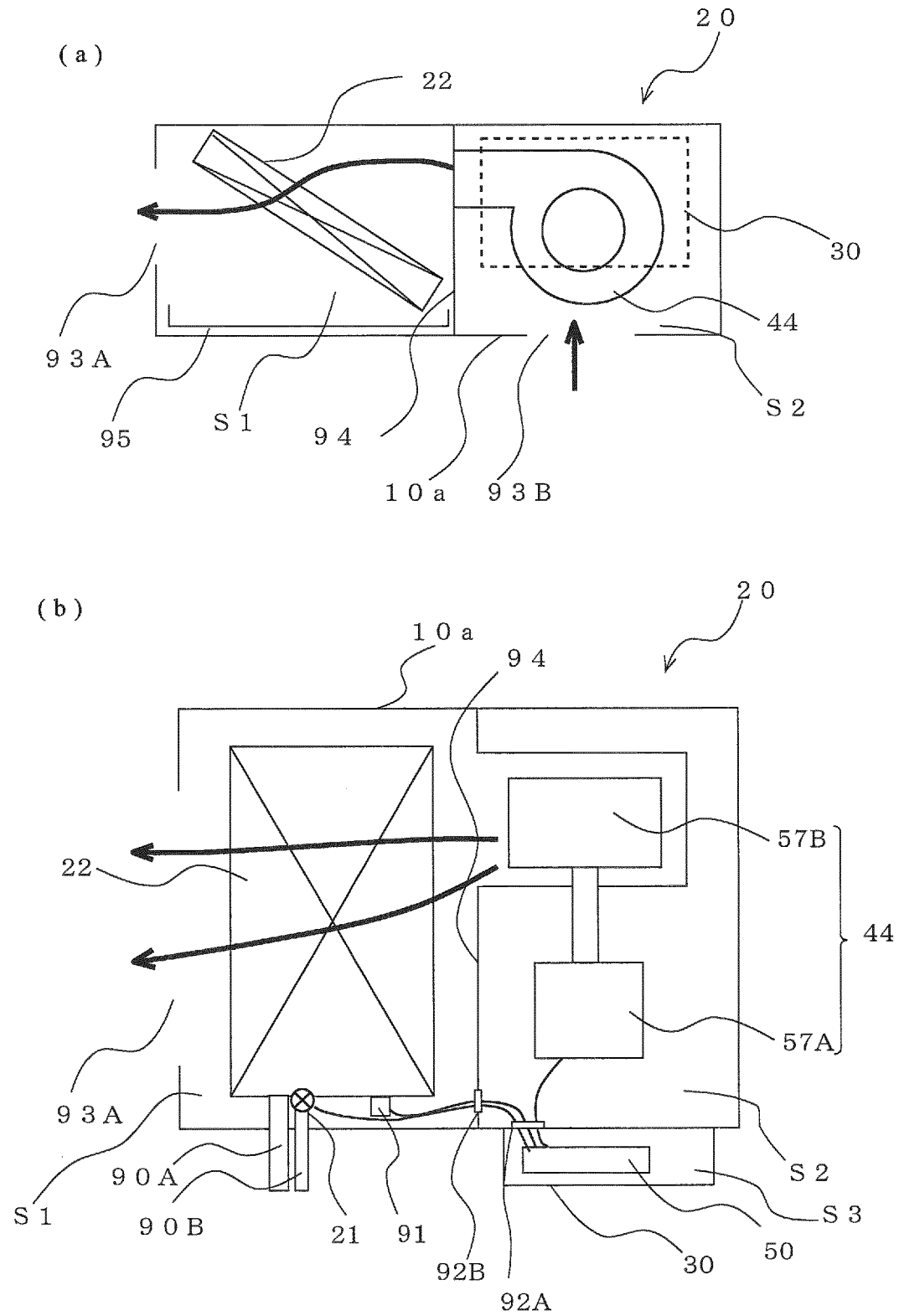


FIG. 8

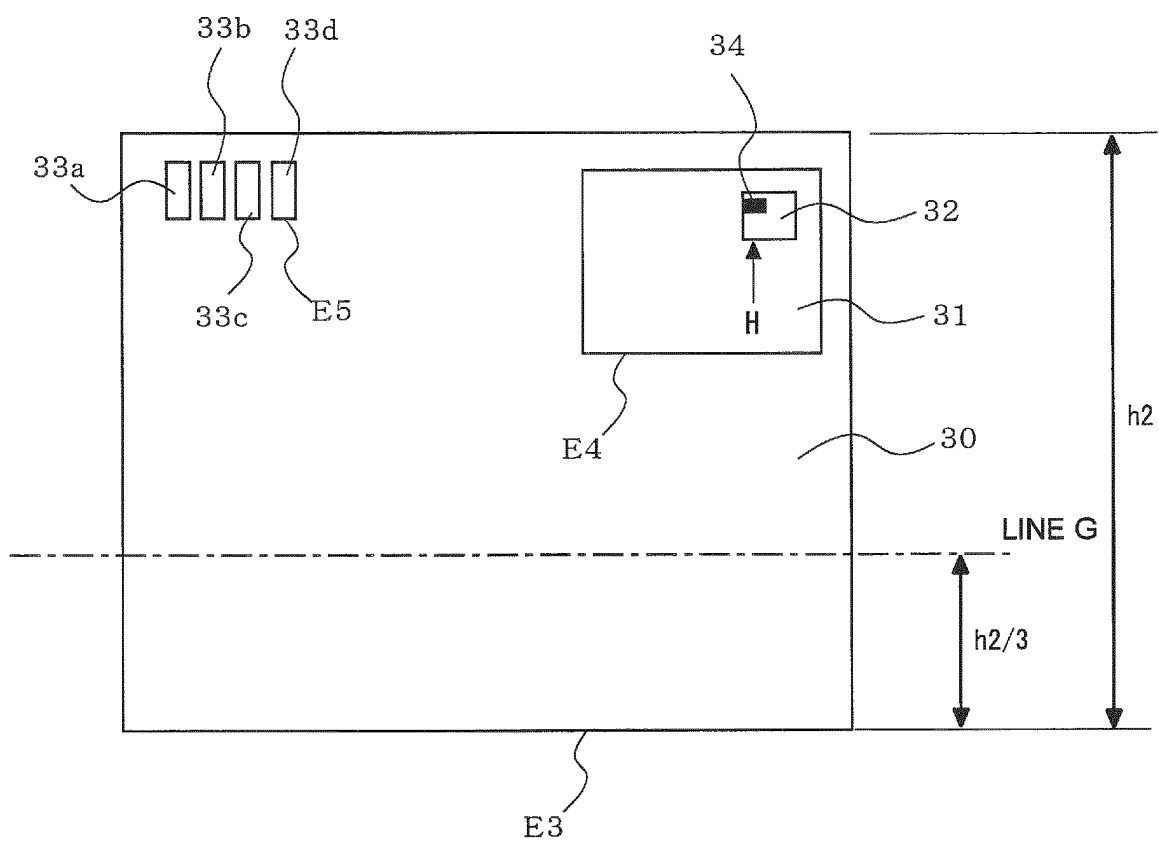
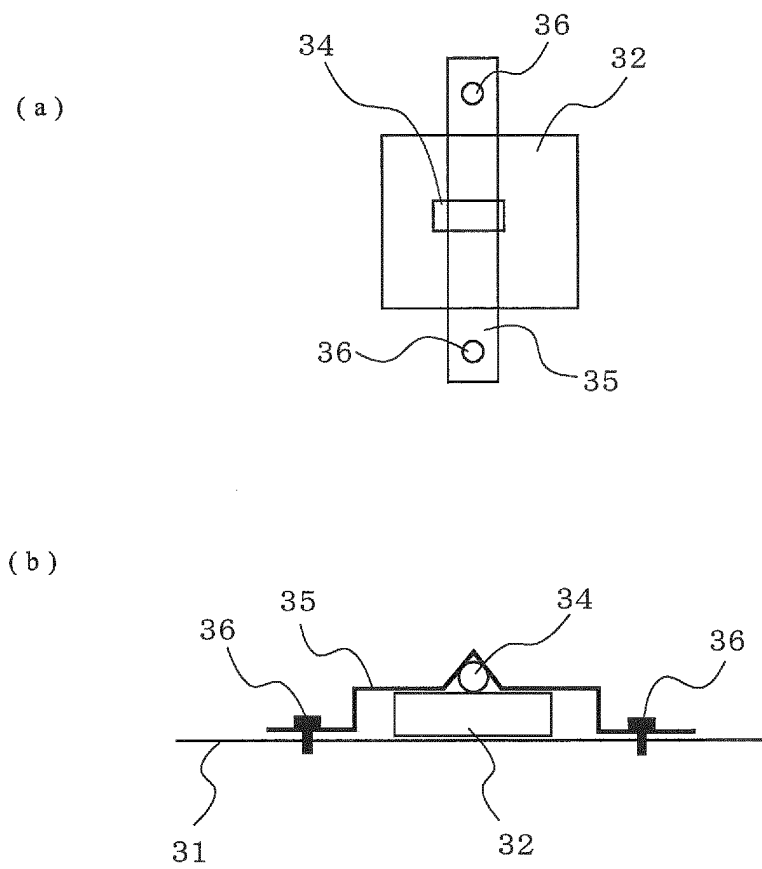


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/002202

A. CLASSIFICATION OF SUBJECT MATTER

F24F13/20(2006.01) i, F24F11/02(2006.01) i, F25B41/00(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)

F24F13/20, F24F11/02, F25B41/00

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2002-243192 A (Mitsubishi Electric Corp.), 28 August 2002 (28.08.2002), paragraphs [0011] to [0016]; fig. 3 (Family: none)	1, 2, 4-16 3
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 10481/1990 (Laid-open No. 103921/1991) (Mitsubishi Heavy Industries, Ltd.), 29 October 1991 (29.10.1991), fig. 1 (Family: none)	1, 2, 4-16

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

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"&" document member of the same patent family

Date of the actual completion of the international search
01 June, 2012 (01.06.12)Date of mailing of the international search report
12 June, 2012 (12.06.12)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/002202

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 2009-30829 A (Sanyo Electric Co., Ltd.), 12 February 2009 (12.02.2009), fig. 1 & US 2009/0025413 A1 & EP 2023048 A1 & CN 101354160 A & KR 10-2009-0012035 A	1, 2, 4-16
Y	JP 2002-267353 A (Matsushita Refrigeration Co.), 18 September 2002 (18.09.2002), paragraphs [0001], [0074] to [0076]; fig. 9 (Family: none)	1, 2, 4-16
Y	JP 2001-41635 A (Matsushita Refrigeration Co.), 16 February 2001 (16.02.2001), paragraph [0061]; fig. 2, 3 (Family: none)	1, 2, 4-16
Y	JP 2011-85299 A (Chofu Seisakusho Co., Ltd.), 28 April 2011 (28.04.2011), paragraph [0024] (Family: none)	2, 4-16
Y	JP 2004-144318 A (Mitsubishi Electric Corp.), 20 May 2004 (20.05.2004), paragraph [0016]; fig. 1, 3 (Family: none)	2, 4-16
Y	WO 2012/029099 A1 (Mitsubishi Electric Corp.), 08 March 2012 (08.03.2012), paragraph [0026] (Family: none)	4-16
Y	JP 2008-57870 A (Daikin Industries, Ltd.), 13 March 2008 (13.03.2008), paragraphs [0027], [0029] (Family: none)	4-16
Y	JP 9-273799 A (Sanyo Electric Co., Ltd.), 21 October 1997 (21.10.1997), claim 2; paragraph [0044] (Family: none)	5-7, 9-16
Y	JP 2010-144976 A (Mitsubishi Electric Corp.), 01 July 2010 (01.07.2010), paragraphs [0019], [0043]; fig. 5 (Family: none)	5-7, 9-16
Y	JP 2012-13348 A (Panasonic Corp.), 19 January 2012 (19.01.2012), paragraphs [0041], [0042] (Family: none)	10, 12, 14

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/002202

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