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(54) Outdoor unit and air-conditioning apparatus

(57) The present invention has an object to provide an air-conditioning apparatus securing the connection flexibility between the outdoor unit and the indoor unit and, at the same time, preventing an inflammable refrigerant flowing into an indoor unit not sufficiently fireproof.

The air-conditioning apparatus 100 of the present invention is an air-conditioning apparatus 100 comprising an outdoor unit 1 having a compressor 5 for compressing a refrigerant and a heat source side heat exchanger 8 for exchanging heat between the refrigerant and an outdoor air and an indoor unit 2 having a load side heat exchanger 13 for exchanging heat between the refrigerant and an indoor air, in which the outdoor unit 1 comprises a first valve 51 provided in a gas pipe 3 to be connected with the indoor unit 2 and closed when shipped and a second valve 71 provided in a liquid pipe 4 to be connected with the indoor unit 2 and closed when shipped, the outdoor unit 1 is filled with the refrigerant when shipped, the outdoor unit 1 has a first information concerning flammability of refrigerants that can be used for the outdoor unit 1, and the indoor unit has a second information concerning flammability of refrigerants that can be used for the indoor unit.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention intends to secure the safety of inflammable refrigerant of the air-conditioning apparatus.

Description of the Related Art

[0002] Hitherto, HCFC, HFC or others gases that might destroy the ozone layer or provoke global warming when they are released in the air were used as refrigerant of devises using heat pump cycle such as air-conditioning apparatus. However, as HCFC or HFC refrigerants are high in load to the environment or in global warming potential, recently, it is expected to change to other refrigerants presenting low ozone layer destruction potential or low global warming potential such as butane, propane or other natural refrigerants(HC). Among HFC refrigerants, those refrigerants showing a global warming potential similar to the natural refrigerant such as R32 are desired. However, natural refrigerants or R32 should be used carefully, because they are inflammable or slightly inflammable and different in specifications required for the conventional device. Especially, from the viewpoint of safety, it is undesirable to use inflammable refrigerant for outdoor units and indoor units not provided with an explosion-proof means.

[0003] In the conventional air-conditioning apparatus, the outdoor unit and the indoor unit confirm if the refrigerant kind compatible with the outdoor unit are the same with the refrigerant kind compatible with the indoor unit by communicating when they are started and comparing the records in their memories and if they are different, the device is stopped and an alert is emitted. (For instance, refer to the Patent Document 1).

[0004] Certain device detects the refrigerant kind from the operating status, and if the detected refrigerant kind is unsuitable for the refrigeration cycle, the operation is stopped an alert is emitted. (For instance, refer to the Patent Document 2).

[0005]

Patent Document 1: Japan Patent Publication No. 10-038354 (page 3, page 4, Fig. 12)
Patent Document 2: Japan Patent Publication No. 08-254363 (page 3)

SUMMARY OF THE INVENTION

[0006] However, the conventional air-conditioning apparatus limited the scope of unit connection, because a perfect agreement of refrigerant kind was required between the outdoor unit and the indoor unit, while required unit specifications may be compatible actually even if the refrigerants are different. Especially, it was impossible to use an inflammable refrigerant for the indoor unit even if the unit is sufficiently fireproof.

[0007] The present invention, devised to solve the problems mentioned above, has an object to provide an air-conditioning apparatus securing the connection flexibility between the outdoor unit and the indoor unit and, at the same time, improving the safety of inflammable refrigerant and especially preventing an inflammable refrigerant being used for an indoor unit not sufficiently fireproof.

[0008] The air-conditioning apparatus of the present invention is an air-conditioning apparatus composed of an outdoor unit having a compressor for compressing a refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and an outdoor air and an indoor unit having a load side heat exchanger for exchanging heat between the refrigerant and an indoor air, in which the outdoor unit includes a first valve provided in a gas pipe to be connected with the indoor unit and closed when shipped and a second valve provided in a liquid pipe to be connected with the indoor unit and closed when shipped, the outdoor unit is filled with the refrigerant when shipped, the outdoor unit has a first information concerning flammability of refrigerants that can be used for the outdoor unit, and the indoor unit has a second information concerning flammability of refrigerants that can be used for the indoor unit.

[0009] Also, the air-conditioning apparatus of the present invention is an air-conditioning apparatus composed of an outdoor unit having a compressor for compressing a refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and an outdoor air and a plurality of indoor units having a load side heat exchanger for exchanging heat between the refrigerant and an indoor air, in which the outdoor unit includes a first valve provided in a gas pipe to be connected with each indoor unit and closed when shipped and a second valve provided in a liquid pipe to be connected with each indoor unit and closed when shipped, the outdoor unit is filled with the refrigerant when shipped, the outdoor unit has a first memory storing a first information concerning flammability of refrigerants that can be used for the outdoor unit, and each indoor unit has a second memory for storing a second information concerning flammability of refrigerants that can be used for the indoor unit and a control unit for comparing the first information and the second information and controlling not to open the first valve and the second valve when the refrigerant that can be used for the outdoor unit is determined to be more flammable than the refrigerant that can be used for any one of the plurality of indoor units.

[0010] Moreover, the air-conditioning apparatus of the present invention is an air-conditioning apparatus composed of a plurality of outdoor units each having a compressor for compressing a refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and the outdoor air and a plurality of indoor

units each having a load side heat exchanger for exchanging heat between the refrigerant and the indoor air, in which each outdoor unit includes a first valve provided in a pipe to be connected with each indoor unit and closed when shipped and a second valve provided in a liquid pipe to be connected with each indoor unit and closed when shipped, each outdoor unit is filled with the refrigerant when shipped, each outdoor unit has a first memory storing a first information concerning flammability of refrigerants that can be used for the outdoor unit, and each indoor unit has a second memory for storing a second information concerning flammability of refrigerants that can be used for the indoor unit and a control unit for comparing the first information and the second information and controlling not to open the first valve and the second valve when the most inflammable refrigerant among those that can be used for the plurality of outdoor units is determined to be more flammable than the refrigerant that can be used for any one of the plurality of indoor units.

[0011] An outdoor unit for an air-conditioning apparatus has a compressor for compressing a refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and an outdoor air, a plurality of indoor units having a load side heat exchanger for exchanging heat between the refrigerant and an indoor air and a branching box for branching pipes connected to the outdoor units respectively and connecting with the plurality of indoor units, in which the branching box includes a first valve provided in a pipe to be connected with each indoor unit and closed when shipped and a second valve provided in a liquid pipe to be connected with each indoor unit and closed when shipped, the outdoor unit is filled with the refrigerant when shipped, the outdoor unit has a first memory storing a first information concerning flammability of refrigerants that can be used for the outdoor unit, each indoor unit has a second memory for storing a second information concerning flammability of refrigerants that can be used for the indoor unit, and a control unit compares the first information and the second information and controls not to open the first valve and the second valve when the refrigerant that can be used for the outdoor unit is determined to be more flammable than the refrigerant that can be used for any one of the plurality of indoor units.

[0012] The outdoor unit of the air-conditioning apparatus of the present invention is an outdoor unit of the air-conditioning apparatus having a compressor for compressing the refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and the outdoor air and being connected to an indoor unit having a load side heat exchanger for exchanging heat between the refrigerant and the indoor air, characterized by that the outdoor unit comprises a first valve provided in a gas pipe to be connected with the indoor unit and closed when shipped and a second valve provided in a liquid pipe to be connected with the indoor unit and closed when shipped, the outdoor unit is filled with the refrigerant when shipped and provided with a first information concerning the flammability of refrigerants that can be used for the outdoor unit.

[0013] The air-conditioning apparatus and the outdoor unit of the present invention, as the outdoor unit has a first information concerning flammability of refrigerants that can be used for the outdoor unit and the indoor unit has a second information concerning flammability of refrigerants that can be used for the indoor unit, can prevent an inflammable refrigerant from flowing into a non-fireproof indoor unit by comparing the first information and the second information and, at the same time, secure the connection flexibility with the outdoor unit if the indoor unit is fireproof.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

Fig. 1 shows the composition of an air-conditioning apparatus 100 of the first embodiment of the present invention;

Fig. 2 is a table showing the combustibility of refrigerant of the first embodiment of the present invention;

Fig. 3 shows the information stored in the indoor unit of the first embodiment of the present invention;

Fig. 4 shows the composition of an air-conditioning apparatus 200 of the second embodiment of the present invention;

Fig. 5 shows the composition of another air-conditioning apparatus 300 of the second embodiment of the present invention;

Fig. 6 shows the composition of another air-conditioning apparatus 400 of the second embodiment of the present invention;

Fig. 7 shows the composition of another air-conditioning apparatus 500 of the second embodiment of the present invention;

Fig. 8 shows the composition of an outdoor unit 1 of the air-conditioning apparatus of the third embodiment of the present invention; and

Fig. 9 shows the information stored in an indoor unit 2 of the fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED

First Embodiment

[0015] Fig. 1 shows the composition of an air-conditioning apparatus 100 of the First Embodiment of the present invention. Now an outdoor unit 1 and an indoor unit 2 of the air-conditioning apparatus 100 used as direct dilatation type air-conditioning system of the first embodiment shall be described.

[0016] In Fig. 1, the outdoor unit 1 and the indoor unit 2 of the air-conditioning apparatus 100 are connected by a gas pipe 3 for flowing a gas refrigerant and a liquid pipe 4 for flowing a liquid refrigerant, and a heat pomp cycle

is composed by the circulation of a refrigerant in the outdoor unit 1, the indoor unit 2, the gas pipe3 and the liquid pipe 4.

[0017] The outdoor unit 1 corresponds to the heat source device in the heat pump cycle, while the indoor unit 2 to the load device. In other words, in general, the indoor unit 2 is installed in a space to be air-conditioned, while the outdoor unit 1 is installed outside the space to be air-conditioned.

[0018] The outdoor unit 1 includes a compressor 5 for compressing and discharging the refrigerant, a four-way valve 6 for changing the flow direction of the refrigerant discharged from the compressor 5 according to the heating operation and the cooling operation, an expansion valve 7 for depressing the refrigerant returning from the indoor unit 2 through a liquid pipe 4, a heat source side heat exchanger 8 for receiving the refrigerant depressed by the expansion valve 7, a first valve 51 disposed on the connection unit between the four-way valve 6 and the gas pipe 3, a second valve 71 disposed on between the expansion valve 7 and the connection unit of the liquid pipe4, an outdoor fan 9 for sending outdoor air to the heat source side heat exchanger 8 and a control board 10 composing a control unit for controlling the operation of actuators such as compressor 5, four-way valve 6, expansion valve, outdoor fan 9, first valve 51 and second valve 71. The control board 10 is provided with a memory 11 for storing various information concerning the operation of the air-conditioning apparatus 100 and a display 12 for indicating anomalies during the operation. The display 12 is provided with LEDs allowing the user or maintenance operator to determine the nature of anomalies happening in the air-conditioning apparatus 100 from the LED lightening color, lightening place or number of lightening.

[0019] The indoor unit 2 includes a load side heat exchanger 13 for receiving refrigerant discharged from the four-way valve 6 through a gas pipe 3, an indoor fan 14 for sending indoor air to the load side heat exchanger 13 and a control board 15 having a control unit for controlling the operation of the indoor fan 14. The control board 15 is provided with a memory 16 for storing various information concerning the operation of the air-conditioning apparatus 100. The control board is provided with a display having a liquid crystal screen that can indicate the set temperature, the indoor temperature, the outdoor temperature or anomalies during the operation. Moreover, the display 17 may be provided with LED similarly as the display 12 of the outdoor unit 1 for allowing the user or maintenance operator to determine the nature of anomalies happening in the air-conditioning apparatus 100 from the LED lightening color, lightening place or number of lightening.

[0020] The control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2 are connected with an inter-device communication line 18 allowing an interactive data communication.

[0021] The room where the indoor unit 2 is installed is provided with a remote controller 19 allowing the communication with the control board 15 of the indoor unit 2 and the user can set operating conditions such as cooling operation, heating operation or room set temperature with the remote controller 19. The remote controller 19 has a liquid crystal screen that can indicate the set temperature, the indoor temperature, the outdoor temperature or anomalies during the operation.

The operating conditions set by the remote controller 19 are output to the control board 15 of the indoor unit 2 and also to the control board 10 of the outdoor unit 1 from the control board 15 through the inter-device communication line 18. Here, the communication between the control board 10 and the control board 15 or the remote controller 19 and the control board 15 may respectively be wired or wireless.

[0022] The outdoor unit 1 is provided with a plurality of (not shown) temperature sensors and a plurality of (not shown) pressure sensors, and the control board 10 of the outdoor unit 1 reads also data output from these sensors.

The control board 10 reads data such as outdoor air temperature, evaporating temperature of refrigerant during heating operation, condensing temperature of refrigerant during cooling operation, temperature of refrigerant discharged from the compressor 5 or pressure of refrigerant discharged from the compressor 5 and pressure value of refrigerant sucked by the compressor 5. Moreover, the control board 10 of the outdoor unit 1 can read sensor detection data loaded in the control board 15 of the indoor unit 2 through the inter-device communication line 18 and can read operating conditions set by the remote controller 19 through the control board 15 of the indoor unit 2 and the inter-device communication line 18. The control board 10 of the outdoor unit 1 control actuators in the outdoor unit 1 such as rotation speed of the compressor 5, switchover of the four-way valve 6, opening of the expansion valve 7 or the rotation speed of the outdoor fan 9 based on data such as loaded operating conditions, indoor air temperature or outdoor air temperature.

[0023] The indoor unit 2 is provided with a plurality of (not shown) temperature sensors and one or a plurality of refrigerant leakage sensor 81, the control board 15 of the indoor unit 2 reads data output from these sensors and, as mentioned above, the control board 10 of the outdoor unit 1 reads these data through the inter-device communication line 18. These data include, for instance, the temperature of indoor air, evaporating temperature of refrigerant during cooling operation, condensing temperature of refrigerant during heating operation or leakage of refrigerant in the indoor unit 2.

[0024] Now, refrigerant circulation during the operation of the air-conditioning apparatus 100 shall be described based on the composition of Fig. 1. The air-conditioning apparatus 100 can switchover the heating operation and the cooling operation by switching over the four-way valve 6 with the control board 10 of the outdoor unit 1. Here, the first valve 51 and the second valve 71

are completely open during the normal operation of the air-conditioning apparatus 100.

[0025] First, refrigerant circulation during the heating operation shall be described. During the heating operation, high temperature high pressure gas refrigerant discharged from the compressor 5 installed in the outdoor unit 1 flows into the four-way valve 6 and then flows into the indoor unit 2 from the four-way valve 6 through the gas pipe 3. Refrigerant flowed into the indoor unit 2 from the four-way valve 6 rejects heat by exchanging heat with the indoor air sent by the indoor fan 14 in the load side heat exchanger 13 and becomes low temperature high pressure liquid refrigerant of subcooling state. Thereafter, the low temperature high pressure liquid refrigerant flows into the outdoor unit 1 from the indoor unit 2 through the liquid pipe 4. The low temperature high pressure refrigerant flowed into the outdoor unit 1 from the indoor unit 2 is depressed by the expansion valve 7, becomes low temperature low pressure two-phase gas-liquid state and flows into the heat source side heat exchanger 8. The low temperature low pressure refrigerant exchanges heat with outdoor air sent by the outdoor fan 9 and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5 from the heat source side heat exchanger 8 through the four-way valve 6.

[0026] Now, refrigerant circulation during the cooling operation shall be described. During the cooling operation, high temperature high pressure gas refrigerant discharged from the compressor 5 flows into the heat source side heat exchanger 8 thorough the four-way valve 6. The high temperature high pressure gas refrigerant exchanges heat with the outdoor air, namely the open air, sent by the outdoor fan 9 in the heat source side heat exchanger 8 turning into low temperature high pressure subcooling liquid refrigerant and flows into the expansion valve 7. The low temperature high pressure subcooling liquid refrigerant is depressed in the expansion valve 7 and becomes low temperature low pressure two-phase gas-liquid state. Thereafter, the low temperature low pressure two-phase gas-liquid refrigerant flows from the outdoor unit 1 into the indoor unit 2 through the liquid pipe 4. The two-phase gas-liquid refrigerant flowed from the outdoor unit 1 into the indoor unit 2 exchanges heat with indoor air sent by the indoor fan 14 in the load side heat exchanger 13 installed in the indoor unit 2 and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant flows into the outdoor unit 1 from the indoor unit 2 through the gas pipe 3 and is sucked into the compressor 5 through the four-way valve 6.

[0027] Hereto, the basic composition of the air-conditioning apparatus 100 of the First Embodiment has been described. Now, the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2, the memory 11 of the control board 10 and the memory 16 of the control board 15 and the first valve 51 and the second valve 71, composing characteristic elements of the present invention, shall be described.

[0028] The memory 11 disposed on the control board 10 of the outdoor unit 1 stores anti-combustibility class CfS that can be determined from the combustibility class of refrigerants that can be used for the outdoor unit 1. Similarly, the memory 16 disposed on the control board 15 of the indoor unit 2 stores anti-combustibility class CfL that can be determined from the combustibility class of refrigerants that can be used for the indoor unit 2.

[0029] Now, the anti-combustibility class CfS of the outdoor unit 1 and the anti-combustibility class CfL of the indoor unit 2 shall be described. The anti-combustibility class can be determined from the combustibility class of refrigerants that can be or might be used for the concerned unit.

[0030] First, the combustibility class of refrigerant shall be described. The combustibility class of refrigerant can be determined from combustion lower limit concentration (LFL), combustion speed and combustion heat under certain conditions and is defined as in Fig. 2 for instance. LFL in Fig. 2 means the concentration (vol%) at which gas state refrigerant starts to burn in the air, burning speed means the speed (m/s) at which the refrigerant flames extend and combustion heat means the heat quantity (kJ/kg) generated by the combustion of the refrigerant.

According to the definition of refrigerant combustibility class shown in Fig. 2, refrigerants whose combustion will not spread even if it is ignited in the air of 60°C 1 atmospheric pressure are classified as combustibility class 1. Those refrigerants satisfying 3 conditions, namely LFL higher than 3.5%, combustion speed equal or inferior to 0.1m/sec under 23°C 1 atmospheric pressure and combustion heat less than 19000 kJ/kg under 25°C 1 atmospheric pressure, are classified as combustibility class 2. Those refrigerants satisfying 3 conditions, namely the combustion will spread under the condition of 60°C 1 atmospheric pressure, LFL higher than 3.5% and combustion heat less than 19000 kJ/kg under 25°C 1 atmospheric pressure are classified as combustibility class 3. Those refrigerants satisfying 3 conditions, namely the combustion will spread under 60°C 1 atmospheric pressure, LFL equal or inferior to 3.5% and combustion heat equal or superior to 19000 kJ/kg under 25°C 1 atmospheric pressure are classified as combustibility class 4. Thus, refrigerants of combustibility class 1 are noninflammable, while those of combustibility class 2 or superior are inflammable. In other words, it can be said that higher is the combustibility class more inflammable is the refrigerant. By the way, among inflammable refrigerants, those of combustibility class 2 are named as slightly inflammable refrigerant.

[0031] Based on the aforementioned definition, R134a, R410A and carbon dioxide refrigerant can be classified into the combustibility class 1, R32 and R717 (ammonia) into the combustibility class 2,R152a into the combustibility class 3, while R170 (ethane), R290 (propane) and R600a (isobutene) into the combustibility class

4. Note that such classification of combustibility is internationally settled by ISO 817, while a similar classification is also settled by ASHRAE 34. Notwithstanding that, the classification of refrigerant combustibility class of the present invention is not limited to the classification of Fig. 2,ISO 817 or the classification of ASHRAE 34.

[0032] The outdoor unit 1 of class 1 in anti-combustibility class CfS or the outdoor unit 2 of class 1 in anti-combustibility class CfL are generally not provided with measures for improving the safety against the leakage of refrigerant such as double walled heat exchanger or anti-deflagration of electronic devices, so if inflammable refrigerant of class 2 or superior in combustibility class is used for these outdoor unit 1 or indoor unit 2 and leaks, the refrigerant might ignites at the contact electric. On the other hand, as outdoor unit 1 and indoor unit 2 designed to use refrigerant of class 2 or superior in combustibility class are provided with measures for improving the safety against the leakage or ignition of refrigerant, the safety will be secured even if inflammable refrigerant of class 2 or inferior in combustibility class is used for these outdoor unit 1 or indoor unit 2.

[0033] As for the possibility of ignition of refrigerant in the outdoor unit 1 or indoor unit 2, in the designing stage, it should be checked if the concerned refrigerant ignites or not when each unit is operated normally with the case inside of the unit full of the refrigerant, supposing leakage of the refrigerant.

[0034] For instance, the anti-combustibility class CfS of an outdoor unit 1 not supposing the use of refrigerant of class 2 or superior in combustibility class and manufactured only for the use of noninflammable refrigerant of class is class 1, and the memory 11 of the outdoor unit 1 stores the information that the anti-combustibility class CfS is class 1. Similarly, the anti-combustibility class CfL of an indoor unit 2 not supposing the use of inflammable refrigerant of combustibility class 2 or superior and manufactured only for the use of noninflammable refrigerant of class is class 1, and the memory 16 of the outdoor unit 2 stores the information that the anti-combustibility class CfL is class 1.

[0035] For other examples, the anti-combustibility class CfS of an outdoor unit 1 that allows to use natural refrigerant of combustibility class 4 such as R290 (propane) or R600a (isobutene) is class 4, and similarly, the anti-combustibility class CfL of an indoor unit 2 that allows to use refrigerant of combustibility class 4 is class 4, and the memory 11 stores the information that the anti-combustibility class CfS is class 4 while the memory 16 stores the information that the anti-combustibility class CfL is class 4.

[0036] Fig. 3 shows the information stored in the memory 16. For instance, if R410A, R32, R290 and R717 can be used for the indoor unit 2, the memory 16 stores the kind of usable refrigerant and the combustibility class of the refrigerant. In case of Fig. 3, the information that the combustibility class of R410A is class 1, the combustibility class of R32 is class 2, the combustibility class of R290 (propane) is class 4 and the combustibility class of R717 (ammonia) is class 2 is stored. Moreover, among the combustibility class of usable refrigerant, the maximum value is recorded as the anti-combustibility class CfL of the indoor unit 2. In other words, in case of Fig. 3, the combustibility class of R290 becomes the anti-combustibility class CfL=class 4 of the indoor unit 2.

[0037] It has been described above that the memory 16 stores the kind of usable refrigerant for the indoor unit 2, the combustibility class of the refrigerant and the anti-combustibility class CfL, however, the present invention can also be executed by storing beforehand only the anti-combustibility class CfL of the indoor unit 2 in the memory 16 in the step of manufacturing, even if the kind of usable refrigerant and the combustibility class of the refrigerant are not stored in the memory 16.

[0038] Note that the information stored in the memory 11 of the outdoor unit 1 is the same.

[0039] Recently, as their global warming potential is lower than R410A, hydrofluoroolefin family refrigerant (HFO1234yf), R32(difluoromethane) , R290 (propane) or others attract a great deal of attention. However, these refrigerants are slightly inflammable or flammable and their combustibility class will be 2 or higher according to the aforementioned classification.

[0040] Hereinafter, it is supposed that heat pump devices which can use these refrigerants and, there, by mistake, an indoor unit not compatible with inflammable refrigerant might be connected to an outdoor unit compatible with inflammable refrigerant.

[0041] In general, as the outdoor unit is filled with refrigerant in the factory and shipped, the anti-combustibility class CfS of the outdoor unit agrees with the combustibility class of the refrigerant. There, when the outdoor unit or the indoor unit is to be replaced by one compatible with the inflammable refrigerant, the anti-combustibility class CfL of the indoor unit comes into question from the viewpoint of safety. Measures should be taken in case where the anti-combustibility class CfL of the indoor unit connected to an outdoor unit filled with inflammable refrigerant is lower than the combustibility class of the refrigerant filled in the outdoor unit, namely, where the anti-combustibility class CfL of the indoor unit is lower than the anti-combustibility class CfS of the outdoor unit.

[0042] Especially, as properties such as ebullition point or vapor pressure of R32 are similar to those of R410A, which is one of HFC refrigerants, the anti-combustibility class CfS supposing the use of HFC refrigerant of combustibility class 1 might be used for the outdoor unit of class 1 or for the indoor unit of class 1 in terms of anti-combustibility class CfL.

[0043] The air-conditioning apparatus of the First Embodiment can take measures by using the information stored in the memory 11 and the memory 16 for controlling. Especially, it can prevent inflammable refrigerant of the outdoor unit from flowing into the indoor unit without supposing the use of inflammable refrigerant, when non-standardized outdoor unit and indoor unit are connected

during the execution at the installation place.

[0044] Now, the action of the control board 10 of the outdoor unit 1, the control board 15 of the indoor unit 2, the first valve 51 and the second valve 71 during the installation work of the outdoor unit 1 and the indoor unit 2 of the First Embodiment.

First, the contractor connects the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2 by means of inter-device communication line 18 allowing the control board 10 and the control board 15 to communicate, and at the same time, connects the outdoor unit 1 and the indoor unit 2 to the gas pipe 3 and the liquid pipe 4. In this step, the first valve 51 and the second valve 71 are stilled closed and the refrigerant filled in the outdoor unit 1 does not yet flow into the indoor unit 2.

Here, the first valve 51 and the second valve 71 are preferably electric valve instead of manual valve so as to prevent the contractor from opening them by mistake.

Next, when the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2 connected by the inter-device communication line 18 are turned on electricity, the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2 communicate automatically and the control board 10 of the outdoor unit 1 sends a signal to the control board 15 of the indoor unit 2 commanding to notice the corresponding anti-combustibility class CfL. Upon reception of this command, the control board 15 of the indoor unit 2 informs the control board 10 of the outdoor unit 1 of the anti-combustibility class CfL stored in the memory 16. Upon reception of message, the control board 10 of the outdoor unit 1 compares the anti-combustibility class CfS stored in the memory 11 and the anti-combustibility class CfL.

If anti-combustibility class CfL $\neq$ anti-combustibility class CfS and anti-combustibility class CfL < anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1 determines that the refrigerant usable for the outdoor unit 1 is more inflammable than the refrigerant that can be used for the indoor unit 2, the control board 10 inhibits operation of devices such as compressor 5, outdoor fan 9 or indoor fan 14, does not open valves such as expansion valve 7, first valve 51 and second valve 71 by keeping them completely closed and indicates abnormality at least on one of the display 12 of the outdoor unit 1, display 17 of the indoor unit 2 or remote controller 19. The indicated abnormality shows that the indoor unit 2 does not compatible with the inflammable refrigerant. Here, it is also possible to replace the second valve 71 by the expansion valve 7 without composing the second valve 71.

If anti-combustibility class CfL $\geq$ anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1 determines that the refrigerant usable for the indoor unit 2 is equally or more inflammable than the refrigerant that can be used for the outdoor unit 1, the control board 10 opens completely the first valve 51 and the second valve 71 and, moreover, permits the operation of devices and the driving of actuators. In this case, any abnormality will not be indicated.

It should be noted that anti-combustibility class CfL < anti-combustibility class CfS corresponds to anti-combustibility class CfL $\neq$ anti-combustibility class CfS and anti-combustibility class CfL $\geq$ anti-combustibility class CfS includes anti-combustibility class CfL = anti-combustibility class CfS.

[0045] As aforementioned, the indoor side safety can be secured even if the indoor unit 2 is connected by mistake, because the operation and valve opening are inhibited and the abnormality will be indicated when the corresponding anti-combustibility class CfL to the indoor unit 2 is lower than the corresponding combustibility class CfS to the outdoor unit 1.

[0046] In general, the connection unit with the gas pipe 3 of the outdoor unit 1 and the connection of the liquid pipe 4 are composed of a (not shown) manual valve such as ball valve or stop valve and, in some execution procedures, pipe works including the vacuuming of the indoor unit 2, the gas pipe 3 and the liquid pipe 4 after the connection of the gas pipe 3 and the liquid pipe 4 and opening manual valves such as ball valve or stop valve are performed before electric works of inter-device communication line 18 or (not shown) power source line. In this case, the refrigerant might be released to the indoor unit to be installed in a residential space before turning on electricity and determining permission/inhibition of device operation; however, in the air-conditioning apparatus 100 of the present invention, independently of the execution procedures, the inflammable refrigerant will not be released to the space to be air-conditioned which is a residential space, because it is inhibited to open the first valve 51 and the second valve 71.

Moreover, by making the first valve 51 and the second valve 71 electric-driven, the opening of valve can also be controlled automatically by comparison determination of anti-combustibility class CfS of the outdoor unit and anti-combustibility class CfL of the indoor unit in the outdoor unit 1.

[0047] Thus, the combination of the outdoor unit 1 and the indoor unit 2 can be more flexible so long as the safety can be secured, because the operation or the opening of valves are permitted when the corresponding combustibility class CfL to the indoor unit 2 is equal or superior to the corresponding combustibility class CfS to the outdoor unit 1. Therefore, specification modification of the indoor unit 2 following the change of used refrigerant can be made minimum, the development cost of the air-conditioning apparatus can be reduced, the time of delivery can be shortened and resources and energy can be saved.

[0048] In the First Embodiment, the command is sent from the outdoor unit 1 to the indoor unit 2 requesting to inform the anti-combustibility class; however, on the contrary, it may also so composed that the command is sent from the indoor unit 2 to the outdoor unit 1 and the control board 15 of the indoor unit 2 determines the magnitude relation of the anti-combustibility class CfL and the anti-

combustibility class CfS and when the anti-combustibility class CfL < the anti-combustibility class CfS, the indoor unit 2 sends a command to the outdoor unit 1 so as to inhibit the operation of the outdoor unit 1 and the opening of valves. It may also be so composed that the remote controller 19 sends a command to the outdoor unit 1 and the indoor unit 2 for permitting/inhibition the operation or the opening of valves through the comparison of the anti-combustibility class CfL and the anti-combustibility class CfS by the remote controller 19.

[0049] Moreover, using presence/absence information of refrigerant leakage of a refrigerant leakage sensor 81 of the indoor unit 2, in case of refrigerant leakage to a space to be air-conditioned, which is often a residential space, the air-conditioning apparatus 100 of the First Embodiment can suppress further leakage to the space to be air-conditioned by automatically and completely closing the first valve 51 and the second valve 71 or by collecting refrigerant to the outdoor unit 1 side.

[0050] Now, this action shall be described. When the refrigerant leakage sensor 81 of the indoor unit 2 detects leakage of refrigerant, the control board 15 of the indoor unit 2 reads the refrigerant leakage information of the refrigerant leakage sensor 81, while the control board 10 of the outdoor unit 1 reads the information through the inter-device communication line 18. Upon reception of a command from the control board 10, the outdoor unit 1 closes completely the first valve 51 and the second valve 71. Otherwise, receiving the command from the control board 10, the outdoor unit 1 puts the four-way valve to the cooling operation position, completely opens the second valve 71, the expansion valve 7 and the first valve 51 operates the compressor 5 and the outdoor fan 9 and, after the operation time set beforehand or the automatic determination by the suction pressure value when the pressure value of refrigerant sucked by the compressor 5 attains by and large the atmospheric pressure, closes completely the first valve 51, stops the compressor 5 and the outdoor fan 9, collects and seals the refrigerant in the pipes of the outdoor unit 1 or in the heat source side heat exchanger 8. Such action suppresses further leakage to the space side to be air-conditioned.

[0051] As mentioned above, if refrigerant leaks in a space side to be air-conditioned, which is often a residential space, the indoor side security can be secured by automatically collecting the refrigerant to the outdoor unit 1 side and suppressing further leakage into the space to be air-conditioned.

Second Embodiment

[0052] In the First Embodiment, an air-conditioning apparatus where one indoor unit is connected to one outdoor unit was described. In the Second Embodiment, an air-conditioning apparatus 200 where a plurality of indoor units are connected to one outdoor unit and an air-conditioning apparatus 300 where a plurality of indoor units are connected to a plurality of outdoor units shall be described. Note that in the Second Embodiment, the same components as the First Embodiment shall be represented by the same symbol and the description thereof shall be omitted.

[0053] Fig. 4 shows the air-conditioning apparatus 200 of the Second Embodiment. In the air-conditioning apparatus 200, three (3) indoor units 2A, 2B and 2C are connected to one outdoor unit 1. The indoor units 2A, 2B and 2C are connected in parallel to the gas pipe 3 and the liquid pipe 4. The indoor units 2A, 2B and 2C are provided with an expansion valve 7A, 7B and 7C respectively between the liquid pipe 4 and a load side heat exchanger 13A, 13B and 13C. The indoor units 2A, 2B and 2C respectively have a control board 15A, 15B and 15C and the control board 15 is connected to the control board 10 of the outdoor unit 1 through the inter-device communication line 18. The control board 15A, 15B and 15C are respectively connected to a remote controller 19A, 19B and 19C. The user sets the operation information of the indoor units 2A, 2B and 2C by managing the respective remote controller 19A, 19B and 19C.

The control board 15A, 15B and 15C can control the opening of the expansion valve 7A, 7B and 7C respectively based on the set operation information and adjust the flow of refrigerant through the load side heat exchanger 13A, 13B and 13C. As the expansion valve 7A, 7B and 7C is disposed in the indoor units 2A, 2B and 2C, it is so composed not to provide the outdoor unit 1 with an expansion valve; otherwise, the other composition of the outdoor unit 1 is same as the First Embodiment.

Moreover, the indoor units 2A, 2B and 2C are provided with a refrigerant leakage sensor 81A, 81B and 81C respectively and when refrigerant leaks in any one of the indoor units 2A, 2B and 2C, these refrigerant leakage sensors 81A, 81B and 81C detect leakage of refrigerant and output detection results to the control board 15A, 15B and 15C.

[0054] Like as the First Embodiment, the control board 15A, 15B and 15C respectively has a memory 16A, 16B and 16C and a display 17A, 17B and 17C. The memory 16A, 16B and 16C respectively stores the anti-combustibility class CfLA, CfLB and CfLC of the indoor units 2A, 2B and 2C. The control board 15A, the control board 15B and the control board 15C are respectively connected through a communication line and respective ones can communicate mutually.

[0055] Now, refrigerant circulation during the heating operation of the air-conditioning apparatus 200 of the Second Embodiment shall be described. High temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1 flows in the gas pipe 3 through the four-way valve 6 and then flows from the gas pipe 3 to the load side heat exchanger 13A, 13B and 13C respectively in parallel, exchanges heat with the indoor air sent by the indoor fan 14A, 14B and 14C and becomes low temperature high pressure liquid refrigerant of subcooling state. The liquid refrigerant discharged from the load side heat exchanger 13A, 13B and 13C is

depressed by the expansion valve 7A, 7B and 7C respectively, becomes low temperature low pressure two-phase gas-liquid state and flows from the liquid pipe 4 to the outdoor unit 1. The two-phase refrigerant flowing into the heat source side heat exchanger 8 from the liquid pipe 4 exchanges heat with outdoor air sent by the outdoor fan 9 and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5 from the heat source side heat exchanger 8 through the four-way valve 6.

[0056] Hereto, the basic composition of the air-conditioning apparatus 200 of the Second Embodiment has been described. Now, the control board 10 of the outdoor unit 1 and the control board 15A, 15B and 15C of the indoor unit 2A, 2B and 2C, the memory 11 of the control board 10 of the outdoor unit 1 and the memory 16A, 16B and 16C of the control board 15 A, 15B and 15C composing characteristic elements of the present invention, shall be described.

[0057] In the First Embodiment, the anti-combustibility class CfS of the outdoor unit 1 and the anti-combustibility class CfL of the indoor unit 2 were compared, while in the Second Embodiment, as there are a plurality of indoor units, it shall be described the anti-combustibility class of which indoor unit will be compared with the anti-combustibility class CfS of the outdoor unit 1 in the Second Embodiment.

[0058] In the air-conditioning apparatus 200 of the Second Embodiment, when the control board 10 of the outdoor unit 1 and the control board 15A of the indoor unit 2A connected by the inter-device communication line 18 are turned on electricity, the control board 10 of the outdoor unit 1 and the control board 15A of the indoor unit 2A communicate automatically and the control board 10 of the outdoor unit 1 sends a signal to the control board 15A of the indoor unit 2A commanding to notice the anti-combustibility class CfL of the indoor unit. Upon reception of this command, the control board 15A of the indoor unit 2A sends a command to the remaining control board 15B and control board 15C asking to inform the control board 15A of respective anti-combustibility class CfLB and anti-combustibility class CfLC. Receiving the message from the control board 15B and the control board 15C, the control board 15A informs the control board 10 of the outdoor unit 1 of the smallest of anti-combustibility class CfLA, CfLB and CfLC, in other words the anti-combustibility class of the indoor unit the least compatible with the inflammable refrigerant among the indoor units 2A, 2B and 2C, as anti-combustibility class CfLmin.

[0059] For instance, if anti-combustibility class CfLA=class 4, anti-combustibility class CfLB= class 3 and anti-combustibility class CfLC = class 2, the anti-combustibility class CfLmin = class 2 (= and anti-combustibility class CfLC). Besides, if anti-combustibility class CfLA=class 4, anti-combustibility class CfLB= class 3 and anti-combustibility class CfLC = class 3, the anti-combustibility class CfLmin = class 3.

[0060] Upon reception of anti-combustibility class CfLmin from the control board 15A of the indoor unit 2A, the control board 10 of the outdoor unit 1 compares the anti-combustibility class CfS stored in the memory 11 and the anti-combustibility class CfLmin.

If anti-combustibility class CfLmin < anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1 determines that the refrigerant usable for the outdoor unit 1 is more inflammable than the refrigerant that can be used for any one of the indoor unit 2A, 2B and 2C, the control board 10 inhibits operation of actuators such as compressor 5, outdoor fan 9, expansion valve 7 or indoor fan 14, indicates abnormality at least on one of the display 12 of the outdoor unit 1, display 12, 17A, 17B and 17C of the indoor unit 2A, 2B and 2C or remote controller 19A, 19B and 19C and does not open the first valve 51 and the second valve 71 of the outdoor unit 1 by keeping them completely closed. The indicated abnormality shows that any one of the indoor units 2A, 2B and 2C is not compatible with the inflammable refrigerant.

If anti-combustibility class CfLmin $\geq$ anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1 determines that the refrigerant usable for all of the indoor units 2A, 2B and 2C is equally or more inflammable than the refrigerant that can be used for the outdoor unit 1, the control board 10 permits the operation, does not indicates abnormality and opens the first valve 51 and the second valve 71 without closing them completely.

Moreover, if any one of refrigerant leakage sensors 81A, 81B and 81C of the indoor units 2A, 2B and 2C detects leakage of refrigerant, receiving a command from the control board 10, the outdoor unit 1A closes completely the first valve 51 and the second valve 71. Otherwise, receiving a command from the control board 10, the outdoor unit 1A puts the four-way valve 6 in the cooling operation position, closes completely the second valve 71, opens completely the expansion valve 7A, 7B and 7C and the first valve 51, operates the compressor 5 and the outdoor fan 9, and after the operation time set beforehand or through the automatic determination by the suction pressure value when the pressure value of refrigerant sucked by the compressor 5 attains by and large the atmospheric pressure, closes completely the first valve 51, stops the compressor 5 and the outdoor fan 9, collects and seals the refrigerant in the pipes of the outdoor unit 1 or in the heat source side heat exchanger 8. Such action suppresses further leakage to the space side to be air-conditioned.

[0061] As mentioned above, in the air-conditioning apparatus 200 of the Second Embodiment, even if it is so composed to connect a plurality of indoor units 2A, 2B and 2C to a single outdoor unit 1A, the safety of inflammable refrigerant can be improved, because the smallest of anti-combustibility classes of the indoor units 2A, 2B and 2C, namely the anti-combustibility class CfLmin the least compatible with the inflammable refrigerant is com-

pared with the anti-combustibility class CfS of the outdoor unit 1A. Also, if refrigerant leaks in a space side to be air-conditioned, which is often a residential space, the indoor side security can be secured by automatically collecting the refrigerant to the outdoor unit 1A side and suppressing further leakage into the space side to be air-conditioned.

[0062] Fig. 5 shows the air-conditioning apparatus 300 of the Second Embodiment. The composition of the air-conditioning apparatus 300 shall be described based on Fig. 5. Note that in the air-conditioning apparatus 300, the same components as the air-conditioning apparatus 200 shall be represented by the same symbol and the description thereof shall be omitted.

[0063] In the air-conditioning apparatus 300, three (3) indoor units 2A, 2B and 2C are connected to two (2) outdoor units 1A and 1B. The outdoor units 1A and 1B and the indoor units 2A, 2B and 2C are connected with the gas pipe 3 for gas refrigerant circulation and the liquid pipe 4 for two-phase gas-liquid circulation, and during heating operation, high temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1B joins the gas pipe 3, while two-phase refrigerant flowing in the liquid pipe 4 from the indoor units 2A, 2B and 2C bifurcates to the outdoor unit 1A and the outdoor unit 1B at the liquid pipe 4. The control board 10B of the outdoor unit 1B has a memory 11B and a display 12B same as the First Embodiment. The memory 11B stores the anti-combustibility class CfSB of the outdoor unit 1B. Respective outdoor unit 1A and outdoor unit 1B are provided with a first valve 51A and 51B between the connection part with the gas pipe 3 and the four-way valve 6A and 6B respectively and a second valve 71A and 71B between the heat source side heat exchanger 8A and 8B and the connection part with the liquid pipe 4.

[0064] Now, refrigerant circulation during the heating operation of the air-conditioning apparatus 300 shall be described. High temperature high pressure gas refrigerant discharged from the compressor 5A of the outdoor unit 1A flows in the gas pipe 3 through the four-way valve 6A. Similarly, high temperature high pressure gas refrigerant discharged from the compressor 5B of the outdoor unit 1B flows into the gas pipe 3 through the four-way valve 6B. Then it flows from the gas pipe 3 to the load side heat exchanger 13A, 13B and 13C respectively in parallel, exchanges heat with the indoor air sent by the indoor fan 14A, 14B and 14C and becomes low temperature high pressure liquid refrigerant of subcooling state. The liquid refrigerant discharged from the load side heat exchanger 13A, 13B and 13C is depressed by the expansion valve 7A, 7B and 7C respectively, becomes low temperature low pressure two-phase gas-liquid state and flows from the liquid pipe 4 to the outdoor unit 1A and 1B.

[0065] The two-phase refrigerant flowing into the heat source side heat exchanger 8A from the liquid pipe 4 exchanges heat with outdoor air sent by the outdoor fan 9A and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5A from the heat source side heat exchanger 8A through the four-way valve 6A. Similarly, the two-phase refrigerant flowing into the heat source side heat exchanger 8B from the liquid pipe 4 exchanges heat with outdoor air sent by the outdoor fan 9B and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5B from the heat source side heat exchanger 8B through the four-way valve 6B. In other words, the same refrigerant circulates in the outdoor units 1A and 1B and the indoor units 2A, 2B and 2C.

[0066] Now, the comparison of anti-combustibility class of the outdoor unit and the indoor unit of the air-conditioning apparatus 300 shall be described. When the control board 10A of the outdoor unit 1A and the control board 10B of the outdoor unit 1B connected and the control board 15A of the indoor unit 2A and the control board 15B of the indoor unit 2B connected by the inter-device communication line 18 are turned on electricity, the control board 10A of the outdoor unit 1A and the control board 15A of the indoor unit 2A communicate automatically, Similarly as the air-conditioning apparatus 200 of Fig. 4, the control board 10A of the outdoor unit 1A sends a signal to the control board 15A of the indoor unit 2A commanding to notice the anti-combustibility class CfL of the indoor unit. Upon reception of this command, the control board 15A of the indoor unit 2A sends a command to the remaining control board 15B and control board 15C asking to inform the control board 15A of respective anti-combustibility class CfLB and anti-combustibility class CfLC. Receiving the message from the control board 15B and the control board 15C, the control board 15A informs the control board 10 of the outdoor unit 1A of the smallest of anti-combustibility class CfLA, CfLB and CfLC, in other words the anti-combustibility class of the indoor unit the least compatible with the inflammable refrigerant among the indoor units 2A, 2B and 2C, as anti-combustibility class CfLmin.

[0067] At the same time, the control board 10A of the outdoor unit 1A sends also to the control board 10B a signal commanding to notice the anti-combustibility class CfSB.

[0068] The control board 10A of the outdoor unit 1A sends a signal commanding to notice the anti-combustibility class CfSB stored in the control board 10B of the outdoor unit 1B. Upon reception of this command, the control board 10B of the outdoor unit 1B informs the control board 10A of the anti-combustibility class CfSB stored in the memory 11B. Upon reception of the anti-combustibility class CfSB, the control board 10A compares the anti-combustibility class CfSA stored in the memory 11A and the anti-combustibility class CfSB and adopts the higher anti-combustibility class as anti-combustibility class CfSmax.

[0069] Then, the control board 1A compares the magnitude relation of anti-combustibility class CfLmin and anti-combustibility class CfSmax.

[0070] If anti-combustibility class CfLmin < anti-combustibility class CfSmax, in other words, when the control board 10A of the outdoor unit 1A determines that the refrigerant usable for one of the outdoor units 1A or 1B is more inflammable than the refrigerant that can be used for any one of the indoor unit 2A, 2B and 2C, the control board 10A inhibits operation of actuators such as compressor 5A, outdoor fan 9A, expansion valve 7A or indoor fan 14A, 14B and 14C, and at the same time, sends a command to the control board 10B in order to inhibit the operation of the actuator of the outdoor unit 1B. Moreover, it indicates abnormality at least on one of the display 12A, 12B, display 17A, 17B and 17C or remote controller 19A, 19B and 19C and does not open the first valve 51A, 51B and the second valve 71A, 71B of the outdoor unit 1A, 1B by keeping them completely closed. The indicated abnormality shows that one of the indoor units 2A, 2B and 2C does not compatible with the inflammable refrigerant.

[0071] If anti-combustibility class CfLmin ≥ anti-combustibility class CfSmax, in other words, when the control board 10A of the outdoor unit 1A determines that the refrigerant usable for all of the indoor units 2A, 2B and 2C is more inflammable than the refrigerant that can be used for the any one of the outdoor units 1A and 1B, the control board 10A permits the operation, opens the first valve 51A, 51B and the second valve 71A, 71B of the outdoor unit 1A and 1B without closing them completely and does not indicate abnormality.

[0072] Moreover, if any one of refrigerant leakage sensors 81A, 81B and 81C of the indoor units 2A, 2B and 2C detects leakage of refrigerant, by receiving a command from the control board 10A, the outdoor unit 1A, 1B closes completely the first valve 51A, 51B and the second valve 71A, 71B. Otherwise, by receiving a command from the control board 10A, the outdoor unit 1A, 1B puts the four-way valve 6A, 6B in the cooling operation position, closes completely the second valve 71A, 71B, opens completely the expansion valve 7A, 7B and 7C and the first valve 51A, 51B, operates the compressor 5A, 5B and the outdoor fan 9A, 9B and after an operation time set beforehand or through an automatic determination by the suction pressure value as to when the pressure value of refrigerant sucked by the compressor 5A, 5B attains by and large the atmospheric pressure, closes completely the first valve 51A, 51B, stops the compressor 5A, 5B and the outdoor fan 9A, 9B, collects and seals the refrigerant in the pipes of the outdoor unit 1A, 1B or in the heat source side heat exchanger 8A, 8B. Such action suppresses further leakage to the space side to be air-conditioned.

[0073] Note that the anti-combustibility class CfLmin and the anti-combustibility class CfSmax may be compared by any one of control boards 10B, 15A, 15B and 15C.

[0074] As mentioned above, in the air-conditioning apparatus 300 of the Second Embodiment, even if it is so composed to connect a plurality of indoor units to a plurality of outdoor units, the safety of the air-conditioning apparatus 300 to the inflammable refrigerant can be improved, because the smallest of anti-combustibility classes of the indoor units 2A, 2A and 2C is compared with the largest of anti-combustibility classes CfS of the outdoor unit 1A, 2A, the operation is inhibited when the anti-combustibility class of any one of the indoor units and the first valve 51A, 51B and the second valve 71A, 71B are closed completely, thus preventing the inflammable refrigerant from flowing by mistake into an indoor unit incompatible with the inflammable refrigerant.

Also, if refrigerant leaks in a space side to be air-conditioned, which is often a residential space; the indoor side security can be secured by automatically collecting the refrigerant to the outdoor unit 1A, 1B side and suppressing further leakage into the space side to be air-conditioned.

[0075] Fig. 6 shows the air-conditioning apparatus 400 of the Second Embodiment. The composition of the air-conditioning apparatus 400 shall be described based on Fig. 6. Note that in the air-conditioning apparatus 400, the same components as the air-conditioning apparatus 200, 300 shall be represented by the same symbol and the description thereof shall be omitted.

[0076] In the air-conditioning apparatus 400, three (3) indoor units 20A, 20B and 20C are connected to a single outdoor unit 1C. The outdoor unit 1C and the indoor units 20A, 20B and 20C are connected with the gas pipe 3A, 3B 3C for gas refrigerant circulation and the liquid pipe 4A, 4B, 4C for two-phase gas-liquid circulation, and during heating operation, high temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1C bifurcates in outdoor unit 1C after passing through the four-way valve 6, and flows into the indoor units 20A, 20B and 20C through the gas pipe 3A, 3B, 3C. The liquid refrigerant flowing in the liquid pipe 4A, 4B, 4C prom the indoor units 20A, 20B and 20C joins after being depressed by the respective expansion valve 70A, 70B and 70C, flows into the heat source side heat exchanger 8 and returns to the compressor 5 again through the four-way valve 6. Also, the control board 10 of the outdoor unit 1C has a memory 11 and a display 12 same as the First Embodiment. The memory 11 stores the anti-combustibility class CfS of the outdoor unit 1C. The outdoor unit 1C is provided with a first valve 52A, 52B, 52C in the vicinity of the connection part with the gas pipe 3A, 3B, 3C respectively and a second valve 72A, 72B, 72C in the vicinity of the connection with the liquid pipe 4A, 4B, 4C.

[0077] Now, refrigerant circulation during the heating operation of the air-conditioning apparatus 400 shall be described. High temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1C bifurcates in outdoor unit1C and flows in the gas pipe 3A, 3B, 3C through the four-way valve 6. Then it flows from the gas pipe 3A, 3B, 3C to the load side heat exchanger 13A, 13B and 13C respectively in parallel, exchanges heat with the indoor air sent by the indoor fan 14A, 14B and 14C and becomes low temperature high

pressure liquid refrigerant of subcooling state. The liquid refrigerant discharged from the load side heat exchanger 13A, 13B and 13C, flows in the liquid pipe 4A, 4B, 4C towards the outdoor unit 1C and then is depressed by the expansion valve 70A, 70B and 70C respectively, becomes low temperature low pressure two-phase gas-liquid state and flows into the heat source side heat exchanger 8.

[0078] The two-phase refrigerant flowing into the heat source side heat exchanger 8 exchanges heat with outdoor air sent by the outdoor fan 9 and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5 from the heat source side heat exchanger 8 through the four-way valve 6. In other words, the same refrigerant circulates in the indoor units 20A, 20B and 20C respectively.

[0079] Now, the comparison of anti-combustibility class of the outdoor unit and the indoor unit of the air-conditioning apparatus 400 shall be described. When the control board 10 of the outdoor unit 1C and the control board 15A of the indoor unit 20A connected by the inter-device communication line 18 are turned on electricity, the control board 10 of the outdoor unit 1C and the control board 15A of the indoor unit 20A communicate automatically. Similarly as the air-conditioning apparatus 200 of Fig. 4, the control board 10 of the outdoor unit 1C sends a signal to the control board 15A of the indoor unit 20A commanding to notice the anti-combustibility class CfL of the indoor unit. Upon reception of this command, the control board 15A of the indoor unit 20A sends a command to the remaining control board 15B and control board 15C asking to inform the control board 15A of respective anti-combustibility class CfLB and anti-combustibility class CfLC. By receiving the message from the control board 15B and the control board 15C, the control board 15A informs the control board 10 of the outdoor unit 1C of the smallest of anti-combustibility class CfLA, CfLB and CfLC, in other words the anti-combustibility class of the indoor unit the least compatible with the inflammable refrigerant among the indoor units 20A, 20B and 20C, as anti-combustibility class CfLmin.

[0080] Then, the control board 1 compares the magnitude relation of anti-combustibility class CfLmin and anti-combustibility class CfS.

[0081] If anti-combustibility class CfLmin < anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1C determines that the refrigerant usable for the outdoor unit 1C is more inflammable than the refrigerant that can be used for any one of the indoor unit 20A, 20B and 20C, the control board 10 inhibits the operation of actuators such as compressor 5, outdoor fan 9, expansion valve 70A, 70B, 70C and indoor fan 14A, 14B and 14C. Moreover, it indicates abnormality at least on one of the display 12 or 17A, 17B and 17C or remote controller 19A, 19B and 19C and does not open the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C of the outdoor unit 1C by keeping them completely closed. The indicated abnormality shows that one of the indoor units 20A, 20B and 20C does not compatible with the inflammable refrigerant.

[0082] If anti-combustibility class CfLmin ≥ anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1C determines that the refrigerant usable for all of the indoor units 20A, 20B and 20C is more inflammable than the refrigerant that can be used for the outdoor unit 1C, the control board 10 permits the operation, opens the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C without closing them completely and does not indicates abnormality.

If anti-combustibility class CfLmin ≠ anti-combustibility class CfS and, anti-combustibility class CfLmin < anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1C determines that the refrigerant usable for the outdoor unit 1C is more inflammable than the refrigerant that can be used for the indoor unit 20A, 20B and 20C, the control board 10 inhibits operation of devices such as compressor 5, does not open the expansion valve 70A, 70B, 70C, the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C by keeping them completely closed and indicates abnormality at least on one of the display 12 of the outdoor unit 1, the display of the indoor unit 20A, 20B, 20C or remote controller. The indicated abnormality shows that one of the indoor units 20A, 20B and 20C does not compatible with the inflammable refrigerant. Here, the second valve 72A, 72B, 72C can be replaced by the expansion valve 70A, 70B, 70C, without composing them.

[0083] Moreover, if any one of refrigerant leakage sensors 81A, 81B and 81C of the indoor units 20A, 20B and 20C detects leakage of refrigerant, similarly to the action of the First Embodiment, by receiving the command from the control board 10, the outdoor unit 1C closes completely the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C. Otherwise, by receiving the command from the control board 10, the outdoor unit 1C puts the four-way valve 6 in the cooling operation position, closes completely the second valve 72A, 72B, 72C and the expansion valve 70A, 70B, 70C, opens completely the first expansion valve 52A, 52B, 52C, operates the compressor 5 and the outdoor fan 9 and after the operation time set beforehand or through an automatic determination by the suction pressure value as to when the pressure value of refrigerant sucked by the compressor 5 attains by and large the atmospheric pressure, closes completely the first valve 52A, 52B, 52C, stops the compressor 5 and the outdoor fan 9, collects and seals the refrigerant in the pipes of the outdoor unit 1C or in the heat source side heat exchanger 8. Such action suppresses further leakage to the space side to be air-conditioned.

Here, if the object of action of the expansion valve 70A, 70B, 70C, the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C is limited to those connected to the indoor unit where the refrigerant leakage is detected, it becomes possible to collect refrigerant only from the indoor unit where leakage happens, and after collection of

refrigerant, the air-conditioning apparatus can be operated excluding the indoor unit where leakage happens.

[0084] Note that the anti-combustibility class CfLmin and the anti-combustibility class CfS may be compared by any one of control boards 15A, 15B and 15C.

[0085] As mentioned above, in the air-conditioning apparatus 400 of the Second Embodiment, even if it is so composed to connect a plurality of indoor units to a single outdoor unit, the safety of the air-conditioning apparatus 400 against the inflammable refrigerant can be improved, because the smallest of anti-combustibility classes of the indoor units 20A, 20A and 20C is compared with the anti-combustibility classes CfS of the outdoor unit 1C, the operation is inhibited when the anti-combustibility class of any one of the indoor units is smaller than the anti-combustibility class of the outdoor unit and the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C are closed completely, thus preventing the inflammable refrigerant from flowing by mistake into an indoor unit incompatible with the inflammable refrigerant.

Also, if refrigerant leaks in a space side to be air-conditioned, which is often a residential space, the indoor side security can be secured by automatically collecting the refrigerant to the outdoor unit 1C side and suppressing further leakage into the space to be air-conditioned.

[0086] Fig. 7 shows the air-conditioning apparatus 500 of the Second Embodiment. The composition of the air-conditioning apparatus 500 shall be described based on Fig. 7. Note that in the air-conditioning apparatus 500, the same components as the air-conditioning apparatus 200, 300, 400 shall be represented by the same symbol and the description thereof shall be omitted.

[0087] In the air-conditioning apparatus 500, a branch box 30 is disposed between the outdoor unit 1D and the indoor unit 20A, 20B, 20C.In the branch box 30, three (3) pipes branched from the gas pipe 3 are provided with the first valve 52A, 52B, 52C respectively, while three (3) pipes branched from the liquid pipe 4 are respectively provided with the second valve 72A, 72B, 72C and the expansion valve 70A,70B and 70C.

[0088] In the air-conditioning apparatus 500, three (3) indoor units 20A, 20B and 20C are connected to a single outdoor unit 1D through a single branch box 30. The outdoor unit 1D and the branch box 30 are connected with the gas pipe 3 for gas refrigerant circulation and the phase liquid pipe 4, while the branch box 30 and the indoor unit 20A, 20B, 20C are connected with the gas pipe 3A, 3B, 3C for gas refrigerant circulation and the liquid pipe 4A, 4B, 4C for liquid refrigerant circulation, and during the heating operation, high temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1D flows into the branch box 30 by the gas pipe 3 after passing through the four-way valve 6, branches in the branch box 30 and flows into the indoor units 20A, 20B and 20C through the gas pipe 3A, 3B, 3C. The liquid refrigerant flowing in the liquid pipe 4A, 4B, 4C from the indoor units 20A, 20B and 20C joins after being depressed by the respective expansion valve 70A, 70B and 70C in the branch box 30, flows into the heat source side heat exchanger 8 through the liquid pipe 4 and returns to the compressor 5 again through the four-way valve 6. Also, the control board 10 of the outdoor unit 1D has a memory 11 and a display 12 same as the First Embodiment. The memory 11 stores the anti-combustibility class CfS of the outdoor unit 1D. The branch box 30 is provided with a first valve 52A, 52B, 52C in the vicinity of the connection part with the gas pipe 3A, 3B, 3C respectively and a second valve 72A, 72B, 72C in the vicinity of the connection with the liquid pipe 4A, 4B, 4C. The control board 10 of the outdoor unit 1D and the control board 31 of the branch box 30, and the control board 31 of the branch box 30 and the control board 15A of the indoor unit 20A are connected with inter-device communication line 18, while the control board 15A, 15B, 15C of the indoor units 20A, 20B and 20C are connected with a communication line, allowing to communicate mutually.

[0089] Now, refrigerant circulation during the heating operation of the air-conditioning apparatus 500 shall be described. High temperature high pressure gas refrigerant discharged from the compressor 5 of the outdoor unit 1D passes through the four-way valve 6, branches in the branch box 30 through the gas pipe 3, and flows into the indoor units 20A, 20B and 20C through the gas pipe 3A, 3B, 3C. Then it flows from the gas pipe 3A, 3B, 3C to the load side heat exchanger 13A, 13B and 13C respectively in parallel, exchanges heat with the indoor air sent by the indoor fan 14A, 14B and 14C and becomes low temperature high pressure liquid refrigerant of subcooling state. The liquid refrigerant discharged from the indoor units 20A, 20B and 20C load flows in the liquid pipe 4A, 4B, 4C joins after being depressed by the expansion valve 70A, 70B and 70C respectively in the branch box 30, and flows into the heat source side heat exchanger 8 through the liquid pipe 4.

[0090] The two-phase refrigerant flowing into the heat source side heat exchanger 8 exchanges heat with outdoor air sent by the outdoor fan 9 and becomes high temperature low pressure gas refrigerant of superheated state. Then the superheated gas refrigerant is sucked into the compressor 5 from the heat source side heat exchanger 8 through the four-way valve 6. In other words, the same refrigerant circulates in the indoor units 20A, 20B and 20C respectively.

[0091] Now, the comparison of anti-combustibility class of the outdoor unit 1D and the indoor unit 20A, 20B, 20C of the air-conditioning apparatus 500 shall be described. When the control board 10 of the outdoor unit 1D, the control board 31 of the branch box 30 and the control board 15A of the indoor unit 20A connected by the inter-device communication line 18 are turned on electricity, the control board 10 of the outdoor unit 1D, the control board 31 of the branch box 30 and the control board 15A of the indoor unit 20A communicate automatically. The control board 10 of the outdoor unit 1 sends a signal commanding to notice the anti-combustibility class CfL of the indoor unit 20A. Upon reception of this

command, the control board 15A of the indoor unit 20A sends a command to the remaining control board 15B and control board 15C asking to inform the control board 15A of respective anti-combustibility class CfLB and anti-combustibility class CfLC. By receiving the message from the control board 15B and the control board 15C, the control board 15A informs the control board 31 of the branch box 30 of the smallest of the anti-combustibility classes CfLA, CfLB and CfLC, in other words the anti-combustibility class of the indoor unit the least compatible with the inflammable refrigerant among the indoor units 20A, 20B and 20C, as the anti-combustibility class CfLmin. The control board 31 of the branch box 30 sends the anti-combustibility class CfLmin of the indoor unit to the control board 10 of the outdoor unit 1D.

[0092] Then, the control board 1 compares the magnitude relation of anti-combustibility class CfLmin and anti-combustibility class CfS.

[0093] If anti-combustibility class CfLmin < anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1D determines that the refrigerant usable for the outdoor unit 1D is more inflammable than the refrigerant that can be used for any one of the indoor unit 20A, 20B and 20C, the control board 10 inhibits the operation of actuators such as compressor 5, outdoor fan 9, expansion valve 70A, 70B, 70C and indoor fan 14A, 14B and 14C. Moreover, it indicates abnormality at least on one of the display 12, the display 33 or the display 17A, 17B and 17C and the remote controller 19A, 19B and 19C and does not open the first valve 52A, 52B, 52C of the branch box 30 and the second valve 72A, 72B, 72C by keeping them completely closed. The indicated abnormality shows that one of the indoor units 20A, 20B and 20C is not compatible with the inflammable refrigerant.

[0094] If anti-combustibility class CfLmin ≥ anti-combustibility class CfS, in other words, when the control board 10 of the outdoor unit 1D determines that the refrigerant usable for all of the indoor units 20A, 20B and 20C is more inflammable than the refrigerant that can be used for the outdoor unit 1D, the control board 10 permits the operation, opens the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C of the branch box 30 without closing them completely and does not indicate abnormality.

[0095] Moreover, if any one of refrigerant leakage sensors 81A, 81B and 81D of the indoor units 20A, 20B and 20C detects leakage of refrigerant, similarly to the action of the First Embodiment, by receiving the command from the control board 10, the outdoor unit 1D closes completely the first valve 52A, 52B, 52C and the second valve 72A, 72B, 72C. Otherwise, by receiving the command from the control board 10, the outdoor unit 1D puts the four-way valve 6 in the cooling operation position, closes completely the second valve 72A, 72B, 72C and the expansion valve 70A, 70B, 70C, opens completely the first valve 52A, 52B, 52C, operates the compressor 5 and the outdoor fan 9 and after the operation time set beforehand or through an automatic determination by the suction pressure value as to when the pressure value of refrigerant sucked by the compressor 5 attains by and large the atmospheric pressure, closes completely the first valve 52A, 52B, 52C, stops the compressor 5 and the outdoor fan 9, collects and seals the refrigerant in the pipes of the outdoor unit 1D or in the heat source side heat exchanger 8. Such action allows collecting automatically refrigerant in the branch box 30 and the outdoor unit 1D side so as to suppress further leakage to the space side to be air-conditioned.

Here, if the object of action of the expansion valve, the first valve and the second valve is limited to those connected to the indoor unit where the refrigerant leakage is detected, it becomes possible to collect refrigerant only from the indoor unit where leakage happens, and after collection of refrigerant, the air-conditioning apparatus can be operated excluding the indoor unit where leakage happens.

[0096] Note that the magnitude relation between the anti-combustibility class CfLmin and the anti-combustibility class CfS may be compared by any one of control boards 31, 15A, 15B and 15C.

[0097] As mentioned above, in the air-conditioning apparatus 500 of the Second Embodiment, even if it is so composed to connect one branch box and a plurality of indoor units to a single outdoor unit, the safety of the air-conditioning apparatus 500 against the inflammable refrigerant can be improved, because the smallest of anti-combustibility classes CfL of the indoor units 20A, 20A and 20C is compared with the anti-combustibility classes CfS of the outdoor unit 1D, the operation is inhibited when the anti-combustibility class of any one of the indoor units is smaller than the anti-combustibility class of the outdoor unit and the first valve and the second valve in the branch box are closed completely, thus preventing the inflammable refrigerant from flowing by mistake into an indoor unit incompatible with the inflammable refrigerant. Also, if refrigerant leaks in a space side to be air-conditioned, which is often a residential space, the indoor side security can be secured by automatically collecting the refrigerant in the branch box 30 and the outdoor unit 1 side and suppressing further leakage into the space to be air-conditioned.

Third Embodiment

[0098] In the First and the Second Embodiments, the composition where the air-conditioning apparatus is provided with both of the outdoor unit and the indoor unit has been described. However, when only one of indoor unit and outdoor unit is exchanged while the other is kept for the further use, or the outdoor unit and the indoor unit are connected for the first time in the place of installation of an air-conditioning apparatus, it may be supposed that the control board of one unit stores the anti-combustibility class of the unit, but the control board of the other unit does not store the anti-combustibility class of the unit. In

such a case, it is impossible to compare the anti-combustibility class of the outdoor unit and the indoor unit.

[0099] There, in the Third Embodiment, when the outdoor unit is exchanged while the indoor unit is kept for the further use, supposing that the outdoor unit can respond to a case where the anti-combustibility class is not stored in the indoor unit, an indoor unit coping with the case where anti-combustibility class is not stored in the outdoor unit shall be described. Note that in the Third Embodiment, the same components as the First Embodiment shall be represented by the same symbol and the description thereof shall be omitted.

[0100] Fig 8 shows the composition on an outdoor unit of the case where the outdoor unit is exchanged while the indoor unit is kept for the further use as existing indoor unit. The outdoor unit 1 shown in Fig.8 is identical to the outdoor unit 1 shown in Fig. 1, while the indoor unit shown in Fig. 8 is an existing indoor unit 21 kept for the further use. The existing indoor unit 21 is provided with a control board 22, but the control board 22 does not store the anti-combustibility class of the existing indoor unit 21. In this case, when the control board 10 of the outdoor unit 1 sends a signal to the control board 22 of the existing indoor unit 21, but the control board 22 cannot inform the control board 10 of the outdoor unit 1 of the anti-combustibility class, because the existing indoor unit 21 does not store its own anti-combustibility class information. Therefore, the control board 10 of the outdoor unit 1 cannot compare the anti-combustibility class CfS stored in the memory 11 with the anti-combustibility class of the existing indoor unit 21, determines that there is an abnormality in the existing indoor unit 21, inhibits the operation, closes completely the first valve 51 and the second valve 71 and will not open them.

[0101] At this time, the display 12 of the outdoor unit 1 indicates that the anti-combustibility class of the existing indoor unit 21 is unknown and refuses to send or receive control signal to and from the existing indoor unit 21 or sends an error signal from the outdoor unit 1 to the existing indoor unit 21.

[0102] Above, it was described that if the anti-combustibility class is not stored in the existing indoor unit 21, it is determined that there is an abnormality in the existing indoor unit 21 and the operation is inhibited; however, in such a case, the control board 10 of the outdoor unit 1 may treat in the existing indoor unit 21 as the one corresponding only to the nonflammable refrigerant and the anti-combustibility class CfL of the existing indoor unit 21 as class 1.

[0103] Though it has been described that the indoor unit of Fig. 8 is an existing unit in the Third Embodiment, the existing indoor unit 21 and the existing outdoor unit may be new indoor unit prepared separately at the site of execution.

[0104] It is preferable that the default conditions at the shipment of the outdoor unit 1 inhibit the operation of actuators such as the compressor 5 and, only when the control board 10 of the outdoor unit 1 confirms that the anti-combustibility class CfL of the existing indoor unit 21 is equal or superior to the anti-combustibility class CfS of the outdoor unit 1, control to permit the operation of actuators of the outdoor unit 1.

[0105] As mentioned above, the use of the outdoor unit 1 of the Third Embodiment, can secure the safety, because when the outdoor unit 1 is to be replaced by the one coping with the inflammable refrigerant, if the anti-combustibility class is not stored in the other existing indoor units 21 kept for further use, the operation as heat pump device is inhibited as these existing indoor units 21 might not cope with the inflammable refrigerant and the first valve and the second valve are closed completely, preventing inflammable refrigerant from flowing by mistake into an indoor unit not coping with the inflammable refrigerant.

[0106] Moreover, when a new outdoor unit 1 using different refrigerant from the old unit is introduced, the indoor unit 2 may be kept for further use without replacing the indoor unit 2 at the same time as the replacement of the outdoor unit 1, allowing to save resources and energy and to shorten the term of works.

[0107] Also, the security of users can be secured, because the default conditions at the shipment of the outdoor unit 1 inhibit the operation and permit the operation as air-conditioning apparatus only when the anti-combustibility class stored in the existing indoor unit 21 to be used in combination with the outdoor unit 1 is checked for confirming that the existing indoor unit 21 is suitable for the inflammable refrigerant.

Fourth Embodiment

[0108] In the First to Third Embodiments, the device wherein the anti-combustibility class of the outdoor unit and the indoor unit is compared to control the inhibition or the permission of operation has been described, while in the Fourth Embodiment, in case of using a refrigerant toxic to the human body, the control of the inhibition or the permission of operation shell be described. Note that in the Fourth Embodiment, it shall be described supposing that the air-conditioning apparatus, the outdoor unit and the indoor unit of any one of the First to Third Embodiments shall be used.

[0109] In the Fourth Embodiment, the memory 11 of the outdoor unit 1 stores the antitoxic class CtS of the outdoor unit 1 is stored, while the memory 16 of the indoor unit 2 stores the antitoxic class CtL of the indoor unit 2 is stored. Here, the antitoxic class CtS of the outdoor unit 1 and the antitoxic class CtL of the indoor unit 2 shall be described based on the Table 9.

[0110] The antitoxic class can be determined from the toxic class of the refrigerant, so first, the classification of refrigerant toxic class shall be described.

[0111] Those refrigerants whose concentration which is anoxic to the human body even if the exposition is 8 hours per day or continuous 40 hours per week (admissible concentration) is less than 400 ppm(vol%) is clas-

sified as toxic class 1 while those refrigerants whose admissible concentration is equal or superior to 400 ppm (vol%) is classified as toxic class 2. It can be said that higher is the class, stronger is the toxicity of the refrigerant. Like as class of combustibility, such classification is settled by ISO 817 or ASHRAE 34.

[0112] Based on the aforementioned definition, R410A, R22, R32, R134 or other HFC refrigerants, and R290 (propane), R600a (isobutene) or other natural refrigerants are classified as toxicity class, while R717 (ammonia) or other refrigerants irritant to the human body are classified as toxicity 2.

[0113] Fig.9 is Fig.3 addition to toxicity of refrigerant and antitoxic class CtL of the indoor unit 2. Like as Fig. 3, if R410A, R32, R290, R717 can be used for the indoor unit 2, the memory 16 stores the toxicity of these refrigerants. In case of Fig. 9, information indicating that the toxicity class of R410A is class 1, the toxicity class of R32 is class 1, the toxicity class of R290 is class1 and the toxicity class of R717 is class 2 is stored. Besides, the largest of the toxicity class of usable refrigerants is stored as the antitoxic class CtL of the indoor unit 2. In case of Fig. 9, the toxicity class of R717 is the antitoxic class CtL of the indoor unit 2.

[0114] Like as Fig. 3, it has been described that the memory 16 stores the kind of refrigerant usable for the indoor unit 2, the toxicity of the refrigerant and the antitoxic class CtL though, only the antitoxic class CtL of the indoor unit 2 may be stored in the memory 16 in the step of manufacturing, without storing the kind of usable refrigerant usable for the indoor unit 2 and the toxicity of the refrigerant.

[0115] The same shall be applied to the information stored in the memory 11 of the outdoor unit 1.

[0116] In the Fourth Embodiment, the anti-combustibility class CfS and CfL and also the antitoxic class CtS and CtL are compared by either the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2.

[0117] If anti-combustibility class CfS $\leq$ CfL and antitoxic class CtS $\leq$ CtL, the operation of the air-conditioning apparatus shall be permitted and the first valve 51 and the second valve 71 shall be opened.

[0118] If anti-combustibility class CfS > CfL and antitoxic class CtS > CtL, the operation of heat pump cycle shall be inhibited.

Any one of the display 12 of the outdoor unit 1, the display 17 of the indoor unit 1 and the remote controller 19 shall indicate abnormality and the first valve 51 and the second valve 71 shall be completely closed and not opened. Especially, when the antitoxic class CtS > CtL, it shall be indicated as abnormality that the indoor unit 2 does not cope with the toxic refrigerant.

[0119] As it was the case for Third Embodiment, when one of the outdoor unit 1 and the indoor unit 2 is to be replaced, it is supposed that the memory of the existing unit does not store the corresponding antitoxic class of the unit. In such a case, the outdoor unit 1 cannot compare the antitoxic class with the existing indoor unit 21. Therefore, the control board 10 of the outdoor unit 1 determines that there is an abnormality in the existing indoor unit 21 and inhibits the operation of the air-conditioning apparatus in the respective case.

[0120] Similarly as the anti-combustibility of the Third Embodiment, when the antitoxic class is not stored in the existing unit, the control board 10 of the outdoor unit 1 may treat the existing indoor unit 21 as one coping only with the atoxic refrigerant, and treat the antitoxic class CtL of the existing indoor unit 21 as class 1.

[0121] As mentioned above, the security of the indoor unit 2 side space can be secured even if an outdoor unit 1 or indoor unit 2 using not only inflammable but also toxic refrigerant is connected by mistake, because not only the anti-combustibility class but also the antitoxic classes are compared. Moreover, the combination of the outdoor unit 1 and the indoor unit 2 can be made flexible provided that the security can be secured, because the operation is permitted when the anti-combustibility class CfL and the antitoxic class CtL of the indoor unit 2 are equal or superior to the anti-combustibility class CfS and the antitoxic class CtS of the outdoor unit 1.

Therefore, specification modification of the indoor unit 2 following the change of used refrigerant can be made minimum, the development cost of the device can be reduced, the time of delivery can be shortened and resources and energy can be saved. Also, the indoor unit 2 can be kept for further use, when a new outdoor unit 1 using a different refrigerant from the old device is introduced into a system already installed and operated, making unnecessary to renew the indoor unit 2 following the replacement of the outdoor unit 1 and contributing to save resources and energy and shorten the term of work.

Fifth Embodiment

[0122] In the First to Fourth Embodiments, it has been described that the anti-combustibility class or antitoxic class of the outdoor unit 1 and the indoor unit 2 are compared to control the inhibition or the permission of operation. However, it is highly probable that refrigerant leaks at the indoor unit 2 and fills the space when the pressure of the refrigerant flowing from the outdoor unit 1 exceeds the designed pressure of the indoor unit 2, even if the anti-combustibility class CfL and the antitoxic class CtL of the indoor unit 2 are equal or superior to the anti-combustibility class CfS and the antitoxic class CtS of the outdoor unit 1 and if explosion-proof means are taken for the indoor unit 2, and this is not desirable from the viewpoint of security.

[0123] In the Fifth Embodiment, therefore, it shall be described that the permission or inhibition of the operation is controlled considering also the pressure resistance of the device. In the Fifth Embodiment, it shall be described supposing the use of air-conditioning apparatus, outdoor unit and indoor unit of any one of the First to Fourth Embodiments.

[0124] In addition to the anti-combustibility class CfS and CfL and the antitoxic class CtS and CtL to be stored respectively in the memory 11 and the memory 16 in the First to Fourth Embodiments, the memory 11 stores the designed pressure PS of the outdoor unit 1 while the memory 16 stores the designed pressure PL of the indoor unit 2.

[0125] The designed pressure means a pressure value to be taken as standard in the strength design calculation for the compressor 5 or the heat side heat exchanger 8 for the outdoor unit 1, the load side heat exchanger 13 for the indoor unit 2 and the like. Namely, the designed pressure PS of the outdoor unit 1 and the designed pressure PL of the indoor unit 2 are already determined respectively in the design phase of the manufacturing step. For instance, higher is the condensation pressure or evaporation pressure of the refrigerant to be used, higher is the designed pressure and, on the contrary, lower are they lower is the designed pressure.

[0126] When the power supply is switched on, the control board 10 of the outdoor unit 1 and the control board 15 of the indoor unit 2 communicate and either the control board 10 or the control board 15 compares the anti-combustibility class and the antitoxic class similarly to the First to Fourth Embodiments, for determining the permission or the inhibition of operation. Moreover, the designed pressure PS and the designed pressure PL are compared. The operation of the air-conditioning apparatus is permitted when the designed pressure PS $\leq$ designed pressure PL and the first valve 51 and the second valve 71 are opened. On the contrary, if the designed pressure PS > designed pressure PL, the operation is inhibited and the first valve 51 and the second valve 71 are completely closed and would not be opened.

[0127] In other words, either the control board 10 or the control board 15 permits the operation of the air-conditioning apparatus and opens the first valve 51 and the second valve 71 when the anti-combustibility class CfS $\leq$ anti-combustibility class CfL and the designed pressure PS $\leq$ designed pressure PL, or when the anti-combustibility class CfS $\leq$ anti-combustibility class CfL, the designed pressure PS $\leq$ designed pressure PL and the antitoxic class CtS $\leq$ antitoxic class CtL.

[0128] On the contrary, it inhibits the operation of the air-conditioning apparatus and closes completely the first valve 51 and the second valve 71 and does not open them when the anti-combustibility class CfS > anti-combustibility class CfL, when the antitoxic class CtS > antitoxic class CtL or when the designed pressure PS > designed pressure PL.

[0129] In other words, the operation is permitted only when the comparison result of the anti-combustibility class and the designed pressure or the comparison result of the anti-combustibility class and the antitoxic class is permissible, and if any one of comparison result turns to inhibition, the operation shall be inhibited, the first valve 51 and the second valve 71 are completely closed without opening, and the abnormality will be displayed.

[0130] As mentioned above, the Fifth Embodiment can secure the security of the indoor unit 2 side, because it is so controlled to inhibit the operation of the air-conditioning apparatus when any one of the anti-combustibility class CfL, the antitoxic class CtL and the designed pressure PL of the indoor unit 2 is smaller than the anti-combustibility class CfS, the antitoxic class CtS and the designed pressure PS of the outdoor unit 1. Moreover, the combination of the outdoor unit 1 and the indoor unit 2 can be made flexible provided that the security can be secured, because the operation is permitted when the anti-combustibility class CfL and the designed pressure of the indoor unit 2 are equal or superior to those of the outdoor unit 1. Therefore, specification modification of the indoor unit 2 following the change of used refrigerant can be made minimum, the development cost of device can be reduced, the time of delivery can be shortened and resources and energy can be saved. Also, the indoor unit can be kept for further use, when a new outdoor unit using a different refrigerant from the old device is introduced into an air-conditioning apparatus already installed and operated, making unnecessary to renew the indoor unit following the replacement of the outdoor unit and contributing to save resources and energy and shorten the term of work.

[0131] In the First to Fifth Embodiments, even if it is permitted to operate as air-conditioning apparatus, when the anti-combustibility class CfS of the outdoor unit and the anti-combustibility class CfL of indoor unit are different, the display disposed on either the outdoor unit 1 and the indoor unit 2 may indicate that the anti-combustibility class CfS $\neq$ anti-combustibility class CfL. Such indication will help the user or the contractor to avoid erroneous connection of the outdoor unit and the indoor unit.

[0132] In the First to Fifth Embodiments, it is so composed to permit the operation of outdoor unit 1 and the indoor unit 2 by storing the anti-combustibility class and the like in the memory 11, 16 respectively and comparing, for instance, the anti-combustibility class CfL and CfS in the control board 10. However, the object of the present invention can also be attained by comparing the anti-combustibility class CfL and CfS not by the control board 10 but by the contractor of the device. Provided that the outdoor unit 1 stores the information of its anti-combustibility class CfS and that the indoor unit 2 stores the information of its anti-combustibility class CfL, the comparison thereof may be performed by the contractor and not by the control board 10. In this case, the first valve 51 and the second valve 71 might not be electric and they can be replaced by (not shown) manual valve, such as usually provided ball valve or stop valve. In other words, the contractor can confirm the information of anti-combustibility class CfS and CfL stored in the memory 11, 16 respectively before connecting the outdoor unit 1 and the indoor unit 2, thus preventing an erroneous connection. Moreover, supposing that the contractor compares the anti-combustibility class CfS and CfL, the anti-combustibility class CfS and CfL may not be stored in the memory

11, 16 respectively, but a seal or similar indication means indicating the information of the anti-combustibility class CfS and CfL may be affixed to the outdoor unit 1 and the indoor unit 2. Otherwise, the information of the anti-combustibility class CfS and CfL may be indicated by the display 12, 17.
For instance, if a seal indicating the information of the anti-combustibility CfS is affixed to the outdoor unit 1 while a seal indicating the information of the anti-combustibility CfL is affixed to the indoor unit 2, the contractor can confirm visually the information and compare the anti-combustibility class CfS and CfL.
The seal or similar indication means is only required for confirming the information of the anti-combustibility class. It may be replaced by a switch or jumper line for setting the anti-combustibility class and may be set beforehand during the manufacturing of the device.

[0133] The present invention can be applied for the air-conditioning apparatus provided with an outdoor unit and an indoor unit.

Reference Signs List

[0134] 100, 200, 300, 400, 500 Air-conditioning apparatus, 1 Outdoor unit, 2 Indoor unit, 3 Gas pipe, 4 Liquid pipe, 5 Compressor, 6 Four-way valve, 7 Expansion valve, 8 Heat side heat exchanger, 9 Outdoor fan, 10 Control board, 11 Memory, 12 Display, 13 Load side heat exchanger, 14 Indoor fan, 15 Control board, 16 Memory, 17 Display, 18 Inter-device communication line, 19 Remote controller, 21 Existing indoor unit, 22 Control board, 30 Branch box, 31 Control board, 32 Memory, 33 Display, 51 First valve, 71 Second valve, 81 Refrigerant leakage sensor

Claims

1. An air-conditioning apparatus (100, 200, 300, 400, 500) comprising:

   an outdoor unit (1) having a compressor (5) for compressing a refrigerant and a heat source side heat exchanger for exchanging heat between the refrigerant and an outdoor air and
   an indoor unit (2) having a load side heat exchanger (13) for exchanging heat between the refrigerant and an indoor air,
   the outdoor unit (1) including
   a first valve (51) provided in a gas pipe (3) to be connected with the indoor unit (2) and closed when shipped and
   a second valve (71) provided in a liquid pipe (4) to be connected with the indoor unit (2) and closed when shipped, wherein:
   the outdoor unit (1) has a first information concerning flammability of refrigerants that can be used for the outdoor unit (1); and
   the indoor unit (2) has a second information concerning flammability of refrigerants that can be used for the indoor unit (2).

2. The air-conditioning apparatus (100, 200, 300, 400, 500) of Claim 1, wherein
   the first information is stored in a first memory (11) disposed in the outdoor unit (1); and
   the second information is stored in a second memory (16) disposed in the indoor unit (2).

3. The air-conditioning apparatus (100, 200, 300, 400, 500) of Claim 2, further comprising
   a control unit for comparing the first information and the second information; and controlling not to open the first valve (51) and the second valve (71) when it is determined that the refrigerant usable for the outdoor unit (1) is more flammable than the refrigerant usable for the indoor unit (2).

4. The air-conditioning apparatus (100, 200, 300, 400, 500) of Claim 3, wherein
   the control unit controls to open the first valve (51) and the second valve (71) when the refrigerant usable for the indoor unit (2) is as flammable as or more inflammable than the refrigerant usable for the outdoor unit (1).

5. The air-conditioning apparatus (100, 200, 300, 400, 500) of any one of Claims 1 to 4, wherein
   the outdoor unit (1) is provided with a first display means (12) for indicating the first information; and
   the indoor unit (2) is provided with a second display means (17) for indicating the second information.

6. The air-conditioning apparatus (100, 200, 300, 400, 500) of any one of Claims 3 to 5, wherein
   a plurality of the indoor units (2) connected to the outdoor unit (1) via the gas pipe (3) and liquid pipe (4) are provided;
   the first valve (51) is provided with the gas pipe (3) that connects the outdoor unit (1) with the plurality of the indoor units (2);
   the second valve (71) is provided with the liquid pipe (4) that connects the outdoor unit (1) with the plurality of the indoor units (2);
   each indoor unit (2) has a second memory (16) for storing a second information concerning flammability of refrigerants that can be used for the indoor unit (2); and
   the control unit compares the first information and a plurality of the second information to control not to open all the first valve (51) and the second valve (71) when the refrigerant that can be used for the outdoor unit (1) is determined to be more flammable than the refrigerant that can be used for any one of the plurality of indoor units (2).

7. The air-conditioning apparatus (100, 200, 300, 400, 500) of Claims 6, wherein
the plurality of the indoor units (2) are connected to the outdoor unit (1) by a plurality of the gas pipes (3) and a plurality of the liquid pipes (4);
the first valve (51) is provided for each of the gas pipes (3);
the second valve (71) is provided for each of the liquid pipes (4).

8. The air-conditioning apparatus (100, 200, 300, 400, 500) of any one of Claims 3 to 5, wherein
a plurality of the outdoor units (2) and a plurality of the indoor units connected by each of a plurality of the gas pipes (3) and a plurality of the liquid pipes (4) are provided;
the first valve (51) is provided for each of the plurality of gas pipes (3);
the second valve (71) is provided for each of the plurality of liquid pipes (4); each outdoor unit (1) has a first memory (11) storing a first information concerning flammability of refrigerants that can be used for the outdoor unit (1);
each indoor unit (2) has a second memory (16) for storing a second information concerning the flammability of refrigerants that can be used for the indoor unit (2); and
the control unit compares a plurality of the first information and a plurality of the second information to control not to open all the first valve (51) and the second valve (71) when the most inflammable refrigerant that can be used for the plurality of the outdoor unit (1) is determined to be more flammable than the refrigerant that can be used for any one of the plurality of indoor units (2).

9. The outdoor unit (1) of the air-conditioning apparatus (100, 200, 300, 400, 500) of any one of Claims 2 to 8, wherein
the first memory (11) stores the third information concerning toxicity of the refrigerant usable for the outdoor unit (1);
the second memory (16) stores the fourth information concerning toxicity of the refrigerant usable for the indoor unit (2); and
the control unit compares the third information and the fourth information and controls not to open the first valve (51) and the second valve (71) when the refrigerant that can be used for the outdoor unit (1) is determined to be more toxic than the refrigerant that can be used for the indoor unit (2).

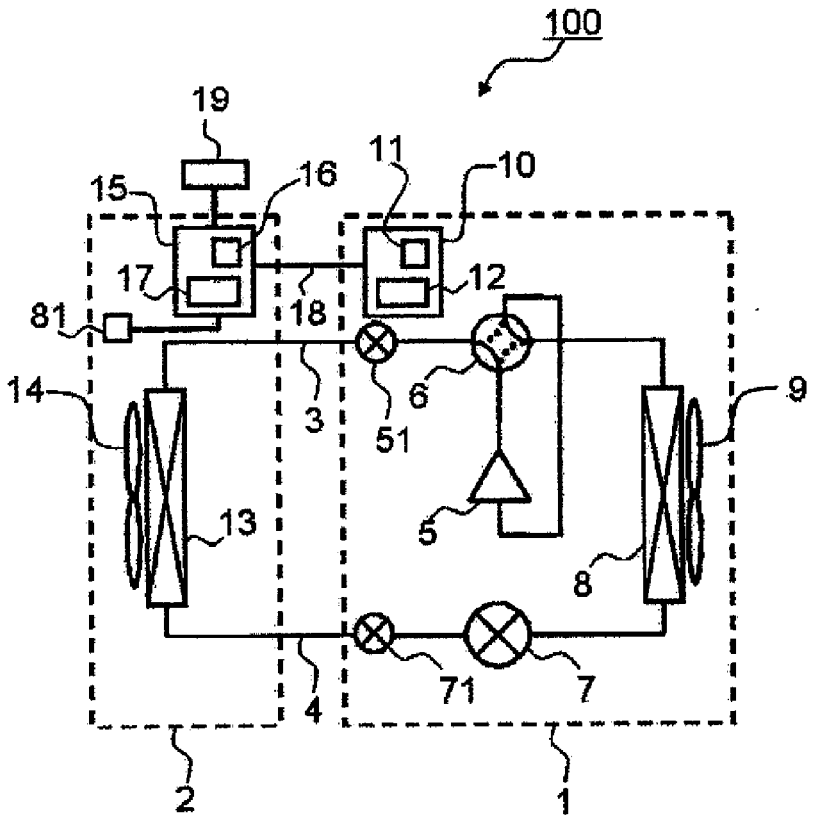
10. The outdoor unit (1) of the air-conditioning apparatus (100, 200, 300, 400, 500) of any one of Claims 2 to 9, wherein
the first memory (11) stores the designed pressure value of the outdoor unit (1);
the second memory (16) stores the designed pressure value of the indoor unit (2); and
the control unit compares the designed pressure value of the outdoor unit (1) and the designed pressure value of the indoor unit (2) and controls not to open the first valve (51) and the second valve (71) when the designed pressure value of the outdoor unit (1) is lower than the designed pressure value of the indoor unit (2).

11. An outdoor unit (1) of the air-conditioning apparatus (100, 200, 300, 400, 500) comprising
a compressor (5) for compressing a refrigerant,
a heat source side heat exchanger for exchanging heat between the refrigerant and an outdoor air and being connected to an indoor unit (2) having a load side heat exchanger (13) for exchanging heat between the refrigerant and an indoor air,
a first valve (51) provided in a gas pipe (3) to be connected with the indoor unit (2) and closed when shipped and
a second valve (71) provided in a liquid pipe (4) to be connected with the indoor unit (2) and closed when shipped, wherein:

the outdoor unit (1) is provided with a first information concerning flammability of refrigerants that can be used for the outdoor unit (1).

12. The outdoor unit (1) of the air-conditioning apparatus (100, 200, 300, 400, 500) of Claim 11, comprising
a memory (11) storing the first information; and
a control unit for communicating with the control unit to be connected, reading the second information concerning inflammability of the refrigerant that can be used for the indoor unit (2), comparing the first information and the second information and controlling not to open the first valve (51) and the second valve (71) when the refrigerant that can be used for the outdoor unit (1) is determined to be more flammable than the refrigerant that can be used for the indoor unit (2).

F I G. 1



F I G. 2

Combustibility class	LFL	Combustion speed	Combustion heat
1	—	Not spreading	—
2	>3.5%	≦0.1m/s	<19000kJ/kg
3	>3.5%	Spreading	<19000kJ/kg
4	≦3.5%	Spreading	≦19000kJ/kg

F I G. 3

Usable refrigerant	Combustibility class	Anti-combustibility class CfL
R410A	1	4
R32	2	
R290 (propane)	4	
R717 (ammonia)	2	

FIG. 4

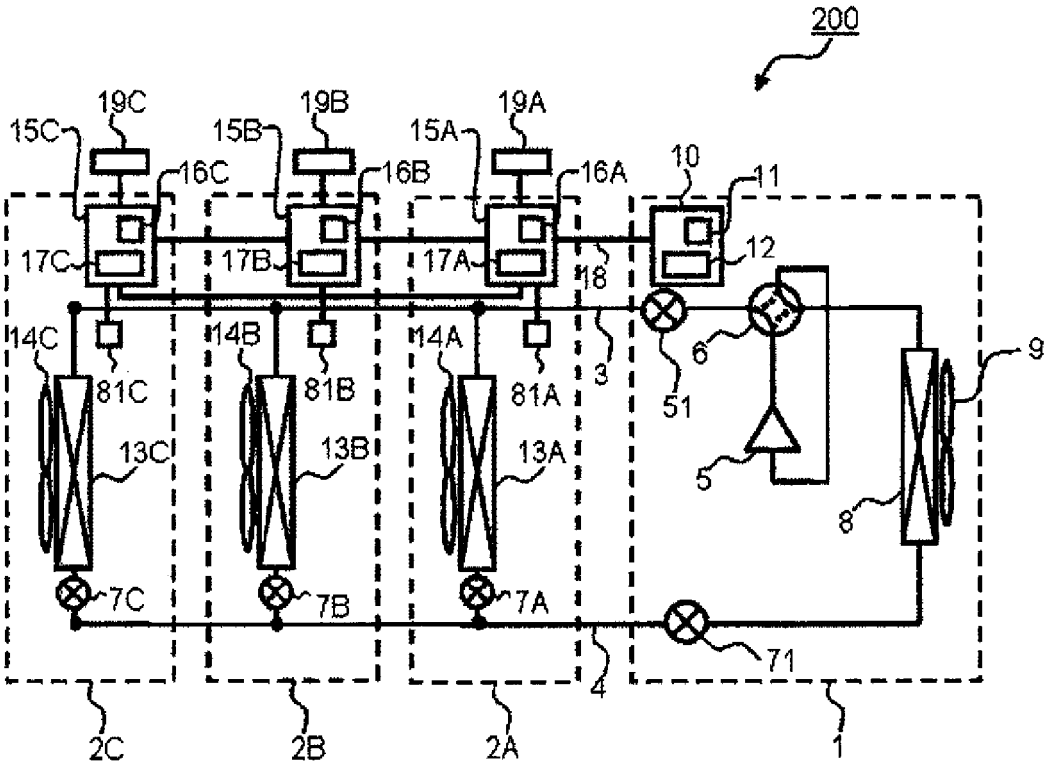

200
19C
19B
19A
15C
15B
15A
16C
16B
16A
10
11
12
17C
17B
17A
18
14C
14B
14A
81C
81B
81A
3
6
9
51
13C
13B
13A
5
8
7C
7B
7A
71
4
2C
2B
2A
1

FIG. 5

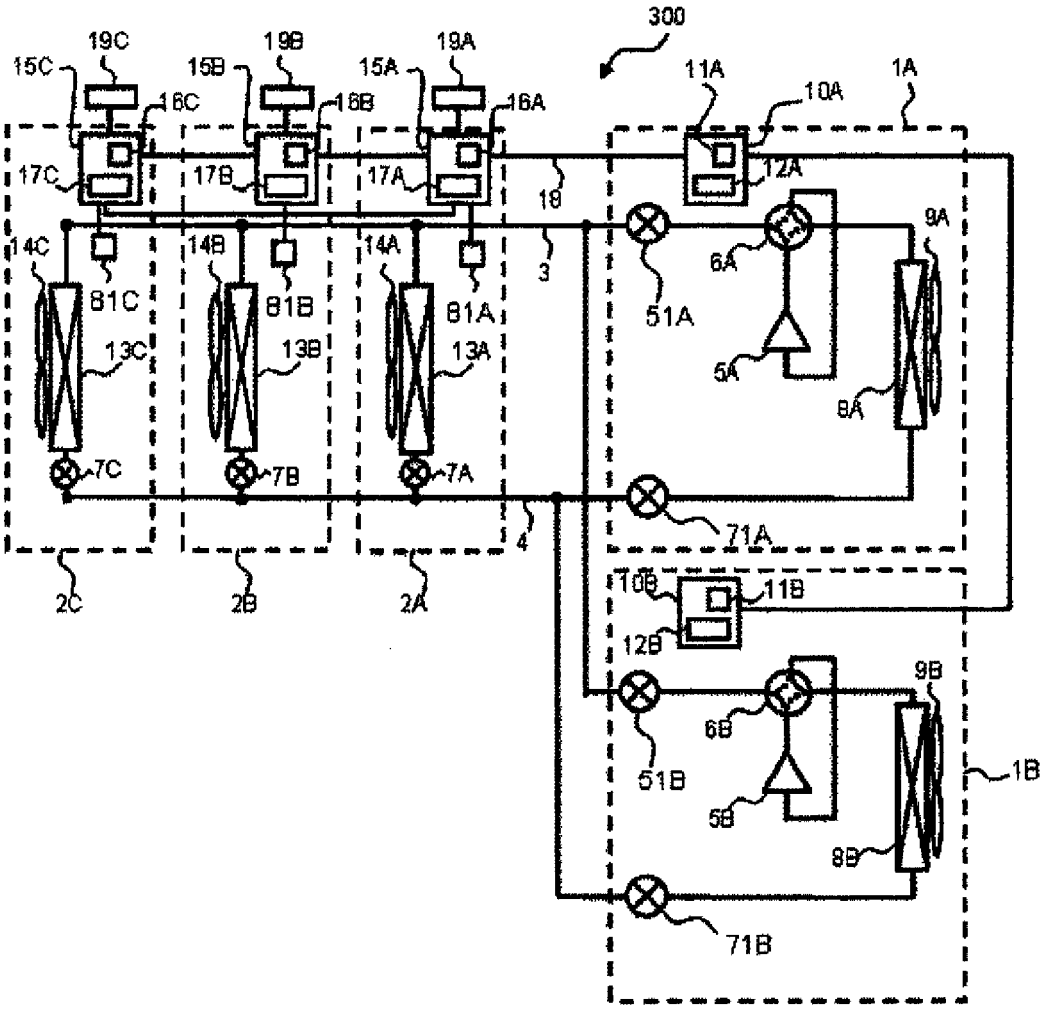

300
19C
19B
19A
15C
15B
15A
16C
16B
16A
11A
10A
1A
17C
17B
17A
12A
18
3
14C
14B
14A
81C
81B
81A
51A
6A
9A
13C
13B
13A
5A
8A
7C
7B
7A
71A
4
2C
2B
2A
10B
11B
12B
9B
6B
51B
1B
5B
8B
71B

FIG. 6

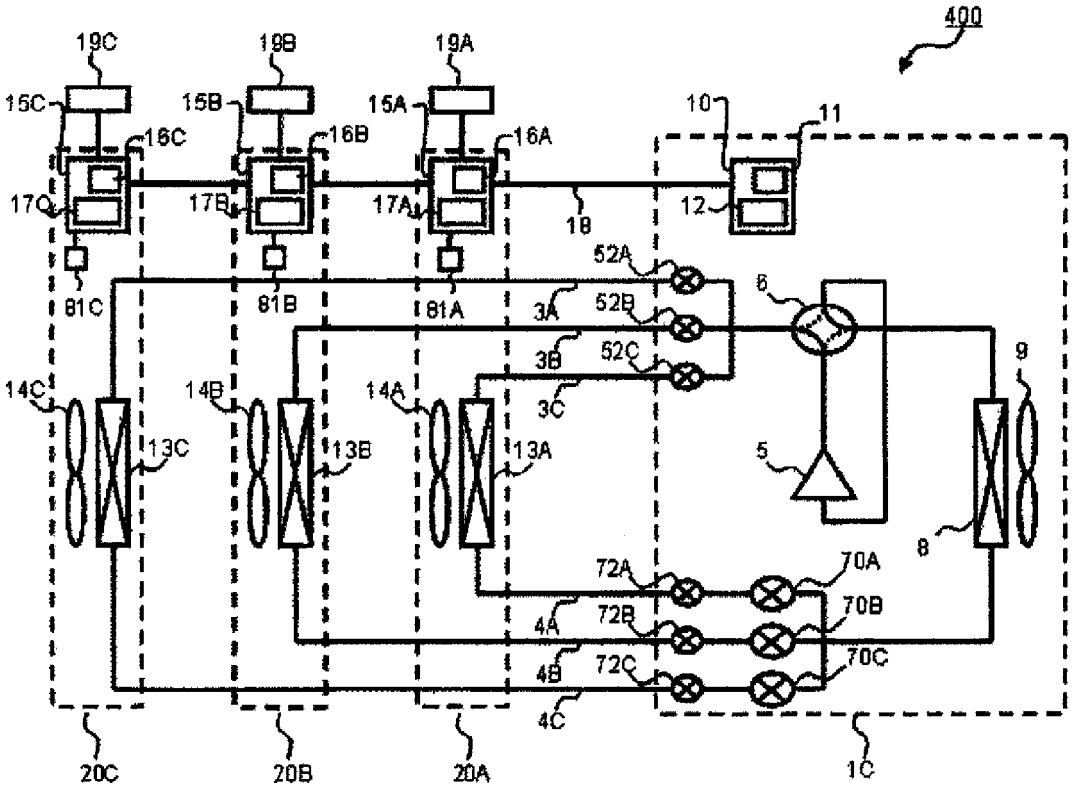

400
19C
19B
19A
15C
15B
15A
16C
16B
16A
10
11
17C
17B
17A
18
12
81C
81B
81A
52A
3A
52B
6
3B
52C
9
3C
14C
14B
14A
13C
13B
13A
5
8
72A
70A
4A
72B
70B
4B
72C
70C
4C
20C
20B
20A
1C

FIG. 7

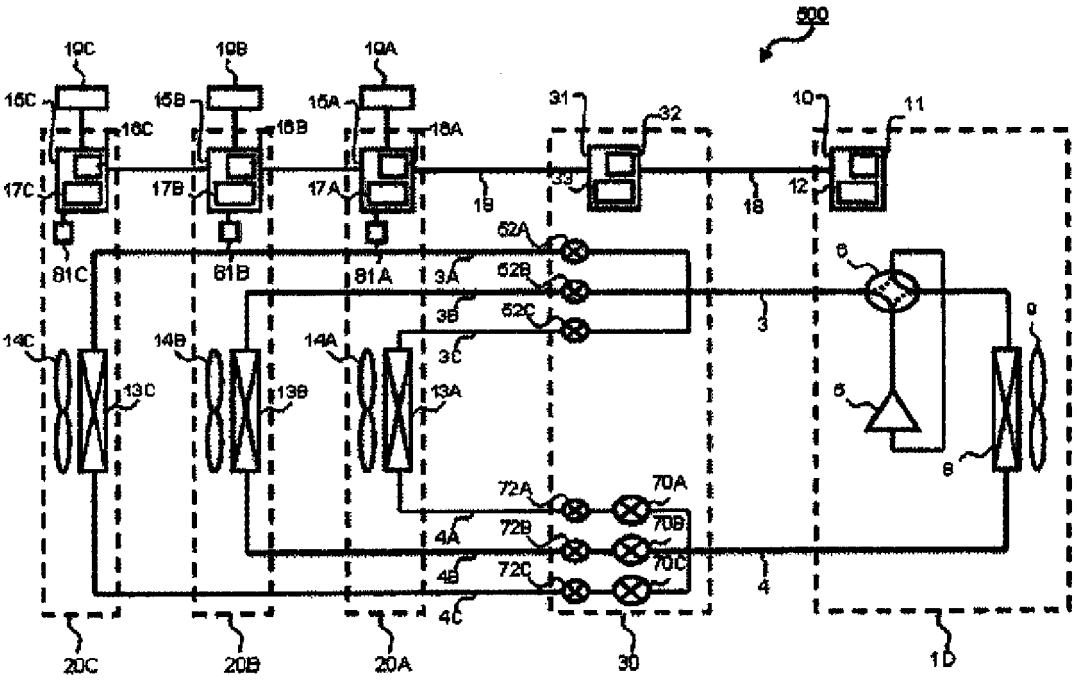

500
19C
19B
19A
15C
15B
15A
16C
16B
16A
31
32
10
11
17C
17B
17A
33
19
18
12
81C
81B
81A
52A
3A
52B
6
3B
52C
9
3
3C
14C
14B
14A
13C
13B
13A
5
8
72A
70A
4A
72B
70B
4B
72C
70C
4
4C
20C
20B
20A
30
1D

FIG. 8

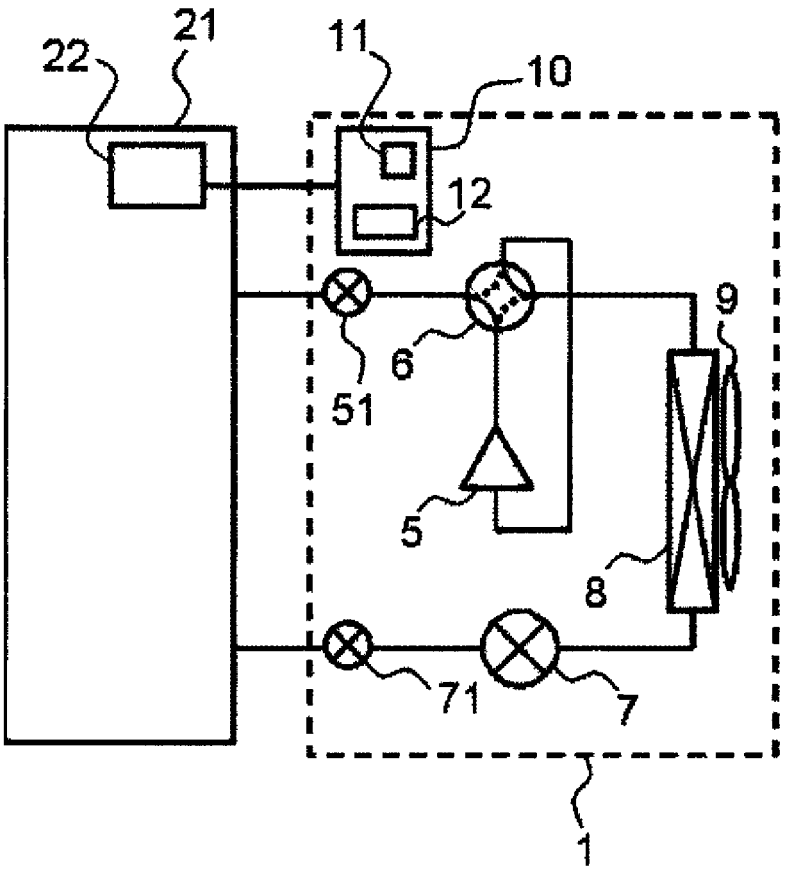


FIG. 9

Usable refrigerant	Combustibility class	Anti-combustibility class CfL	Toxicity class	Anti-toxicity class CtL
R410A	1	4	1	2
R32	2		1	
R290 (propane)	4		1	
R717 (ammonia)	2		2	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10038354 A **[0005]**
- JP 8254363 A **[0005]**