METHOD FOR JUDGING AMOUNT OF REFRIGERANT OF AIR CONDITIONER AND AIR CONDITIONER

It is a problem of the present invention to reduce detection errors by performing control such that a degree of supercooling that becomes an index and a conversion value based on the degree of supercooling become values with which it is easy to determine the adequacy of the quantity of refrigerant. An air conditioning apparatus (1) refrigerant quantity determination method of the present invention is a refrigerant quantity determination method of determining, in an air conditioning apparatus having a refrigerant circuit (10) that includes a heat source unit (2) having a compressor (21), a heat source-side heat exchanger (23), and cooling heat source adjusting means (27), a utilization unit (4) having a utilization-side heat exchanger (41), an expansion mechanism (33), and a liquid refrigerant connection pipe (6) and a gas refrigerant connection pipe (7), with the refrigerant circuit being capable of performing at least cooling operation, the adequacy of the quantity of the refrigerant in the refrigerant circuit, the method comprising storing the compressor frequency, the degree of superheat, and the degree of supercooling in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value. After the elapse of a predetermined time period, the degree of supercooling of the refrigerant is detected while various controls are performed such that the compressor frequency and the degree of superheat become the stored compressor frequency and degree of superheat, and the detected degree of supercooling is compared with the stored degree of supercooling to determine the adequacy of the quantity of the refrigerant inside the refrigerant circuit.

![Diagram](FIG. 1)
Description

TECHNICAL FIELD

[0001] The present invention relates to the function of determining the adequacy of the quantity of refrigerant with which the inside of a refrigerant circuit of an air conditioning apparatus is charged and particularly relates to the function of determining the adequacy of the quantity of refrigerant with which the inside of a refrigerant circuit of an air conditioning apparatus where a heat source unit and a utilization unit are interconnected via refrigerant connection pipes is charged.

BACKGROUND ART

[0002] Conventionally, there are air conditioning apparatus such as in patent citation 1 (JP-A No. 2006-23072) that perform refrigerant quantity determination operation where the quantity of refrigerant is determined on the basis of the degree of supercooling in the condenser. In the technology of patent citation 1 (JP-A No. 2006-23072), the refrigerant quantity determination operation is performed a first time (e.g., at the time of installation of the air conditioning apparatus) and periodically (e.g., every year after the time of installation, etc.) in the air conditioning apparatus. In this refrigerant quantity determination operation, control is performed such that the degree of superheat and the evaporation pressure in the evaporator become constant in a cooling operation state, and the degree of supercooling in the condenser is measured. Then, in the refrigerant quantity determination operation, whether or not the refrigerant is leaking is determined on the basis of the difference between the degree of supercooling that has been measured at that time and the degree of supercooling that was measured the first time or before then.

SUMMARY OF THE INVENTION

<technical Problem>

[0003] However, in the refrigerant leak detection of the air conditioning apparatus of patent citation 1 (JP-A No. 2006-23072), there is additional charging with refrigerant, the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger can be automatically secured to a certain extent by performing the degree of superheat constant control, but in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, there is the potential for the quantity of the refrigerant with which the refrigerant circuit is charged to vary greatly with respect to the circuit volume of the refrigerant circuit, and there is the fear that a sufficiently large value will become unable to be secured as a benchmark index (e.g., the degree of supercooling, etc.) when the degree of superheat constant control is performed like in the air conditioning apparatus of patent citation 1 (JP-A No. 2006-23072).

[0004] It is a problem of the present invention to reduce detection errors by performing control such that the degree of supercooling that becomes a benchmark index and a conversion value based on the degree of supercooling becomes values with which it is easy to determine the adequacy of the quantity of refrigerant.

<Solution to the Problem>

[0005] An air conditioning apparatus refrigerant quantity determination method pertaining to a first aspect of the present invention is a refrigerant quantity determination method of determining, in an air conditioning apparatus having a refrigerant circuit that includes a heat source unit having a compressor capable of adjusting its operational dosage, a heat source-side heat exchanger, an expansion mechanism, and an accumulator, a utilization unit having a utilization-side heat exchanger, and a liquid refrigerant connection pipe and a gas refrigerant connection pipe that interconnect the heat source unit and the utilization unit, with the refrigerant circuit being capable of performing at least cooling operation where the heat source-side heat exchanger is caused to function as a condenser of refrigerant compressed in the compressor and where the utilization-side heat exchanger is caused to function as an evaporator of the refrigerant condensed in the heat source-side heat exchanger, the adequacy of the quantity of the refrigerant inside the refrigerant circuit, the air conditioning apparatus refrigerant quantity determination method comprising an initial operating step, a storing step, a normal operation transitioning step, a stable state reproducing step, and a refrigerant quantity adequacy determining step. In the initial operating step, the refrigerant circuit is caused to perform the cooling operation from a normal operation mode where control of each device of the heat source unit and the utilization unit is performed according to the operating load of the utilization unit, the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or an operating state quantity that fluctuates in response to fluctuations in the degree of supercooling is detected while the expansion mechanism is controlled such that the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger becomes a positive value, and the refrigerant circuit is placed in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value or where the operating state quantity has been made equal to or greater than a second predetermined value.

In the storing step, the frequency of the compressor in the stable state is stored as a first index value. In the normal operation tran-
An air conditioning apparatus refrigerant quantity determination method pertaining to a second aspect of the present invention is the air conditioning apparatus refrigerant quantity determination method pertaining to the first aspect of the present invention, wherein the first predetermined value is a suitable value equal to or greater than the degree of supercooling with which it can be judged that the refrigerant has leaked. Further, the second predetermined value is a suitable value equal to or greater than a magnitude of the operating state quantity with which it can be judged that the refrigerant has leaked.

In an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

In the present invention, the compressor and the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger are controlled such that the index value for determining the adequacy of the quantity of refrigerant becomes equal to or greater than the first predetermined value (in the case of the degree of supercooling) or equal to or greater than the second predetermined value (in the case of the operating state quantity) set beforehand in the initial operating step; the frequency of the compressor at that time (in the stable state) is stored as the first frequency, the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger at that time (in the stable state) is stored as the first degree of superheat, and the degree of supercooling or the operating state quantity at that time (in the stable state) is stored as the first index value. Additionally, in the stable state reproducing step which is performed after the elapse of the predetermined time period after the normal operation transitioning step, control is performed such that the frequency of the compressor becomes the first frequency and such that the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger becomes the first degree of superheat, and the degree of supercooling or the operating state quantity at that time is detected as the detected value; and in the refrigerant quantity adequacy determining step, the index value and the detected value are compared to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.

In this manner, in the initial operating step, the index employed to determine the adequacy of the quantity of refrigerant is set beforehand such that it becomes equal to or greater than the first predetermined value in the case where the degree of supercooling serves as the index value or such that it becomes equal to or greater than the second predetermined value in the case where the operating state quantity serves as the index value, so even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

Consequently, even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

Consequently, even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

Consequently, even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.
utilization-side heat exchanger becomes a positive value, and places the refrigerant circuit in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value or where the operating state quantity has been made equal to or greater than a second predetermined value. The storing means stores the frequency of the compressor in the stable state as a first frequency, stores the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger in the stable state as a first degree of superheat, and stores the degree of supercooling or the operating state quantity in the stable state as a first index value. The normal operation transitioning means again switches the refrigerant circuit to the normal operation mode after the end of the storing step. After the elapse of a predetermined time period after the normal operation transitioning step, the stable state reproducing means detects the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or the operating state quantity that fluctuates in response to fluctuations in the degree of supercooling as a detected value while performing control of the compressor such that the frequency of the compressor becomes the first frequency stored by the storing step and performing control of the expansion mechanism such that the degree of superheat becomes the first degree of superheat. The refrigerant quantity adequacy determining means compares the index value and the detected value to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.  

In the present invention, the compressor and the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger are controlled such that the index value for determining the adequacy of the quantity of refrigerant becomes equal to or greater than the first predetermined value (in the case of the degree of supercooling) or equal to or greater than the second predetermined value (in the case of the operating state quantity) set beforehand in the initial operating step; the frequency of the compressor at that time (in the stable state) is stored as the first frequency, the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger at that time (in the stable state) is stored as the first degree of superheat, and furthermore the degree of supercooling or the operating state quantity at that time (in the stable state) is stored as the first index value. Additionally, in the stable state reproducing step, which is performed after the elapse of the predetermined time period after the normal operation transitioning step, control is performed such that the frequency of the compressor becomes the first frequency and such that the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger becomes the first degree of superheat, and the degree of supercooling or the operating state quantity at that time is detected as the detected value; and in the refrigerant quantity adequacy determining step, the index value and the detected value are compared to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.  

In this manner, in the initial operating step, the index employed to determine the adequacy of the quantity of refrigerant is set beforehand such that it becomes equal to or greater than the first predetermined value in the case where the degree of supercooling serves as the index value or such that it becomes equal to or greater than the second predetermined value in the case where the operating state quantity serves as the index value, so even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.  

<Advantageous Effects of the Invention>  

In the air conditioning apparatus refrigerant quantity determination method pertaining to the first aspect of the present invention, in the initial operating step, the index employed to determine the adequacy of the quantity of refrigerant is set beforehand such that it becomes equal to or greater than the first predetermined value in the case where the degree of supercooling serves as the index value or such that it becomes equal to or greater than the second predetermined value in the case where the operating state quantity serves as the index value, so even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.  

In the air conditioning apparatus refrigerant quantity determination method pertaining to the second aspect of the present invention, even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.  

In the air conditioning apparatus pertaining to the third aspect of the invention, in the initial operating step, the index employed to determine the adequacy of the quantity of refrigerant is set beforehand such that it becomes equal to or greater than the first predetermined value in the case where the degree of supercooling serves as the index value or such that it becomes equal
to or greater than the second predetermined value in the case where the operating state quantity serves as the index value, so even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0016]**

FIG. 1 is a general refrigerant circuit diagram of an air conditioning apparatus of one embodiment pertaining to the present invention.

FIG. 2 is a schematic diagram showing states of refrigerant flowing through the inside of the refrigerant circuit in cooling operation.

FIG. 3 is a flowchart of initial setup operation.

FIG. 4 is a schematic diagram showing states of the refrigerant flowing through the inside of the refrigerant circuit in a refrigerant quantity determination operation mode (initial setup operation and determination operation).

FIG. 5 is a flowchart of determination operation.

FIG. 6 is a graph showing a condensation temperature Tc and an outdoor heat exchanger outlet temperature T1 when an outdoor temperature Ta with respect to outdoor fan air volume is constant.

FIG. 7 is a graph showing a distribution of degree of supercooling values with respect to outdoor fan air volume.

FIG. 8 is a graph showing a distribution of relative degree of supercooling values with respect to outdoor fan air volume.

**DESCRIPTION OF THE EMBODIMENTS**

**[0017]** Embodiments of an air conditioning apparatus pertaining to the present invention will be described below on the basis of the drawings.

(1) Configuration of Air Conditioning Apparatus

**[0018]** FIG. 1 is a general refrigerant circuit diagram of an air conditioning apparatus 1 of one embodiment pertaining to the present invention. The air conditioning apparatus 1 is an apparatus used to heat and cool the inside of a building or the like or by being mounted on a wall surface inside a room in a building or the like or by being mounted on a wall surface inside a room. The air conditioning apparatus 1 is mainly equipped with one outdoor unit 2, an indoor unit 4, and a liquid refrigerant connection pipe 6 and a gas refrigerant connection pipe 7 that interconnect the outdoor unit 2 and the indoor unit 4. That is, a vapor compression refrigerant circuit 10 of the air conditioning apparatus 1 of the present embodiment is configured as a result of the outdoor unit 2, the indoor unit 4, and the liquid refrigerant connection pipe 6 and the gas refrigerant connection pipe 7 being connected.

<Indoor Unit>

**[0019]** The indoor unit 4 is installed by being embedded in or hung from a ceiling inside a room in a building or the like or by being mounted on a wall surface inside a room. The indoor unit 4 is connected to the outdoor unit 2 via the liquid refrigerant connection pipe 6 and the gas refrigerant connection pipe 7 and configures part of the refrigerant circuit 10.

**[0020]** Next, the configuration of the indoor unit 4 will be described.

**[0021]** The indoor unit 4 mainly has an indoor-side refrigerant circuit 11 that configures part of the refrigerant circuit 10. This indoor-side refrigerant circuit 11 mainly has an indoor heat exchanger 41 serving as a utilization-side heat exchanger.

**[0022]** In the present embodiment, the indoor heat exchanger 41 is a cross-fin type fin-and-tube heat exchanger configured by heat transfer tubes and numerous fins and is a heat exchanger that functions as an evaporator of the refrigerant during cooling operation to cool the room air and functions as a condenser of the refrigerant during heating operation to heat the room air. In the present embodiment, the indoor heat exchanger 41 is a cross-fin type fin-and-tube heat exchanger, but the indoor heat exchanger 41 is not limited to this and may also be another type of heat exchanger.

**[0023]** In the present embodiment, the indoor unit 4 has an indoor fan 42 serving as a blowing fan for sucking the room air into the inside of the unit, allowing heat to be exchanged with the refrigerant in the indoor heat exchanger 41, and thereafter supplying the air to the inside of the room as supply air. The indoor fan 42 is a fan capable of varying the volume of the air it supplies to the indoor heat exchanger 41 and, in the present embodiment, is a centrifugal fan or a multiblade fan driven by a motor 42m comprising a DC fan motor or the like.

**[0024]** Further, in the indoor unit 4, an indoor temperature sensor 43 that detects the temperature of the room air (that is, the indoor temperature) flowing into the inside of the unit is disposed on a room air suction opening side of the indoor unit 4. In the present embodiment, the indoor temperature sensor 43 comprises a thermistor. Further, the indoor unit 4 has an indoor-side controller 44 that controls the operation of each part configuring the indoor unit 4. Additionally, the indoor-side controller 44 has a microcomputer, memory and the like disposed in order to perform control of the indoor unit 4 and is configured such that it can exchange control signals and the like with a remote controller (not shown) for individually operating the indoor unit 4 and such that it can exchange control signals and the like with the outdoor unit 2 via a trans-
mission line 8a.

**<Outdoor Unit>**

[0025] The outdoor unit 2 is installed outdoors of a building or the like, is connected to the indoor unit 4 via the liquid refrigerant connection pipe 6 and the gas refrigerant connection pipe 7, and configures the refrigerant circuit 10 together with the indoor unit 4.

[0026] Next, the configuration of the outdoor unit 2 will be described. The outdoor unit 2 mainly has an outdoor-side refrigerant circuit 12 that configures part of the refrigerant circuit 10. This outdoor-side refrigerant circuit 12 mainly has a compressor 21, a four-way switching valve 22, an outdoor heat exchanger 23 serving as a heat source-side heat exchanger, an outdoor expansion valve 33, a liquid-side temperature sensor 28, a condensation pressure sensor 29, a suction temperature sensor 30, and a liquid-side stop valve 25, and a gas-side stop valve 26.

[0027] The compressor 21 is a compressor capable of varying its operating capacity and, in the present embodiment, is a positive displacement compressor driven by a motor 21m whose speed is controlled by an inverter. In the present embodiment, the compressor 21 comprises only one compressor, but the compressor 21 is not limited to this, and two or more compressors may also be connected in parallel depending on the connection number of the indoor units and the like.

[0028] The four-way switching valve 22 is a valve for switching the direction of the flow of the refrigerant such that, during the cooling operation, the four-way switching valve 22 is capable of interconnecting the discharge side of the compressor 21 and the gas side of the outdoor heat exchanger 23 and also interconnecting the suction side of the compressor 21 (specifically, the accumulator 24) and the gas refrigerant connection pipe 7 side to cause the outdoor heat exchanger 23 to function as a condenser of the refrigerant compressed by the compressor 21 and to cause the indoor heat exchanger 41 to function as an evaporator of the refrigerant condensed in the outdoor heat exchanger 23 (a cooling operation state; see the solid lines of the four-way switching valve 22 in FIG. 1) and such that, during the heating operation, the four-way switching valve 22 is capable of interconnecting the discharge side of the compressor 21 and the gas refrigerant connection pipe 7 side and also interconnecting the suction side of the compressor 21 and the gas side of the outdoor heat exchanger 23 to cause the indoor heat exchanger 41 to function as a condenser of the refrigerant compressed by the compressor 21 and to cause the outdoor heat exchanger 23 to function as an evaporator of the refrigerant condensed in the indoor heat exchanger 41 (a heating operation state; see the broken lines of the four-way switching valve 22 in FIG 1).

[0029] In the present embodiment, the outdoor heat exchanger 23 is a cross-fin type fin-and-tube heat exchanger configured by heat transfer tubes and numerous fins and is a heat exchanger that functions as a condenser of the refrigerant during the cooling operation and functions as an evaporator of the refrigerant during the heating operation. The gas side of the outdoor heat exchanger 23 is connected to the four-way switching valve 22, and the liquid side of the outdoor heat exchanger 23 is connected to the liquid refrigerant connection pipe 6. In the present embodiment, the outdoor heat exchanger 23 is a cross-fin type fin-and-tube heat exchanger, but the outdoor heat exchanger 23 is not limited to this and may also be another type of heat exchanger.

[0030] In the present embodiment, the outdoor expansion valve 33 is a motor-driven expansion valve placed on the downstream side of the outdoor heat exchanger 23 in the flow direction of the refrigerant in the refrigerant circuit 10 when performing the cooling operation (in the present embodiment, the outdoor expansion valve 33 is connected to the liquid side of the outdoor heat exchanger 23) in order to adjust, for example, the pressure and the flow rate of the refrigerant flowing through the inside of the outdoor-side refrigerant circuit 12.

[0031] In the present embodiment, the outdoor unit 2 has an outdoor fan 27 serving as a blowing fan for sucking outdoor air into the inside of the unit, allowing heat to be exchanged with the refrigerant in the outdoor heat exchanger 23, and thereafter expelling the air to the outdoors. This outdoor fan 27 is a fan capable of varying the volume of the air it supplies to the outdoor heat exchanger 23 and, in the present embodiment, is a propeller fan driven by a motor 27m comprising a DC fan motor or the like.

[0032] The accumulator 24 is connected between the four-way switching valve 22 and the compressor 21 and is a container capable of accumulating surplus refrigerant generated inside the refrigerant circuit 10 depending on, for example, fluctuations in the operating load of the indoor unit 4.

[0033] The liquid-side stop valve 25 and the gas-side stop valve 26 are valves disposed in openings to which external devices and pipes (specifically, the liquid refrigerant connection pipe 6 and the gas refrigerant connection pipe 7) connect. The liquid-side stop valve 25 is connected to the outdoor heat exchanger 23. The gas-side stop valve 26 is connected to the four-way switching valve 22.

[0034] Further, various sensors are disposed in the outdoor unit 2. Specifically, an evaporation pressure sensor 28 that detects the pressure of the gas refrigerant that has flowed in from the indoor heat exchanger 41, a condensation pressure sensor 29 that detects the condensation pressure of the refrigerant condensed by the outdoor heat exchanger 23, a suction temperature sensor 30 that detects the suction temperature of the compressor 21, and a liquid-side temperature sensor 31 that detects the temperature of the refrigerant in a liquid state or in a gas-liquid two-phase state on the liquid side of the outdoor heat exchanger 23 are disposed in the outdoor unit 2. An outdoor temperature sensor 32 that detects the temperature of the outdoor air (that is, the outdoor...
temperature) flowing into the inside of the unit is disposed on an outdoor air suction opening side of the outdoor unit 2. In the present embodiment, the suction temperature sensor 30, the liquid-side temperature sensor 31, and the outdoor temperature sensor 32 comprise thermistors. Further, the outdoor unit 2 is equipped with an outdoor-side controller 34 that controls the operation of each part configuring the outdoor unit 2. Additionally, the outdoor-side controller 34 has a microcomputer and a memory disposed in order to perform control of the outdoor unit 2 and an inverter circuit that controls the motor 21m, and the outdoor-side controller 34 is configured such that it can exchange control signals and the like with the indoor-side controller 44 of the indoor unit 4. That is, a controller 8 that performs operation control of the entire air conditioning apparatus 1 is configured by the indoor-side controller 44, the outdoor-side controller 34, and the transmission line 8a that interconnects the controllers 34 and 44.

[0035] As described above, the refrigerant circuit 10 of the air conditioning apparatus 1 is configured as a result of the indoor-side refrigerant circuit 11, the outdoor-side refrigerant circuit 12, and the refrigerant connection pipes 6 and 7 being connected. Additionally, the air conditioning apparatus 1 of the present embodiment uses the four-way switching valve 22 to switch between the cooling operation and the heating operation and performs operation, and the air conditioning apparatus 1 performs control of each device of the outdoor unit 2 and the indoor unit 4 according to the operating load of the indoor unit 4.

(2) Operation of Air Conditioning Apparatus

[0036] Next, the operation of the air conditioning apparatus 1 of the present embodiment will be described.

[0037] As operation modes of the air conditioning apparatus 1 of the present embodiment, there are a normal operation mode, where control of each device of the outdoor unit 2 and the indoor unit 4 is performed according to the operating load of the indoor unit 4, and a refrigerant quantity determination operation mode, where the degree of supercooling of the refrigerant in the outlet of the outdoor heat exchanger 23 functioning as a condenser is detected while all of the indoor units 4 are run in the cooling operation and the adequacy of the quantity of refrigerant with which the inside of the refrigerant circuit 10 is charged is judged. Additionally, in the normal operation mode, there are the cooling operation and the heating operation, and in the refrigerant quantity determination operation mode, there is refrigerant leak detection operation.

[0038] The operation in each operation mode of the air conditioning apparatus 1 will be described below.

<Normal Operation Mode>

[0039] First, the cooling operation in the normal operation mode will be described.

[0040] During the cooling operation, the four-way switching valve 22 is in the state indicated by the solid lines in FIG. 1, that is, a state where the discharge side of the compressor 21 is connected to the gas side of the outdoor heat exchanger 23 and where the suction side of the compressor 21 is connected to the gas side of the indoor heat exchanger 41. Here, the liquid-side stop valve 25 and the gas-side stop valve 26 are placed in an open state. Further, the opening degree of the outdoor expansion valve 33 is adjusted such that the degree of supercooling of the refrigerant in the outlet of the outdoor heat exchanger 23 becomes a predetermined value. In the present embodiment, the degree of supercooling of the refrigerant in the outlet of the outdoor heat exchanger 23 is detected by converting the refrigerant pressure (the condensation pressure) value on the outlet side of the outdoor heat exchanger 23 detected by the condensation pressure sensor 29 into the saturation temperature value of the refrigerant and subtracting the refrigerant temperature value detected by the liquid-side temperature sensor 31 from this saturation temperature value of the refrigerant.

[0041] When the compressor 21 and the outdoor fan 27 are started in this state of the refrigerant circuit 10, low-pressure gas refrigerant is sucked into the compressor 21, is compressed, and becomes high-pressure gas refrigerant. Thereafter, the high-pressure gas refrigerant is sent to the outdoor heat exchanger 23 via the four-way switching valve 22, undergoes heat exchange with the outside air supplied by the outdoor fan 27, is condensed, and becomes high-pressure liquid refrigerant. Then, the high-pressure liquid refrigerant has its pressure reduced by the outdoor expansion valve 33, becomes low-pressure refrigerant in a gas-liquid two-phase state, and is sent to the indoor unit 4 via the liquid-side stop valve 25 and the liquid refrigerant connection pipe 6. Here, the outdoor expansion valve 33 controls the flow rate of the refrigerant flowing through the inside of the outdoor heat exchanger 23 such that the degree of supercooling in the outlet of the outdoor heat exchanger 23 becomes the predetermined value, so the high-pressure liquid refrigerant that has been condensed in the outdoor heat exchanger 23 reaches a state where it has the predetermined degree of supercooling.

[0042] The low-pressure refrigerant in the gas-liquid two-phase state that has been sent to the indoor unit 4 is sent to the indoor heat exchanger 41 and undergoes heat exchange with the inside air, is evaporated, and becomes low-pressure gas refrigerant in the indoor heat exchanger 41. Then, refrigerant with a flow rate corresponding to the required operating load in the air-conditioned space where the indoor unit 4 is installed flows in the indoor heat exchanger 41.

[0043] This low-pressure gas refrigerant is sent to the outdoor unit 2 via the gas refrigerant connection pipe 7 and flows into the accumulator 24 via the gas-side stop valve 26 and the four-way switching valve 22. Then, the low-pressure gas refrigerant that has flowed into the ac-
cumulator 24 is again sucked into the compressor 21. Here, surplus refrigerant accumulates in the accumulator 24 depending on the operating load of the indoor unit 4, such as, for example, when the operating load of the indoor unit 4 is small or when the indoor unit 4 is stopped.

[0044] Here, the state of distribution of the refrigerant in the refrigerant circuit 10 when it is performing the cooling operation in the normal operation mode is such that, as shown in FIG. 2, the refrigerant takes each of the states of a liquid state (the filled-in hatching portion in FIG. 2), a gas-liquid two-phase state (the grid-like hatching portions in FIG. 2), and a gas state (the diagonal line hatching portion in FIG. 2). Specifically, the portion from near the outlet of the outdoor heat exchanger 23 to the outdoor expansion valve 33 is filled with the refrigerant in the liquid state. Additionally, the portion in the middle of the outdoor heat exchanger 23 and the portion between the outdoor expansion valve 33 and near the inlet of the indoor heat exchanger 41 are filled with the refrigerant in the gas-liquid two-phase state. Further, the portion from the middle portion of the outdoor heat exchanger 41, via the gas refrigerant connection pipe 7, the accumulator 24 excluding a part thereof, and the compressor 21, to near the inlet of the outdoor heat exchanger 23 via the gas refrigerant is filled with the refrigerant in the gas state. Sometimes accumulated liquid refrigerant accumulates as surplus refrigerant in the part of the accumulator 24 that is excluded here. Here, FIG. 2 is a schematic diagram showing states of the refrigerant flowing through the inside of the refrigerant circuit 10 in the cooling operation.

[0045] Next, the heating operation in the normal operation mode will be described.

[0046] During the heating operation, the four-way switching valve 22 is in the state indicated by the broken lines in FIG. 1, that is, a state where the discharge side of the compressor 21 is connected to the gas side of the indoor heat exchanger 41 and where the suction side of the compressor 21 is connected to the gas side of the outdoor heat exchanger 23. The opening degree of the outdoor expansion valve 33 is adjusted in order to reduce the pressure of the refrigerant flowing into the outdoor heat exchanger 23 to a pressure capable of allowing the refrigerant to evaporate in the outdoor heat exchanger 23 (that is, the evaporation pressure). Further, the liquid-side stop valve 25 and the gas-side stop valve 26 are placed in an open state.

[0047] When the compressor 21 and the outdoor fan 27 are started in this state of the refrigerant circuit 10, low-pressure gas refrigerant is sucked into the compressor 21, is compressed, becomes high-pressure gas refrigerant, and is sent to the indoor unit 4 via the four-way switching valve 22, the gas-side stop valve 26, and the gas refrigerant connection pipe 7.

[0048] Then, the high-pressure gas refrigerant that has been sent to the indoor unit 4 undergoes heat exchange with the inside air, is condensed, and becomes high-pressure liquid refrigerant in the indoor heat exchanger 41, and the high-pressure liquid refrigerant is thereafter sent to the outdoor unit 2 via the liquid refrigerant connection pipe 6.

[0049] This high-pressure liquid refrigerant has its pressure reduced by the outdoor expansion valve 33 via the liquid-side stop valve 25, becomes low-pressure refrigerant in a gas-liquid two-phase state, and flows into the outdoor heat exchanger 23. Then, the low-pressure refrigerant in the gas-liquid two-phase state that has flowed into the outdoor heat exchanger 23 undergoes heat exchange with the outside air supplied by the outdoor fan 27, is evaporated, becomes low-pressure gas refrigerant, and flows into the accumulator 24 via the four-way switching valve 22. Then, the low-pressure gas refrigerant that has flowed into the accumulator 24 is again sucked into the compressor 21. Here, when a quantity of surplus refrigerant is generated inside the refrigerant circuit 10 depending on the operating load of the indoor unit 4, such as, for example, when the operating load of the indoor unit 4 is small, the surplus refrigerant accumulates in the accumulator 24 like during the cooling operation.

<Refrigerant Quantity Determination Operation Mode>

[0050] In the refrigerant quantity determination operation mode, the refrigerant leak detection operation is performed, and within that, the method of operation differs between operation that is first performed after the air conditioning apparatus 1 has been installed (hereinafter called "initial setup operation") and operation from the second time on (hereinafter called "determination operation"). For this reason, the refrigerant quantity determination operation mode will be divided between the initial setup operation and the determination operation and described below.

(Initial Setup Operation)

[0051] When a command to perform automatic refrigerant charging operation, which is one operation in the refrigerant quantity determination operation mode, is given through the remote controller (not shown) or directly with respect to the indoor-side controller 44 of the outdoor unit 4 or the outdoor-side controller 34 of the outdoor unit 2 after the refrigerant circuit 10 has been configured by interconnecting the outdoor unit 2 charged beforehand with the refrigerant and the indoor unit 4 via the liquid refrigeration connection pipe 6 and the gas refrigerant connection pipe 7 on site, the initial setup operation is performed by the procedure of step S1 to step S7 described below.

-Step S 1: Running of Indoor Unit in Cooling Operation (Outdoor Fan Air Volume at Maximum)

[0052] First, in step S1, when a command to start the initial setup operation is issued, in the refrigerant circuit 10, the four-way switching valve 22 of the outdoor unit 2
is placed in the state (the cooling operation state) indicated by the solid lines in FIG. 2. Then, the compressor 21 and the outdoor fan 27 are started, and the cooling operation (the method of controlling the outdoor fan 27 differs from that in the cooling operation in the normal operation mode) is forcibly performed in regard to all of the indoor units 4 (see FIG. 2). At this time, the speed of the motor 27m becomes a maximum such that the air volume of the outdoor fan 27 becomes a maximum. In step S1, the air volume of the outdoor fan 27 is maximized in the cooling operation state, so the heat transfer coefficient in the air side of the efficiency of heat exchange performed by the outdoor heat exchanger 23 can be maximized, and the influence of disturbances can be reduced. Verification in regard to this effect will be described later. Further, the "disturbances" here are dirt in the outdoor heat exchanger 23, the installation situation described later. Additionally, when this air volume of the outdoor fan 27 has become a maximum, the initial setup operation moves to the next step S2.

-Step S2: Reading of Temperatures-

[0053] In step S2, reading of the indoor temperature Tb detected by the indoor temperature sensor 43 and the outdoor temperature Ta detected by the outdoor temperature sensor 32 is performed. When the indoor temperature Tb and the outdoor temperature Ta are detected, the initial setup operation moves to the next step S3.

-Step S3: Determination of Whether or Not Temperatures Are in Detectable Ranges-

[0054] In step S3, whether or not the indoor temperature Tb and the outdoor temperature Ta that have been detected are within predetermined temperature ranges suitable for the refrigerant quantity determination operation mode that are set beforehand is determined. In step S3, when the indoor temperature Tb and the outdoor temperature Ta are within the predetermined temperature ranges, the initial setup operation moves to the next step S4, and when the indoor temperature Tb and the outdoor temperature Ta are not within the predetermined temperature ranges, the cooling operation of step S1 is continued.

-Step S4: Determination of Whether or Not Relative Degree of Supercooling is Equal to or Greater than Predetermined Value-

[0055] In step S4, a relative degree of supercooling value is derived to determine whether or not the relative degree of supercooling value is equal to or greater than a predetermined value (e.g., equal to or greater than 0.3). The "relative degree of supercooling" here is a value obtained by dividing the degree of supercooling value in the outlet of the outdoor heat exchanger 23 by the difference between the condensation temperature value and the outdoor temperature. Further, in the drawings, the relative degree of supercooling is written as "relative SC". The relative degree of supercooling value will be described in detail later. In the present embodiment, a value obtained by converting the pressure (the condensation pressure) value on the outlet side of the outdoor heat exchanger 23 detected by the condensation pressure sensor 29 into the saturation temperature of the refrigerant is used for the condensation temperature value. In step S4, when it is determined that the relative degree of supercooling value is less than the predetermined value, the initial setup operation moves to the next step S5, and when it is determined that the relative degree of supercooling value is equal to or greater than the predetermined value, the initial setup operation moves to step S6. When 10% of the refrigerant with which the inside of the refrigerant circuit is charged has leaked, the relative degree of supercooling falls 0.3, so in the present embodiment, the value of the relative degree of supercooling is made equal to or greater than 0.3 as an example. That is, it is desirable for this predetermined value to be at least equal to or greater than 0.3.

-Step S5: Control of Relative Degree of Supercooling-

[0056] In step S5, the relative degree of supercooling value is less than the predetermined value, so the rotational frequency of the compressor 21 and the degree of superheat in the outlet of the indoor heat exchanger 41 are controlled such that the relative degree of supercooling value becomes equal to or greater than the predetermined value. For example, the cooling operation in step S1 is performed in a state where the rotational frequency of the compressor 21 is 40 Hz and the degree of superheat in the outlet of the indoor heat exchanger 41 is 5°C, and whether or not the relative degree of supercooling value is equal to or greater than the predetermined value is determined. In this operating state, when the relative degree of supercooling value is less than the predetermined value, the rotational frequency of the compressor 21 is left unchanged, the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 is raised by 5°C to 10°C, the relative degree of supercooling value is derived, and whether or not the relative degree of supercooling value will become equal to or greater than the predetermined value is determined. Then, when the relative degree of supercooling value is less than the predetermined value even when the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 has risen as far as it can, the rotational frequency of the compressor 21 is raised from 40 Hz to 50 Hz, for example, the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 is lowered to 5°C, and whether or not the relative degree of supercooling value is equal to or greater than the predetermined
value is similarly determined. Then, control is performed such that the relative degree of supercooling value becomes equal to or greater than the predetermined value by repeating raising the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 again by 5°C at a time as described above. When the relative degree of supercooling value becomes equal to or greater than the predetermined value, the initial setup operation moves to step S6. Control of the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 (e.g., control to raise the degree of superheat from 5°C by 5°C at a time) is performed by narrowing the outdoor expansion valve 33 from an open state. Further, control of the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 is not limited to this and may also be performed by controlling the air volume of the indoor fan 42 or by combining control of the valve opening degree of the outdoor expansion valve 33 and control of the air volume of the indoor fan 42. The degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 here is detected by subtracting, from the refrigerant temperature value obtained by converting the evaporation pressure value detected by the refrigerant temperature sensor 30, a value obtained by converting the evaporation pressure value detected by the evaporation pressure sensor 28 into the saturation temperature value of the refrigerant.

**[0057]** The degree of superheat is controlled so as to become a positive value by step S5; thus, as shown in FIG. 4, the state becomes one where surplus refrigerant is not accumulating in the accumulator 24, and the refrigerant that had accumulated in the accumulator 24 moves to the outdoor heat exchanger 23.

**-Step S6: Storage of Relative Degree of Supercooling-**

**[0058]** In step S6, the relative degree of supercooling value that is equal to or greater than the predetermined value in step S5 or step S6 is stored as an initial relative degree of supercooling value, and then the initial setup operation moves to the next step S7.

**-Step S7: Storage of Parameters-**

**[0059]** In step S7, the rotational frequency of the compressor 21, the rotational frequency of the indoor fan 42, the outdoor temperature Ta, and the indoor temperature Tb in the operating state at the time of the degree of supercooling value stored in step S6 are stored, and then the initial setup operation is ended.

**(Determination Operation)**

**[0060]** Next, the determination operation, which is one operation in the refrigerant quantity detection operation mode, will be described using FIG. 5. FIG. 5 is a flowchart at the time of the determination operation.

**[0061]** This determination operation is operation to which the refrigerant circuit 10 is switched from the cooling operation or the heating operation in the normal operation mode periodically (e.g., once a year, when a load is not required in the air-conditioned space, etc.) after the initial setup operation has been performed and where whether or not the refrigerant inside the refrigerant circuit is leaking to the outside due to some accidental cause is detected.

**-Step S11: Determination of Whether or Not Normal Operation Mode Has Gone On a Certain Amount of Time-**

**[0062]** First, whether or not operation in the normal operation mode, such as the cooling operation or the heating operation described above, has gone on a certain amount of time is determined, and when operation in the normal operation mode has gone on a certain amount of time, the determination operation moves to the next step S12.

**-Step S12: Running of Indoor Unit in Cooling Operation-**

**[0063]** When operation in the normal operation mode has gone on a certain amount of time, in the refrigerant circuit 10, the four-way switching valve 22 of the outdoor unit 2 is placed in the state indicated by the solid lines in FIG. 1, the compressor 21 and the outdoor fan 27 are started, and the cooling operation is performed forcibly in regard to all of the indoor units 4 like in step S1 of the initial setup operation described above.

**-Step S13: Reading of Temperatures-**

**[0064]** In step S 13, reading of the indoor temperature and the outdoor temperature is performed like in step S2 of the initial setup operation described above. When the indoor temperature Tb and the outdoor temperature Ta are detected, the detection operation moves to the next step S14.

**-Step S 14: Determination of Whether or Not Temperatures Are in Detectable Ranges-**

**[0065]** In step S 14, whether or not the indoor temperature Tb and the outdoor temperature Ta that have been detected are within the predetermined temperature ranges suitable for the refrigerant quantity determination operation mode that are set beforehand is determined like in step S3 of the initial setup operation described above. In step S 14, when the indoor temperature Tb and the outdoor temperature Ta are within the predetermined temperature ranges, the determination operation moves to the next step S15, and when the indoor temperature Tb and the outdoor temperature Ta are not within the predetermined temperature ranges, the cooling operation of step S 12 is continued.
-Step S15: Control in Conditions in Initial Setup Operation-

[0066] In step S15, the compressor 21 and the indoor fan 42 are controlled at the rotational frequency of the compressor 21 and the rotational frequency of the indoor fan 42 that were stored in step S7 of the initial setup operation described above. Thus, the state of the refrigerant inside the refrigerant circuit 10 can be regarded as a state that is the same as in the initial setup operation. That is, unless the quantity of refrigerant inside the refrigerant circuit 10 has changed, conditions that are identical to the conditions of the cooling operation that was performed in the initial setting operation become reproduced, and the degree of supercooling value and the like can be made into substantially the same values. When step S15 ends, the determination operation moves to the next step S16.

-Step S16: Determination of Adequacy of Refrigerant Quantity-

[0067] In step S16, the relative degree of supercooling is derived like in step S4 of the initial setup operation described above. Then, whether or not the difference (hereinafter called the relative degree of supercooling difference) between the initial relative degree of supercooling and the relative degree of supercooling is equal to or greater than a second predetermined value is determined. In step S16, when it is determined that the relative degree of supercooling difference is less than the second predetermined value, the determination operation is ended, and when it is determined that the relative degree of supercooling difference is equal to or greater than the second predetermined value, the determination operation moves to step S17.

-Step S17: Warning Indication-

[0068] In step S17, it is determined that leakage of the refrigerant is occurring, a warning indication informing that a refrigerant leak has been detected is given, and thereafter the determination operation is ended.

<Regarding Relative Degree of Supercooling Value>

[0069] The relative degree of supercooling value will be described on the basis of FIGS. 6 to 8.

[0070] First, FIG. 6 is a graph showing the condensation temperature Tc and the outdoor heat exchanger outlet temperature T1 when the outdoor temperature Ta with respect to outdoor fan air volume is constant. Looking at FIG. 6, in a condition where the outdoor temperature Ta is constant, as the outdoor fan air volume increases, the condensation temperature Tc and the outdoor heat exchanger outlet temperature T1 decrease. Additionally, the drop of that decrease is larger in the condensation temperature Tc than in the outdoor heat exchanger outlet temperature T1. That is, it will be understood that when the outdoor fan air volume becomes larger, the degree of supercooling value that is the difference between the condensation temperature Tc and the outdoor heat exchanger outlet temperature T1 becomes smaller.

[0071] Here, when looking at FIG. 7, which is a graph showing a distribution of degree of supercooling values with respect to outdoor fan air volume, it will be understood that when the outdoor fan air volume increases, the degree of supercooling value becomes smaller. Further, in FIG. 7, variations in the degree of supercooling value become larger when the outdoor fan air volume is small than when the outdoor fan air volume is large. This is thought to be because it is easier when the outdoor fan air volume is small to be affected by disturbances such as dust in the outdoor heat exchanger, the installation situation of the outdoor unit, and wind and rain and it is more difficult when the outdoor fan air volume is large to be affected by disturbances. For this reason, by maximizing the outdoor fan air volume, variations in the detected degree of supercooling can be suppressed and detection errors can be reduced.

[0072] Additionally, FIG. 8 is a graph showing a distribution of relative degree of supercooling values with respect to outdoor fan air volume. The relative degree of supercooling value is, as described above, a value obtained by dividing the degree of supercooling value by the difference between the condensation temperature and the outdoor temperature. Looking at FIG 8, it will be understood that those values stay substantially between 0.3 and 0.4 regardless how large or small the magnitude of the outdoor fan air volume is and that there are few variations. For this reason, by utilizing this relative degree of supercooling value as an index when determining the adequacy of the quantity of the refrigerant, the adequacy of the quantity of the refrigerant can be determined without being affected as much as possible by disturbances and detection errors can be suppressed. Consequently, utilizing the relative degree of supercooling value to determine the adequacy of the quantity of the refrigerant is useful.

(3) Characteristics of Air Conditioning Apparatus

[0073] In the present embodiment, the frequency of the compressor 21 and the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 are controlled such that the relative degree of supercooling that is detected becomes equal to or greater than the predetermined value (e.g., 0.3) set beforehand in the initial setup operation; the frequency of the compressor at that time (in a stable state) is stored as a first frequency, the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger at that time (in a stable state) is stored, and the relative degree of supercooling at that time is stored as an index value for determining the adequacy of the quantity of refrigerant. Additionally, in the determination operation, which is performed after...
the elapse of a predetermined time period (in the present embodiment, one year) after the initial setup operation, control is performed such that the frequency of the compressor 21 becomes the frequency stored by the initial setup operation and such that the degree of superheat of the refrigerant in the outlet of the indoor heat exchanger 41 becomes the degree of superheat stored by the initial setup operation, the relative degree of supercooling at that time is detected as a detected value, and the detected value and the index value that was stored in the initial setup operation are compared to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.

Consequently, in the initial setup operation, the index employed to determine the adequacy of the quantity of refrigerant is set beforehand utilizing the relative degree of supercooling such that it becomes equal to or greater than 0.3, for example, so even in an air conditioning apparatus in which additional charging with refrigerant is basically not assumed, a large value can be secured to a certain extent for the degree of supercooling or the operating state quantity in the refrigerant quantity adequacy determination, it becomes easier to detect that those values will become small when the quantity of refrigerant has decreased, and refrigerant quantity detection errors can be reduced.

In the present embodiment, the degree of supercooling of the refrigerant in the outlet of the outdoor heat exchanger 23 is detected by converting the refrigerant pressure (which corresponds to the condensation pressure) value on the outlet side of the outdoor heat exchanger 23 detected by the condensation pressure sensor 29 into the saturation temperature value of the refrigerant and subtracting the refrigerant temperature value detected by the liquid-side temperature sensor 31 from this saturation temperature value of the refrigerant, but the invention is not limited to this.

For example, the invention may also be configured such that the degree of supercooling of the refrigerant in the outlet of the outdoor heat exchanger 23 is detected by disposing an outdoor heat exchange sensor that can detect the temperature of the refrigerant in the outdoor heat exchanger 23, detecting the condensation temperature value as the saturation temperature value of the refrigerant, and subtracting the refrigerant temperature value detected by the liquid-side temperature sensor 31 from this saturation temperature value of the refrigerant.

In the present embodiment, the relative degree of supercooling value is used as the index to determine the adequacy of the quantity of the refrigerant, but the invention is not limited to this and may also be configured such that the degree of supercooling value is used as the index to determine the adequacy of the quantity of the refrigerant.

(6) Modification 3

(7) Other Embodiments

Embodiment of the present invention have been described above on the basis of the drawings, but the specific configurations thereof are not limited to these embodiments and are alterable in a scope that does not depart from the gist of the invention.

For example, in the embodiment described above, an example where the present invention is applied to an air conditioning apparatus capable of switching between heating and cooling has been described, but the invention is not limited to this and is applicable as long as the air conditioning apparatus is a separate type air conditioning apparatus; the present invention may also be applied to pair type air conditioning apparatus and air conditioning apparatus dedicated to cooling.

INDUSTRIAL APPLICABILITY

By utilizing the present invention, it can be ensured that the adequacy of the quantity of refrigerant with which the inside of a refrigerant circuit is charged can be precisely determined in a separate type air conditioning apparatus where a heat source unit and a utilization unit are interconnected via refrigerant connection pipes.

REFERENCE SIGNS LIST

1 Air Conditioning Apparatus
2 Outdoor Unit (Heat Source Unit)
3 Indoor Unit (Utilization Unit)
4 Liquid Refrigerant Connection Pipe
5 Gas Refrigerant Connection Pipe
6 Refrigerant Circuit
A refrigerant quantity determination method of determining,
in an air conditioning apparatus (1) having a refrigerant circuit (10) that includes a heat source unit (2) having a compressor (21) capable of adjusting its operational capacity, a heat source-side heat exchanger (23), an expansion mechanism (33), and an accumulator (24), a utilization unit (4) having a utilization-side heat exchanger (41), and a liquid refrigerant connection pipe (6) and a gas refrigerant connection pipe (7) that interconnect the heat source unit and the utilization unit, with the refrigerant circuit being capable of performing at least cooling operation where the heat source-side heat exchanger is caused to function as a condenser of refrigerant compressed in the compressor and where the utilization-side heat exchanger is caused to function as an evaporator of the refrigerant condensed in the heat source-side heat exchanger;
the adequacy of the quantity of the refrigerant inside the refrigerant circuit, the air conditioning apparatus refrigerant quantity determination method comprising:

an initial operating step of causing the refrigerant circuit to perform the cooling operation from a normal operation mode where control of each device of the heat source unit and the utilization unit is performed according to the operating load of the utilization unit, detecting the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or an operating state quantity that fluctuates in response to fluctuations in the degree of supercooling while controlling the expansion mechanism such that the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger becomes a positive value, and placing the refrigerant circuit in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value or where the operating state quantity has been made equal to or greater than a second predetermined value;
a storing step of storing the frequency of the compressor in the stable state as a first frequency, storing the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger in the stable state as a first degree of superheat, and storing the degree of supercooling or the operating state quantity in the stable state as a first index value;
a normal operation transitioning step of switching the refrigerant circuit to the normal operation mode after the end of the storing step;
a stable state reproducing step of, after the elapse of a predetermined time period after the normal operation transitioning step, detecting the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or the operating state quantity that fluctuates in response to fluctuations in the degree of supercooling as a detected value while performing control of the compressor such that the frequency of the compressor becomes the first frequency stored by the storing step and performing control of the expansion mechanism such that the degree of superheat becomes the first degree of superheat;
and a refrigerant quantity adequacy determining step of comparing the index value and the detected value to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.

The air conditioning apparatus refrigerant quantity determination method according to claim 1, wherein
the first predetermined value is a suitable value equal to or greater than a magnitude of the degree of supercooling with which it can be judged that the refrigerant has leaked, and
the second predetermined value is a suitable value equal to or greater than a magnitude of the operating state quantity with which it can be judged that the refrigerant has leaked.

An air conditioning apparatus (1) comprising:

a refrigerant circuit (10) that includes a heat source unit (2) having a compressor (21) capable of adjusting its operational capacity, a heat source-side heat exchanger (23), an expansion mechanism (33), and an accumulator (24), a utilization unit (4) having a utilization-side heat exchanger (41), and a liquid refrigerant connection pipe (6) and a gas refrigerant connection pipe (7) that interconnect the heat source unit and the utilization unit, with the refrigerant circuit being capable of performing at least cooling operation where the heat source-side heat exchanger is caused to function as a condenser of refrigerant compressed in the compressor and where the utilization-side heat exchanger is caused to function as an evaporator of the refrigerant condensed in the heat source-side heat exchanger;
the adequacy of the quantity of the refrigerant inside the refrigerant circuit, the air conditioning apparatus refrigerant quantity determination method comprising:

an initial operating step of causing the refrigerant circuit to perform the cooling operation from a normal operation mode where control of each device of the heat source unit and the utilization unit is performed according to the operating load of the utilization unit, detecting the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or an operating state quantity that fluctuates in response to fluctuations in the degree of supercooling while controlling the expansion mechanism such that the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger becomes a positive value, and placing the refrigerant circuit in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value or where the operating state quantity has been made equal to or greater than a second predetermined value;
a storing step of storing the frequency of the compressor in the stable state as a first frequency, storing the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger in the stable state as a first degree of superheat, and storing the degree of supercooling or the operating state quantity in the stable state as a first index value;
a normal operation transitioning step of switching the refrigerant circuit to the normal operation mode after the end of the storing step;
a stable state reproducing step of, after the elapse of a predetermined time period after the normal operation transitioning step, detecting the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or the operating state quantity that fluctuates in response to fluctuations in the degree of supercooling as a detected value while performing control of the compressor such that the frequency of the compressor becomes the first frequency stored by the storing step and performing control of the expansion mechanism such that the degree of superheat becomes the first degree of superheat;
and a refrigerant quantity adequacy determining step of comparing the index value and the detected value to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.
changer (41), and a liquid refrigerant connection pipe (6) and a gas refrigerant connection pipe (7) that interconnect the heat source unit and the utilization unit, with the refrigerant circuit being capable of performing at least cooling operation where the heat source-side heat exchanger is caused to function as a condenser of refrigerant compressed in the compressor and where the utilization-side heat exchanger is caused to function as an evaporator of the refrigerant condensed in the heat source-side heat exchanger;

initial operating means that causes the refrigerant circuit to perform the cooling operation from a normal operation mode where control of each device of the heat source unit and the utilization unit is performed according to the operating load of the utilization unit, detects the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or an operating state quantity that fluctuates in response to fluctuations in the degree of supercooling while controlling the expansion mechanism such that the degree of superheat of the refrigerant in the outlet of the heat source-side heat exchanger becomes a positive value, and places the refrigerant circuit in a stable state where the degree of supercooling has been made equal to or greater than a first predetermined value or where the operating state quantity has been made equal to or greater than a second predetermined value;

storing means that performs a storing step which is storing the frequency of the compressor in the stable state as a first frequency, stores the degree of superheat of the refrigerant in the outlet of the utilization-side heat exchanger as a first degree of superheat, and stores the degree of supercooling or the operating state quantity in the stable state as a first index value;

normal operation transitioning means that performs a normal operation transitioning step which is switching the refrigerant circuit to the normal operation mode after the end of the storing step;

stable state reproducing means which, after the elapse of a predetermined time period after the normal operation transitioning step, detects the degree of supercooling of the refrigerant in the outlet of the heat source-side heat exchanger or the operating state quantity that fluctuates in response to fluctuations in the degree of supercooling as a detected value while performing control of the compressor such that the frequency of the compressor becomes the first frequency stored by the storing step and performing control of the expansion mechanism such that the degree of superheat becomes the first degree of superheat; and

refrigerant quantity adequacy determining means that compares the index value and the detected value to determine the adequacy of the quantity of the refrigerant with which the inside of the refrigerant circuit is charged.
START

RUN INDOOR UNIT IN COOLING OPERATION

DETECT OUTDOOR TEMPERATURE AND INDOOR TEMPERATURE

DETECTABLE RANGES?

Yes

RELATIVE SC ≥ PREDETERMINED VALUE?

Yes

PERFORM CONTROL SUCH THAT RELATIVE SC ≥ PREDETERMINED VALUE

S6

STORE RELATIVE SC

S7

STORE VARIOUS PARAMETERS

END

FIG. 3
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

**F25B49/02(2006.01)**

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

**Minimum documentation searched (classification system followed by classification symbols)**

**F25B49/02**

**Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched**

- **Jitsuyo Shinan Koho 1922-1996**
- **Jitsuyo Shinan Toroku Koho 1996-2009**
- **Kokai Jitsuyo Shinan Koho 1971-2009**
- **Toroku Jitsuyo Shinan Koho 1994-2009**

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>JP 2006-292214 A (Daikin Industries, Ltd.), 26 October, 2006 (26.10.06), Par. Nos. [0046] to [0080]; Figs. 3 to 12 (Family: none)</td>
<td>1-3</td>
</tr>
</tbody>
</table>

- **Special categories of cited documents:**
  - **A** document defining the general state of the art which is not considered to be of particular relevance
  - **E** earlier application or patent but published on or after the international filing date
  - **L** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - **O** document referring to an oral disclosure, use, exhibition or other means of publication prior to the international filing date but later than the priority date claimed
  - **T** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - **X** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - **Y** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - **K** document member of the same patent family

- **Date of the actual completion of the international search:**
  - **13 August, 2009 (13.08.09)**

- **Date of mailing of the international search report:**
  - **25 August, 2009 (25.08.09)**

- **Name and mailing address of the ISA,**
  - **Japanese Patent Office**

- **Authorized officer**
  - **Telescop No.**

Form PCT/ISA/210 (second sheet) (April 2007)
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006023072 A [0002] [0003] [0084]