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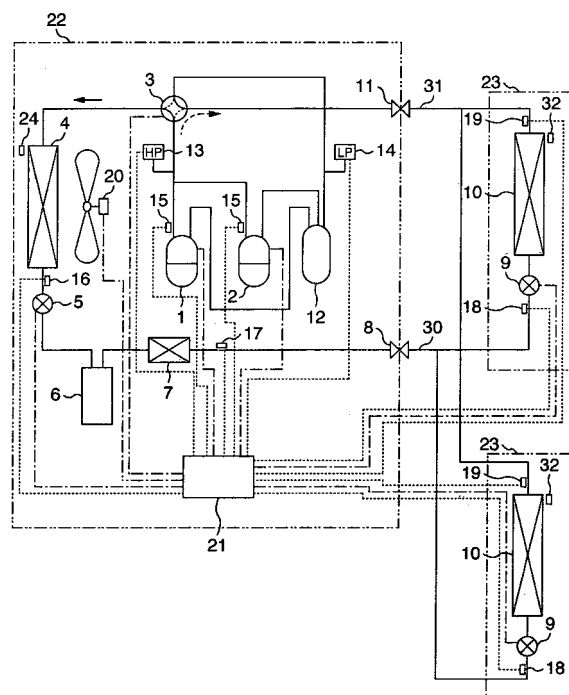
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(54) **Air conditioner and method of determining refrigerant quantity**

(57) In an air conditioner, an occurrence of a refrigerant leakage can be immediately detected after a normal operation thereof is started. The air conditioner includes an outdoor unit having compressors 1,2, a four-way valve 3, an outdoor heat exchanger 4, an outdoor expander 5 and an outdoor air blower 20, and an indoor unit having an indoor expander 9, an indoor heat exchanger 10 and an indoor air blower, the outdoor unit being connected to the indoor unit through a liquid pipe line 30 and a gas pipe line 31. Beforehand, in a state where an appropriate quantity of refrigerant is charged, a relationship between an ambient temperature and a coefficient χ related to a ratio between an output quantity delivered to the indoor or outdoor expander and an output quantity delivered to the compressor is obtained and stored in memory, and then, the coefficient χ related to the ratio between the output quantity delivered to the indoor or outdoor expander and the output quantity delivered to the compressor which are obtained during operation of the air conditioner is compared with the beforehand stored value with respect to the present ambient temperature, thereby determining advisability of the refrigerant quantity.

FIG. 1



Description

Background of the invention

(1) Field of the invention

[0001] The present invention relates to an air conditioner which is so designed as to determine whether or not a refrigerant quantity filled in the air conditioner is appropriate, and a method of determining a quantity of refrigerant quantity, and in particular to an air conditioner and a method which can determine whether or not an appropriate quantity of refrigerant is charged or whether or not refrigerant leaks after an air conditioner is installed.

(2) Description of related art

[0002] An air conditioner including an outdoor unit and an indoor unit, in particular, a separate-type air conditioner including a plurality of indoor units coupled to an outdoor unit, the indoor units and the outdoor unit are installed in various ways. Accordingly, it is difficult to deliver the air conditioner having the outside unit which has been fully charged with refrigerant by a quantity required for the air conditioner. For this reason, after a predetermined quantity of refrigerant is charged in the outdoor unit, it is necessary to additionally charge the refrigerant during site installation of the air conditioner.

[0003] On the other hand, for example, JP-A-2005-114184 discloses such a configuration that a main passage portion of a supercooling heat-exchanger having a sub passage portion between a refrigerant quantity controller (liquid receiver) of an outdoor unit and indoor units during test operation after the site installation, in order to determine whether the refrigerant quantity in the air conditioner (refrigeration cycle) is appropriate being based on a supercooling degree of refrigerant at an exit of the main passage portion.

Brief summary of the invention

[0004] In the configuration disclosed in JP-A-2005-114184, a procedure for determining a refrigerant quantity is carried out during trial operation during which all outdoor units coupled to an outdoor unit are operated, in order to determine whether or not the quantity of refrigerant is appropriate in such a state that the condition of refrigeration cycle is stabilized. For this reason, after the test operation is completed, when a normal operation is started, it is difficult to determine a degree of leakage of the refrigerant leaking from a refrigerant circuit into the outside. In particular, in the air conditioner including a plurality of indoor units which can be started and stopped independently, the operational conditions are different among the indoor units, resulting in lowering of precision of determination of a refrigerant quantity.

[0005] An object of the invention is to provide an air conditioner capable of determining whether or not the refrigerant leaks from the air conditioner into the outside after the normal operation is started, and a method of determining a quantity of refrigerant.

[0006] Another object of the invention is to promptly detect occurrence of leakage of refrigerant after the normal operation is started.

[0007] Still another object of the invention is to early detect a leakage of refrigerant after the normal operation is started and to determine the quantity of refrigerant with a high degree of precision.

[0008] In order to solve the above-described problems, according to an aspect of the invention, there is provided an air conditioner in which an outdoor unit having a compressor, a four-way valve, an outdoor heat exchanger, an outdoor expander and an outdoor air blower is connected to an indoor unit having an indoor expander, an indoor heat exchanger and an indoor air blower through a liquid connection pipe line and a gas connection pipe line, characterized by the provision of means for obtaining a coefficient χ based on an output quantity delivered to the indoor or outdoor expander and an output quantity delivered to the compressor; means for detecting an ambient temperature; and means for determining a quantity of refrigerant based on the thus obtained coefficient χ and the thus detected ambient temperature.

[0009] It is noted that the coefficient χ may be obtained by the following formula: Coefficient χ = Output Quantity delivered to indoor or outdoor expander / Output Quantity delivered to the compressor.

[0010] Incidentally, the output quantity delivered to the indoor or outdoor expander may be set by using an opening degree or a number of pulses (in case of an electric expansion valve) of the expander may be used. The output quantity delivered to the compressor may be set by using a rotational speed of the compressor (in the case of a rotational speed controlled compressor) or a number of compressors to be driven (in the case where a plurality of compressors are provided) may be used.

[0011] Further, the means for determining a quantity of refrigerant may be configured such that a value of the coefficient χ relative to the ambient temperature and an upper limit value of an allowable range of the coefficient χ has been previously obtained through the operation of the air conditioner in a condition in which the quantity of refrigerant is appropriate and are stored in memory, and the quantity of refrigerant is determined being based upon the quantity of

refrigerant based on the coefficient χ which is obtained during a normal operation, and the ambient temperature.

[0012] It is noted that when the coefficient χ is obtained, the output quantity delivered to the indoor expander may be used during cooling operation and the output quantity delivered to the outdoor expander may be used during heating operation.

[0013] The determination of the quantity of refrigerant preferably includes data as to a length of a pipe line between the outdoor unit and the indoor unit or a height difference between the outdoor unit and the indoor unit in order to determine the quantity of refrigerant with a high degree of accuracy.

[0014] When it is determined that the quantity of refrigerant decreases, it is preferable to indicate a leakage of refrigerant and to automatically stop the operation.

[0015] Preferably, a refrigerant quantity determining operation mode for forcibly operating all indoor units in order to determine a quantity of refrigerant is provided, and when a decrease in the quantity of refrigerant is detected during normal operation, the refrigerant quantity determining operation mode may be automatically performed to check whether or not the refrigerant quantity is appropriate, with a high degree of accuracy.

[0016] Information on a determination as to the refrigerant may be displayed on a terminal of a service center through an internet.

[0017] According to another aspect of the invention, said means for obtaining a coefficient χ carry out a calculation based on an output quantity delivered to the indoor expander and an output quantity delivered to the compressor with the use of Formula: Coefficient $\chi = (\text{Output Quantity delivered to indoor expander}) / (\text{Output Quantity to compressor})$.

[0018] According to still another aspect of the invention, there is provided a method of determining a quantity of refrigerant in an air conditioner in which an outdoor unit having a compressor, a four-way valve, an outdoor heat exchanger, an outdoor expander and an outdoor air blower is connected to an indoor unit having an indoor expander, an indoor heat exchanger and an indoor air blower, through a liquid connection pipe line and a gas connection pipe line, the method including the steps of obtaining beforehand a relationship between an ambient temperature and a value related to a ratio between an output quantity delivered to the indoor or outdoor expander and an output quantity delivered to the compressor in such a condition that an appropriate quantity of refrigerant is charged; and comparing a value related to a ratio between the output quantity delivered to the indoor or outdoor expander and the output quantity delivered to the compressor, which are obtained during operation of the air conditioner, with the beforehand obtained value with respect to a present ambient temperature, so as to determine the refrigerant quantity.

[0019] It is noted that the value may be obtained by a coefficient χ which is based upon Formula: Coefficient $\chi = \text{Output Quantity to delivered indoor or outdoor expander} / \text{Output Quantity delivered to compressor}$. It is preferable to use the output Quantity delivered to the indoor expander during cooling operation but to use the output quantity delivered to the outdoor expander during heating operation.

[0020] According to the invention, there may be exhibited such an advantage that a leakage of refrigerant from the air conditioner into the outside when occurs can be detected early or promptly after the normal operation is started.

[0021] Further, there may be exhibited such an advantage that the refrigerant leakage can be early detected after the normal operation is started, and when it is determined a decrease in the quantity of refrigerant, it is possible to determine whether or not the refrigerant quantity is appropriate with a high degree of precision in the case of the provision of the refrigerant quantity determining operation mode.

Brief description of the several views of the drawing

[0022]

Fig. 1 is a configuration diagram illustrating a refrigeration cycle of an air conditioner according to an embodiment of the invention.

Fig. 2 is a flowchart illustrating a refrigerant quantity determining procedure during normal operation.

Fig. 3 is a graph illustrating a relationship between an ambient temperature and a coefficient χ to determine a refrigerant quantity during normal cooling operation.

Fig. 4 is a graph illustrating a relationship between the ambient temperature and the coefficient χ in order to determine a refrigerant quantity during normal heating operation.

Detailed description of the invention

[0023] Hereinafter, an exemplary embodiment of the invention will be described with reference to the accompanying drawings.

Embodiment 1:

[0024] In Fig. 1, an outdoor unit 22 includes a variable displacement type compressor 1, which is controlled by changing an operation frequency with the use of an inverter, and a fixed displacement type compressor 2. As shown in Fig. 1, the compressors 1 and 2 are arranged in parallel and connected to a four-way valve 3. The four-way valve 3 is connected to an outdoor heat exchanger 4 and a gas blocking valve 11 through pipe lines. Additionally, the outdoor heat exchanger 4 is connected to a refrigerant quantity controller (liquid receiver) 6, a supercooling heat exchanger 7, and a liquid blocking valve 8 through an outdoor expander 5.

[0025] As shown in Fig. 1, a plurality of indoor units 23 are connected in parallel to the outdoor unit 22 through a liquid pipe line 30 and a gas pipe line 31. Each of the indoor units 23 includes an indoor expander 9, an indoor heat exchanger 10, and an indoor air blower (not shown).

[0026] On the side of each discharge pipe of the compressors 1 and 2 of the outdoor unit 22, there are provided a discharge pressure sensor 13 for detecting a pressure of a refrigerant gas which is discharged from the compressor, and a discharge temperature sensor 15 for detecting a temperature of the refrigerant gas. A temperature sensor 17 for detecting a temperature of a liquid pipe line (for liquid refrigerant) is arranged between the supercooling heat exchanger 7 and the liquid blocking valve 8. The indoor unit 23 includes a suction temperature sensor (indoor temperature thermistor) 32 for detecting a temperature of an air which flows into the indoor heat exchanger 10, and a discharge temperature sensor 24 (outdoor temperature thermistor) for detecting a temperature of the air which is discharged from the indoor heat exchanger 10. Further, the indoor unit 23 includes a gas temperature sensor 19 in a gas pipe line connected to the indoor heat exchanger 10, and a liquid temperature sensor 18 in a liquid pipe line connected between the indoor expander 9 and the liquid blocking valve 8.

[0027] Then, the numerals 16, 18 and 19 denote temperature sensors, respectively, and the numeral 21 denotes a calculation unit for controlling the air conditioner.

[0028] Next, explanation will be made of the normal cooling operation of the air conditioner with the above-described configuration.

[0029] During cooling operation, the refrigerant flows in a direction of the solid line arrow shown in Fig. 1. The gas refrigerant discharged from the compressors 1 and 2 flows into the outdoor heat exchanger 4 through the four-way valve 3, and then is condensed therein. The condensed liquid refrigerant flows into the refrigerant quantity controller 6, then, the liquid refrigerant derived from the refrigerant quantity controller 6 is supercooled by the supercooling heat exchanger 7, and thereafter, flows into the indoor expander 9 through the liquid pipe line 30 which connects the outdoor unit 22 to the indoor unit 23. The indoor expander 9 is an expansion unit which can be set to an arbitrary throttle degree. The refrigerant pressurized by the indoor expander 9 is delivered to the indoor heat exchanger 10 so as to be evaporated so as to cool the indoor air. The evaporated refrigerant returns to the suction sides of the compressors 1 and 2 through the gas pipe line 31.

[0030] Next, explanation will be made of normal heating operation of the air conditioner. In the case of the heating operation, the four-way valve 3 is changed over so that the refrigerant flows in a direction of the dotted line arrow shown in Fig. 1, and accordingly, the refrigerant discharged from the compressors 1 and 2 flow through the four-way valve 3 and the gas blocking valve 11, and radiates its heat while it is condensed in the indoor heat exchanger 10. Accordingly, the indoor air is heated for carrying out the heating operation. The condensed liquid refrigerant flows into the outdoor unit 22 through the liquid pipe line 30, and then flows into the refrigerant quantity controller 6. Subsequently, the liquid refrigerant is derived from the refrigerant quantity controller 6 and then flows into the outdoor expander 5. The outdoor expander 5 is also an expansion unit which can be set to an arbitrary throttle degree. The refrigerant pressurized by the outdoor expander 5 flows into the outdoor heat exchanger 4 and then evaporates. Subsequently, the evaporated refrigerant whose degree of dehydration becomes higher is returned into to the compressors 1 and 2 through the four-way valve 3.

[0031] This embodiment incorporates a refrigerant quantity determining operation mode which is performed, independent from the cooling operation and the heating operation is provided. Hereinafter, the refrigerant quantity determining operation mode will be described with reference to Fig. 1. In the refrigerant quantity determining operation mode, all of the indoor units 23 which are connected to the air conditioner are operated (accordingly, the refrigerant flows in a direction of a solid line arrow). Until variations in the temperature and the pressure of the discharge gas of the compressors 1 and 2 become small, that is, until the refrigeration cycle is stabilized, a superheat degree of the discharge gas is controlled by means of the indoor expander 9 in order to exceed the set value. When the superheat degree of the discharge gas is exceeds the set value (i.e., in a state where a heat degree at the discharge of the compressor is stabilized), and when a value of a supercool degree obtained being based on a saturated temperature calculated from the discharge pressure sensor 13 and a temperature detected by the temperature sensor 17 at an exit of the supercooling heat exchanger 7 is within a preset range, it is determined that the refrigerant quantity is appropriate.

[0032] In the refrigerant quantity determining operation mode described above, whether or not the charged refrigerant quantity is appropriate is determined while performing the cooling operation of all of the indoor units 23 which are

connected to the air conditioner. At this time, in order to perform the operation in this mode, the normal air conditioning operation should have been stopped for a while. However, in the embodiment, it is possible to determine whether or not the refrigerant quantity is appropriate (alternatively, it is determined whether or not a refrigerant leakage occurs) while the normal air conditioning operation is continued. Hereinafter, explanation will be made of the refrigerant quantity determination during normal air conditioning operation with reference to Figs. 1 to 4.

[0033] First, the refrigerant quantity determination during the normal cooling operation will be described. During the cooling operation, the throttle degree of the indoor expander is adjusted so as to set the superheat degree of the discharge gas within a preset range. When the superheat degree of the discharge gas is within the set temperature range, and the variations in the pressure and the temperature of the discharge gas becomes smaller, a coefficient χ based on the output quantity (an opening degree in the case of an expansion valve, a pulse etc. in the case of an electric valve, or a total opening degree that is, the sum of the opening degrees of a plurality of indoor expansion valves in the case of a plurality of indoor units) delivered to the indoor expander 9 and the output quantity (a frequency in the case of a rotational speed control compressor) delivered to the compressor is obtained by, for example, the following expression (1).

$$\text{Coefficient } \chi = (\text{Output Amount delivered to indoor expander}) / (\text{Output Amount delivered to compressor}) \dots (1)$$

[0034] The ambient temperature (outside temperature) of the outdoor unit 22 is detected by the outdoor temperature thermistor 24. Additionally, when the coefficient χ exceeds the preset value based on the ambient temperature, it is determined that the refrigerant quantity is insufficient. An example of the determination is shown in Fig. 3. Beforehand, the air conditioner is operated in such a state that the refrigerant quantity is appropriate, and the coefficient χ with respect to the ambient temperature is obtained as shown by the solid line in Fig. 3. Additionally, an upper limit of an allowable range of the coefficient χ with respect to the ambient temperature is beforehand obtained as shown by the dotted line in Fig. 3. Subsequently, during the normal operation, the coefficient χ based on the expression (1) and the ambient temperature are obtained, and if the thus obtained coefficient χ is within an insufficient refrigerant region shown in Fig. 3, it is determined that the refrigerant quantity is insufficient. On the contrary, if the coefficient χ is not more than the upper limit of the allowable range, it is determined that the refrigerant quantity is appropriate. Additionally, when it is judged that the refrigerant quantity is insufficient, it can be understood that the refrigerant leaks becomes greater than that at the time when the refrigerant was filled in the air conditioner.

[0035] In the embodiment described above, in the case of such a configured that the suction temperature (indoor temperature) of the indoor unit 23 is detected by the indoor temperature thermistor 32, and a relationship between the coefficient χ and the outdoor and indoor temperatures is obtained, it is possible to determined the refrigerant quantity with a higher degree of precision. Further, although explanation has been made of such that is ad, the frequency is used to detect the output quantity delivered to the compressor in the case of the rpm-control compressor, a number of compressors to be driven may be used in the case of incorporating one or more of fixed displacement type compressors are provided. That is, parameters relating to a total discharge flow rate from all compressors may be used.

[0036] Next, the refrigerant quantity determination during normal heating operation will be described. During the heating operation, the throttle degree of the outdoor expander 5 is adjusted so that the superheat degree of the discharge gas is within a preset range. When the superheat degree of the discharge gas is within a preset temperature range and variations in the pressure and the temperature of the discharge gas become smaller, the coefficient χ based on the output quantity delivered to the outdoor expander 5 and the output quantity delivered to the compressor is obtained by, for example, the following expression (2).

$$\text{Coefficient } \chi = (\text{Output Quantity to outdoor expander}) / (\text{Output Quantity to compressor}) \dots (2)$$

[0037] The ambient temperature (outside temperature) of the outdoor unit 22 is detected by the thermistor 24. Additionally, in the same manner as the cooling operation, the air conditioner is operated in such a state that the refrigerant quantity is appropriate, and then the coefficient χ with respect to the ambient temperature is beforehand obtained as shown in Fig. 4 (where the solid line indicates an optimal value and the dotted line indicates an upper limit value of an

allowable range). Then, it is determined that whether or not the refrigerant quantity is appropriate.

[0038] Fig. 2 is a flowchart illustrating the procedure for determining whether or not the refrigerant quantity is appropriate, in series during normal operation in this embodiment.

[0039] It is noted that, as described above, although only the ambient temperature (and the indoor temperature) is used as the condition for the determination, since it is considered that the output quantity delivered to the expander may vary due to an installed condition (a pipe line length / a height difference between the outdoor unit and the indoor unit, and the like), if the installed condition is included in the refrigerant quantity determination, it is possible to further improve the precision of the determination. Additionally, the calculation unit 21 (see Fig. 1) for controlling the air conditioner may be provided with a memory unit in which a variation in the coefficient χ is recorded in order to add information as to variation in the coefficient χ with time, to the refrigerant quantity determination.

[0040] In the refrigerant quantity determination during the normal operation which is described above, when it is determined that the refrigerant quantity is insufficient, the result may be displayed on a remote control switch unit (not shown) etc. in order to inform a user of a leakage of refrigerant. Thus, the operation of the air conditioner can be stopped. Further, an alarm sound may be issued by an alarm to inform the user of the refrigerant leakage. Furthermore, when the air conditioner is connected to the internet etc., the information as to the refrigerant leakage can be displayed on a terminal of a service center, and thus it is possible to call a service man in a short time.

[0041] In the refrigerant quantity determination during the normal operation which is described above, when it is determined that the refrigerant amount is not sufficient, the above-described refrigerant quantity determining operation mode may be configured so as to be forcedly carried out automatically while the cooling operation of all indoor units which are connected to the air conditioner is carried out, and accordingly, by carrying out the refrigerant quantity determination, it is possible to further improve the precision of the refrigerant quantity. Further, in this case, the refrigerant quantity determining operation mode may not be automatically carried out, but the service man may operate a switch etc. installed in the outdoor unit, or the refrigerant quantity determining operation mode may be carried out using a personal computer by connecting the personal computer to the air conditioner. Additionally, the refrigerant quantity determining operation may be carried out by connecting the air conditioner to a network computer or a central controller in order to change over the operation thereof into the refrigerant quantity determining operation mode.

[0042] According to the embodiment, during the operation of the air conditioner, by detecting an operation state quantity (the output quantity delivered to the expander and the output quantity delivered to the compressor, or the like), it is possible to promptly determine whether or not the refrigerant quantity decreases in a refrigerant circuit (including the connection pipe line or the air conditioner). When it is determined that the refrigerant quantity decreases, the refrigerant leakage is displayed and then the operation is stopped so that the refrigerant leakage can be promptly informed, thereby it is possible to prepare measures for preventing refrigerant from leaking. When it is determined that the refrigerant quantity decreases, it is possible to determine whether the refrigerant quantity is appropriate with a higher degree of precision by performing the refrigerant quantity determining operation mode again.

Claims

1. An air conditioner in which an outdoor unit (22) having a compressor (1, 2), a four-way valve (3), an outdoor heat exchanger (4), an outdoor expander (5) and an outdoor air blower (20) is connected to an indoor unit (23) having an indoor expander (9), an indoor heat-exchanger (10) and an indoor air blower through a liquid connection pipe line (30) and a gas connection pipe line (31), **characterized by** comprising means for obtaining a coefficient χ based on an output quantity delivered to the indoor or outdoor expander (9 or 5) and an output quantity delivered to the compressor (1, 2);
 - means for detecting an ambient temperature; and
 - means for determining a refrigerant quantity based on the thus obtained coefficient χ and the detected ambient temperature.
2. The air conditioner according to Claim 1, **characterized in that** the coefficient χ is obtained by Formula Coefficient $\chi = (\text{Output Quantity delivered to indoor or outdoor expander (9 or 5)}) / (\text{Output Quantity delivered to Compressor (1, 2)})$.
3. The air conditioner according to Claim 2, **characterized in that** the means for determining a refrigerant quantity obtains and stores in memory a value of the coefficient χ relative to the ambient temperature and an upper limit value of an allowable range of the coefficient χ by beforehand operating the air conditioner in an appropriate refrigerant quantity state, and then determines a refrigerant quantity based on the coefficient χ which is obtained during normal operation and the ambient temperature.

4. The air conditioner according to Claim 2, **characterized in that** the output quantity delivered to the indoor expander (9) is used during cooling operation and the output quantity delivered to the outdoor expander (5) is used during heating operation.

5. The air conditioner according to Claim 1, **characterized in that** data as to a pipe line length between the outdoor unit (22) and the indoor unit (23) or a height difference between the outdoor unit (22) and the indoor unit (23) are added for determination of a refrigerant quantity.

6. The air conditioner according to Claim 1, **characterized in that** when it is determined that the refrigerant quantity decreases, a refrigerant leakage is displayed and an operation is automatically stopped.

7. The air conditioner according to Claim 1, **characterized in that** a refrigerant quantity determining operation mode for determining a refrigerant quantity by forcedly operating all indoor units (23) is incorporated, and when it is determined that the refrigerant quantity decreases during normal operation, the refrigerant quantity determining operation mode is automatically performed to determine whether the refrigerant quantity is appropriate.

8. The air conditioner according to Claim 1 **characterized in that** information as to determination of a refrigerant quantity is displayed on a terminal of a service center through an Internet.

9. The air conditioner according to claim 1, **characterized in that** said

means for obtaining said coefficient χ based on an output quantity delivered to the indoor expander (9) and an output quantity delivered to the compressor (1, 2), carry out a calculation being based upon the following Formula: Coefficient $\chi = (\text{Output Quantity delivered to indoor expander (9)})/(\text{Output Quantity delivered to Compressor(1, 2)})$.

10. A method of determining a refrigerant quantity in an air conditioner in which an outdoor unit (22) having a compressor (1, 2), a four-way valve (3), an outdoor heat exchanger (4), an outdoor expander (5) and an outdoor air blower (20) is connected to an indoor unit (23) having an indoor expander (9), an indoor heat exchanger (10) and an indoor air blower through a liquid connection pipe line (30) and a gas connection pipe line (31), **characterized by** the steps of

beforehand obtaining a relationship between an ambient temperature and a value related to a ratio between an output quantity delivered to the indoor or outdoor expander (9 or 5) and an output quantity delivered to the compressor (1, 2) in such a state that an appropriate quantity of refrigerant is charged and comparing the value related to the ratio between the output quantity delivered to the indoor or outdoor expander (9 or 5) and the output quantity delivered to the compressor (1, 2) which are obtained during operation of the air conditioner, with the beforehand obtained value with respect to the present ambient temperature, so as to determine the refrigerant quantity.

11. The method of determining a refrigerant quantity in the air conditioner according to Claim 10, **characterized in that** the value is obtained from a coefficient χ being based upon Formula, Coefficient $\chi = (\text{Output Quantity delivered to indoor or outdoor expander (9 or 5)})/(\text{Output Quantity delivered to compressor (1, 2)})$, and in the Formula, the output quantity delivered to the indoor expander (9) is used during cooling operation, but the output quantity delivered to the outdoor expander (5) is used during heating operation.

FIG.1

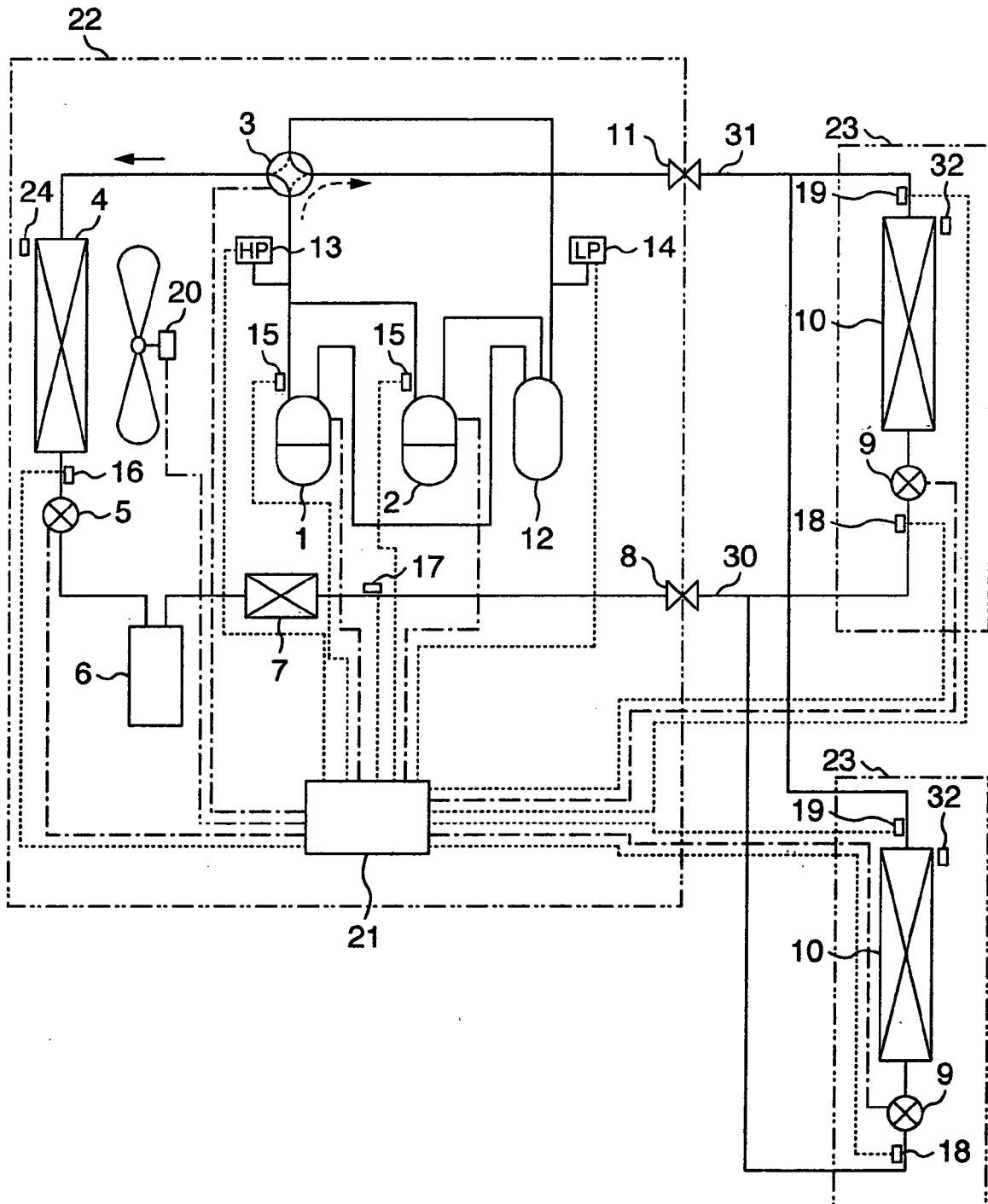


FIG.2

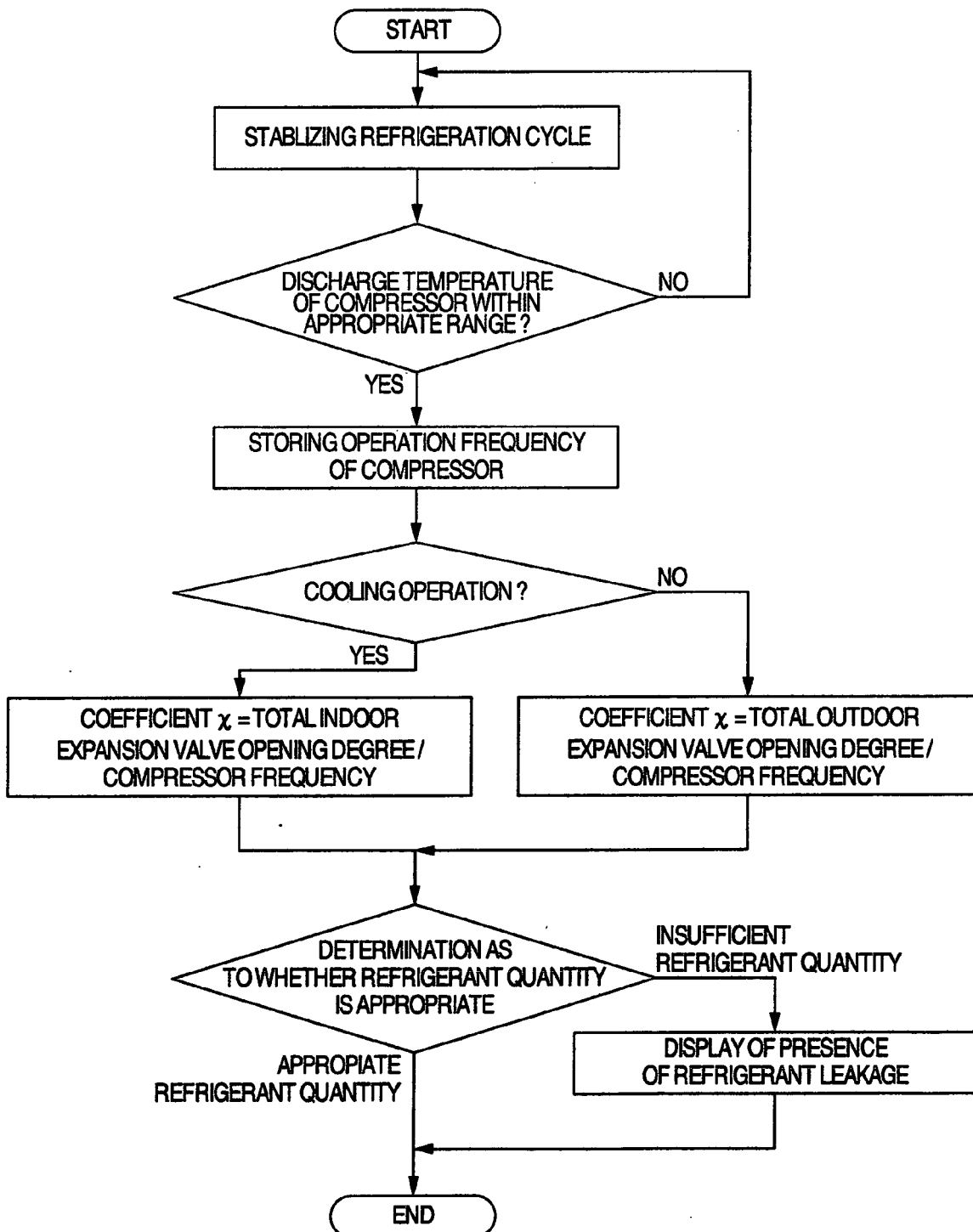


FIG.3

DETERMINATION VALUE DURING COOLING OPERATION

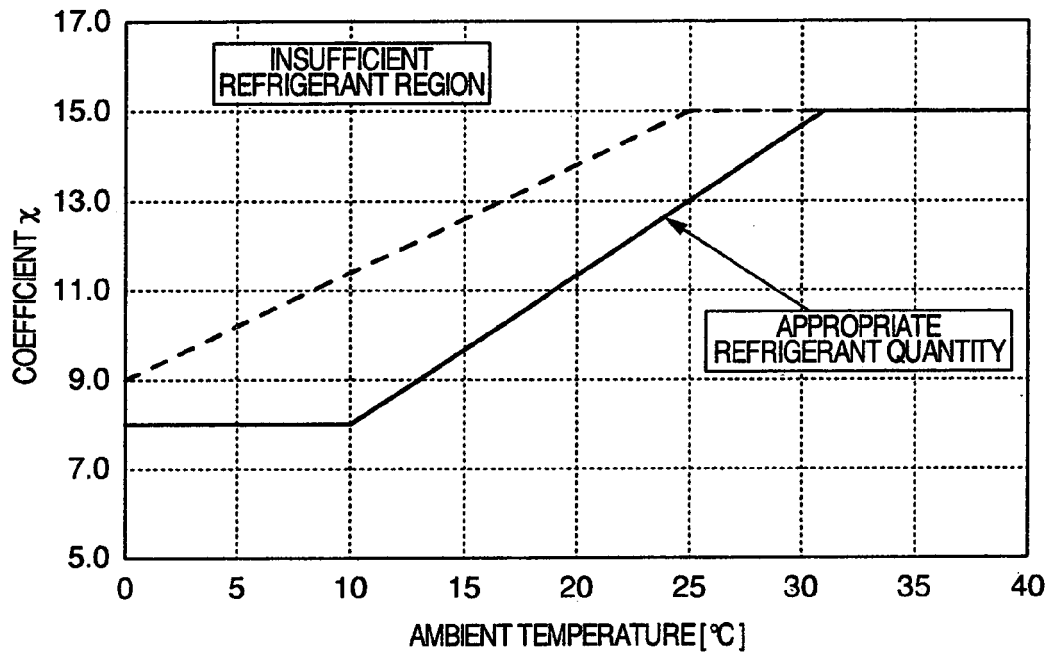
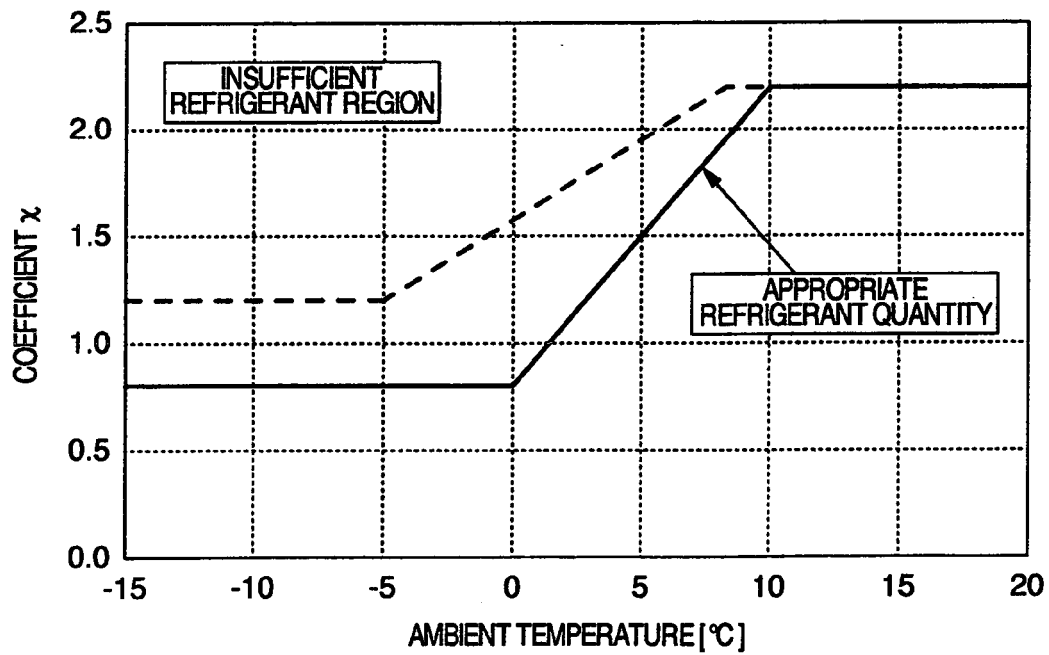


FIG.4

DETERMINATION VALUE DURING HEATING OPERATION



REFERENCES CITED IN THE DESCRIPTION

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