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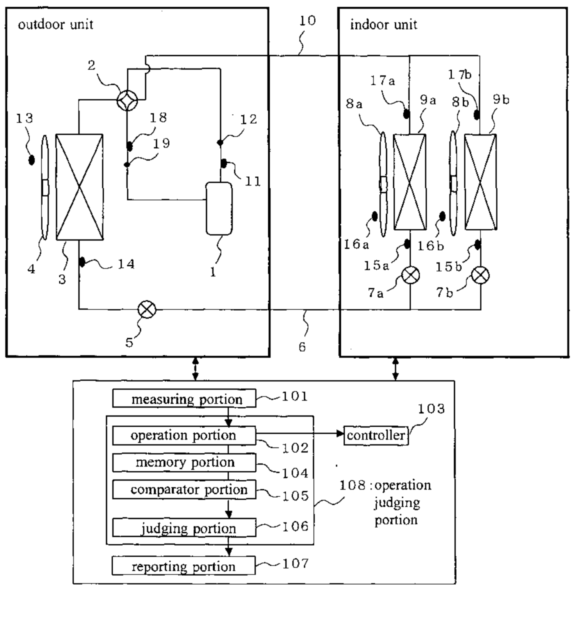
(54) REFRIGERATING/AIR CONDITIONING SYSTEM HAVING REFRIGERANT LEARAGE DETECTING FUNCTION, REFRIGERATOR/AIR CONDITIONER AND METHOD FOR DETECTING LEAKAGE OF REFRIGERANT

(57) A refrigerating air-conditioning system and a method for detecting a refrigerant leakage capable of automatically detecting a slight refrigerant leakage, while performing an air-conditioning operation, regardless of an environmental condition or installation condition, is provided.
Accordingly, a judging means for judging the refrigerant leakage of a refrigerating cycle on the basis of a past data relating to a past refrigerant volume of the refrigerating cycle at a past time point and a new data relating to the refrigerant volume at a time point after performing a plurality of times of sopping and starting up operations of the refrigerating cycle since the past time point, is provided in the refrigerating air-conditioning system constituting a refrigerating cycle by connecting an outdoor unit including a compressor, an outdoor heat exchanger, and a throttling device, and one or a plurality of indoor units each including an indoor heat exchanger and a throttling device with communication piping.

F I G. 1



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Description

Technical Field

[0001] The present invention relates to a refrigerating air-conditioning system having a refrigerant leakage detection function, refrigerating air-conditioner, and method therefor.

Background Art

[0002] With regard to a method for detecting refrigerant leakage of a refrigerating air-conditioner, various methods are already developed, and as a hitherto known method for detecting the refrigerant leakage of the refrigerating air-conditioner, for example, a below described methods are known.

[0003] In refrigerators, there is a method to judge that there is refrigerant leakage when a refrigerant temperature difference between an inlet and an outlet of an evaporator is greater than a reference temperature difference (refer to the Patent Document 1, for example). This judging operation for the refrigerant leakage is performed by judging a temperature difference at a time point in an operation.

Further, there is also a method to judge that there is the refrigerant leakage, when a temperature of a refrigerant, which is detected by a temperature sensor attached to a header of a heat exchanger of an indoor unit, is lowered at a speed faster than the predetermined speed after a stop of a compressor (refer to the Patent Document 2 for example). In this judging method, it is required to stop the compressor when judging and therefore an air-conditioning operation cannot be performed while performing this judging method.

Furthermore, there is also a method to judge with a refrigerant sensor attached to an inside of a room. However, a refrigerant gas detecting sensor itself is special and therefore expensive, and in addition, the refrigerant leakage cannot be detected unless density of the leaked refrigerant in the air exists to some extent (refer to the Patent Document 3, for example).

Moreover, there is also a method to judge it by closing an electromagnetic valve during operation of the compressor, and comparing the driving electric current reducing ratio of the compressor at that time with a reference value. However, this method can detect the refrigerant leakage caused only between the electromagnetic valve and an inflow side of the compressor, but cannot detect the leakage caused between a discharge side of the compressor and the electromagnet valve. In addition, the compressor stops when the refrigerant leakage is judged and therefore the air-conditioning operation cannot be performed while performing this judging method. (For example, refer to the Patent Document 4).

[0004]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2005-90953
Patent Document 2: Japanese Unexamined Patent Application Publication No. 2005-9857
Patent Document 3: Japanese Unexamined Patent Application Publication No. 2004-69198
Patent Document 4: Japanese Unexamined Patent Application Publication No. 2004-36985

Disclosure of Invention

Problems to be Solved by the Invention

[0005] In the aforementioned conventional method (the Patent Document 1), the temperature difference between the inlet and outlet of the evaporator varies depending on a fluctuation of the circumferential temperature or the evaporator load. In addition, when multiple evaporators exist there is a case where temperature differences between the inlet and outlet of the respective evaporators are different. Thus it is difficult to detect the refrigerant leakage in an accurate fashion.

Further, in the conventional method (Patent Document 2), there is a problem that when the pressure in a circuit at the judgment time is assumed to be 2.0 MPa using, for example, R410A as a refrigerant, a small leakage with a pressure reducing ratio of 0.02 MPa per minute or less, can not be detected.

Furthermore, also in the conventional method (Patent Document 3), since the data is a detected value at a momentary time point, or the driving electric current reducing ratio occurred once in a brief period of time such as one minute, as described in the Patent Document 4, a so-called slow leak, in which the refrigerant gradually leaks taking a long time, can not be detected. In addition, there is a problem in operating the air-conditioner when the refrigerant leakage is detected using the conventional methods.

Moreover, conventionally, the judging operation for the refrigerant volume is performed in light of deterioration of capability, or prevention of damage to the compressor. The reduction of a refrigerant volume is detected using a fixed threshold value regardless of a filled up refrigerant volume. Therefore, in a case where the refrigerant is excessively filled up in an initial condition of filing up the refrigerant, there is a long time before the refrigerant volume is detected, and a large

volume of the refrigerant is leaked before the refrigerant volume is detected.
Accordingly, there has also been a problem in which an influence on the environment increases.

Means for Solving the Problems

[0006] The present invention is made to solve the aforementioned problems and a below mentioned construction is adopted accordingly.
A refrigerating air-conditioning system according to the present invention, in which a refrigerating cycle is constituted by connecting an outdoor unit including a compressor, an outdoor heat exchanger and a throttling device, and one or a plurality of indoor units each including an indoor heat exchanger and a throttling device, with communication piping, is provided with a judging means for judging a refrigerant leakage in the refrigerating cycle, on the basis of a past data relating to a past refrigerant volume in the refrigerating cycle at a past time point and a new data relating to a refrigerant volume at a time point after performing a plurality of times of stopping and starting up operations of the refrigerating cycle since the past time point. Further, a refrigerating air-conditioner according to the present invention is provided with a judging means for judging a refrigerant leakage in the refrigerating cycle, on the basis of past data relating to a past refrigerant volume in the refrigerating cycle at a past time point and new data relating to a refrigerant volume at a time point after performing a plurality of times of stopping and starting up operations of the refrigerating cycle since the past time point.
Furthermore, a method for detecting a refrigerant leakage of the present invention is a method for detecting a refrigerant leakage of a refrigerating air-conditioning unit, in which a refrigerating cycle is constituted by connecting an outdoor unit including a compressor, an outdoor heat exchanger and a throttling device, and one or a plurality of indoor units each including an indoor heat exchanger and a throttling device, with communication piping. The method includes the steps of judging an elapsed time after filling up a refrigerant, judging whether all of indoor heat exchangers constituting the indoor units are performing a cooling operation or a heating operation, and judging whether there is the refrigerant leakage from the refrigerating cycle on the basis of a historical data relating to a refrigerant volume in the refrigerating cycle, when all the indoor heat exchangers are judged to be performing the cooling operation or the heating operation.

Advantages

[0007] In a refrigerating air-conditioning system, a refrigerating air-conditioning unit, and a method for detecting a refrigerant leakage according to the present invention, it becomes possible to detect even a refrigerant leakage with a little leaking volume per unit time, while performing an air-conditioning operation.

Brief Description of the Drawings

[0008]

Fig. 1 is a constructional view illustrating a refrigerating air-conditioner in the first embodiment;
Fig. 2 is a flowchart illustrating a refrigerant leakage detection of the air-conditioner in Fig. 1;
Fig. 3 is a constructional view illustrating a refrigerating air-conditioner according to the second embodiment;
Fig. 4 is a flowchart showing a part to be added to the flowchart in Fig. 2, which is a specific operation to the refrigerating air-conditioner in Fig. 3;
Fig. 5 is a constructional view illustrating a refrigerating air-conditioner according to the third embodiment;
Fig. 6 is a flowchart illustrating a refrigerant leakage detection of the air-conditioner in Fig. 5;
Fig. 7 is an exemplary view illustrating time variations of a high pressure and a low pressure in a refrigerating cycle according to the third embodiment;
Fig. 8 is a constructional view illustrating an air-conditioning system according to the fourth embodiment;
Fig. 9 is a sequential view illustrating an operation of the air-conditioning system according to the fourth embodiment;
Fig. 10 is a constructional view illustrating an air-conditioning system according to the fifth embodiment;
Fig. 11 is a sequential view illustrating an operation of the air-conditioning system according to the fifth embodiment;
Fig. 12 is a sequential view illustrating an operation of the air-conditioning system according to the sixth embodiment; and
Fig. 13 is a sequential view illustrating an operation of the air-conditioning system according to the seventh embodiment.

Reference Numerals

[0009] 1: compressor, 2: four-way valve, 3: outdoor heat exchanger, 4: outdoor air blower, 5: throttling device, 6: gas-refrigerant piping, 7a and 7b: throttling device, 8a and 8b: indoor air blower, 9a and 9b: indoor heat exchanger, 10: liquid-refrigerant piping, 11: discharge temperature sensor, 12: discharge pressure sensor, 13: outdoor temperature sensor, 14: temperature sensor, 15a and 15b: temperature sensor, 16a and 16b: indoor unit intake temperature sensor, 17a and 17b: temperature sensor, 18: intake temperature sensor, 19: intake pressure sensor, 101: measurement portion, 102: operation portion, 103: control portion, 104: memory portion, 105: comparator portion, 106: judging portion, 107: reporting portion, 108: operation judging portion, 100: outdoor unit, 110: indoor unit, 120: concentration controller, 130: remote monitoring device

Best Mode for Carrying Out the Invention

First Embodiment

[0010] Fig. 1 is a view illustrating a construction of a refrigerant circuit of a refrigerating air-conditioner according to a first embodiment of the present invention, and Fig. 2 is a flowchart illustrating a refrigerant leakage detection performed by the air-conditioner in Fig. 1.

[0011] As shown in Fig. 1, this refrigerating air-conditioner constructs a refrigerating cycle including an outdoor unit and an outdoor unit. In the outdoor unit, a compressor 1, a four-way valve 2 serving as a flow path switching device, an outdoor heat exchanger 3, and a throttling device 5 are sequentially connected, and thus, a main circuit of a refrigerant is constructed. Further, in the indoor units, throttling devices 7a and 7b, and indoor heat exchangers 9a and 9b are sequentially connected and thus, the main circuit of the refrigerant is constructed. The outdoor unit and the indoor units are connected with a liquid-refrigerant pipeline 6 and a gas-refrigerant pipeline 10. In the outdoor heat exchanger 3, a fan 4 for blowing air is provided and in the indoor heat exchangers 9a and 9b, fans 8a and 8b for sending air are similarly provided.

At a discharge side of the compressor 1, a discharge temperature sensor 11 for detecting a temperature of the refrigerant, and a discharge pressure sensor 12 for measuring a pressure in the pipeline are installed. At an intake side of the compressor 1, an intake temperature sensor 18 for detecting a temperature of an intake side refrigerant and an intake pressure sensor 19 for measuring a pressure in the pipeline are installed. Further, an outdoor temperature sensor 13 for detecting a surrounding air temperature of the outdoor unit, and a temperature sensor 14 for detecting a temperature of the refrigerant at an outlet of the outdoor heat exchanger 3 (during cooling operation) are provided.

At inlets and outlets of the refrigerant in the indoor heat exchangers 9a and 9b, temperature sensors 15a, 15b, 17a, and 17b are provided and the surrounding air temperature of the indoor unit is detected by the indoor unit intake temperature sensors 16a and 16b.

Each temperature sensor is provided in a manner so as to be in contact with, or to be inserted into the refrigerant pipeline, and the refrigerant temperature at that portion is enabled to be detected. In addition, each throttling device is constituted by a pressure-adjusting valve or the like.

[0012] Each quantity detected by each temperature sensor and each pressure sensor is inputted to a measurement portion 101 for gathering measured results, and is utilized for an arithmetic processing at an operation portion 102 corresponding to a necessity. A controller 103 is provided to control the refrigerating cycle to be within a desired control target range by controlling the compressor 1, the four-way valve 2, the air blowers 4, 8a, and 8b and the throttling devices 5, 7a, and 7b, on the basis of a computed result of the operation portion 102. The control portion 103 is connected to each device constituting this refrigerating cycle by wire or wireless, and is enabled to control each of the devices. The control portion 103 is also provided with an operation-confirming means for judging whether the indoor unit is in operation, an integrating means (or a timer device) for integrating an operation time of the compressor 1, a timecounting means for counting the date and hour, or the like. Further, the refrigerating air-conditioner is provided with a memory portion 104 serving as a memory means (or a memory device) for memorizing a result obtained by the operation portion 102, a predetermined constant, or the like, and is provided with a comparator portion 105 for comparing the stored result and a predetermined value in a current refrigerating cycle condition. Furthermore, the refrigerating air-conditioner includes a judging portion 106 for judging a filled-up condition of the refrigerant of this refrigerating air-conditioner from the result compared by the comparator portion 105, and a reporting portion 107 serving as a reporting means for reporting the result that is judged by the judging portion 106 to a remote controller of the indoor unit, LED (light emitting diode) and/or a monitor or the like at a distant place. Here, the operation portion 102, the memory portion 104, the comparator portion 105, and the judging portion 106 are to be collectively called as an operation judging portion (or a judging means) 108. Incidentally, the measurement portion 101, the control portion 103, the reporting portion 107, and the operation judging portion 108 are usually composed of a microcomputer, a personal computer, or a CPU and a program or the like.

[0013] Although a case of two indoor heat exchangers of the indoor units is shown in Fig. 1, the number of the indoor heat exchanger is not limited thereto, and the number of the indoor heat exchangers may be one or more than two. Further, a capacity of each indoor heat exchanger may be different, or all the indoor heat exchangers may have the same capacity. Furthermore, as for the outdoor heat exchanger, a construction, in which a plurality of the outdoor heat exchangers are connected, may also be adopted in a similar manner.

[0014] Next, an operation of the refrigerating air-conditioner will be explained.

In the cooling operation, a gas-refrigerant at high temperature and high pressure discharged from the compressor 1 reaches the outdoor heat exchanger 3 via the four-way valve 2 and is condensed (at this time, the outdoor heat exchanger 3 functions as a condenser). The condensing temperature at this moment can be found as a saturation temperature of a pressure of the pressure sensor 12 attached to the discharge side of the compressor 1. Further, a super-cooling rate of the refrigerant at the outlet of the outdoor heat exchanger 3 is found by a difference between the condensing temperature and the temperature sensor 14. The condensed refrigerant passes the fully open throttling device 5 of the outdoor unit and the liquid-refrigerant pipeline 6, and is depressurized by the throttling devices 7a and 7b of the indoor unit. This results in a two-phase condition. The refrigerant discharged from the throttling devices 7a and 7b evaporates at the indoor heat exchangers 9a and 9b (at the time, the indoor heat exchangers 9a and 9b function as evaporators). Thereafter, the refrigerant returns to the compressor 1 via the gas-refrigerant pipeline 10 and the four-way valve 2. A superheating rate of the refrigerant at the outlet of the outdoor heat exchanger 3 is found by a difference between the temperature sensors 17a and 15a, or a difference between the temperature sensors 17b and 15b.

[0015] In a heating operation, the gas-refrigerant at high temperature and high pressure discharged from the compressor 1 reaches the indoor heat exchangers 9a and 9b via the four-way valve 2 and the gas-refrigerant pipeline 10 and is condensed (at this time, the indoor heat exchangers 9a and 9b function as condensers). The condensing temperature at this moment can be found as the saturation temperature of the pressure of the pressure sensor 12 attached to the discharge side of the compressor 1. Further, super-cooling rates of the refrigerant at the outlets of respective indoor heat exchangers 9a and 9b are found as differences between the condensing temperature and the respective temperature sensors 15a and 15b. The condensed refrigerant passes the fully open throttling devices 15a and 15b of the indoor unit and a liquid-refrigerant pipeline 6, and is depressurized by the throttling device 5 of the outdoor unit. This results in the two-phase condition. The refrigerant discharged from the throttling device 5 evaporates at the outdoor heat exchanger 3 (at this time, the outdoor heat exchanger 3 functions as an evaporator). Thereafter, the refrigerant returns to the compressor 1 via the four-way valve 2. The superheating rates of the refrigerant at the outlets of the indoor heat exchangers 9a and 9b are found by a difference between the temperature sensor 18 and the temperature sensor 14.

[0016] Next, the refrigerant leakage detection performed by the aforementioned refrigerating air-conditioner will be explained.

In a case that the refrigerant volume is intentionally changed because of an installation works or a maintenance, such as a case that a pipeline is newly laid down and the indoor unit and the outdoor unit are newly installed, that an existing pipeline being already laid down in a building is reutilized and an old indoor unit and an old outdoor unit are replaced with a new indoor unit and a new outdoor unit, or that the refrigerant is additionally filled up, the operation judging portion 108 previously stores the amount of the refrigerant (or an operating condition data) at that time, as an initial value of the sealed refrigerant. Namely, at a time of a test run or the like, performed just after installation of refrigerating air-conditioner, the operation judging portion 108 performs a judging operation of a refrigerant volume, and stores the result (AL% value, temperature, and the like, described later) at that time by performing a calculation by the operation portion 102. The judging operation of the initial value can be performed in an ordinary operation. However an appropriate condition for the judging operation of the refrigerant volume can easily be made at the time of the test run. This is because an installation worker can set a condition regardless of a using condition of a user.

Further, in performing the judging operation for the refrigerant leakage detection, it is preferable to display a caution, such as "under refrigerant leakage detecting operation", "under refrigerant volume judging operation", or the like, on a remote controller or an indicator of the indoor unit so as to indicate this condition. This is because a user of the air-conditioner or a maintenance worker can thereby easily figure out an operating condition of the air-conditioner.

[0017] Here, a concrete example of the refrigerant leakage detection based on a measurement, a control, and a judgment function of the measurement portion 101, the controller 103, and the operation judging portion 108 will be explained along the flowchart in Fig. 2.

In the cooling operation or the heating operation, the controller judges whether a time (integrated operating time) elapses over a predetermined time (for example, 100 hours) after a previous judging operation for a refrigerant leakage of the compressor 1 was performed (Step S1). When the time elapses, the program proceeds to the next step, and when the time does not elapse, the program returns to an ordinary air-conditioning operation.

The measurement of the integrated operating time is performed by memorizing a time, when the control portion 103 (integrating means) is outputting an operating command (outputting a command frequency) to the compressor 1, as an integrated time, in a memory every one hour, for example. Alternatively, the integrated time may be calculated by the controller 103 by providing an electric current sensor in a wire to the compressor, and detecting a time, when the electric current is flowing in the wire to drive the compressor, with the electric current sensor, instead of the time when the operating command is outputting.

[0018] Incidentally, since there is a high possibility of the refrigerant leakage due to bad brazing or the like, just after installation of the air-conditioner or replacement of parts, it is preferable to frequently perform the judging operation for the refrigerant leakage in a shorter time intervals than the above-described time period.

[0019] Further, instead of using the integrated operating time of the compressor 1 in Step S1, the judging operation for the refrigerant leakage may be performed at a predetermined date and hour using a built-in timekeeping device (including date-and-hour outputting function). As for the timekeeping device, an existing timer circuit or the like can be used. The controller 103 resets this timer circuit when the refrigerating air-conditioner is installed, and the timer counts the elapsing time from the time of the installation. The controller 103 obtains time information from the timer at regular intervals or irregular intervals, and judges whether a predetermined set time has elapsed. Thereby, even in case that the air-conditioning operation is not performed for a long time, the judging operation for the refrigerant leakage is performed and the refrigerant leakage can be detected. Incidentally, when the refrigerant leakage detection is once performed as described above, the controller 103 resets the timer circuit or newly set a set time, and thereby prepares to perform the next leakage detection at a predetermined timing.

Now, for example, when the leakage detection is performed at intermediate seasons of spring and fall (twice a year), the judging operation can be performed at a condition of an outdoor air temperature close to each other. Thereby, the pressure or the temperature of the refrigerant at the time when the air-conditioner is operated becomes approximately equal at each judging timing, and the density of the refrigerant in each portion of the refrigerant piping becomes approximately equal at the judging timing. Therefore, the error occurring due to a difference between the densities of the refrigerant is decreased and the judging operation with good accuracy can be performed.

[0020] Further, although not included in the flowchart in Fig. 2, the judging operation for the refrigerant leakage may be performed after the end of the Step S1 only when the control portion 103 judges that the outdoor air temperature in the outdoor air temperature information detected by the outdoor temperature sensor 13 is within a predetermined area (for example, the temperature at the time of the initial run $\pm$ 5°C). For example, the control portion 103 stores the outdoor temperature detected at the time of previous judging operation for the refrigerant leakage, such as the outdoor temperature detected at the time of the test run, in the memory portion 104 or other memory device. Operation for the refrigerant leakage is performed when the control portion 103 judges that the difference between the stored outdoor temperature and a current outdoor temperature is within the predetermined area ($\pm$ 5°C). When the difference of the outdoor temperature is in an area equal to or greater than the predetermined area, the controller 103 waits until the outdoor temperature reaches the predetermined area, and then proceeds to perform the judging operation for the refrigerant leakage. By thus performing, the pressure or the temperature of the refrigerant during operation of the refrigerating air-conditioner becomes approximately equal at every timing of the judging operation, so that the density of the refrigerant in each portion of the refrigerant piping becomes approximately equal at the judging timing. Therefore, the error occurring due to a difference between the densities of the refrigerant is decreased and the judging operation with good accuracy can be performed.

Incidentally, in a case that the difference of the outdoor temperature does not reach the predetermined area, the judging operation for the refrigerant leakage can be performed, after the control portion 103 corrects a judging parameter to a predetermined correction value of the judging parameter for judging the refrigerant leakage (for example, the AL% or the like, described later) corresponding to the difference of the outdoor temperature. The correction value is found by previous measurement performed corresponding to the difference of the outdoor temperature and stored in the memory or the like. Or it is determined in the way that the controller 103 founds the same by a calculation as a function of the difference of the outdoor temperature or the outdoor temperature. The refrigerant leakage detection by the correction may be performed in a case that the outdoor temperature does not reach the predetermined area whereas the predetermined time has elapsed, or may be performed without waiting for elapse of the time.

[0021] Subsequently, the stability of the operation on the refrigerating cycle is judged (step S2). This judging operation is performed by the way that the control portion 103 judges whether predetermined variation values of a physical quantities on the refrigerating cycle, are within the predetermined area. The control portion 103 judges whether the variation value of the temperature or the pressure of the refrigerant in the predetermined time period is equal to or less than the previously determined quantity or not, utilizing the temperature sensor or the pressure sensor as a physical quantity detecting device. For example, the control portion 103 monitors the temperature detected by the discharge temperature sensor 11, and judges that the refrigerating cycle is stable when the difference between an upper limit value and a lower limit value in 3 minutes is within 2 centigrade. Further, the controller 103 monitors the detected value of the pressure sensor provided in a discharge piping of the compressor 1 or an intake piping of the same as a parameter for judging the stability, and the control portion 103 can also judge that the refrigerating cycle is stabilized when the difference of an upper limit value and a lower limit value of the detected value in 3 minutes is 1 kgf/cm^2. It is preferable that these condition values are determined to an appropriate value, while previously performing an examination, and considering an allowable value of an error for judging the refrigerant volume. Besides the above-described operations, it may be judged whether the refrigerating cycle is stabilized, on the basis of stability of a frequency of the compressor 1, an opening extent of the throttling devices 5, 7a, and 7b, super-cooling rate and the superheating rate of the outlet of each of the heat exchangers 3, 9a, and 9b, and so forth. When the refrigerating cycle is unstable, the refrigerant leakage cannot be detected accurately, and therefore the program proceeds to the next step only when a condition of the refrigerating cycle is judged to be stable. When the stability is not confirmed, the program returns to an ordinary operation.

[0022] Further, when judging the refrigerant leakage, the refrigerant volume accumulated in the indoor heat exchangers 9a and 9b which are out of operation is difficult to be estimated from the temperature sensor or the like. Therefore, judging accuracy is lowered when the judging operation for the refrigerant leakage is performed under a condition in which the indoor heat exchangers 9a and 9b which are out of operation exists. Accordingly, so as to perform the judging operation for the refrigerant leakage at good accuracy, the controller 103 judges whether all the indoor heat exchangers 9a and 9b being connected are performing the cooling operation or the heating operation. When all the indoor heat exchangers 9a and 9b are performing the cooling operation or all the indoor heat exchangers are performing the heating operation, the program proceeds to the next step (Step S3). When not all the indoor heat exchangers are in operation, the program proceeds to the next step after operating all the indoor heat exchangers (Step S3'). Incidentally, when not all the indoor heat exchangers are in operation, the program may return to the ordinary air-conditioning operation, while suspending the judging operation.

[0023] Incidentally, in a case that a refrigerant leakage judging operation has a small influence on the capability or the like compared to the ordinary operation, and all the indoor heat exchangers are performing the cooling operation or the heating operation, the judging operation for the refrigerant leakage may always be performed regardless of the integrated operating time of the compressor 1 or the date.

[0024] Subsequently, the controller 103 controls the superheating rate of the refrigerant at the outlet of the evaporator to become the predetermined value or more (Step S4) by the throttling device at the evaporator inlet (the throttling devices 7a and 7b correspond thereto in the cooling operation and the throttling device 5 corresponds thereto in the heating operation). Thereby, the gas-refrigerant piping 10 is configured to be in a condition in which no liquid-refrigerant is accumulated, so that the judging operation can be performed with a liquid-phase area ratio AL% of the condenser as an indicator, under a condition where the liquid-refrigerant is accumulated only in the liquid-refrigerant pipeline 6 and the condenser.

[0025] Subsequently, the operation judging portion 108 performs the judging operation to judge whether the refrigerant volume is appropriate (Steps S5 and S6). The operation portion 102 performs the arithmetic processing utilizing the following formula (1).

$$AL\% = -Ln(1-SC/dTc)\times dTc\times Cpr/\Delta hcon \quad (1)$$

Thereafter, the comparator portion 105 compares the result with the past result of the arithmetic processing AL% saved as a history data, and the judging portion 106 performs the judging operation for the refrigerant leakage on the basis of the compared result. The AL% is a ratio of the liquid-phase volume to an entire volume of the condenser, and is an indicator which is the super-cooling rate of the condenser corrected with an outdoor temperature, discharge enthalpy of the compressor, and liquid-specific heat at low pressure of the refrigerant.

In the above formula (1), SC is defined as the super-cooling rate of the refrigerant at an outlet of the condenser, dTc is defined as a difference between the outdoor temperature and a condensing temperature, Cpr is defined as liquid-specific heat at constant pressure of the refrigerant, and Δhcon is defined as a difference of the enthalpies at an inlet of the condenser and the outlet of the condenser. Incidentally, in a case that the condensers are plural in number, the refrigerant leakage is judged on the basis of a result of the arithmetic processing of the following formula (2), in which the AL% of each of the condensers is calculated and weighted average calculation is performed corresponding to the volume.

[0026]

[Mathematical Expression 1]

$$A_L\% = \frac{\sum_{k=1}^{n}\left(Q_{j(k)}\times\left[-Ln\left(1-\frac{SC_{(k)}}{dTc_{(k)}}\right)\times\frac{dTc_{(k)}\times Cpr_{(k)}}{\Delta hcon_{(k)}}\right]\right)}{\sum_{k=1}^{n}Q_{j(k)}} \quad \cdots (2)$$

In the above formula (2), $Q_j(k)$ expresses a heat exchange capacity of each condenser (for example, air-conditioning ability such as 28kW or the like), k denotes the number of the condensers, and n denotes the total number of the condensers. In a case of the cooling operation, the outdoor heat exchanger serves as the condenser, and in a case of the heating operation, the indoor heat exchanger serves as the condenser. In the example of the construction shown in

Fig. 1, the indoor heat exchangers 9a and 9b are plural in number, and therefore the formula (2) is to be applied for the heating operation. Further, in a case of a circuit construction in which a plurality of outdoor heat exchangers is connected, a plurality of condensers exists in the cooling operation, and therefore the AL% is also calculated by the formula (2) in this case.

[0027] When the refrigerant volume is lacking, the super-cooling rate at the outlet of the condenser is not taken and thereby the value of the AL% is lowered. Accordingly, when the value of the AL% is less than that at the time of the test run (or the initial value just after the refrigerant is filled up), the judging portion 106 judges that the refrigerant is lacking, and a reporting portion 107 reports an abnormality to a display device such as the remote controller of the indoor unit, the LED of the outdoor unit, or the like (Step S7). The controller 103 receives a transmission of the judged result of the judging portion 106 indicating the abnormality, and stops the operation of the refrigerating cycle (Step S8). On the other hand, when the AL% is equal to or more than the value at the time of the test run or a predetermined value, the judging portion 106 judges that the refrigerant volume is within an appropriate range. Then, the program proceeds to the ordinary air-conditioning operation, after the controller 103 resets the integrated operating time of the compressor 1 upon this judged result (Step S6'). Namely, the program returns to the operating condition before performing the judging operation.

[0028] Incidentally, a judging operation for the refrigerant leakage at the time of the test run is performed by comparing with an appropriate AL% value, which is previously determined by an examination or the like.

[0029] In the judging operation for the refrigerant leakage mentioned above, the refrigerant volume in the refrigerating cycle is not judged only by a single operating-condition quantity such as the superheating rate or the super-cooling rate of the refrigerating air-conditioner, but by calculating the liquid-phase area ratio of the condenser based on a plurality of parameters. Accordingly, stable accuracy can also be obtained against a variation of an environmental condition such as the outdoor temperature. By performing the weighted average calculation for the liquid-phase area ratio corresponding to the number of the condenser and the volume of the same, an accurate refrigerant volume in the circuit can be judged, even in a case that the condensers having different volumes exist in plurality, and thereby the refrigerant leakage can accurately be detected.

[0030] Further, in the refrigerating air-conditioner according to this embodiment, since the refrigerant leakage is detected by calculating the refrigerant volume in the entire circuit, the judging accuracy does not depend on a leaking speed of the refrigerant, and thereby the refrigerant leakage can be detected even in a case that the refrigerant is leaking little by little. Furthermore, by judging the refrigerant volume at a time in which a operation mode of the refrigerating cycle, the outdoor temperature, and the driving condition of the indoor unit are in similar conditions, the refrigerant volume can be judged each time at a timing when the pressure or the temperature of the refrigerant is close to each other. Accordingly, the density of the refrigerant in the refrigerant piping becomes approximately equal, so that an estimation error is reduced, and the accuracy of the judging operation can be raised.

[0031] Moreover, in the refrigerating air-conditioner according to this embodiment, a specific sensor or the like is not used, and the judging operation is performed using only the temperature sensor and the pressure sensor. Accordingly, refrigerant leakage detection can be performed at low cost. Further, since the physical quantities (reference quantities) to judge the stability of the refrigerating cycle are the temperature of the refrigerating cycle and the pressure of the same, or the super-cooling rate and the superheating rate of the refrigerant calculated from these temperature and the pressure, the stable judging operation can be performed with a construction at a low cost in the judging timing as well.

Further, in the refrigerating air-conditioner according to this embodiment, it is possible to detect the refrigerant leakage, while performing a cooling air-conditioning operation or a heating air-conditioning operation.

[0032] Incidentally, the Steps S1 through S3 shown in Fig. 2 have the similar effect even when the order thereof is counterchanged. Further, in this embodiment, although the indicator referring to AL% is used to judge the refrigerant volume, the refrigerant leakage may be judged by grasping a correlation between the refrigerant volume and parameters having correlation with the refrigerant volume, such as the super-cooling rate of the refrigerant at the outlet of the condenser in operation, the superheating rate of the refrigerant at the outlet of the evaporator in operation, or the temperature of the refrigerant at the discharge side of the compressor, in advance, reading a variation of the parameters regarding the refrigerant volume at the above-described judging timing to detect the refrigerant volume. In addition, the refrigerant leakage may be judged by providing a liquid reservoir at the outlet of the condenser or the outlet of the evaporator, providing a device for judging the liquid volume inside the liquid reservoir on the basis of the liquid surface height of an inside of the liquid reservoir, and judging the refrigerant volume at the aforementioned judging timing so as to detect the refrigerant volume. Incidentally, the judging operation utilizing the liquid reservoir will be explained in detail in the third embodiment.

Further, although the operation judging portion 108 judges the initial value of the refrigerant during the test run of the refrigerating air-conditioner, the operation judging portion 108 can also judge the initial value of the refrigerant volume in the ordinary operation as far as it is before the refrigerant volume is changed, namely when the refrigerant is judged at an initial stage after filing up the refrigerant. Furthermore, as far as it is before the refrigerant volume is changed, the judging operation may be performed at any timing. For example, the initial value of the refrigerant volume can be judged during the ordinary operation in the integrated time of the compressor within 10 hours, under preferable measurement conditions (aforementioned condition, in which all the indoor units are operated, and the stability of the refrigerating cycle, or the like).

Second Embodiment

[0033] Fig. 3 is a view illustrating a construction of a refrigerant circuit of a refrigerating air-conditioner according to the second embodiment of the present invention. Fig. 4 is a flowchart showing part to be added to the flowchart in Fig. 2, illustrating an operation that is specific to the refrigerating air-conditioner in Fig. 3.
As shown in Fig. 3, this refrigerating air-conditioner is different from the refrigerating air-conditioner in Fig. 1 in a point of providing an accumulator 20 at the intake side of the compressor. Further, at the exit of the accumulator 20, a temperature sensor 21 for measuring the refrigerant temperature is installed.
[0034] In a case of the refrigerating air-conditioner in Fig. 3, since the refrigerant volume accumulated in the accumulator 20 is difficult to estimate, there is a need not to accumulate the liquid-refrigerant in the accumulator 20 at the time of judging the refrigerant leakage. Therefore, it is controlled that the refrigerant superheating rate is sufficiently taken at the outlet of the evaporator by a throttling device at the evaporator inlet (Step S4 in Fig. 4).
In a case that the liquid-refrigerant is accumulated in the accumulator 20, when the refrigerant gas that is fully overheated by the throttling device at the evaporator inlet flows into the accumulator 20, the refrigerant gas is cooled down by the liquid-refrigerant in the accumulator 20. Therefore, an exit temperature of the accumulator 20 becomes lower than an entrance temperature of the accumulator 20. Thereby, in a case that the entrance temperature of the accumulator 20 is judged to be greater than the exit temperature of the accumulator 20, the controller judges that the liquid-refrigerant is accumulated in the accumulator 20 (Step S4' in Fig. 4), and the judging operation for the refrigerant leakage is not performed. On the contrary, in a case that the entrance temperature of the accumulator 20 is judged to be less than the exit temperature of the accumulator 20, the controller judges that the liquid-refrigerant is not accumulated in the accumulator 20 (Step S4' in Fig. 4), and the judging operation for the refrigerant leakage is performed (Step S5 in Fig. 4). The Step S4 and the Step S5 shown in Fig. 4 corresponds to those shown in Fig. 2.
[0035] Incidentally, in a case that the liquid-refrigerant is accumulated in the accumulator 20, an intake superheating rate of the compressor 1 and a discharge superheating rate of the same are lowered. By utilizing the above-described, it may be judged whether the liquid-refrigerant is accumulated in the accumulator 20, by the temperature of the refrigerant superheating rate at the intake side and the discharge side of the compressor 1, without installing the temperature sensor 21 at the exit of the accumulator 20.
[0036] Further, when the operation that is fully taking the superheating rate of the outlet of the evaporator is performed, the liquid-refrigerant in the accumulator 20 is gradually evaporated, and therefor it may be judged whether the liquid-refrigerant is accumulated in the accumulator 20 utilizing an elapsing of time of operation in which the superheating ratio of the outlet of the evaporator is fully high.
[0037] As described above, in the refrigerating air-conditioner provided with the accumulator 20 in the refrigerant circuit, existence or nonexistence of an accumulation of the liquid-refrigerant in the accumulator 20 is judged, and only in a case that the accumulation of the liquid-refrigerant does not exist, the refrigerant volume is judged and the refrigerant leakage detection is performed. Therefore, the accuracy of the refrigerant detection is improved.

Third Embodiment

[0038] The judging operation for the liquid medium volume utilizing the liquid reservoir, and the refrigerant leakage detection utilizing the same will be explained here. Fig. 5 is a view illustrating the construction of the refrigerant circuit of the refrigerating air-conditioner according to the third embodiment of the present invention. In Fig. 5, the same numerals are attached to the same elements as the second embodiment in Fig. 3, and hereinafter, explanation is centered on a different point from Fig. 3.
The refrigerating air-conditioner in Fig. 5 is provided with a liquid reservoir 28 connected between the throttling device 5 of the outdoor unit and the liquid-refrigerant piping 6, to accumulate a refrigerant liquid, and a refrigerant heat exchanger 30 connected in series to the liquid reservoir 28, to remove the super-cooling rate of the refrigerant. Further, one end of the refrigerant heat exchanger 30 is connected to a refrigerant piping between the refrigerant heat exchanger 30 and the liquid-refrigerant pipeline 6 via a bypass throttling device 26 for use of super-cooling rate, and the other end is connected to an entrance pipeline of the accumulator 20. At an upper part of the liquid reservoir 28, a bypass pipeline connected to a low pressure part such as the entrance of the accumulator 20, via throttling devices 25a and 25b for judging the refrigerant volume, is connected. The bypass pipeline is provided for detecting the liquid surface in the liquid reservoir 28, and two bypass pipings are disposed here in an inside of the liquid reservoir 28 with a predetermined vertical height difference. The number of the bypass pipeline for detecting the liquid surface taken out from the liquid reservoir 28 is not limited to two, but the number may appropriately be increased and decreased corresponding to a level to be judged.

Incidentally, in Fig. 5, the numerals 27a and 27b denote temperature sensors for use in a liquid surface detection provided in the bypass pipeline, the numeral 31 denotes a temperature sensor for detecting the super-cooling rate, which is provided between the refrigerant heat exchanger 30 and the liquid-refrigerant pipeline 6, and the numeral 32 denotes a temperature sensor for the bypass circuit provided in the bypass circuit.
Furthermore, numerals 33a and 33b denote a refrigerant heating devices used at the time when the liquid surface of the liquid reservoir 28 is detected. As for the refrigerant heating device, an outside heat source such as an electric heater may also be utilized and a heating structure to bring the refrigerant in contact with a high-temperature portion on the refrigerant circuit, such as a hot gas or the like may be adopted.

[0039] Next, a method for detecting an initial liquid surface in the liquid reservoir during the cooling operation in the refrigerating air-conditioner shown in Fig. 5 will be explained. The gas-refrigerant at high temperature and high pressure discharged from the compressor 1 is condensed and liquefied in the outdoor heat exchanger 3 and slightly throttled in the throttling device 5, and thereafter flows into the liquid reservoir 28. In the liquid reservoir 28, the liquid surface is raised, and when the liquid reservoir 28 is approximately filled with the liquid, the liquid refrigerant flows into the refrigerant heat exchanger 30, and when the throttling device 25a for judging the refrigerant volume is opened, the liquid refrigerant starts to flow into the bypass pipeline via the throttling device 25a for judging the refrigerant volume, as well. The liquid refrigerant that flows into the refrigerant heat exchanger 30 bypasses from the liquid refrigerant piping 6 in the refrigerant heat exchanger 30, and exchanges heat with the gas-liquid two-phase refrigerant that is caused to have low temperature, via the bypass throttling device 26 for use in the super-cooling rate. In addition, the liquid refrigerant flows into the indoor heat exchangers 9a and 9b, while increasing the super-cooling rate. In the indoor heat exchangers 9a and 9b, the refrigerant is evaporated, vaporized, and used for the cooling operation. The vaporized refrigerant returns to the compressor 1 via the gas-refrigerant piping 10, the four-way valve 2, and the accumulator 20. In the indoor heat exchangers 9a and 9b, in order to completely evaporate the refrigerant, the superheating ratio of the refrigerant at the outlet of the indoor heat exchanger is found by a difference between the temperature sensors 17a and 15a, or 17b and 15b, and a flowing amount is controlled by the throttling devices 7a and 7b of the indoor unit so that the superheating ratio is brought to a predetermined value or more.

[0040] On the other hand, the liquid-refrigerant which flows out from an upper part of the liquid reservoir 28 filled with the liquid is brought to a gas-liquid two-phase refrigerant having low temperature, which is throttled up to low pressure by the throttling device 25a for judging the refrigerant volume. The refrigerant is then heated by the heating device 33a. A heated amount by the heating device 33a is previously adjusted to be an amount of heat to evaporate only part of the refrigerant liquid. By thus performing, in a case that the refrigerant flowing through the throttling device 25a for judging the refrigerant volume contains a liquid, only part of the refrigerant is evaporated even when the refrigerant is heated by the heating device 33a. The temperature of the refrigerant still remains at a low temperature, even when the refrigerant passes through the heating device 33a. On the contrary, in a case that the refrigerant flowing through the throttling device 25a for judging the refrigerant volume completely contains only gas, the temperature of the refrigerant rises corresponding to a heating amount when the same is heated by the heating device 33a. Utilizing this fact, it is judged whether a sufficient amount of liquid is accumulated in the liquid reservoir 28 by detecting the temperature with the temperature sensor 27a for detecting the liquid surface, which is installed on a downstream side of the heating device 33a. Incidentally, in a case that the liquid surface is not that filled with liquid, the throttling device 25b for judging the refrigerant volume is opened, and the temperature is detected by the temperature sensor 27b for detecting the liquid surface, while utilizing the heating device 33b. Thereby, it is judged whether the liquid exists up to a low end position of the corresponding bypass pipeline in the liquid reservoir 28.

[0041] Subsequently, a method for detecting an initial liquid surface of the liquid reservoir, during heating operation in the refrigerating air-conditioner in Fig. 5 will be explained. The gas-refrigerant at high temperature and high pressure discharged from the compressor 1 flows through the gas-refrigerant pipeline 10, and condensed and liquefied in the indoor heat exchangers 9a and 9b. The gas-refrigerant is slightly throttled in the throttling devices 15a and 15b, and flows into the liquid reservoir 28. In a case that the liquid surface is raised in the liquid reservoir 28 and the liquid reservoir 28 is filled with a liquid, the liquid-refrigerant flowing out from an upper part of the liquid reservoir is evaporated in the outdoor heat exchanger 3.
The vaporized refrigerant returns to the compressor 1 through the four-way valve 2 and the accumulator 20. In the outdoor heat exchanger 3, in order to completely evaporate the refrigerant, the superheating ratio of the refrigerant at the outlet of the outdoor heat exchanger 3 is found from a difference between the temperature sensor 14 and the temperature sensor 32, and the flowing amount is controlled by the throttling device 5 of the outdoor unit, so that the superheating ratio is brought to a predetermined value or more.

[0042] On the other hand, the liquid-refrigerant flowing out from the upper part of the liquid reservoir 28 filled with a liquid is brought to a gas-liquid two-phase refrigerant having low temperature, which is throttled up to low pressure by the throttling device 25a for judging the refrigerant volume, and heated by the heating device 33a.
At the time, the heating amount of the heating device 33a is previously adjusted to a heat quantity for evaporating only part of the refrigerant liquid. By thus performing, in a case that the refrigerant flowing through the throttling device 25a

for judging the refrigerant volume contains a liquid, only part of the refrigerant is evaporated even when the refrigerant is heated by the heating device 33a. The temperature of the refrigerant still remains at a low temperature, even when the refrigerant passes through the heating device 33a. On the contrary, in a case that the refrigerant flowing through the throttling device 25a for judging the refrigerant volume completely contains only gas, the temperature of the refrigerant rises corresponding to a heating amount when the same is heated by the heating device 33a. Utilizing this fact, it is judged whether a sufficient amount of liquid is accumulated in the liquid reservoir 28 by detecting the temperature with the temperature sensor 27a for detecting the liquid surface, which is installed on a downstream side of the heating device 33a. Incidentally, in a case that the liquid surface is not that filled with liquid, the throttling device 25b for judging the refrigerant volume is opened, and the temperature is detected by the temperature sensor 27b for detecting the liquid surface, while utilizing the heating device 33b. Thereby, it is judged whether the liquid exists up to a low end position of the corresponding bypass pipeline in the liquid reservoir 28.

In this example, a liquid surface level of the liquid reservoir 28 is detected by two steps, while utilizing the two bypass pipelines. However, the detection for the liquid surface level may be performed by only one step, or may be performed by three steps or more.

[0043] A method for judging whether the refrigerant leakage occurs, on the basis of judging the refrigerant volume in the refrigerant circuit by the detection of the liquid surface level of the liquid reservoir 28 as described above, will be explained. Fig. 6 is a flowchart showing an example of an operation for the refrigerant leakage detection in the refrigerating air-conditioner in Fig. 5 and the explanation will be made along the flowchart.

After installation or replacement of the refrigerating air-conditioner is completed, a test run of the refrigerating air-conditioner is performed in Step S1. Here, the controller 103 transmits control signals to each device of the indoor unit and the outdoor unit after judging that either the cooling operation or the heating operation is appropriate, corresponding to an outdoor air temperature, room temperature or an air-conditioner's load, so as to start the refrigerating air-conditioner in the test run mode, and control the operation thereof. This judging operation may either be automatically performed on a previously determined judging basis, or be performed manually by an operator to operate the refrigerating air-conditioner. However, in a multi-type refrigerating air-conditioner including a plurality of indoor units exist, the volume of the liquid refrigerant accumulated in the liquid reservoir 28 varies at the time of the judging operation for the refrigerant. This is because a condition of an inside of the indoor heat exchanger being turned off is brought into a liquid-sealing condition or into a gaseous condition. Accordingly, in light of keeping the condition of insides of the indoor heat exchangers equal, all the plurality of the indoor units (indoor heat exchanger) is operated.

[0044] A timing for detecting the refrigerant volume is the time after waiting until the time when the liquid refrigerant is accumulated in the liquid reservoir 28, or the high and low pressure of the refrigerating cycle is stabilized and the density of the refrigerant in the refrigerant pipeline is stabilized is preferable. In the test run, movement of the high pressure and the low pressure from a start of the operation is, as shown in Fig. 7, stabilized toward a target, after once overshooting or undershooting against the target. Consequently, as a basis for judging that the operation of the refrigerating cycle is stabled, for example, the time until a variation width of the pressure, the temperature, the superheating ratio, the super-cooling rate, or the like of the refrigerant reaches within a predetermined value is used.

[0045] In step S2, the control portion 103 controls the throttling devices 25a and 25b for judging the refrigerant volume and opens the throttling. Then, the measurement portion 101 reads a temperature detection signal of the temperature sensors 27a and 27b for detecting the liquid surface.

Subsequently, the control portion 103 stores a condition of the test run in the memory portion 104. As for the contents to be stored at this moment, operating conditions, such as the detected temperature of the temperature sensors 27a and 27b for detecting each liquid surface (liquid surface level of the liquid reservoir 28), the operation mode of the cooling operation or the heating operation, the high pressure of the refrigerant, the low pressure of the refrigerant, a discharge temperature of the compressor, super-cooling rate of the outlet of the condenser, or an evaporation temperature of the outlet of the evaporator, are stored. As described above, it is preferable to be enabled to grasp a delicate difference of the filled up volumes of the refrigerant by the super-cooling rate of the refrigerant of the outlet of the condenser or the like, in addition to the liquid surface level of the liquid reservoir 28. Thereafter, in Step S3, the controller 103 starts an ordinary air-conditioning operation control. Incidentally, in the ordinary operation, the controller 103 controls the temperature sensors 27a and 27b for detecting the liquid surface to be in a closed condition.

[0046] In Step S4, the control portion 103 judges whether a predetermined time has elapsed from the first test run or a previous leakage judging operation, and when the predetermined time has elapsed, the program proceeds to the next Step S5. In Step S5, the control portion 103 waits until the refrigerating cycle becomes stable. In Step S6, the control portion 103 confirms whether all the indoor heat exchangers of the indoor units are performing the heating operation or the cooling operation. Further, as in Step S7, it is preferable to perform a judging operation only in a case that the outdoor air temperature is within the predetermined temperature area, after judging whether the outdoor air temperature has a value close to the temperature at the time of judging the initial liquid surface level (for example, within $\pm$ 5°C). However, in a case that it is impossible to cause the outdoor air temperature to be within the predetermined temperature area, the Step S7 may be skipped.

After performing the Steps S4 through S7, in a case that the operating condition of the refrigerating air-conditioner is brought into approximately the same outdoor air temperature, the same operation mode, and the same operating condition of the indoor unit as those stored in Step S2, the operation judging portion 108 performs the judging operation for the refrigerant leakage in Step S8.
In Step S9, existence or nonexistence of the refrigerant leakage is judged on the basis of whether the refrigerant volume is appropriate or inappropriate. Specifically, in the judging operation in Step S8, in a case that the detected temperature of the temperature sensors 27a and 27b for detecting the liquid surface is confirmed to be higher by the predetermined value or more than the temperature, stored at the time of the test run, while opening the throttling devices 25a and 25b for judging the refrigerant volume, it is judged that the liquid surface of the liquid reservoir 28 is lowered and the refrigerant leakage has occurred. In that case, the program proceeds to Step S10, and the reporting portion 107 causes the remote controller, the indicator, or the like to display such a notice that the refrigerant leakage has occurred. The operation of the air-conditioner is turned off in Step S11.
Incidentally, in a case that a negative judging operation is performed in Steps S4 through S7, the throttling devices 25a and 25b for judging the refrigerant volume are closed again, and the program returns to the ordinary air-conditioning operation. Further, in a case that the refrigerant volume is judged to be within an appropriate range in Step S9, the program proceeds to the ordinary air-conditioning operation after resetting the integrated operating time of the compressor 1 (Step S9').

[0047] In the meantime, the density of the liquid and the gas of the refrigerant varies corresponding to pressure or a temperature in the refrigerant circuit. Therefore, in consideration of a density variation of the refrigerant in each element of the refrigerant circuit caused by the pressure and the temperature in the refrigerant circuit, in a case that the value measured at the time of judging operation differs from the pressure and the temperature initially stored, it is preferable to perform a correction. As a correcting method, the difference between the refrigerant volumes in the condenser is corrected corresponding to a difference between the measured super-cooling rates of the outlet of the condenser while, for example, previously grasping a relationship between the super-cooling rate of the outlet of the condenser and the volume of the refrigerant in the condenser. Thereby, even when the liquid surface level of the liquid reservoir 28 is identical, the leakage may be judged depending upon difference between the refrigerant volumes in the inside of the condenser. The correction can be similarly dealt with by utilizing the superheating ratio of the outlet of the evaporator, or the superheating ratio of the discharge of the compressor as well. Further, the leakage of the refrigerant may be judged by inputting a length of the piping in the memory portion 104 at the time of the test run, calculating the density of the refrigerant from the temperature and the pressure of the piping, and calculating the refrigerant volume in the piping from the stored length of the piping and the calculated density of the refrigerant.

[0048] Furthermore, it is preferable that the initial value of the refrigerant is reset at timing when the refrigerant is drained for maintenance of the refrigerant circuit or the like, a test run is performed again at the next operation, and an initial value is stored again. The way how to reset is that the worker may operate a reset switch manually, or the controller may automatically reset by judging that the refrigerant in the refrigerant circuit is withdrawn when the detected value of the pressure sensor reaches a predetermined value or less.

[0049] As described above, in the third embodiment, the condition of the liquid surface of the liquid reservoir 28 at the initial stage is detected as the temperature of a bypass-refrigerant at the upper part of the liquid reservoir 28, and is stored. A rise of the temperature of the bypass-refrigerant is detected in refrigerant leakage detection performed thereafter. Thereby, an increase and a decrease of the refrigerant volume in the circuit are judged and the resultant leakage of the refrigerant is detected. Thus, the leakage of the refrigerant can easily be detected.

[0050] Further, the operating condition of the refrigerating cycle is stored in the memory portion 104. Therefore, it becomes possible to estimate the refrigerant volume (including a condition of the excessive filling-up) at the initial stage from the super-cooling rate at the outlet of the condenser or the superheating ratio at the outlet of the evaporator. Thereby, a slight amount of the refrigerant leakage can be detected even when the same occurs, by comparing the refrigerant volume at the initial stage and the refrigerant volume at the time of judging for the leakage. Consequently, a correction for the place where the refrigerant has leaked can be performed earlier, by reporting the detected refrigerant leakage to the remote controller or the like. Furthermore, the air-conditioner is turned off when the refrigerant leakage occurs, and therefore an overheated operation of the compressor due to continuing the operation in a less volume condition of the refrigerant is prevented, and a damage of the compressor can be prevented.

[0051] Moreover, the operating mode and the outdoor air temperature at the initial stage are stored, and the leakage detection is performed in the same operating mode and a similar outdoor air temperature. As a result, an influence of the density variation in the refrigerant pipeline, due to differences of the operating mode and the outdoor air temperature can be reduced, and it becomes possible to detect the refrigerant leakage with good accuracy by simple algorithm.

[0052] Further, in the judging operation for the refrigerant leakage, the operating condition of the indoor unit can always be monitored, and the refrigerant volume can be judged during the time when the air-conditioning operation is performed by the user of the air-conditioner as needed. Accordingly, there is no need to perform a useless air-conditioning operation for the judging operation, and therefore the air-conditioner can contribute to an energy saving. In addition, there is no possibility to give an uncomfortable feeling to the user due to performing the needless air-conditioning operation for the judging operation for the refrigerant leakage.

Fourth Embodiment

[0053] Next, an embodiment of a refrigerating air-conditioning system using a centralized controller for collectively controlling a plurality of refrigerating air-conditioner, and a remote management apparatus will be explained.
Fig. 8 is a constructional view illustrating an air-conditioning system for comprehensively managing the refrigerating air-conditioner in the first to the third embodiments described above.
Refrigerating air-conditioner including indoor units 110 and an outdoor unit 100 is connected to a centralized controller 120, through communication lines 121 which are laid down in a building. The centralized controller 120 is typically provided in the same building as the refrigerating air-conditioner that is an object to be controlled and is a control device for controlling one or a plurality of refrigerating air-conditioner. The centralized controller 120 performs a plurality of control operations such as starting up or stopping operations for the indoor units 110 or the outdoor unit 100, a set-temperature control operation, an air volume or a wind direction control operation, and further, a monitoring operation for an operating condition of the refrigerating air-conditioner and a detecting operation for an abnormality, and so fourth.
The indoor units 100 and the outdoor unit 110 transmit operating condition data as described below at regular intervals or irregular intervals.

(1) Detected temperature information of each of the temperature sensors 11, 13, 14, 15a, 15b, 16a, 16b, 17a, and 17b, namely the refrigerant temperature, indoor/outdoor temperature, or the like.
(2) Detected pressure information of each of the pressure sensors 12 and 19.
(3) Various types of control parameters of the controller 103 (for example, a driving frequency of the compressor, the set temperature directly set to the indoor unit by a user, the air volume, the operation mode, a number of revolutions of the fan, the operating time of the compressor, the number of times of starting up and stopping operations of the compressor, and so forth).
Incidentally, there is no need for the centralized controller 120 to collect all the information, and the centralized controller 120 appropriately makes a choice on the basis of a sort or a property of the refrigerating air-conditioner, the control operation corresponding to a demand of a user, and so forth and thus, the necessary information is set.

[0054] A remote monitoring device 130 is connected to one or more centralized controllers 120 via communication lines 131, and monitors an operating condition of the refrigerating air-conditioner of each building. The centralized controller 120 collects information necessary for performing maintenance in case of occurrence of an abnormality.
Further, the remote monitoring device 130 has a function to perform an energy saving control or the like to the centralized controller 120, corresponding to a demand of the user. The remote monitoring device 130 is provided in a remote monitoring center that controls equipment of each building from a remote place outside each building. The communication line 131 is a wired/wireless phone line, a communication line by internet protocol, or the like, and is called as a public circuit.
[0055] Next, an operation of the refrigerating air-conditioning system will be explained using a sequential view in Fig. 9. Since the refrigerating air-conditioner basically performs the refrigerant leakage detection in a manner as explained in the aforementioned Figs. 2, 4, and 6, the explanation below will be made focusing on a cooperating operation of the refrigerating air-conditioner, the centralized controller 120, and the remote monitoring device 130.
[0056] Firstly, the control portion 103 of the refrigerating air-conditioner starts up and drives the outdoor unit 100 and all the indoor units 110 in a test run mode when the refrigerant is filled up in the refrigerating air-conditioner (Step S21). Typically, the test run is performed when the refrigerating air-conditioner is newly installed in a building. However, in a case that the outdoor unit 100 or the indoor unit 110 is replaced, or that the refrigerant is exchanged or additionally filled up, or in the like case, this process is performed.
Next, the control portion 103 performs a judging operation for the stability of the operation (Step S22). Incidentally, the judging operation for the stability is performed in the similar manner as in Step S2 in Fig. 2.
The control portion 103 continues driving until the refrigerating cycle becomes stable, and after the stability is confirmed, the control portion 103 performs the judging operation for the refrigerant volume (Step S25). Although the judging operation for the refrigerant volume is performed by the operation portion 102 or the controller 103 of the refrigerating air-conditioner by a similar method to that in the first to the third embodiments described above, any method may be used as far as the method can substantially specify the refrigerant volume.
Subsequently, the control portion 103 saves the judged refrigerant volume as a historical data in the memory portion 104 together with a judged time (Step S26). Incidentally, the historical data may be only an initial data, or a plurality of data being saved in time series manner while adding at each refrigerant volume judging time, as well. However, the initial data at the time of filling up the refrigerant is important for judging a total amount of the refrigerant leakage.
Incidentally, the aforementioned initial judging operation and a saved data of the refrigerant volume are not limited to

the time of the test run, and the same may be performed at the time of ordinary operation during the time when the refrigerant volume does not differ very much by the slow leak after the refrigerant is filled up.

[0057] The initial operation after the refrigerant is filled up is completed in the aforementioned process, and the program proceeds to an ordinary operation.

The refrigerating air-conditioner repeats the starting up and stopping operations thereafter, along the ON/OFF operations of the power by the user, or the starting up/stopping commands of the centralized controller 120 or the remote monitoring device 130. In the meantime, the control portion 103 is monitoring the elapsed time from the time stored in the memory portion 104 at regular intervals or irregular intervals (Step S27). Further, when the control portion 103 judges that a predetermined time (for example, one month, three months, six months, one year, or the like) has elapsed, the refrigerating air-conditioner performs the refrigerant leakage judging operation. The predetermined time is set to be a sufficiently long time so that the slow leak, in which the leaking volume of the refrigerant per unit time is extremely small, can be detected, after the starting up and stopping operations for the refrigerating cycle are repeated. Specifically, the control portion 103 transmits a starting up signal to the outdoor unit 100 and all the indoor units 110, and starts up these devices (Step S21a). The reason why all the indoor units 110 are caused to operate is to raise measuring accuracy of the refrigerant volume as described above. However, in a case to avoid driving the indoor unit 110 at a time when the user does not anticipate, the judging time for the refrigerant can be shifted. For example, the control portion 103 judges whether all the indoor units 110 are in operation after a predetermined time has elapsed, on the basis of own control data or an operating signal from each indoor unit 110. The control portion 103 postpones a refrigerant volume judging operation until all the indoor units 110 are driven. Further, the control portion 103 may proceed to the next step after confirming that all the indoor units 110 starts up.

[0058] Subsequently, the control portion 103 performs the judging operation for the stability of the operation (Step S22), and judges the refrigerant volume (Step S25). The judged refrigerant volume is stored in the memory portion 104 (Step S26). Incidentally, in a case that only the refrigerant volume data at the time of filling up the refrigerant is used for judging the refrigerant leakage at regular intervals, and the historical data of the refrigerant is not necessary, this step may be omitted.

Next, the operation judging portion 108 of the refrigerating air-conditioner compares the data of the refrigerant volume at the time of filling up the refrigerant, stored in the memory portion 104 (namely, the past data regarding the past refrigerant volume) and the data of the current refrigerant volume (namely, a new data regarding the refrigerant volume obtained after performing the stopping and starting up operations of the refrigerating cycle once or a plurality of times from a past time point), and judges whether a difference between both of the refrigerant volumes is within a predetermined area (Step S29). When the difference does not exist within the predetermined area, the operation judging portion 108 judges that the refrigerant leakage occurs. Further, the reporting portion 107 receives the judged result and transmits the judged result to the centralized controller 120 and the remote monitoring device 130 (Step S30). Incidentally, it is preferable that the centralized controller 120 and the remote monitoring device 130 are enabled to recognize the judged result by transmitting the judged result, even in a case that the refrigerant leakage does not exist. The data to be transmitted includes the time when the judging operation is performed, the judged result, the historical data of the refrigerant volume, the data of the current refrigerant volume, and so forth.

[0059] The remote monitoring device 130 that receives the judged result via the communication line 121, the centralized controller 120, and the communication line 131 automatically generates a leakage-examination document on the basis of the judged result. For example, document data in a fixed format is stored in a memory device of the remote monitoring device 130. A control portion of the remote monitoring device 130 adds the received time when the judging operation is performed, the judged result, the historical data of the refrigerant volume, the data of the current refrigerant volume to the document data in the fixed format, and automatically generates the leakage-examination document. The control portion of the remote monitoring device 130 prints out the leakage-examination document using a printer. Thereby, the leakage-examination document can be sent to a manager that manages the building.

[0060] As described above, the embodiment of the refrigerating air-conditioning system having a leakage detection function for the refrigerant leakage is explained. According to this embodiment, since the refrigerant leakage is detected by a difference after repeating the starting up and stopping operations, the slow leak of the refrigerant that cannot be conventionally detected can be detected. In addition, since a refrigerant leakage examination is automatically performed at a predetermined timing, the examination is not forgotten to be performed and the slow leak can assuredly be detected.

Fifth Embodiment

[0061] Although the refrigerant leakage detection is performed by the refrigerating air-conditioner itself in the fourth embodiment, the embodiment in which the refrigerant leakage detection is performed by the centralized controller 120 will be explained next. In this embodiment, since the refrigerant leakage is detected by the centralized controller 120, there is an advantage that the refrigerant leakage can be detected even when the detection function capable of detecting the slow leak is not provided in the refrigerating air-conditioner itself.

In this embodiment, as shown in Fig. 10, the controller 103 and the operation judging portion 108 are provided in the centralized controller 120. Here, although the control portion for performing the operation control of the refrigerating air-conditioner is provided in the refrigerating air-conditioner, the control portion 103 and the operation judging portion 108 that control the judging operation for the refrigerant leakage are provided in the centralized controller 120. The controller 103 controls the judging timing for the refrigerant leakage, or the operation of the refrigerating air-conditioner via the communication line 121. Further, the operation judging portion 108 performs the operation for judging the refrigerant volume, and the judging operation for judging the refrigerant leakage. Incidentally, although the controller 103 and the operation judging portion 108 are also provided in the remote monitoring device 130 in Fig. 10, these devices are used in a case that the refrigerant leakage judging operation is performed by the remote monitoring device 130, as in an embodiment described later, and are not essential.
Fig. 11 is a sequential view explaining an operation of the refrigerating air-conditioning system according to the fifth embodiment. In Fig. 11, the same numeral in Fig. 9 denotes the same or corresponding processing as that in Fig. 9, and hereinafter the explanation will be made focusing on the part different from the processing in Fig. 9.

[0062] When the refrigerant is filled up in the cooling refrigerating air-conditioner, the controller 103 of the refrigerating air-conditioner transmits a signal indicating that the refrigerant is filled up, to the centralized controller 120 (Step S20). Incidentally, a notice for notifying that the refrigerant is filled up in this step is not necessary to be automatically performed, and can also be judged on the basis of a signal inputted by the maintenance worker, while providing an inputting device in the centralized controller 120.
Thereafter, the controller 103 of the refrigerating air-conditioner judges whether the refrigerating cycle is stabilized (Step S22). Incidentally, the judging operation for judging whether the refrigerating cycle is stabilized may be performed by the refrigerating air-conditioner itself as explained in the above-described first embodiment or the second embodiment. Alternatively, the judging operation may be performed by the centralized controller 120 by the similar algorithm (Step S22), while receiving the operating condition data from the refrigerating air-conditioner once or at a plurality of times in advance (Step S23).

[0063] The centralized controller 120 receives the operating condition data transmitted by the refrigerating air-conditioner, and the operation judging portion 108 of the centralized controller 120 judges the refrigerant volume on the basis of the operating condition data (Step S24). When the refrigerant volume is specified by the similar algorithm to that in the first embodiment, the refrigerant temperature such as the super-cooling rate of the refrigerant at an outlet of the condenser SC, the difference between the outdoor temperature and a condensing temperature dTc, the liquid-specific heat at constant pressure of the refrigerant Cpr, or a difference of the enthalpies between inlet and the outlet of the condenser Δhcon, the outside air temperature, and the pressure data in the refrigerating cycle are received as the operating condition data. In a case that the refrigerating air-conditioner similar to that in the third embodiment is connected, the refrigerant volume is judged by receiving temperature information of the temperature sensor for detecting the liquid surface. In a case that the present embodiment is connected to the existing refrigerating air-conditioner, there is a possibility that a type of the operating condition data being transmitted by the refrigerating air-conditioner is different. Therefore, it is preferable for the centralized controller 120 to prepare algorithm for judging the refrigerant volume corresponding to a plurality of types of the operating condition data, respectively, and select the algorithm for judging the refrigerant to be used, while matching the received operating condition data with a data necessary for the refrigerant judging algorithm. Incidentally, the selecting operation for the algorithm for judging the refrigerant volume may also be performed to select corresponding to a model number of the refrigerating air-conditioner.

[0064] Next, the centralized controller 120 saves the refrigerant volume and the time in the memory (Step S26), and transmits a starting up command to the refrigerating air-conditioner after a predetermined time elapses (Step S31). The starting up command is a command for starting up the outdoor unit 100 and all the indoor units 110. However, in a case that all the indoor units 110 are already in operation, there is no need to say that the transmission of the command is not necessary. Further, the centralized controller 120 manages the starting up operation, the operating mode, the set temperature, or the like for one or a plurality of refrigerating air-conditioner. However, the starting up command for all the indoor units 110 may be transmitted upon waiting until the time when all the indoor units 110 are operated along a starting up program previously stored in the centralized controller 120.
Further, after the operation of the refrigerating cycle is judged to be stabilized in the centralized controller 120 or the refrigerating air-conditioner, the centralized controller 120 receives the operating condition data from the refrigerating air-conditioner, and judges the refrigerant volume (Step S24). The judged refrigerant volume is stored in the memory (Step S26). Furthermore, the centralized controller 120 judges the refrigerant leakage on the basis of a difference between a data regarding the past refrigerant volume and a data regarding the current refrigerant volume (Step S29), and transmits the same to the remote monitoring device 130 (Step S30).

[0065] As described above, according to the refrigerating air-conditioning system of this embodiment, there is an advantage that the refrigerant leakage can be detected, even in a case that the refrigerating air-conditioner is not provided with a function to detect the slow leak of the refrigerant. Moreover, since the centralized controller 120 that manages an operation schedule of the refrigerating air-conditioner performs the refrigerant leakage detection, the detection of the refrigerant leakage can be performed, while keeping the previously determined operation schedule.

Sixth Embodiment

[0066] Next, an embodiment for measuring the refrigerant volume with the centralized controller 120 and judging the refrigerant leakage with the remote monitoring device 130 will be explained. According to the refrigerating air-conditioning system of this embodiment, there is an advantage that the stable refrigerant leakage detection can be performed without a setting of the local centralized controller 120 in a case that the refrigerant leakage detection is performed at regular intervals.
Fig. 12 is a sequential view explaining an operation of the refrigerating air-conditioning system according to the fifth embodiment. In Fig. 12, the same numeral in Fig. 11 denotes the same or corresponding processing as that in Fig. 11, and hereinafter the explanation will be made focusing on the part different from the processing in Fig. 11.
[0067] A characteristic of this embodiment is the point that the judging operation for the refrigerant leakage is performed with the remote monitoring device 130. The centralized controller 120 performs the refrigerant volume judging operation, and transmits the data regarding the refrigerant volume to the remote monitoring device 130 via the communication line 131 (Steps S24 and 25).
When receiving the data regarding the refrigerant volume and the time data, together with the data indicating that the refrigerant is filled up (transmission of these data is an option), from the centralized controller 120, the remote monitoring device 130 stores the data (Step S26). The remote monitoring device 130 then starts counting the elapsing time. Further, when a predetermined time has elapsed, the remote monitoring device 130 transmits a refrigerant volume transmission request, requesting the transmission of the refrigerant volume to the centralized controller 120 (Step S28). However, this request is not essential. The remote monitoring device 130 may judge the refrigerant leakage on the basis of the data regarding the refrigerant volume that is sent by the centralized controller 120 at regular intervals.
[0068] The centralized controller 120 may promptly perform the refrigerant volume judging operation, or may collect the operating condition data while controlling the refrigerating air-conditioner on the predetermined operation schedule (Step S23). However, the centralized controller 120 controls the operation of the refrigerating air-conditioner, so that a previously determined maximum delay time does not elapse after receiving the refrigerant volume transmission request. That is, when it is anticipated to exceed the maximum delay time from the operation schedule, or the elapsing time after receiving the request, the centralized controller 120 transmits a signal to request the transmission of the starting up signal for all the indoor units 110 and the operating condition data to the refrigerating air-conditioner before a predetermined time elapses. Further, the centralized controller 120 is operated to transmit the data regarding the refrigerant volume to the remote monitoring device 130 within the maximum delay time.
When receiving the operating condition data from the refrigerating air-conditioner, the centralized controller 120 performs the refrigerant volume judging operation (Step S24), and transmits the data regarding the refrigerant volume (new data) to the remote monitoring device 130 (Step S25).
The remote monitoring device 130 compares the data regarding the past refrigerant volume received by the comparator portion 105 of the operation judging portion 108 with the data regarding the new refrigerant volume, and the judging portion 106 judges the refrigerant leakage (Step S29). After this judging operation, the remote monitoring device 130 transmits the judged result to the centralized controller 120 (Step S30).
[0069] As described above, even when the refrigerant leakage judging operation is performed by the remote monitoring device 130, there is a similar effect to that in the above-described embodiment. Further, since the refrigerant volume transmission request is transmitted from the remote monitoring device 130, in a case that the refrigerant leakage detection is performed at a regular intervals, the refrigerant leakage detection can be stably performed without the setting of the local centralized controller 120. Furthermore, a change of the schedule for the refrigerant leakage detection can also be concurrently performed from the remote monitoring device 130. In addition, the change of the schedule for the refrigerant leakage detection can be immediately rapidly and assuredly performed in comparison with a case of setting the schedule while making a tour of the buildings where the refrigerating air-conditioners are provided.
[0070] Seventh Embodiment
This seventh embodiment is an embodiment in which the refrigerant volume judging operation and the refrigerant leakage judging operation are performed by the remote monitoring device 130. Since the refrigerant volume is judged by the remote monitoring device 130, there is a characteristic in which the refrigerant leakage judging operation can be performed even when the centralized controller 120 is not provided with a refrigerant volume judging function.
Fig. 13 is a sequential view explaining an operation of the refrigerating air-conditioning system according to this fifth embodiment. In Fig. 13, the same numeral in Fig. 12 denotes the same or corresponding processing as that in Fig. 12, and hereinafter the explanation will be made focusing on the part different from the processing in Fig. 12.
In this embodiment, the controller 103 for controlling the refrigerant leakage judging operation and the operation judging portion 108 for judging are provided in the remote monitoring device 130.
[0071] When the refrigerant is filled up, the refrigerating air-conditioner transmits the operating condition data to the

remote monitoring device 130 via the centralized controller 120 (Step S23). The remote monitoring device 130 judges the refrigerant volume on the basis of the operating condition data (Step S24), and stores the refrigerant volume and the time (Step S26). At this moment, the remote monitoring device 130 selects an algorithm for judging the refrigerant volume conforming to the transmitted operating condition data, from a plurality of algorithms for judging the refrigerant volume, and judges the refrigerant volume, similarly to the concentration controller 120 in the fifth embodiment.

[0072] Next, the remote monitoring device 130 judges the elapsing time (Step S27), while the refrigerating air-conditioner is repeating the starting up/stopping operations. The remote monitoring device 130 transmits an operating condition transmission request for requesting the transmission of the operating condition to the refrigerating air-conditioner via the centralized controller 120, after a predetermined time has elapsed (Step S28a). Incidentally, the operating condition transmission request is not necessary in a case that the operating condition is transmitted from the refrigerating air-conditioner at regular intervals. In this case, when the remote monitoring device 130 judges whether all the indoor units 110 are in operation or the refrigerating cycle is stabilized, on the basis of the operating condition data transmitted at regular intervals, an accuracy of the refrigerant volume detection is improved (Steps S21 and S22).

[0073] Subsequently, the remote monitoring device 130 performs the operation for judging the refrigerant volume on the basis of the received operating condition data (Step S24). The remote monitoring device 130 performs the refrigerant leakage judging operation on the basis of the past data regarding the refrigerant volume and the new data (Step S29). In addition, the remote monitoring device 130 generates a refrigerant leakage-examination document (Step S32). However, in a case that the centralized controller 120 accepts an indicating data from the remote monitoring device 130, it is also possible to transmit the data of the refrigerant leakage-examination document to the centralized controller 120 as a judged result (Step S30). Further, it is also possible to directly transmit the data to a terminal of the building's manager via a public circuit (communication line 131) without interposing the centralized controller 120 while encoding the data so that the third person or the like cannot freely browse.

[0074] As described above, according to the refrigerating air-conditioning system of this embodiment, there is an advantage that even in a case that the refrigerating air-conditioner and the centralized controller 120 are not provided with a function to detect the slow leak of the refrigerant, the refrigerant leakage can be detected. Further, by selecting/changing the refrigerant judging algorithm of the remote monitoring device 130, this embodiment can be applied to the refrigerant leakage detection of various types of the refrigerating air-conditioner.

[0075] Incidentally, the judging operation for the refrigerant leakage may be performed not after repeating the starting up or stopping operation of the refrigerating cycle of the refrigerating air-conditioner once or a plurality of numbers of times, but on the basis of the operating condition data in one operation. Specifically, in a case that the judging device for the refrigerant leakage is provided in the centralized controller 120 or the remote monitoring device 130, there is an advantage that the refrigerant leakage detection can be performed for the refrigerating air-conditioner which is not provided with the refrigerant leakage detecting function.

Claims

1. A refrigerating air-conditioning system comprising a refrigerating cycle by connecting an outdoor unit and one or a plurality of indoor units, with communication piping, the outdoor unit having a compressor, an outdoor heat exchanger, and throttling device, each of the indoor units including an indoor heat exchanger and an throttling device,
wherein the refrigerating air-conditioning system comprises
judging means for judging a refrigerant leakage of the refrigerating cycle, on a basis of past data relating to a past refrigerant volume of the refrigerating cycle at a past time point and new data relating to a refrigerant volume at a time point after performing a plurality of times of stopping and starting up operations of the refrigeration since the past time point.

2. The refrigerating air-conditioning system according to Claim 1, wherein the judging means compares initial operating condition data after filling up the refrigerant in the refrigerating cycle, defined as the past data, with operating condition data after performing the plurality of stopping and starting up operations of the refrigerating cycle, defined as the new data.

3. The refrigerating air-conditioning system according to Claim 1 or 2, comprising an integrating means for integrating operating time of the compressor, wherein the judging means performs a judging operation for the refrigerant leakage when the operating time integrated in the integrating means reaches a predetermined time.

4. The refrigerating air-conditioning system according to Claim 1 or 2, comprising timekeeping means, wherein the judging means judges the refrigerant leakage when the timekeeping means keeps a predetermined date and time.

5. The refrigerating air-conditioning system according to Claim 1 or 2, wherein the judging means judges the refrigerant leakage when an outdoor air temperature is within a predetermined range in comparison to an outdoor air temperature at a time of taking data to be compared in the judging operation for the refrigerant leakage, and a predetermined time has elapsed from the time of taking the data.

6. The refrigerating air-conditioning system according to any one of Claims 1 through 5, comprising detecting means for detecting a variation of physical quantity on the refrigerating cycle, wherein the judging means judges the refrigerant leakage when a varying value detected by the detecting means is within a predetermined range.

7. The refrigerating air-conditioning system according to any one of Claims 1 through 5, wherein the judging means judges the refrigerant leakage when all of the indoor heat exchangers constituting the indoor units are performing a cooling operation or a heating operation.

8. The refrigerating air-conditioning system according to Claim 7, wherein the judging operation for the refrigerant leakage is performed on the basis of a super-cooling rate of the refrigerant at an outlet of a condenser, a difference between the outdoor air temperature and a condensing temperature, liquid-specific heat at constant pressure of the refrigerant, and liquid-phase square measure ratio of the condenser caused by a difference between enthalpies of an inlet of the condenser and the outlet of the condenser.

9. The refrigerating air-conditioning system according to Claim 8, wherein the judging operation for the refrigerant leakage is performed on the basis of the super-cooling rate of the refrigerant at the outlet of the condenser, or a parameter having correlation with the super-cooling rate.

10. The refrigerating air-conditioning system according to Claim 8 or 9, wherein in a type of the refrigerating air-conditioning system where an accumulator is disposed at an intake side of the compressor, the judging means judges the refrigerant leakage upon judging that a liquid refrigerant is not accumulated in the accumulator.

11. The refrigerating air-conditioning system according to any one of Claims 1 through 10, wherein when the judging operation for the refrigerant leakage is being performed, the fact is displayed accordingly on a remote controller and/or an indicating device for the indoor unit.

12. The refrigerating air-conditioning system according to any one of Claims 1 through 11, comprising a reporting means for reporting a judged result of the refrigerant leakage to an outside, wherein when the refrigerant leakage is judged, the fact is displayed accordingly on the remote controller for the indoor unit and/or the indicating device.

13. The refrigerating air-conditioning system according to any one of Claims 1 through 7, wherein in a type of the refrigerating air-conditioning system where a liquid reservoir for accumulating the refrigerant is disposed between flow paths of the throttling device of the indoor unit and the communication piping, the refrigerant leakage is judged by comparing liquid surface levels of the liquid reservoir.

14. The refrigerating air-conditioning system according to any one of Claims 1 through 13, wherein the judging means is provided in a remote monitoring device connected to a centralized controller for controlling a plurality of refrigerating air-conditioners, or a plurality of the centralized controllers via a communication line so as to perform a remote monitoring operation for the refrigerating air-conditioners.

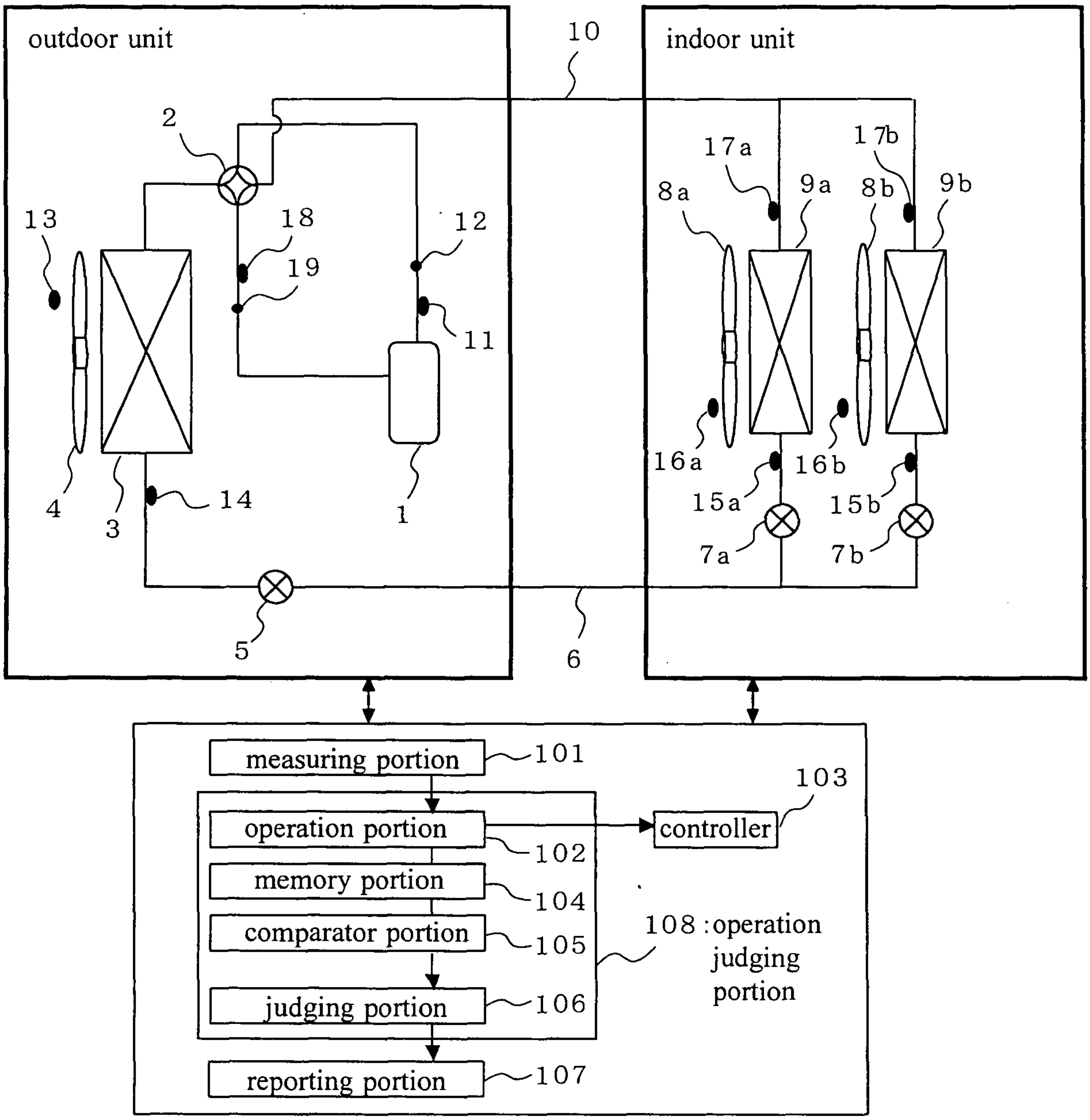
15. A refrigerating air-conditioning unit comprising a refrigerating cycle by connecting an outdoor unit and one or a plurality of indoor units, with communication piping, the outdoor unit having a compressor, an outdoor heat exchanger, and throttling device, each of the indoor units including an indoor heat exchanger and an throttling device,
wherein the refrigerating air-conditioning unit comprises
judging device for judging a refrigerant leakage of the refrigerating cycle, on a basis of past data relating to a past refrigerant volume of the refrigerating cycle at a past time point and new data relating to a refrigerant volume at a time point after performing one or plurality of times of stopping and starting up operations of the refrigeration since the past time point.

16. A method for detecting a refrigerant leakage of the refrigerating air-conditioner comprising a refrigerating cycle by connecting an outdoor unit and one or a plurality of indoor units with communication piping, the outdoor unit having a compressor, an outdoor heat exchanger, and throttling device, each of the indoor units including an indoor heat exchanger and an throttling device,

comprising the steps of:

judging an elapsed time after filling up a refrigerant;
judging whether all of the indoor heat exchangers constituting the indoor units are performing a cooling operation or a heating operation; and
judging the refrigerant leakage from the refrigerating cycle on a basis of a historical data relating to a refrigerant volume of the refrigerating cycle, when all the indoor heat exchangers are judged to be performing the cooling operation or the heating operation.

F I G. 1


outdoor unit
indoor unit
10
2
13
18
12
19
11
4
3
14
1
5
6
17a
17b
8a
9a
8b
9b
16a
16b
15a
15b
7a
7b
measuring portion
101
103
operation portion
controller
102
memory portion
104
comparator portion
105
108 :operation judging portion
judging portion
106
reporting portion
107

F I G. 2

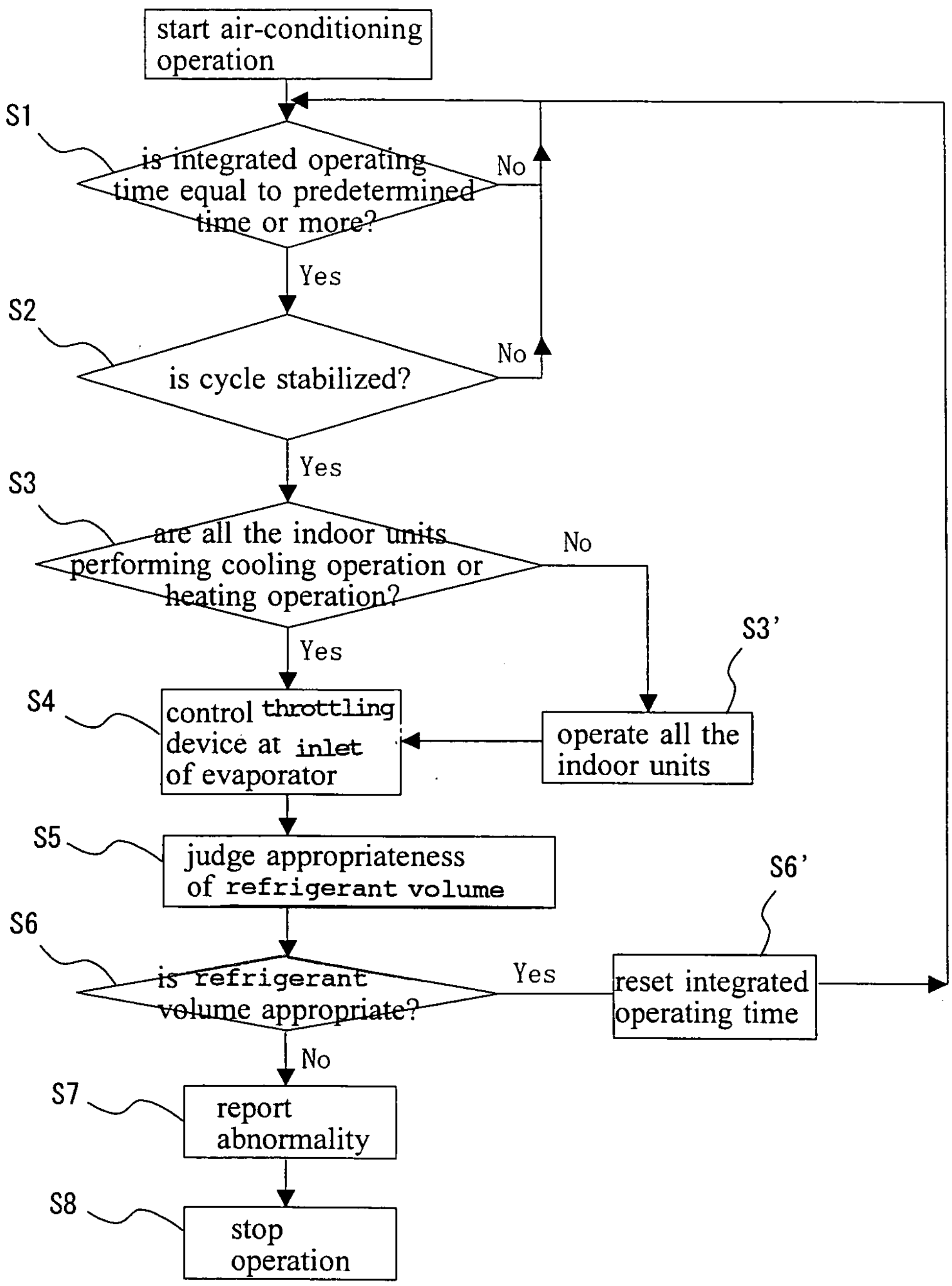
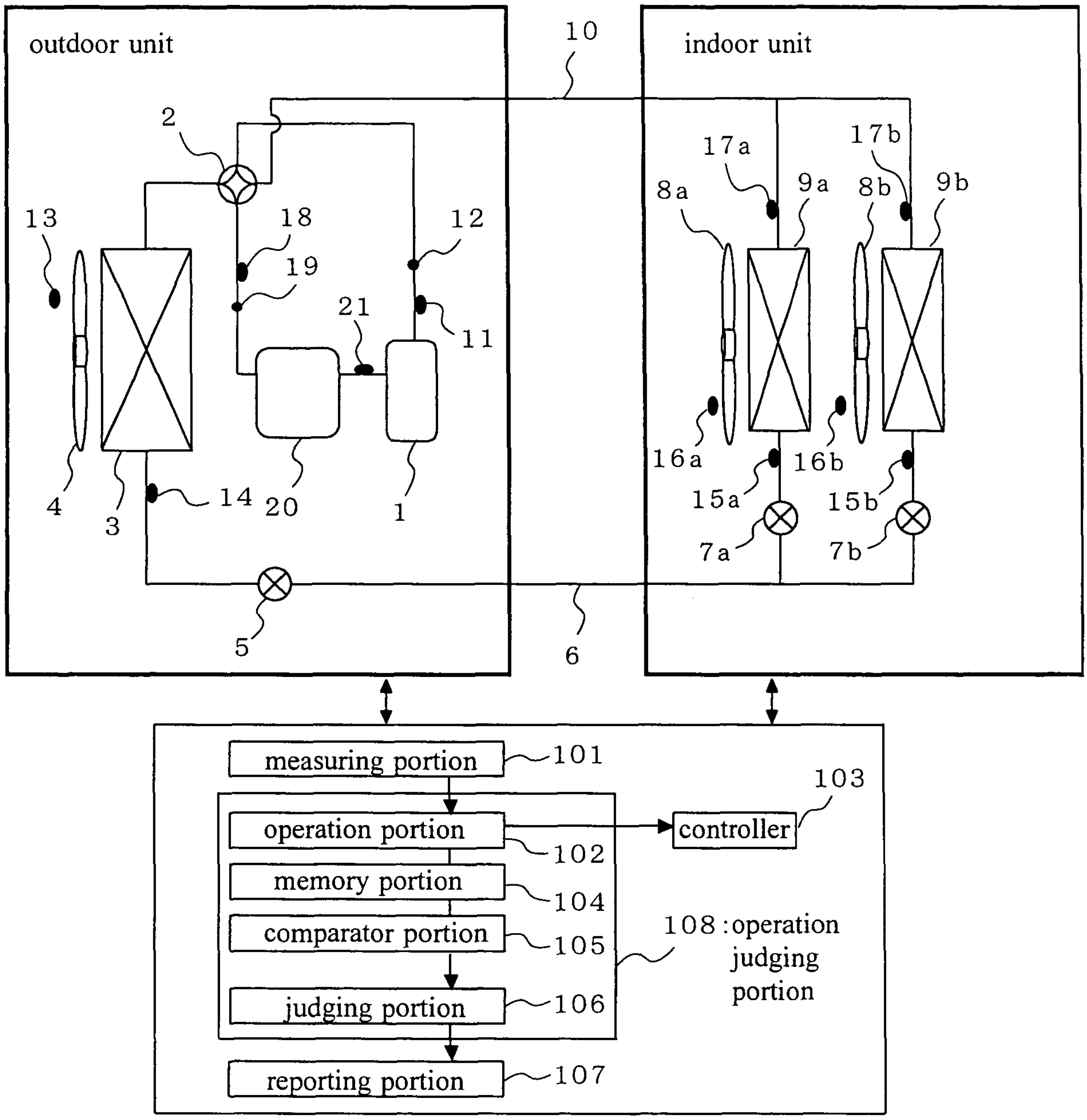
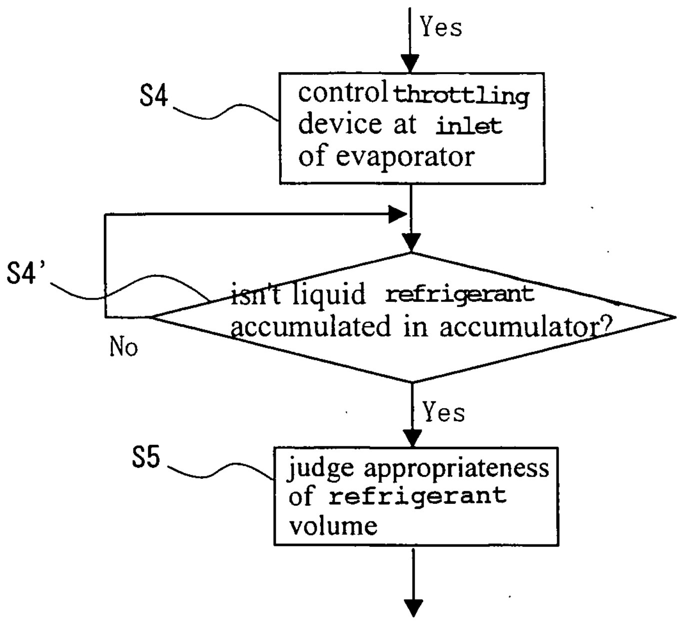

start air-conditioning operation
S1
is integrated operating time equal to predetermined time or more?
No
Yes
S2
is cycle stabilized?
No
Yes
S3
are all the indoor units performing cooling operation or heating operation?
No
Yes
S3'
operate all the indoor units
S4
control throttling device at inlet of evaporator
S5
judge appropriateness of refrigerant volume
S6
is refrigerant volume appropriate?
Yes
S6'
reset integrated operating time
No
S7
report abnormality
S8
stop operation

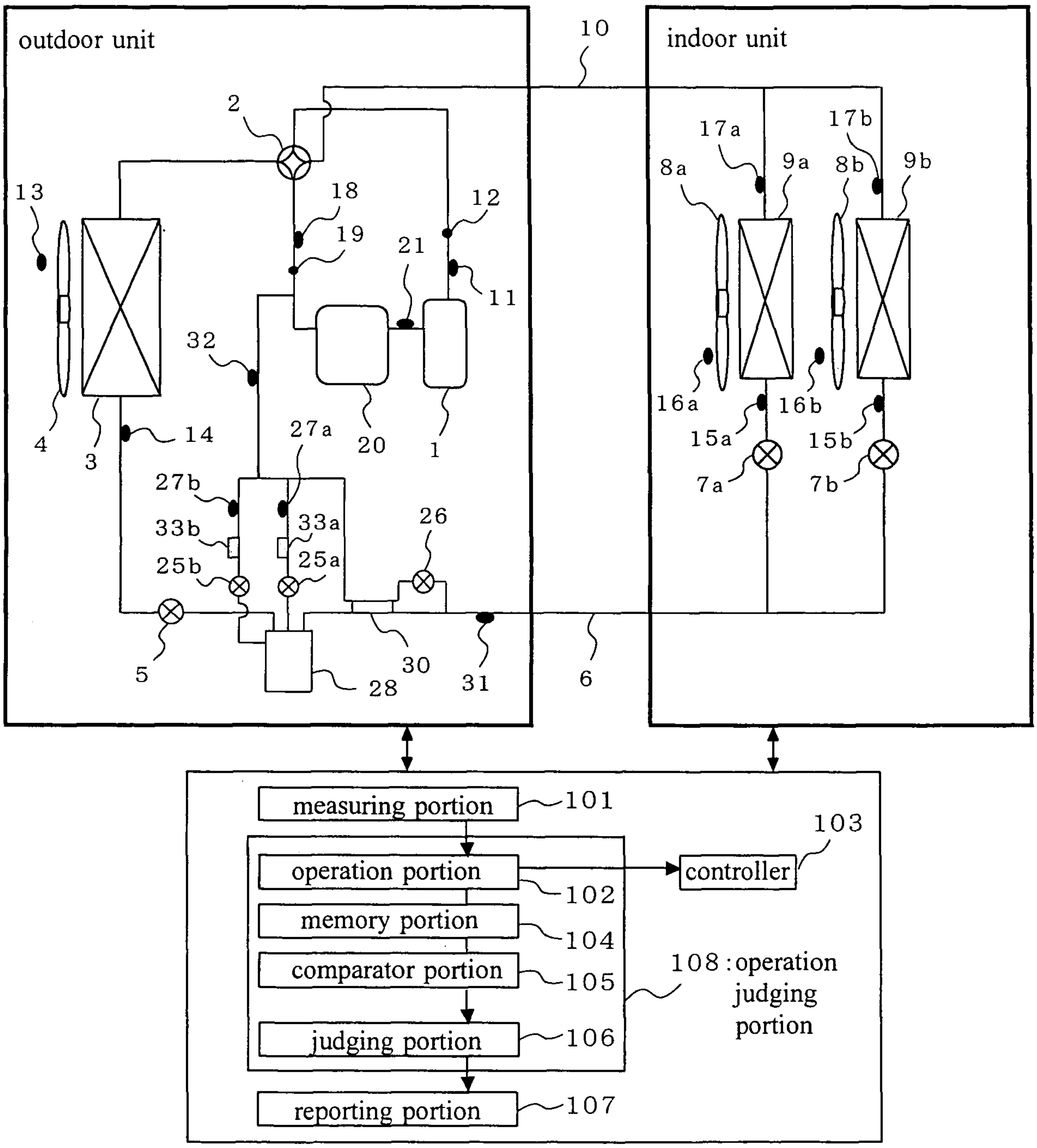
FIG. 3


outdoor unit
indoor unit
10
2
13
18
12
19
21
11
4
3
14
20
1
5
6
17a
17b
8a
9a
8b
9b
16a
16b
15a
15b
7a
7b
measuring portion
101
operation portion
102
controller
103
memory portion
104
comparator portion
105
108 :operation judging portion
judging portion
106
reporting portion
107

F I G. 4

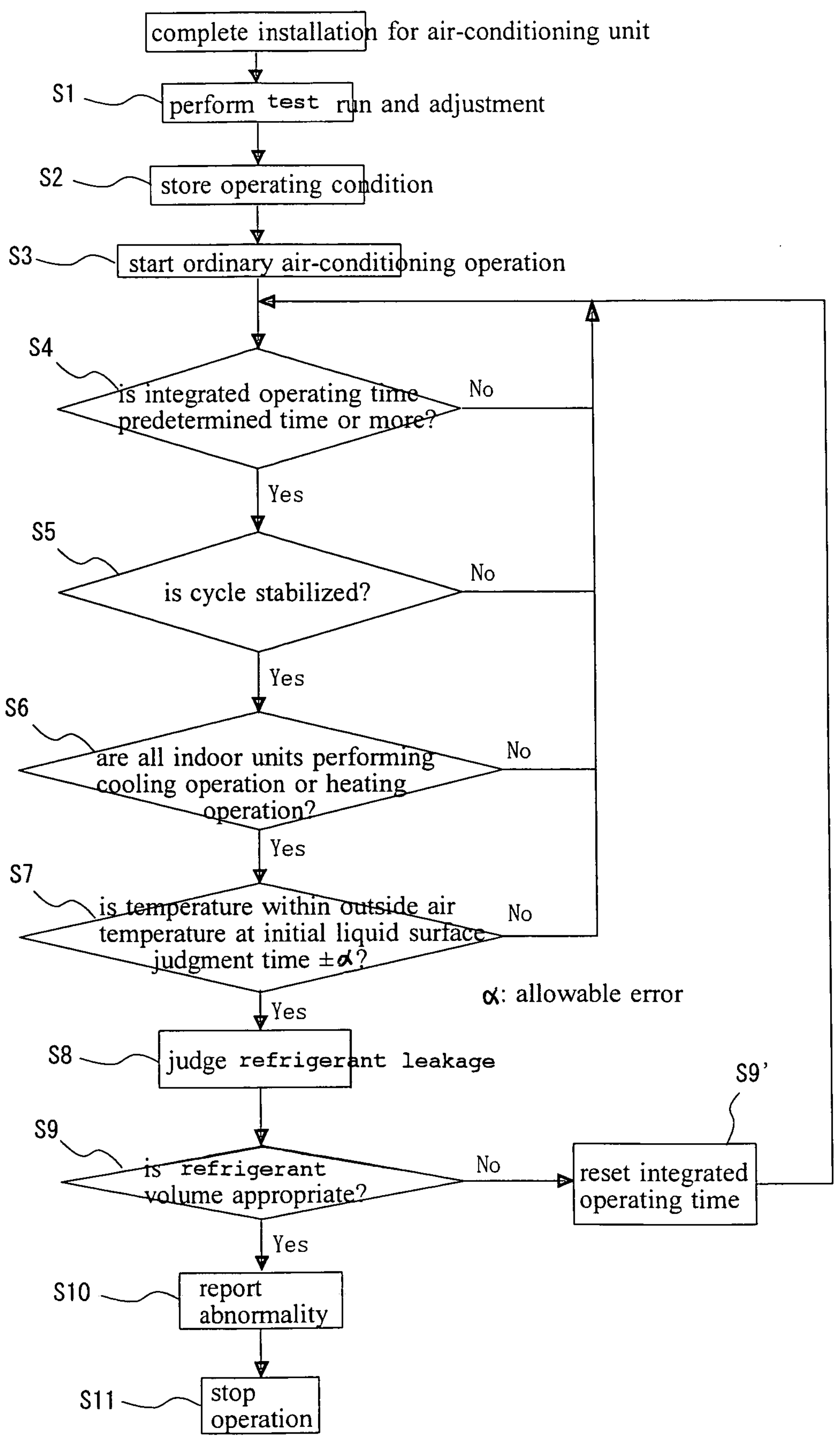

Yes
S4
control throttling device at inlet of evaporator
S4'
isn't liquid refrigerant accumulated in accumulator?
No
Yes
S5
judge appropriateness of refrigerant volume

F I G. 5

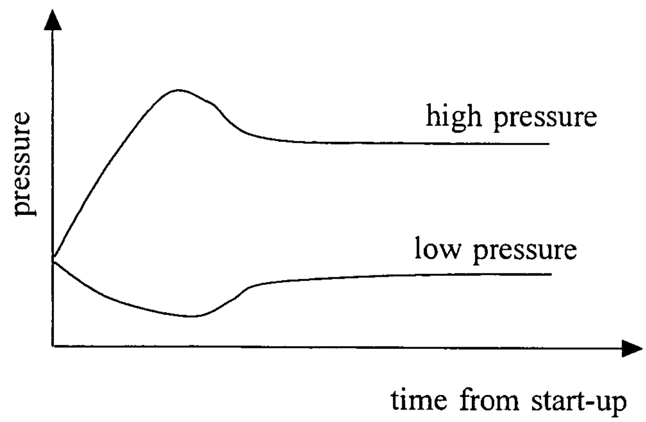


outdoor unit
indoor unit
10
2
13
18
12
19
21
11
32
4
3
14
27a
20
1
27b
33b
33a
26
25b
25a
5
30
28
31
6
17a
17b
8a
9a
8b
9b
16a
16b
15a
15b
7a
7b
measuring portion
101
103
operation portion
controller
102
memory portion
104
comparator portion
105
108 : operation judging portion
judging portion
106
reporting portion
107

F I G. 6


complete installation for air-conditioning unit
S1
perform test run and adjustment
S2
store operating condition
S3
start ordinary air-conditioning operation
S4
is integrated operating time predetermined time or more?
No
Yes
S5
is cycle stabilized?
No
Yes
S6
are all indoor units performing cooling operation or heating operation?
No
Yes
S7
is temperature within outside air temperature at initial liquid surface judgment time ±α?
No
Yes
α: allowable error
S8
judge refrigerant leakage
S9
is refrigerant volume appropriate?
No
S9'
reset integrated operating time
Yes
S10
report abnormality
S11
stop operation

F I G. 7



F I G. 8

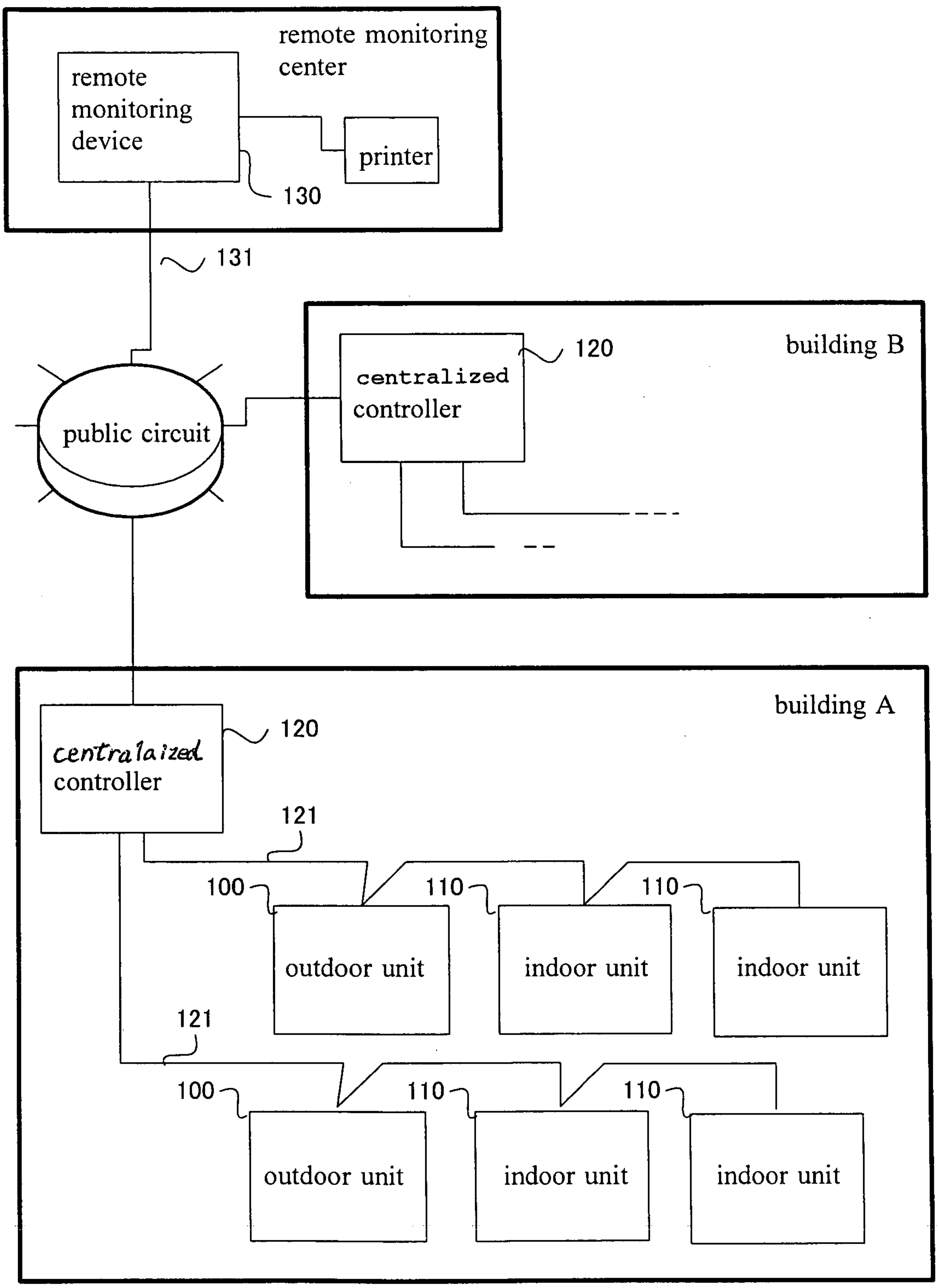

remote monitoring center
remote monitoring device
printer
130
131
public circuit
centralized controller
120
building B
building A
centralaized controller
120
121
100
110
110
outdoor unit
indoor unit
indoor unit
121
100
110
110
outdoor unit
indoor unit
indoor unit

FIG. 9

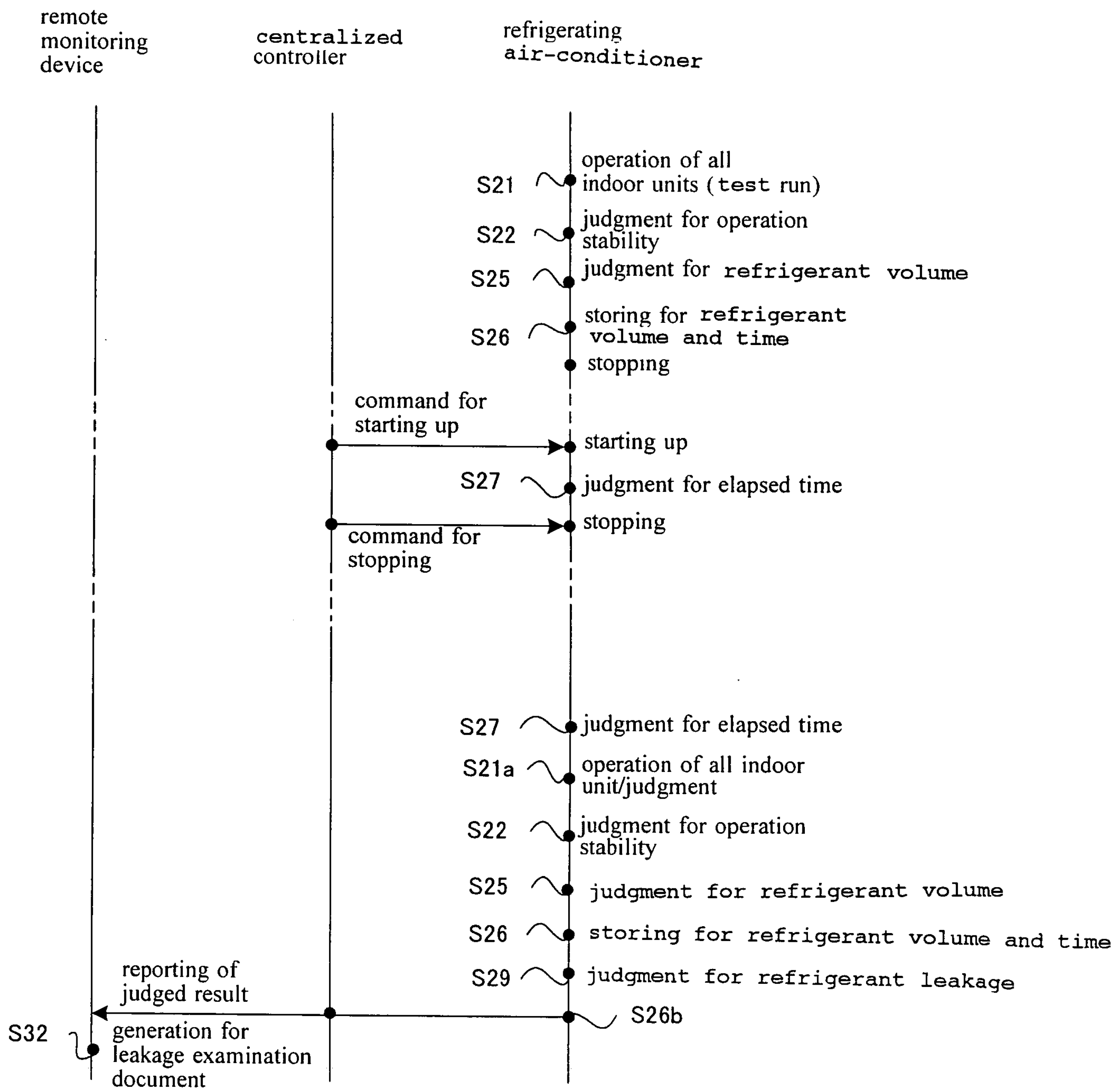

remote monitoring device
centralized controller
refrigerating air-conditioner
S21
operation of all indoor units (test run)
S22
judgment for operation stability
S25
judgment for refrigerant volume
S26
storing for refrigerant volume and time
stopping
command for starting up
starting up
S27
judgment for elapsed time
stopping
command for stopping
S27
judgment for elapsed time
S21a
operation of all indoor unit/judgment
S22
judgment for operation stability
S25
judgment for refrigerant volume
S26
storing for refrigerant volume and time
S29
judgment for refrigerant leakage
reporting of judged result
S26b
S32
generation for leakage examination document

FIG. 10

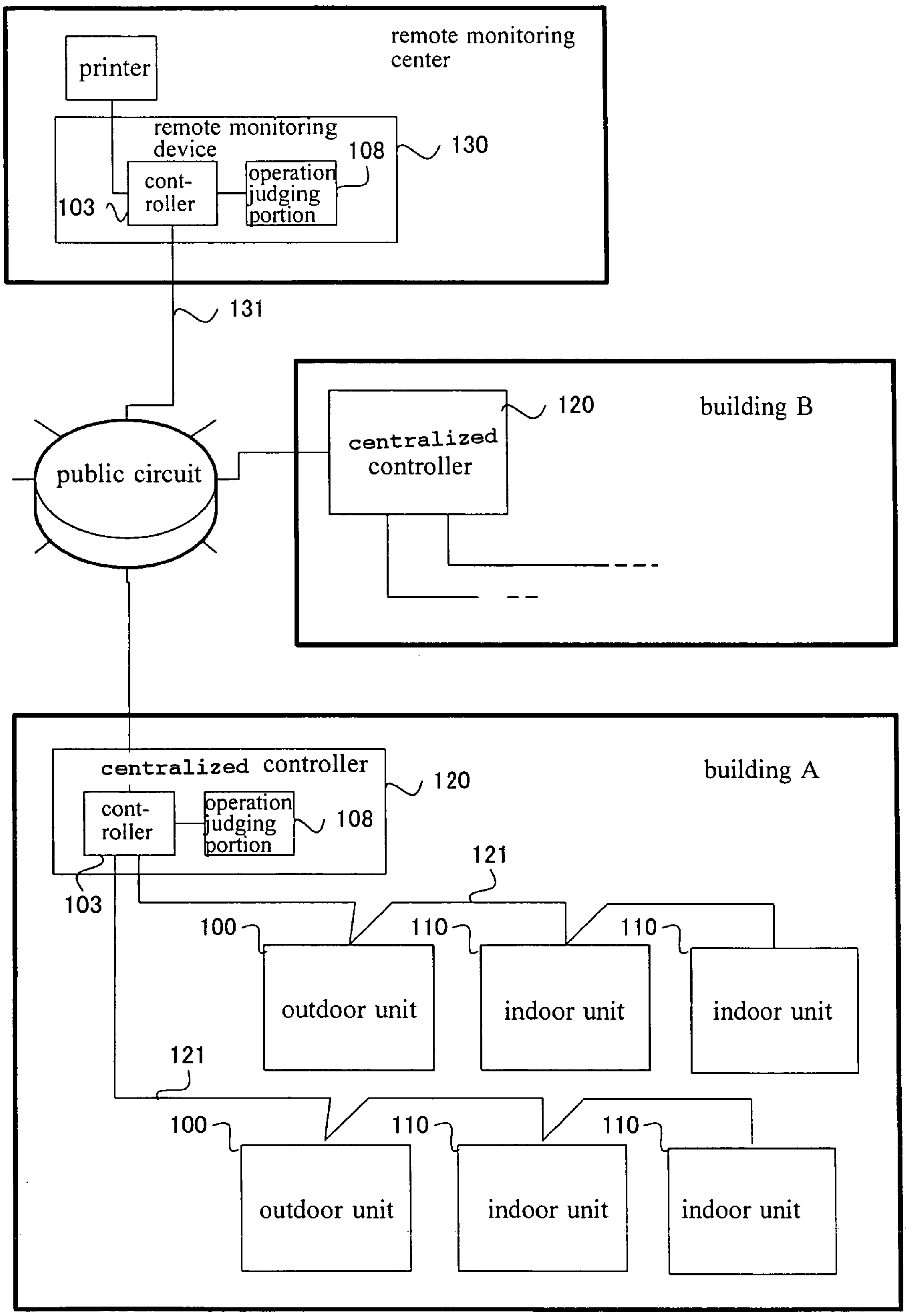
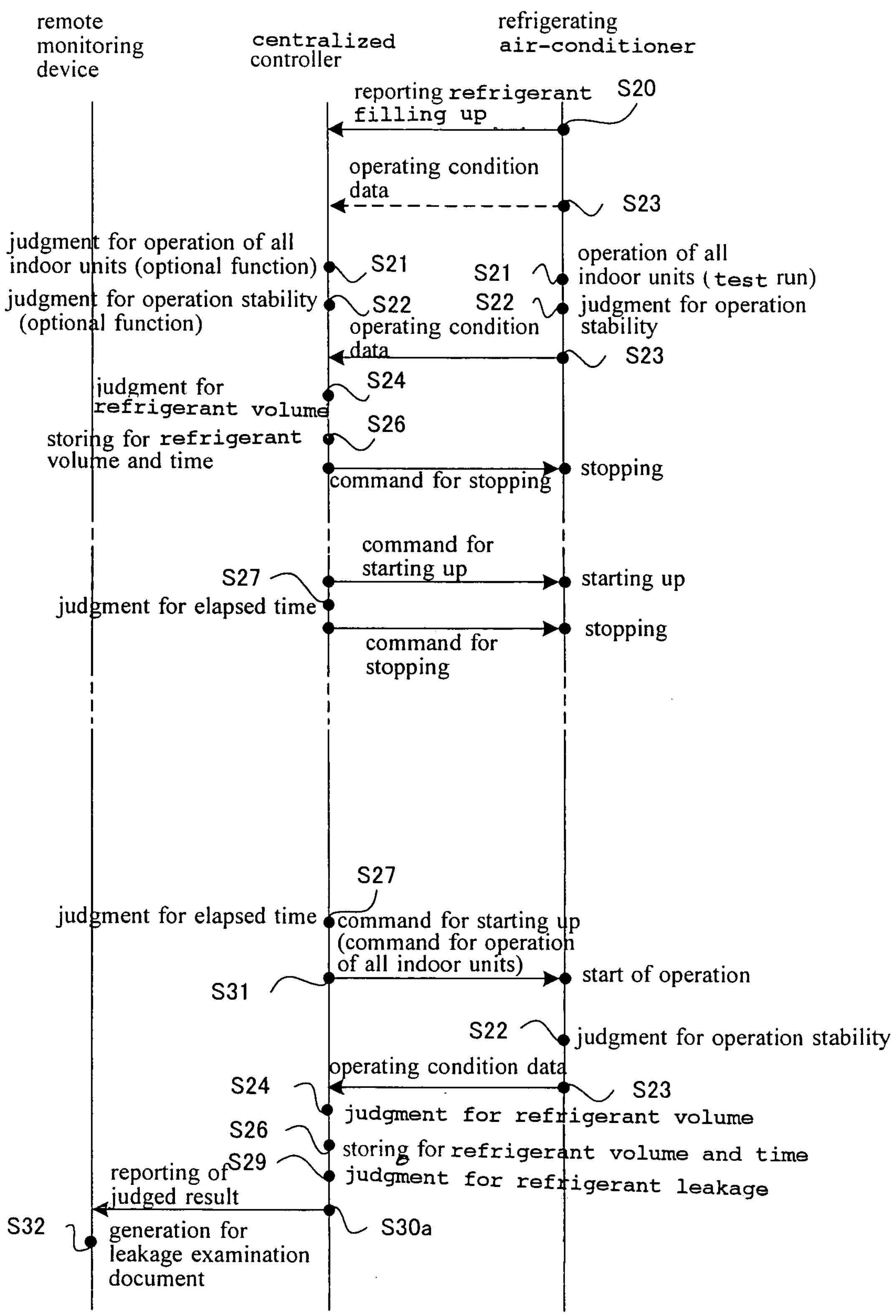

remote monitoring center
printer
remote monitoring device
108
130
cont-roller
operation judging portion
103
131
120
building B
centralized controller
public circuit
centralized controller
120
building A
cont-roller
operation judging portion
108
121
103
100
110
110
outdoor unit
indoor unit
indoor unit
121
100
110
110
outdoor unit
indoor unit
indoor unit

FIG. 11


remote monitoring device
centralized controller
refrigerating air-conditioner
reporting refrigerant filling up
S20
operating condition data
S23
judgment for operation of all indoor units (optional function)
S21
S21
operation of all indoor units (test run)
judgment for operation stability (optional function)
S22
S22
judgment for operation stability
operating condition data
S23
judgment for refrigerant volume
S24
storing for refrigerant volume and time
S26
command for stopping
stopping
command for starting up
S27
starting up
judgment for elapsed time
command for stopping
stopping
S27
judgment for elapsed time
command for starting up (command for operation of all indoor units)
S31
start of operation
S22
judgment for operation stability
operating condition data
S24
S23
judgment for refrigerant volume
S26
storing for refrigerant volume and time
reporting of judged result
S29
judgment for refrigerant leakage
S32
generation for leakage examination document
S30a

F I G. 1 2

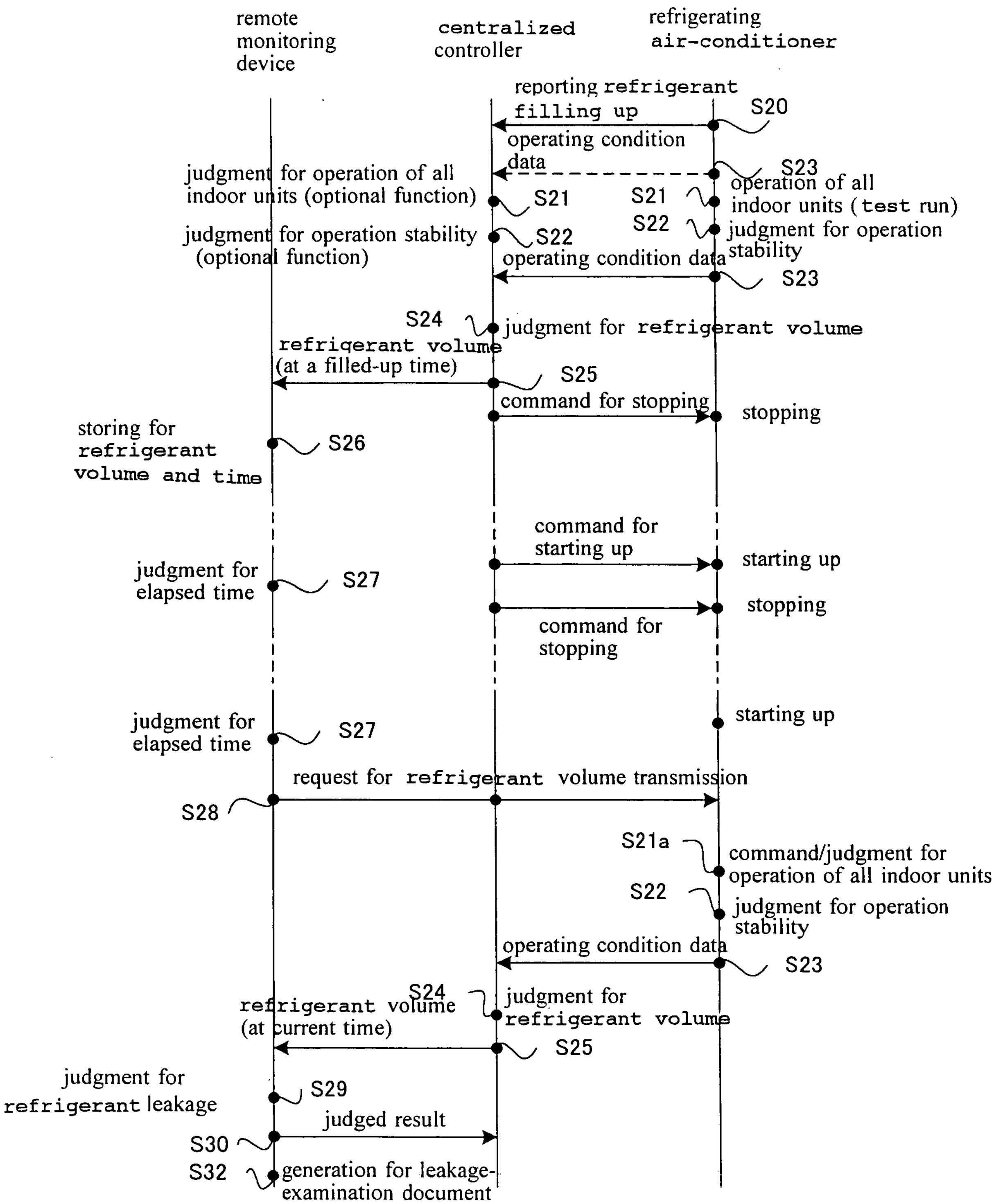
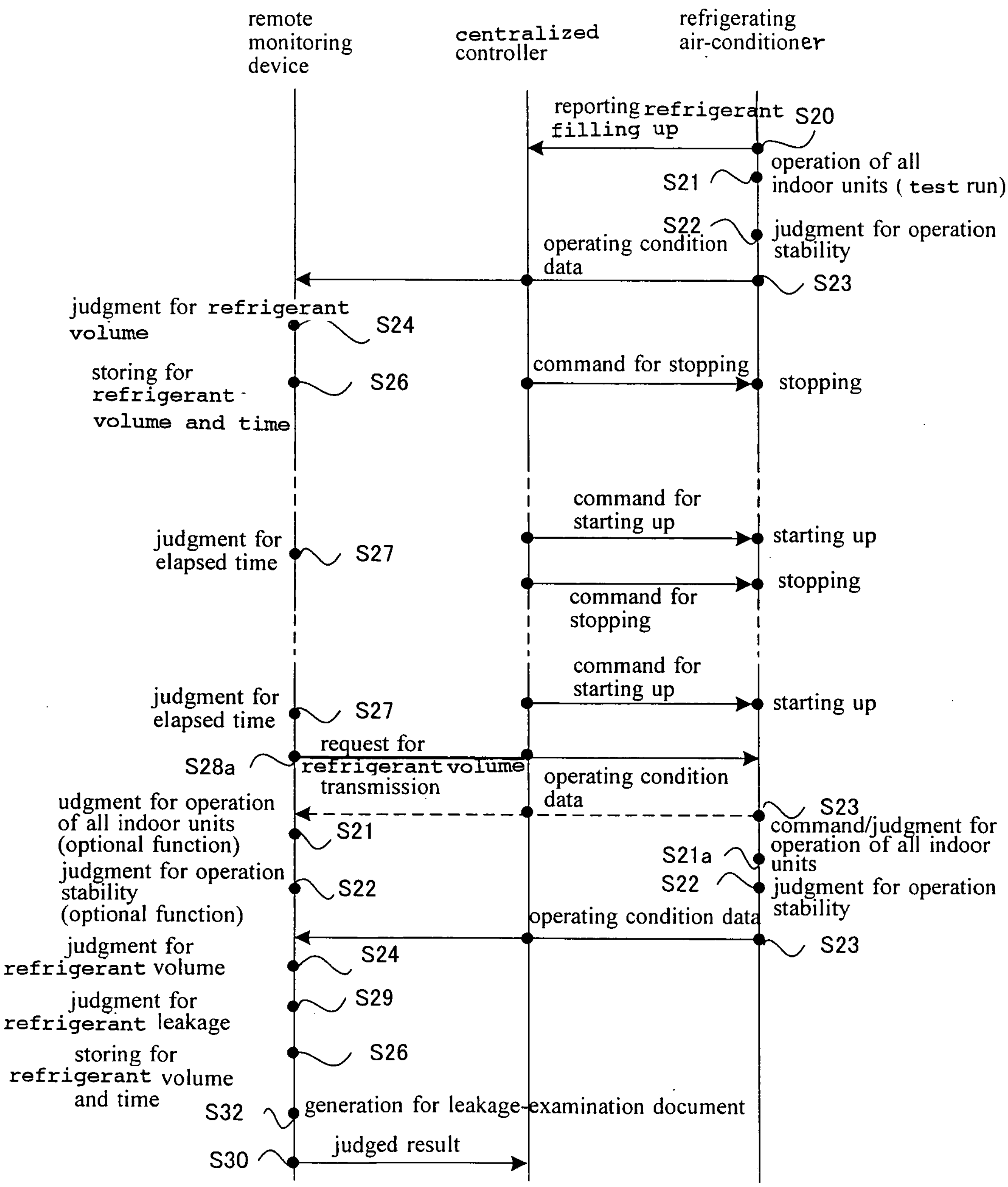

remote monitoring device
centralized controller
refrigerating air-conditioner
reporting refrigerant filling up
S20
operating condition data
S23
operation of all indoor units (test run)
judgment for operation of all indoor units (optional function)
S21
S21
judgment for operation stability (optional function)
S22
S22
judgment for operation stability
operating condition data
S23
S24
judgment for refrigerant volume
refrigerant volume (at a filled-up time)
S25
command for stopping
stopping
storing for refrigerant volume and time
S26
command for starting up
starting up
judgment for elapsed time
S27
stopping
command for stopping
starting up
judgment for elapsed time
S27
request for refrigerant volume transmission
S28
S21a
command/judgment for operation of all indoor units
S22
judgment for operation stability
operating condition data
S23
S24
refrigerant volume (at current time)
judgment for refrigerant volume
S25
judgment for refrigerant leakage
S29
judged result
S30
S32
generation for leakage-examination document

FIG. 13



remote monitoring device
centralized controller
refrigerating air-conditioner
reporting refrigerant filling up
S20
operation of all indoor units (test run)
S21
S22
judgment for operation stability
operating condition data
S23
judgment for refrigerant volume
S24
storing for refrigerant volume and time
S26
command for stopping
stopping
command for starting up
starting up
judgment for elapsed time
S27
stopping
command for stopping
command for starting up
judgment for elapsed time
S27
starting up
request for refrigerant volume transmission
S28a
operating condition data
S23
udgment for operation of all indoor units (optional function)
S21
command/judgment for operation of all indoor units
S21a
judgment for operation stability (optional function)
S22
S22
judgment for operation stability
operating condition data
judgment for refrigerant volume
S24
S23
judgment for refrigerant leakage
S29
storing for refrigerant volume and time
S26
S32
generation for leakage-examination document
judged result
S30

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2006/318704

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	WO 2005/121664 A1 (Daikin Industries, Ltd.), 22 December, 2005 (22.12.05), Full text; Figs. 1 to 10 (Family: none)	1-4,7,15,16 5,6,11-14 8-10
Y	JP 2006-112698 A (Matsushita Electric Industrial Co., Ltd.), 27 April, 2006 (27.04.06), Full text; Figs. 1 to 3 (Family: none)	5,6
Y	JP 2000-249434 A (Daikin Industries, Ltd.), 14 September, 2000 (14.09.00), Full text; Figs. 1 to 3 (Family: none)	11,12

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

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"P" document published 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 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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December, 2006 (15.12.06)	26 December, 2006 (26.12.06)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/318704

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-156271 A (Mitsubishi Electric Corp.), 30 May, 2003 (30.05.03), Full text; Figs. 1 to 12 (Family: none)	13,14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP 2005009857 A **[0004]**
- JP 2004069198 A **[0004]**
- JP 2004036985 A **[0004]**