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(54) **REFRIGERATION DEVICE**

(57) Provided is a refrigeration apparatus for preventing reduction in performance due to start/stop operation. In an air conditioning apparatus (1), it is possible to suppress an outdoor unit (2) from being in a resting state or a low capabilities state due to the number of rotations of a compressor (21) being returned to a region where rotation control using an inverter is possible by indoor units which are in a thermo-off state among of a plurality of indoor units (4a, 4b, 4c) being forcibly switched to a thermo-on state since it is assumed that the number of rotations of the compressor (21) will be equal to or less than the region where rotation control using an inverter is possible when there is a low capabilities state where the outdoor unit (2) seems likely to switch to a resting state.

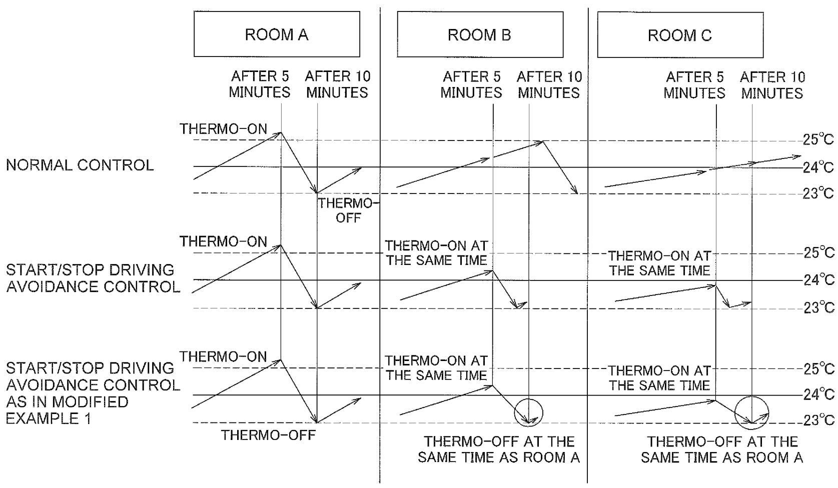

FIG. 6

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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration apparatus.

BACKGROUND ART

[0002] There is a tendency in recent years for the insulating performance of buildings to improve and also for the cooling load (heat load) in buildings to be reduced due to the introduction of ventilation flow amount control and the like. Cooling capabilities (heating capabilities) are chosen in combination with peak times in summer (winter), and driving with partial load is dominant during intermediate periods such as spring and autumn, at mornings and in the evenings, and in cases where outside air load is low. The operating region, where control using an inverter is possible, is typically said to be such that 20-30% is the lower limit with a rated ratio and the compressor stops when the operating region is below this.

[0003] In this case, it is necessary for high-pressure refrigerant and low-pressure refrigerant to be equal pressure at one point due to the safety and durability of the device, and movement of heat is generated between the refrigerant. For this reason, although there is no effect on the coefficient of performance (COP) and the performance in consideration of seasonal variations (APF) in a case where on/off is frequently repeated (referred to below as start/stop operation), there is a possibility that the actual performance in a building (system performance) will be reduced.

[0004] In contrast to this, for example, in Patent Literature 1 (JP 2002-61925 A), air conditioning capabilities are matched as much as possible with air conditioning load by carrying out correction on the target value of the evaporation temperature during cooling operation and on the condensation temperature during heating operation based on the number of times of an outdoor thermo-off state and the like.

SUMMARY OF THE INVENTION

<Problems to be Solved by the Invention>

[0005] However, while it is possible to reduce the extent of the number of times of the outdoor thermo-off state in a method for adjusting the air conditioning capabilities described in Patent Literature 1, it is not possible to deal with this case in a case where the air conditioning load inside each of the rooms match since it is easy for the timings, where each of the indoor units is in the indoor thermo-off state, to be synchronized.

[0006] The purpose of the present invention is to propose a refrigeration apparatus where a reduction in performance due to start/stop operation is prevented.

<Means to Solve the Problems>

[0007] A refrigeration apparatus according to a first aspect of the present invention performs temperature control such that each temperature of a plurality of control targets is within permissible ranges for setting temperatures which are set in advance utilizing a vapor compression type of cooling cycle and is provided with a plurality of utilizing units, a heat source unit, and a control section. The utilizing units heat or cool each of the control targets. The heat source unit is mounted with a compressor and is connected to the plurality of utilizing units. The control section controls the utilizing units and the heat source unit such that the temperatures of the control targets reach within the permissible ranges for the setting temperatures. In addition, the control section switches from a thermo-on state where the state of the utilizing units is a state where refrigerant is flowing to a thermo-off state which is a state where movement of refrigerant inside the utilizing units stops without the heat source unit being rested when the temperatures of the control targets reach within the permissible ranges for the setting temperatures. Furthermore, the control section switches the heat source unit to a resting state by stopping the compressor of the heat source unit when the all of the utilizing units which are being operated are switched to the thermo-off state. Furthermore, the control section forcibly switches the utilizing units which are in the thermo-off state among of the plurality of utilizing units to the thermo-on state when there is a low capabilities state where the heat source unit seems likely to switch to a resting state.

[0008] In this refrigeration apparatus, it is possible to suppress the heat source unit from being in a resting state or a low capabilities state due to the number of rotations of the compressor being returned to a region where rotation control using an inverter is possible by the utilizing units which are in the thermo-off state among of the plurality of utilizing units being forcibly switched to the thermo-on state since it is assumed that the number of rotations of the compressor will be equal to or less than a region where rotation control using an inverter is possible when there is a low capabilities state where the heat source unit seems likely to switch to a resting state.

[0009] A refrigeration apparatus according to a second aspect of the present invention is the refrigeration apparatus according to the first aspect of the present invention, where the control section forcibly switches the utilizing units, which satisfy designated conditions among of the remaining of the plurality of utilizing units which are in the thermo-off state, to the thermo-on state in addition to the utilizing units which are in the thermo-on state when the compressor is driven again in a case where the heat source unit is in the resting state.

[0010] In this refrigeration apparatus, it is estimated that low capabilities driving and stopping of the compressor will be generated over short time intervals and performance will be remarkably reduced in a case where the on/off states of the heat source unit are frequently repeated, that is, in a case of start/stop operation. For this reason, it is possible for the number of rotations of the compressor to be returned to the region where rotation control using an inverter is possible and for low capabilities driving to be avoided due to the appropriate utilizing units among the utilizing units which are in the thermo-off state being forcibly switched to the thermo-on state during reactivating of the compressor.

[0011] A refrigeration apparatus according to a third aspect of the present invention is the refrigeration apparatus according to the second aspect of the present invention, where a first threshold, which is a threshold for the control section to perform determining of switching the utilizing units which are in the thermo-off state to the thermo-on state, and a second threshold, which is a threshold for the control section to perform determining of switching the utilizing units which are in the thermo-on state to the thermo-off state, are set as the setting temperatures. Furthermore, the control section forcibly switches the utilizing units to the thermo-on state by giving priority to the utilizing units, which are close to the threshold of the permissible range of the setting temperature, among the group of the utilizing units which are in the thermo-off state.

[0012] In this refrigeration apparatus, it is possible for the compressor to be operated for a longer period of time in the region where rotation control using an inverter is possible since the utilizing units are switched to the thermo-on state by giving priority to the utilizing units which are close to the first threshold of the setting temperature instead of the utilizing units which are in the thermo-off state being randomly selected.

[0013] A refrigeration apparatus according to a fourth aspect of the present invention is the refrigeration apparatus according to the second aspect of the present invention, where the control section does not perform control, where the remaining of the utilizing units are forcibly switched to the thermo-on state, after the total capacity of the group of the utilizing units which are the thermo-on state reaches the capacity which is appropriate for high efficiency driving of the compressor.

[0014] In this refrigeration apparatus, it is possible to prevent the number of the utilizing units which are being operated from being needlessly increased due to being forcibly switched to the thermo-on state and to prevent separating of the number of the utilizing units which are being operated from the ideal number of the utilizing units to be operated based on the characteristics of the compressor.

[0015] A refrigeration apparatus according to a fifth aspect of the present invention is the refrigeration apparatus according to the first aspect of the present invention, where a first threshold, which is a threshold for the control section to perform determining of switching the utilizing units which are in the thermo-off state to the thermo-on state, and a second threshold, which is a threshold for the control section to perform determining of switching the utilizing units which are in the thermo-on state to the thermo-off state, are set as the setting temperatures. Furthermore, the control section forcibly switches the utilizing units, which are close to the first threshold of the setting temperature among the group of the utilizing units which are in the thermo-off state, to the thermo-on state when the group of the utilizing units which are in the thermo-on state are close to the conditions of being switched to the thermo-off state.

[0016] In this refrigeration apparatus, it is possible to continue operating of the compressor by returning the number of rotations of the compressor, where the compressor is at or below the region where rotation control using an inverter is possible, to the region where rotation control is possible since the control section forcibly switches the utilizing units, which are close to the first threshold of the setting temperature among the group of the utilizing units which are in the thermo-off state, to the thermo-on state when the group of the utilizing units which are in the thermo-on state are close to the conditions of being switched to the thermo-off state.

[0017] A refrigeration apparatus according to a sixth aspect of the present invention is the refrigeration apparatus according to the first aspect of the present invention, where the control section predicts the power consumption amount in a case where the remaining of the utilizing units which are in the thermo-off state are forcibly switched to the thermo-on state and in a case where the remaining of the utilizing units which are in the thermo-off state are not switched to the thermo-on state and performs determining of whether or not to forcibly switch the remaining of the utilizing units which are in the thermo-off state to the thermo-on state.

[0018] In this refrigeration apparatus, it is not necessarily the case that efficiency of the compressor will increase due to the number of the utilizing units which are being operated being increased by being forcibly switched to the thermo-on state. For this reason, it is determined whether or not the utilizing units which are in the thermo-off state are to be forcibly switched to the thermo-on state based on the prepotency seen from the point of view of the consumed power amount.

[0019] A refrigeration apparatus according to a seventh aspect of the present invention is the refrigeration apparatus according to the sixth aspect of the present invention, where the control section performs predicting of the power consumption amount based on at least the driving frequency of the compressor and/or the difference between the temperature of the control targets and the outside air temperature.

[0020] In this refrigeration apparatus, prediction accuracy is increased since the predicted value of the power consumption amount is calculated based on the driving frequency of the compressor and/or the difference between the temperature of the control targets and the outside air temperature.

[0021] A refrigeration apparatus according to an eighth aspect of the present invention is the refrigeration apparatus according to the sixth aspect of the present invention, where the control section maintains controlling which is performed with regard to the control targets and the results of the controlling as control history, calculates estimated values of the degree of insulating of the control targets and the internal load from the control history over a designated amount of time, and performs predicting of the power consumption amount.

[0022] In this refrigeration apparatus, prediction accuracy is more logical since it is possible to calculate estimated values of the degree of insulating of the control targets and the internal load from the control history over a designated amount of time and to perform predicting of the power consumption amount in consideration of variance in the air conditioning load due to the instillation conditions, the number of years of usage, and the like.

[0023] A refrigeration apparatus according to a ninth aspect of the present invention is the refrigeration apparatus according to the first aspect of the present invention, where each of the utilizing units has an expansion valve which reduces the pressure of refrigerant which flows in the utilizing units during cooling operation. The control section adjusts the openings of the expansion valves, which correspond to the utilizing units which are forcibly switched to the thermo-on state, in a direction so that switching to the thermo-off state is delayed.

[0024] In this refrigeration apparatus, it is possible to operate the compressor with a highly efficient number of rotations since the other utilizing units are switched to the thermo-off state at a timing which is the same as the timing where the utilizing units where the load is large are switched to the thermo-off state.

<Effects of the Invention>

[0025] In the refrigeration apparatus according to the first aspect of the present invention, it is possible to suppress the heat source unit from being in a resting state or a low capabilities state due to the number of rotations of the compressor being returned to a region where rotation control using an inverter is possible by the utilizing units which are in the thermo-off state among of the plurality of utilizing units being forcibly switched to the thermo-on state.

[0026] In the refrigeration apparatus according to the second aspect of the present invention, it is possible for the number of rotations of the compressor to be returned to the region where rotation control using an inverter is possible and for low capabilities driving to be avoided due to the appropriate utilizing units among the utilizing units which are in the thermo-off state being forcibly switched to the thermo-on state during reactivating of the compressor.

[0027] In the refrigeration apparatus according to the third aspect of the present invention, it is possible for the compressor to be operated for a longer period of time in the region where rotation control using an inverter is possible since the utilizing units are switched to the thermo-on state by giving priority to the utilizing units which are close to the threshold of the permissible range of the setting temperature.

[0028] In the refrigeration apparatus according to the fourth aspect of the present invention, it is possible to prevent the number of the utilizing units which are being operated from being needlessly increased due to being forcibly switched to the thermo-on state and to prevent separating of the number of the utilizing units which are being operated from the ideal number of the utilizing units to be operated based on the characteristics of the compressor.

[0029] In the refrigeration apparatus according to the fifth aspect of the present invention, it is possible to continue operating of the compressor by returning the number of rotations of the compressor, where the compressor is at or below the region where rotation control using an inverter is possible, to the region where rotation control is possible.

[0030] In the refrigeration apparatus according to the sixth aspect of the present invention, it is determined in a logical manner whether or not to forcibly switch the utilizing units which are in the thermo-off state to the thermo-on state based on the prepotency seen from the point of view of the consumed power amount.

[0031] In the refrigeration apparatus according to the seventh aspect of the present invention, prediction accuracy is increased since the predicted value of the power consumption amount is calculated based on the driving frequency of the compressor and/or the difference between the temperature of the control targets and the outside air temperature.

[0032] In the refrigeration apparatus according to the eighth aspect of the present invention, prediction accuracy is more logical since it is possible to calculate estimated values of the degree of insulating of the control targets and the internal load from the control history over a designated amount of time and to perform predicting of the power consumption amount in consideration of variance in the air conditioning load due to the instillation conditions, the number of years of usage, and the like.

[0033] In the refrigeration apparatus according to the ninth aspect of the present invention, it is possible to operate the compressor with a highly efficient number of rotations since the other utilizing units are switched to the thermo-off state at a timing which is the same as the timing where the utilizing units where the load is large are switched to the thermo-off state.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

Fig. 1 is a perspective diagram of an air conditioning apparatus according to an embodiment of the present invention.

Fig. 2 is a schematic configuration diagram of the air conditioning apparatus.

Fig. 3 is a control block diagram of an air conditioning apparatus 1.

Fig. 4 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control and start/stop operation avoidance control during cooling operation.

Fig. 5A is a flow chart for start/stop operation avoidance control.

Fig. 5B is a flow chart for start/stop operation avoidance control.

Fig. 6 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control, start/stop operation avoidance control, and start/stop operation avoidance control according to modified example 1 during cooling operation.

Fig. 7 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control, start/stop operation avoidance control, and start/stop operation avoidance control according to modified example 2 during cooling operation.

Fig. 8 is a perspective diagram of a water heating apparatus according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0035] Embodiments of the present invention will be described below while referencing the drawings. Here, the embodiments below are specific examples of the present invention and do not limit the technical scope of the present invention.

(1) Basic Configuration of Air Conditioning Apparatus 1

[0036] Fig. 1 is a perspective diagram of an air conditioning apparatus 1 according to an embodiment of the present invention. In addition, Fig. 2 is a schematic configuration diagram of the air conditioning apparatus 1. The air conditioning apparatus 1 in Fig. 1 and Fig. 2 is an apparatus which is used in indoor air conditioning such as in a building by performing a vapor compression type of refrigeration cycle operation. The air conditioning apparatus 1 is mainly configured by connected an outdoor unit 2 and a plurality (three in the present embodiment) of indoor units 4a, 4b, and 4c. Here, the outdoor unit 2 and the plurality of indoor units 4a, 4b, and 4c are connected via a liquid refrigerant communication pipe 6 and a gas refrigerant communication pipe 7. That is, a vapor compression type of refrigerant circuit 10 in the air conditioning apparatus 1 is configured by connecting the outdoor unit 2 and the plurality of indoor units 4a, 4b, and 4c via the refrigerant communication pipes 6 and 7.

(2) Detailed Configuration

(2-1) Indoor Units 4a, 4b, and 4c

[0037] The indoor units 4a, 4b, and 4c are provided indoors. The indoor units 4a, 4b, and 4c are connected to the outdoor unit 2 via the refrigerant communication pipes 6 and 7 and configure a portion of the refrigerant circuit 10.

[0038] Since the indoor units 4b and the indoor unit 4c have the same configuration as the indoor unit 4a, only the configuration of the indoor unit 4a is described here, the suffix b and the suffix c is respectively given instead of the suffix a, which indicates each section of the indoor unit 4a, in the configurations of the indoor units 4b and 4c, and description of each section of the indoor units 4b and 4c is omitted.

[0039] The indoor unit 4a mainly has an indoor side refrigerant circuit 10a which configures a portion of the refrigerant circuit 10. The indoor side refrigerant circuit 10a has an indoor expansion valve 41 a and an indoor heat exchanger 42a.

(2-1-1) Indoor Expansion Valves 41 a, 41 b, and 41 c

[0040] The indoor expansion valve 41 a is an electric expansion valve which is connected to the liquid side of the indoor heat exchanger 42a. The indoor expansion valve 41 a adjusts the flow amount of the refrigerant by reducing the pressure of the refrigerant which flows in the indoor side refrigerant circuit 10a.

(2-1-2) Indoor Heat Exchangers 42a, 42b, and 42c

[0041] The indoor heat exchanger 42a is a fin and tube type heat exchanger of the cross-fin type. Heat exchange is performed between refrigerant and indoor air in the indoor heat exchanger 42a. The indoor heat exchanger 42a functions as a condenser of the refrigerant during heating operation and functions as an evaporator of the refrigerant during cooling operation.

(2-1-3) Indoor Fans 43a, 43b, and 43c

[0042] The indoor fan 43a is arranged in the vicinity of the indoor heat exchanger 42a in order to send indoor air to the indoor heat exchanger 42a. The indoor fan 43a is driven by an indoor fan motor 44a.

(2-1-4) Various Types of Sensors

[0043] Various types of sensors are provided in the indoor unit 4a. A liquid side temperature sensor 45a is provided on the liquid side of the indoor heat exchanger 42a and detects the temperature of refrigerant which is in a liquid state or a gas-liquid two-phase state.

[0044] A gas side temperature sensor 46a is provided on the gas side of the indoor heat exchanger 42a and detects the temperature of refrigerant which is in a gas state.

[0045] An indoor temperature sensor 47a is provided at an indoor air suction opening side of the indoor unit 4a and detects the indoor temperature in the indoor unit 4a.

(2-1-5) Indoor Side Control Sections 48a, 48b, and 48c

[0046] An indoor side control section 48a controls the actions of each section which configures the indoor unit 4a. The indoor side control section 48a has a CPU and a memory, and performs transferring of control signals and the like with a remote controller 49a for individually operating the indoor unit 4a, and performs transferring of control signals with the outdoor unit 2. The user performs various types of settings and commands for driving and stopping which relate to operating the air conditioning via the remote controller49a.

(2-2) Outdoor Unit 2

[0047] The outdoor unit 2 is provided outdoors. The outdoor unit 2 is connected to the indoor units 4a, 4b, and 4c via the refrigerant communication pipes 6 and 7 and configures an outdoor side refrigerant circuit 10d which is a portion of the refrigerant circuit 10. The outdoor side refrigerant circuit 10d has a compressor 21, a four way switching valve 22, an outdoor heat exchanger 23, an accumulator 24, an outdoor expansion valve 25, a liquid side shut-off valve 26, and a gas side shut-off valve 27.

(2-2-1) Compressor 21

[0048] The compressor 21 is such that power is supplied via an inverter apparatus which is not shown in the drawings and it is possible to be able to vary the driving capabilities by changing the output frequency (that is, the number of rotations) of the inverter apparatus.

(2-2-2) Four Way Switching Valve 22

[0049] The four way switching valve 22 switches the direction of the flow of refrigerant. The four way switching valve 22 connects the discharge side of the compressor 21 and the gas side of the outdoor heat exchanger 23 and connects the suction side of the compressor 21 and the gas refrigerant communication pipe 7 during cooling operation (refer to the solid line in the four way switching valve 22 in Fig. 2) so that the outdoor heat exchanger 23 functions as a condenser of the refrigerant and the indoor heat exchangers 42a, 42b, and 42c functions as an evaporator of the refrigerant.

[0050] In addition, the four way switching valve 22 connects the discharge side of the compressor 21 and the gas refrigerant communication pipe 7 and connects the suction side of the compressor 21 and the gas side of the outdoor heat exchanger 23 during heating operation (refer to the dashed line in the four way switching valve 22 in Fig. 2) so that the indoor heat exchangers 42a, 42b, and 42c functions as a condenser of the refrigerant and the outdoor heat exchanger 23 functions as an evaporator of the refrigerant.

(2-2-3) Outdoor Heat Exchanger 23

[0051] The outdoor heat exchanger 23 is a fin and tube type heat exchanger of the cross-fin type. Heat exchange is performed between refrigerant and outdoor air in the outdoor heat exchanger 23. The outdoor heat exchanger 23 functions as a condenser of the refrigerant during cooling operation and functions as an evaporator of the refrigerant during heating operation.

(2-2-4) Outdoor Fan 28

[0052] The outdoor fan 28 is provided in the vicinity of the outdoor heat exchanger 23 in order to send outdoor air to the outdoor heat exchanger 23. The outdoor fan 28 is driven to rotate by an outdoor fan motor 28a.

(2-2-5) Accumulator 24

[0053] The accumulator 24 is a tightly sealed container which connects between the four way switching valve 22 and the suction side of the compressor 21.

(2-2-6) Outdoor Expansion Valve 25

[0054] The outdoor expansion valve 25 is an electric expansion valve which is connected to the liquid side of the outdoor heat exchanger 23. The outdoor expansion valve 25 reduces the pressure of the refrigerant which flows in the outdoor side refrigerant circuit 10d.

(2-2-7) Liquid Side Shut-Off Valve 26 and Gas Side Shut-Off Valve 27

[0055] The liquid side shut-off valve 26 and the gas side shut-off valve 27 are valves which are provided at the connection opening with external equipment or piping (specifically, the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7). The liquid side shut-off valve 26 is connected to the outdoor expansion valve 25. The gas side shut-off valve 27 is connected to the four way switching valve 22.

(2-2-7) Various Types of Sensors

[0056] Various types of sensors are provided in the outdoor unit 2. A suction pressure sensor 29 detects suction pressure Ps in the compressor 21. A discharge pressure sensor 30 detects discharge pressure Pd in the compressor 21.

[0057] A suction temperature sensor 31 detects the suction temperature in the compressor 21. A discharge temperature sensor 32 detects the discharge temperature in the compressor 21. The suction temperature sensor 31 is provided at the input side of the accumulator 24. A liquid side temperature sensor 33 is provided on the liquid side of the outdoor heat exchanger 23 and detects the temperature of refrigerant which is in a liquid state or a gas-liquid two-phase state. An outdoor temperature sensor 34 is provided on the outdoor air suction opening side of the outdoor unit 2 and detects the outdoor temperature in the outdoor unit 2.

(2-2-8) Outdoor Side Control Section 35

[0058] An outdoor side control section 35 controls the actions of each section which configures the outdoor unit 2. The outdoor side control section 35 has a CPU, a memory, and an inverter circuit which controls the compressor 21, and is able to perform transferring of control signals and the like with the indoor side control sections 48a, 48b, and 48c in the indoor units 4a, 4b, and 4c.

(2-3) Control Section 8

[0059] Fig. 3 is a control block diagram of the air conditioning apparatus 1. First, a control section 8 which is described in Fig. 2 is general notation which includes the remote controllers 49a, 49b, and 49c, the indoor side control sections 48a, 48b, and 48c, and the outdoor side control section 35.

[0060] In Fig. 3, the control section 8 receives detection signals from each of the sensors 29 to 34, 45a to 45c, 46a to 46c, and 47a to 47c. In addition, the control section 8 controls each of the devices 21 a, 22, 25, 28a, 41 a to 41 c, and 44a to 44c based on these detection signals and the like and performs air conditioning driving (cooling operation and heating operation).

(3) Basic Actions of Air Conditioning Apparatus

[0061] The basic actions of the cooling operation and heating operation in the air conditioning apparatus 1 will be described.

(3-1) Cooling operation

[0062] The four way switching valve 22 being switched to the cooling operation state (the state which is indicated by the solid line in the four way switching valve 22 in Fig. 2), the compressor 21, the outdoor fan 28, and the indoor fans 43a, 43b, and 43c are activated by when instructing of cooling operation from the remote controllers 49a, 49b, and 49c is carried out.

[0063] Low-pressure gas refrigerant inside the refrigerant circuit 10 becomes high-pressure gas refrigerant due to being compressed by being sucked into the compressor 21. The high-pressure gas refrigerant is sent to the outdoor heat exchanger 23 via the four way switching valve 22.

[0064] The high-pressure gas refrigerant which is sent to the outdoor heat exchanger 23 is cooled and condensed by heat exchange being performed with outdoor air which is supplied from the outdoor fan 28 and becomes high-pressure liquid refrigerant in the outdoor heat exchanger 23. The high-pressure liquid refrigerant is sent from the outdoor unit 2 to the indoor units 4a, 4b, and 4c via the outdoor expansion valve 25, the liquid side shut-off valve 26, and the liquid refrigerant communication pipe 6.

[0065] The high-pressure liquid refrigerant becomes low-pressure refrigerant in a gas-liquid two-phase state by the pressure being reduced using the indoor expansion valves 41 a, 41 b, and 41 c in the indoor units 4a, 4b, and 4c. The low-pressure refrigerant in a gas-liquid two-phase state is sent to the indoor heat exchangers 42a, 42b, and 42c. At the indoor heat exchanger 42a, 42b and 42c, the low-pressure refrigerant in a gas-liquid two-phase state evaporates due to heat exchange performed with indoor air provided by the indoor fan 43a, 43b and 43c, and then becomes the low-pressure refrigerant. The low-pressure gas refrigerant is sent from the indoor units 4a, 4b, and 4c to the outdoor unit 2 via the gas refrigerant communication pipe 7.

[0066] The low-pressure gas refrigerant which is to the outdoor unit 2 is sent to the accumulator 24 via the gas side shut-off valve 27 and the four way switching valve 22. Then, the low-pressure gas refrigerant which is sent to the accumulator 24 is again sucked into the compressor 21.

(3-2) Heating operation

[0067] The compressor 21, the outdoor fan 28, and the indoor fans 43a, 43b, and 43c are activated by the four way switching valve 22 being switched to the heating operation state (the state which is indicated by the dashed line in the four way switching valve 22 in Fig. 2) when instructing of heating operation from the remote controllers 49a, 49b, and 49c is carried out.

[0068] Low-pressure gas refrigerant inside the refrigerant circuit 10 becomes high-pressure gas refrigerant due to being compressed by being sucked into the compressor 21. The high-pressure gas refrigerant is sent from the outdoor unit 2 to the indoor units 4a, 4b, and 4c via the four way switching valve 22, the gas side shut-off valve 27, and the gas refrigerant communication pipe 7.

[0069] The high-pressure gas refrigerant is sent to the indoor heat exchangers 42a, 42b, and 42c in the indoor unit 4a, 4b, and 4c. The high-pressure gas refrigerant is subject to condensation due to being cooled by heat exchange being performed with indoor air which is supplied from the indoor fan 43a, 43b, and 43c and becomes high-pressure liquid refrigerant in the indoor heat exchangers 42a, 42b, and 42c, and is sent to the outdoor unit 2.

[0070] The refrigerant is sent to the outside expansion valve 25 via the liquid side shut-off valve 26, is reduced the pressure by the outside expansion valve 25, becomes the low-pressure gas-liquid two-phase refrigerant. The low-pressure refrigerant in a state being in two phases of liquid and gas is sent to the outdoor heat exchangers 23. The low-pressure refrigerant in a state being in two phases of liquid and gas is subject to evaporation due to being heated by heat exchange being performed with outdoor air which is supplied from the outdoor fan 28 and becomes low-pressure gas refrigerant in the outdoor heat exchangers 23. The low-pressure gas refrigerant is sent to the accumulator 24 via the four way switching valve 22. Then, the low-pressure gas refrigerant which is sent to the accumulator 24 is again sucked into the compressor 21.

(4) Indoor Temperature Control Using Air Conditioning Apparatus

[0071] Indoor temperature control sets the permissible range (for example, ±1°C) with regard to setting temperatures Tras, Trbs, and Trcs of the respective indoor units 4a, 4b, and 4c and performs indoor thermo-off, indoor thermo-on, outdoor thermo-off, and outdoor thermo-on.

[0072] Here, indoor thermo-off is that the indoor unit is rested from air conditioning driving in a case where the indoor temperature reaches within the permissible range for the setting temperature when the indoor unit is performing air conditioning driving outside the permissible range for the setting temperature.

[0073] In addition, indoor thermo-on is that the indoor unit which is in the indoor thermo-off state restarts air conditioning driving of the corresponding indoor unit in a case where the indoor temperature is removed from the permissible range for the setting temperature.

[0074] Outdoor thermo-off is that the compressor 21 stops in a case where all of the indoor units which are performing air conditioning driving are in the indoor thermo-off state.

[0075] Outdoor thermo-on is that the compressor 21 is reactivated in a case where at least one of the indoor units becomes in the indoor thermo-on state in the outdoor thermo-off state.

[0076] Here, upper thresholds Trax, Trbx, and Trcx of the permissible ranges of the setting temperatures of the respective indoor units 4a, 4b, and 4c are values where upper limit latitudes ΔTax, Δtbx, and ΔTcx are added to the respective setting temperatures Tras, Trbs, and Trcs. In addition, lower thresholds Tran, Trbn, and Trcn of the permissible ranges of the setting temperatures of the respective indoor units 4a, 4b, and 4c are values where lower limit latitudes ΔTan, ΔTbn, and ΔTcn are subtracted from the respective setting temperatures Tras, Trbs, and Trcs.

(4-1) Case of when Cooling operation

[0077] When, for example, the indoor unit 4a performs cooling operation, the control section 8 is such that refrigerant does not flow in the indoor heat exchanger 42a due to the indoor expansions valve 41 a being closed off in a case where the indoor temperature Tra falls to the lower threshold Tran. Due to this, the indoor unit 4a switches to the indoor thermo-off state where heat exchange between refrigerant and indoor air is not performed.

[0078] Next, after the indoor unit 4a switches to the indoor thermo-off state, the control section 8 is such that refrigerant flows in the indoor heat exchanger 42a due to the indoor expansions valve 41 a being opened in a case where the indoor temperature Tra rises to the upper threshold Trax. Due to this, the indoor unit 4a switches to the indoor thermo-on state where heat exchange between refrigerant and indoor air is performed.

[0079] In addition, when the indoor units 4a, 4b and 4c perform cooling operation, the control section 8 stops refrigerant flowing inside the refrigerant circuit 10 by stopping the compressor 21 in a case where all of the indoor units 4a, 4b and 4c are in the indoor thermo-off state. Due to this, while instructing of driving for cooling operation is being carried out, the air conditioning apparatus 1 is in the outdoor thermo-off state where all of the cooling operation is stopped in practice.

[0080] Next, in the outdoor thermo-off state, the control section 8 is such that refrigerant flows inside the refrigerant circuit 10 and the indoor heat exchanger 42a due to the indoor expansion valve 41 a in the indoor unit 4a being opened and the compressor 21 being activated in a case where the indoor unit 4a is in the indoor thermo-on state. Due to this, the air conditioning apparatus 1 is in the outdoor thermo-on state and the indoor unit 4a is in the indoor thermo-on state.

(4-2) Case of when Heating operation

[0081] When, for example, the indoor unit 4a performs heating operation, the control section 8 is such that refrigerant does not flow in the indoor heat exchanger 42a due to the indoor expansions valve 41 a being closed off in a case where the indoor temperature Tra rises to the upper threshold Trax. Due to this, the indoor unit 4a switches to the indoor thermo-off state where heat exchange between refrigerant and indoor air is not performed.

[0082] Next, after the indoor unit 4a switches to the indoor thermo-off state, the control section 8 is such that refrigerant flows in the indoor heat exchanger 42a due to the indoor expansions valve 41 a being opened in a case where the indoor temperature Tra is lowered to the lower threshold Tran. Due to this, the indoor unit 4a switches to the indoor thermo-on state where heat exchange between refrigerant and indoor air is performed.

[0083] In addition, when the indoor units 4a, 4b and 4c perform heating operation, the control section 8 stops refrigerant flowing inside the refrigerant circuit 10 by stopping the compressor 21 in a case where all of the indoor units 4a, 4b and 4c are in the indoor thermo-off state. Due to this, while instructing of driving for heating operation is being carried out, the air conditioning apparatus 1 is in the outdoor thermo-off state where all of the heating operation is stopped in practice.

[0084] Next, in the outdoor thermo-off state, the control section 8 is such that refrigerant flows inside the refrigerant circuit 10 and the indoor heat exchanger 42a due to the indoor expansion valve 41 a in the indoor unit 4a being opened and the compressor 21 being activated in a case where the indoor unit 4a is in the indoor thermo-on state. Due to this, the air conditioning apparatus 1 is in the outdoor thermo-on state and the indoor unit 4a is in the indoor thermo-on state.

(5) Control where Start/stop operation is Avoided

[0085] Cooling capabilities and heating capabilities are appropriately controlled according to the air conditioning load due to indoor temperature control as described above such that indoor temperatures Tra, Trb, and Trc in the respective indoor units 4a, 4b, and 4c become the setting temperatures Tras, Trbs, and Trcs for the indoor temperatures in the respective indoor units 4a, 4b, and 4c.

(5-1) Problems when Load is Low

[0086] However, it is easy for there to be excess capabilities and the frequency of indoor thermo-off becomes large when the air conditioning load is low. There is a concern that outdoor thermo-off and outdoor thermo-on will be frequently repeated, that is, there will be start/stop operation, in particular, during intermediate periods such as spring and autumn, at mornings and in the evenings, and in cases where outside air load is low, and actual performance in a building will be remarkably lowered. This is described below using the drawings.

[0087] Fig. 4 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control and start/stop operation avoidance control during cooling operation.

[0088] As the assumed conditions in Fig. 4, the indoor unit 4a is arranged in room A, the indoor unit 4b is arranged in room B, and the indoor unit 4c is arranged in room C. The setting temperatures Tras, Trbs, and Trcs in the rooms A, B, and C are all 24°C and the permissible range is ±1°C. Accordingly, the upper thresholds Trax, Trbx, and Trcx are 25°C and the lower thresholds Tran, Trbn, and Trcn are 23°C.

[0089] The upper level in Fig. 4 is a diagram illustrating changes over time in the indoor thermo-on/off states when normal control is performed. Since the indoor units 4b and 4c in the rooms B and C are in the indoor thermo-off state even in a state where the indoor unit 4a in the room A is in the indoor thermo-on state after five minutes from a certain point in time as shown in the drawings, the air conditioning load is low, the compressor 21 performs low capabilities driving, and the indoor unit 4a switches to the indoor thermo-off state again after five minutes (a total of ten minutes).

[0090] At this time, the indoor temperatures in the rooms A, B, and C are all within the permissible range for the setting temperatures, the indoor units 4a, 4b, and 4c are all in the indoor thermo-off state, and there is the outdoor thermo-off state due to the compressor 21 being stopped.

[0091] After this, since the indoor unit 4b in the room B switches to the indoor thermo-on state, the compressor 21 is reactivated and there is the outdoor thermo-on state. In this manner, it is estimated that performance is remarkably lowered since low capabilities driving and stopping of the compressor are generated over short time intervals.

(5-2) Concept of Start/stop operation Avoidance Control

[0092] Therefore, in the air conditioning apparatus 1, the control section 8 performs control (referred to as start/stop operation avoidance control) where start/stop operation is avoided and lowering of performance is prevented.

[0093] The lower level in Fig. 4 is a diagram illustrating changes over time in the indoor thermo-on/off states when start/stop operation avoidance control is performed. Here, the room A is dominant in terms of air conditioning driving and the room B and C is in a subordinate relationship.

[0094] The indoor units 4b and 4c in the room B and C are originally in the indoor thermo-off state when the indoor unit 4a in the room A switches to the indoor thermo-on state after five minutes from a certain point of time. However, the indoor units 4b and 4c are forcibly switched to the indoor thermo-on state in order to avoid low capabilities driving of the compressor 21. Due to this, it is possible to avoid low capabilities driving since the number of rotations of the compressor 21 returns to the region where rotation control using an inverter is possible.

(5-3) Control Flow of Start/stop operation Avoidance Control

[0095] The actions during start/stop operation avoidance control in the air conditioning apparatus 1 will be described below following the "flow chart for start/stop operation avoidance control" which is illustrated in Fig. 5A and Fig. 5B.

[0096] First, the control section 8 determines whether or not air conditioning driving which is accompanied by operation of the compressor 21 is performed in step S1, the flow proceeds to step S2 when air conditioning driving is to be performed, and whether or not air conditioning driving which is accompanied by operation of the compressor 21 is to be performed is continually monitored when air conditioning driving is not to be performed.

[0097] Next, the control section 8 determines whether or not the outdoor unit 2 is in a state where start/stop operation seems likely in step S2, the flow proceeds to step S3 when it is determined that there is a state where start/stop operation seems likely, and whether or not the outdoor unit 2 is in a state where start/stop operation seems likely is continually monitored when it is determined that there is not a state where start/stop operation seems likely.

[0098] Here, the state where start/stop operation seems likely is a state where the number of rotations of the compressor 21 reaches a rated ratio of 20%. The specific conditions are assumed to be, for example, when one of the indoor units switches to the indoor thermo-on state and the outdoor unit 2 changes from the outdoor thermo-off state to the outdoor thermo-on state from when all of the indoor units are in the indoor thermo-off state.

[0099] In addition, the specific conditions are assumed to be when, although the outdoor unit 2 is in the outdoor thermo-on state, all of the indoor units seem likely to switch to the indoor thermo-off state after a certain period of time or when the driving settings for the indoor units change and one of the indoor units switches to the indoor thermo-on state.

[0100] Next, the control section 8 detects the indoor units which are in the indoor thermo-off state in step S3. This is necessarily detected since one or more of the indoor units are in the indoor thermo-off state when the outdoor unit 2 seems likely to switch to start/stop operation.

[0101] Next, the control section 8 switches the indoor units which are in the indoor thermo-off state to the indoor thermo-on state in step S4.

[0102] Next, the control section 8 determines again whether or not the outdoor unit 2 is in a state where start/stop operation seems likely in step S5, the flow proceeds to step S6 when it is determined that there is a state where start/stop operation seems likely, and whether or not the outdoor unit 2 is in a state where start/stop operation seems likely is continually monitored when it is determined that there is not a state where start/stop operation seems likely.

[0103] Next, the control section 8 calculates a consumed power prediction value Qs during start/stop operation and a consumed power prediction value Qc during continuous driving in step S6. The control section 8 calculates the consumed power prediction value Qs and the consumed power prediction value Qc based on at least the number of rotations of the compressor 21 and/or the difference between the indoor temperature and the outdoor temperature.

[0104] Next, the control section 8 determines whether or not the consumed power prediction value Qs during start/stop operation is greater than the consumed power prediction value Qc during continuous driving in step S7, the flow returns to step S3 when $Qs > Qc$, and the flow proceeds to step S8 when $Qs \leq Qc$.

[0105] Next, the control section 8 determines whether or not the compressor 21 is to be reactivated in step S8 after being stopped, the flow proceeds to step S9 when it is determined that the compressor 21 is to be reactivated, and whether or not the compressor 21 is to be reactivated is continually monitored when it is determined that the compressor 21 is not to be reactivated.

[0106] Next, the control section 8 detects the indoor units which are in the indoor thermo-off state in step S9.

[0107] Next, the control section 8 forcibly switches the indoor units to the indoor thermo-on state by giving priority to the indoor units, which are close to the upper threshold of the permissible range of the setting temperature among the detected indoor units which are in the thermo-off state, to the thermo-on state in step S10.

[0108] Next, the control section 8 calculates a total capacity Cr of the group of the indoor units which are in the thermo-on state in step S11.

[0109] Next, the control section 8 calculates a capacity Cc which is appropriate for high efficiency driving of the compressor 21 in step S12.

[0110] Next, the control section 8 determines whether or not the total capacity Cr of the group of the indoor units which is in the thermo-on state reaches the capacity Cc which is appropriate for high efficiency driving of the compressor 21 (that $Cr \geq Cc$) in step S13, the control ends when it is determined that it is the case that $Cr \geq Cc$ and the flow returns to step S9 when it is determined that it is not the case that $Cr \geq Cc$.

[0111] It is determined in step S13 whether or not the number of the indoor units which are forcibly switched to the indoor thermo-on state is separated from the ideal number of the indoor units which based on the characteristics of the compressor.

(6) Modified Examples

(6-1) Modified Example 1

[0112] Fig. 6 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control, start/stop operation avoidance control, and start/stop operation avoidance control according to modified example 1 during cooling operation.

[0113] The upper level of Fig. 6 is a diagram illustrating changes over time in the indoor thermo-on/off states in normal control, the middle level of Fig. 6 is a diagram illustrating changes over time in the indoor thermo-on/off states in start/stop operation avoidance control according to the embodiment described above, and the lower level of Fig. 6 is a diagram illustrating changes over time in the indoor thermo-on/off states in start/stop operation avoidance control according to modified example 1.

[0114] There are differences in the timings when the indoor units 4a, 4b, and 4c become the indoor thermo-off state in the pattern in the embodiment described above, but the control section 8 switches the indoor units 4b and 4c to the thermo-off state in the pattern in modified example 1 at a timing which is the same as the timing where the indoor unit 4a is switched to the thermo-off state by adjusting the opening of the indoor expansion valves 41 b and 41 c so that switching of the indoor units 4b and 4c to the indoor thermo-off state is delayed. Accordingly, it is possible for the compressor 21 to be normally operated with a number of rotations which is highly efficient.

(6-2) Modified Example 2

[0115] Fig. 7 is a diagram illustrating changes over time in the indoor thermo-on/off states in each of normal control, start/stop operation avoidance control, and start/stop operation avoidance control according to modified example 2 during cooling operation.

[0116] The upper level of Fig. 7 is a diagram illustrating changes over time in the indoor thermo-on/off states in normal control, the middle level of Fig. 7 is a diagram illustrating changes over time in the indoor thermo-on/off states in start/stop operation avoidance control according to the embodiment described above, and the lower level of Fig. 7 is a diagram illustrating changes over time in the indoor thermo-on/off states in start/stop operation avoidance control according to modified example 2.

[0117] In the pattern in modified example 2, the room A is set as the room where the air conditioning load is the largest and switching of the indoor thermo-on/off states of the indoor units 4b and 4c forcibly follows the indoor thermo-on/off states of the indoor unit 4a.

[0118] As shown in the lower level of Fig. 7, the indoor unit 4a firstly switches to the indoor thermo-on state and the indoor units 4b and 4c are forcibly switched to the indoor thermo-on state even if the room temperatures in the rooms B and C is to the extent of being 0.3 to 0.5 degrees lower than the setting temperature of 24°C. As a result, the indoor temperatures in the rooms B and C are controlled within a range which is narrower than the permissible range of the setting temperature.

(6-3) Modified Example 3

[0119] Since the air conditioning load typically varies due to the instillation conditions, the number of years of usage, and the like, monitoring of the designated data over a designated period may be performed in consideration of this variation, and system optimal riving points and an optimal driving algorithm may be constructed.

[0120] Here, the designated data is air conditioning driving data, atmospheric data, and building data. In addition, at least driving conditions, air conditioning load, and consumed power of the outside unit 2 and the indoor units 4a, 4b, and 4c are included in the air conditioning driving data.

[0121] At least the outside air temperature, humidity, weather forecast data are included in the atmospheric data. At least insulation performance, activity data such as the days which the building is in operation, refrigerant system data, and refrigerant piping lengths are included in the building characteristics data. The air conditioning driving state, the air conditioning load, and the consumed power, in a case where control with the method in the background art is continued, are predicted from the data described above (referred to below as the prediction logical for controlling in the background art).

[0122] At the same time as this, the air conditioning driving state, the air conditioning load, and the consumed power, in a case where start/stop operation avoidance control is executed, are predicted (referred to below as the prediction logical for start/stop operation avoidance controlling).

[0123] Here, the number of the indoor units in operation is reduced on the basis of the compressor characteristics in a case where the number of the indoor units in operation is large prior to the predicting. In addition, it is determined operating which is of the refrigerant systems is preferable in a case where there are a plurality of refrigerant systems in one room. Based on this, a control method for the indoor expansion valves 41 a, 41 b, and 41 c and a control method for the indoor fans 43a, 43b, and 43c are constructed in order for the time with which the indoor units which are driven are in the indoor thermo-on state to be the same and for the compressor 21 to be continually operated with high efficiency.

[0124] Then, energy saving effect is compared from the prediction logic for controlling in the background art and prediction logical for start/stop operation avoidance controlling and it is determined whether or not start/stop operation avoidance control is to be executed.

[0125] In this case, control is possible due to an external controller being connected with the outdoor unit 2 since there are concerns that the control section 8 which is already provided may have insufficient memory capacity.

(7) Characteristics

(7-1)

[0126] In the air conditioning apparatus 1, it is possible to suppress the outdoor unit 2 from being in a resting state or a low capacity state due to the number of rotations of the compressor 21 being returned to the region where rotation control using an inverter is possible by the indoor units which are in the thermo-off state among of the plurality of indoor units 4a, 4b, and 4c being forcibly switched to the thermo-on state since it is assumed that the number of rotations of the compressor 21 will be equal to or less than a region where rotation control using an inverter is possible when there is a low capabilities state where the outdoor unit 2 seems likely to switch to a resting state.

(7-2)

[0127] In the air conditioning apparatus 1, it is possible for the number of rotations of the compressor 21 to be returned to the region where rotation control using an inverter is possible and for low capabilities driving to be avoided due to the appropriate indoor units among the indoor units 4a, 4b, and 4c which are in the thermo-off state being forcibly switched to the thermo-on state during reactivating of the compressor 21 since it is estimated that low capabilities driving and stopping of the compressor 21 will be generated over short time intervals and performance will be remarkably reduced in a case where the outdoor thermo-on/off states are frequently repeated, that is, in a case of start/stop operation.

(7-3)

[0128] In the air conditioning apparatus 1, it is possible for the compressor 21 to be operated for a longer period of time in the region where rotation control using an inverter is possible since the indoor units are switched to the thermo-on state by giving priority to the indoor units which are close to the threshold of the permissible range of the setting temperature instead of the indoor units 4a, 4b, and 4c which are in the thermo-off state being randomly selected.

(7-4)

[0129] In the air conditioning apparatus 1, it is possible to prevent the number of the indoor units 4a, 4b, and 4c which are being operated from being needlessly increased due to being forcibly switched to the thermo-on state and to prevent separating of the number of the indoor units 4a, 4b, and 4c which are being operated from the ideal number of the indoor units 4a, 4b, and 4c to be operated based on the characteristics of the compressor.

(7-5)

[0130] In the air conditioning apparatus 1, it is possible to continue operating of the compressor 21 by returning the number of rotations of the compressor 21, which are equal to or less than the region where rotation control using an inverter is possible, to the region where rotation control is possible.

(7-6)

[0131] In the air conditioning apparatus 1, it is determined whether or not the indoor units which are in the thermo-off state are to be forcibly switched to the thermo-on state based on the prepotency seen from the point of view of the consumed power amount since it is not necessarily the case that efficiency of the compressor 21 will increase due to the number of the indoor units 4a, 4b, and 4c which are being operated being increased by being forcibly switched to the thermo-on state.

(7-7)

[0132] In the air conditioning apparatus 1, prediction accuracy is increased since the predicted value of the power consumption amount is calculated based on the number of rotations of the compressor 21 and/or the difference between the temperature of the control targets and the outside air temperature.

(7-8)

[0133] In the air conditioning apparatus 1, prediction accuracy is more logical since it is possible to calculate estimated values of the degree of insulating of the control targets and the internal load from the control history over a designated amount of time and to perform predicting of the power consumption amount in consideration of variance in the air conditioning load due to the instillation conditions, the number of years of usage, and the like.

(7-9)

[0134] In the air conditioning apparatus 1, it is possible to operate the compressor 21 with a highly efficient number of rotations since the indoor units 4b and 4c are switched to the thermo-off state at a timing which is the same as the timing where the indoor unit 4a where the load is large are switched to the thermo-off state.

(8) Other

[0135] In the embodiment described above, the air conditioning apparatus is described as an example of a refrigeration apparatus, but the invention of the present application is not limited to the air conditioning apparatus and it is possible to also apply the invention of the present application to, for example, a water heater which has a target of controlling to the same temperature.

[0136] Fig. 8 is a perspective diagram of a water heating apparatus 101 according to another embodiment of the present invention. The water heating apparatus 101 in Fig. 8 is provided with an outdoor unit 102, an indoor unit 104, a hot water storage tank 106, and a hot water valve 108.

[0137] A vapor compression type of refrigerant circuit is configured by the outdoor unit 102 and the indoor unit 104 being connected via a liquid refrigerant communication pipe and a gas refrigerant communication pipe. A water heat exchanger which performs heat exchange between high-temperature high-pressure refrigerant and water is arranged in the indoor unit 104 and the water which is heated there is supplied for a floor heater in room 1, a floor heater in room 2, and a radiator in room 3 via the hot water storage tank 106 and the hot water valve 108.

[0138] Accordingly, it is easy for outdoor thermo-off and outdoor thermo-on of the outdoor unit 102 to be frequently repeated, that is, for there to be start/stop operation in a case where variance in the temperature of the high-temperature water, which is used in the hot water storage tank 106, the floor heater in room 1, the floor heater in room 2, and the radiator in room 3, is small and the load is low.

[0139] That is, it is possible to perform the same control with a diagnosis where the water temperature in the hot water storage tank 106, the floor heater in room 1, the floor heater in room 2, and the radiator in room 3 are respectively the indoor temperatures in the rooms A, B, and C which are the control targets in the embodiment described above.

[0140] That is, it is possible for the load rate to be improved and for the system COP to be improved due to driving to boil water in the hot water storage tank 106 or forcibly opening the hot water valve 108 in the floor heaters or the radiator in a case where low load driving is predicted.

INDUSTRIAL APPLICABILITY

[0141] As described above, the refrigeration apparatus according to the present invention is effective as an air conditioning apparatus and a water heating apparatus.

REFERENCE SIGNS LIST

[0142]

1	AIR CONDITIONING APPARATUS (REFRIGERATION APPARATUS)
2	OUTDOOR UNIT (HEAT SOURCE UNIT)
4a, 4b, 4c	INDOOR UNIT (UTILIZING UNIT)
8	CONTROL SECTION
21	COMPRESSOR
41a, 41b, 41c	INDOOR EXPANSION VALVE

CITATION LIST

PATENT LITERATURE

[0143] Patent Literature 1: Japanese Laid-open Patent Application No. 2002-61925

Claims

1. A refrigeration apparatus, which performs temperature control such that each temperature of a plurality of control targets is within permissible ranges for setting temperatures which are set in advance utilizing a vapor compression type of cooling cycle, comprising:

   a plurality of utilizing units (4a, 4b, 4c) which heat or cool each of the control targets;
   a heat source unit (2) which is mounted with a compressor (21) and is connected to the plurality of utilizing units (4a, 4b, 4c); and
   a control section (8) which is configured to control the utilizing units (4a, 4b, 4c) and the heat source unit (2) such that the temperatures of the control targets reach within the permissible ranges for the setting temperatures,
   wherein the control section (8) is configured to switch the status of the utilizing units (4a, 4b, 4c) from a thermo-on state to a thermo-off state when the temperatures of the control targets reach within the permissible ranges for the setting temperatures,
   the thermos-on state being a state where refrigerant is flowing, and the thermo-off state being a state where movement of refrigerant inside the utilizing units (4a, 4b, 4c) stops without the heat source unit (2) being rested,
   the control section (8) is configured to switch the heat source unit (2) to a resting state by stopping the compressor (21) when the all of the utilizing units (4a, 4b, 4c) which are being operated are switched to the thermo-off state, and
   the control section (8) is configured to forcibly switch the utilizing units which are in the thermo-off state among of the plurality of utilizing units (4a, 4b, 4c) to the thermo-on state when there is a low capabilities state where the heat source unit (2) seems likely to switch to a resting state.

2. The refrigeration apparatus according to claim 1, wherein
   the control section (8) is configured to forcibly switch the utilizing units, which satisfy designated conditions among of the remaining of the plurality of utilizing units (4a, 4b, 4c) which are in the thermo-off state, to the thermo-on state in addition to the utilizing units (4a, 4b, 4c) which are in the thermo-on state when the compressor (21) is driven again in a case where the heat source unit (2) is in the resting state.

3. The refrigeration apparatus according to claim 2, wherein
   a first threshold, which is a threshold for the control section (8) to perform determining of switching the utilizing units (4a, 4b, 4c) which are in the thermo-off state to the thermo-on state, and
   a second threshold, which is a threshold for the control section (8) to perform determining of switching the utilizing units (4a, 4b, 4c) which are in the thermo-on state to the thermo-off state, are set as the setting temperatures, and
   the control section (8) is configured to forcibly switch the utilizing units to the thermo-on state by giving priority to the utilizing units, which are close to the first threshold of the setting temperature, among the group of the utilizing units (4a, 4b, 4c) which are in the thermo-off state.

4. The refrigeration apparatus according to claim 2, wherein
   the control section (8) is configured not to perform control such that the remaining of the utilizing units (4a, 4b, 4c) are forcibly switched to the thermo-on state, after the total capacity of the group of the utilizing units (4a, 4b, 4c) which are the thermo-on state reaches the capacity which is appropriate for high

efficiency driving of the compressor (21).

5. The refrigeration apparatus according to claim 1, wherein a first threshold and a second threshold are set as the setting temperatures, the first threshold being a threshold for the control section (8) to perform determining of switching the utilizing units (4a, 4b, 4c) which are in the thermo-off state to the thermo-on state, and the second threshold being a threshold for the control section (8) to perform determining of switching the utilizing units (4a, 4b, 4c) which are in the thermo-on state to the thermo-off state, and the control section (8) is configured to forcibly switch the utilizing units, which are close to the first threshold of the setting temperature among the group of the utilizing units (4a, 4b, 4c) in the thermo-off state, to the thermo-on state when the group of the utilizing units (4a, 4b, 4c) in the thermo-on state are close to the conditions of being switched to the thermo-off state.

6. The refrigeration apparatus according to claim 1, wherein the control section (8) is configured to predict the power consumption amount in a case where the remaining of the utilizing units (4a, 4b, 4c) in the thermo-off state are forcibly switched to the thermo-on state and in a case where the remaining of the utilizing units (4a, 4b, 4c) in the thermo-off state are not switched to the thermo-on state, and to perform determining of whether or not to forcibly switch the remaining of the utilizing units (4a, 4b, 4c) in the thermo-off state to the thermo-on state.

7. The refrigeration apparatus according to claim 6, wherein the control section (8) is configured to perform predicting of the power consumption amount based on at least the driving frequency of the compressor (21) and/or the difference between the temperature of the control targets and the outside air temperature.

8. The refrigeration apparatus according to claim 6, wherein the control section (8) is configured to maintain controlling which is performed with regard to the control targets and the results of the controlling as control history, calculate estimated values of the degree of insulating of the control targets and the internal load from the control history over a designated amount of time, and perform predicting of the power consumption amount.

9. The refrigeration apparatus according to claim 1, wherein each of the utilizing units (4a, 4b, 4c) has an expansion valve which reduces the pressure of refrigerant which flows in the utilizing units (4a, 4b, 4c) during cooling operation, and the control section (8) is configured to adjust the openings of the expansion valves (41 a, 41 b, 41 c) in a direction so that switching to the thermo-off state is delayed, the expansion valves (41 a, 41 b, 41 c) corresponding to the utilizing units (4a, 4b, 4c) which are forcibly switched to the thermo-on state.

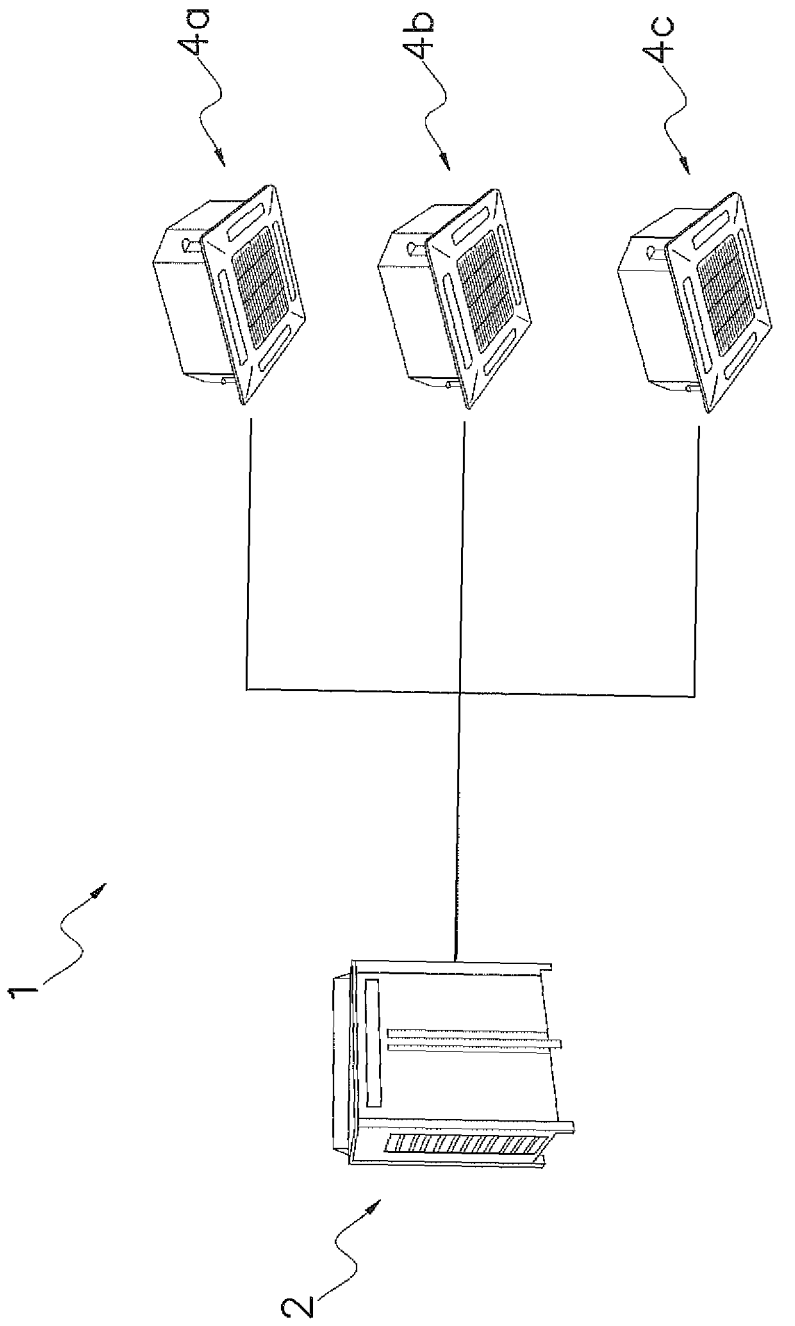
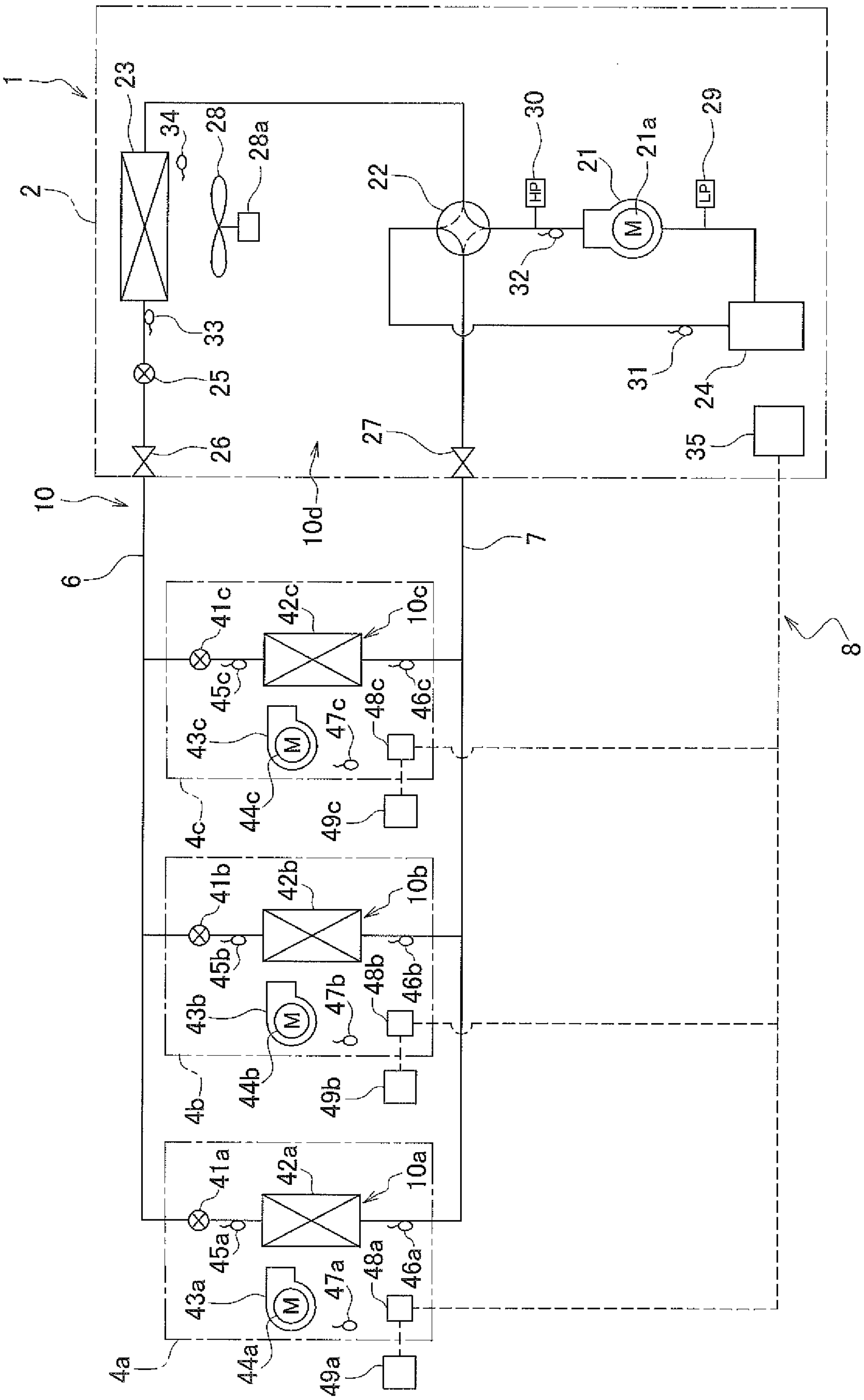


FIG. 1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10a
45a
46a
43a
48a
47a
4a
44a
49a

FIG. 2

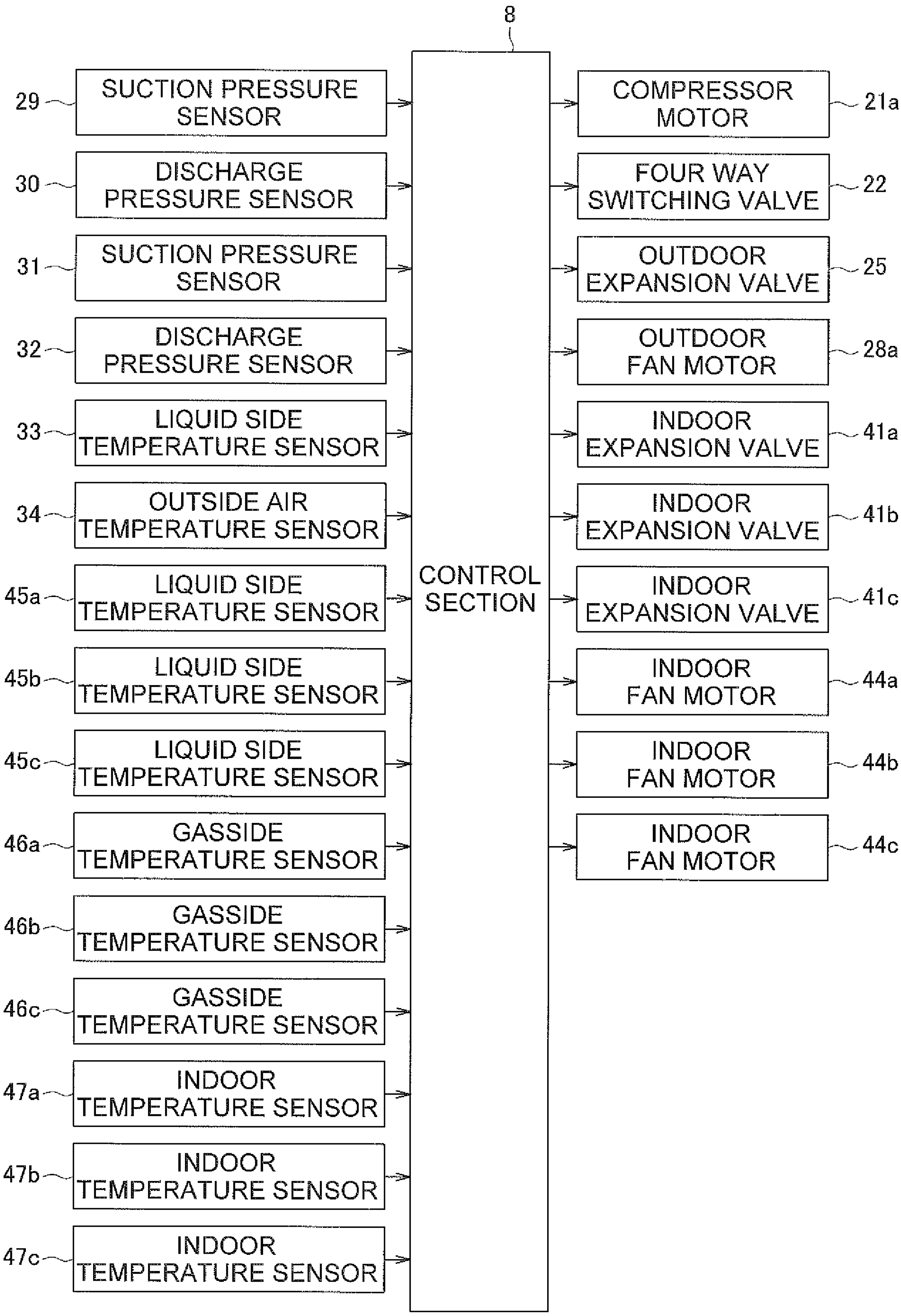

8
29
SUCTION PRESSURE SENSOR
30
DISCHARGE PRESSURE SENSOR
31
SUCTION PRESSURE SENSOR
32
DISCHARGE PRESSURE SENSOR
33
LIQUID SIDE TEMPERATURE SENSOR
34
OUTSIDE AIR TEMPERATURE SENSOR
45a
LIQUID SIDE TEMPERATURE SENSOR
45b
LIQUID SIDE TEMPERATURE SENSOR
45c
LIQUID SIDE TEMPERATURE SENSOR
46a
GASSIDE TEMPERATURE SENSOR
46b
GASSIDE TEMPERATURE SENSOR
46c
GASSIDE TEMPERATURE SENSOR
47a
INDOOR TEMPERATURE SENSOR
47b
INDOOR TEMPERATURE SENSOR
47c
INDOOR TEMPERATURE SENSOR
CONTROL SECTION
COMPRESSOR MOTOR
21a
FOUR WAY SWITCHING VALVE
22
OUTDOOR EXPANSION VALVE
25
OUTDOOR FAN MOTOR
28a
INDOOR EXPANSION VALVE
41a
INDOOR EXPANSION VALVE
41b
INDOOR EXPANSION VALVE
41c
INDOOR FAN MOTOR
44a
INDOOR FAN MOTOR
44b
INDOOR FAN MOTOR
44c

FIG. 3

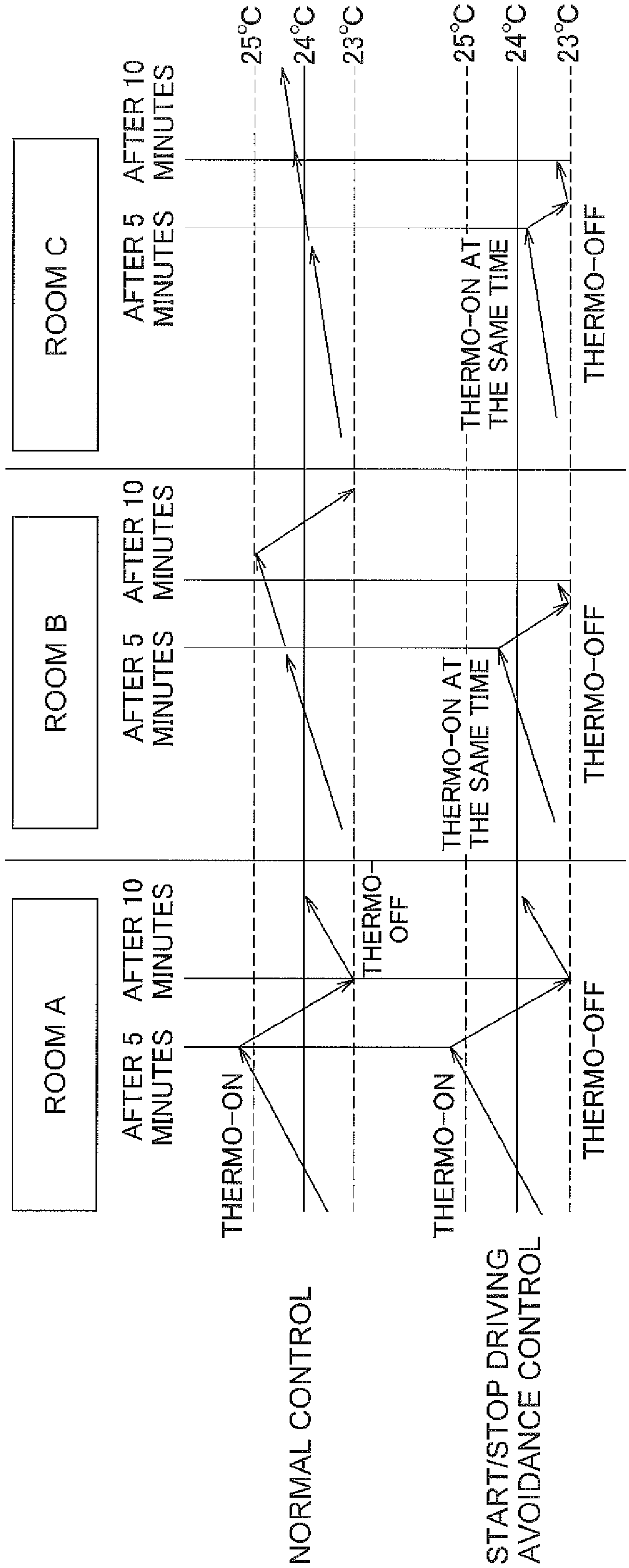

ROOM A
ROOM B
ROOM C
AFTER 5 MINUTES
AFTER 10 MINUTES
AFTER 5 MINUTES
AFTER 10 MINUTES
AFTER 5 MINUTES
AFTER 10 MINUTES
25°C
24°C
23°C
25°C
24°C
23°C
NORMAL CONTROL
THERMO-ON
THERMO-OFF
START/STOP DRIVING AVOIDANCE CONTROL
THERMO-ON
THERMO-OFF
THERMO-ON AT THE SAME TIME
THERMO-OFF
THERMO-ON AT THE SAME TIME
THERMO-OFF

FIG. 4

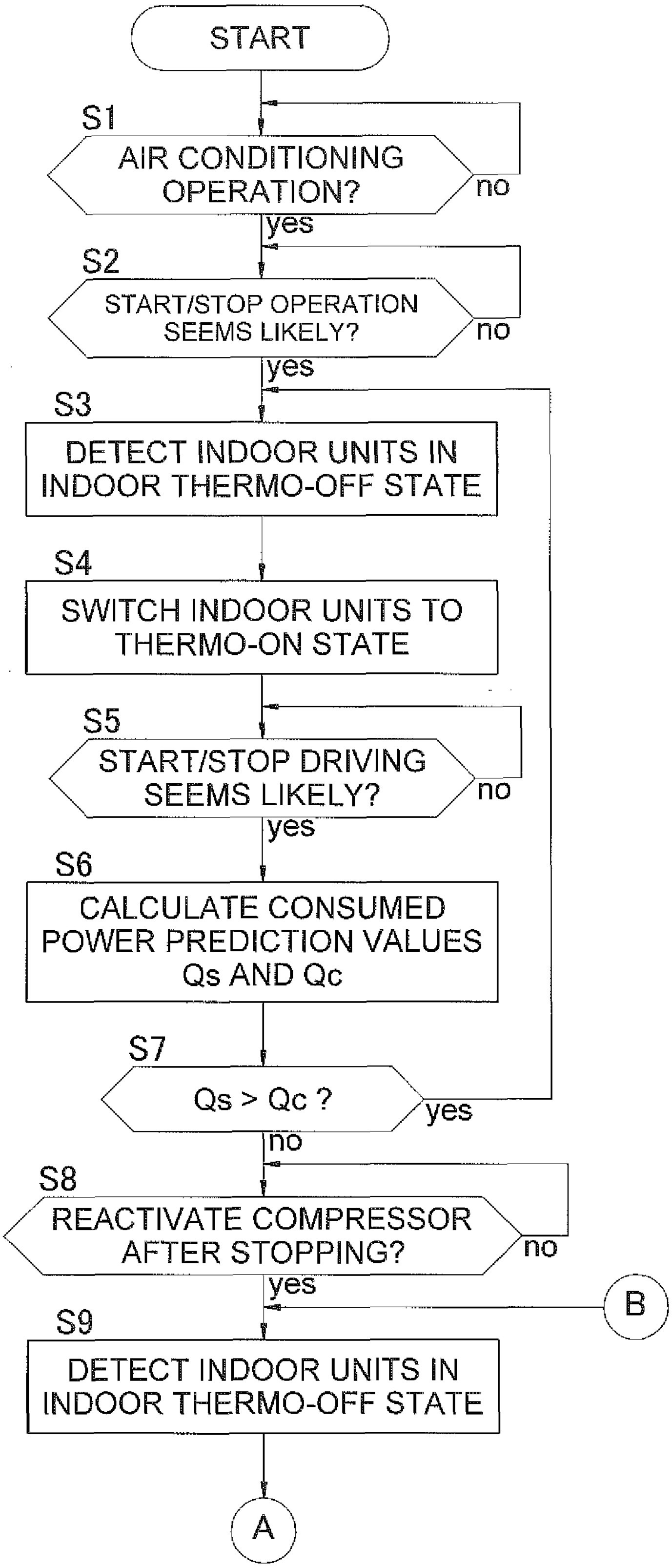

START
S1
AIR CONDITIONING OPERATION?
no
yes
S2
START/STOP OPERATION SEEMS LIKELY?
no
yes
S3
DETECT INDOOR UNITS IN INDOOR THERMO-OFF STATE
S4
SWITCH INDOOR UNITS TO THERMO-ON STATE
S5
START/STOP DRIVING SEEMS LIKELY?
no
yes
S6
CALCULATE CONSUMED POWER PREDICTION VALUES Qs AND Qc
S7
Qs > Qc ?
yes
no
S8
REACTIVATE COMPRESSOR AFTER STOPPING?
no
yes
B
S9
DETECT INDOOR UNITS IN INDOOR THERMO-OFF STATE
A

FIG. 5A

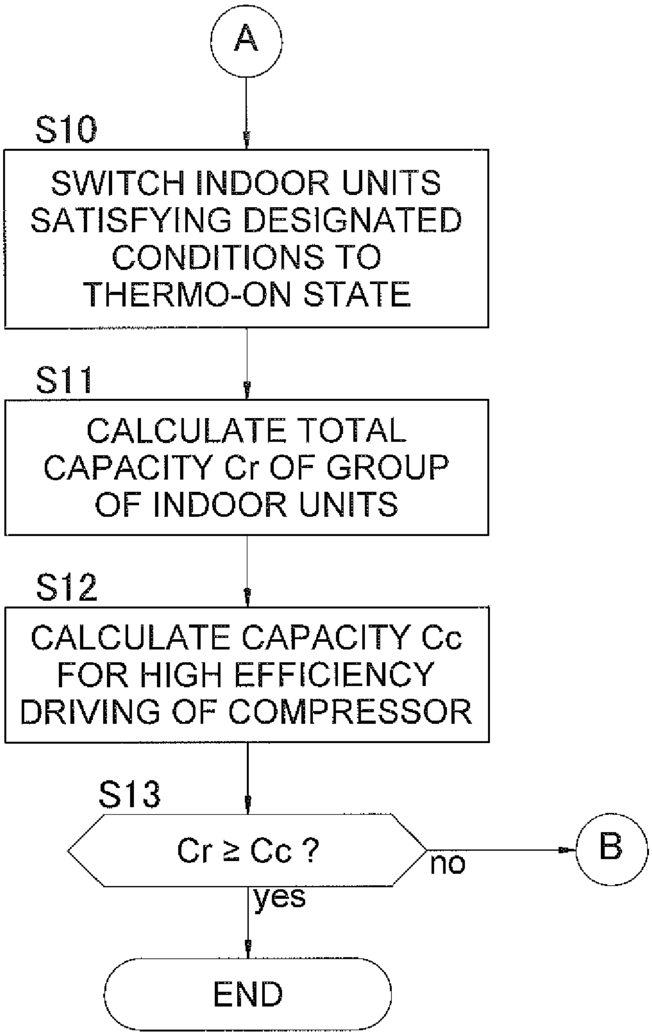
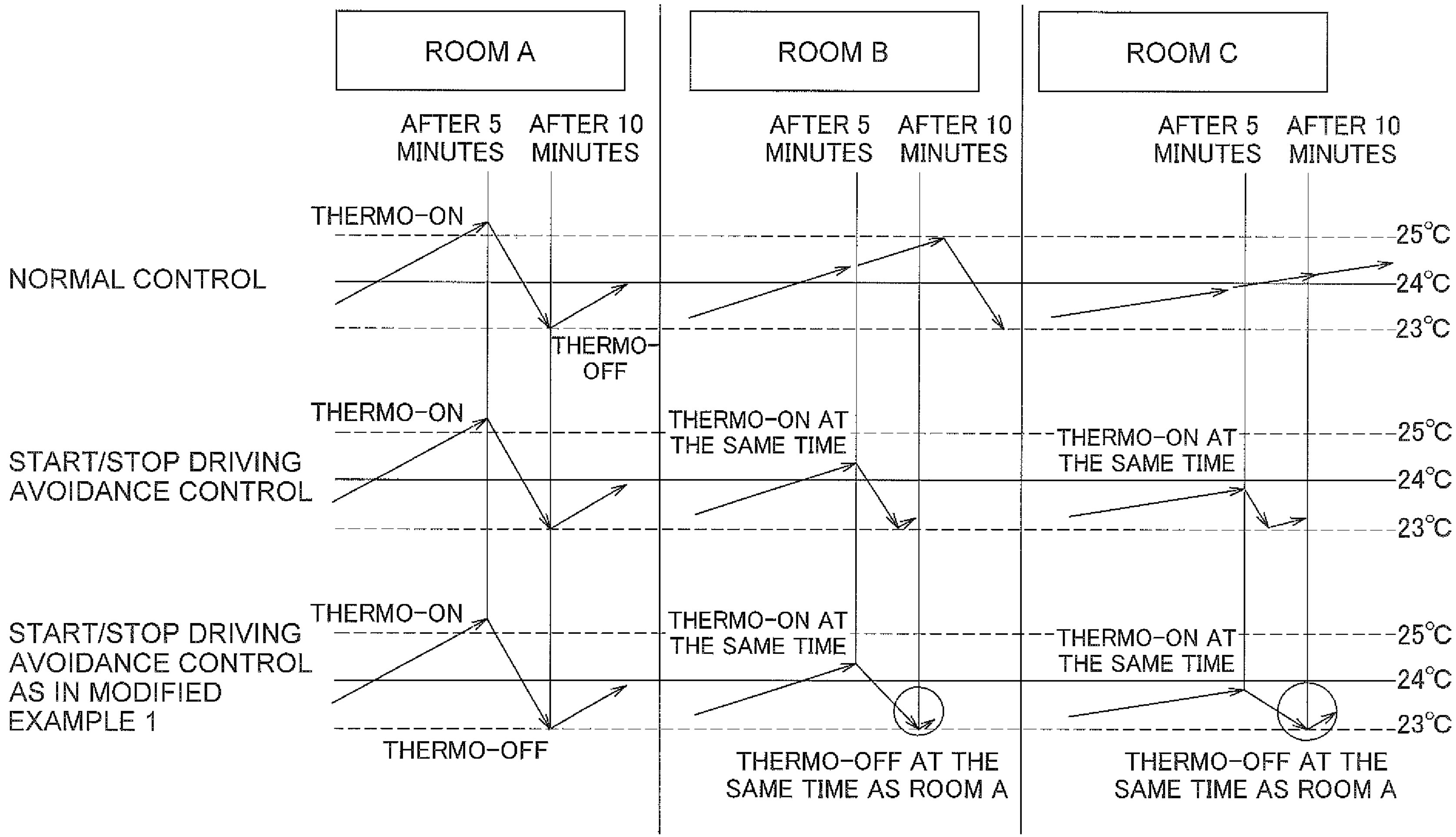

A
S10
SWITCH INDOOR UNITS SATISFYING DESIGNATED CONDITIONS TO THERMO-ON STATE
S11
CALCULATE TOTAL CAPACITY Cr OF GROUP OF INDOOR UNITS
S12
CALCULATE CAPACITY Cc FOR HIGH EFFICIENCY DRIVING OF COMPRESSOR
S13
Cr ≥ Cc ?
no
B
yes
END

FIG. 5B



ROOM A
ROOM B
ROOM C
AFTER 5 MINUTES
AFTER 10 MINUTES
NORMAL CONTROL
START/STOP DRIVING AVOIDANCE CONTROL
START/STOP DRIVING AVOIDANCE CONTROL AS IN MODIFIED EXAMPLE 1
THERMO-ON
THERMO-OFF
THERMO-ON AT THE SAME TIME
THERMO-OFF AT THE SAME TIME AS ROOM A
25°C
24°C
23°C

FIG. 6

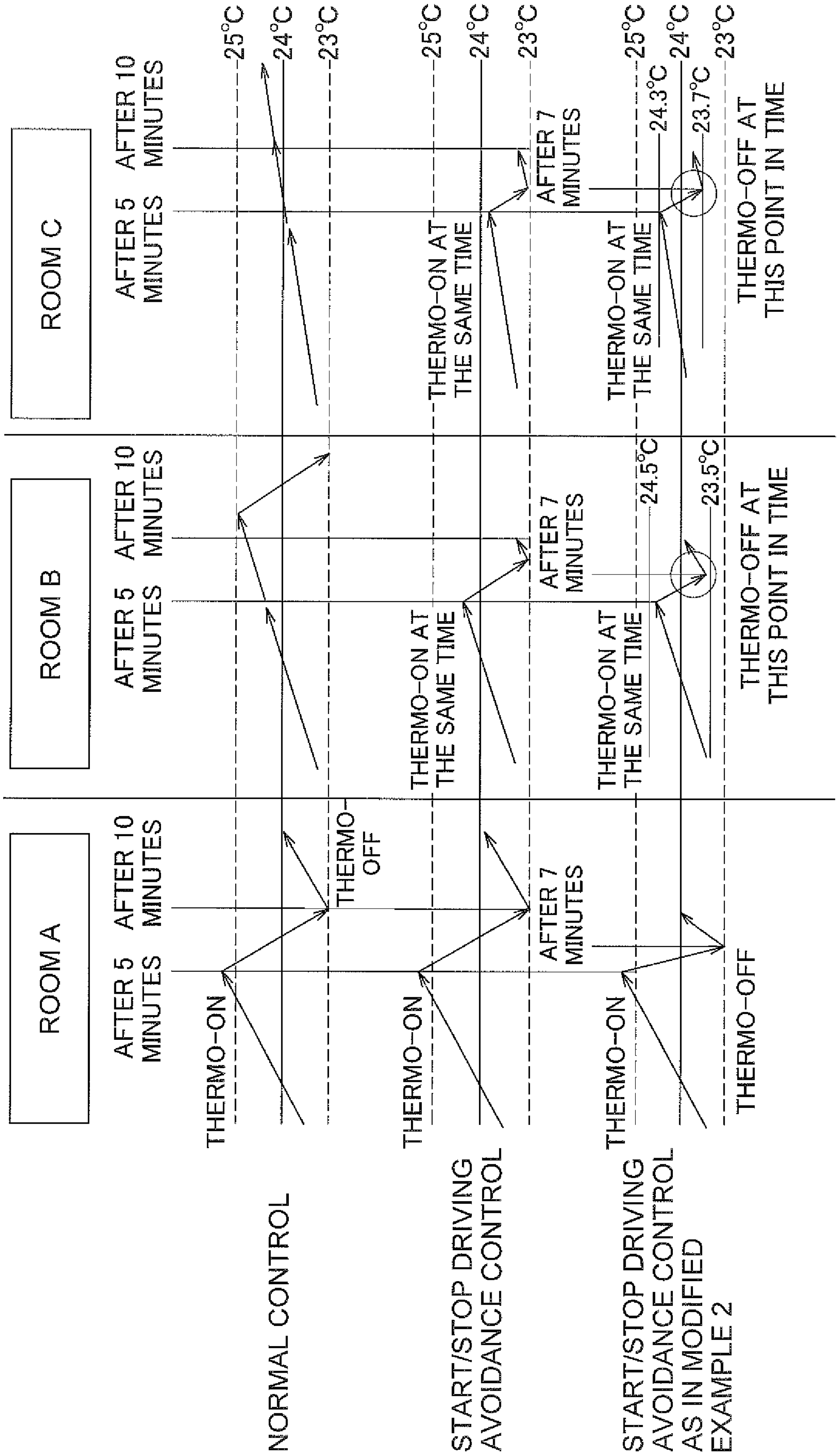

ROOM A
ROOM B
ROOM C
AFTER 5 MINUTES
AFTER 10 MINUTES
AFTER 7 MINUTES
THERMO-ON
THERMO-OFF
THERMO-ON AT THE SAME TIME
THERMO-OFF AT THIS POINT IN TIME
25°C
24°C
23°C
24.5°C
23.5°C
24.3°C
23.7°C
NORMAL CONTROL
START/STOP DRIVING AVOIDANCE CONTROL
START/STOP DRIVING AVOIDANCE CONTROL AS IN MODIFIED EXAMPLE 2

FIG. 7

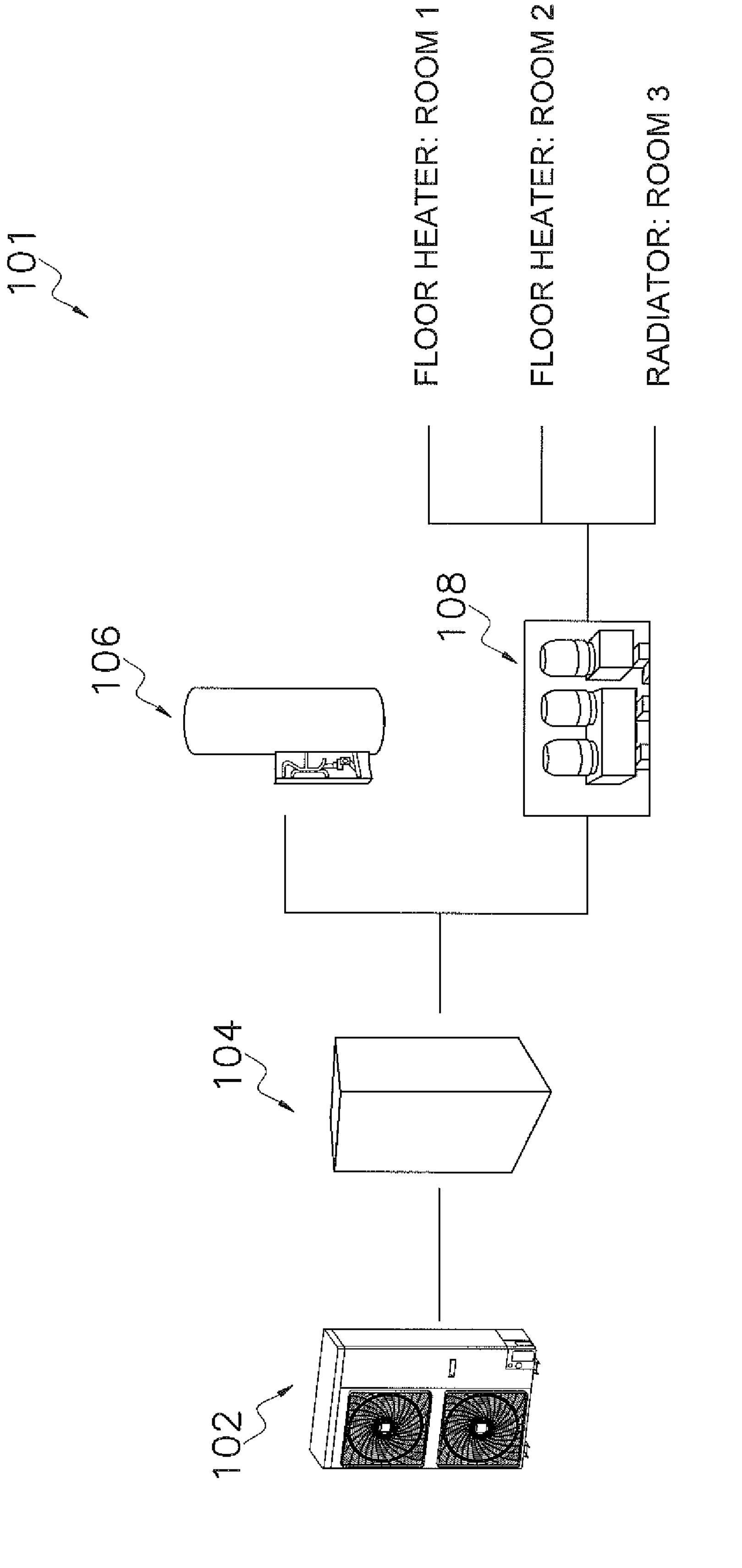

101
106
108
104
102
FLOOR HEATER: ROOM 1
FLOOR HEATER: ROOM 2
RADIATOR: ROOM 3

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/052737

A. CLASSIFICATION OF SUBJECT MATTER
F25B13/00(2006.01)i, *F25B1/00*(2006.01)i, *F25B29/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B13/00, F25B1/00, F25B29/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2012-233689 A (Mitsubishi Electric Corp.), 29 November 2012 (29.11.2012), paragraphs [0027] to [0030]; fig. 2, 3 (Family: none)	1 2-9
Y A	WO 2009/119150 A1 (Mitsubishi Electric Corp.), 01 October 2009 (01.10.2009), claim 9; paragraph [0028] & EP 2256422 A1 & CN 101946131 A	1 2-9
A	JP 2011-226767 A (Daikin Industries, Ltd.), 10 November 2011 (10.11.2011), paragraph [0075] (Family: none)	1-9

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
01 May, 2013 (01.05.13)	14 May, 2013 (14.05.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/052737

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-228297 A (Daikin Industries, Ltd.), 14 August 2002 (14.08.2002), paragraph [0004] (Family: none)	1-9
A	JP 2005-241195 A (Sanyo Electric Co., Ltd.), 08 September 2005 (08.09.2005), claim 2; paragraphs [0063] to [0080] (Family: none)	1-9

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Patent documents cited in the description

- JP 2002061925 A **[0004] [0143]**