(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 067 765 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
05.10.2022 Bulletin 2022/40

(21) Application number: **19954508.8**

(22) Date of filing: **29.11.2019**

(51) International Patent Classification (IPC):
F24F 11/32 *(2018.01)* ***F24F 5/00*** *(2006.01)*
F24F 11/64 *(2018.01)* ***F25B 1/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F24F 5/00; F24F 11/32; F24F 11/64; F25B 1/00

(86) International application number:
PCT/JP2019/046796

(87) International publication number:
WO 2021/106193 (03.06.2021 Gazette 2021/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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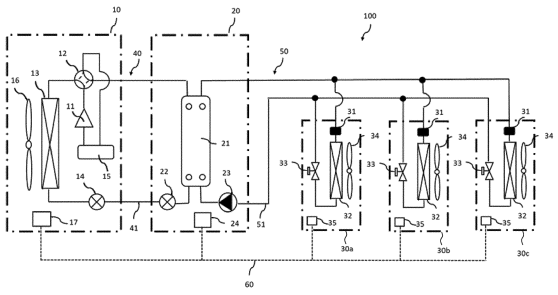
(54) AIR-CONDITIONING SYSTEM AND METHOD FOR CONTROLLING SAME

(57) An air-conditioning system includes: a heat source apparatus; a plurality of indoor units; a relay device; a refrigerant circuit; and a heat medium circuit, the heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger. The indoor units each include an indoor-side heat exchanger. The relay device includes a pump and an inter-medium heat exchanger. In the refrigerant circuit, the compressor, the flow switching valve, the heat-source-side heat exchanger, and the inter-medium heat exchanger are connected by refrigerant pipes and refrigerant is circulated. In the heat medium circuit, the pump, the inter-medium heat exchanger, and the indoor-side heat exchanger of each of the plurality of indoor units are connected by heat medium pipes and a heat medium is circulated. The air-conditioning system further includes: flow-rate detection devices each provided in an associated one of the plurality of indoor units, and each detect flow-rate information regarding a flow rate of the heat medium in the associated indoor unit; and a controller that controls, when the flow-rate information detected by the flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off, an operation of at least one of the compressor, the pump, and the control target indoor unit.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to an air-conditioning system in which a heat source apparatus and a plurality of indoor units are connected via a relay device, and to a method of controlling the air-conditioning system.

Background Art

[0002] An air-conditioning system in which a plurality of indoor units individually perform a heating operation or a cooling operation has a refrigerant circuit and a structure in which heating energy, cooling energy, or both heating energy and cooling energy that are produced by a heat source apparatus, for example, are efficiently supplied to a plurality of loads. Such an air-conditioning system is adopted as, for example, a central air-conditioning system for use in, for example, a building or a hotel that has a large number of air-conditioned spaces.

[0003] In an existing central air-conditioning system, for example, a heat source apparatus is installed outdoors, indoor units are installed indoors, and the heat source apparatus and the indoor units are connected via a relay device. In such an air-conditioning system, a refrigerant pipe through which refrigerant circulates is provided between the heat source apparatus and the relay device, and heat medium pipes through which a heat medium, such as water or brine, circulates, are provided between the relay device and the respective indoor units. In the refrigerant pipe, refrigerant is circulated, and in the heat medium pipe, a heat medium is circulated, whereby a cooling operation or a heating operation is performed. To be more specific, air that is cooled by refrigerant when the refrigerant receives heat from the air or that is heated by the refrigerant when the refrigerant transfers heat to the air exchanges heat with a heat medium that circulates between the relay device and each of the indoor units, thereby performing the cooling operation or the heating operation on each of air-conditioned spaces.

[0004] In the air-conditioning system, in the case where an outage of a heat medium occurs in an indoor unit because of occurrence of a failure, such as freezing of an indoor heat exchanger, if the operation of the indoor unit continues, there is a possibility that a failure, such as non-cooling or non-heating, may occur. This is because the air-conditioning system does not have a function of detecting a water outage of each of the indoor units, although the air-conditioning system can detect a water outage at the entire heat-medium pipes that connect detect the indoor units and the relay unit that is located on the secondary side in a region between the heat source apparatus and the relay unit.

[0005] In view of the above, an air-conditioning system is proposed that includes a sensor that detects a state of an air-conditioned space that is a parameter for controlling air-conditioning, and a plurality of adjustment devices each of which adjusts the flow rate of a heat medium supplied to the air-conditioned space based on information from the sensor (see Patent Literature 1, for example). In such an air-conditioning system, the sensor and the plurality of adjustment devices are collectively controlled, a collective control device that controls the supply flow rate of a heat medium is provided, the respective adjustment devices and the collective control device are capable of wirelessly communicating with each other, and the volume of cooling/heating air or the flow rate of cooling/heating water of an air-conditioning apparatus is controlled. Therefore, in the air-conditioning system disclosed in Patent Literature 1, it is possible to detect occurrence of a water outage at each of the indoor units.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2005-249238

Summary of Invention

Technical Problem

[0007] However, in the air-conditioning system disclosed in Patent Literature 1, a central monitoring device and the collective control device control each of the adjustment devices via a wireless communication. Therefore, although electric wiring can be simplified, it is necessary to construct a control system that uses a central monitoring device and a collective control device.

[0008] The present disclosure is applied to solve the above problem. According to the present disclosure, it is possible to specify an indoor unit in which an air outage occurs from among a plurality of indoor units on the basis of the flow rate of a heat medium, and also detect a failure, without constructing a new control system, by controlling the pump, the compressor, or the indoor unit. Furthermore, the present disclosure relates to an air-conditioning system that can solve, by stopping an indoor unit in which an abnormality occurs, a problem that a failure, such as non-cooling or non-heating, would occur if the indoor unit continued to operate, and also to a method of controlling the air-conditioning system.

Solution to Problem

[0009] An air-conditioning system according to an embodiment of the present application includes: a heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger; a plurality of indoor units each including an indoor-side heat exchanger; a relay device including a pump and an intermedium heat exchanger; a refrigerant circuit formed by connecting the compressor, the flow switching valve, the

heat-source-side heat exchanger, and the inter-medium heat exchanger via a refrigerant pipe, refrigerant circulating through the refrigerant circuit; and a heat medium ci An air-conditioning system comprising: a heat source apparatus; a plurality of indoor units; a relay device; a refrigerant circuit; and a heat medium circuit, the heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger, the plurality of indoor units each including an indoor-side heat exchanger, the relay device including a pump and an inter-medium heat exchanger; the refrigerant circuit being provided as a circuit in which the compressor, the flow switching valve, the heat-source-side heat exchanger, and the inter-medium heat exchanger are connected by refrigerant pipes and refrigerant is circulated, the heat medium circuit being provided as a circuit in which the pump, the inter-medium heat exchanger, and the indoor-side heat exchanger of each of the plurality of indoor units are connected by heat medium pipes and a heat medium is circulated. The air-conditioning system further includes: flow-rate detection devices each provided in an associated one of the plurality of indoor units, and each configured to detect flow-rate information regarding a flow rate of the heat medium in the associated indoor unit; and a controller configured to control, when the flow-rate information detected by the flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off, an operation of at least one of the compressor, the pump, and the control target indoor unit.

[0010] A method of controlling an air-conditioning system, according to another embodiment of present application, includes steps as described below. The air-conditioning system includes a heat source apparatus; a plurality of indoor units; a relay device; a refrigerant circuit; and a heat medium circuit, the heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger, the plurality of indoor units each including an indoor-side heat exchanger, the relay device including a pump and an inter-medium heat exchanger; the refrigerant circuit being provided as a circuit in which the compressor, the flow switching valve, the heat-source-side heat exchanger, and the inter-medium heat exchanger are connected by refrigerant pipes and refrigerant is circulated, the heat medium circuit being provided as a circuit in which the pump, the inter-medium heat exchanger, and the indoor-side heat exchanger of each of the plurality of indoor units are connected by heat medium pipes and a heat medium is circulated. The method includes: detecting flow-rate information regarding a flow rate of the heat medium in each of the plurality of indoor units, using an associated one of a plurality of flow-rate detection devices provided in the plurality of indoor units; and controlling an operation of at least one of the compressor, the pump, or the control target indoor unit, using a controller provided in at least one of the heat source apparatus, the relay device, and the plurality of indoor units, in the case where the flow-rate information detected using the plurality of flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off.

Advantageous Effects of Invention

[0011] According to the embodiment of the present disclosure, in the case where flow-rate information detected by the flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off, the operation of at least one of the compressor, the pump, or the control target indoor unit is controlled, and it is therefore possible to detect a failure without constructing a new control system. Furthermore, by stopping the indoor unit in which an abnormality occurs, it is possible to solve a problem in which a failure, such as non-cooling or non-heating, would occur when such an indoor unit continued to operate.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is circuit diagram illustrating an air-conditioning system according to Embodiment 1.
[Fig. 2] Fig. 2 is a block diagram for explanation of a relay control device of the air-conditioning system according to Embodiment 1.
[Fig. 3] Fig. 3 is a flowchart indicating an operation of the air-conditioning system according to Embodiment 1.

Description of Embodiment

Embodiment 1

[0013] An air-conditioning system and a method of controlling the air-conditioning system, both according to the embodiment of the present disclosure, will be described with reference to the accompanying drawings. Configurations as illustrated in the drawings are examples, and illustrations of the configurations are not limiting. In each of figures, components that are the same as or equivalent to those in a previous figure or previous figures are denoted by the same reference signs, and the same is true of the entire text of the present specification. Furthermore, the configurations of components described in the entire text of the present specification are examples, and descriptions of the configurations are not limiting.

<Air-Conditioning System 100>

[0014] Fig. 1 is a circuit diagram illustrating an air-conditioning system 100 according to Embodiment 1. The air-conditioning system 100 will be described with reference to Fig. 1. As illustrated in Fig. 1, the air-conditioning system 100 includes a heat source apparatus 10, a relay device 20, and a plurality of indoor units 30a, 30b, and 30c. It should be noted that Embodiment 1 will be described by referring to by way of example the case where three indoor units 30a, 30b, and 30c are connected to one heat source apparatus 10. However, the number of heat source apparatuses 10 may be two or more. Furthermore, the number of indoor units may be three or more. In addition, the plurality of indoor units 30a, 30b, and 30c may have the same capacity or may have different capacities.

[0015] As illustrated in Fig. 1, the air-conditioning system 100 is configured such that the heat source apparatus 10, the relay device 20, and the indoor units 30a, 30b, and 30c are connected. The heat source apparatus 10 has a function of suppling heating energy or cooling energy to the three indoor units 30a, 30b, and 30c via the relay device 20. The three indoor units 30a, 30b, and 30c are connected in parallel, and have the same configuration. Each of the indoor units 30a, 30b, and 30c has a function of performing a cooling operation or a heating operation in an associated room, which is an air-conditioned space, with heating energy or cooling energy supplied from the heat source apparatus 10. The relay device 20 is interposed between the heat source apparatus 10 and the indoor units 30a, 30b, and 30c, and has a function of switching the flow of refrigerant supplied from the heat source apparatus 10 in response to a request from each of the indoor units 30a, 30b, and 30c.

(Heat Source Apparatus 10)

[0016] The heat source apparatus 10 includes a compressor 11 having a variable capacity, a flow switching valve 12, a heat-source-side heat exchanger 13, a heat-source-side expansion device 14, and an accumulator 15. The flow switching valve 12 switches the flow direction of refrigerant in the heat source apparatus 10. The heat-source-side heat exchanger 13 serves as an evaporator or a condenser. The heat source apparatus 10 also includes a heat-source-side fan 16 and a heat-source-side control device 17. The heat-source-side fan 16 sends outside air to the heat-source-side heat exchanger 13. The heat-source-side control device 17 controls the operation of the heat source apparatus 10.

[0017] The compressor 11 includes a compressor motor that is driven by an inverter, for example. The compressor 11 sucks and compresses refrigerant. The flow switching valve 12 is connected to the compressor 11, and is controlled by the heat-source-side control device 17 to switch the flow passage for refrigerant.

[0018] The heat-source-side fan 16 varies the amount of air that is sent to the heat-source-side heat exchanger 13, to control a heat exchange capacity.

[0019] The heat-source-side control device 17 controls operations of the compressor 11, the flow switching valve 12, and the heat-source-side expansion device 14. The heat-source-side control device 17 can communicate in data with a relay control device 24 of the relay device 20 and with an indoor-side control device 35 of each of the indoor units 30a, 30b, and 30c.

[0020] Although in this example, the flow switching valve 12 is a four-way valve, the flow switching valve 12 may be formed by combining two-way valves, three-way valves, or other valves. Furthermore, in the case where frost forms on the heat-source-side heat exchanger 13 during the heating operation, the heat source apparatus 10 performs a defrosting operation.

(Relay Device 20)

[0021] The relay device 20 includes an inter-medium heat exchanger 21, a relay expansion device 22, a pump 23, and the relay control device 24. The relay device 20 is interposed between the heat source apparatus 10 and the indoor units 30a, 30b, and 30c. The relay device 20 has a function of switching the flow of refrigerant supplied from the heat source apparatus 10, in response to a request from each of the indoor units 30a, 30b, and 30c, and distributing heating energy or cooling energy supplied from the heat source apparatus 10 to the plurality of indoor units 30a, 30b, and 30c.

[0022] The air-conditioning system 100 includes a refrigerant circuit 40 in which refrigerant circulates. In the refrigerant circuit 40, the compressor 11, the flow switching valve 12, the heat-source-side heat exchanger 13, the heat-source-side expansion device 14, the relay expansion device 22, the inter-medium heat exchanger 21, and the accumulator 15 are provided, and are connected by refrigerant pipes 41. That is, the heat source apparatus 10 and the relay device 20 are connected by the refrigerant pipe 41.

[0023] The inter-medium heat exchanger 21 is, for example, a plate type heat exchanger, and is connected between the refrigerant circuit 40 and a heat medium circuit 50, which will be described later. The inter-medium heat exchanger 21 causes heat exchange to be performed between the refrigerant that circulates in the refrigerant circuit 40 and a heat medium that circulates in the heat medium circuit 50. The relay expansion device 22 is, for example, an electronic expansion valve, and decompresses the refrigerant to expand the refrigerant. The relay expansion device 22 is provided between the heat-source-side heat exchanger 13 and the inter-medium heat exchanger 21 in the refrigerant circuit 40.

[0024] The pump 23 includes a motor (not illustrated) that is driven by an inverter, for example. The pump 23 is driven by the motor, which serves as a power source, and causes the heat medium in the heat medium circuit 50 to circulate. That is, the pump 23 is controlled by the

relay control device 24, and applies a pressure to cause the heat medium to circulate in the heat medium circuit 50.

[0025] The relay control device 24 controls operations of the relay expansion device 22 and the pump 23. In addition, the relay control device 24 can control operations of the compressor 11 and the heat-source-side expansion device 14 via the heat-source-side control device 17. In Embodiment 1, based on flow-rate information from flow switches 31, which will be described later, the relay control device 24 controls the operations of the compressor 11 and the pump 23 in conjunction with the heat-source-side control device 17 and each indoor-side control device 35 to improve an energy efficiency. That is, the relay control device 24 performs a centralized control of the air-conditioning system 100.

(Indoor Units 30a, 30b, and 30c)

[0026] Each of the indoor units 30a, 30b, and 30c is, for example, a fan coil unit, and is provided with the flow switch 31, which serves as a flow-rate detection device. Each of the indoor units 30a, 30b, and 30c includes an indoor-side heat exchanger 32 and a flow control valve 33. The indoor-side heat exchanger 32 serves as a condenser or an evaporator. The flow control valve 33 adjusts the flow rate of the heat medium. Each of the indoor units 30a, 30b, and 30c also includes an indoor-side fan 34 and the indoor-side control device 35. The indoor-side fan 34 sends indoor air to the indoor-side heat exchanger 32. The indoor units 30a, 30b, and 30c have a function of performing the cooling operation or the heating operation in a room, with cooling energy or heating energy supplied from the heat source apparatus 10.

[0027] The air-conditioning system 100 includes the heat medium circuit 50 in which the heat medium circulates. In the heat medium circuit 50, the inter-medium heat exchanger 21, the pump 23, the indoor-side heat exchanger 32 of each of the indoor units 30a, 30b, and 30c, and the flow control valve 33 of each of the indoor units 30a, 30b, and 30c are provided, and are connected by heat medium pipes 51. That is, the relay device 20 and the indoor units 30a, 30b, and 30c are connected by the heat medium pipes 51.

[0028] The flow switches 31 are provided upstream of the indoor-side heat exchangers 32, and detect flow-rate information regarding the flow rates of a heat medium that flows into the indoor units 30a, 30b, and 30c. This flow-rate information includes the value of the flow rate of a heat medium that actually flows through the heat medium pipe 51, and abnormal flow-rate information indicating the presence of a control target indoor unit that is an indoor unit to be controlled of the indoor units 30a, 30b, and 30c (for example, an indoor unit 30a) in which the flow of a heat medium is cut off.

[0029] The indoor-side heat exchanger 32 is, for example, a fin-and-tube heat exchanger, and causes heat exchange to be performed between the heat medium that flows in the heat medium circuit 50 and indoor air. The flow control valve 33 is, for example, a motor-operated ball valve, and adjusts the flow rate of a heat medium that is made to flow into the indoor-side heat exchanger 32. During the cooling operation, the flow control valve 33 is controlled by the indoor-side control device 35 on the basis of a superheat amount on an outlet side of the indoor-side heat exchanger 32. During the heating operation, the flow control valve 33 is controlled by the indoor-side control device 35 on the basis of a subcooling amount on the outlet side of the indoor-side heat exchanger 32.

[0030] In each of the indoor units 30a, 30b, and 30c, the indoor-side control device 35 controls the opening degree of the flow control valve 33 on the basis of the difference between a temperature in a room and a target temperature therefor, for example, and the indoor-side control device 35 outputs opening-degree information indicating the value of the opening degree of the flow control valve 33 to the relay control device 24, for example. The relay control device 24 controls the operation of the pump 23 to adjust the flow rate of the heat medium based on the opening-degree information.

[0031] In the air-conditioning system 100 having the above configuration, the heat-source-side control device 17 of the heat source apparatus 10, the relay control device 24 of the relay device 20, and the indoor-side control device 35 of each of the indoor units 30a, 30b, and 30c are capable of communicate with each other via a control communication line 60. The control communication line 60 may be a wireless communication line.

[0032] For example, in the indoor unit 30a, when the flow switch 31 detects abnormal flow-rate information indicating that the flow rate of a heat medium is reduced to a value lower than a threshold, the indoor-side control device 35 transmits the abnormal flow-rate information to the heat-source-side control device 17 and the relay control device 24 via the control communication line 60. Furthermore, the indoor-side control device 35 stops the indoor-side fan 34 of the indoor unit 30a, which is a control target indoor unit for which the abnormal flow-rate information is detected, to prevent occurrence of a failure, such as non-cooling or non-heating, and closes the flow control valve 33 of the control target indoor unit 30a to prevent an inflow of the heat medium.

[0033] It should be noted that regarding Embodiment 1, it is described above by way of example that the heat-source-side control device 17 is provided in the heat source apparatus 10, the relay control device 24 is provided in the relay device 20, and the indoor-side control devices 35 are provided in the indoor units 30a, 30b, and 30c. However, a single control device may be provided in one of the heat source apparatus 10, the relay device 20, or the indoor unit 30a, 30b, or 30c. In such a case, the above control is performed by the single control device provided in one of the heat source apparatus 10, the relay device 20, and the indoor unit 30a, 30b, or 30c.

(Refrigerant and Heat Medium)

[0034] In the air-conditioning system 100, the refrigerant pipe 41 is filled with refrigerant. As the refrigerant, any of the following refrigerants is used: natural refrigerant, such as carbon dioxide (CO_2), hydrocarbon, or helium; chlorofluorocarbon substitute refrigerant that does not contain chlorine, such as HFC410A, HFC407C, or HFC404A; or a fluorocarbon refrigerant, such as R22 or R134a, for use in existing products. It should be noted that HFC407C is a zeotropic refrigerant mixture where R32, R125, and R134a of HFC are mixed at respective ratios of 23 wt%, 25 wt%, and 52 wt%. In the air-conditioning system 100, the heat medium pipe 51 is filed with a heat medium. The heat medium is, for example, water or brine.

[0035] Next, the relay control device 24 will be described with reference to Fig. 2. Fig. 2 is a block diagram for use in explanation of the relay control device 24 of the air-conditioning system 100 according to Embodiment 1. As illustrated in Fig. 2, the relay control device 24 includes a flow-rate arithmetic unit 241, a temperature-difference arithmetic unit 242, a capacity arithmetic unit 243, and a criterion flow-rate value storage unit 244.

[0036] The flow-rate arithmetic unit 241 calculates the flow rate of the heat medium that circulates in the heat medium circuit 50 on the basis of a pressure difference obtained from the results of detection by a pump inlet pressure sensor 25 and a pump outlet pressure sensor 26. At the heat medium pipe 51, the pump inlet pressure sensor 25 is provided on the inlet side of the pump 23, and the pump outlet pressure sensor 26 is provided on the outlet side of the pump 23.

[0037] The temperature-difference arithmetic unit 242 calculates a difference between temperatures of the heat medium that circulates in the heat medium circuit 50 before and after heat exchange, on the basis of the results of detection by a water inlet temperature sensor 27 and a water outlet temperature sensor 28. At the heat medium pipe 51, the water inlet temperature sensor 27 is provided on the inlet side of the inter-medium heat exchanger 21, and the water outlet temperature sensor 28 is provided on the outlet side of the inter-medium heat exchanger 21.

[0038] Based on the difference between the temperatures of the heat medium between before and after the heat exchange, which is calculated by the temperature-difference arithmetic unit 242, and the flow rate of the heat medium, which is calculated by the flow-rate arithmetic unit 241, the capacity arithmetic unit 243 calculates an operating capacity for cooling or heating by the heat medium which circulates such that the calculated temperature difference is made and circulates at the calculated flow rate. The capacity arithmetic unit 243 also calculates an operating capacity required for cooling or heating by the indoor units 30a to 30c, which are control targets. That is, as an operating capacity required for cooling or heating by the control target indoor units 30a to 30, the capacity arithmetic unit 243 holds a threshold for the flow rate that is applied as a reference for determination whether to increase or decrease the rotation speed of the compressor 11. When the operating capacity for cooling or heating by the heat medium which circulates such that the calculated temperature difference is made exceeds the operating capacity required for cooling or heating by the control target indoor units 30a to 30c, the capacity arithmetic unit 243 causes the heat-source-side control device 17 to decrease the frequency of the compressor 11. In contrast, when the operating capacity for cooling or heating by the heat medium, which is subjected to the heat exchange such that the calculated temperature difference is made, is below the operating capacity required for cooling or heating by the control target indoor units 30a to 30c, the capacity arithmetic unit 243 causes the heat-source-side control device 17 to increase the frequency of the compressor 11.

[0039] The criterion flow-rate value storage unit 244 stores the threshold for flow rate which is applied as the reference for determination whether to increase or decrease the rotation speed of the pump 23 (which will hereinafter be referred to as "pump control threshold"). In Embodiment 1, two pump control thresholds are set as a first criterion flow-rate value and a second criterion flow-rate value. The first criterion flow-rate value is set for the case where a water outage occurs at two of the three indoor units 30a to 30c. The second criterion flow-rate value is set for a case where a water outage occurs at one of the three indoor units 30a to 30c.

[0040] The criterion flow-rate value storage unit 244 stores a threshold for flow rate which is applied as a reference for determination whether to close the flow control valve 33 of each of the indoor units 30a, 30b, and 30c (which will hereinafter be referred to as "control valve threshold"). The criterion flow-rate value storage unit 244 also stores a threshold for the flow rate that is applied as a reference for determination whether to increase or decrease the rotation speed of the indoor-side fans 34 (which will hereinafter be referred to as "fan threshold").

[0041] When flow-rate information detected by the flow switches 31 and received from the indoor-side control devices 35 is abnormal flow-rate information indicating that the flow rate is lower than the pump control threshold including the above first and second criterion flow-rate values, the relay control device 24 decreases an output of the pump 23. When a water outage occurs at all of the three indoor units 30a to 30c, the pump 23 is stopped.

[0042] As described above, in the air-conditioning system 100, when flow-rate information detected by the flow switches 31 is abnormal flow-rate information, the relay control device 24 controls the indoor-side control devices 35 based on the abnormal flow-rate information received from the heat-source-side control device 17. The indoor-side control device 35 controls at least one operation of the control target indoor unit that is the indoor unit 30a in the above case. By virtue of the above feature, it is possible to specify the control target indoor unit 30a in which the flow of a heat medium is cut off, and it is possible

to stop the flow of a heat medium in the indoor unit 30a. That is, in the air-conditioning system 100, it is possible to detect a failure without constructing a new control system. Furthermore, by stopping the indoor unit 30a in which an abnormality occurs, it is also possible to solve a problem in which a failure, such as non-cooling or non-heating, would occur when such an indoor unit 30a continued to operate.

[0043] Also, when receiving abnormal flow-rate information detected by the flow switches 31, from the indoor-side control devices 35 via the relay control device 24, the heat-source-side control device 17 controls the operation of the compressor 11. Furthermore, when receiving the abnormal flow-rate information detected by the flow switches 31, from the indoor-side control devices 35, the relay control device 24 controls the operation of the pump 23. Under these controls, it is possible to cause the heat medium to flow in the indoor units other than the control target indoor unit 30a, that is, the indoor units 30b and 30c, at a proper flow rate, and thus possible to prevent occurrence of a failure, such as non-cooling or non-heating, at the indoor units 30b and 30c. In addition, even in the case where an abnormality also occurs at the indoor unit 30b or 30c in addition to the indoor unit 30a, it is possible to improve the energy efficiency by controlling the flow rate at the compressor 11 or the pump 23. As described above, in the air-conditioning system 100, it is possible to improve the energy efficiency by performing a control according to the operation state of the entire air-conditioning system 100.

[0044] Next, the operation of the air-conditioning system 100 will be described. The air-conditioning system 100 has a cooling only operation and a heating only operation as operation modes. The cooling only operation is a mode where all of the indoor units 30a, 30b, and 30c perform the cooling operation. The heating only operation is a mode where all of the indoor units 30a, 30b, and 30c perform the heating operation.

(Cooling Only Operation)

[0045] First of all, the cooling only operation will be described. In the air-conditioning system 100, all the indoor units 30a, 30b, and 30c perform the cooling operation. High-temperature and high-pressure gas refrigerant discharged from the compressor 11 passes through the flow switching valve 12, and flows into the heat-source-side heat exchanger 13. At the heat-source-side heat exchanger 13, the high-temperature and high-pressure gas refrigerant exchanges heat with air that is sent by the heat-source-side fan 16, thereby condensing and liquefying. It should be noted that the heat-source-side fan 16 can vary the amount of air that the heat-source-side fan 16 sends. Thereafter, the refrigerant passes through the heat-source-side expansion device 14 and the relay expansion device 22 in this order, and flows into the inter-medium heat exchanger 21. The refrigerant that has flowed into the inter-medium heat exchanger 21 is decompressed to a low pressure by the heat-source-side control device 17 that is controlled based on a superheat amount on the outlet side of the inter-medium heat exchanger 21. At the inter-medium heat exchanger 21, the refrigerant that has been decompressed exchanges heat with a heat medium that circulates in the heat medium circuit 50, thereby evaporating and gasifying. Thus, rooms in which the indoor units 30a, 30b, and 30c are installed are cooled. The refrigerant that has gasified is sucked by the compressor 11 via the accumulator 15.

[0046] In contrast, at the inter-medium heat exchanger 21, the heat medium exchanges heat with the refrigerant that has been decompressed to a low pressure, and is thus cooled such that the heat medium is sufficiently subcooled. The heat medium then passes through the heat medium pipe 51 and flows into the indoor units 30a, 30b, and 30c when the indoor units 30a, 30b, and 30c are ready to perform the cooling operation. The heat-source-side control device 17 adjusts the capacity of the compressor 11 having a variable capacity and an air sending amount of the heat-source-side fan 16 that is the amount of air that the heat-source-side fan 16 sends, such that an evaporating temperature in the indoor units 30a, 30b, and 30c and a condensing temperature in the heat-source-side heat exchanger 13 reach respective target temperatures determined in advance. Therefore, each of the indoor units 30a, 30b, and 30c can obtain a target cooling capacity.

(Heating Only Operation)

[0047] Next, the heating only operation will be described. In the air-conditioning system 100, all the indoor units 30a, 30b, and 30c perform the heating operation. High-temperature and high-pressure gas refrigerant discharged from the compressor 11 passes through the flow switching valve 12 and flows into the inter-medium heat exchanger 21. The refrigerant that has flowed into the inter-medium heat exchanger 21 exchanges heat with a heat medium that has exchanged heat with indoor air at each of the indoor-side heat exchangers 32, thereby condensing and liquefying. The refrigerant that has condensed and liquefied passes through the relay expansion device 22 and the heat-source-side expansion device 14 in this order, and is thus decompressed to change into low-pressure two-phase gas-liquid refrigerant.

[0048] The low-pressure two-phase gas-liquid refrigerant flows into the heat-source-side heat exchanger 13, and is caused to exchange heat with air sent by the heat-source-side fan 16, which can vary the air sending amount thereof, thereby evaporating. The refrigerant that has evaporated and gasified is sucked by the compressor 11 via the flow switching valve 12 and the accumulator 15.

[0049] In contrast, the heat medium that has exchanged heat with the high-temperature and high-pressure gas refrigerant at the inter-medium heat exchanger 21 passes through the heat medium pipe 51 and flows into the indoor units 30a, 30b, and 30c that are ready to

perform the heating operation. The heat-source-side control device 17 adjusts the capacity of the compressor 11 having a variable capacity and the air sending amount of the heat-source-side fan 16 such that an evaporating temperature in the indoor units 30a, 30b, and 30c and a condensing temperature in the heat-source-side heat exchanger 13 reach respective target temperatures determined in advance. Therefore, each of the indoor units 30a, 30b, and 30c can obtain a target heating capacity.

[0050] Next, it will be described how the heat-source-side control device 17, the relay control device 24, and each indoor-side control device 35 are operated in the case where the flow switches 31 detect abnormal flow-rate information indicating the presence of a control target indoor unit in which the flow of a heat medium is cut off, and which is one of the indoor units 30a, 30b, and 30c, that is, the control target indoor unit 30a in the above case. Fig. 3 is a flowchart illustrating the operation of the air-conditioning system 100 according to Embodiment 1.

[0051] As illustrated in Fig. 3, the indoor-side control devices 35 confirm flow-rate information regarding the heat medium in the indoor units 30a, 30b, and 30c that is detected by the flow switches 31 (step S1). Then, it is determined whether the detected flow-rate information includes abnormal flow-rate information (information on water outage of the heat medium in Embodiment 1) indicating the presence of a control target indoor unit in which the flow of a heat medium is cut off, and which is one of the indoor units 30a, 30b, and 30c, that is, the control target indoor unit 30a in the above case.

[0052] When it is determined that the flow-rate information does not include abnormal flow-rate information (N in step S2), the process returns to step S1, and the flow switches 31 re-detect flow-rate information regarding the heat medium in the indoor units 30a, 30b, and 30c.

[0053] When the flow-rate information includes abnormal flow-rate information (Y in step S2), it is determined that of the indoor units 30a, 30b, and 30c, a control target indoor unit, that is, the indoor unit 30a in the above case, in which the flow of a heat medium is cut off is present. Then, the indoor-side fan 34 of the control target indoor unit 30a for which the abnormal flow-rate information is detected is stopped (step S3), and the flow control valve 33 of the control target indoor unit 30a for which the abnormal flow-rate information is detected is closed (step S4). As a result, it is possible to specify the control target indoor unit 30a in which the flow of the heat medium is cut off, and it is possible to stop the flow of the heat medium in the indoor unit 30a.

[0054] Next, a required flow rate of the heat medium in the indoor units 30b and 30c excluding the control target indoor unit 30a is calculated (step S5), and it is determined whether or not the required flow rate exceeds the second criterion flow-rate value that is a threshold for the flow rate of the heat medium that is determined in advance (step S6). When it is determined that the required flow rate exceeds the second criterion flow-rate value (N in step S6), the rotation speed of the pump is not adjusted, and the process proceeds to step S9 at which the frequency of the compressor is adjusted. When the required flow rate does not exceed the second criterion flow-rate value (step S6: Y), it is determined whether or not the required flow rate exceeds the first criterion flow-rate value that is another threshold for the flow rate of the heat medium that is determined in advance (step S7).

[0055] When it is determined that the required flow rate does not exceed the first criterion flow-rate value (Y in step S7), the rotation speed of the pump 23 is reduced until the required flow rate reaches the first criterion flow-rate value (step S8).

[0056] In contrast, when the required flow rate exceeds the first criterion flow-rate value (N in step S7), the process shifts to step S14 at which the rotation speed of the pump 23 is reduced until the required flow rate reaches the second criterion flow-rate value.

[0057] Next, a difference between temperatures of the heat medium, which circulates through the heat medium circuit 50, at the outlet and the inlet of the inter-medium heat exchanger 21 is obtained from results of detection by the water inlet temperature sensor 27 and the water outlet temperature sensor 28 (step S9). It should be noted that at the heat medium pipe 51, the water inlet temperature sensor 27 is provided on the inlet side of the inter-medium heat exchanger 21, and the water outlet temperature sensor 28 is provided on the outlet side of the inter-medium heat exchanger 21. Furthermore, the flow rate of the heat medium that circulates in the heat medium circuit 50 is obtained from the results of detection by the pump inlet pressure sensor 25 and the pump outlet pressure sensor 26 (step S10). It should be noted that at the heat medium pipe 51, the pump inlet pressure sensor 25 is provided on the inlet side of the pump 23, and the pump outlet pressure sensor 26 is provided on the outlet side of the pump 23.

[0058] Based on the calculated difference between the temperatures of the heat medium at the outlet and the inlet and the calculated flow rate, the capacity arithmetic unit 243 calculates an operating capacity for cooling or heating by the heat medium, which circulates such that the calculated temperature difference is made and circulates at the calculated flow rate. The capacity arithmetic unit 243 also calculates an operating capacity required for cooling or heating at the indoor units 30b and 30c. Then, it is determined whether or not the operating capacity for cooling or heating by the heat medium, which is subjected to heat exchange such that the calculated temperature difference is made and circulates at the calculated flow rate, exceeds the operating capacity required for cooling or heating by the indoor units 30b and 30c (step S11).

[0059] When it is determined that the calculated operating capacity exceeds the operating capacity required for cooling or heating by the indoor units 30b and 30c (Y in step S11), the heat-source-side control device 17 reduces the frequency of the compressor 11 (step S12).

When the operating capacity for cooling or heating by the heat medium, which is subjected to heat exchange such that the calculated temperature difference is made, is below the operating capacity required for cooling or heating by the indoor units 30b and 30c (N in step S11), the heat-source-side control device 17 increases the frequency of the compressor 11 (step S13). Thereafter, the process returns to step S1, and the flow switches 31 redetect flow-rate information regarding the heat medium in the indoor units 30a, 30b, and 30c. Thus, it is possible to cause the heat medium to flow through the indoor units 30b and 30c excluding the control target indoor unit 30a, at a proper flow rate, and it is thus possible to prevent occurrence of a failure, such as non-cooling or non-heating, at the indoor units 30b and 30c. Furthermore, in the case where an abnormality occurs at the indoor unit 30b or 30c in addition to the indoor unit 30a, it is possible to improve the energy efficiency by controlling the flow rate at the compressor 11 or the pump 23. As described above, in the air-conditioning system 100, by performing the control according to the operation state of the entire air-conditioning system 100, it is possible to prevent occurrence of a failure without constructing a new control system and also to improve the energy efficiency.

<Advantages of Embodiment 1>

[0060] In Embodiment 1, in the air-conditioning system 100 and the method of controlling the air-conditioning system 100, when flow-rate information detected by the flow switches 31 is abnormal flow-rate information indicating the presence of a control target indoor unit in which the flow of a heat medium is cut off, and which is one of the plurality of indoor units 30a, 30b, and 30c, that is, the indoor unit 30a in the above case, the relay control device 24 controls the indoor-side control devices 35 based on the abnormal flow-rate information received from the heat-source-side control device 17. The indoor-side control device 35 controls at least one operation of the control target indoor unit 30a. Thus, it is possible to specify the control target indoor unit 30a in which the flow of a heat medium is cut off, and to stop the flow of the heat medium in the indoor unit 30a. That is, in the air-conditioning system 100, it is possible to detect a failure without constructing a new control system. Furthermore, by stopping the indoor unit 30a in which an abnormality occurs, it is possible to solve a problem in which a failure, such as non-cooling or non-heating, would occur when such an indoor unit 30a continued to operate. When receiving abnormal flow-rate information detected by the flow switches 31, from the indoor-side control devices 35 via the relay control device 24, the heat-source-side control device 17 controls the operation of the compressor 11. Furthermore, when receiving the abnormal flow-rate information detected by the flow switches 31, from the indoor-side control devices 35, the relay control device 24 controls the operation of the pump 23. Thus, it is possible to cause the heat medium to flow in the indoor units 30b and 30c excluding the control target indoor unit 30a, at a proper flow rate, and is thus possible to prevent occurrence of a failure, such as non-cooling or non-heating, at the indoor units 30b and 30c. Furthermore, in the case where an abnormality occurs at the indoor unit 30b or 30c in addition to the indoor unit 30a, it is possible to improve the energy efficiency by controlling the flow rate of the compressor 11 or the pump 23. Therefore, in the air-conditioning system 100, by performing the control according to the operation state of the entire air-conditioning system 100, it is possible to prevent occurrence of a failure without constructing a new control system and to improve the energy efficiency.

[0061] In the method of controlling the air-conditioning system 100, the following two pump control thresholds are set: the first criterion flow-rate value for the case where water outage occurs at two of the three indoor units 30a to 30c; and the second criterion flow-rate value for the case where water outage occurs at one of the three indoor units 30a to 30c. Therefore, it is possible to perform a control according to an installed air-conditioning system 100. Needless to say, in the case where four indoor units are used, the number of pump control thresholds is three; that is, a third criterion flow-rate value, a second criterion flow-rate value, and a first criterion flow-rate value are set.

Reference Signs List

[0062] 10: heat source apparatus, 11: compressor, 12: flow switching valve, 13: heat-source-side heat exchanger, 14: heat-source-side expansion device, 15: accumulator, 16: heat-source-side fan, 17: heat-source-side control device, 20: relay device, 21: inter-medium heat exchanger, 22: relay expansion device, 23: pump, 24: relay control device, 25: pump inlet pressure sensor, 26: pump outlet pressure sensor, 27: water inlet temperature sensor, 28: water outlet temperature sensor, 30a: indoor unit, 30b: indoor unit, 31: flow switch, 32: indoor-side heat exchanger, 33: flow control valve, 34: indoor-side fan, 35: indoor-side control device, 40: refrigerant circuit, 41: refrigerant pipe, 50: heat medium circuit, 51: heat medium pipe, 60: control communication line, 100: air-conditioning system, 241: flow-rate arithmetic unit, 242: temperature-difference arithmetic unit, 243: capacity arithmetic unit, 244: criterion flow-rate value storage unit

Claims

1. An air-conditioning system comprising: a heat source apparatus; a plurality of indoor units; a relay device; a refrigerant circuit; and a heat medium circuit, the heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger, the plurality of indoor units each including an indoor-side heat exchanger, the relay device including a pump and an inter-medium heat ex-

changer; the refrigerant circuit being provided as a circuit in which the compressor, the flow switching valve, the heat-source-side heat exchanger, and the inter-medium heat exchanger are connected by refrigerant pipes and refrigerant is circulated, the heat medium circuit being provided as a circuit in which the pump, the inter-medium heat exchanger, and the indoor-side heat exchanger of each of the plurality of indoor units are connected by heat medium pipes and a heat medium is circulated, the air-conditioning system further comprising:

flow-rate detection devices each provided in an associated one of the plurality of indoor units, and each configured to detect flow-rate information regarding a flow rate of the heat medium in the associated indoor unit; and
a controller configured to control, when the flow-rate information detected by the flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off, an operation of at least one of the compressor, the pump, and the control target indoor unit.

2. The air-conditioning system of claim 1, wherein each of the plurality of indoor units includes an indoor-side fan and a flow control valve configured to adjust the flow rate of the heat medium, and
the controller is configured to close the flow control valve of the control target indoor unit after stopping the indoor-side fan of the control target indoor unit.

3. The air-conditioning system of claim 2, wherein the controller is configured to calculate a required flow rate of the heat medium in the control target indoor unit, and reduce, when the required flow rate is lower than a threshold for a flow rate of the heat medium that is determined in advance, a rotation speed of the pump until the required flow rate reaches the threshold.

4. The air-conditioning system of claim 3, wherein

the controller is configured to calculate a temperature difference between temperatures of the heat medium at an outlet and an inlet of the control target indoor unit,
the controller is configured to reduce a frequency of the compressor when an operating capacity for cooling or heating by the heat medium in a case where the calculated temperature difference is made exceeds an operating capacity required for cooling or heating by the control target indoor unit, and
the controller is configured to increase the frequency of the compressor when the operating capacity for cooling or heating by the heat medium in the case where the calculated temperature difference is made is below the operating capacity required for cooling or heating by the control target indoor unit.

5. A method of controlling an air-conditioning system including: a heat source apparatus; a plurality of indoor units; a relay device; a refrigerant circuit; and a heat medium circuit, the heat source apparatus including a compressor, a flow switching valve, and a heat-source-side heat exchanger, the plurality of indoor units each including an indoor-side heat exchanger, the relay device including a pump and an inter-medium heat exchanger; the refrigerant circuit being provided as a circuit in which the compressor, the flow switching valve, the heat-source-side heat exchanger, and the inter-medium heat exchanger are connected by refrigerant pipes and refrigerant is circulated, the heat medium circuit being provided as a circuit in which the pump, the inter-medium heat exchanger, and the indoor-side heat exchanger of each of the plurality of indoor units are connected by heat medium pipes and a heat medium is circulated, the method comprising:

detecting flow-rate information regarding a flow rate of the heat medium in each of the plurality of indoor units, using an associated one of a plurality of flow-rate detection devices provided in the plurality of indoor units; and
controlling an operation of at least one of the compressor, the pump, or the control target indoor unit, using a controller provided in at least one of the heat source apparatus, the relay device, and the plurality of indoor units, in a case where the flow-rate information detected using the plurality of flow-rate detection devices is abnormal flow-rate information indicating presence of a control target indoor unit which is an indoor unit to be controlled of the plurality of indoor units and in which a flow of the heat medium is cut off.

6. The method of controlling an air-conditioning system of claim 5, wherein

each of the plurality of indoor units includes an indoor-side fan and a flow control valve configured to adjust the flow rate of the heat medium, and
in the controlling the operation, in the control target indoor unit, after the indoor-side fan of the control target indoor unit is stopped, the flow control valve of the control target indoor unit is closed.

7. The method of controlling an air-conditioning system of claim 6, wherein in the controlling the operation, a required flow rate of the heat medium in the control target indoor unit is calculated, and in a case where the required flow rate exceeds a threshold for a flow rate of the heat medium that is determined in advance, a rotation speed of the pump is reduced until the required flow rate reaches the threshold.

8. The method of controlling an air-conditioning system of claim 7, wherein in the controlling the operation,

a temperature difference between temperatures of the heat medium at an outlet and an inlet of the control target indoor unit is calculated, and
a frequency of the compressor is reduced, when an operating capacity for cooling or heating by the heat medium in the case where the calculated temperature difference is made exceeds an operating capacity required for cooling or heating by the control target indoor unit, and
the frequency of the compressor is increased, when the operating capacity for cooling or heating by the heat medium in the case where the calculated temperature difference is made is below the operating capacity required for cooling or heating by the control target indoor unit.

FIG. 1

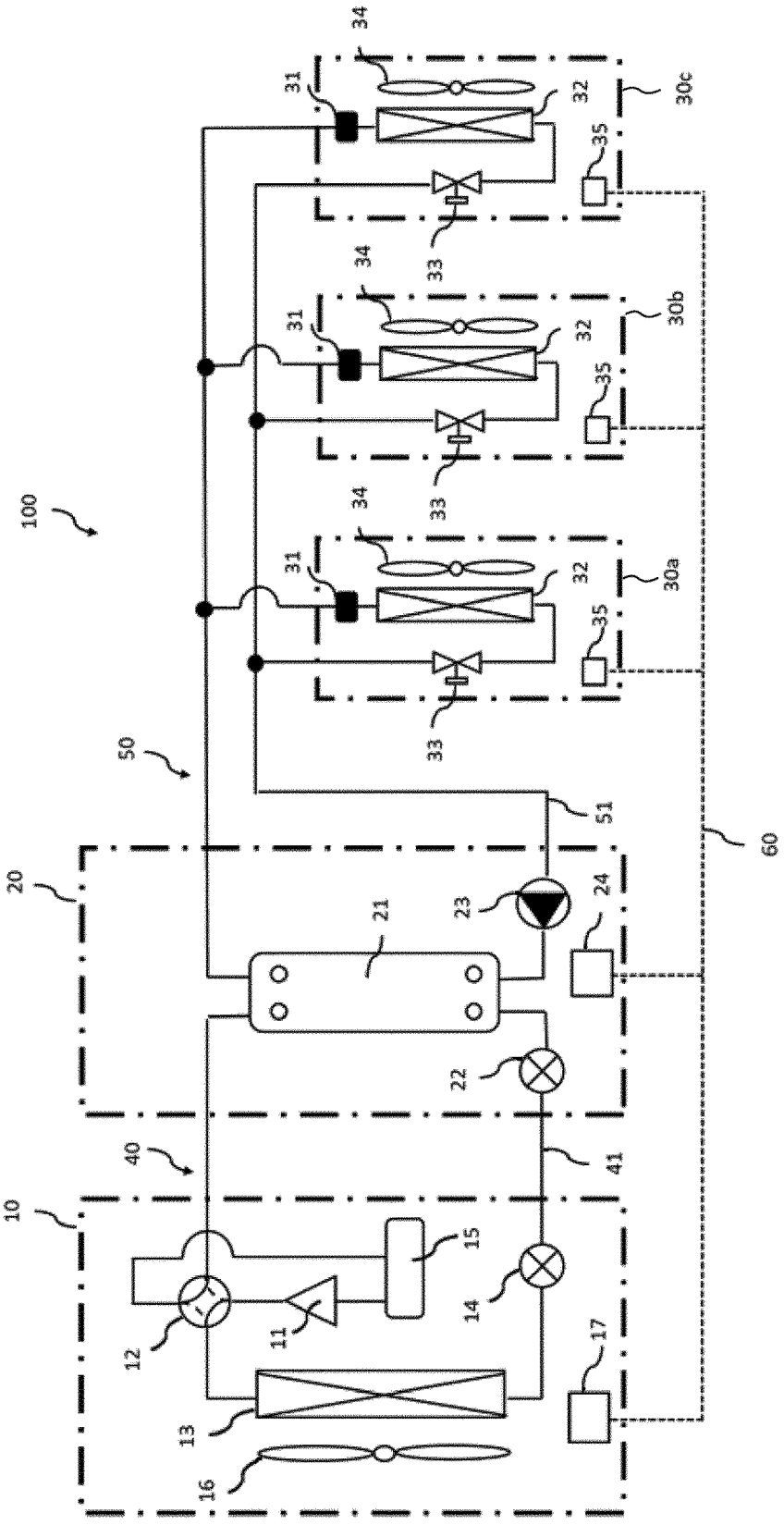

100
10
11
12
13
14
15
16
17
20
21
22
23
24
30a
30b
30c
31
32
33
34
35
40
41
50
51
60

FIG. 2

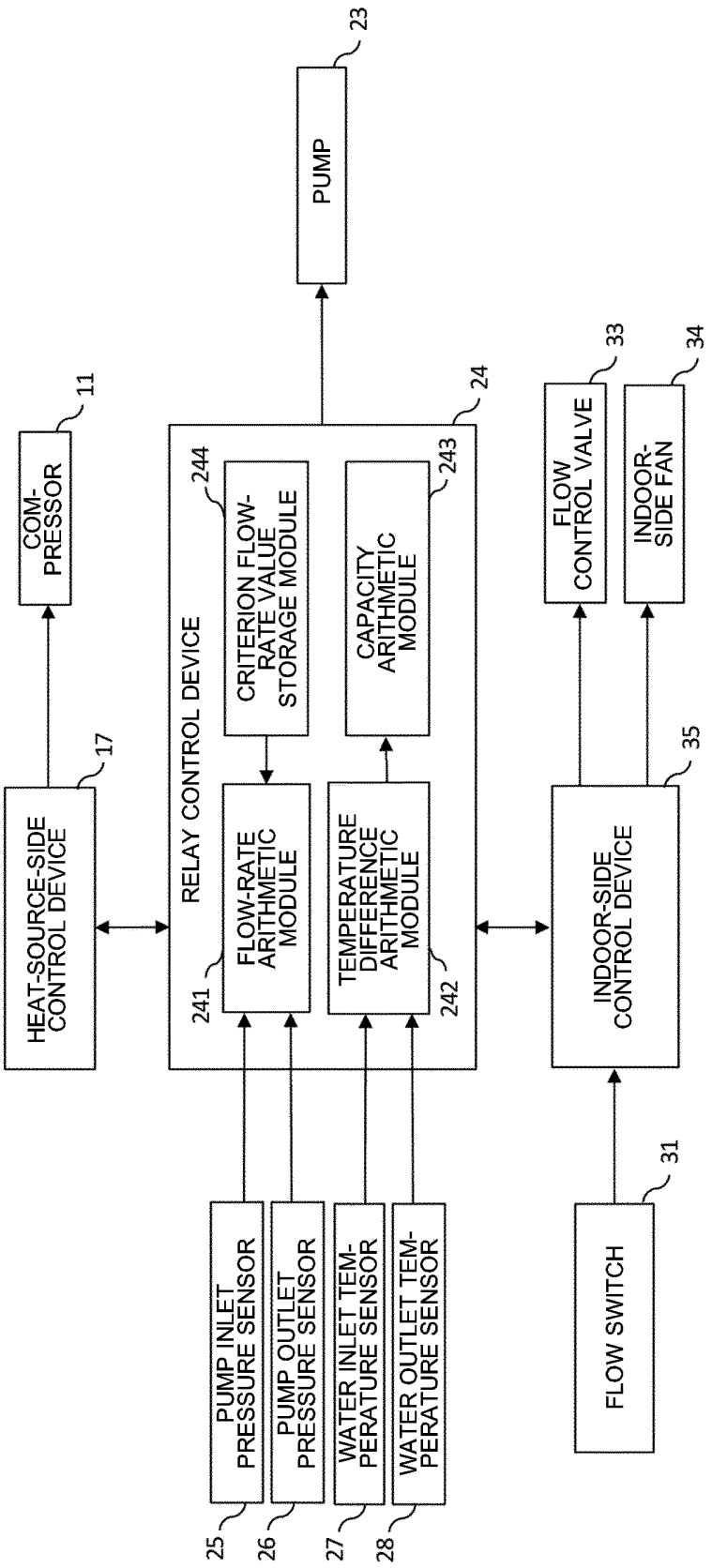
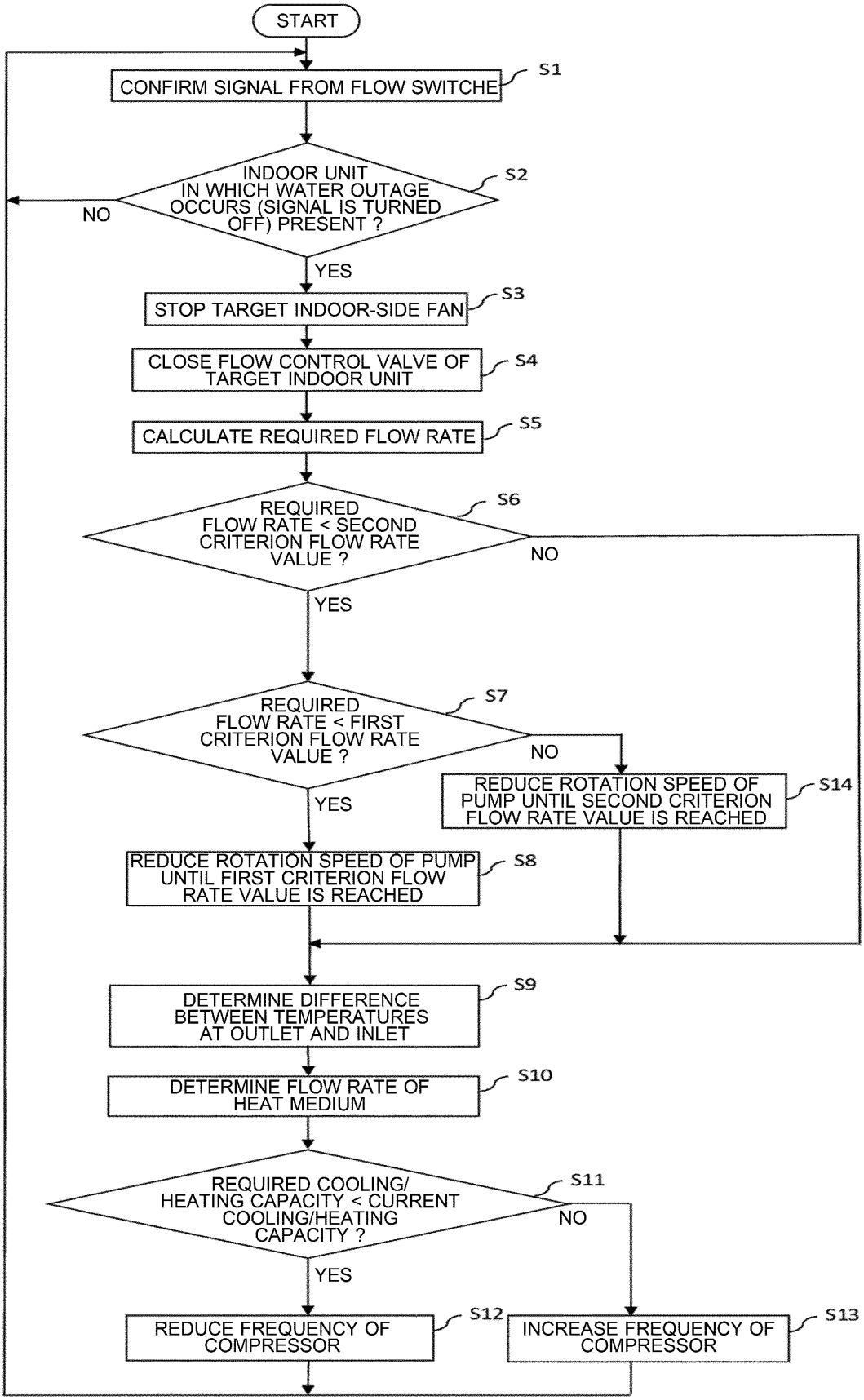

PUMP
23
COM-PRESSOR
11
RELAY CONTROL DEVICE
24
CRITERION FLOW-RATE VALUE STORAGE MODULE
244
CAPACITY ARITHMETIC MODULE
243
FLOW CONTROL VALVE
33
INDOOR-SIDE FAN
34
HEAT-SOURCE-SIDE CONTROL DEVICE
17
FLOW-RATE ARITHMETIC MODULE
241
TEMPERATURE DIFFERENCE ARITHMETIC MODULE
242
INDOOR-SIDE CONTROL DEVICE
35
PUMP INLET PRESSURE SENSOR
25
PUMP OUTLET PRESSURE SENSOR
26
WATER INLET TEM-PERATURE SENSOR
27
WATER OUTLET TEM-PERATURE SENSOR
28
FLOW SWITCH
31

FIG. 3


START
CONFIRM SIGNAL FROM FLOW SWITCHE
S1
INDOOR UNIT IN WHICH WATER OUTAGE OCCURS (SIGNAL IS TURNED OFF) PRESENT ?
S2
NO
YES
STOP TARGET INDOOR-SIDE FAN
S3
CLOSE FLOW CONTROL VALVE OF TARGET INDOOR UNIT
S4
CALCULATE REQUIRED FLOW RATE
S5
REQUIRED FLOW RATE < SECOND CRITERION FLOW RATE VALUE ?
S6
NO
YES
REQUIRED FLOW RATE < FIRST CRITERION FLOW RATE VALUE ?
S7
NO
YES
REDUCE ROTATION SPEED OF PUMP UNTIL SECOND CRITERION FLOW RATE VALUE IS REACHED
S14
REDUCE ROTATION SPEED OF PUMP UNTIL FIRST CRITERION FLOW RATE VALUE IS REACHED
S8
DETERMINE DIFFERENCE BETWEEN TEMPERATURES AT OUTLET AND INLET
S9
DETERMINE FLOW RATE OF HEAT MEDIUM
S10
REQUIRED COOLING/ HEATING CAPACITY < CURRENT COOLING/HEATING CAPACITY ?
S11
NO
YES
REDUCE FREQUENCY OF COMPRESSOR
S12
INCREASE FREQUENCY OF COMPRESSOR
S13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/046796

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F24F11/32(2018.01)i, F24F5/00(2006.01)i, F24F11/64(2018.01)i, F25B1/00(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)
Int. Cl. F24F11/32, F24F5/00, F24F11/64, F25B1/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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	WO 2010/109571 A1 (MITSUBISHI ELECTRIC CORP.) 30 September 2010, paragraphs [0004]-[0114], fig. 1-7 & US 2011/0297363 A1, paragraphs [0004]-[0147], fig. 1-7 & EP 2413055 A1 & CN 102362126 A	1-6 7-8
Y	WO 2013/108290 A1 (MITSUBISHI ELECTRIC CORP.) 25 July 2013, paragraphs [0011]-[0128], fig. 1-10 & US 2014/0305152 A1, paragraphs [0024]-[0150], fig. 1-10 & EP 2806228 A1 & CN 103998870 A	1-6
Y	WO 2010/050001 A1 (MITSUBISHI ELECTRIC CORP.) 06 May 2010, paragraphs [0049]-[0051], fig. 8 & EP 2312228 A1, paragraphs [0050]-[0052], fig. 8	1-6

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

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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17.12.2019	24.12.2019
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/046796

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/061365 A1 (MITSUBISHI ELECTRIC CORP.) 02 May 2013, paragraphs [0046], [0057], fig. 1 (Family: none)	2-4, 6
Y	WO 2017/221383 A1 (MITSUBISHI ELECTRIC CORP.) 28 December 2017, paragraphs [0015]-[0039], fig. 1-3 & EP 3477221 A1, paragraphs [0017]-[0065], fig. 1-3	3-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005249238 A **[0006]**