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(72) Inventors:
• **TAKIGAWA, Masayuki**
Tokyo 108-8215 (JP)
• **KATO, Takahiro**
Tokyo 108-8215 (JP)
• **YASUDA, Tatsuhiko**
Tokyo 108-8215 (JP)
• **SAKAGUCHI, Tomohiro**
Tokyo 108-8215 (JP)

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(71) Applicant: **Mitsubishi Heavy Industries Thermal Systems, Ltd.**
Tokyo 108-8215 (JP)

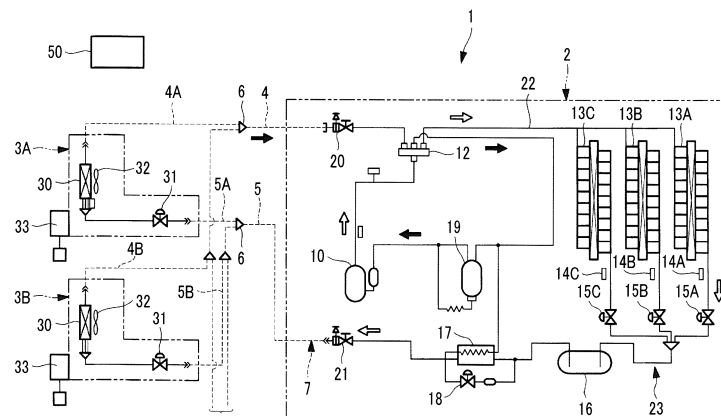
(74) Representative: **Henkel, Breuer & Partner**
Patentanwälte
Maximiliansplatz 21
80333 München (DE)

(54) **MULTI-SPLIT AIR CONDITIONER CONTROL DEVICE, MULTI-SPLIT AIR CONDITIONER, MULTI-SPLIT AIR CONDITIONER CONTROL METHOD, AND MULTI-SPLIT AIR CONDITIONER CONTROL PROGRAM**

(57) This multi-split air conditioner control device is provided with: an outdoor unit provided with a plurality of outdoor heat exchangers (13) among which the volume of at least one outdoor heat exchanger (13) is different from the volume of another outdoor heat exchanger (13); and a plurality of indoor units. Each of the plurality of outdoor heat exchangers (13) is provided with an outdoor

expansion valve (15) for adjusting the flow rate of refrigerant being supplied to the outdoor heat exchanger (13), and the flow rate of the refrigerant supplied to each of the plurality of outdoor heat exchangers (13) is adjusted by controlling the outdoor expansion valves (15) according to the volumes of the plurality of outdoor heat exchangers (13).

FIG. 2



Description

Technical Field

[0001] The present invention relates to a control device of a multi-split air conditioner, a multi-split air conditioner, a method of controlling a multi-split air conditioner, and a program of controlling a multi-split air conditioner.

Background Art

[0002] In a case where frost is formed on a heat exchanger in a multi-split air conditioner, defrosting operation is performed. The defrosting operation is operation of defrosting the frost attached to the heat exchanger by causing a high-temperature and high-pressure refrigerant to flow into the heat exchanger. In the defrosting operation of a multi-split air conditioner configured of a plurality of heat exchangers, a refrigerant flow rate required for defrosting varies according to each heat exchanger in a case where the volumes of the heat exchangers are different from each other. For example, in a case where the refrigerant flow rates of all the respective heat exchangers are substantially the same instead of appropriately assigning refrigerant flow rates required for defrosting, a refrigerant is continued to flow in a heat exchanger on which defrosting is completed, and the refrigerant flow rate of a heat exchanger on which defrosting is not completed does not change. As a result, defrosting operation is prolonged in some cases.

[0003] Therefore, control of appropriately assigning a refrigerant flow rate required for defrosting of each heat exchanger is under consideration.

[0004] For example, a technique of comparing temperatures of respective heat exchangers, which are measured by heat exchanging temperature measuring means, and controlling a refrigerant flow rate by means of the opening degree of an electric expansion valve is disclosed in PTL 1. In addition, a technique of measuring the temperature of an upper path and the temperature of a lower path of a heat exchanger and adjusting a refrigerant flow rate by means of the opening degree of an expansion valve according to a temperature difference is disclosed in PTL 2.

Citation List

Patent Literature

[0005]

[PTL 1] Japanese Unexamined Patent Application Publication No. 5-322388

[PTL 2] Japanese Unexamined Patent Application Publication No. 2002-89980

Summary of Invention

Technical Problem

[0006] In both of the inventions disclosed in PTLs 1 and 2, the temperature of the heat exchanger is measured, the opening degree of the expansion valve is regulated based on the temperature, and the refrigerant flow rate of each heat exchanger (or the upper and lower paths inside the heat exchanger) is adjusted. However, since the temperature of each heat exchanger is measured and the expansion valve is adjusted, it is difficult to effectively make defrosting regular due to a response delay of the expansion valve, thereby not leading to the shortening of the time it takes for defrosting.

[0007] The present invention is devised in consideration of such circumstances, and an object thereof is to provide a control device of a multi-split air conditioner, a multi-split air conditioner, a method of controlling a multi-split air conditioner, and a program of controlling a multi-split air conditioner, which can shorten the time it takes for defrosting of heat exchangers having different volumes.

Solution to Problem

[0008] In order to solve the problems, the control device of a multi-split air conditioner, the multi-split air conditioner, the method of controlling a multi-split air conditioner, and the program of controlling a multi-split air conditioner of the present invention adopt the following means.

[0009] According to a first aspect of the present invention, there is provided a control device of a multi-split air conditioner including an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units. In the control device of a multi-split air conditioner, each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat exchanger, and the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, is adjusted by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation.

[0010] According to the aspect, the control device of a multi-split air conditioner that includes the outdoor unit including the plurality of heat exchangers, at least one of which is the outdoor heat exchanger having a different volume, and the plurality of indoor units controls a refrigerant flow rate according to the volume of each of the heat exchangers at the time of defrosting operation. Accordingly, the defrosting of each of the heat exchangers can be substantially simultaneously completed. For example, even when the defrosting of only one heat exchanger is completed, it is necessary to circulate a re-

refrigerant in order to prevent refrosting with respect to the heat exchanger in a case where the same amount of refrigerant is supplied to the plurality of heat exchangers having different volumes. That is, when defrosting completion timings are different from each other, a refrigerant loss by an amount of the refrigerant circulated for refrosting prevention is caused. Therefore, the defrosting of each of the heat exchangers is substantially simultaneously completed by controlling a refrigerant flow rate according to the volume of each of the heat exchangers. Accordingly, it is not necessary to circulate the refrigerant for refrosting prevention, and a refrigerant flow rate necessary for defrosting can be reduced.

[0011] In addition, when the refrigerant continues to flow in the heat exchanger on which defrosting is completed, defrosting operation is prolonged in some cases since a refrigerant flow rate with respect to the heat exchangers, which are being defrosted, is limited. However, according to the aspect, since a refrigerant flow rate necessary for each of the heat exchangers is assigned by the flow rate adjusting device, the defrosting of each of the heat exchangers is substantially simultaneously completed, and defrosting operation is terminated early.

[0012] In addition, in a case where control is performed based on a heat exchanger temperature, it can be considered that it requires time until a heat exchanger temperature stabilizes due to defrosting and it takes time until the presence or absence of frosting is reflected in the temperature. On the contrary, the volume of each of the heat exchangers is an acquirable value beforehand, control can be performed from the start of defrosting operation, and time necessary for defrosting can be shortened.

[0013] In the first aspect, the flow rate adjusting device may include an electric expansion valve, each of the plurality of heat exchangers may include a temperature sensor that measures a heat exchanger temperature of the heat exchanger, and valve opening degree determination control of determining an opening degree of each of the electric expansion valves of the plurality of heat exchangers such that the heat exchanger temperatures of all of the heat exchangers substantially simultaneously reach a defrosting completion temperature, which is a reference value of defrosting completion, may be performed.

[0014] According to the aspect, in the air conditioner that includes the plurality of heat exchangers having different volumes, timings at which defrosting is completed become different from each other when refrigerant flow rates are made the same since refrigerant flow rates necessary for defrosting are different from each other due to a difference in volume. When controlling a refrigerant flow rate according to the volume of each of the heat exchangers, the opening degree of each of the electric expansion valves is set with respect to each of the heat exchangers with a defrosting completion temperature as reference since the opening degree of each of the electric expansion valves is adjusted and control of a refrigerant

flow rate is performed such that the heat exchanger temperature of each of the heat exchangers simultaneously reaches a defrosting completion temperature. Specifically, a ratio between refrigerant flow rates of the respective heat exchangers is determined beforehand, and based on this, the opening degree of each of the electric expansion valves is set such that the respective heat exchangers substantially simultaneously reach a defrosting completion temperature. Even in the multi-split air conditioner that includes the plurality of heat exchangers having different volumes, a refrigerant flow rate necessary for defrosting can be reduced since the defrosting of the respective heat exchangers is simultaneously completed.

[0015] In the first aspect, in a case where the heat exchanger temperature of at least one heat exchanger has become the defrosting completion temperature or higher, the opening degree of the electric expansion valve of the heat exchanger may be set to a minimum opening degree.

[0016] Even in a case where control is performed such that defrosting is simultaneously completed in the plurality of heat exchangers having different volumes, a case where defrosting completion timings become different due to various factors is considered. In a case where a heat exchanger, on which defrosting is completed earlier than the other heat exchanger, exists, it is not necessary or needless to supply the same amount of refrigerant as an amount before defrosting completion. Thus, in the aspect, the opening degree of the electric expansion valve of the heat exchanger on which defrosting is completed, that is, the heat exchanger of which the temperature has become a defrosting completion temperature or higher is set to have a minimum opening degree. Accordingly, a refrigerant flow rate can be minimized, a larger amount of refrigerant can be supplied to the other heat exchanger, on which defrosting is not completed, and the time it takes for defrosting all of the plurality of heat exchangers can be reduced. In addition, since the opening degree of the expansion valve is set to a minimum opening degree instead of full closing, refrosting can be prevented so as to be kept to a minimum.

[0017] Herein, the minimum opening degree is an opening degree that allows a small amount of refrigerant to an extent that an outdoor heat exchanger, on which defrosting is completed, are not refrosted to flow therein. For example, it is approximately 60 pulses.

[0018] In the first aspect, in a case where the heat exchanger temperature has become lower than the defrosting completion temperature after the opening degree of the electric expansion valve of the heat exchanger is set to the minimum opening degree, the opening degree of the electric expansion valve of the heat exchanger may be gradually increased.

[0019] There is a possibility that the heat exchanger, on which defrosting is completed and of which the electric expansion valve is set such that the opening degree is a minimum opening degree, is refrosted since a refrigerant flow rate is set to a minimum. On the contrary, in the

aspect, in a case where the heat exchanger temperature of this heat exchanger becomes lower than the defrosting completion temperature, there is a possibility of refrosting and thus the opening degree of the electric expansion valve is gradually increased. Accordingly, the frosting of the heat exchanger can be prevented by increasing the refrigerant flow rate.

[0020] In the first aspect, in a case where the heat exchanger temperature of only one of the heat exchangers is lower than the defrosting completion temperature, the opening degree of the electric expansion valve of the heat exchanger may be set to full opening.

[0021] Even in a case where control is performed such that defrosting is simultaneously completed in the plurality of heat exchangers having different volumes, a case where defrosting completion timings become different due to various factors is considered. In a case where the defrosting of all of the other heat exchanger is completed and only one heat exchanger on which defrosting is not completed exists, the opening degree of the electric expansion valve of the other heat exchanger becomes a minimum opening degree, and there is a margin in a refrigerant supply amount. However, insofar as the opening degree of the electric expansion valve of the heat exchanger on which defrosting is not completed does not change and remains constant, it takes time for defrosting without an increase in the supply of a refrigerant flow rate. In the aspect, in a case where there is only one heat exchanger on which defrosting is not completed, the opening degree of the electric expansion valve of the heat exchanger is set to full opening. Accordingly, a maximum amount of excess refrigerant can be supplied to the heat exchanger on which defrosting is not completed, and the time it takes for defrosting can be shortened.

[0022] In the first aspect, the valve opening degree determination control may be carried out at a time of shipping from a factory or at a time of test operation, and the opening degree of the electric expansion valve may be stored in storage means.

[0023] According to the aspect, valve opening degree determining control for the electric expansion valve, which serves as reference, is carried out at the time of shipping from a factory or at the time of test operation, and the opening degree is stored in the storage means. Accordingly, a refrigerant flow rate can be appropriately stored at the time of valve opening degree determining control which is carried out at the time of test operation, at the time of shipping from a factory, or the like before starting regular air conditioning operation. Therefore, since a refrigerant is supplied at a flow rate based on an opening degree, which serves as reference, at the time of regular air conditioning operation, defrosting operation can be started quickly, and defrosting can be simultaneously completed even in the air conditioner that has the plurality of heat exchangers having different volumes.

[0024] According to a second aspect of the present invention, there is provided a multi-split air conditioner including an outdoor unit that includes a plurality of heat

exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, a plurality of indoor units, and the control device according to any description made above.

[0025] According to a third aspect of the present invention, there is provided a method of controlling a multi-split air conditioner which includes an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units. The method of controlling a multi-split air conditioner, in which each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat exchanger, includes a step of adjusting the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation.

[0026] According to a fourth aspect of the present invention, there is provided a program of controlling a multi-split air conditioner which includes an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units. The program of controlling a multi-split air conditioner, in which each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat exchanger, includes a step of adjusting the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation.

Advantageous Effects of Invention

[0027] According to the present invention, since each refrigerant flow rate is adjusted by performing control of the flow rate adjusting device based on the volume of each of the heat exchangers having different volumes in defrosting operation, the time it takes for defrosting can be shortened by substantially simultaneously completing the defrosting of each heat exchanger.

Brief Description of Drawings

[0028]

Fig. 1 is a refrigerant circuit diagram showing heating operation of a multi-split air conditioner according to a first embodiment of the present invention.

Fig. 2 is a refrigerant circuit diagram showing defrosting operation of the multi-split air conditioner according to the first embodiment of the present invention.

Fig. 3 is a block diagram showing a refrigerant flow rate at a time of defrosting operation of each heat

exchanger of the multi-split air conditioner according to the first embodiment of the present invention.

Fig. 4 is a block diagram showing a refrigerant flow rate at a time of defrosting completion of each heat exchanger of the multi-split air conditioner according to the first embodiment of the present invention.

Fig. 5 is a flow chart showing control of an electric expansion valve at a time of defrosting operation by a control device of a multi-split air conditioner according to a second embodiment of the present invention.

Fig. 6 is a block diagram showing a refrigerant flow rate at a time of making defrosting regular in each heat exchanger of the multi-split air conditioner according to the second embodiment of the present invention.

Description of Embodiments

[0029] Hereinafter, embodiments of a control device of a multi-split air conditioner, a multi-split air conditioner, a method of controlling a multi-split air conditioner, and a program of controlling a multi-split air conditioner according to the present invention will be described with reference to the drawings.

[First Embodiment]

[0030] Hereinafter, a first embodiment of the present invention will be described with reference to Figs. 1 to 4.

[0031] Fig. 1 is a refrigerant circuit diagram at the time of heating operation of a multi-split air conditioner according to the embodiment.

[0032] In the multi-split air conditioner 1, a plurality of indoor units 3A and 3B are connected in parallel to one outdoor unit 2. The plurality of indoor units 3A and 3B are connected to each other in parallel via splitters 6 between a gas side pipe 4 and a liquid side pipe 5, which are connected to the outdoor unit 2.

[0033] The outdoor unit 2 includes an inverter-driven compressor 10 that compresses a refrigerant, a four-way switching valve 12 that switches between refrigerant circulation directions, a plurality of outdoor heat exchangers (heat exchangers) 13A, 13B, and 13C that causes heat exchange between a refrigerant and outside air, outdoor heat exchanger temperature sensors (temperature sensors) 14A, 14B and 14C that measure heat exchanger temperatures of the outdoor heat exchangers 13A, 13B, and 13C respectively, outdoor expansion valves (electric expansion valve: EEVH) (flow rate adjusting devices) 15A, 15B, and 15C that adjust refrigerant flow rates of the outdoor heat exchangers 13A, 13B, and 13C respectively, a receiver 16 that stores a liquid refrigerant, a supercooling heat exchanger 17 that supercools a liquid refrigerant, an expansion valve for supercooling (EEVSC) 18 that controls a refrigerant amount to be divided for the supercooling heat exchanger 17, an accumulator 19 that separates a liquid out from a refrigerant

gas to be sucked by the compressor 10 and sucks only a gas into a compressor 10 side, a gas side operating valve 20, and a liquid side operating valve 21.

[0034] In the embodiment, the volumes of the outdoor heat exchangers 13A, 13B, and 13C are different from each other.

[0035] Although a case where the three outdoor heat exchangers 13A, 13B, and 13C are mounted is illustrated as an example in Figs. 1 and 2, the number of outdoor heat exchangers to be mounted may be determined as appropriate.

[0036] In the following description, in a case of differentiating between the respective outdoor heat exchangers 13, any one of A, B, or C will be assigned at the end, and in a case of not differentiating between the respective outdoor heat exchangers 13, A, B, or C will be omitted. In a case of differentiating between the respective outdoor heat exchanger temperature sensors 14, any one of A, B, or C will be assigned at the end, and in a case of not differentiating between the respective outdoor heat exchanger temperature sensors 14, A, B, or C will be omitted. In addition, in a case of differentiating between the respective outdoor expansion valves 15, any one of A, B, or C will be assigned at the end, and in a case of not differentiating between the respective outdoor expansion valves 15, A, B, or C will be omitted.

[0037] The respective devices on an outdoor unit 2 side are connected in turn via a refrigerant pipe 22, and configure a known outdoor side refrigerant circuit 23. In addition, the outdoor unit 2 is provided with an outdoor fan (not illustrated) that blows outside air with respect to the respective outdoor heat exchangers 13.

[0038] The gas side pipe 4 and the liquid side pipe 5 are refrigerant pipes which are respectively connected to the gas side operating valve 20 and the liquid side operating valve 21 of the outdoor unit 2. At the time of mounting in the field, the lengths of the pipes are set as appropriate according to a distance between the outdoor unit 2 and the plurality of indoor units 3A and 3B connected thereto. The plurality of splitters 6 are provided in the middle of the gas side pipe 4 and the liquid side pipe 5, and an appropriate number of indoor units 3A and 3B are connected via the splitters 6. Accordingly, one closed refrigerating cycle (refrigerant circuit) 7 is configured.

[0039] The indoor units 3A and 3B each include an indoor heat exchanger 30 that cools or heats indoor air by causing heat exchange with a refrigerant and contributes to indoor air conditioning, an indoor expansion valve (EEVC) 31, an indoor fan 32 that circulates indoor air via the indoor heat exchanger 30, and an indoor controller 33. The indoor units are connected to the splitters 6 via gas side branch pipes 4A and 4B and liquid side branch pipes 5A and 5B on an indoor side.

[0040] A control device 50 acquires values set by the indoor controllers 33, a refrigerant temperature, and the like, and performs switching control of the four-way switching valve 12 and control of opening and closing or an opening degree of each valve.

[0041] The control device 50 is configured with, for example, a central processing unit (CPU), a random access memory (RAM), a read only memory (ROM), a computer readable storage medium, and the like. A series of processes for realizing a variety of functions are stored, for example, in a storage medium or the like in a form of a program. A variety of functions are realized by the CPU reading the program from the RAM or the like and executing processing and computing of information. The program may be applied in a form of being installed in advance in the ROM or other storage media, a form of being provided in a state where the program is stored in the computer readable storage medium, a form of being transmitted via communication means in a wired or wireless manner, or the like. The computer readable storage medium is a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, or the like.

[0042] In the multi-split air conditioner 1, heating operation is performed as follows.

[0043] A high-temperature and high-pressure refrigerant gas which is compressed and discharged by the compressor 10 circulates to a gas side operating valve 20 side via the four-way switching valve 12. The high-pressure gas refrigerant is led out from the outdoor unit 2 via the gas side operating valve 20 and the gas side pipe 4, and is introduced into the plurality of indoor units 3A and 3B via the splitters 6 and the gas side branch pipes 4A and 4B on the indoor side.

[0044] The high-temperature and high-pressure refrigerant gas introduced in the indoor units 3A and 3B exchanges heat with indoor air circulating in the indoor heat exchangers 30 via the indoor fans 32, and accordingly the heated indoor air is blown out indoors and contributes to heating. On the other hand, a refrigerant which is condensed and liquefied by the indoor heat exchangers 30 reaches the splitters 6 via the indoor expansion valves 31 and the liquid side branch pipes 5A and 5B, joins a refrigerant from the other indoor unit, and returns to the outdoor unit 2 via the liquid side pipe 5. At the time of heating, in the indoor units 3A and 3B, the opening degree of each of the indoor expansion valves 31 is controlled via the indoor controller 33 such that a refrigerant outlet temperature or a degree of refrigerant supercooling of the indoor heat exchanger 30, which functions as a condenser, becomes a control target value.

[0045] In the process of reaching the supercooling heat exchanger 17 via the liquid side operating valve 21 and flowing to a liquid refrigerant pipe side, the refrigerant which has returned to the outdoor unit 2 is partially divided from a liquid refrigerant pipe, exchanges heat with a refrigerant adiabatically expanded by the expansion valve for supercooling 18 to be given with a degree of supercooling. After then, a circulation amount is adjusted by the refrigerant flowing to the receiver 16 and being temporarily stored in the receiver. After being supplied to the respective outdoor expansion valves 15 and being adiabatically expanded, the liquid refrigerant flows into the

outdoor heat exchangers 13.

[0046] In the respective outdoor heat exchangers 13, outside air blown from the outdoor fan exchanges heat with the refrigerant, and the refrigerant absorbs heat from the outside air to evaporate and become a gas. After joining a refrigerant gas from the supercooling heat exchanger 17 via the four-way switching valve 12 from the respective outdoor heat exchangers 13, the refrigerant is introduced into the accumulator 19. In the accumulator 19, a liquid is separated out from the refrigerant gas and only a gas is sucked into the compressor 10. The gas is again compressed by the compressor 10. Heating operation is performed by repeating such cycle.

[0047] For example, in a case where an outside temperature is low and humidity is high at the time of heating operation of the multi-split air conditioner 1, the temperature of the refrigerant flowing in the respective outdoor heat exchangers 13 decreases by the pressure thereof being lowered by the respective outdoor expansion valves 15. Thus, there is a possibility that frost is formed on the respective outdoor heat exchangers 13. When frost is formed on the outdoor heat exchangers 13, heating performance decreases. Therefore, in this case, defrosting operation is performed by switching of the four-way switching valve 12.

[0048] The defrosting operation is carried out in general in a case where the temperature of any one of the respective outdoor heat exchangers 13, which is measured by the outdoor heat exchanger temperature sensor 14, has become a certain temperature or lower. A temperature that causes the defrosting operation to be carried out varies according to each type of multi-split air conditioner 1, but the temperature is, for example, a value that is approximately 0°C.

[0049] Fig. 2 is a refrigerant circuit diagram at the time of defrosting operation of the multi-split air conditioner according to the embodiment.

[0050] In the multi-split air conditioner 1, defrosting operation is performed as follows.

[0051] A high-temperature and high-pressure refrigerant gas, which is compressed and discharged by the compressor 10, circulates to an outdoor heat exchanger 13 side by means of the four-way switching valve 12, and exchanges heat with outside air blown to the respective outdoor heat exchangers 13 by the outdoor fan so as to be condensed and liquefied. The liquid refrigerant passes through the respective outdoor expansion valves 15 and is temporarily stored inside the receiver 16.

[0052] In such a manner, defrosting is performed by a high-temperature and high-pressure refrigerant gas flowing in the respective outdoor heat exchangers 13.

[0053] The liquid refrigerant of which a circulation amount is adjusted in the receiver 16 reaches the supercooling heat exchanger 17, and is supercooled as in the case of heating. The liquid refrigerant is led from the outdoor unit 2 to the liquid side pipe 5 via the liquid side operating valve 21, and is divided into the liquid side branch pipes 5A and 5B of the indoor units 3A and 3B

respectively via the splitter 6.

[0054] The liquid refrigerant divided into the liquid side branch pipes 5A and 5B flows into the indoor units 3A and 3B respectively, is adiabatically expanded by the indoor expansion valves 31, and forms a gas-liquid two-phase flow to flow into the indoor heat exchangers 30. In the indoor heat exchangers 30, the refrigerant becomes a gas, reaches the splitters 6 via the gas side branch pipes 4A and 4B, and joins a refrigerant from the other indoor unit in the gas side pipe 4.

[0055] After the refrigerant gas which has joined in the gas side pipe 4 returns to the outdoor unit 2 again and joins a refrigerant gas from the supercooling heat exchanger 17 via the gas side operating valve 20 and the four-way switching valve 12, the refrigerant is introduced into the accumulator 19. In the accumulator 19, a liquid is separated out from the refrigerant gas, and only a gas is sucked into the compressor 10. The refrigerant is again compressed by the compressor 10, and defrosting operation is performed by repeating such cycle.

[0056] The defrosting operation is completed in general in a case where the temperatures of all of the respective outdoor heat exchangers 13, which are measured by all of the outdoor heat exchanger temperature sensors 14, have become a certain temperature or lower. A temperature that serves as a reference value for defrosting operation completion, that is, a defrosting completion temperature varies according to each type of multi-split air conditioner 1, but the temperature is, for example, a value that is approximately 9°C.

[0057] Next, opening degree control of the outdoor expansion valves at the time of defrosting operation will be described with reference to Figs. 3 and 4.

[0058] Fig. 3 is a block diagram of outline of a refrigerant flow rate at the time of defrosting operation of each heat exchanger of the multi-split air conditioner according to the first embodiment of the present invention.

[0059] In addition, Fig. 4 is a block diagram of outline of a refrigerant flow rate at the time of defrosting completion of each heat exchanger of the multi-split air conditioner according to the first embodiment of the present invention.

[0060] Prior to the start of defrosting operation, the control device 50 first determines the opening degree of each of the outdoor expansion valves 15 according to the volume of each of the outdoor heat exchangers 13, and performs setting control of setting a valve opening degree. Since the volumes of the respective outdoor heat exchangers 13 are different from each other, and control is performed such that the defrosting of the respective outdoor heat exchangers 13 completes substantially simultaneously, that is, a defrosting completion temperature is reached almost simultaneously, a refrigerant flow rate at which a refrigerant flows into each of the outdoor heat exchangers 13 is determined by a ratio between the respective volumes. Based on each of determined refrigerant flow rates, the opening degree of each of the outdoor expansion valves 15 of the outdoor heat exchangers

13 is determined, and the opening degree is set in each of the outdoor expansion valves 15. After the opening degrees of the outdoor expansion valves 15 are set, defrosting operation is started.

[0061] It is possible to calculate the volume of each of the outdoor heat exchangers 13 based on the inner diameter, length, and number of pipes. As shown in Figs. 3 and 4, the volume of the outdoor heat exchanger 13A is the largest, the volume of the outdoor heat exchanger 13B is the second largest, and the volume of the outdoor heat exchanger 13C is the smallest in the embodiment.

[0062] Since the volume of the outdoor heat exchanger 13A is the largest as shown in Fig. 3, the opening degree of the outdoor expansion valve 15A according to a refrigerant flow rate acquired based on a ratio between the respective volumes is set such that the amount of a refrigerant flowing into the outdoor heat exchanger 13A is the largest. Similarly, also the opening degrees of the outdoor expansion valves 15B and 15C are simultaneously set based on a ratio between the respective volumes of the outdoor heat exchangers 13B and 13C. When the opening degree of each of the outdoor expansion valves 15 is set, defrosting operation is performed.

[0063] The control of the opening degree of each of the outdoor expansion valves 15 according to each refrigerant flow rate acquired based on the ratio between the respective volumes of the outdoor heat exchangers 13 causes each heat exchanger temperature of each of all the outdoor heat exchangers 13, which is measured by each of the outdoor heat exchanger temperature sensors 14, to substantially simultaneously reach a defrosting completion temperature, and defrosting is completed as shown in Fig. 4.

[0064] In the embodiment, prior to the start of defrosting operation, the opening degree of each of the outdoor expansion valves 15 according to the volume of each of the outdoor heat exchangers 13 is first determined and set.

[0065] Determining and setting of the opening degrees of the outdoor expansion valves 15 may be carried out at the time of shipping from a factory or at the time of test operation, and the opening degrees of the outdoor expansion valves 15 may be stored in storage means (not illustrated) of the control device 50.

[0066] As illustrated hereinbefore, the following effects are achieved in the control device of a multi-split air conditioner, the multi-split air conditioner, the method of controlling a multi-split air conditioner, and the program of controlling a multi-split air conditioner according to the embodiment.

[0067] In the embodiment, the control device 50 of the multi-split air conditioner 1 that includes the outdoor unit 2 including the plurality of outdoor heat exchangers 13, at least one of which is the outdoor heat exchanger 13 having a different volume, and the plurality of indoor units 3A and 3B controls a refrigerant flow rate according to the volume of each of the outdoor heat exchangers 13 at the time of defrosting operation. Accordingly, the de-

frosting of the respective outdoor heat exchangers 13 can be substantially simultaneously completed. For example, even when the defrosting of only one outdoor heat exchanger 13 is completed, it is necessary to circulate a refrigerant in order to prevent refrosting with respect to the outdoor heat exchanger 13 in a case where the same amount of refrigerant is supplied to the plurality of outdoor heat exchangers 13 having different volumes. That is, when defrosting completion timings are different from each other, a refrigerant loss by an amount of the refrigerant circulated for refrosting prevention is caused. Thus, in the embodiment, the defrosting of the respective outdoor heat exchangers 13 is substantially simultaneously completed by controlling a refrigerant flow rate according to the volume of each of the outdoor heat exchangers 13. Consequently, it is not necessary to circulate a refrigerant for refrosting prevention, and a refrigerant flow rate necessary for defrosting can be reduced.

[0068] In addition, when a refrigerant continues to flow in the outdoor heat exchangers 13 on which defrosting is completed, defrosting operation is prolonged since refrigerant flow rates with respect to the outdoor heat exchangers 13, which are being defrosted, are limited. In the embodiment, since a refrigerant flow rate necessary for each of the outdoor heat exchangers 13 is assigned by each of the outdoor expansion valves 15, the defrosting of the respective outdoor heat exchangers 13 is substantially simultaneously completed, and defrosting operation is terminated early.

[0069] In addition, in a case where control is performed based on a heat exchanger temperature, it can be considered that it requires time until a heat exchanger temperature stabilizes due to defrosting and it takes time until the presence or absence of frosting is reflected in the temperature. On the contrary, the volume of each of the outdoor heat exchangers 13 is an acquirable value beforehand, control can be performed from the start of defrosting operation, and time necessary for defrosting can be shortened in the embodiment.

[0070] In the multi-split air conditioner 1 that includes the plurality of outdoor heat exchangers 13 having different volumes, timings at which defrosting is completed become different from each other when refrigerant flow rates are made the same since refrigerant flow rates necessary for defrosting are different from each other due to a difference in volume. In the embodiment, when controlling a refrigerant flow rate according to the volume of each of the outdoor heat exchangers 13, the opening degree of each of the outdoor expansion valves 15 is set with respect to each of the outdoor heat exchangers 13 with a defrosting completion temperature as reference since the opening degree of each of the outdoor expansion valves 15 is adjusted and control of a refrigerant flow rate is performed such that the heat exchanger temperature of each of the outdoor heat exchangers 13 simultaneously reaches a defrosting completion temperature. Specifically, a ratio between refrigerant flow rates of the respective outdoor heat exchangers 13 is determined be-

forehand based on the ratio between the volumes of the respective outdoor heat exchangers 13, and based on this, the opening degree of each of the outdoor expansion valves 15 is set such that the respective outdoor heat exchangers 13 substantially simultaneously reach a defrosting completion temperature. Even in an air conditioner that includes the plurality of outdoor heat exchangers 13 having different volumes, a refrigerant flow rate necessary for defrosting can be reduced since the defrosting of the respective outdoor heat exchangers 13 is simultaneously completed.

[0071] In the embodiment, since valve opening degree determination control for the respective outdoor expansion valves 15, which serve as reference, is carried out at the time of shipping from a factory or at the time of test operation, and opening degrees thereof are stored in the storage means, each refrigerant flow rate can be appropriately stored at the time of valve opening degree determination control, which is carried out at the time of test operation, at the time of shipping from a factory, or the like, before starting regular air conditioning operation. Therefore, since a refrigerant is supplied at a flow rate based on an opening degree, which serves as reference, at the time of regular air conditioning operation, defrosting operation can be started quickly, and defrosting can be substantially simultaneously completed even in the multi-split air conditioner 1 that has the plurality of outdoor heat exchangers 13 having different volumes.

[Second Embodiment]

[0072] Hereinafter, a second embodiment of the present invention will be described with reference to Figs. 5 and 6.

[0073] Although the opening degree of each of the outdoor expansion valves is set based on the ratio between the volumes of the respective outdoor heat exchangers prior to the start of defrosting operation and defrosting is substantially simultaneously completed in the first embodiment described above, the opening degree of each of the outdoor expansion valves is controlled in a case where defrosting operation is not simultaneously completed in the embodiment. Since other points are the same as those of the first embodiment, the same configurations will be assigned with the same reference signs and description thereof will be omitted.

[0074] Fig. 5 is a flow chart of control of the electric expansion valves at the time of defrosting operation by the control device of a multi-split air conditioner according to the second embodiment of the present invention.

[0075] Prior to the start of defrosting operation, the opening degree of each of the outdoor expansion valves 15 according to the volume of each of the outdoor heat exchangers 13 is set first (S101). After the opening degree of each of the outdoor expansion valves 15 is set, defrosting operation is started.

[0076] Next, each heat exchanger temperature is measured by each of the outdoor heat exchanger tem-

perature sensors 14 of the outdoor heat exchangers 13 (S102).

[0077] Next, it is determined whether or not each heat exchanger temperature measured in Step S102 has reached a defrosting completion temperature (for example, 9°C) (S103). In a case where it is determined that the heat exchanger temperature has reached the defrosting completion temperature in Step S103, processing proceeds to Step S104. In a case where it is determined that the heat exchanger temperature has not reached the defrosting completion temperature in Step S103, processing proceeds to Step S107. Determination of Step S103 for each of the outdoor heat exchangers 13 is performed side by side.

[0078] For example, in a case where it is determined that the heat exchanger temperature of the outdoor heat exchanger 13A has reached the defrosting completion temperature in Step S103, the opening degree of the outdoor expansion valve 15A is set to a minimum opening degree (S104). The minimum opening degree is an opening degree that allows a small amount of refrigerant to an extent that the outdoor heat exchangers 13, on which defrosting is completed, are not refrosted to flow therein. For example, it is approximately 60 pulses. Next, processing proceeds to Step S110.

[0079] For example, in a case where it is determined that the heat exchanger temperature of the outdoor heat exchanger 13A falls short of the defrosting completion temperature in Step S110, the opening degree of the outdoor expansion valve 15A is gradually increased (S106). The refrosting of the outdoor heat exchanger 13A is prevented by gradually increasing the opening degree of the outdoor expansion valve 15A. Specifically, for example, control of increasing the opening degree of the outdoor expansion valve 15A by x pulse/20s is performed for n times.

[0080] When the control of gradually increasing the opening degree of the outdoor expansion valve 15A is completed, processing proceeds to Step S110.

[0081] On the other hand, for example, in a case where it is determined that the heat exchanger temperature of the outdoor heat exchanger 13A has not reached the defrosting completion temperature in Step S103, the opening degree of the outdoor expansion valve 15A is maintained (S107).

[0082] Next, it is determined that whether or not the heat exchanger temperature of each of all the other outdoor heat exchangers 13 other than the outdoor heat exchanger 13A (in this case, the outdoor heat exchanger 13B and the outdoor heat exchanger 13C) has reached the defrosting completion temperature (S108). In a case where it is determined that the heat exchanger temperatures of all the other outdoor heat exchangers 13 have reached the defrosting completion temperature in Step S108, processing proceeds to Step S109. In a case where it is determined that the heat exchanger temperatures of all the other outdoor heat exchangers 13 have not reached the defrosting completion temperature in

Step S108, processing returns to Step S107.

[0083] In a case where it is determined that whether or not the heat exchanger temperatures of all the other outdoor heat exchangers 13 other than the outdoor heat exchanger 13A (the outdoor heat exchanger 13B and the outdoor heat exchanger 13C) have reached the defrosting completion temperature in Step S108, the opening degree of the outdoor expansion valve 15A is set to a maximum opening degree (S109). That is, the maximum opening degree means full opening.

[0084] After then, processing proceeds to Step S110.

[0085] It is determined that whether or not the defrosting completion temperature is reached in all the outdoor heat exchangers 13 in Step S110. In a case where it is determined that the heat exchanger temperatures of all the outdoor heat exchangers 13 have reached the defrosting completion temperature in Step S110, defrosting operation is terminated.

[0086] On the other hand, in a case where it is determined that the heat exchanger temperatures of all the outdoor heat exchangers 13 have not reached the defrosting completion temperature in Step S110, processing returns to Step S106.

[0087] Fig. 6 is a block diagram of a refrigerant flow rate at the time of making defrosting regular in each heat exchanger of the multi-split air conditioner according to the second embodiment of the present invention.

[0088] As shown in Fig. 6, in a case where the defrosting of the outdoor heat exchanger 13B and the outdoor heat exchanger 13C is completed and the outdoor heat exchanger 13A is being defrosted, the opening degree of the outdoor expansion valve 15B of the outdoor heat exchanger 13B and the opening degree of the outdoor expansion valve 15C of the outdoor heat exchanger 13C are set to a minimum opening degree, and the opening degree of the outdoor expansion valve 15A of the outdoor heat exchanger 13A is set to a maximum opening degree, that is full opening, as described in Step S104 and Step S109 of the flow chart in Fig. 5. Accordingly, a small amount of refrigerant to an extent that refrosting is prevented flows into the outdoor heat exchanger 13B and the outdoor heat exchanger 13C, and a refrigerant that has not flowed into the outdoor heat exchanger 13B and the outdoor heat exchanger 13C flows into the outdoor heat exchanger 13A. Therefore, the time it takes for defrosting the outdoor heat exchanger 13A is shortened, and thus the time it takes for defrosting all of the outdoor heat exchangers 13 is shortened.

[0089] As illustrated hereinbefore, the following effects are achieved in the control device of a multi-split air conditioner, the multi-split air conditioner, the method of controlling a multi-split air conditioner, and the program of controlling a multi-split air conditioner according to the embodiment.

[0090] Even in a case where control is performed such that defrosting is simultaneously completed in the plurality of outdoor heat exchangers 13 having different volumes, a case where defrosting completion timings be-

come different due to various factors is considered. In a case where an outdoor heat exchanger 13 on which defrosting is completed earlier than the other outdoor heat exchangers 13 exists, it is not necessary or needless to supply the same amount of refrigerant as an amount before defrosting completion. Then, the opening degree of the outdoor expansion valve 15 of the outdoor heat exchanger 13 on which defrosting is completed, that is, the outdoor heat exchanger 13 of which the temperature has become a defrosting completion temperature or higher is set to have a minimum opening degree. Accordingly, a refrigerant flow rate can be minimized, a larger amount of refrigerant can be supplied to the other outdoor heat exchangers 13 on which defrosting is not completed, and the time it takes for defrosting all of the plurality of outdoor heat exchangers 13 can be reduced. In addition, since the opening degrees of the outdoor expansion valves 15 are set to a minimum opening degree instead of full closing, refrosting can be prevented so as kept to a minimum.

[0091] There is a possibility that the outdoor heat exchanger 13, on which defrosting is completed and of which the outdoor expansion valve 15 is set such that the opening degree is a minimum opening degree, is refrosted since a refrigerant flow rate is set to a minimum. On the contrary, in a case where the heat exchanger temperature of this outdoor heat exchanger 13 becomes lower than the defrosting completion temperature, there is a possibility of refrosting, and thus the opening degree of the outdoor expansion valve 15 is gradually increased. Accordingly, the frosting of the outdoor heat exchanger 13 can be prevented by increasing the refrigerant flow rate.

[0092] Even in a case where control is performed such that defrosting is simultaneously completed in the plurality of outdoor heat exchangers 13 having different volumes, a case where defrosting completion timings become different due to various factors is considered. In a case where the defrosting of all of the other outdoor heat exchangers 13 is completed and only one outdoor heat exchanger 13 on which defrosting is not completed exists, the opening degrees of the outdoor expansion valves 15 of the other outdoor heat exchangers 13 become a minimum opening degree, and there is a margin in a refrigerant supply amount. However, insofar as the opening degree of the electric expansion valve of the outdoor heat exchangers 13 on which defrosting is not completed does not change and remains constant, it takes time for defrosting without an increase in the supply of a refrigerant flow rate. In a case where there is only one outdoor heat exchanger 13 on which defrosting is not completed, the opening degree of the outdoor expansion valve 15 of the outdoor heat exchanger 13 is set to full opening. Accordingly, a maximum amount of excess refrigerant can be supplied to the outdoor heat exchanger 13 on which defrosting is not completed, and the time it takes for defrosting can be shortened.

[0093] Although each of the embodiments of the present invention has been described in detail hereinbe-

fore with reference to the drawings, specific configurations are not limited to the embodiments, and design that is modified without departing from the spirit of the present invention may be included as well.

[0094] For example, although the flow rate adjusting device is the outdoor expansion valve (electric expansion valve) in each of the embodiments described above, other devices may be used insofar as it is a device including a function in which a flow rate can be adjusted by the control device 50.

Reference Signs List

[0095]

- 1: multi-split air conditioner
- 2: outdoor unit
- 3: indoor unit
- 10: compressor
- 12: four-way switching valve
- 13: outdoor heat exchanger (heat exchanger)
- 14: outdoor heat exchanger temperature sensor (temperature sensor)
- 15: outdoor expansion valve (flow rate adjusting device)
- 50: control device

Claims

1. A control device of a multi-split air conditioner including an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units, wherein each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat exchanger, and the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, is adjusted by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation.
2. The control device of a multi-split air conditioner according to Claim 1, wherein the flow rate adjusting device includes an electric expansion valve, each of the plurality of heat exchangers includes a temperature sensor that measures a heat exchanger temperature of the heat exchanger, and valve opening degree determination control of determining an opening degree of each of the electric expansion valves of the plurality of heat exchangers such that the heat exchanger temperatures of all of the heat exchangers substantially simultaneously

reach a defrosting completion temperature, which is a reference value of defrosting completion, is performed.

3. The control device of a multi-split air conditioner according to Claim 2,
wherein in a case where the heat exchanger temperature of at least one heat exchanger has become the defrosting completion temperature or higher, the opening degree of the electric expansion valve of the heat exchanger is set to a minimum opening degree. 5
4. The control device of a multi-split air conditioner according to Claim 3,
wherein in a case where the heat exchanger temperature has become lower than the defrosting completion temperature after the opening degree of the electric expansion valve of the heat exchanger is set to the minimum opening degree, the opening degree of the electric expansion valve of the heat exchanger is gradually increased. 10
5. The control device of a multi-split air conditioner according to Claim 3 or 4,
wherein in a case where the heat exchanger temperature of only one of the heat exchangers is lower than the defrosting completion temperature, the opening degree of the electric expansion valve of the heat exchanger is set to full opening. 15
6. The control device of a multi-split air conditioner according to any one of Claims 2 to 5,
wherein the valve opening degree determination control is carried out at a time of shipping from a factory or at a time of test operation, and the opening degree of the electric expansion valve is stored in storage means. 20
7. A multi-split air conditioner comprising: 25
 - an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger; 30
 - a plurality of indoor units; and
 - the control device according to any one of Claims 1 to 6. 35
8. A method of controlling a multi-split air conditioner including an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units, 40
 - wherein each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat ex-

changer,

the method comprising: a step of adjusting the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation.

9. A program of controlling a multi-split air conditioner including an outdoor unit that includes a plurality of heat exchangers, at least one of which is the heat exchanger having a volume different from a volume of the other heat exchanger, and a plurality of indoor units,
wherein each of the plurality of heat exchangers includes a flow rate adjusting device that adjusts a flow rate of a refrigerant to be supplied to the heat exchanger,
the program comprising:
a step of adjusting the flow rate of the refrigerant, which is to be supplied to each of the heat exchangers, by control of the flow rate adjusting device according to each of the volumes of the plurality of heat exchangers at a time of defrosting operation. 45

FIG. 1

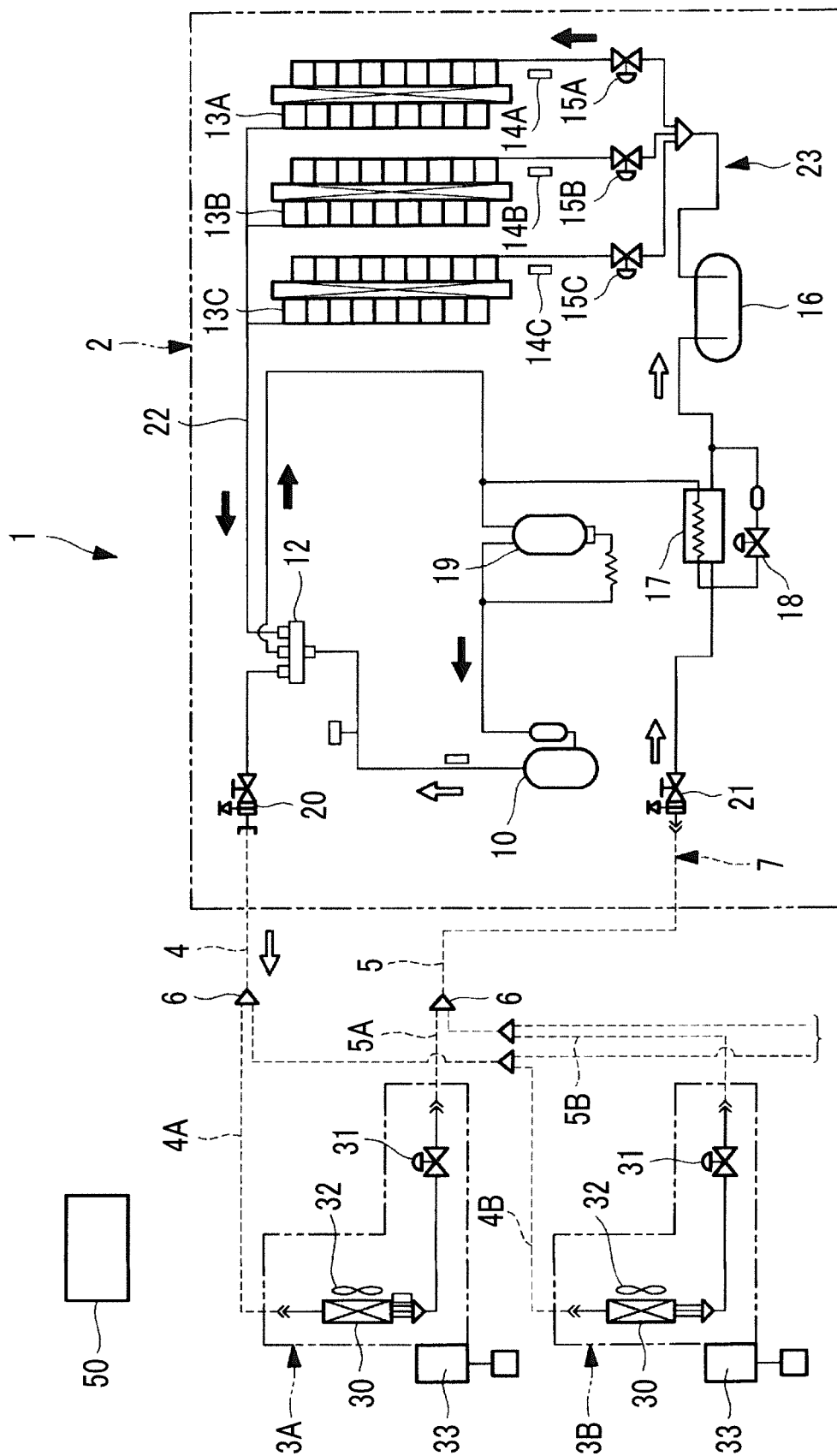


FIG. 2

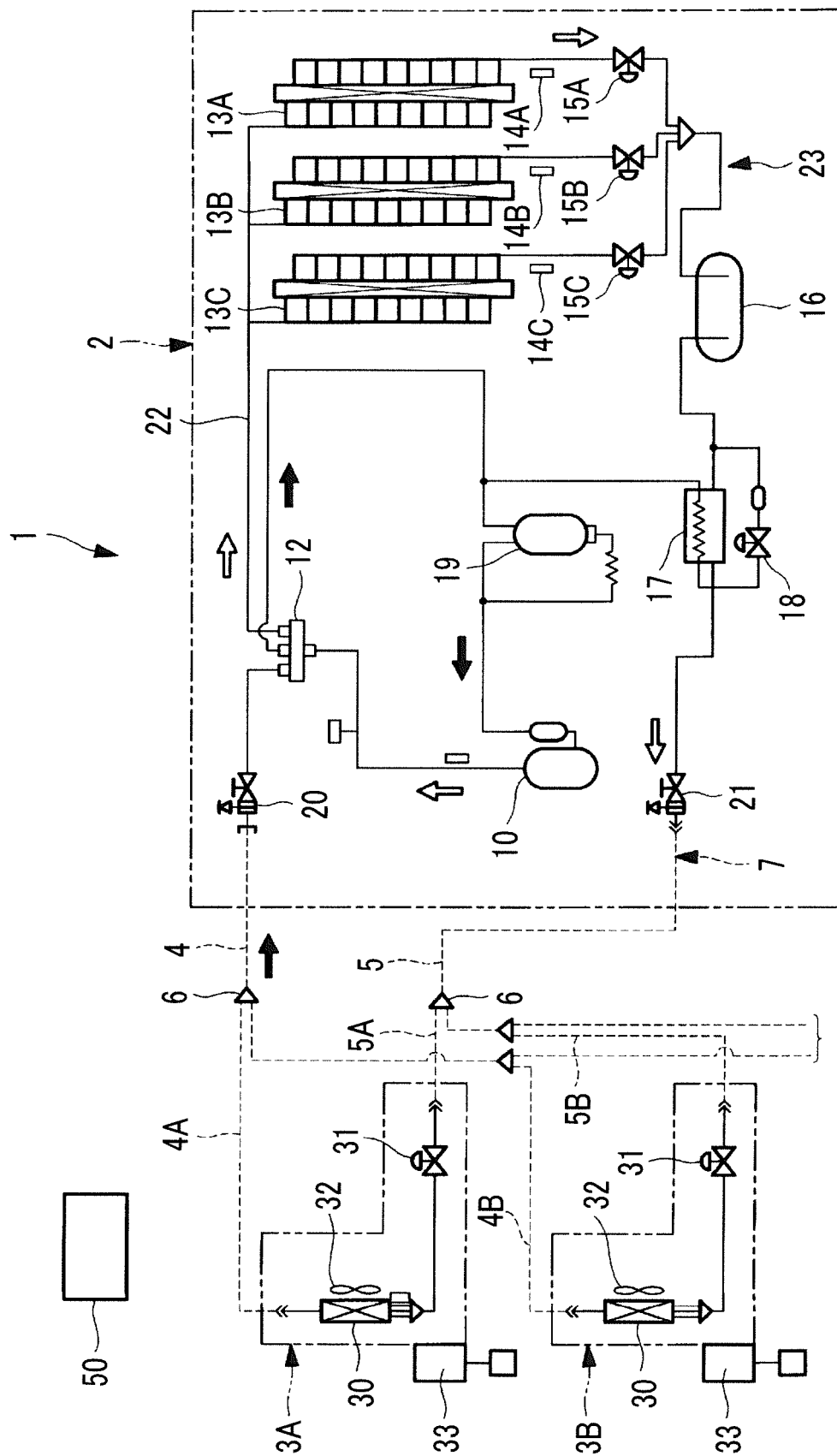


FIG. 3

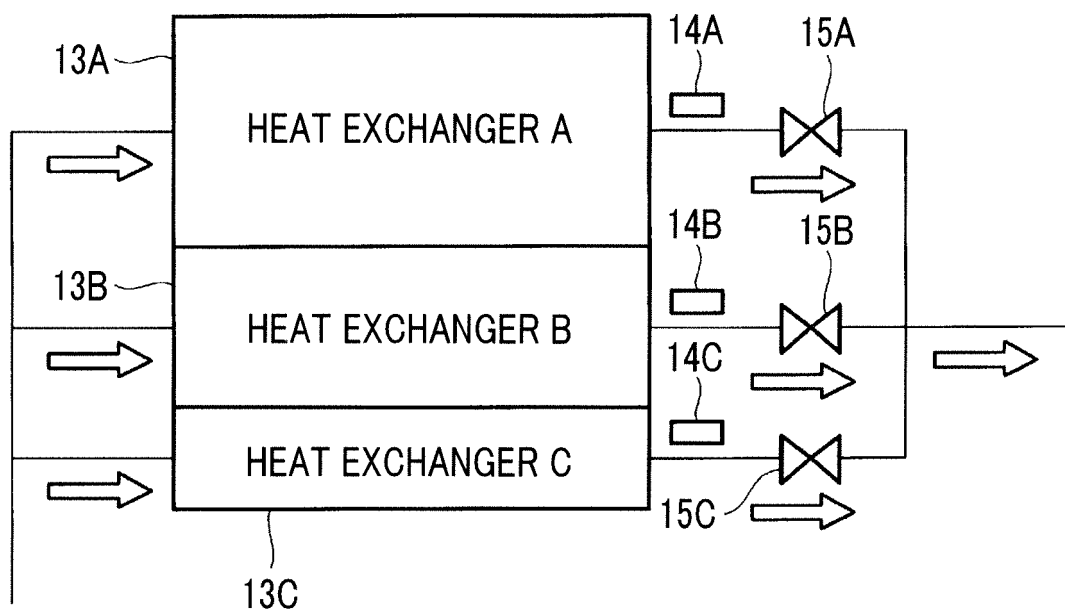


FIG. 4

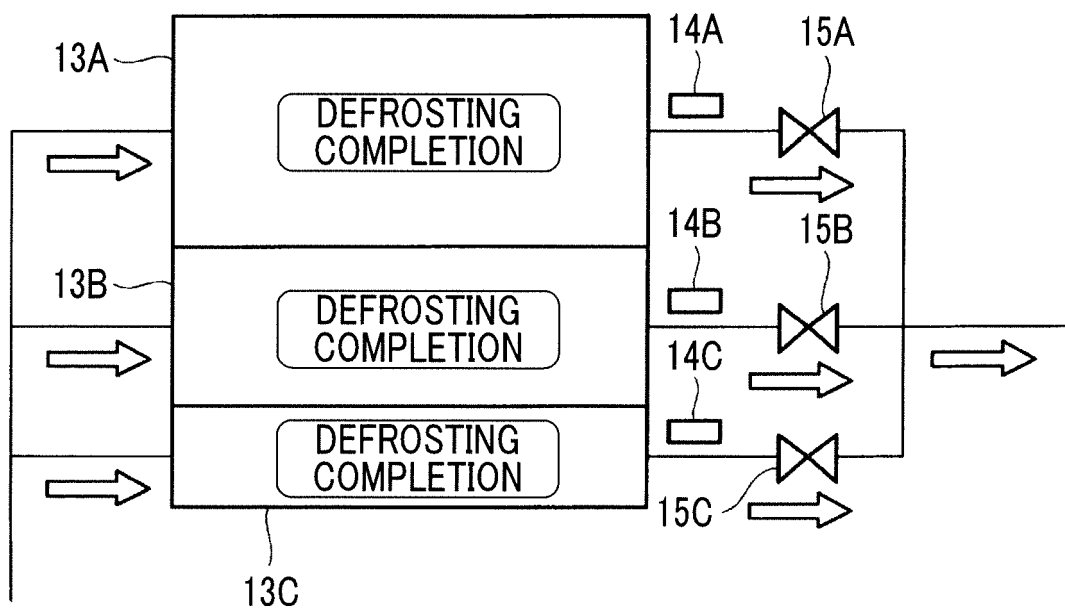


FIG. 5

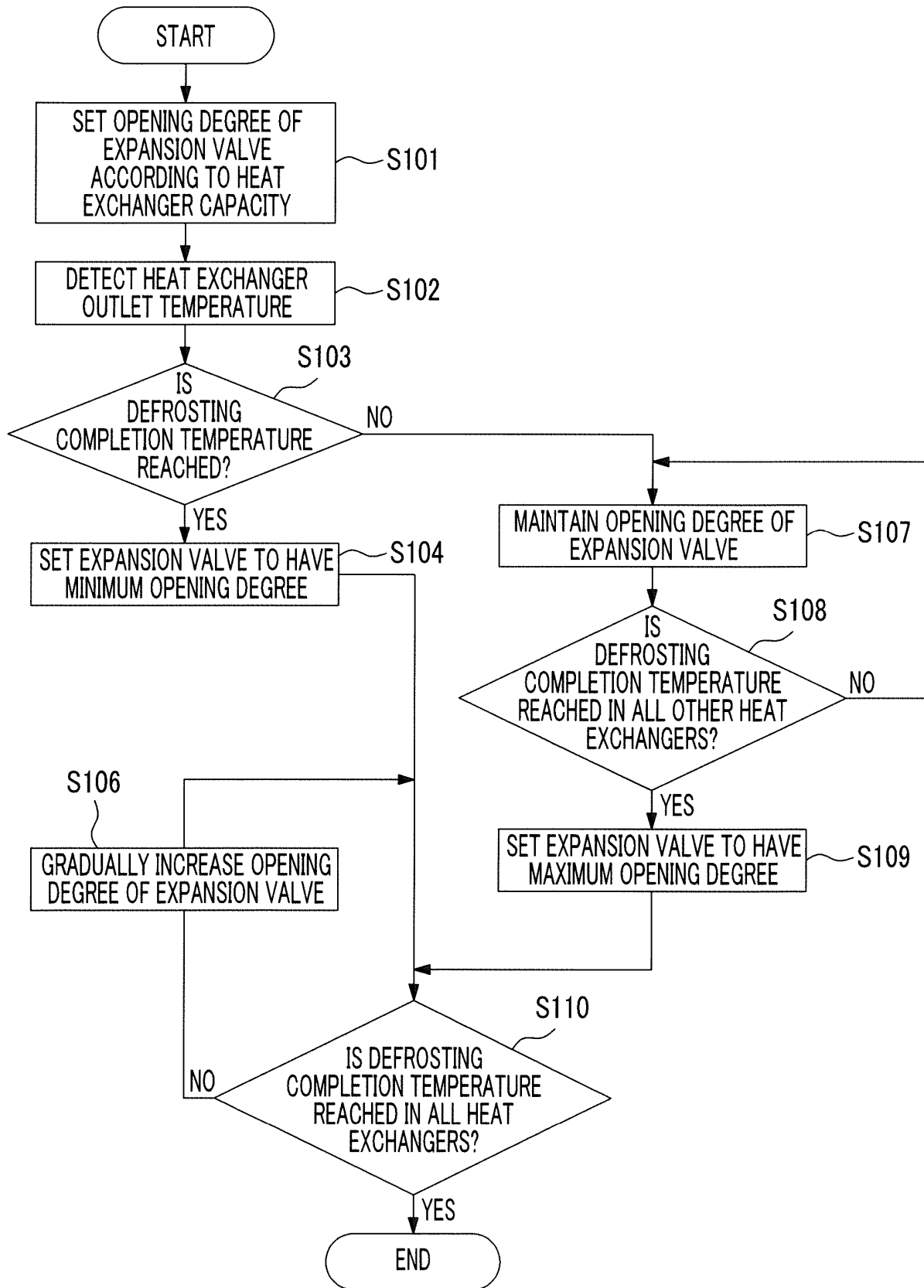
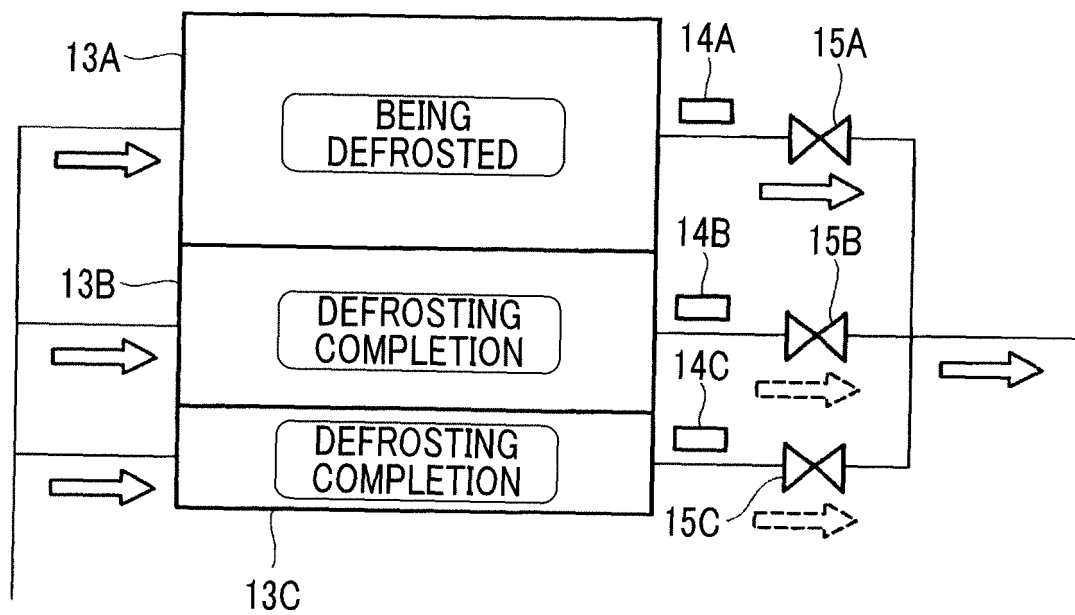


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/041936

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F24F11/46 (2018.01) i, F24F11/41 (2018.01) i, F24F11/49 (2018.01) 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. F24F11/46, F24F11/41, F24F11/49

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 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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.
A	JP 2-82061 A (SANDEN CORP.) 22 March 1990, page 3, upper left column, line 17 to page 5, lower right column, line 13, fig. 1-5 (Family: none)	1-9
A	JP 4-297762 A (SANYO ELECTRIC CO., LTD.) 21 October 1992, paragraphs [0009]-[0042], fig. 1-4 & TW 198091 B	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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REFERENCES CITED IN THE DESCRIPTION

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