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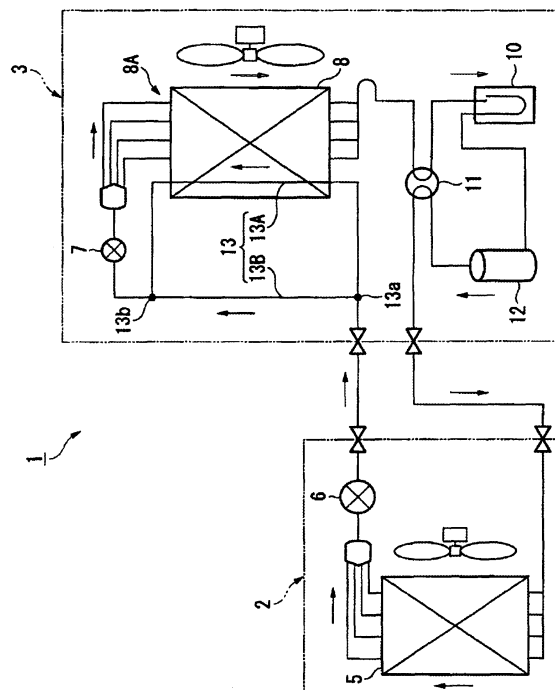
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(54) **Cooling cycle apparatus and method of operating the same**

(57) A cooling cycle apparatus and a method of operating the same that is capable of preventing frost or ice formation at the lower part of an outdoor heat exchanger without damage to hot line function and improving heating capacity. A refrigerant pipe is connected between an indoor expansion valve and an outdoor expansion valve. The refrigerant pipe is branched into a hot line pipe (a first pipe), which extends through a part of the outdoor heat exchanger, and a bypass pipe (a second pipe), which does not extend through the outdoor heat exchanger. The refrigerant pipe is designed such that a predetermined circulating amount of the refrigerant can be divided through the hot line pipe and the bypass pipe at a predetermined ratio.

Fig 1



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Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present general inventive concept relates to a cooling cycle apparatus and a method of operating the same.

2. Description of the Related Art

[0002] An air conditioner capable of performing cooling and heating operations, which is representative of a cooling cycle apparatus having a cooling cycle constituted by an outdoor heat exchanger, an indoor heat exchanger, and a compressor, which are connected to each other through pipes, is well known. Flow direction of refrigerant in the air conditioner is changed by a four-way valve to allow the air conditioner to be operated in a cooling operation mode or a heating operation mode. In the cooling operation mode, the outdoor heat exchanger serves as a condenser, and the indoor heat exchanger as an evaporator. In the heating operation mode, on the other hand, the outdoor heat exchanger serves as the evaporator, and the indoor heat exchanger as the condenser.

[0003] When the air conditioner is operated in the heating operation mode, drain water (defrosting water) generated from the outdoor heat exchanger, serving as the evaporator, may be frozen at the lower part of the outdoor heat exchanger depending upon the temperature of outdoor air. Occurrence of such a freezing phenomenon is effectively prevented by the provision of a cooling cycle apparatus characterized in that a portion of the refrigerant pipe connected between an indoor expansion valve and an outdoor expansion valve, which serves as a hot line pipe, is arranged at the lower part of the outdoor heat exchanger, and high-temperature and high-pressure refrigerant passes through the hot line pipe (Japanese Unexamined Patent Publication No. H09-138008).

[0004] According to the air conditioner disclosed in the above-mentioned publication, the opening level of the indoor expansion valve and the outdoor expansion valve is controlled to maintain the temperature of the hot line pipe at a predetermined range. Consequently, the refrigerant flowing through the hot line pipe is maintained in a two-phase state, i.e., in a gas-and-liquid state, and therefore, frost or ice formation at the lower part of the outdoor heat exchanger as well as the hot line pipe is effectively prevented.

[0005] In the conventional cooling cycle apparatus, however, all the refrigerant flowing to the outdoor expansion valve from the indoor expansion valve is introduced into the hot line pipe when the cooling operation is performed. As a result, more heat than necessary to prevent frost or ice formation may be discharged out of the cooling cycle apparatus depending upon the temperature of outdoor air.

[0006] Consequently, even heat usable as indoor side heating capacity is excessively discharged out of the cooling cycle apparatus, and therefore, heating capacity of the cooling cycle apparatus is deteriorated.

[0007] When the temperature of outdoor air is low during the cooling operation, the refrigerant condensing pressure of the outdoor heat exchanger, which fully serves as the condenser, is abnormally lower than usual. In addition, the refrigerant evaporating pressure is lower. In this way, the equilibrium of the cooling cycle is maintained. At this time, frequent on/off control of the compressor is performed to prevent drain water from being frozen at the surface of the indoor side heat exchanger. As a result, air-conditioning pleasantness is lowered, and compressor reliability is considerably lowered.

[0008] In order to overcome the above-mentioned problems, a cooling cycle apparatus has been proposed wherein a plurality of outdoor heat exchangers having different capacities are arranged, and flow of refrigerant to the respective outdoor heat exchangers is controlled, whereby the continuous operation of the compressor is accomplished (Japanese Unexamined Patent Publication No. 2002-061978).

[0009] In the cooling cycle apparatus according to the above-mentioned publication, however, the refrigerant may remain in the outdoor heat exchanger(s) not used when the heating operation is performed. In this case, the heating operation is continuously performed while the circulating amount of the refrigerant necessary to form the cooling cycle is insufficient, and therefore, reliability of the cooling cycle apparatus is deteriorated.

SUMMARY OF THE INVENTION

[0010] Accordingly, the present general inventive concept provides a cooling cycle apparatus that is capable of preventing frost or ice formation at the lower part of an outdoor heat exchanger without damage to a hot line operation and maintaining the pressure of refrigerant in the cooling cycle at a predetermined range, thereby improving heating and cooling capacities at the indoor unit side.

[0011] The present general inventive concept also provides a method of operating such a cooling cycle apparatus.

[0012] Additional aspects and advantages of the present general inventive concept will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the general inventive concept.

[0013] The foregoing and/or other aspects and advantages of the present general inventive concept may be achieved by providing a cooling cycle apparatus including an indoor heat exchanger, an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle, wherein the pipe includes a refrigerant pipe connected between the indoor expansion part and the outdoor expansion part, the refrigerant pipe being branched into a first pipe, which extends through at least a part of the outdoor heat exchanger, and a second pipe, which does not extend through the outdoor heat exchanger.

[0014] According to the cooling cycle apparatus as described above, the whole circulating amount of the refrigerant can be divided through the first pipe and the second pipe at a predetermined ratio. Consequently, when the heating operation is performed with the outdoor heat exchanger used as an evaporator, high-temperature and high-pressure refrigerant passes through the lower part of the outdoor heat exchanger, and the refrigerant flowing to the outdoor expansion part from the indoor expansion part is maintained at high temperature and high pressure, and therefore, frost or ice formation at the lower part of the outdoor heat exchanger is prevented.

[0015] The cooling cycle apparatus may further include: a first temperature detection part to detect the temperature of the first pipe; a second temperature detection part to detect the temperature of outdoor air; and a flow rate control unit disposed on the first pipe to control flow rate of the refrigerant based on the temperature of the first pipe and the temperature of the outdoor air.

[0016] According to the cooling cycle apparatus as described above, the flow rate control unit can be opened or closed based on the temperature of the first pipe and the temperature of the outdoor air. Consequently, the refrigerant can be allowed or prohibited to flow through the first pipe as required, and therefore, the temperature at the lower part of the outdoor heat exchanger can be changed by controlling flow rate of the refrigerant flowing through the first pipe.

[0017] The cooling cycle apparatus may further include: a guide mechanism to guide at least some of the refrigerant to the first pipe, when the refrigerant flows to the outdoor heat exchanger from the outdoor expansion part, based on the temperature of the first pipe and the temperature of the outdoor air.

[0018] According to the cooling cycle apparatus as described above, when the heating operation is performed with the entire area of the outdoor heat exchanger used as an evaporator, some of the refrigerant flowing through the first pipe can be guided in the same direction as the refrigerant passing through the outdoor heat exchanger by controlling an opening/closing valve and the guide mechanism based on the temperature of the first pipe and the temperature of the outdoor air. Consequently, frost or ice formation at the lower part of the outdoor heat exchanger is prevented. Furthermore, the first pipe can be used as the evaporator, and therefore, the capacity of the outdoor heat exchanger is increased.

[0019] The outdoor heat exchanger has a heat exchange part, which allows a larger amount of refrigerant to pass therethrough than through the first pipe, and the cooling cycle apparatus may further include: a pipe selection mechanism disposed at at least one side of the first pipe and the heat exchange part to guide the refrigerant, in one direction, to the outdoor heat exchanger from the outlet side of the compressor.

[0020] The foregoing and/or other aspects and advantages of the present general inventive concept may also be achieved by providing a method of a operating cooling cycle apparatus including an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle, the pipe including a refrigerant pipe connected between the indoor expansion part and the outdoor expansion part and branched into a first pipe, which extends through at least a part of the outdoor heat exchanger, and a second pipe, which does not extend through the outdoor heat exchanger, wherein the method includes: detecting the temperature of outdoor air; detecting the temperature of the first pipe; and controlling flow rate of the refrigerant flowing through the first pipe based on the temperature of the outdoor air and the temperature of the first pipe.

[0021] According to the operation method of the cooling cycle apparatus as described above, at least some of the high-temperature and high-pressure refrigerant is allowed to flow through the first pipe based on the temperature of the outdoor air and the temperature of the first pipe when the heating operation is performed. Consequently, the temperature at the lower part of the outdoor heat exchanger can be increased while the refrigerant flowing to the outdoor expansion part is maintained at high temperature and high pressure, and therefore, frost or ice formation at the lower part of the outdoor heat exchanger is prevented. Furthermore, the refrigerant can be prohibited to flow through the first pipe when it is not necessary for the refrigerant to pass through the lower part of the outdoor heat exchanger, and flow rate of the refrigerant flowing through the first pipe can be controlled as required.

[0022] The operation method may further include: guiding the refrigerant flowing through the first pipe in the same direction as the refrigerant passing through the outdoor heat exchanger.

[0023] According to the method of operating the cooling cycle apparatus as described above, when the heating

operation is performed with the outdoor heat exchanger used as an evaporator, the refrigerant flowing through the first pipe can be guided in the same direction as the refrigerant passing through the outdoor heat exchanger based on the temperature of the first pipe and the temperature of the outdoor air. Consequently, the first pipe can be used as the evaporator, and therefore, the capacity of the outdoor heat exchanger is increased.

[0024] The foregoing and/or other aspects and advantages of the present general inventive concept may also be achieved by providing a method of operating of a cooling cycle apparatus including an indoor heat exchanger, an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle, wherein the method includes: detecting the temperature of outdoor air; and guiding the refrigerant, in one direction, to the outdoor heat exchanger from the outlet side of the compressor through a first pipe, which extends through at least a part of the outdoor heat exchanger, and/or a heat exchange part disposed in the outdoor heat exchanger to allow a larger amount of refrigerant to pass therethrough than through the first pipe based on the detected temperature of the outdoor air.

[0025] According to the method of operating the cooling cycle apparatus as described above, the refrigerant can be guided in one direction through the first pipe and the heat exchange part by a pipe selection mechanism when the refrigerant flows to the outdoor heat exchanger from the compressor. Alternatively, the refrigerant may be guided in one direction through either the first pipe or the heat exchange part. Furthermore, the amount of the refrigerant passing through the outdoor heat exchanger can be controlled based on the temperature of the outdoor air. Consequently, flow rate of the refrigerant heat-exchanged in the outdoor heat exchanger is minimized when the refrigerant discharged from the compressor flows only through the first pipe, and therefore, the refrigerant can be maintained at high temperature and high pressure even when the temperature of the outdoor air is low.

[0026] The method may further include: detecting discharge pressure of the compressor, and the operation of guiding the refrigerant in one direction is performed based the detected discharge pressure of the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] These and/or other aspects and advantages of the general inventive concept will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings, of which:

[0028] FIG. 1 is a circuit diagram showing an air conditioner according to an embodiment of the present general inventive concept;

[0029] FIG. 2 is a circuit diagram showing an air conditioner according to second and third embodiments of the present invention;

[0030] FIG. 3 is a flow chart illustrating a method of operating the air conditioner according to FIG. 2 when a heating operation is performed, according to another embodiment of the present general inventive concept;

[0031] FIG. 4 is a flow chart illustrating a method of operating the air conditioner according to FIG. 2 when a heating operation is performed, according to another embodiment of the present general inventive concept;

[0032] FIG. 5 is a circuit diagram showing an air conditioner according to another embodiment of the present general inventive concept;

[0033] FIG. 6 is a flow chart illustrating a method of operating the air conditioner according to FIG. 5 when a heating operation is performed, according to another embodiment of the present general inventive concept;

[0034] FIG. 7 is a flow chart illustrating a method of operating the air conditioner according to FIG. 5 when a heating operation is performed, according to another embodiment of the present general inventive concept;

[0035] FIG. 8 is a circuit diagram showing an air conditioner according to another embodiment of the present general inventive concept;

[0036] FIG. 9 is a flow chart illustrating a method of operating the air conditioner according to FIG. 8 when a cooling operation is performed;

[0037] FIG. 10 is a circuit diagram showing an air conditioner according to another embodiment of the present general inventive concept;

[0038] FIG. 11 is a flow chart illustrating a method of operating the air conditioner according to FIG. 10 when a cooling operation is performed;

[0039] FIG. 12 is a circuit diagram showing an air conditioner according to another embodiment of the present general inventive concept; and

[0040] FIG. 13 is a flow chart illustrating a method of operating the air conditioner according to FIG. 12 when a cooling operation is performed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] Reference will now be made in detail to the embodiment of the present general inventive concept, examples

of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiment is described below to explain the present general inventive concept by referring to the figures.

[0042] An air conditioner 1 according to an embodiment of the present general inventive concept will be described with reference to FIG. 1.

[0043] As illustrated in FIG. 1, the air conditioner (cooling cycle apparatus) 1 comprises an indoor unit 2 and an outdoor unit 3.

[0044] In the indoor unit 2 are disposed an indoor heat exchanger 5 and an indoor expansion valve (indoor expansion part) 6. In the outdoor unit 3 are disposed an outdoor expansion valve (outdoor expansion part) 7, an outdoor heat exchanger 8, an accumulator 10, a four-way valve 11, and a compressor 12. All the parts are connected to each other through pipes to provide a cooling cycle for refrigerant circulation.

[0045] Specifically, a refrigerant pipe 13 is connected between the indoor expansion valve 6 and the outdoor expansion valve 7. The refrigerant pipe 13 branches into: a hot line pipe (a first pipe) 13A extending through the lower part of the outdoor heat exchanger 8 between a first diverging point 13a adjacent to the indoor expansion valve 6 and a second diverging point 13b adjacent to the outdoor expansion valve 7; and a bypass pipe (a second pipe) 13B connected between the first diverging point 13a and the second diverging point 13b without extending through the lower part of the outdoor heat exchanger 8. The refrigerant pipe 13 is designed such that the whole circulating amount of the refrigerant can be divided through the hot line pipe 13A and the bypass pipe 13B at a predetermined ratio.

[0046] The outdoor heat exchanger 8 has two refrigerant channels disposed therein. Also, the outdoor heat exchanger 8 has the hot line pipe 13A and a heat exchange part 8A, which allows a larger amount of refrigerant to pass therethrough than through the hot line pipe 13A.

[0047] Now, a method of operating the air conditioner 1 according to an embodiment of the present general inventive concept when the heating operation is performed, will be described.

[0048] High-temperature and high-pressure refrigerant discharged from the compressor 12 flows into the indoor heat exchanger 5 of the indoor unit 2 from the outdoor unit 3 via the four-way valve 11, and is then expanded by the indoor expansion valve 6. As a result, the refrigerant is decompressed. The decompressed refrigerant flows through the refrigerant pipe 13 in the outdoor unit 3. At this time, the refrigerant flows through the hot line pipe 13A and the bypass pipe 13B at the first diverging point 13a at a predetermined ratio. The refrigerant flowing through the hot line pipe 13A passes through the lower part of the outdoor heat exchanger 8.

[0049] At this time, heat is radiated from the refrigerant flowing through the hot line pipe 13A at the lower part of the outdoor heat exchanger 8.

[0050] The refrigerant flowing through the hot line pipe 13A joins the refrigerant flowing through the bypass pipe 13B at the second diverging point 13b. Also, the refrigerant bypassing the hot line pipe 13A flows through the bypass pipe 13B. The refrigerant flows into the heat exchange part 8A of the outdoor heat exchanger 8, which serves as the evaporator, via the outdoor expansion valve 7 such that heat exchange between outdoor air and the heat exchange part is performed.

[0051] According to the air conditioner 1, the refrigerant flowing to the outdoor expansion valve 7 from the indoor expansion valve 6, temperature and pressure of which are unchanged, flows through the hot line pipe 13A as well as the bypass pipe 13B. As a result, frost or ice formation at the lower part of the outdoor heat exchanger 8 is prevented by the refrigerant flowing through the hot line pipe 13A.

[0052] Consequently, excessive heat radiation to outdoor air is effectively prevented without damage to hot line function when the heating operation is performed, and therefore, heating efficiency of the air conditioner is improved.

[0053] An air conditioner 20 according to another embodiment of the present general inventive concept will be described with reference to FIGS. 2 and 3.

[0054] Components of the air conditioner 20 according to this embodiment of FIGS. 2-3, which are identical to those of the air conditioner 1 according to the previous embodiment, are indicated by the same reference numerals as those of the air conditioner 1 according to the embodiment of FIG. 1, and a detailed description thereof will not be given.

[0055] The air conditioner 20 according to this embodiment is different from the air conditioner 1 according to the embodiment of FIG. 1 in that the air conditioner 20 further includes: a hot line pipe temperature detecting device (a first temperature detection part) 21 to detect the temperature of the inlet part of the hot line pipe 13A, through which the refrigerant is introduced into the lower part of the outdoor heat exchanger 8 when the heating operation is performed; an outdoor air temperature detecting device (a second temperature detection part) 22 to detect the temperature of outdoor air; and a hot line circuit electromagnetic valve (flow rate control unit) 23 to control flow rate of the refrigerant based on the temperature detected by the hot line pipe temperature detecting device 21 and the temperature detected by the outdoor air temperature detecting device 22.

[0056] The hot line circuit electromagnetic valve 23 is disposed at the inlet part of the hot line pipe 13A, through which the refrigerant is introduced into the outdoor heat exchanger 8 when the heating operation is performed, such that the hot line circuit electromagnetic valve 23 is opened/closed by a flow rate control device 25.

[0057] Now, a method of operating the air conditioner 20 when the heating operation is performed will be described.

[0058] The method of operating the air conditioner 20 includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S01); detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S02); and controlling flow rate of the refrigerant flowing through the hot line pipe 13A by opening/closing the hot line circuit electromagnetic valve 23 based on the temperature of the outdoor air and the temperature of the hot line pipe 13A (operation S03).

[0059] When the heating operation is initiated, the hot line circuit electromagnetic valve 23 is closed. As a result, the refrigerant flows to the outdoor expansion valve 7 from the indoor expansion valve 6 through the bypass pipe 13B.

[0060] After the heating operation is initiated, the hot line circuit electromagnetic valve 23 is opened. In the operation of detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S01), the temperature T_A of the outdoor air is detected by the outdoor air temperature detecting device 22. In the operation of detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S02), the temperature T_r of the hot line pipe 13A is detected by the hot line pipe temperature detecting device 21.

[0061] Subsequently, a comparison between the temperature T_A of the outdoor air and a predetermined temperature α , which is set higher than the freezing point, is made. If $T_A < \alpha$, frost or ice may be formed at the lower part of the outdoor heat exchanger 8. Consequently, the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S03) is performed such that the hot line circuit electromagnetic valve 23 is opened by the flow rate control device 25.

[0062] At this time, some of the refrigerant flowing through the refrigerant pipe 13 is introduced into the hot line pipe 13A. As a result, the refrigerant passes through the outdoor heat exchanger 8, and therefore, the lower part of the heat exchanger 8 is heated by the refrigerant. After that, the refrigerant flowing through the hot line pipe 13A joins the refrigerant flowing through the bypass pipe 13B, and then flows to the outdoor expansion valve 7.

[0063] The above process is repeated until $T_A \geq \alpha$, and then a comparison between T_A and T_r is made. If $T_r > T_A$, the hot line circuit electromagnetic valve 23 is closed by the flow rate control device 25.

[0064] As a result, flow of the refrigerant through the hot line pipe 13A is interrupted, and the refrigerant flows through the bypass pipe 13B. Consequently, excessive heat radiation from the lower part of the outdoor heat exchanger 8 is effectively prevented.

[0065] If $T_r \leq T_A$, on the other hand, the hot line circuit electromagnetic valve 23 is opened. At this time, the refrigerant flows through the hot line pipe 13A, but the temperature of outdoor air is higher than the temperature of the hot line pipe 13A. Consequently, heat radiation to the outdoor air does not occur.

[0066] In this way, the above-mentioned process is repeated to perform the heating operation.

[0067] According to the air conditioner 20 and the method of operating the air conditioner 20, the same effect as the previous embodiment can be obtained. For example, the hot line circuit electromagnetic valve 23 can be opened/closed based on the relation between the temperature of the hot line pipe 13A and the temperature of the outdoor air such that the refrigerant flows through the hot line pipe 13A as required. As a result, the flow rate of the refrigerant flowing through the hot line pipe 13A can be controlled depending upon the temperature condition when the heating operation is performed, and therefore, excessive heat radiation from the lower part of the outdoor heat exchanger 8 is effectively prevented without damage to the hot line function. Consequently, heating efficiency of the indoor unit is improved.

[0068] An air conditioner according to this embodiment of the present general inventive concept will be described with reference to FIGS. 2 and 4.

[0069] Components of the air conditioner according to this embodiment of FIGS. 2 and 4, which are identical to those of the air conditioner according to any one of the previous embodiments, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments, and therefore a detailed description thereof will not be given.

[0070] The air conditioner according to the present embodiment of FIGS. 2 and 4 is different from the air conditioner according to the previous embodiment of FIGS. 2 and 4 in that the air conditioner according to the embodiment of FIGS. 3 and 4 further includes a flow rate control valve, which can be substituted for the hot line circuit electromagnetic valve 23.

[0071] The opening level of the flow rate control valve is changed by the flow rate control device 25.

[0072] Now, a method of operating the air conditioner 20 according to the embodiment of FIGS. 2 and 4 when the heating operation is performed will be described.

[0073] The method of operating the air conditioner 20 includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S11); detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S12); and controlling flow rate of the refrigerant flowing through the hot line pipe 13A by controlling the opening level of the flow rate control valve based on the temperature of the outdoor air and the temperature of the hot line pipe 13A (operation S13).

[0074] When the heating operation is initiated, the flow rate control valve is closed. As a result, the refrigerant flows to the outdoor expansion valve 7 from the indoor expansion valve 6 through the bypass pipe 13B.

[0075] After the heating operation is initiated, the flow rate control valve is fully opened. In the operation of detecting

the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S11), the temperature TA of the outdoor air is detected by the outdoor air temperature detecting device 22. In the operation of detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S12), the temperature Tr of the hot line pipe 13A is detected by the hot line pipe temperature detecting device 21.

[0076] Subsequently, a comparison between the temperature TA of the outdoor air and a predetermined temperature α , which is set higher than the freezing point, is made. If $TA < \alpha$, frost or ice may be formed at the lower part of the outdoor heat exchanger 8. Consequently, the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A by controlling the opening level of the flow rate control valve (operation S13) is performed such that the flow rate control valve is fully opened by the flow rate control device 25.

[0077] At this time, some of the refrigerant flowing through the refrigerant pipe 13 is introduced into the hot line pipe 13A. As a result, the refrigerant passes through the lower part of the outdoor heat exchanger 8, and therefore, the lower part of the heat exchanger 8 is heated by the refrigerant. After that, the refrigerant flowing through the hot line pipe 13A joins the refrigerant flowing through the bypass pipe 13B, and then flows to the outdoor expansion valve 7.

[0078] The above process is repeated until $TA \geq \alpha$, and then a comparison between TA and Tr is made. If $Tr > TA$, the opening level of the flow rate control valve is decreased to a predetermined level by the flow rate control device 25.

[0079] As a result, flow rate of the refrigerant flowing through the hot line pipe 13A is decreased, and therefore, excessive heat radiation from the lower part of the outdoor heat exchanger 8 is effectively prevented.

[0080] If $Tr = TA$, on the other hand, the opening level of the flow rate control valve is unchanged. If $Tr < TA$, the opening level of the flow rate control valve is increased to the predetermined level. At this time, the refrigerant flows through the hot line pipe 13A, but the temperature of outdoor air is equal to or higher than the temperature of the hot line pipe 13A. Consequently, heat radiation to the outdoor air does not occur. In this way, the above-mentioned process is repeated to perform the heating operation.

[0081] According to the air conditioner with the above-stated construction and the operation method of the air conditioner, the same effect as the previous embodiment can be obtained. For example, the opening level of the flow rate control valve can be controlled to accurately control the flow rate of the refrigerant flowing through the hot line pipe 13A. Consequently, the hot line function is more efficiently utilized.

[0082] An air conditioner 40 according to yet another embodiment of the present general inventive concept will be described with reference to FIGS. 5 and 6.

[0083] Components of the air conditioner 40 according to the embodiment of FIGS. 5 and 6, which are the same as to those of the air conditioner according to any one of the previous embodiments of the present general inventive concept, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments, and therefore a detailed description thereof will not be given.

[0084] The air conditioner 40 according to the present embodiment of FIGS. 5 and 6 is different from the air conditioner according to the embodiment of FIGS. 2 and 3 in that the air conditioner 40 further includes: a guide mechanism 41 to guide at least some of the refrigerant to the hot line pipe 13A, when the refrigerant flows to the outdoor heat exchanger 8 from the outdoor expansion valve 7, based on the temperature of the hot line pipe 13A and the temperature of the outdoor air.

[0085] The guide mechanism 41 includes: a first bypass pipe 42 connected between the heat exchange part 8A and the hot line pipe 13A at the outlet part of the outdoor heat exchanger 8; a second bypass pipe 43 connected between the heat exchange part 8A and the hot line pipe 13A at the inlet part of the outdoor heat exchanger 8; a first non-return valve 45 disposed between a connection 44A at which the first bypass pipe 42 and the hot line pipe 13A are connected to each other and a connection 44B (the second diverging point 13b) at which the hot line pipe 13A and the bypass pipe 13B are connected to each other; and a second non-return valve 46 disposed on the first bypass pipe 42; and an evaporator side electromagnetic valve 47 disposed on the second bypass pipe 43.

[0086] The first bypass pipe 42 is connected between the hot line pipe 13A and the heat exchange part 8A at the outdoor expansion valve side. Also, the first bypass pipe 42 is connected to the heat exchange part 8A at a connection 44C. The second bypass pipe 43 is connected between the hot line pipe 13A and the heat exchange part 8A at the compressor side. Also, the second bypass pipe 43 is connected to the hot line pipe 13A at a connection 44D, and is connected to the heat exchange part 8A at a connection 44E.

[0087] The first non-return valve 45 serves to allow the refrigerant to flow to the connection 44B from the connection 44A, and the second non-return valve 46 serves to allow the refrigerant discharged from the outdoor expansion valve 7 to flow to the hot line pipe 13A right before introduction to the outdoor heat exchanger 8.

[0088] The evaporator side electromagnetic valve 47 is opened/closed by the flow rate control device 25.

[0089] Now, a method of operating the air conditioner 40 according to the present embodiment of FIGS. 5 and 6 when the heating operation is performed, will be described.

[0090] The method of operating the air conditioner 40 includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S21); detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S22); guiding the refrigerant flowing through the hot line

pipe 13A in the same direction as the refrigerant passing through the outdoor heat exchanger 8 (operation S23); and controlling flow rate of the refrigerant flowing through the hot line pipe 13A by opening/closing the hot line circuit electromagnetic valve 23 based on the temperature of the outdoor air and the temperature of the hot line pipe 13A (operation S24).

[0091] The heating operation is performed such that the hot line circuit electromagnetic valve 23 is opened, and the evaporator side electromagnetic valve 47 is closed. In the operation of detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S21), the temperature T_A of the outdoor air is detected by the outdoor air temperature detecting device 22. In the operation of detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S22), the temperature T_r of the hot line pipe 13A is detected by the hot line pipe temperature detecting device 21.

[0092] If $\beta < T_A < \alpha$ (α is a predetermined temperature, which is set higher than the freezing point, and β is a predetermined temperature, which is set lower than the freezing point), frost or ice may be formed at the lower part of the outdoor heat exchanger 8. Consequently, the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S24) is performed such that only the hot line circuit electromagnetic valve 23 is opened by the flow rate control device 25.

[0093] At this time, some of the refrigerant flowing through the refrigerant pipe 13 is introduced into the hot line pipe 13A, and then flows to the outdoor expansion valve 7 from the indoor expansion valve 6 through the lower part of the outdoor heat exchanger 8 by the first non-return valve 45 and the second non-return valve 46. As a result, the lower part of the heat exchanger 8 is heated by the refrigerant. After that, the refrigerant flowing through the hot line pipe 13A joins the refrigerant flowing through the bypass pipe 13B, and then flows to the outdoor expansion valve 7.

[0094] The above process is repeated until $T_A \leq \beta$, and then the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S24) is performed such that the hot line circuit electromagnetic valve 23 is closed by the flow rate control device 25, and the evaporator side electromagnetic valve 47 is opened.

[0095] At this time, some of the refrigerant passing through the outdoor expansion valve 7 flows to the second bypass pipe 43 from the first bypass pipe 42 through the hot line pipe 13A. As a result, the hot line pipe 13A serves as an evaporator.

[0096] The above process is further repeated until $T_r > T_A$, and then the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S24) is performed such that both the hot line circuit electromagnetic valve 23 and the evaporator side electromagnetic valve 47 are closed. If $T_r \leq T_A$, on the other hand, the hot line circuit electromagnetic valve 23 is opened, and the evaporator side electromagnetic valve 47 is closed.

[0097] As a result, the refrigerant flowing through the hot line pipe 13A flows to the outdoor expansion valve 7 from the indoor expansion valve 6, and therefore, excessive heat radiation to the outdoor air is effectively prevented.

[0098] According to the air conditioner 40 and the method of operating the air conditioner 40, the refrigerant flows through the hot line pipe 13A when the heating operation is performed, and therefore, frost or ice formation at the lower part of the outdoor heat exchanger 8 is effectively prevented. In addition, excessive heat radiation to the outdoor air is effectively prevented by opening/closing the hot line circuit electromagnetic valve 23, and therefore, heating efficiency of the air conditioner is improved. Furthermore, the evaporator side electromagnetic valve 47 is also opened/closed, when the frost or ice formation does not occur at the lower part of the outdoor heat exchanger 8, such that the refrigerant flows through the hot line pipe 13A in the same direction as the refrigerant passing through the outdoor heat exchanger 8 by the first non-return valve 45 and the second non-return valve 46. Moreover, the hot line pipe 13A serves as the same evaporator as the outdoor heat exchanger 8, and therefore, the capacity of the outdoor heat exchanger is increased.

[0099] An air conditioner according to yet another embodiment of the present general inventive concept will be described with reference to FIGS. 5 and 7.

[0100] Components of the air conditioner according to this embodiment, which are identical to those of the air conditioner according to any one of the previous embodiments, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments, and therefore a detailed description thereof will not be given.

[0101] The air conditioner according to the embodiment of FIGS. 5 and 7 is different from the air conditioner according to the embodiment of FIGS. 5 and 6 in that the air conditioner according to FIGS. 5 and 7 further includes a flow rate control valve, which is a substitute of the hot line circuit electromagnetic valve 23, as in the embodiment of FIGS. 2 and 4.

[0102] Now, a method of operating the air conditioner according to the embodiment of FIGS. 5 and 7 when the heating operation is performed, will be described.

[0103] As illustrated in FIG. 7, the method of operating the air conditioner includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S31); detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S32); guiding the refrigerant flowing through the hot line pipe 13A in the same direction as the refrigerant passing through the outdoor heat exchanger 8 (operation S33); and controlling flow rate of the refrigerant flowing through the hot line pipe 13A by controlling the

opening level of the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) based on the temperature of the outdoor air and the temperature of the hot line pipe 13A (operation S34).

[0104] The heating operation is performed such that the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) is fully opened, and the evaporator side electromagnetic valve 47 is closed. In the operation of detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S31), the temperature T_A of the outdoor air is detected by the outdoor air temperature detecting device 22. In the operation of detecting the temperature of the hot line pipe 13A with the hot line pipe temperature detecting device 21 (operation S32), the temperature T_r of the hot line pipe 13A is detected by the hot line pipe temperature detecting device 21.

[0105] If $\beta < T_A < \alpha$, frost or ice may be formed at the lower part of the outdoor heat exchanger 8. Consequently, the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S34) is performed such that the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) is fully opened by the flow rate control device 25.

[0106] At this time, some of the refrigerant flowing through the refrigerant pipe 13 is introduced into the hot line pipe 13A, and then flows to the outdoor expansion valve 7 from the indoor expansion valve 6 through the lower part of the outdoor heat exchanger 8 by the first non-return valve 45 and the second non-return valve 46. As a result, the lower part of the heat exchanger 8 is heated by the refrigerant. After that, the refrigerant flowing through the hot line pipe 13A joins the refrigerant flowing through the bypass pipe 13B, and then flows to the outdoor expansion valve 7.

[0107] The above process is repeated until $T_A \leq \beta$, and then the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S34) is performed such that the flow rate control valve is fully closed, and the evaporator side electromagnetic valve 47 is opened.

[0108] At this time, some of the refrigerant passing through the outdoor expansion valve 7 flows to the second bypass pipe 43 from the first bypass pipe 42 through the hot line pipe 13A. As a result, the hot line pipe 13A serves as an evaporator.

[0109] The above process is further repeated until $T_A \geq \beta$ and $T_r > T_A$, and then the operation of controlling flow rate of the refrigerant flowing through the hot line pipe 13A (operation S34) is performed such that the opening level of the flow rate control valve is decreased, and the evaporator side electromagnetic valve 47 is closed. If $T_r = T_A$, on the other hand, the opening level of the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) is unchanged, and the evaporator side electromagnetic valve 47 is closed.

[0110] If $T_r < T_A$, the opening level of the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) is increased. As a result, the refrigerant flowing through the hot line pipe 13A flows to the outdoor expansion valve 7 from the indoor expansion valve 6, and therefore, excessive heat radiation to the outdoor air is effectively prevented.

[0111] According to the air conditioner with the above-stated construction and the method of operating the air conditioner, the same effect as the previous embodiment can be obtained. Furthermore, the opening level of the flow rate control valve (substituting the hot line circuit electromagnetic valve 23) is controlled to accurately control of the flow rate of the refrigerant flowing through the hot line pipe 13A. Consequently, the hot line function is more efficiently utilized.

[0112] An air conditioner 60 according to still another embodiment of the present general inventive concept will be described with reference to FIGS. 8 and 9.

[0113] Components of the air conditioner 40 according to this embodiment, which are identical to those of the air conditioner according to any one of the previous embodiments, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments, and therefore a detailed description thereof will not be given.

[0114] The air conditioner 60 according to the present embodiment of FIGS. 8 and 9 is different from the air conditioner 40 according to the embodiment of FIGS. 5 and 6 in that, as shown in FIG. 8, the air conditioner 60 further includes: a pipe selection mechanism 61 disposed at at least one side of the hot line pipe 13A and the heat exchange part 8A to guide the refrigerant, in one direction, to the outdoor heat exchanger 8 from the outlet part of the compressor 12, instead of the guide mechanism 41 of the air conditioner 40 according to the embodiment of FIGS. 5 and 6.

[0115] The pipe selection mechanism 61 may include: a first opening/closing valve (an electromagnetic valve) 63 disposed on a pipe 62 connected between the four-way valve 11 and the heat exchange part 8A; a third bypass pipe 65 connecting the connection 44D and a connection 44F disposed between four-way valve 11 and the first opening/closing valve 63, the third bypass pipe 65 being substituted for the second bypass pipe 43; a third non-return valve 66 disposed on the third bypass pipe 65; and a fourth non-return valve 67, which is substituted for the hot line circuit electromagnetic valve 23.

[0116] The third non-return valve 66 is disposed such that the refrigerant flowing through the third bypass pipe 65 flows to the connection 44D from the connection 44F in one direction, and the fourth non-return valve 67 is disposed such that the refrigerant flows to the connection 44D from the first diverging point 13a in one direction.

[0117] The opening level of the first opening/closing valve 63 and the opening level of the outdoor expansion valve 7 are controlled by a flow rate control device 69.

[0118] The first bypass pipe 42 and the hot line pipe temperature detecting device 21 are not provided in the air

conditioner 60.

[0119] Now, a method of operating the air conditioner 60 according to this embodiment will be described.

[0120] When the heating operation is performed, the outdoor expansion valve 7 is controlled to a predetermined opening level, and the first opening/closing valve 63 is constantly opened.

[0121] At this time, the refrigerant flows in the same fashion as in the air conditioner 1 according to the embodiment of FIG. 1.

[0122] Specifically, the refrigerant reaching the first diverging point 13a flows through the hot line pipe 13A and the bypass pipe 13B.

[0123] The refrigerant flowing through the hot line pipe 13A and then passing through the fourth non-return valve 67 flows through the lower part of the outdoor heat exchanger 8, not through the third bypass pipe 65, as a result of the third non-return valve 66, and then joins the refrigerant flowing through the bypass pipe 13B at the second diverging point 13b.

[0124] The joined refrigerant passes through the heat exchange part 8A of the outdoor heat exchanger 8 via the outdoor expansion valve 7, and then reaches the four-way valve 11 through the first opening/closing valve 63.

[0125] As a result, the air conditioner 60 according to the embodiment of FIGS. 8 and 9 provides the same effect as the air conditioner 1 according to the embodiment of FIG. 1.

[0126] When the cooling operation is performed, as shown in FIG. 9, the method of operating the air conditioner 60 includes: detecting the temperature of outdoor air TA with the outdoor air temperature detecting device 22 (operation S41); and guiding the refrigerant, in one direction, to the outdoor heat exchanger 8 from the outlet part of the compressor 12 through either the hot line pipe 13A or the entire area of the outdoor heat exchanger 8 based on the detected temperature of the outdoor air (operation S42).

[0127] The operation of detecting the temperature of the outdoor air with the outdoor air temperature detecting device 22 (operation S41) is identical to the operation of detecting the temperature of the outdoor air with the outdoor air temperature detecting device 22 according to the embodiments of FIGS. 1-7 of the present general inventive concept.

[0128] The operation of guiding the refrigerant (operation S42) includes: allowing the refrigerant to flow only through the hot line pipe 13A (operation S42A); and allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S42B).

[0129] First, the cooling operation is performed. At this time, the outdoor expansion valve 7 is controlled to a predetermined opening level, and the first opening/closing valve 63 is opened to drive a cooling cycle.

[0130] Subsequently, the operation of detecting the temperature of the outdoor air (operation S41) is performed to detect the temperature TA of the outdoor air.

[0131] If $TA < \alpha$ (Condition 1), the operation of allowing the refrigerant to flow only through the hot line pipe 13A (operation S42A) is performed.

[0132] Specifically, the outdoor expansion valve 7 is fully closed, and the first opening/closing valve 63 is closed. At this time, the refrigerant discharged from the compressor 12 flows to the connection 44F via the four-way valve 11, flows into the hot line pipe 13A via the third non-return valve 66, and is then guided to the indoor expansion valve 6 through the bypass pipe 13B. Meanwhile, the outdoor expansion valve 7 and the first opening/closing valve 63 are closed, and therefore, no refrigerant passes through the heat exchange part 8A.

[0133] Consequently, only the hot line pipe 13A serves as an evaporator, and therefore, operation pressure (high pressure and low pressure) having a predetermined range is maintained in a state of low outdoor air temperature.

[0134] Subsequently, the operation of detecting the temperature of the outdoor air (operation S41) is repeated to detect the temperature TA of the outdoor air. If $TA < \alpha$, the operation of allowing the refrigerant to flow only through the hot line pipe 13A (operation S42A) is repeatedly performed.

[0135] If the condition of $TA \geq \alpha$ is satisfied (Condition 2), the operation of allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S42B) is performed.

[0136] Specifically, the outdoor expansion valve 7 is opened to the predetermined opening level, and the first opening/closing valve 63 is opened. At this time, the refrigerant discharged from the compressor 12 flows to the connection 44F via the four-way valve 11, and is then guided to the heat exchange part 8A via the first opening/closing valve 63. At the same time, the refrigerant is guided to the third bypass pipe 65 from the connection 44F via the third non-return valve 66. Also, the refrigerant flows through the hot line pipe 13A.

[0137] Consequently, both the hot line pipe 13A and the heat exchange part 8A of the outdoor heat exchanger 8 serves as the evaporator, where heat exchange is performed.

[0138] The refrigerant compressed in the outdoor heat exchanger 8 is guided to the indoor expansion valve 6 from the outdoor expansion valve 7 through the bypass pipe 13B. The status of the outdoor expansion valve 7 and the first opening/closing valve 63 at the respective operations described above is indicated in Table 1.

Table 1

		Outdoor expansion valve (7)	First opening/closing valve (63)
5	Cooling operation (Normal)	Predetermined opening level	Opened
	Heating operation	Controlled	Opened
10	Cooling & low outdoor air temperature	Condition 1 Fully closed	Closed
		Condition 2 Predetermined opening level	Opened

[0139] According to the air conditioner 60 and the method of operating the air conditioner 60, the refrigerant passing through the outdoor heat exchanger 8 is divided into two predetermined amounts by the pipe selection mechanism 61. Consequently, flow rate of the refrigerant passing through the outdoor heat exchanger 8 is minimized when the refrigerant discharged from the compressor 12 flows only through the hot line pipe 13A. In this case, only the hot line pipe 13A serves as the evaporator, and therefore, the heat exchange capacity is decreased. Consequently, the refrigerant maintained in a high-temperature and high-pressure state is guided to the indoor unit 2.

[0140] As a result, the drain water is prevented from being frozen at the surface of the indoor heat exchanger 5, and therefore, the compressor 12 can be operated in a continuous fashion. Consequently, the cooling operation at a predetermined temperature is accomplished, and durability of the compressor 12 is increased.

[0141] An air conditioner 70 according to yet another embodiment of the present general inventive concept will be described with reference to FIGS. 10 and 11.

[0142] Components of the air conditioner 70 according to the embodiment of FIGS. 10 and 11, which are identical to those of the air conditioner according to any one of the previous embodiments of the present invention, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments of the present invention, and therefore a detailed description thereof will not be given.

[0143] The air conditioner 70 according to the present embodiment of FIGS. 10 and 11 is different from the air conditioner 60 according to the previous embodiment in that, as illustrated in FIG. 10, the air conditioner 70 further includes: a pipe selection mechanism 71 having a discharge pressure detecting device 72 disposed adjacent to the compressor 12 to detect discharge pressure of the compressor 12 and a second opening/closing valve (an electromagnetic valve) 73, which is substituted for the first non-return valve 45 of the air conditioner 40 according to FIG 5.

[0144] The discharge pressure detecting device 72, as well as other valves, is controlled by a flow rate control device 74.

[0145] Now, a method of operating the air conditioner 70 according to the embodiment of FIGS. 10 and 11 will be described.

[0146] When the heating operation is performed, the outdoor expansion valve 7 is controlled to a predetermined opening level, and the first and second opening/closing valves 63 and 73 are constantly opened.

[0147] As a result, the air conditioner 70 provides the same operation and effect as the air conditioner 60 according to the embodiment of FIG. 8.

[0148] When the cooling operation is performed, as illustrated in FIG. 11, the method of operating the air conditioner 70 includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S51); detecting discharge pressure of the compressor 12 with the discharge pressure detecting device 72 (operation S52); interrupting guide of the refrigerant not only through the hot line pipe 13A but also through the heat exchange part 8A (operation S53); and guiding the refrigerant, in one direction, to the outdoor heat exchanger 8 from the outlet part of the compressor 12 through either the hot line pipe 13A or the entire area of the outdoor heat exchanger 8 based on the detected temperature of the outdoor air and the detected discharge pressure of the compressor 12 (operation S54).

[0149] Similar to the embodiment of FIG. 8, the operation of guiding the refrigerant (operation S54) includes: allowing the refrigerant to flow only through the hot line pipe 13A (operation S54A); and allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S54B).

[0150] When the air conditioner 70 is operated, the operation of detecting the temperature of the outdoor air (operation S51) and the operation of detecting discharge pressure of the compressor 12 (operation S52) are performed to detect the temperature TA of the outdoor air and the discharge pressure Pd of the compressor 12, respectively.

[0151] If $TA < \alpha$ and $Pd < \gamma$ (γ is a predetermined pressure value) (Condition 3), the operation of interrupting guide of the refrigerant not only through the hot line pipe 13A, but also through the heat exchange part 8A (operation S53), is performed.

[0152] Specifically, the outdoor expansion valve 7 is fully closed, and the first and second opening/closing valves 63

and 73 are closed. At this time, the refrigerant does not flow in the cooling cycle although the refrigerant is discharged from the compressor 12. As a result, the discharge pressure is quickly increased.

[0153] In this state, the operation of detecting discharge pressure of the compressor 12 (operation S52) is repeated to detect the discharge pressure P_d of the compressor 12.

[0154] If $\gamma \leq P_d < \delta$ (δ is a predetermined pressure value, which is greater than γ) (Condition 4), the operation of allowing the refrigerant to flow only through the hot line pipe 13A (operation S54A), which corresponds to the operation of allowing the refrigerant to flow only through the hot line pipe 13A (operation S42A) according to the embodiment FIG. 8, is performed to continue the cooling operation.

[0155] At this time, the refrigerant discharged from the compressor 12 flows through the hot line pipe 13A, and no refrigerant passes through the heat exchange part 8A, as in the sixth embodiment of FIG. 8.

[0156] Consequently, only the hot line pipe 13A serves as an evaporator.

[0157] In this case, the refrigerant, the amount of which is less than that of the refrigerant passing through the heat exchange part 8A, passes through the outdoor heat exchanger 8, and therefore, the refrigerant discharged from the compressor 12 is maintained at a high-pressure state.

[0158] Subsequently, the operation of detecting the temperature of the outdoor air (operation S51) and the operation of detecting discharge pressure of the compressor 12 (operation S52) are repeated to detect the temperature T_A of the outdoor air and the discharge pressure P_d of the compressor 12, respectively. If $T_A \geq \alpha$ and $P_d \geq \delta$ (Condition 5), the operation of allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S54B) is performed.

[0159] Specifically, the outdoor expansion valve 7 is opened to the predetermined opening level, and the first and second opening/closing valves 63 and 73 are opened. At this time, the refrigerant discharged from the compressor 12 flows through the entire area of the outdoor heat exchanger 8 such that heat exchange is performed, like the operation of allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S42B) according to the embodiment of FIG. 8. The status of the outdoor expansion valve 7, the first opening/closing valve 63, and the second opening/closing valve 73 at the respective operations described above is indicated in Table 2.

Table 2

		Outdoor expansion valve (7)	First opening/closing valve (63)	Second opening/closing valve (73)
Cooling operation (Normal)		Predetermined opening level	Opened	Opened
Heating operation		Controlled	Opened	Opened
Cooling & low outdoor air temperature	Condition 1	Fully closed	Closed	Closed
	Condition 2	Fully closed	Closed	Opened
	Condition 3	Predetermined opening level	Opened	Opened

[0160] According to the air conditioner 70 and the method of operating the air conditioner 70, the operation of interrupting guide of the refrigerant not only through the hot line pipe 13A, but also through the heat exchange part 8A (operation S53), is performed. Consequently, the discharge pressure of the compressor 12 can be quickly increased, and therefore, rising time of the entire cooling cycle right before the initiation of the operation of the air conditioner is reduced.

[0161] Furthermore, the discharge pressure of the compressor 12 is directly detected by the discharge pressure detecting device 72, and flow of the refrigerant is controlled based on the detected temperature of the outdoor air. Consequently, more accurate condensing pressure control can be performed than when the operation is controlled only based on the detected temperature of the outdoor air, and therefore, the refrigerant is maintained in a high-pressure state.

[0162] An air conditioner 80 according to yet another embodiment of the present general inventive concept will be described with reference to FIGS. 12 and 13.

[0163] Components of the air conditioner 80 according to the present embodiment, which are the same to those of the air conditioner according to any one of the previous embodiments of the present invention, are indicated by the same reference numerals as those of the air conditioner according to any one of the previous embodiments of the present invention, and therefore a detailed description thereof will not be given.

[0164] The air conditioner 80 according to the embodiment of FIGS. 12 and 13 is different from the air conditioner 70 according to the embodiment of FIGS. 10 and 11 in that the air conditioner 80 further includes: a pipe selection

mechanism 81 having a non-step flow rate control valve 82, which is substituted for the second opening/closing 73 of the pipe selection mechanism 71 of the air conditioner 70 according to the embodiment of FIG. 10. The flow rate control valve 82 as well as other valves is controlled by a flow rate control device 83.

[0165] Now, an operation method of operating the air conditioner 80 according to the embodiment of FIGS. 12 and 13 will be described.

[0166] When the heating operation is performed, the outdoor expansion valve 7 is controlled to a predetermined opening level, the first opening/closing valve 63 is opened, and the flow rate control valve 82 is fully opened.

[0167] As a result, the air conditioner 80 according to FIG. 12 provides the same operation and effect as the air conditioner 70 according to the embodiment of FIG. 10.

[0168] When the cooling operation is performed, as illustrated in FIG. 13, the method of operating the air conditioner 80 includes: detecting the temperature of outdoor air with the outdoor air temperature detecting device 22 (operation S61); detecting discharge pressure of the compressor 12 with the discharge pressure detecting device 72 (operation S62); and guiding the refrigerant, in one direction, to the outdoor heat exchanger 8 from the outlet part of the compressor 12 through either the hot line pipe 13A or the entire area of the outdoor heat exchanger 8 based on the detected temperature of the outdoor air and the detected discharge pressure of the compressor 12 (operation S63).

[0169] The operation of guiding the refrigerant (operation S63) includes: allowing the refrigerant to flow only through the hot line pipe 13A (operation S63A); gradually increasing flow rate of the refrigerant flowing through the hot line pipe 13A (operation S63B); and allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S63C).

[0170] When the cooling operation is performed, the outdoor expansion valve 7 and the flow rate control valve 82 are controlled to predetermined opening levels, respectively, and the first opening/closing valve 63 is opened such that the refrigerant is guided. Subsequently, the operation of detecting the temperature of the outdoor air (operation S61) and the operation of detecting discharge pressure of the compressor 12 (operation S62) are performed to detect the temperature T_A of the outdoor air and the discharge pressure P_d of the compressor 12, respectively.

[0171] If $T_A < \alpha$ and $P_d < \gamma$ (Condition 3), the operation of allowing the refrigerant to flow only through the hot line pipe 13A (operation S63A) is performed.

[0172] Specifically, the outdoor expansion valve 7 is fully closed, the first opening/closing valve 63 is closed, and the flow rate control valve 82 is closed such that the flow rate control valve 82 assumes the predetermined opening level. As a result, the pressure discharged from the compressor and flowing through hot line pipe 13A is increased. Since the outdoor expansion valve 7 is fully closed and the first opening/closing valve 63 is closed, no refrigerant passes through the heat exchange part 8A.

[0173] Consequently, only the hot line pipe 13A serves as an evaporator. Also, the discharge pressure of the compressor 12 is more quickly increased.

[0174] Subsequently, the operation of detecting discharge pressure of the compressor 12 (operation S62) is repeated to detect the discharge pressure P_d of the compressor 12. If $\gamma \leq P_d < \varepsilon$ (ε is a predetermined pressure value, which is greater than γ and less than δ) (Condition 6), the opening level of the flow rate control valve is unchanged, and the cooling operation is continued.

[0175] If $\varepsilon \leq P_d < \delta$ (Condition 7), on the other hand, the operation of gradually increasing flow rate of the refrigerant flowing through the hot line pipe 13A (operation S63B) is performed.

[0176] Specifically, the outdoor expansion valve 7 and the first opening/closing valve 63 are unchanged, and the flow rate control valve 82 is opened to the predetermined opening level.

[0177] As a result, the amount of the refrigerant flowing through the hot line pipe 13A is increased, and therefore, the boost rate of the discharge pressure of the compressor 12 is lowered.

[0178] Subsequently, the operation of detecting the temperature of the outdoor air (operation S61) and the operation of detecting discharge pressure of the compressor 12 (operation S62) are performed to detect the temperature T_A of the outdoor air and the discharge pressure P_d of the compressor 12, respectively. If $T_A \geq \alpha$ and $P_d \geq \delta$ (Condition 5), the operation of allowing the refrigerant to flow through the entire area of the outdoor heat exchanger 8 (operation S63C) is performed.

[0179] Specifically, the outdoor expansion valve 7 is opened to the predetermined opening level, the first opening/closing valve 63 is opened, and the flow rate control valve 82 is fully opened. At this time, the refrigerant discharged from the compressor 12 flows through the entire area of the outdoor heat exchanger 8, as in any one of the previous embodiments of the present general inventive concept. The status of the outdoor expansion valve 7, the first opening/closing valve 63, and the flow rate control valve 82 at the respective operations described above is indicated in Table 3.

Table 3

		Outdoor expansion valve (7)	First opening/closing valve (63)	Flow rate control valve (82)
Cooling operation (Normal)		Predetermined opening level	Opened	Fully opened
Heating operation		Controlled	Opened	Fully opened
Cooling & low outdoor air temperature	Condition 3	Fully closed	Closed	Controlled
	Condition 4	Fully closed	Closed	Controlled
	Condition 5	Fully closed	Closed	Controlled
	Condition 6	Predetermined opening level	Opened	Fully opened

[0180] According to the air conditioner 80 and the method of operating the air conditioner 80, the flow rate control valve 82 is provided instead of the second opening/closing valve 73 of the air conditioner 70 according to the previous embodiment of the present general inventive concept. Consequently, the discharge pressure of the compressor 12 can be more stably controlled than when only the opening/closing control is performed, and therefore, equalization of the refrigerant pressure in the cooling cycle is more appropriately accomplished, and more stable air conditioning is accomplished.

[0181] Although various embodiments of the present general inventive concept have been shown and described, it should be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the general inventive concept, the scope of which is defined in the claims and their equivalents.

[0182] For example, any of the air conditioners may be controlled such that the refrigerant may flow only through the heat exchange part 8A of the outdoor heat exchanger 8 based on operation conditions, although the refrigerant is guided, in one direction, to the outdoor heat exchanger 8 from the outlet part of the compressor 12 through either the hot line pipe 13A or the entire area of the outdoor heat exchanger 8 in the operation method of the air conditioner according to any one of the embodiments of FIGS. 8-13 when the cooling operation is performed.

[0183] As apparent from the above description, excessive heat radiation is effectively prevented without damage to performance of the outdoor heat exchanger when the heating operation is performed. Consequently, the present general inventive concept has the effect of improving heating efficiency of the air conditioner. Also, the predetermined high and low pressure of the refrigerant is maintained even when the cooling operation is performed in the state of low outdoor air temperature. Consequently, the present general inventive concept has the effect of improving reliability of the compressor and cooling efficiency of the air conditioner. Furthermore, no refrigerant remains in the part(s) of the air conditioner not used as the cooling cycle when the operation is performed. Consequently, the present general inventive concept has the effect of improving reliability of the cooling cycle.

Claims

1. A cooling cycle apparatus comprising:

an indoor heat exchanger, an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle,

wherein the pipe includes a refrigerant pipe connected between the indoor expansion part and the outdoor expansion part, the refrigerant pipe being branched into a first pipe, which extends through at least a part of the outdoor heat exchanger, and a second pipe, which does not extend through the outdoor heat exchanger.

2. The cooling cycle apparatus according to claim 1, further comprising:

a first temperature detection part to detect the temperature of the first pipe;

a second temperature detection part to detect the temperature of outdoor air; and
flow rate control means disposed on the first pipe to control flow rate of the refrigerant based on the temperature of the first pipe and the temperature of the outdoor air.

3. The cooling cycle apparatus according to claim 2, further comprising:

a guide mechanism to guide at least some of the refrigerant to the first pipe, when the refrigerant flows to the outdoor heat exchanger from the outdoor expansion part, based on the temperature of the first pipe and the temperature of the outdoor air.

4. The cooling cycle apparatus according to claim 1, wherein

the outdoor heat exchanger has a heat exchange part, which allows a larger amount of refrigerant to pass therethrough than through the first pipe, and

the cooling cycle apparatus further comprises:

a pipe selection mechanism disposed at at least one side of the first pipe and the heat exchange part to guide the refrigerant, in one direction, to the outdoor heat exchanger from the outlet side of the compressor.

5. A method of operating a cooling cycle apparatus comprising an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle, the pipe including a refrigerant pipe connected between the indoor expansion part and the outdoor expansion part and branched into a first pipe, which extends through at least a part of the outdoor heat exchanger, and a second pipe, which does not extend through the outdoor heat exchanger, wherein the method comprises:

detecting the temperature of outdoor air;

detecting the temperature of the first pipe; and

controlling flow rate of the refrigerant flowing through the first pipe based on the temperature of the outdoor air and the temperature of the first pipe.

6. The method according to claim 5, further comprising:

guiding the refrigerant flowing through the first pipe in the same direction as the refrigerant passing through the outdoor heat exchanger.

7. A method of operating a cooling cycle apparatus comprising an indoor heat exchanger, an indoor expansion part, an outdoor expansion part, an outdoor heat exchanger and a compressor, which are successively connected to each other via a pipe through which refrigerant circulates to constitute a cooling cycle, wherein the method comprises:

detecting the temperature of outdoor air; and

guiding the refrigerant, in one direction, to the outdoor heat exchanger from the outlet side of the compressor through a first pipe, which extends through at least a part of the outdoor heat exchanger, and/or a heat exchange part disposed in the outdoor heat exchanger to allow a larger amount of refrigerant to pass therethrough than through the first pipe based on the detected temperature of the outdoor air.

8. The method according to claim 7, further comprising:

detecting discharge pressure of the compressor, wherein

the operation of guiding the refrigerant in one direction is performed based the detected discharge pressure of the compressor.

9. A cooling cycle apparatus comprising:

a compressor;

an indoor heat exchanger to receive refrigerant from the compressor;

an indoor expansion unit connected to the indoor heat exchanger to expand the refrigerant exiting the indoor heat exchanger;

an outdoor heat exchanger to receive the refrigerant from the indoor expansion unit;
 an outdoor heat expansion unit connected between the indoor expansion unit and the outdoor heat exchanger;
 and

a refrigerant pipe assembly connecting the indoor expansion unit and the outdoor expansion unit and having
 a first portion of the pipe assembly to transport refrigerant directly between the indoor expansion unit and the
 outdoor expansion unit and a second portion of the refrigerant pipe assembly to transport the refrigerant be-
 tween the indoor expansion unit through a portion of the outdoor heat exchanger to the outdoor expansion
 unit such that a ratio of flow of the refrigerant through the first portion of the pipe assembly and the second
 portion of the pipe assembly is controlled based on at least one of detected temperature and pressure condi-
 tions.

10. The cooling cycle apparatus according to claim 9, wherein the outdoor heat exchanger includes two channels
 disposed therein in which refrigerant passes through, one of the channels including a heat exchange part and the
 other channel including the second portion of the pipe assembly.

11. The cooling cycle apparatus according to claim 10, further comprising:

a hot line pipe temperature detecting device to detect the temperature of an inlet part of the second portion
 of the pipe assembly;

an outdoor air temperature detecting device to detect the temperature of outdoor air; and

a hot line circuit electromagnetic valve to control flow rate of the refrigerant through the second portion of the
 pipe assembly based on the temperature detected by the hot line pipe temperature detecting device and the
 temperature detected by the outdoor air temperature detecting device.

12. The cooling cycle apparatus according to claim 11, further comprising a flow rate control device to control opening
 and closing of the hot line circuit electromagnetic valve based on the detected temperatures.

13. The cooling cycle apparatus according to claim 10, further comprising:

a hot line pipe temperature detecting device to detect the temperature of an inlet part of the second portion
 of the pipe assembly;

an outdoor air temperature detecting device to detect the temperature of outdoor air; and

a flow rate control valve to control flow rate of the refrigerant through the second portion of the pipe assembly
 based on the temperature detected by the hot line pipe temperature detecting device and the temperature
 detected by the outdoor air temperature detecting device.

14. The cooling cycle apparatus according to claim 13, further comprising a flow rate control device to control opening
 and closing of the flow rate control valve based on the detected temperatures.

15. The cooling cycle apparatus according to claim 12, further comprising a guide mechanism to guide at least a portion
 of the refrigerant to the second portion of the pipe assembly.

16. The cooling cycle apparatus of claim 15, wherein the guide mechanism comprises:

a first bypass pipe connected between the heat exchange part at an outdoor expansion valve side and the
 second portion of the pipe assembly at the outlet part of the outdoor heat exchanger;

a second bypass pipe connected between the heat exchange part and the second portion of the pipe assembly
 at an inlet part of the outdoor heat exchanger;

a first non-return valve disposed between a connection at which the first bypass pipe and the second portion
 of the pipe assembly are connected to each other and a second connection at which the second portion of
 the pipe assembly and the first portion of the pipe assembly are connected to each other; and

a second non-return valve disposed on the first bypass pipe; and

an evaporator side electromagnetic valve disposed on the second bypass pipe.

17. The cooling cycle apparatus according to claim 10, further comprising:

a hot line pipe temperature detecting device to detect the temperature of an inlet part of the second portion
 of the pipe assembly;

an outdoor air temperature detecting device to detect the temperature of outdoor air; and
a pipe selection mechanism disposed at at least one side of the second portion of the pipe assembly and the
heat exchange part to guide the refrigerant in one direction to the outdoor heat exchanger from an outlet part
of the compressor.

5
18. The cooling cycle apparatus according to claim 17, wherein the pipe selection mechanism comprises:

a four-way valve to control flow of refrigerant discharged from the compressor into the indoor heat exchanger
from the outdoor heat exchanger;
10 a first opening/closing valve disposed on a pipe connected between the four-way valve and the heat exchange
part;
a third bypass pipe connecting the second portion of the pipe assembly at the inlet side of the outdoor heat
exchanger and the pipe connected between the four-way valve and the heat exchange part;
a third non-return valve disposed on the third bypass pipe; and
15 a fourth non-return valve to control direction of flow of the refrigerant through the second portion of the pipe
assembly;

wherein the opening level of the first opening/closing valve and the opening level of the outdoor expansion
unit are controlled by a flow rate control device.

20
19. A method of operating a cooling cycle apparatus, comprising:

flowing refrigerant from an indoor heat exchanger to an outdoor heat exchanger through an indoor expansion
unit, a pipe including a first part and a second part and an outdoor expansion unit, the second part of the pipe
25 extending through the outdoor heat exchanger; and
controlling a ratio of flow rate of the refrigerant through the first part and the second part of the pipe based on
temperature of outdoor air and temperature of the second part of the pipe.

30
20. The method according to claim 19, wherein the controlling of the ratio of flow rate is performed based on a com-
parison of the temperature of the outdoor air and a first predetermined value, and a comparison of the temperature
of the second part of the pipe and a second predetermined value.

Fig 1

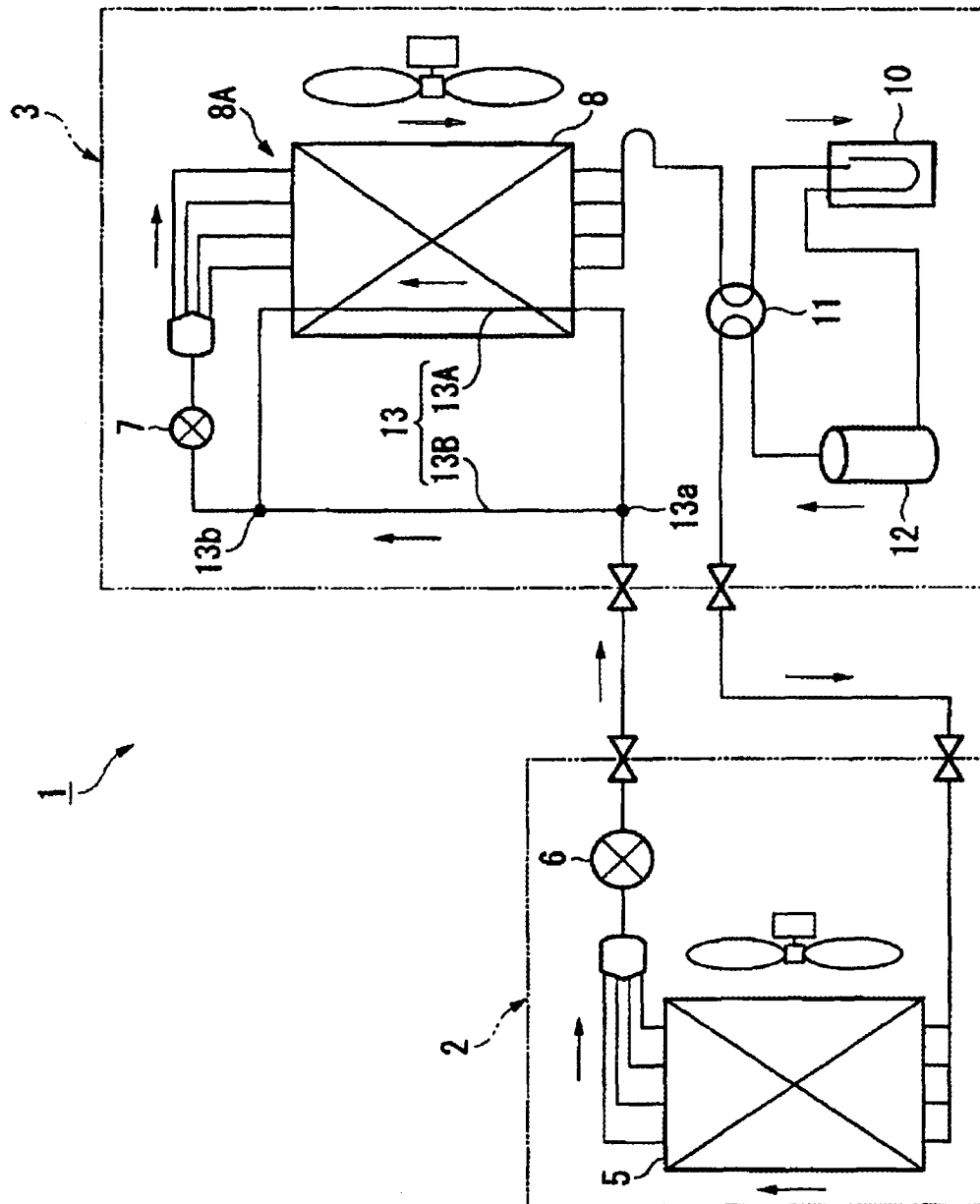


Fig 2

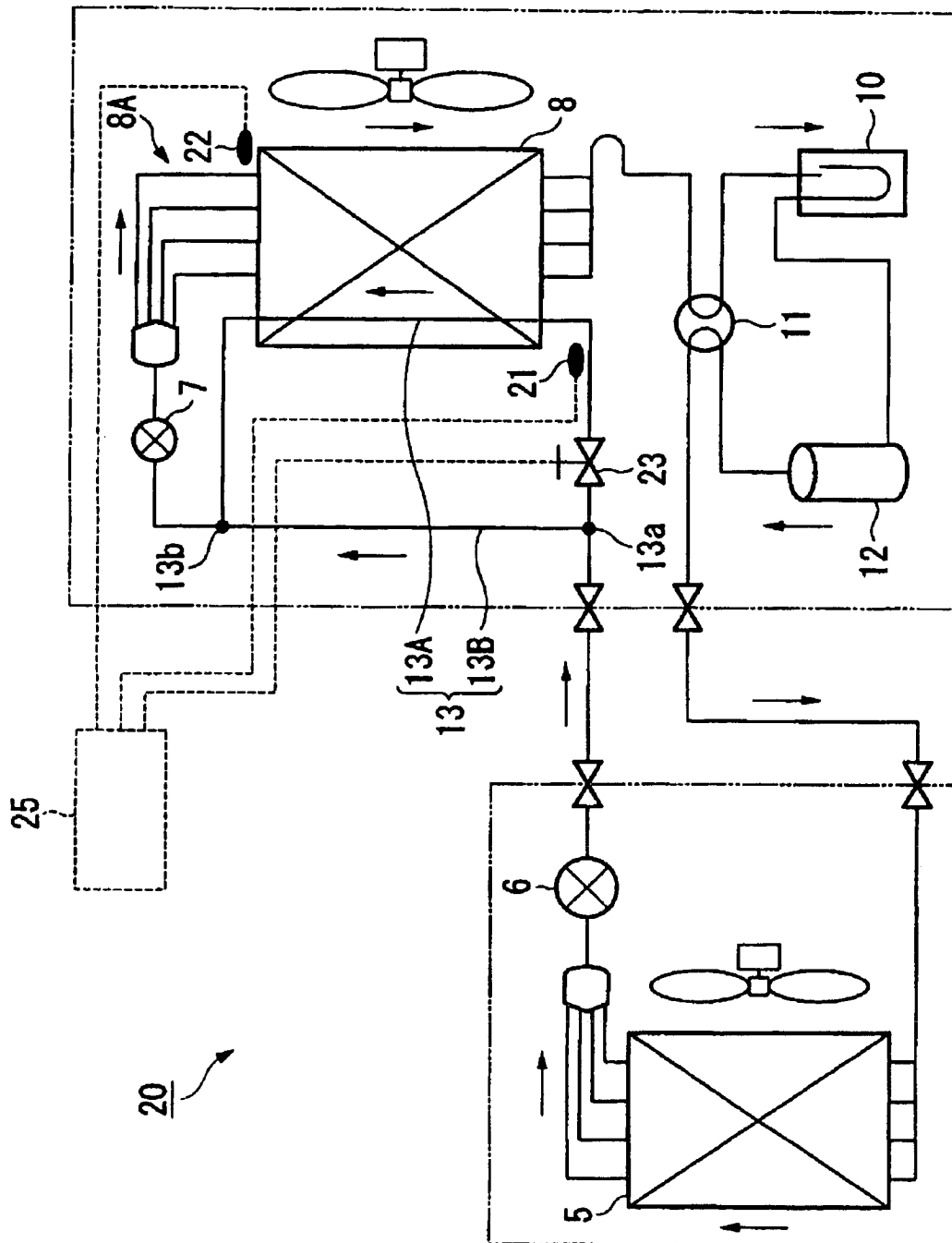


Fig 3

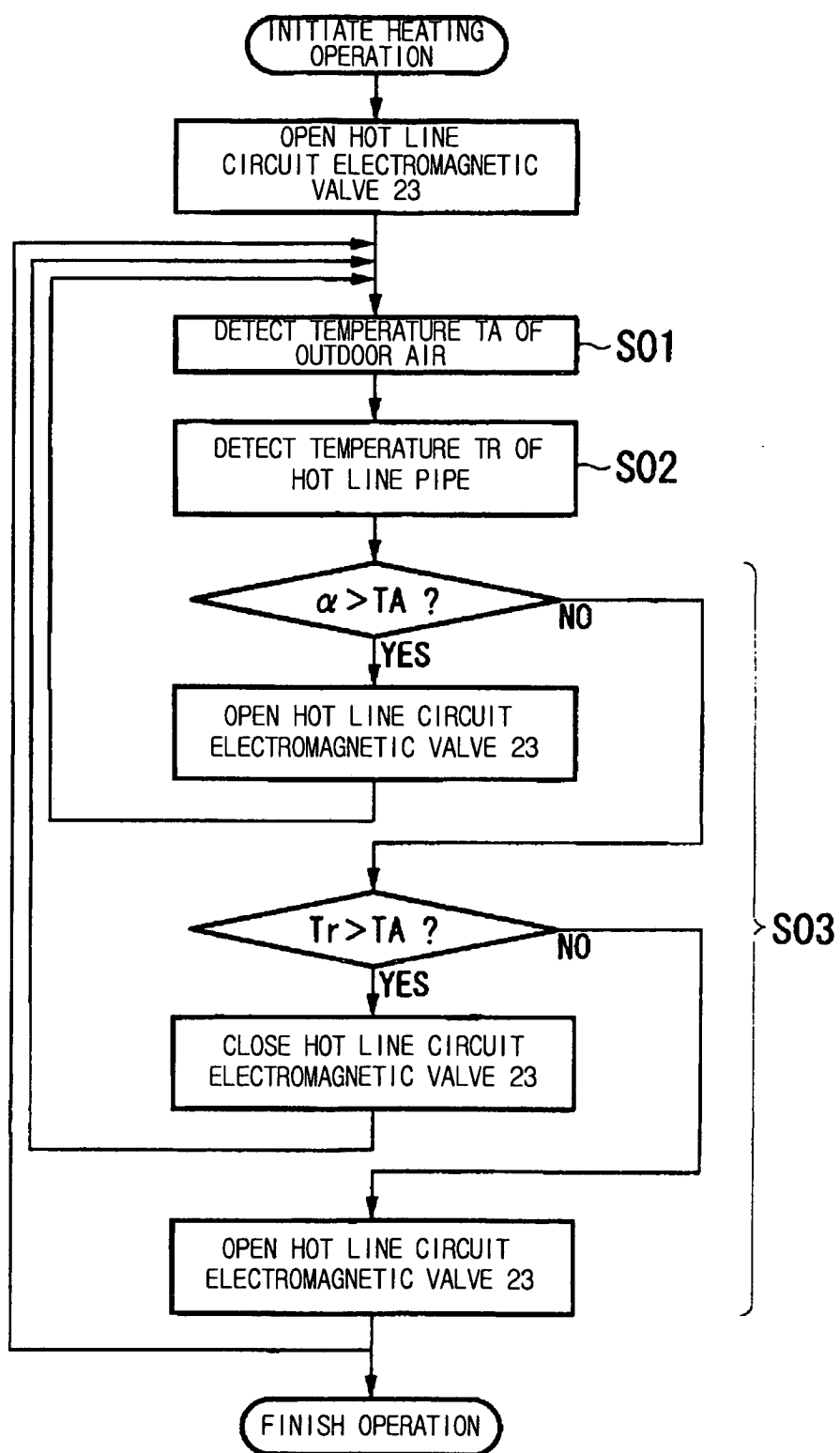


Fig 4

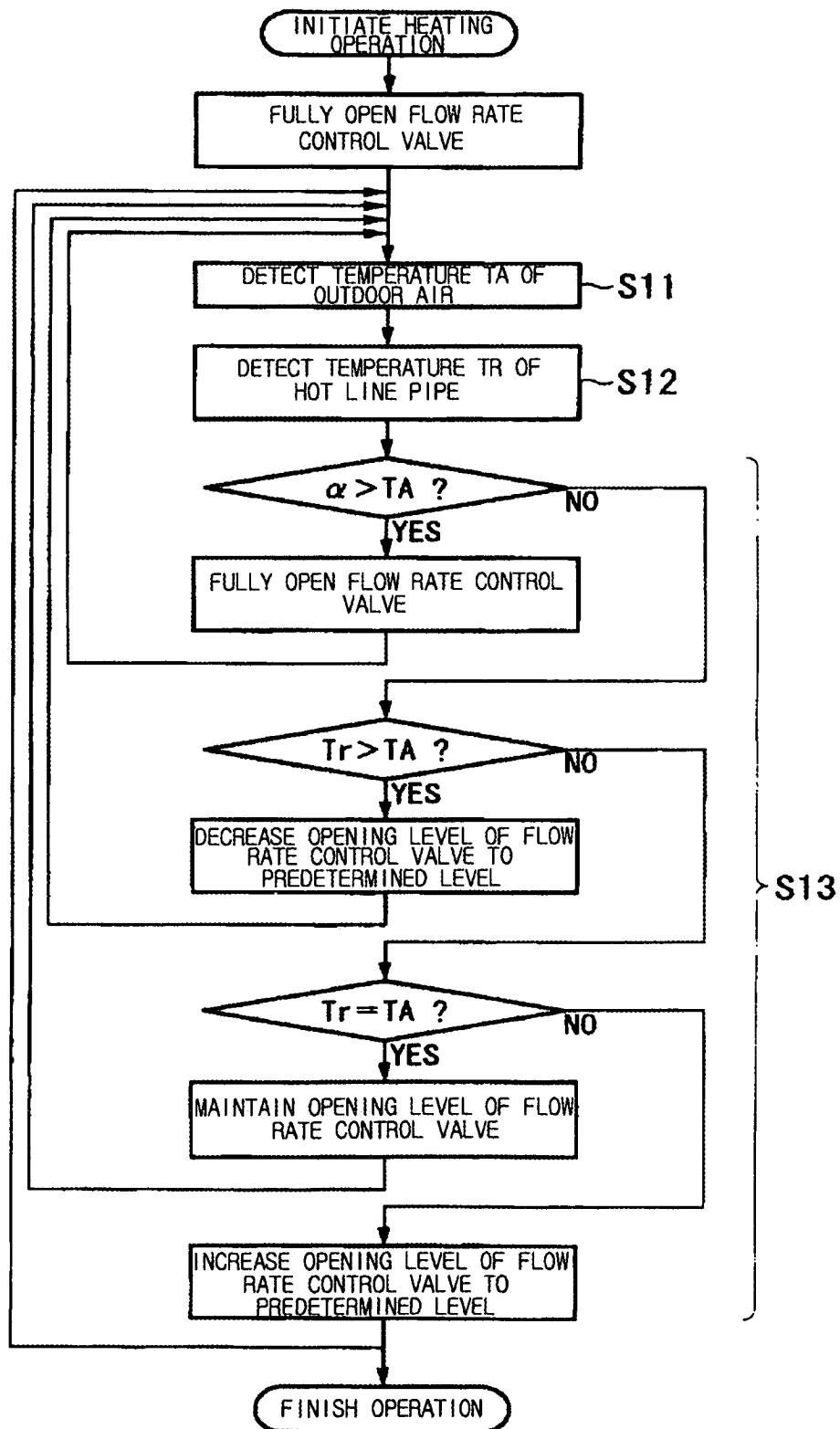


Fig 5

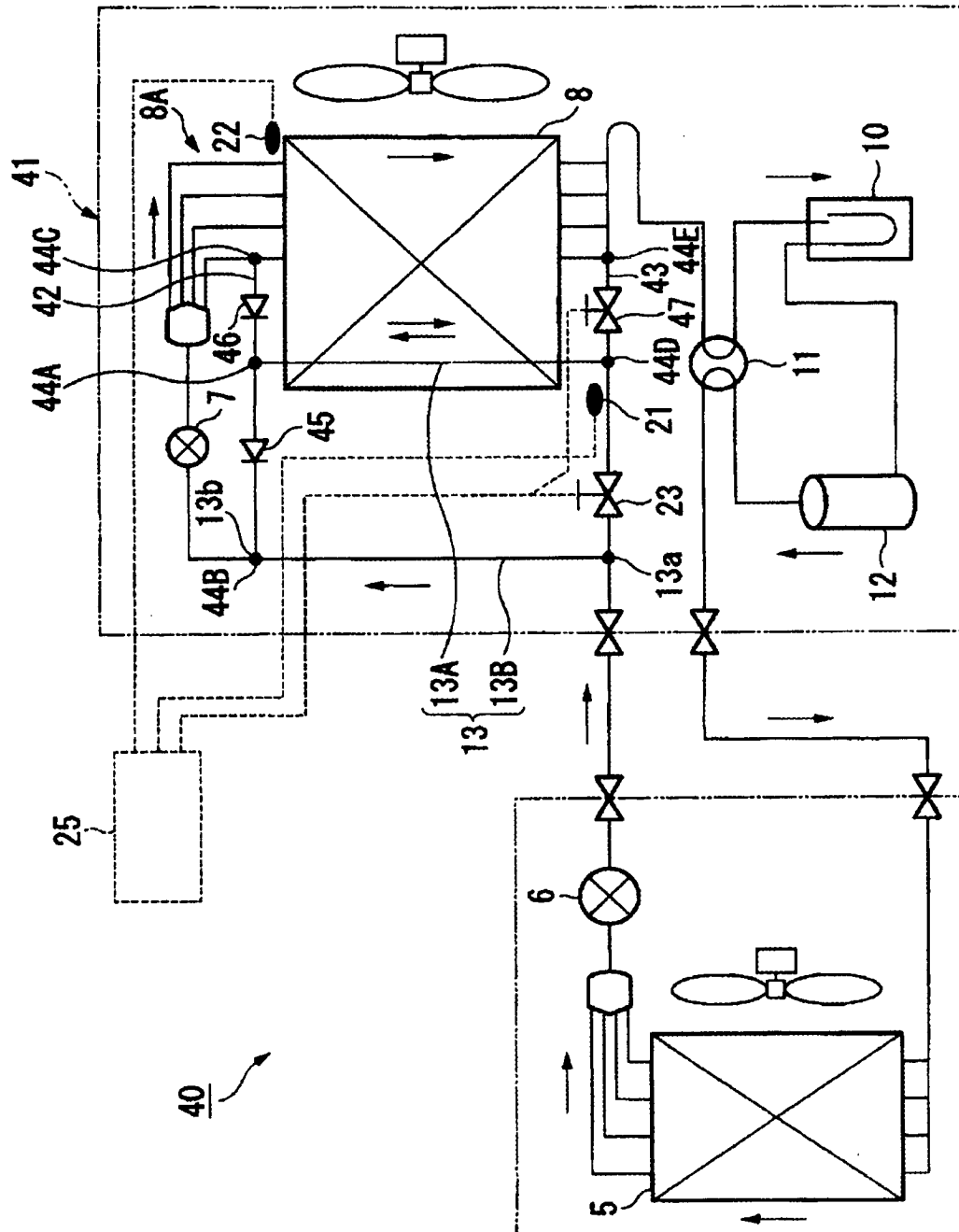


Fig 6

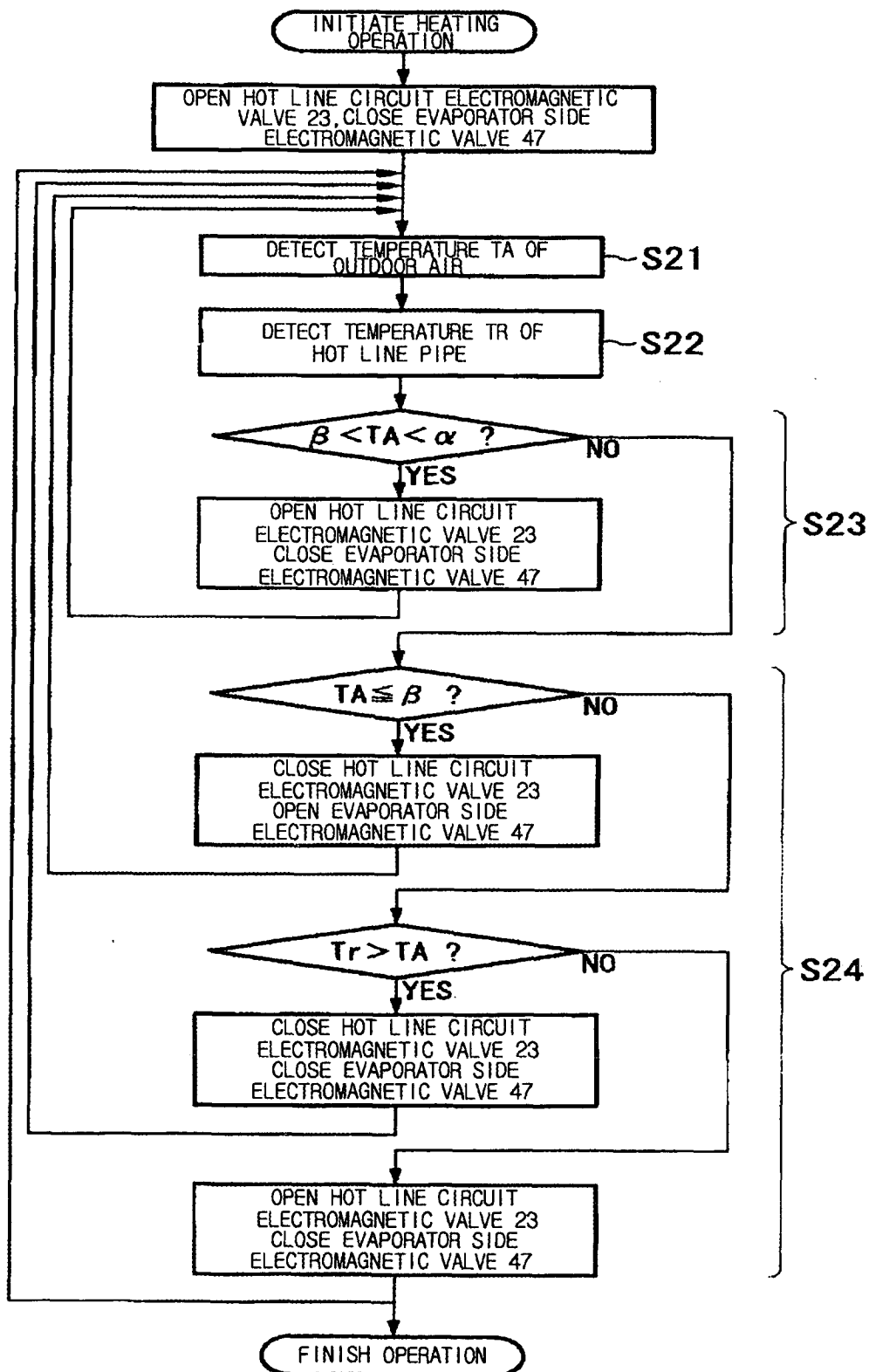


Fig 7

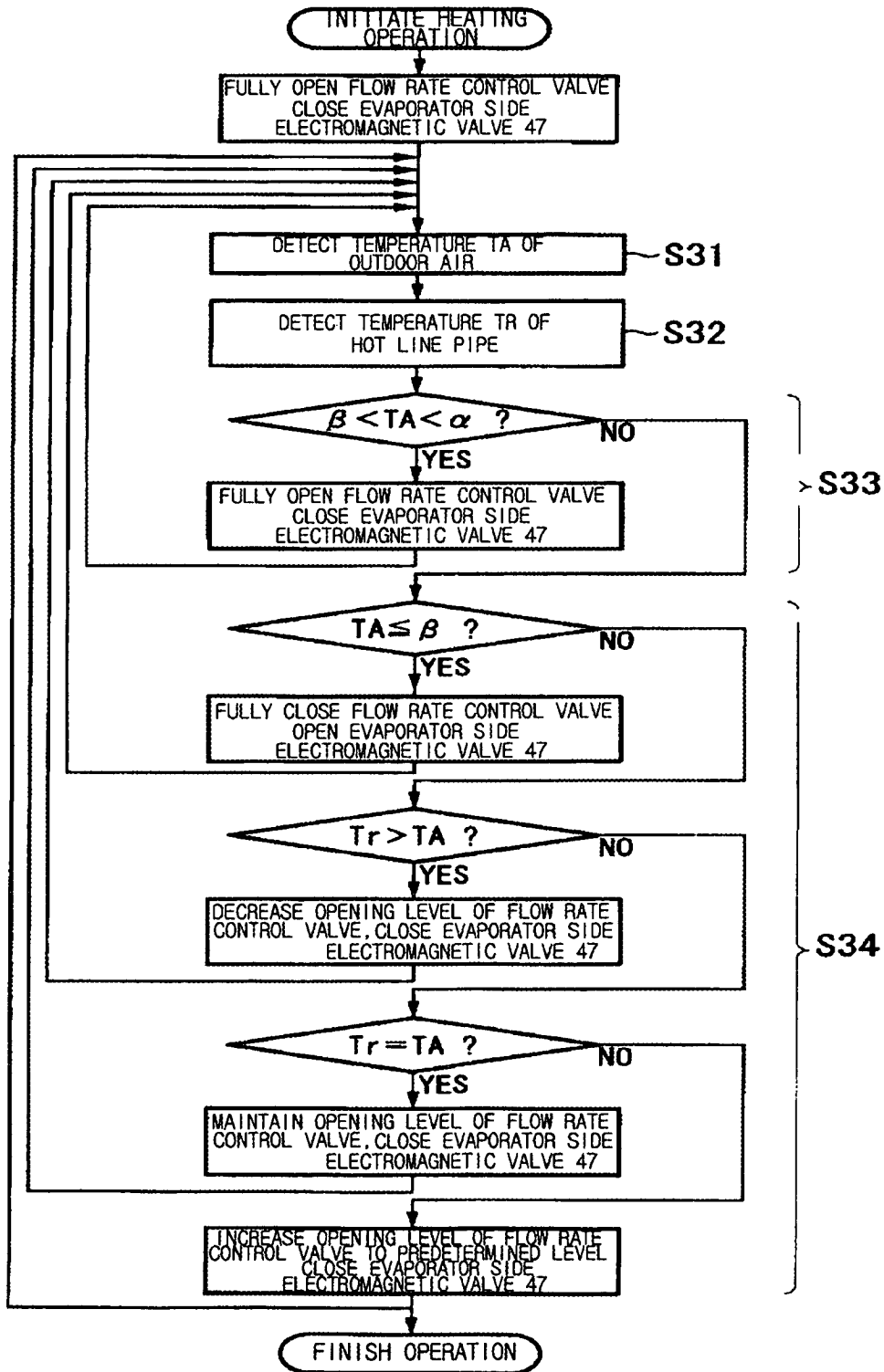


Fig 8

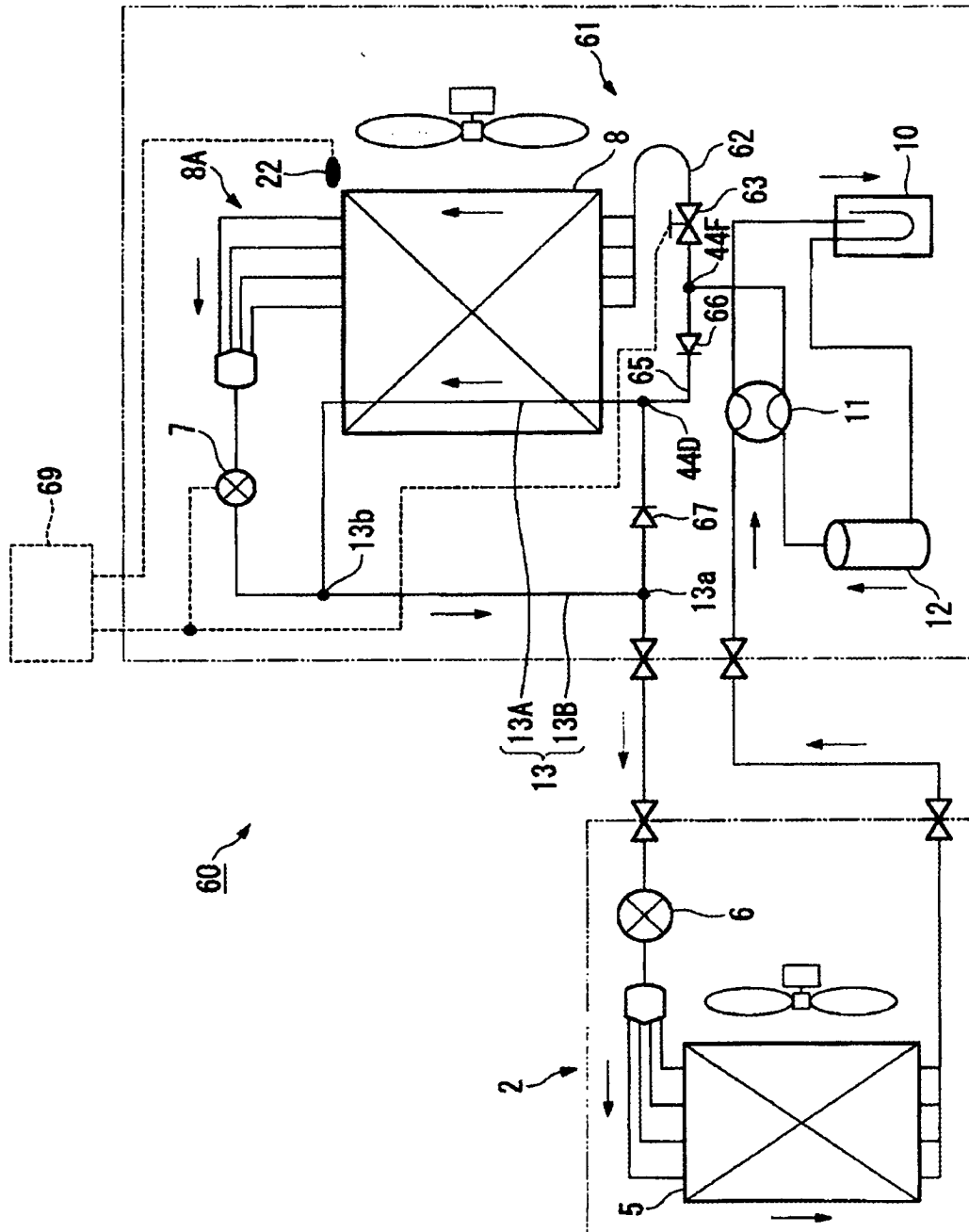


Fig 9

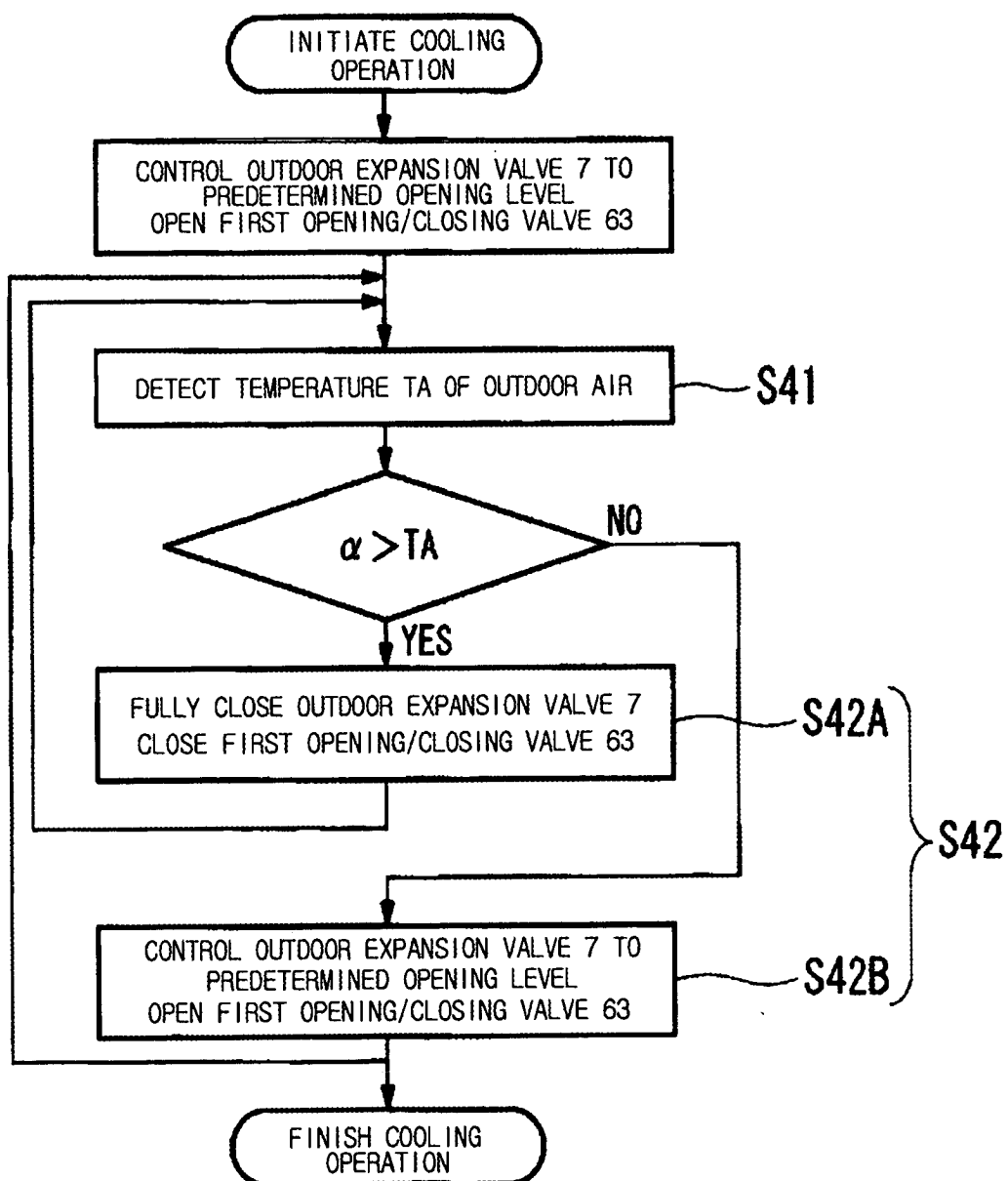


Fig 10

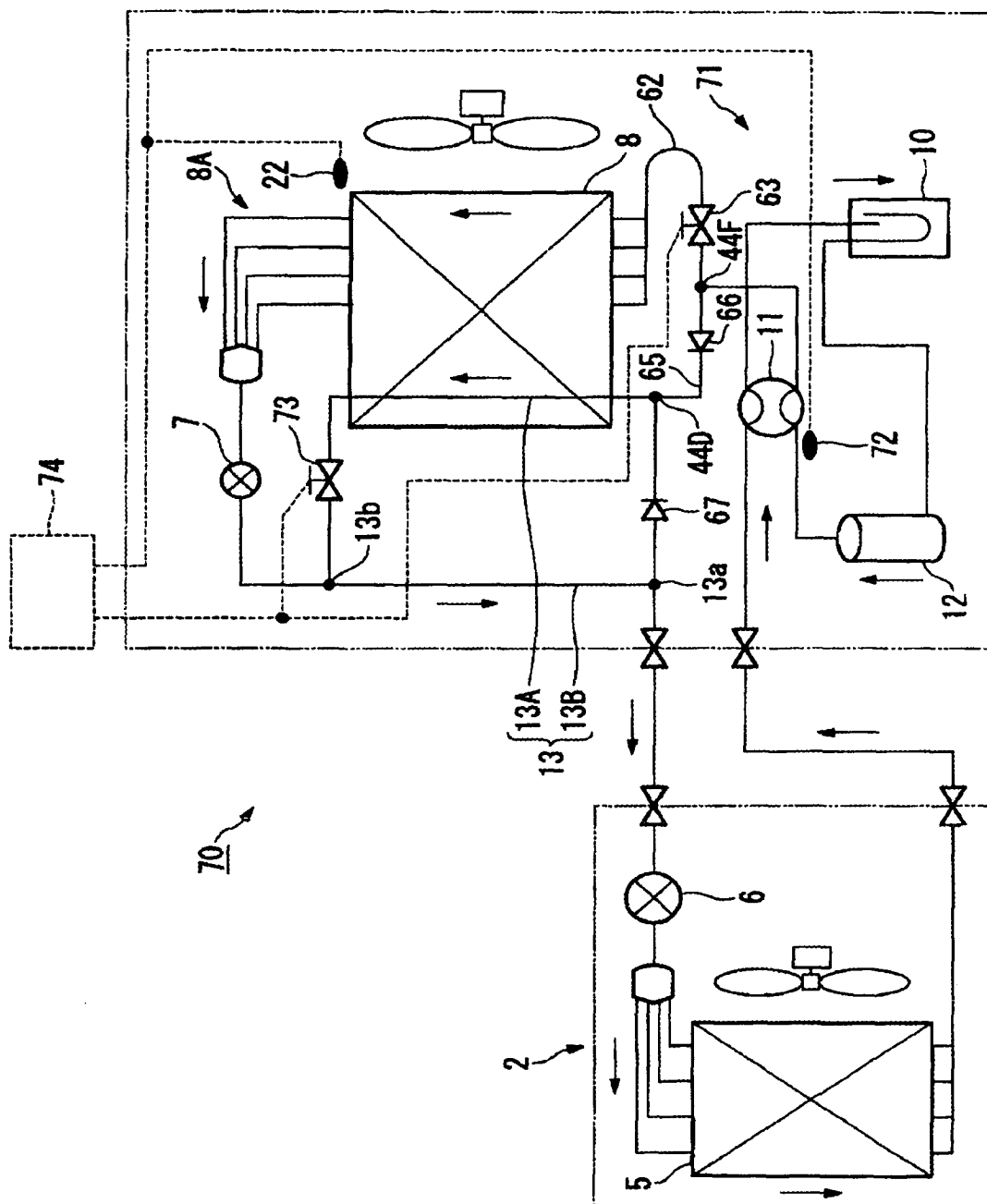


Fig 11

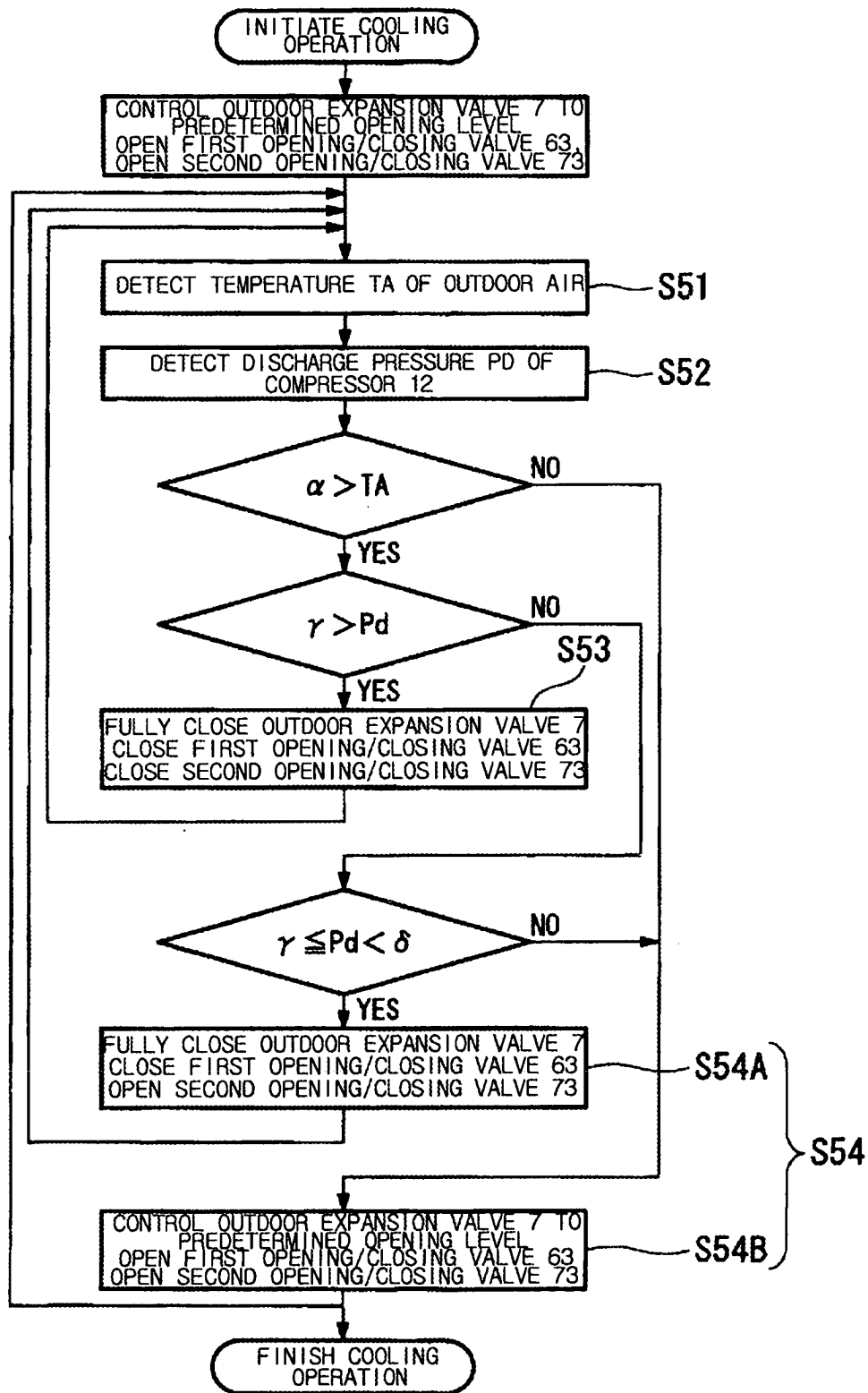


Fig 12

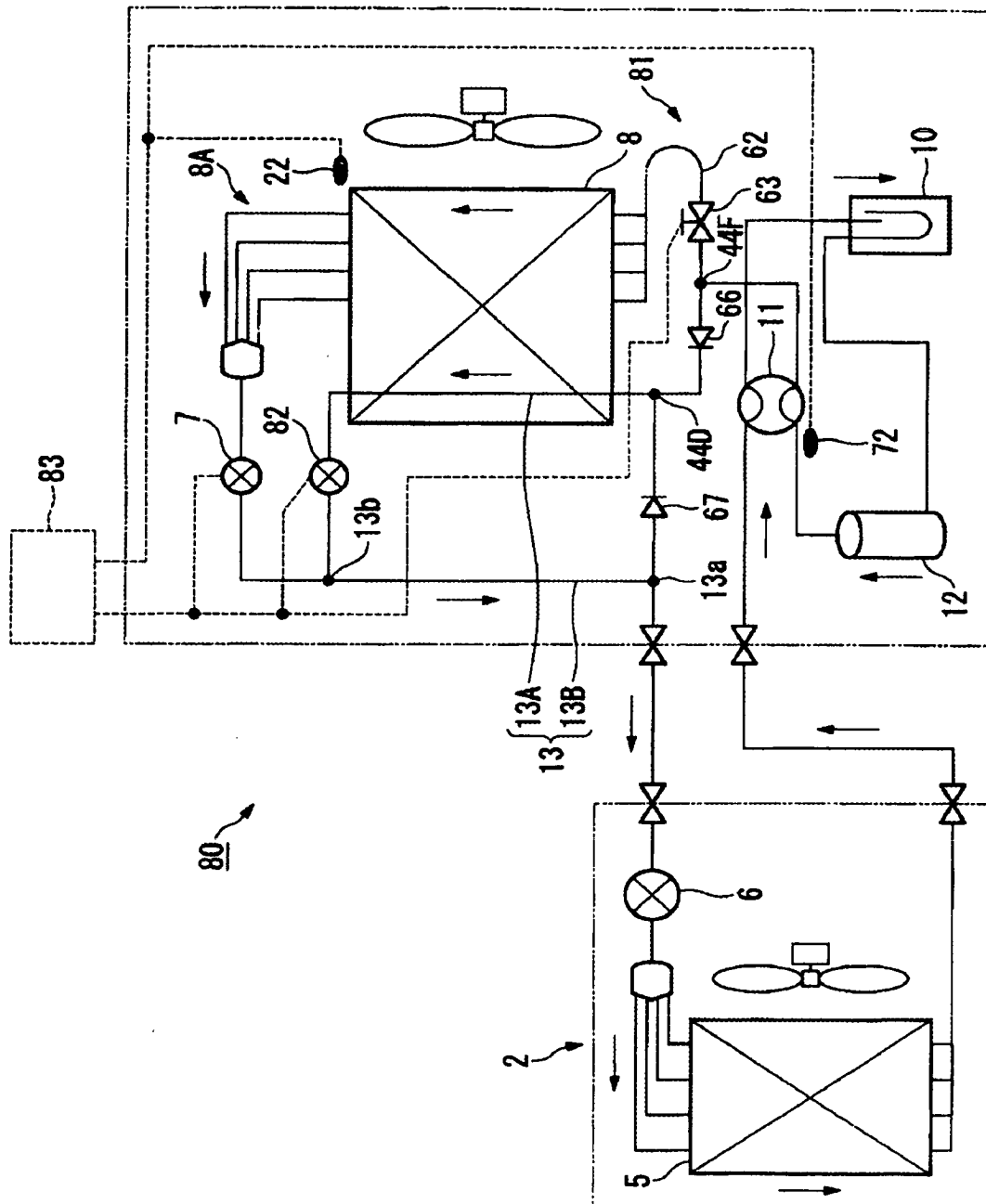


Fig 13

