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(54) **AIR CONDITIONER**

(57) An air conditioning apparatus having a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve (24), a receiver (25), an opening/closing valve, and an indoor heat exchanger, wherein the fully-closing first expansion valve (24) is provided to the refrigerant circuit (10) in a first disposed state in which refrigerant from the receiver (25) flows in to a needle advancing direction side of a valve seat (55). The first expansion valve (24) provided in the first disposed state has a spring (62) for urging a needle (61) in the needle advancing direction.

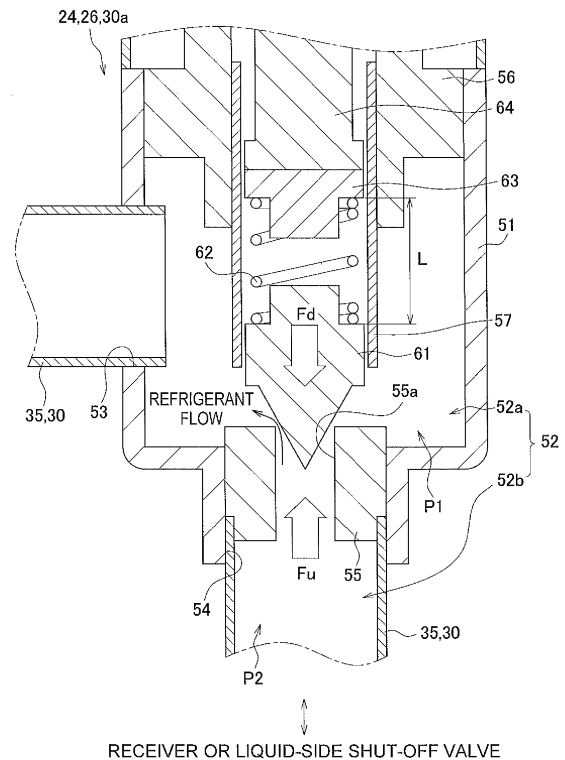


FIG. 5

Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus, and particularly to an air conditioning apparatus having a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve, a receiver, an opening/closing valve, and an indoor heat exchanger.

BACKGROUND ART

[0002] In the past, there have been air conditioning apparatuses that have a refrigerant circuit in which expansion valves are provided on the upstream and downstream sides of a receiver, as shown in Patent Literature 1 (Japanese Laid-open Patent Unexamined publication No. H10-132393). Specifically, the air conditioning apparatus has a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve, a receiver, a second expansion valve (an opening/closing valve), and an indoor heat exchanger.

SUMMARY OF THE INVENTION

[0003] When fully-closing expansion valves are used as the expansion valves provided on the upstream and downstream sides of the receiver, there is a risk of liquid sealing occurring in the receiver when the two expansion valves are fully closed. The term "liquid sealing" herein means a state in which a predetermined space in the refrigerant circuit is filled with liquid refrigerant and the liquid refrigerant becomes sealed within the predetermined space, and problems occur such as the equipment constituting the predetermined space rupturing due to an increase in temperature. Specifically, the portion in the refrigerant circuit between the two expansion valves including the receiver is filled with liquid refrigerant, the liquid refrigerant becomes sealed in this portion, and there is a risk of problems such as an increase in temperature causing the receiver and other equipment constituting this portion to rupture. In the configuration of Patent Literature 1, an injection pipe is provided for drawing refrigerant out of the upper space of the receiver and injecting the refrigerant into the compressor, and a fully-closing expansion valve could be used as a degassing valve provided to this injection pipe, but there is still a risk of liquid sealing in the receiver when the three expansion valves are fully closed in this case as well. Even in a configuration in which a fully-closing expansion valve (e.g., a first expansion valve) is provided to either one of the upstream side and downstream side of the receiver and a liquid-side shut-off valve is provided to the other of the upstream side and downstream side of the receiver, there is still a risk of liquid sealing in the receiver when the first expansion valve and the liquid-side shut-off valve are fully closed.

[0004] To prevent such liquid sealing in the receiver, a liquid sealing prevention pipe must be provided to enable refrigerant to be let out at any time from the upper space of the receiver, but because providing such a liquid sealing prevention pipe increases cost and causes problems with installation space, it would be preferable to prevent liquid sealing in the receiver without providing a liquid sealing prevention pipe.

[0005] An object of the present invention is to provide an air conditioning apparatus having a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve, a receiver, an opening/closing valve, and an indoor heat exchanger, wherein liquid sealing in the receiver can be prevented using fully-closing expansion valves, without providing a liquid sealing prevention pipe.

[0006] An air conditioning apparatus according to a first aspect of the present invention is an air conditioning apparatus having a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve, a receiver, an opening/closing valve, and an indoor heat exchanger. A fully-closing expansion valve that is fully closed by a needle sitting on a valve seat is used as the first expansion valve, and the first expansion valve is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat. The first expansion valve provided to the refrigerant circuit in the first disposed state has a spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat.

[0007] When a fully-closing expansion valve is used as the first expansion valve and there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver, the refrigerant in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver must be able to be let to the rest of the refrigerant circuit in order to make liquid sealing in the receiver preventable without providing a liquid sealing prevention pipe, even when the first expansion valve and the open-

ing/closing valve are fully closed.

[0008] In view of this, the first expansion valve herein is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the valve seat, through a gap between the needle and the valve seat, and out to the needle retracting direction side of the valve seat, as described above. A force will thereby act to push the needle in the needle retracting direction when the counter-pressure valve-opening pressure difference occurs, which is the difference between refrigerant pressure in the space on the needle retracting direction side of the valve seat and refrigerant pressure in the space on the needle advancing direction side of the valve seat when the first expansion valve is fully closed. The force pushing the needle in the needle retracting direction due to this counter-pressure valve-opening pressure difference is utilized to provide a configuration in which the first expansion valve provided to the refrigerant circuit in the first disposed state is provided with the spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and when the force pushing the needle in the needle retracting direction due to the counter-pressure valve-opening pressure difference overcomes the urging force of the spring in the needle advancing direction, the needle is released from sitting on the valve seat. This yields a configuration in which refrigerant in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver can be let toward the outdoor heat exchanger when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver.

[0009] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the opening/closing valve, and the indoor heat exchanger, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite a fully-closing expansion valve being used as the first expansion valve.

[0010] An air conditioning apparatus according to a second aspect is the air conditioning apparatus according to the first aspect, wherein the opening/closing valve is a liquid-side shut-off valve.

[0011] Specifically, the refrigerant circuit is configured with a fully-closing first expansion valve provided to one of the upstream and downstream sides of the receiver, and a liquid-side shut-off valve provided to the other of the upstream and downstream sides of the receiver. Therefore, when the first expansion valve and the liquid-side shut-off valve are fully closed, there is a risk of liquid sealing in the receiver.

[0012] In view of this, the fully-closing first expansion valve herein is provided to the refrigerant circuit in the first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the

valve seat, and out to the needle retracting direction side of the valve seat through a gap between the needle and the valve seat, as described above. Therefore, a configuration can be achieved in which refrigerant in the portion of the refrigerant circuit between the first expansion valve and the liquid-side shut-off valve including the receiver can be let toward the outdoor heat exchanger when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve and the liquid-side shut-off valve including the receiver.

[0013] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the liquid-side shut-off valve, and the indoor heat exchanger, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite a fully-closing expansion valve being used as the first expansion valve.

[0014] An air conditioning apparatus according to a third aspect is the air conditioning apparatus according to the first aspect, wherein the opening/closing valve is a second expansion valve, and the second expansion valve is a fully-closing expansion valve that is fully closed by a needle sitting on a valve seat. At least one of the first expansion valve and the second expansion valve in this case is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat. The first expansion valve and/or the second expansion valve provided to the refrigerant circuit in the first disposed state has a spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve and/or the second expansion valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat.

[0015] Specifically, the refrigerant circuit herein is configured with a fully-closing first expansion valve provided to one of the upstream and downstream sides of the receiver, and a fully-closing second expansion valve provided to the other of the upstream and downstream sides of the receiver. Thus, when fully-closing expansion valves are used as the first and second expansion valves and there is an increase in refrigerant pressure in the

portion of the refrigerant circuit between the two expansion valves including the receiver, the refrigerant in the portion of the refrigerant circuit between the two expansion valves including the receiver must be able to be let to the rest of the refrigerant circuit in order to prevent liquid sealing in the receiver without providing a liquid sealing prevention pipe, even when the two expansion valves are fully closed.

[0016] In view of this, at least one of the first expansion valve and the second expansion valve is provided to the refrigerant circuit in the first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the valve seat, and out to the needle retracting direction side of the valve seat through a gap between the needle and the valve seat, as described above. In the first expansion valve and/or the second expansion valve provided to the refrigerant circuit in the first disposed state, a force thereby acts to push the needle in the needle retracting direction when the counter-pressure valve-opening pressure difference occurs, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat when the valve is fully closed. The force pushing the needle in the needle retracting direction due to this counter-pressure valve-opening pressure difference is utilized to provide a configuration in which the first expansion valve and/or the second expansion valve provided to the refrigerant circuit in the first disposed state is provided with the spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and when the force pushing the needle in the needle retracting direction due to the counter-pressure valve-opening pressure difference overcomes the urging force of the spring in the needle advancing direction, the needle is released from sitting on the valve seat. This makes it possible to yield a configuration in which refrigerant in the portion of the refrigerant circuit between the two expansion valves including the receiver can be let toward the outdoor heat exchanger and/or the indoor heat exchanger when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the two expansion valves including the receiver.

[0017] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the second expansion valve, and the indoor heat exchanger, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve and the second expansion valve.

[0018] An air conditioning apparatus according to a fourth aspect is the air conditioning apparatus according to any of the first through third aspects, wherein the urging force of the spring when the valve is fully closed is set so that the sum total of the counter-pressure valve-open-

ing pressure difference and a maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the receiver, the first expansion valve, and the opening/closing valve are installed.

[0019] Thus, the urging force of the spring when the valve is fully closed is set herein so that the sum total of the counter-pressure valve-opening pressure difference and the maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the first expansion valve and the opening/closing valve are installed, as described above. Even assuming conditions of an atmospheric temperature so high that the refrigerant in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver increases in pressure to the maximum saturation pressure, the force generated by the counter-pressure valve-opening pressure difference to push the needle in the needle retracting direction will thereby overcome the urging force of the spring in the needle advancing direction before the proof pressure of the receiver is exceeded, and the needle can be released from sitting on the valve seat. Therefore, the refrigerant in the portion of the refrigerant circuit between the first expansion valve and the opening/closing valve including the receiver can be let toward the outdoor heat exchanger and/or the indoor heat exchanger before the proof pressure of the receiver is exceeded, and liquid sealing in the receiver can be prevented.

[0020] Thus, in this air conditioning apparatus, liquid sealing in the receiver can be appropriately prevented while taking the proof pressure of the receiver into account.

[0021] An air conditioning apparatus according to a fifth aspect is the air conditioning apparatus according to the first aspect, wherein the refrigerant circuit further has a gas purge valve for purging refrigerant from the upper space of the receiver, and the gas purge valve is a fully-closing expansion valve that is fully closed by a needle sitting on a valve seat. At least one of the first expansion valve and the gas purge valve in this case is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat. The first expansion valve and/or the gas purge valve provided to the refrigerant circuit in the first disposed state has a spring for urging the needle seated on the valve

seat in the needle advancing direction when the valve is fully closed, the first expansion valve and/or the gas purge valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat.

[0022] Specifically, the refrigerant circuit herein is configured with a fully-closing first expansion valve provided to one of the upstream and downstream sides of the receiver, an opening/closing valve provided to the other of the upstream and downstream sides of the receiver, and a fully-closing gas purge valve provided to the receiver. Thus, when fully-closing expansion valves are used as the first expansion valve and the gas purge valve and there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver, the refrigerant in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver must be able to be let to the rest of the refrigerant circuit in order to prevent liquid sealing in the receiver without providing a liquid sealing prevention pipe, even when the first expansion valve, the opening/closing valve, and the gas purge valve are fully closed.

[0023] In view of this, at least one of the first expansion valve and the gas purge valve is provided to the refrigerant circuit in the first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the valve seat, and out to the needle retracting direction side of the valve seat through a gap between the needle and the valve seat, as described above. In the first expansion valve and/or the gas purge valve provided to the refrigerant circuit in the first disposed state, a force thereby acts to push the needle in the needle retracting direction when the counter-pressure valve-opening pressure difference occurs, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat when the valve is fully closed. The force pushing the needle in the needle retracting direction due to this counter-pressure valve-opening pressure difference is utilized to provide a configuration in which the first expansion valve and/or the gas purge valve provided to the refrigerant circuit in the first disposed state is provided with the spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and when the force pushing the needle in the needle retracting direction due to the counter-pressure valve-opening pres-

sure difference overcomes the urging force of the spring in the needle advancing direction, the needle is released from sitting on the valve seat. This yields a configuration in which refrigerant in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver can be let toward the outdoor heat exchanger, the indoor heat exchanger, and/or the compressor when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver.

[0024] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the opening/closing valve, the indoor heat exchanger, and the gas purge valve, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve and the gas purge valve.

[0025] An air conditioning apparatus according to a sixth aspect is the air conditioning apparatus according to the fifth aspect, wherein the opening/closing valve is a liquid-side shut-off valve.

[0026] Specifically, the refrigerant circuit is configured with a fully-closing first expansion valve provided to one of the upstream and downstream sides of the receiver, and a liquid-side shut-off valve provided to the other of the upstream and downstream sides of the receiver. Therefore, when the first expansion valve and the liquid-side shut-off valve are fully closed, there is a risk of liquid sealing in the receiver.

[0027] In view of this, the fully-closing first expansion valve and/or gas purge valve herein is provided to the refrigerant circuit in the first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the valve seat, and out to the needle retracting direction side of the valve seat through a gap between the needle and the valve seat, as described above. Therefore, a configuration can be achieved in which refrigerant in the portion of the refrigerant circuit between the first expansion valve, the liquid-side shut-off valve, and the gas purge valve including the receiver can be let toward the outdoor heat exchanger and/or the compressor when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve, the liquid-side shut-off valve, and the gas purge valve including the receiver.

[0028] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the liquid-side shut-off valve, the indoor heat exchanger, and the gas purge valve, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve and the gas purge valve.

[0029] An air conditioning apparatus according to a seventh aspect is the air conditioning apparatus according to the first aspect, wherein the opening/closing valve is a second expansion valve, the refrigerant circuit further has a gas purge valve for purging refrigerant from the upper space of the receiver, and the second expansion valve and the gas purge valve are fully-closing expansion valves that are each fully closed by a needle sitting on a valve seat. At least one of the first expansion valve, the second expansion valve, and the gas purge valve in this case is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat. The first expansion valve, the second expansion valve, and/or the gas purge valve provided to the refrigerant circuit in the first disposed state has a spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve, the second expansion valve, and/or the gas purge valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat.

[0030] Specifically, the refrigerant circuit herein is configured with fully-closing first and second expansion valves provided to the upstream and downstream sides of the receiver, and a fully-closing gas purge valve provided to the receiver. Thus, when fully-closing expansion valves are used as the first expansion valve, the second expansion valve, and the gas purge valve and there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve, the second expansion valve, and the gas purge valve including the receiver, the refrigerant in the portion of the refrigerant circuit between the first expansion valve, the second expansion valve, and the gas purge valve including the receiver must be able to be let to the rest of the refrigerant circuit in order to prevent liquid sealing in the receiver without providing a liquid sealing prevention pipe, even when the first expansion valve, the second expansion valve, and the gas purge valve are fully closed.

[0031] In view of this, at least one of the first expansion valve, the second expansion valve, and the gas purge valve is provided to the refrigerant circuit in the first disposed state in which refrigerant from the receiver flows in from the needle advancing direction side of the valve

seat, and out to the needle retracting direction side of the valve seat through a gap between the needle and the valve seat, as described above. In the first expansion valve, the second expansion valve, and/or the gas purge valve provided to the refrigerant circuit in the first disposed state, a force thereby acts to push the needle in the needle retracting direction when the counter-pressure valve-opening pressure difference occurs, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat when the valve is fully closed. The force pushing the needle in the needle retracting direction due to this counter-pressure valve-opening pressure difference is utilized to provide a configuration in which the first expansion valve, the second expansion valve, and/or the gas purge valve provided to the refrigerant circuit in the first disposed state is provided with the spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and when the force pushing the needle in the needle retracting direction due to the counter-pressure valve-opening pressure difference overcomes the urging force of the spring in the needle advancing direction, the needle is released from sitting on the valve seat. This yields a configuration in which refrigerant in the portion of the refrigerant circuit between the first expansion valve, the second expansion valve, and the gas purge valve including the receiver can be let toward the outdoor heat exchanger, the indoor heat exchanger, and/or the compressor when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the first expansion valve, the second expansion valve, and the gas purge valve including the receiver.

[0032] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the outdoor heat exchanger, the first expansion valve, the receiver, the second expansion valve, the indoor heat exchanger, and the gas purge valve, liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve, the second expansion valve, and the gas purge valve.

[0033] An air conditioning apparatus according to an eighth aspect is the air conditioning apparatus according to any of the fifth through seventh aspects, wherein the urging force of the spring when the valve is fully closed is set so that the sum total of the counter-pressure valve-opening pressure difference and a maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the receiver, the first expansion valve, the opening/closing valve, and the gas purge valve are installed.

[0034] Thus, the urging force of the spring when the valve is fully closed is set herein so that the sum total of

the counter-pressure valve-opening pressure difference and the maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the first expansion valve, the opening/closing valve, and the gas purge valve are installed, as described above. Even assuming conditions of an atmospheric temperature so high that the refrigerant in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver increases in pressure to the maximum saturation pressure, the force generated by the counter-pressure valve-opening pressure difference to push the needle in the needle retracting direction will thereby overcome the urging force of the spring in the needle advancing direction before the proof pressure of the receiver is exceeded, and the needle can be released from sitting on the valve seat. Therefore, the refrigerant in the portion of the refrigerant circuit between the first expansion valve, the opening/closing valve, and the gas purge valve including the receiver can be let toward the outdoor heat exchanger, the indoor heat exchanger, and/or the compressor before the proof pressure of the receiver is exceeded, and liquid sealing in the receiver can be prevented.

[0035] Thus, in this air conditioning apparatus, liquid sealing in the receiver can be appropriately prevented while taking the proof pressure of the receiver into account.

[0036] An air conditioning apparatus according to a ninth aspect is the air conditioning apparatus according to the fourth or eighth aspect, wherein the proof pressure of the receiver is a pressure value obtained by multiplying the design pressure of the receiver by a safety factor.

[0037] Because the proof pressure herein is obtained on the basis of the design pressure of the receiver, it is possible to appropriately set the counter-pressure valve-opening pressure difference of the first expansion valve, the second expansion valve, and/or the gas purge valve provided in the first disposed state, i.e., to appropriately set the urging force of the spring when the valve is fully closed.

[0038] An air conditioning apparatus according to a tenth aspect is the air conditioning apparatus according to the first or fifth aspect, wherein the opening/closing valves are a second expansion valve and a liquid-side shut-off valve connected between the second expansion valve and the indoor heat exchanger, and the second expansion valve is a fully-closing expansion valve that is fully closed by a needle sitting on a valve seat. The second expansion valve herein is provided to the refrigerant circuit in a second disposed state in which refrigerant from the receiver flows in from the needle retracting direction side of the valve seat, and out to the needle advancing direction side of the valve seat through a gap between the needle and the valve seat. The second expansion valve provided to the refrigerant circuit in the

second disposed state has a spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the second expansion valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space on the needle retracting direction side of the valve seat and refrigerant pressure in a space on the needle advancing direction side of the valve seat.

[0039] When a fully-closing expansion valve is used as the second expansion valve and both the liquid-side shut-off valve and the second expansion valve come to be fully closed due to a mishap such as erroneous operation of the liquid-side shut-off valve and/or the second expansion valve, there is a risk that liquid sealing will occur in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve. Specifically, there is a risk that the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve will be filled with liquid refrigerant, the liquid refrigerant will be sealed within this portion, and an increase in temperature will cause the liquid-side shut-off valve, the second expansion valve, and/or other equipment configuring this portion to suffer a rupture or the like. When there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve, the refrigerant in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve must be able to be let to the rest of the refrigerant circuit in order to make liquid sealing preventable in the portion between the liquid-side shut-off valve and the second expansion valve.

[0040] In view of this, in addition to preventing liquid sealing in the receiver by providing the first expansion valve (the first expansion valve and/or the gas purge valve when there is also a gas purge valve) to the refrigerant circuit in the first disposed state as described above, the second expansion valve is provided to the refrigerant circuit in the second disposed state, in which refrigerant from the receiver flows in from the needle retracting direction side of the valve seat, and out to the needle advancing direction side of the valve seat through the gap between the needle and the valve seat. A force will thereby act to push the needle in the needle retracting direction when the counter-pressure valve-opening pressure difference occurs, which is the difference between refrigerant pressure in the space on the needle retracting direction side of the valve seat and refrigerant pressure in the space on the needle advancing direction side of the valve seat when the second expansion valve is fully closed. The force pushing the needle in the needle retracting direction due to this counter-pressure valve-opening pressure difference is utilized to provide a con-

figuration in which the second expansion valve provided to the refrigerant circuit in the second disposed state is provided with the spring for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and when the force pushing the needle in the needle retracting direction due to the counter-pressure valve-opening pressure difference overcomes the urging force of the spring in the needle advancing direction, the needle is released from sitting on the valve seat. Therefore, a configuration can be achieved in which refrigerant in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve can be let toward the receiver when there is an increase in refrigerant pressure in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve.

[0041] Thus, in the refrigerant circuit of this air conditioning apparatus, configured by connecting the compressor, the receiver, the second expansion valve, the liquid-side shut-off valve, and the indoor heat exchanger (including the gas purge valve when there is also a gas purge valve), liquid sealing in the receiver can be prevented without providing a liquid sealing prevention pipe, and liquid sealing between the liquid-side shut-off valve and the second expansion valve can be prevented.

[0042] An air conditioning apparatus according to an eleventh aspect is the air conditioning apparatus according to the tenth aspect, wherein the urging force of the spring of the second expansion valve when the valve is fully closed is set so that the sum total of a maximum saturation pressure and the counter-pressure valve-opening pressure difference of the second expansion valve is equal to or less than the minimum value of the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the second expansion valve and the liquid-side shut-off valve are installed.

[0043] The urging force of the spring when the valve is fully closed is set herein so that the sum total of the counter-pressure valve-opening pressure difference and the maximum saturation pressure is equal to or less than the minimum value of the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the second expansion valve is installed, as described above. Even assuming conditions of an atmospheric temperature so high that the refrigerant in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve increases in pressure to the maximum saturation pressure, the force generated by the counter-pressure valve-opening pres-

sure difference to push the needle in the needle retracting direction will thereby overcome the urging force of the spring in the needle advancing direction before the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve are exceeded, and the needle can be released from sitting on the valve seat. Therefore, the refrigerant in the portion of the refrigerant circuit between the liquid-side shut-off valve and the second expansion valve can be let toward the receiver before the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve are exceeded, and liquid sealing between the liquid-side shut-off valve and the second expansion valve can be prevented. There is a risk herein that the refrigerant let toward the receiver will cause a pressure increase in the receiver, but because the first expansion valve (and the first expansion valve and/or the gas purge valve when there is also a gas purge valve) is provided in the first disposed state, the refrigerant will be let toward the outdoor heat exchanger (toward the outdoor heat exchanger and/or the compressor when there is also a gas purge valve) before the proof pressure of the receiver is exceeded.

[0044] Thus, in addition to preventing liquid sealing in the receiver without providing a liquid sealing prevention pipe in this air conditioning apparatus, liquid sealing between the liquid-side shut-off valve and the second expansion valve can be appropriately prevented while taking into account the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve.

[0045] An air conditioning apparatus according to a twelfth aspect is the air conditioning apparatus according to the eleventh aspect, wherein the proof pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve are pressure values obtained by multiplying the design pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve by a safety factor.

[0046] Because the proof pressures herein are obtained on the basis of the design pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve, it is possible to appropriately set the counter-pressure valve-opening pressure difference of the second expansion valve provided in the second disposed state, i.e., to appropriately set the urging force of the spring when the valve is fully closed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047]

FIG. 1 is a schematic configuration drawing of an air conditioning apparatus according to an embodiment

of the present invention.

FIG. 2 is a drawing showing the vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve.

FIG. 3 is a schematic cross-sectional view of the expansion valve.

FIG. 4 is a schematic cross-sectional view showing a vicinity of a needle of the expansion valve when the expansion valve is fully closed (with counter-pressure valve-opening inactive).

FIG. 5 is a schematic cross-sectional view showing the vicinity of the needle of the expansion valve when the expansion valve is fully closed (with counter-pressure valve-opening active).

FIG. 6 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 1.

FIG. 7 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 1.

FIG. 8 is a schematic configuration drawing of an air conditioning apparatus according to Modification 2.

FIG. 9 is a schematic configuration drawing of an air conditioning apparatus according to Modification 3.

FIG. 10 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 11 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 12 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 13 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 14 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 15 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 16 is a drawing showing a vicinity of a first expansion valve, a receiver, a second expansion valve, and a liquid-side shut-off valve according to Modification 3.

FIG. 17 is a schematic configuration drawing of an air conditioning apparatus according to Modification 5.

FIG. 18 is a schematic configuration drawing of an

air conditioning apparatus according to Modification 5.

FIG. 19 is a drawing showing a vicinity of a first expansion valve, a receiver, and a liquid-side shut-off valve according to Modification 5.

FIG. 20 is a drawing showing a vicinity of a first expansion valve, a receiver, and a liquid-side shut-off valve according to Modification 5.

FIG. 21 is a drawing showing a vicinity of a first expansion valve, a receiver, and a liquid-side shut-off valve according to Modification 5.

FIG. 22 is a drawing showing a vicinity of a first expansion valve, a receiver, and a liquid-side shut-off valve according to Modification 5.

DESCRIPTION OF EMBODIMENTS

[0048] An embodiment and modifications of an air conditioning apparatus according to the present invention is described below with reference to the drawings. The specific configuration of the air conditioning apparatus according to the present invention is not limited to the following embodiment or the modifications thereof, and can be modified within a range that does not deviate from the scope of the invention.

(1) Configuration of Air Conditioning Apparatus

[0049] FIG. 1 is a schematic configuration drawing of an air conditioning apparatus 1 according to an embodiment of the present invention.

[0050] The air conditioning apparatus 1 is an apparatus capable of cooling or warming the interior of a room in a building or the like by performing a vapor-compression refrigeration cycle operation. The air conditioning apparatus 1 is configured by connecting primarily an outdoor unit 2 and an indoor unit 4. The outdoor unit 2 and the indoor unit 4 herein are connected via a liquid refrigerant communication pipe 5 and a gas refrigerant communication pipe 6. Specifically, a vapor-compression refrigerant circuit 10 of the air conditioning apparatus 1 is configured by connecting the outdoor unit 2 and the indoor unit 4 via the refrigerant communication pipes 5, 6. Various refrigerants can be used as the refrigerant sealed in the refrigerant circuit 10, but R32, a type of HFC refrigerant, is sealed in as the refrigerant in this case.

<Indoor Units>

[0051] The indoor unit 4, which is installed in a room, configures part of the refrigerant circuit 10. The indoor unit 4 has primarily an indoor heat exchanger 41.

[0052] The indoor heat exchanger 41 is a heat exchanger that functions as an evaporator of refrigerant and cools indoor air during an air-cooling operation, and functions as a heat radiator of refrigerant and heats indoor air during an air-warming operation. The liquid side of the indoor heat exchanger 41 is connected to the liquid

refrigerant communication pipe 5, and the gas side of the indoor heat exchanger 41 is connected to the gas refrigerant communication pipe 6.

[0053] The indoor unit 4 has an indoor fan 42 for drawing indoor air into the indoor unit 4 and supplying the air back into the room as supplied air after the air has exchanged heat with the refrigerant in the indoor heat exchanger 41. The indoor fan 42 is driven by an indoor fan motor 43.

[0054] The indoor unit 4 has an indoor-side controller 44 for controlling the actions of the components constituting the indoor unit 4. The indoor-side controller 44 has a microcomputer, memory, and/or the like provided in order to control the indoor unit 4, and the controller is designed to be able to exchange control signals and the like with a remote controller (not shown), and exchange control signals and the like with the outdoor unit 2 via a transmission line 8a.

<Outdoor Unit>

[0055] The outdoor unit 2, which is installed outside of the room, configures part of the refrigerant circuit 10. The outdoor unit 2 has primarily a compressor 21, a four-way switching valve 22, an outdoor heat exchanger 23, a first expansion valve 24, a receiver 25, a second expansion valve 26 (an opening/closing valve), a liquid-side shut-off valve 27 (an opening/closing valve), and a gas-side shutoff valve 28.

[0056] The compressor 21 is a mechanism for compressing low-pressure refrigerant in the refrigeration cycle to a high pressure. The compressor 21 has a sealed structure in which a rotary, scroll, or other type of displacement compression element (not shown) is rotatably driven by a compressor motor 21a controlled by an inverter. An intake pipe 31 is connected to the intake side of the compressor 21, and a discharge pipe 32 is connected to the discharge side. The intake pipe 31 is a refrigerant pipe connecting the intake side of the compressor 21 and a first port 22a of the four-way switching valve 22. An accumulator 29 is provided to the intake pipe 31. The discharge pipe 32 is a refrigerant pipe connecting the discharge side of the compressor 21 and a second port 22b of the four-way switching valve 22. A non-return valve 32a is provided to the discharge pipe 32.

[0057] The four-way switching valve 22 is a mechanism for switching the direction of refrigerant flow in the refrigerant circuit 10. During the air-cooling operation, the four-way switching valve 22 performs a switch that causes the outdoor heat exchanger 23 to function as a heat radiator of refrigerant compressed in the compressor 21, and causes the indoor heat exchanger 41 to function as an evaporator of refrigerant that has radiated heat in the outdoor heat exchanger 23, and thereby switches into an air-cooling cycle state. Specifically, during the air-cooling operation, the four-way switching valve 22 performs a switch that interconnects the second port 22b and a third port 22c, and interconnects the first port 22a

and a fourth port 22d. The discharge side of the compressor 21 (the discharge pipe 32 herein) and the gas side of the outdoor heat exchanger 23 (a first gas refrigerant pipe 33 herein) are thereby connected (refer to the solid lines of the four-way switching valve 22 in FIG. 1). Moreover, the intake side of the compressor 21 (the intake pipe 31 herein) and the gas refrigerant communication pipe 6 side (a second gas refrigerant pipe 34 herein) are connected (refer to the solid lines of the four-way switching valve 22 in FIG. 1). During the air-warming operation, the four-way switching valve 22 performs a switch that causes the outdoor heat exchanger 23 to function as an evaporator of refrigerant that has radiated heat in the indoor heat exchanger 41, and causes the indoor heat exchanger 41 to function as a heat radiator of refrigerant that has been compressed in the compressor 21, and thereby switches into an air-warming cycle state. Specifically, during the air-warming operation, the four-way switching valve 22 performs a switch that interconnects the second port 22b and the fourth port 22d, and interconnects the first port 22a and the third port 22c. The discharge side of the compressor 21 (the discharge pipe 32 herein) and the gas refrigerant communication pipe 6 side (the second gas refrigerant pipe 34 herein) are thereby connected (refer to the dashed lines of the four-way switching valve 22 in FIG. 1). Moreover, the intake side of the compressor 21 (the intake pipe 31 herein) and the gas side of the outdoor heat exchanger 23 (the first gas refrigerant pipe 33 herein) are connected (refer to the dashed lines of the four-way switching valve 22 in FIG. 1). The first gas refrigerant pipe 33 is a refrigerant pipe connecting the third port 22c of the four-way switching valve 22 and the gas side of the outdoor heat exchanger 23. The second gas refrigerant pipe 34 is a refrigerant pipe connecting the fourth port 22d of the four-way switching valve 22 and the gas refrigerant communication pipe 6 side.

[0058] The outdoor heat exchanger 23 is a heat exchanger that functions as a heat radiator of refrigerant that uses outdoor air as a cooling source during the air-cooling operation, and functions as an evaporator of refrigerant that uses outdoor air as a heating source during the air-warming operation. The liquid side of the outdoor heat exchanger 23 is connected to a liquid refrigerant pipe 35, and the gas side is connected to the first gas refrigerant pipe 33. The liquid refrigerant pipe 35 is a refrigerant pipe connecting the liquid side of the outdoor heat exchanger 23 and the liquid refrigerant communication pipe 5 side.

[0059] During the air-cooling operation, the first expansion valve 24 depressurizes high-pressure refrigerant in the refrigeration cycle to an intermediate pressure in the refrigeration cycle, after the refrigerant has radiated heat in the outdoor heat exchanger 23. During the air-warming operation, the first expansion valve 24 depressurizes intermediate pressure refrigerant in the refrigeration cycle, which has accumulated in the receiver 25, to a low pressure in the refrigeration cycle. The first expansion valve

24 is provided to a portion of the liquid refrigerant pipe 35 that is between the outdoor heat exchanger 23 and the receiver 25. The portion of the liquid refrigerant pipe 35 that connects the outdoor heat exchanger 23 and the first expansion valve 24 herein is a first liquid refrigerant pipe 35a, and the portion of the liquid refrigerant pipe 35 that connects the first expansion valve 24 and the receiver 25 is a second liquid refrigerant pipe 35b. An electric expansion valve is used herein as the first expansion valve 24. The detailed structure of the first expansion valve 24 shall be described hereinafter.

[0060] The receiver 25 is provided between the first expansion valve 24 and the second expansion valve 26. The receiver 25 is a container capable of accumulating intermediate pressure refrigerant in the refrigeration cycle during the air-cooling operation and the air-warming operation.

[0061] During the air-cooling operation, the second expansion valve 26 (an opening/closing valve) depressurizes intermediate pressure refrigerant in the refrigeration cycle accumulated in the receiver 25 to a low pressure in the refrigeration cycle. During the air-warming operation, the second expansion valve 26 depressurizes high-pressure refrigerant in the refrigeration cycle to an intermediate pressure in the refrigeration cycle after the refrigerant has radiated heat in the indoor heat exchanger 41. The second expansion valve 26 is provided to a portion of the liquid refrigerant pipe 35 that is between the receiver 25 and the liquid-side shut-off valve 27. The portion of the liquid refrigerant pipe 35 that connects the receiver 25 and the second expansion valve 26 is a third liquid refrigerant pipe 35c, and the portion of the liquid refrigerant pipe 35 that connects the second expansion valve 26 and the liquid-side shut-off valve 27 is a fourth liquid refrigerant pipe 35d. An electric expansion valve is used herein as the second expansion valve 26. The detailed structure of the second expansion valve 26 shall be described hereinafter.

[0062] The liquid-side shut-off valve 27 (an opening/closing valve) and the gas-side shut-off valve 28 are valves provided in ports connected with external devices or piping (specifically, the liquid refrigerant communication pipe 5 and the gas refrigerant communication pipe 6). The liquid-side shut-off valve 27 is provided to an end part of the liquid refrigerant pipe 35 (more specifically, the fourth liquid refrigerant pipe 35d). The gas-side shut-off valve 28 is provided to an end part of the second gas refrigerant pipe 34.

[0063] The outdoor unit 2 has an outdoor fan 36 for drawing outdoor air into the outdoor unit 2 and ejecting the air outside after the air has exchanged heat with the refrigerant in the outdoor heat exchanger 23. The outdoor fan 36 is driven by an outdoor fan motor 37.

[0064] The outdoor unit 2 has an outdoor-side controller 38 for controlling the actions of the components constituting the outdoor unit 2. The outdoor-side controller 38, which has a microcomputer, memory, and/or the like provided in order to control the outdoor unit 2, is designed

to be capable of exchanging control signals and the like with the indoor unit 4 via the transmission line 8a.

<Refrigerant Communication Pipes>

[0065] The refrigerant communication pipes 5, 6, which are refrigerant pipes machined onsite when the air-conditioning apparatus 1 is installed in a building or another installation location, have various lengths and/or pipe diameters according to the installation location and/or installation conditions such as the combination of the outdoor unit and the indoor unit.

[0066] As described above, the refrigerant circuit 10 of the air-conditioning apparatus 1 is configured from the connection between the outdoor unit 2, the indoor unit 4, and the refrigerant communication pipes 5, 6. The air conditioning apparatus 1 is designed so that switching the four-way switching valve 22 to the air-cooling cycle state causes the air-cooling operation to be performed, in which refrigerant is circulated sequentially through the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), the liquid-side shut-off valve 27 (an opening/closing valve) and the indoor heat exchanger 41. The air conditioning apparatus 1 is also designed so that switching the four-way switching valve 22 to the air-warming cycle state causes the air-warming operation to be performed, in which refrigerant is circulated sequentially through the compressor 21, the indoor heat exchanger 41, the liquid-side shut-off valve 27 (an opening/closing valve), the second expansion valve 26 (an opening/closing valve), the receiver 25, the first expansion valve 24, and the outdoor heat exchanger 23. The configuration herein is capable of switching between the air-cooling operation and the air-warming operation, but another option is a configuration that does not have a four-way switching valve and that is capable of only an air-cooling operation or only an air-warming operation.

<Controllers>

[0067] The air conditioning apparatus 1 is designed so that the control of the various devices of the outdoor unit 2 and the indoor unit 4 can be performed by a controller 8, configured from the indoor-side controller 44 and the outdoor-side controller 38. Specifically, the controller 8 is configured to control the operations of the entire air conditioning apparatus 1 including the above-described air-cooling operation, the air-warming operation, and/or the like, through the transmission line 8a connecting the indoor-side controller 44 and the outdoor-side controller 38.

(2) Basic Actions of Air Conditioning Apparatus

[0068] The basic actions of the air conditioning apparatus 1 are described next using FIG. 1. The air condi-

tioning apparatus 1 can perform an air-cooling operation and an air-warming operation as basic actions.

<Air-Warming Operation>

[0069] During the air-warming operation, the four-way switching valve 22 is switched to the air-warming cycle state (the state shown by the dashed lines in FIG. 1).

[0070] In the refrigerant circuit 10, low-pressure gas refrigerant in the refrigeration cycle is drawn into the compressor 21 and discharged after being compressed to a high pressure.

[0071] The high-pressure gas refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22, the gas-side shut-off valve 28, and the gas refrigerant communication pipe 6 to the indoor heat exchanger 41.

[0072] The high-pressure gas refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air supplied as a cooling source by the indoor fan 42 and radiates heat in the indoor heat exchanger 41, becoming high-pressure liquid refrigerant. The indoor air is thereby heated and then supplied into the room, whereby air-warming of the room interior is performed.

[0073] The high-pressure liquid refrigerant that has radiated heat in the indoor heat exchanger 41 is sent through the liquid refrigerant communication pipe 5 and the liquid-side shut-off valve 27 to the second expansion valve 26.

[0074] The high-pressure liquid refrigerant sent to the second expansion valve 26 is depressurized to an intermediate pressure in the refrigeration cycle by the second expansion valve 26, becoming intermediate-pressure, gas-liquid two-phase refrigerant.

[0075] The intermediate-pressure, gas-liquid two-phase refrigerant depressurized by the second expansion valve 26 is temporarily accumulated in the receiver 25, and then sent to the first expansion valve 24.

[0076] The intermediate-pressure, gas-liquid two-phase refrigerant sent to the first expansion valve 24 is depressurized to a low pressure in the refrigeration cycle by the first expansion valve 24, becoming low-pressure, gas-liquid two-phase refrigerant.

[0077] The low-pressure, gas-liquid two-phase refrigerant depressurized by the first expansion valve 24 is sent to the outdoor heat exchanger 23.

[0078] The low-pressure, gas-liquid two-phase refrigerant sent to the outdoor heat exchanger 23 undergoes heat exchange with outdoor air supplied as a heating source by the outdoor fan 36 and evaporates in the outdoor heat exchanger 23, becoming low-pressure gas refrigerant.

[0079] The low-pressure refrigerant evaporated in the outdoor heat exchanger 23 is drawn through the four-way switching valve 22 back into the compressor 21.

<Air-Cooling Operation>

[0080] During the air-cooling operation, the four-way switching valve 22 is switched to the air-cooling cycle state (the state shown by the solid lines in FIG. 1).

[0081] In the refrigerant circuit 10, low-pressure gas refrigerant in the refrigeration cycle is drawn into the compressor 21 and discharged after being compressed to a high pressure in the refrigeration cycle.

[0082] The high-pressure gas refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 to the outdoor heat exchanger 23.

[0083] The high-pressure gas refrigerant sent to the outdoor heat exchanger 23 undergoes heat exchange with outdoor air supplied as a cooling source by the outdoor fan 36 and radiates heat in the outdoor heat exchanger 23, becoming high-pressure liquid refrigerant.

[0084] The high-pressure liquid refrigerant that has radiated heat in the outdoor heat exchanger 23 is sent to the first expansion valve 24.

[0085] The high-pressure liquid refrigerant sent to the first expansion valve 24 is depressurized to an intermediate pressure in the refrigeration cycle by the first expansion valve 24, becoming intermediate-pressure, gas-liquid two-phase refrigerant.

[0086] The intermediate-pressure, gas-liquid two-phase refrigerant depressurized in the first expansion valve 24 is temporarily accumulated in the receiver 25 and then sent to the second expansion valve 26.

[0087] The intermediate-pressure, gas-liquid two-phase refrigerant sent to the second expansion valve 26 is depressurized to a low pressure in the refrigeration cycle by the second expansion valve 26, becoming low-pressure, gas-liquid two-phase refrigerant.

[0088] The low-pressure, gas-liquid two-phase refrigerant depressurized by the second expansion valve 26 is sent through the liquid-side shut-off valve 27 and the liquid refrigerant communication pipe 5 to the indoor heat exchanger 41.

[0089] The low-pressure, gas-liquid two-phase refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air supplied as a heating source by the indoor fan 42 and evaporates in the indoor heat exchanger 41. The indoor air is thereby cooled and then supplied into the room, whereby air-cooling of the room interior is performed.

[0090] The low-pressure gas refrigerant evaporated in the indoor heat exchanger 41 is drawn through the gas refrigerant communication pipe 6, the gas-side shut-off valve 28, and the four-way switching valve 22, back into the compressor 21.

(3) Detailed Structure and Actions of Expansion Valves

<Basic Structures of Expansion Valves>

[0091] In the air conditioning apparatus 1, when grooved-needle type expansion valves are used as the

first expansion valve 24 and the second expansion valve 26 provided on the upstream and downstream sides of the receiver 25, there is a risk of liquid backflow, in which liquid refrigerant returns to the compressor 21, at startup of the air-cooling operation and/or the air-warming operation. A conceivable countermeasure is to use fully-closing expansion valves, in which grooves are not formed in the needles and the valves are fully closed by the needles being seated on the valve seats, as the first expansion valve 24 and the second expansion valve 26.

[0092] First is a description of the basic structures and actions of the first expansion valve 24 and the second expansion valve 26 composed of fully-closing expansion valves.

[0093] The first expansion valve 24 and the second expansion valve 26 each have primarily a valve body 51, a needle 61, and a case 71, as shown in FIG. 3. In the example described herein, the first expansion valve 24 and the second expansion valve 26 are both arranged so that the needle 61 moves vertically, but this does not limit the valves from being arranged so that the needle 61 moves horizontally or in another direction. In addition, here, when the needle 61 sits on a valve seat 55, the direction in which the needle 61 moves (down) is the needle advancing direction, and the when the needle 61 retracts from the valve seat 55, the direction in which the needle 61 moves (up) is the needle retracting direction.

[0094] The valve body 51 herein is a substantially tubular member extending vertically (i.e., in the direction in which the needle 61 moves), in which a valve chamber 52 is formed. The valve chamber 52 has an upper valve chamber 52a large in diameter, and a lower valve chamber 52b small in diameter and positioned beneath the upper valve chamber 52a. Also formed in the valve body 51 are a first refrigerant port 53 opening into the side of the valve chamber 52 (the upper valve chamber 52a herein), and a second refrigerant port 54 opening into the bottom of the valve chamber 52 (the lower valve chamber 52b herein). The valve seat 55 is also provided in the valve body 51. Specifically, the valve seat 55 is provided in the valve body 51 so as to partition the upper valve chamber 52a and the lower valve chamber 52b. The upper valve chamber 52a thereby configures a space on the needle retracting direction side of the valve seat 55 (the upper space herein), and the lower valve chamber 52b configures a space on the needle advancing direction side of the valve seat 55 (the lower space herein). Of the two refrigerant ports 53, 54, the first refrigerant port 53 is provided on the needle retracting direction side of the valve seat 55, and the second refrigerant port 54 is provided on the needle advancing direction side of the valve seat 55. An orifice hole 55a, opened so as to interconnect the upper valve chamber 52a and the lower valve chamber 52b in the direction in which the needle 61 moves (vertically herein), is formed in the valve seat 55. A substantially tubular female-thread-formed member 56 is secured by press-fitting or the like in the internal peripheral surface of the valve body 51. The up-

per part of the female-thread-formed member 56 protrudes above the valve body 51, and a female thread 56a is formed in the internal peripheral surface. A substantially tubular needle guide 57 is secured by press-fitting or the like in the lower part of the female-thread-formed member 56.

[0095] The needle 61 herein is a member that vertically (i.e., in the direction in which the needle moves) advances into and retracts from the valve seat 55, and is inserted into the internal peripheral side of the needle guide 57 so as to be able to move vertically. The needle 61 is linked via a spring 62 and a spring-receiving member 63, described hereinafter, to a valve shaft 64 disposed above the needle 61. The valve shaft 64 is a substantially rod-shaped member extending vertically (i.e., in the direction in which the needle moves) from the valve body 51 through the case 71. The lower end of the valve shaft 64 is inserted into the internal peripheral side of the needle guide 57 so as to be able to rotate and move vertically (i.e., in the direction in which the needle moves). A male thread 64a that meshes with the female thread 56a of the female-thread-formed member 56 is formed in the external peripheral surface of the vertically (i.e., in the direction in which the needle moves) middle portion of the valve shaft 64. A substantially tubular rotor 81 composed of a permanent magnet is secured via a bush 65 to the upper side of the male thread 64a of the valve shaft 64.

[0096] The case 71 herein is a substantially tubular member of which the upper end is closed. The case 71 is secured to the upper end of the valve body 51 via a securing metal fitting or the like (not shown). A substantially tubular sleeve 72 extending downward is provided to the inner surface of the upper end of the case 71. The upper end of the valve shaft 64 is inserted into the internal peripheral side of the sleeve 72 so as to be able to rotate and move vertically (i.e., in the direction in which the needle moves). The external peripheral surface of the rotor 81 faces the internal peripheral surface of the case 71 with a slight gap in between. A stator 82 composed of an electromagnet is provided to a position of facing the rotor 81 on the external peripheral side of the case 71.

[0097] With such a configuration, when electric current is conducted to the stator 82, the stator 82 and the rotor 81 function as a stepping motor, and the rotor 81 rotates in accordance with the amount of current conduction (pulse value). When the rotor 81 rotates, the valve shaft 64, which rotates integrally with the rotor 81, also rotates. When the valve shaft 64 rotates, because the male thread 64a of the valve shaft 64 is meshed with the female thread 56a of the female-thread-formed member 56, the valve shaft 64 is threaded into the valve body 51, and the valve shaft 64 thereby moves vertically (i.e., in the direction in which the needle moves). When the valve shaft 64 moves vertically (i.e., in the direction in which the needle moves), the needle 61 linked to the valve shaft 64 also moves vertically (i.e., in the direction in which the needle moves). The size of the gap between the needle 61 and the valve

seat 55 can thereby be adjusted, and the flow rate of refrigerant through the first expansion valve 24 and/or second expansion valve 26 can be controlled while the refrigerant is depressurized. Therefore, the gap between the needle 61 and the valve seat 55 vanishes when the needle 61 is seated on the valve seat 55 due to the valve shaft 64 being threaded into the valve body 51, and the first expansion valve 24 and/or second expansion valve 26 is fully closed (see FIG. 3).

<Structure for Preventing Liquid Sealing in Receiver>

[0098] However, when fully-closing expansion valves are used as the first expansion valve 24 and the second expansion valve 26 (opening/closing valves), there is a risk of liquid sealing in the receiver 25 when the two expansion valves 24, 26 become fully closed. Therefore, when fully-closing expansion valves are used as the first and second expansion valves 24, 26, in order to enable liquid sealing in the receiver 25 to be prevented without providing a liquid sealing prevention pipe even when the two expansion valves 24, 26 become fully closed, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 must be able to be let into the rest of the refrigerant circuit 10 when there is an increase in the pressure of the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25.

[0099] In view of this, first, the first expansion valve 24 is provided to the refrigerant circuit 10 in a first disposed state, in which refrigerant from the receiver 25 flows in from the needle advancing direction side of the valve seat 55 (the lower side of the valve seat 55 herein), through the gap between the needle 61 and the valve seat 55, and out to the needle retracting direction side of the valve seat 55 (the upper side of the valve seat 55 herein) (see FIGS. 2 and 3). Specifically, the first liquid refrigerant pipe 35a for connecting with the outdoor heat exchanger 23 is connected to the first refrigerant port 53 of the first expansion valve 24, and the second liquid refrigerant pipe 35b for connecting with the receiver 25 is connected to the second refrigerant port 54 of the first expansion valve 24, as shown in FIGS. 2 and 3. When the first expansion valve 24 provided to the refrigerant circuit 10 in the first disposed state is fully closed, these connections cause a pressure difference between the refrigerant pressure P_1 in the space on the needle retracting direction side of the valve seat 55 (the upper valve chamber 52a herein) and the refrigerant pressure P_2 in the space on the needle advancing direction side of the valve seat 55 (the lower valve chamber 52b herein), this pressure difference being denoted as the counter-pressure valve-opening pressure difference $\Delta P (= P_2 - P_1)$. This pressure difference causes a pushing force F_u (an upward pushing force herein) to be exerted on the needle 61 in the needle retracting direction (see FIG. 4). The force F_u pushing the needle 61 in the needle retracting direction

due to this counter-pressure valve-opening pressure difference ΔP is utilized to provide a configuration in which the first expansion valve 24 provided to the refrigerant circuit 10 in the first disposed state is provided with the spring 62 for urging the needle 61 seated on the valve seat 55 in the needle advancing direction (downward herein) when the valve is fully closed, and when the force F_u pushing the needle 61 in the needle retracting direction due to the counter-pressure valve-opening pressure difference ΔP overcomes the urging force F_d of the spring 62 in the needle advancing direction, the needle 61 is released from sitting on the valve seat 55 (see FIGS. 4 and 5). Specifically, the spring-receiving member 63 is linked to the lower end of the valve shaft 64 so as to integrally move in the direction in which the needle 61 moves (vertically herein), and the spring-receiving member 63 and the needle 61 are vertically linked by the spring 62, as shown in FIGS. 3 to 5. A coil spring capable of expanding and contracting in the direction in which the needle 61 moves is used herein as the spring 62. This yields a configuration in which the needle 61 moves vertically due to the vertical movement of the valve shaft 64, while the vertical distance between the valve shaft 64 and the needle 61 can be elastically expanded and contracted. When the lower end of the valve shaft 64 reaches the lowest position in the movable range while the valve is fully closed as shown in FIG. 4, the needle 61 comes to be seated on the valve seat 55 while the spring 62 contracts to less than its free length but could still contract further (this state is referred to below as the "counter-pressure valve-opening inactive state"). The spring 62 thereby generates a force F_d urging the needle 61 seated on the valve seat 55 in the needle advancing direction, and the needle 61 is pushed against the valve seat 55 by the urging force F_d of the spring 62. When the force F_u generated by the counter-pressure valve-opening pressure difference ΔP to push the needle 61 in the needle retracting direction then overcomes the urging force F_d of the needle 61 in the needle advancing direction while the valve is fully closed, the valve shaft 64 does not move in the needle retracting direction (upward herein), the needle 61 separates from the valve seat 55 in the needle retracting direction (upward herein) while the spring 62 is further contracted in the counter-pressure valve-opening inactive state, and the needle 61 is released from sitting on the valve seat 55 (this state is referred to below as the "counter-pressure valve-opening active state"), as shown in FIG. 5. At this time, the length of the spring 62 contracts from the length L_0 in the counter-pressure valve-opening inactive state to the length L in the counter-pressure valve-opening active state. When there is an increase in the refrigerant pressure (equivalent to the pressure P_2) in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 can thereby be let toward the outdoor heat exchanger 23 (refer to the

arrow indicating refrigerant flow in FIG. 5).

[0100] Moreover, the urging force F_d of the spring 62 when the valve is fully closed is herein set so that the sum total of the counter-pressure valve-opening pressure difference ΔP and a maximum saturation pressure P_{sm} is equal to or less than the proof pressure P_{rm} of the receiver 25, the maximum saturation pressure P_{sm} being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the first and second expansion valves 24, 26 (the outdoor unit 2 herein) are installed. Specifically, the maximum saturation pressure P_{sm} is a value obtained by converting the maximum atmospheric temperature (e.g., approximately 50°C) that could be assumed in the location where the first and second expansion valves 24, 26 (the outdoor unit 2 herein) are installed to a refrigerant saturation pressure. The proof pressure P_{rm} is the proof pressure of the receiver 25, which has the lowest proof pressure among the first expansion valve 24, the receiver 25, and the second expansion valve 26 as the components constituting the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25. The proof pressure P_{rm} of the receiver 25 herein is obtained by multiplying the design pressure of the receiver 25 by a safety factor (e.g., approximately 1.5 times corresponding to a proof test pressure). For the spring 62, the spring constant and the spring length L_0 in the counter-pressure valve-opening inactive state (i.e., the contracted length from the free length) are set so that the urging force F_d in the counter-pressure valve-opening inactive state is equal to or less than a force F_{um} pushing the needle 61 in the needle retracting direction, generated when the needle 61 is assumed to be subjected to a pressure difference that is the proof pressure P_{rm} of the receiver 25 minus the maximum saturation pressure P_{sm} . This pressure difference corresponding to the urging force F_d in the counter-pressure valve-opening inactive state is designated as the counter-pressure valve-opening pressure difference ΔP . Because the proof pressure P_{rm} of the receiver 25 herein is obtained on the basis of the design pressure of the receiver 25 as described above, the counter-pressure valve-opening pressure difference ΔP , i.e., the urging force F_d of the spring while the valve is fully closed can be appropriately set. Even assuming conditions of an atmospheric temperature so high that the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 increases in pressure to the maximum saturation pressure P_{sm} , the force F_u generated by the counter-pressure valve-opening pressure difference ΔP to push the needle 61 in the needle retracting direction will overcome the urging force F_d of the spring 62 in the needle advancing direction before the proof pressure P_{rm} of the receiver 25 is exceeded, and the first expansion valve 24 will be in the counter-pressure valve-opening active state. Therefore, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the

receiver 25 can be let toward the outdoor heat exchanger 23 before the proof pressure P_{rm} of the receiver 25 is exceeded, and liquid sealing in the receiver 25 can be prevented. Due to the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 being let toward the outdoor heat exchanger 23, when there is a decrease in the refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25, less force F_u pushing the needle 61 in the needle retracting direction is generated by the counter-pressure valve-opening pressure difference ΔP , and the first expansion valve 24 returns to the counter-pressure valve-opening inactive state. Instances of the first expansion valve 24 going into the counter-pressure valve-opening active state can thereby be kept to the necessary minimum.

[0101] Thus, in the refrigerant circuit 10 configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), and the indoor heat exchanger 41 in the air conditioning apparatus 1, liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve 24 and the second expansion valve 26. Moreover, in the air conditioning apparatus 1, liquid sealing in the receiver 25 can be appropriately prevented while taking the proof pressure P_{rm} of the receiver 25 into account.

<Structure for Preventing Liquid Sealing in Portion Between Liquid-Side Shut-Off Valve and Second Expansion Valve>

[0102] Even when a fully-closing expansion valve is used as the second expansion valve 26 (an opening/closing valve), when both the liquid-side shut-off valve 27 and the second expansion valve 26 come to be fully closed due to a mishap such as erroneous operation of the liquid-side shut-off valve 27 (an opening/closing valve) and/or the second expansion valve 26, there is a risk of liquid sealing occurring in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26. In order to prevent such liquid sealing in the portion between the liquid-side shut-off valve 27 and the second expansion valve 26, it must be possible for the refrigerant in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26 to be let to the rest of the refrigerant circuit 10 when there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26.

[0103] In view of this, in addition to preventing liquid sealing in the receiver 25 by providing the first expansion valve 24 to the refrigerant circuit 10 in a first disposed state as described above, first, the second expansion

valve 26 is provided to the refrigerant circuit 10 in a second disposed state, in which refrigerant from the receiver 25 flows in from the needle retracting direction side of the valve seat 55 (the upper side of the valve seat 55 herein), through the gap between the needle 61 and the valve seat 55, and out to the needle advancing direction side of the valve seat 55 (the lower side of the valve seat 55 herein) (see FIGS. 2 and 3). Specifically, the third liquid refrigerant pipe 35c for connecting with the receiver 25 is connected to the first refrigerant port 53 of the second expansion valve 26, and the fourth liquid refrigerant pipe 35d for connecting with the liquid-side shut-off valve 27 is connected to the second refrigerant port 54 of the second expansion valve 26, as shown in FIGS. 2 and 3. When the second expansion valve 26 provided to the refrigerant circuit 10 in the second disposed state is fully closed, these connections cause a pressure difference between the refrigerant pressure P1 in the space on the needle retracting direction side of the valve seat 55 (the upper valve chamber 52a herein) and the refrigerant pressure P2 in the space on the needle advancing direction side of the valve seat 55 (the lower valve chamber 52b herein), this pressure difference being denoted as the counter-pressure valve-opening pressure difference $\Delta P (= P2 - P1)$. This pressure difference causes a pushing force F_u (an upward pushing force herein) to be exerted on the needle 61 in the needle retracting direction (see FIG. 4). The force F_u pushing the needle 61 in the needle retracting direction due to this counter-pressure valve-opening pressure difference ΔP is utilized to provide a configuration in which the second expansion valve 26 provided to the refrigerant circuit 10 in the second disposed state is provided with the spring 62 for urging the needle 61 seated on the valve seat 55 in the needle advancing direction (downward herein) when the valve is fully closed, and when the force F_u pushing the needle 61 in the needle retracting direction due to the counter-pressure valve-opening pressure difference ΔP overcomes the urging force F_d of the spring 62 in the needle advancing direction, the needle 61 is released from sitting on the valve seat 55 (see FIGS. 4 and 5). Specifically, the spring-receiving member 63 is linked to the lower end of the valve shaft 64 so as to integrally move in the direction in which the needle 61 moves (vertically herein), and the spring-receiving member 63 and the needle 61 are vertically linked by the spring 62, as shown in FIGS. 3 to 5. A coil spring capable of expanding and contracting in the direction in which the needle 61 moves is used herein as the spring 62. This yields a configuration in which the needle 61 moves vertically due to the vertical movement of the valve shaft 64, while the vertical distance between the valve shaft 64 and the needle 61 can be elastically expanded and contracted. When the lower end of the valve shaft 64 reaches the lowest position in the movable range while the valve is fully closed as shown in FIG. 4, the needle 61 comes to be seated on the valve seat 55 while the spring 62 contracts to less than its free length but could still contract further (this

state is referred to below as the "counter-pressure valve-opening inactive state"). The spring 62 thereby generates a force F_d urging the needle 61 seated on the valve seat 55 in the needle advancing direction, and the needle 61 is pushed against the valve seat 55 by the urging force F_d of the spring 62. When the force F_u generated by the counter-pressure valve-opening pressure difference ΔP to push the needle 61 in the needle retracting direction then overcomes the urging force F_d of the needle 61 in the needle advancing direction while the valve is fully closed, the valve shaft 64 does not move in the needle retracting direction (upward herein), the needle 61 separates from the valve seat 55 in the needle retracting direction (upward herein) while the spring 62 is further contracted in the counter-pressure valve-opening inactive state, and the needle 61 is released from sitting on the valve seat 55 (this state is referred to below as the "counter-pressure valve-opening active state"), as shown in FIG. 5. At this time, the length of the spring 62 contracts from the length L_0 in the counter-pressure valve-opening inactive state to the length L in the counter-pressure valve-opening active state. When there is an increase in the refrigerant pressure (equivalent to the pressure P2) in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26, the refrigerant in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26 can thereby be let toward the receiver 25 (refer to the arrow indicating refrigerant flow in FIG. 5).

[0104] Moreover, the urging force F_d of the spring 62 while the valve is fully closed is herein set so that the sum total of the counter-pressure valve-opening pressure difference ΔP and a maximum saturation pressure P_{sm} is equal to or less than the minimum proof pressure value P_{hm} of the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27, the maximum saturation pressure P_{sm} being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the second expansion valve 26 (the outdoor unit 2 herein) is installed. Specifically, the maximum saturation pressure P_{sm} is a value obtained by converting the maximum atmospheric temperature (e.g., approximately 50°C) that could be assumed in the location where the second expansion valve 26 (the outdoor unit 2 herein) is installed to a refrigerant saturation pressure. The minimum proof pressure value P_{hm} is the proof pressure of the component that has the lowest proof pressure among the liquid-side shut-off valve 27, the fourth liquid refrigerant pipe 35d, and the second expansion valve 26 as the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27. When the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27 also include a strainer, a pipe fitting, and/or the like, a minimum proof

pressure value P_{hm} including these components is used. The proof pressures herein are obtained by multiplying the design pressures of the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27 by a safety factor (e.g., approximately 1.5 times corresponding to a proof test pressure). For the spring 62, the spring constant and the spring length L_0 in the counter-pressure valve-opening inactive state (i.e., the contracted length from the free length) are set so that the urging force F_d in the counter-pressure valve-opening inactive state is equal to or less than a force F_{um} pushing the needle 61 in the needle retracting direction, generated when the needle 61 is assumed to be subjected to a pressure difference that is the minimum proof pressure value P_{hm} minus the maximum saturation pressure P_{sm} . This pressure difference corresponding to the urging force F_d in the counter-pressure valve-opening inactive state is designated as the counter-pressure valve-opening pressure difference ΔP . Because the proof pressures herein are obtained on the basis of the design pressures of the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27 as described above, the counter-pressure valve-opening pressure difference ΔP , i.e., the urging force F_d of the spring while the valve is fully closed can be appropriately set. Even assuming conditions of an atmospheric temperature so high that the refrigerant in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26 increases in pressure to the maximum saturation pressure P_{sm} , the force F_u generated by the counter-pressure valve-opening pressure difference ΔP to push the needle 61 in the needle retracting direction will overcome the urging force F_d of the spring 62 in the needle advancing direction before the pressure exceeds the minimum proof pressure value P_{hm} of the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27, and the second expansion valve 26 will be in the counter-pressure valve-opening active state. Therefore, the refrigerant in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26 can be let toward the receiver 25 before the pressure exceeds the proof pressures of the components constituting the portion of the refrigerant circuit 10 from the second expansion valve 26 to the liquid-side shut-off valve 27, and liquid sealing between the liquid-side shut-off valve 27 and the second expansion valve 26 can be prevented. There is a risk herein that the refrigerant let toward the receiver 25 will cause a pressure increase in the receiver 25, but because the first expansion valve 24 is provided in the first disposed state, the refrigerant will be let toward the outdoor heat exchanger 23 before the proof pressure P_{rm} of the receiver 25 is exceeded. Due to the refrigerant in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26 being let toward

the receiver 25, when there is a decrease in the refrigerant pressure in the portion of the refrigerant circuit 10 between the liquid-side shut-off valve 27 and the second expansion valve 26, less force F_u pushing the needle 61 in the needle retracting direction is generated by the counter-pressure valve-opening pressure difference ΔP , and the second expansion valve 26 returns to the counter-pressure valve-opening inactive state. Instances of the second expansion valve 26 going into the counter-pressure valve-opening active state can thereby be kept to the necessary minimum.

[0105] Thus, in the refrigerant circuit 10 configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), the liquid-side shut-off valve 27 (an opening/closing valve), and the indoor heat exchanger 41 in the air conditioning apparatus 1, liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, and liquid sealing between the liquid-side shut-off valve 27 and the second expansion valve 26 can be prevented as well.

(4) Modification 1

[0106] The air conditioning apparatus 1 of the above embodiment (see FIGS. 1 and 2) is configured with the fully-closing first expansion valve 24 and second expansion valve 26 (an opening/closing valve) provided on the upstream and downstream sides of the receiver 25, wherein the first expansion valve 24 is provided in a first disposed state and the second expansion valve 26 is provided in a second disposed state in order to prevent liquid sealing in the receiver 25 and liquid sealing between the liquid-side shut-off valve 27 (an opening/closing valve) and the second expansion valve 26.

[0107] However, if only the liquid sealing in the receiver 25 is a concern, at least one of the first expansion valve 24 and the second expansion valve 26 is preferably provided to the refrigerant circuit 10 in the first disposed state.

[0108] For example, the first expansion valve 24 can be provided in the second disposed state and the second expansion valve 26 can be provided in the first disposed state, as shown in FIG. 6. When the second expansion valve 26 is provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 can be let towards the indoor heat exchanger 41 to prevent liquid sealing in the receiver 25.

[0109] The first expansion valve 24 and the second expansion valve 26 can also both be provided in the first disposed state as shown in FIG. 7. When the first and second expansion valves 24, 26 are provided in the first disposed state and there is an increase in refrigerant

pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 can be let towards the outdoor heat exchanger 23 and the indoor heat exchanger 41 to prevent liquid sealing in the receiver 25.

[0110] Thus, in the refrigerant circuit 10 of the present modification, configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), and the indoor heat exchanger 41, liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve 24 and the second expansion valve 26.

(5) Modification 2

[0111] In the air conditioning apparatus 1 (see FIG. 1) of the above embodiment and Modification 1, a gas purge valve 30a for purging refrigerant from the upper space of the receiver 25 could be provided as shown in FIG. 8.

[0112] For example, the refrigerant circuit 10 is provided with a gas purge pipe 30 for guiding intermediate-pressure gas refrigerant in the refrigeration cycle accumulated in the receiver 25 to the intake pipe 31 of the compressor 21. The gas purge pipe 30 is provided so as to connect the upper part of the receiver 25 and a midway portion of the intake pipe 31. A gas purge valve 30a is provided to the gas purge pipe 30 along with a capillary tube 30b and a non-return valve 30c. The gas purge valve 30a is a valve that can be controlled to open and close to turn the flow of refrigerant on and off in the gas purge pipe 30, and an electromagnetic valve is used herein. The capillary tube 30b is a mechanism for depressurizing gas refrigerant accumulated in the receiver 25 to a low pressure in the refrigeration cycle, and a capillary tube thinner in diameter than the gas purge pipe 30 is used herein. The non-return valve 30c is a valve mechanism for allowing only the flow of refrigerant from the receiver 25 side to the intake pipe 31 side, and a non-return valve is used herein.

[0113] In this configuration as well, there is a risk of liquid sealing in the receiver 25 when the first expansion valve 24, the second expansion valve 26 (an opening/closing valve), and the gas purge valve 30a all become fully closed.

[0114] In view of this, in a configuration having such a gas purge valve 30a, at least one of the first expansion valve 24 and the second expansion valve 26 is provided to the refrigerant circuit 10 in the first disposed state, similar to the above embodiment and Modification 1 (see FIGS. 2, 6, and 7).

[0115] Thus, in the refrigerant circuit 10 of the present modification, configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion

valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), the indoor heat exchanger 41, and the gas purge valve 30a, liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve 24 and the second expansion valve 26. Liquid sealing in the receiver 25 can also be prevented herein without providing a liquid sealing prevention pipe and liquid sealing between the liquid-side shut-off valve 27 (an opening/closing valve) and the second expansion valve 26 (an opening/closing valve) can be prevented (see FIG. 2) by providing the first expansion valve 24 in the first disposed state and providing the second expansion valve 26 in the second disposed state.

(6) Modification 3

[0116] In the air conditioning apparatus 1 of Modification 2 above (see FIG. 8), it is conceivable to use a fully-closing expansion valve as the gas purge valve 30a, similar to the first expansion valve 24 and/or the second expansion valve 26 (an opening/closing valve), as shown in FIG. 9. A fully-closing expansion valve having the same structure as the first expansion valve 24 and/or the second expansion valve 26 (see FIGS. 3 to 5) would be used herein for the gas purge valve 30a.

[0117] In such a configuration, if only the liquid sealing in the receiver 25 is a concern, at least one of the first expansion valve 24, the second expansion valve 26, and the gas purge valve 30a is preferably provided to the refrigerant circuit 10 in the first disposed state.

[0118] For example, first, the first expansion valve 24 can be provided in the first disposed state, and the second expansion valve 26 and the gas purge valve 30a can be provided in the second disposed state, as shown in FIG. 10. The maximum saturation pressure used to set the urging force of the spring 62 herein is the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location (the outdoor unit 2 herein) where the receiver 25, the first expansion valve 24, the second expansion valve 26, and the gas purge valve 30a are installed. When the first expansion valve 24 is provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the outdoor heat exchanger 23 to prevent liquid sealing in the receiver 25. In this case, liquid sealing in the receiver 25 can be prevented and liquid sealing between the liquid-side shut-off valve 27 (an opening/closing valve) and the second expansion valve 26 can be prevented because the second expansion valve 26 is provided in the second disposed state.

[0119] The first expansion valve 24 can be provided in

the first disposed state, and the second expansion valve 26 and the gas purge valve 30a can be provided in the second disposed state as shown in FIG. 11. When the first expansion valve 24 is provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the indoor heat exchanger 41 to prevent liquid sealing in the receiver 25.

[0120] The gas purge valve 30a can also be provided in the first disposed state, and the first expansion valve 24 and the second expansion valve 26 can be provided in the second disposed state, as shown in FIG. 12. When the gas purge valve 30a is provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the compressor 21 to prevent liquid sealing in the receiver 25. In this case, liquid sealing in the receiver 25 can be prevented and liquid sealing between the liquid-side shut-off valve 27 and the second expansion valve 26 can be prevented because the second expansion valve 26 is provided in the second disposed state.

[0121] The first expansion valve 24 and the gas purge valve 30a can also be provided in the first disposed state, and the second expansion valve 26 can be provided in the second disposed state, as shown in FIG. 13. When the first expansion valve 24 and the gas purge valve 30a are provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the outdoor heat exchanger 23 and the compressor 21 to prevent liquid sealing in the receiver 25. In this case, liquid sealing in the receiver 25 can be prevented and liquid sealing between the liquid-side shut-off valve 27 and the second expansion valve 26 can be prevented because the second expansion valve 26 is provided in the second disposed state.

[0122] The second expansion valve 26 and the gas purge valve 30a can also be provided in the first disposed state, and the first expansion valve 24 can be provided in the second disposed state, as shown in FIG. 14. When the second expansion valve 26 and the gas purge valve 30a are provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver

25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the indoor heat exchanger 41 and the compressor 21 to prevent liquid sealing in the receiver 25.

[0123] The first expansion valve 24 and the second expansion valve 26 can also be provided in the first disposed state, and the gas purge valve 30a can be provided in the second disposed state, as shown in FIG. 15. When the first expansion valve 24 and the second expansion valve 26 are provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 and the gas purge valve 30a including the receiver 25 can be let towards the outdoor heat exchanger 23 and the indoor heat exchanger 41 to prevent liquid sealing in the receiver 25.

[0124] The first expansion valve 24, the second expansion valve 26, and the gas purge valve 30a can all be provided in the first disposed state, as shown in FIG. 16. When the two expansion valves 24, 26 and the gas purge valve 30a are provided in the first disposed state and there is an increase in refrigerant pressure in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25, the refrigerant in the portion of the refrigerant circuit 10 between the two expansion valves 24, 26 including the receiver 25 can be let towards the outdoor heat exchanger 23, the indoor heat exchanger 41, and the compressor 21 to prevent liquid sealing in the receiver 25.

[0125] Thus, in the refrigerant circuit 10 of the present modification, configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the second expansion valve 26 (an opening/closing valve), the indoor heat exchanger 41, and the gas purge valve 30a, liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, despite fully-closing expansion valves being used as the first expansion valve 24, the second expansion valve 26, and the gas purge valve 30a. Liquid sealing in the receiver 25 can also be prevented herein without providing a liquid sealing prevention pipe and liquid sealing between the liquid-side shut-off valve 27 (an opening/closing valve) and the second expansion valve 26 can be prevented by providing the first expansion valve 24 and/or the gas purge valve 30a in the first disposed state and providing the second expansion valve 26 in the second disposed state.

(7) Modification 4

[0126] In the air conditioning apparatus 1 of the above embodiment and Modifications 1 to 3 (see FIGS. 1 to 16), a structure for preventing liquid sealing in the receiver 25 (the first expansion valve 24, the second expansion valve 26, and/or the gas purge valve 30a being installed in the

first disposed state) is employed on the premise that the first expansion valve 24 and the second expansion valve 26 (an opening/closing valve) composed of fully-closing expansion valves are provided on the upstream and downstream sides of the receiver 25 (including the configuration having the gas purge valve 30a), and the liquid-side shut-off valve 27 (an opening/closing valve) is provided between the second expansion valve 26 and the indoor heat exchanger 41.

[0127] However, if only the liquid sealing in the receiver 25 is a concern, when the second expansion valve 26 is open but both the first expansion valve 24 (including the configuration having the gas purge valve 30a) and the liquid-side shut-off valve 27 come to be fully closed due to a mishap such as erroneous operation of the liquid-side shut-off valve 27 (an opening/closing valve), it is assumed there could be cases of liquid sealing in the receiver 25. Specifically, in one conceivable case, the first expansion valve 24 composed of a fully-closing expansion valve is provided in the second disposed state (when there is also a gas purge valve 30a composed of a fully-closing expansion valve, the gas purge valve 30a is also provided in the second disposed state), and the second expansion valve 26 composed of a fully-closing expansion valve is provided in the first disposed state (see FIGS. 6 and 11).

[0128] Thus, assuming cases in which there is liquid sealing in the receiver 25 due to a mishap such as erroneous operation of the liquid-side shut-off valve 27, it is preferable that the first expansion valve 24 composed of a fully-closing expansion valve be provided in the first disposed state (when there is also a gas purge valve 30a composed of a fully-closing expansion valve, the first expansion valve 24 and/or the gas purge valve 30a are provided in the first disposed state) (see FIGS. 2, 7, 10, and 12 to 16).

(8) Modification 5

[0129] Taking into account cases of liquid sealing in the receiver 25 due to a mishap such as erroneous operation of the liquid-side shut-off valve 27 (an opening/closing valve) as in the above Modification 4, a first expansion valve 24 composed of a fully-closing expansion valve must be disposed (as does the gas purge valve 30a when there is a gas purge valve 30a composed of a fully-closing expansion valve) assuming that liquid sealing in the receiver 25 will occur even on the premise that there is no second expansion valve 26 (an opening/closing valve), as shown in FIGS. 17 and 18.

[0130] In view of this, the first expansion valve 24 composed of a fully-closing expansion valve and/or the gas purge valve 30a composed of a fully-closing expansion valve are herein provided in the first disposed state. Specifically, the first expansion valve 24 is provided in the first disposed state as shown in FIG. 19 when there is no gas purge valve 30a composed of a fully-closing expansion valve (see FIG. 17), and the first expansion valve

24 and/or the gas purge valve 30a are provided in the first disposed state as shown in FIGS. 20 to 22 when there is a gas purge valve 30a composed of a fully-closing expansion valve (see FIG. 18).

5 [0131] Thus, in the refrigerant circuit 10 of the air conditioning apparatus 1, configured by connecting the compressor 21, the outdoor heat exchanger 23, the first expansion valve 24, the receiver 25, the liquid-side shut-off valve 27, and the indoor heat exchanger 41 (also including the gas purge valve 30a when there is a gas purge valve 30a), liquid sealing in the receiver 25 can be prevented without providing a liquid sealing prevention pipe, despite a fully-closing expansion valve being used as the first expansion valve 24 (and a fully-closing expansion valve being used as the gas purge valve 30a when there is a gas purge valve 30a).

INDUSTRIAL APPLICABILITY

20 [0132] The present invention is widely applicable in air conditioning apparatuses having a refrigerant circuit configured by connecting a compressor, an outdoor heat exchanger, a first expansion valve, a receiver, an opening/closing valve, and an indoor heat exchanger.

REFERENCE SIGNS LIST

[0133]

30	1	Air conditioning apparatus
	10	Refrigerant circuit
	21	Compressor
	23	Outdoor heat exchanger
	41	Indoor heat exchanger
35	24	First expansion valve
	26	Second expansion valve (opening/closing valve)
	27	Liquid-side shut-off valve (opening/closing valve)
	30a	Gas purge valve
	52a	Upper valve chamber (space on needle retracting direction side of valve seat)
40	52b	Lower valve chamber (space on needle advancing direction side of valve seat)
	55	Valve seat
	61	Needle
45	62	Spring

CITATION LIST

PATENT LITERATURE

50 [Patent Literature 1]

55 [0134] Japanese Laid-open Patent Unexamined publication No. H10-132393

Claims

1. An air conditioning apparatus (1) having a refrigerant circuit (10) configured by connecting a compressor (21), an outdoor heat exchanger (23), a first expansion valve (24), a receiver (25), an opening/closing valve (26, 27), and an indoor heat exchanger (41) ; wherein
a fully-closing expansion valve that is fully closed by a needle (61) sitting on a valve seat (55) is used as the first expansion valve, and the first expansion valve is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat; and
the first expansion valve provided to the refrigerant circuit in the first disposed state has a spring (62) for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, and is configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space (52a) on the needle retracting direction side of the valve seat and refrigerant pressure in a space (52b) on the needle advancing direction side of the valve seat.
2. The air conditioning apparatus (1) according to claim 1, wherein
the opening/closing valve is a liquid-side shut-off valve (27).
3. The air conditioning apparatus (1) according to claim 1, wherein
the opening/closing valve is a second expansion valve (26);
the second expansion valve is a fully-closing expansion valve that is fully closed by a needle (61) sitting on a valve seat (55);
at least one of the first expansion valve (24) and the second expansion valve in this case is provided to the refrigerant circuit (10) in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat; and
the first expansion valve and/or the second expansion valve provided to the refrigerant circuit in the first disposed state has a spring (62) for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve and/or the second expansion valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space (52a) on the needle retracting direction side of the valve seat and refrigerant pressure in a space (52b) on the needle advancing direction side of the valve seat.
4. The air conditioning apparatus (1) according to any of claims 1 through 3, wherein
the urging force of the spring when the valve is fully closed is set so that the sum total of the counter-pressure valve-opening pressure difference and a maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the receiver (25), the first expansion valve (24), and the opening/closing valve (26, 27) are installed.
5. The air conditioning apparatus (1) according to claim 1, wherein
the refrigerant circuit (10) further has a gas purge valve (30a) for purging refrigerant from the upper space of the receiver (25);
a fully-closing expansion valve that is fully closed by a needle (61) sitting on a valve seat (55) is used as the gas purge valve;
at least one of the first expansion valve (24) and the gas purge valve in this case is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat; and
the first expansion valve and/or the gas purge valve provided to the refrigerant circuit in the first disposed

state has a spring (62) for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve and/or the gas purge valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space (52a) on the needle retracting direction side of the valve seat and refrigerant pressure in a space (52b) on the needle advancing direction side of the valve seat.

6. The air conditioning apparatus (1) according to claim 5, wherein the opening/closing valve is a liquid-side shut-off valve (27).

7. The air conditioning apparatus (1) according to claim 1, wherein the opening/closing valve is a second expansion valve (26);

the refrigerant circuit (10) further has a gas purge valve (30a) for purging refrigerant from the upper space of the receiver (25);

fully-closing expansion valves that are each fully closed by a needle (61) sitting on a valve seat (55) are used for the second expansion valve and the gas purge valve;

at least one of the first expansion valve (24), the second expansion valve, and the gas purge valve in this case is provided to the refrigerant circuit in a first disposed state in which refrigerant from the receiver flows in from a needle advancing direction side of the valve seat, and out to a needle retracting direction side of the valve seat through a gap between the needle and the valve seat, the needle advancing direction being the direction in which the needle moves when the needle sits on the valve seat, and the needle retracting direction being the direction in which the needle moves when the needle retracts from the valve seat; and

the first expansion valve, the second expansion valve, and/or the gas purge valve provided to the refrigerant circuit in the first disposed state has a spring (62) for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the first expansion valve, the second expansion valve, and/or the gas purge valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space (52a) on the

needle retracting direction side of the valve seat and refrigerant pressure in a space (52b) on the needle advancing direction side of the valve seat.

8. The air conditioning apparatus (1) according to any of claims 5 through 7, wherein the urging force of the spring when the valve is fully closed is set so that the sum total of the counter-pressure valve-opening pressure difference and a maximum saturation pressure is equal to or less than the proof pressure of the receiver, the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the receiver (25), the first expansion valve (24), the opening/closing valve (26, 27), and the gas purge valve (30a) are installed.

9. The air conditioning apparatus (1) according to claim 4 or 8, wherein

the proof pressure of the receiver (25) is a pressure value obtained by multiplying the design pressure of the receiver by a safety factor.

10. The air conditioning apparatus (1) according to claim 1 or 5, wherein

the opening/closing valves are a second expansion valve (26) and a liquid-side shut-off valve (27) connected between the second expansion valve and the indoor heat exchanger (41);

a fully-closing expansion valve that is fully closed by a needle (61) sitting on a valve seat (55) is used as the second expansion valve, the second expansion valve being provided to the refrigerant circuit (10) in a second disposed state in which refrigerant from the receiver (25) flows in from the needle retracting direction side of the valve seat, and out to the needle advancing direction side of the valve seat through a gap between the needle and the valve seat; and the second expansion valve provided to the refrigerant circuit in the second disposed state has a spring (62) for urging the needle seated on the valve seat in the needle advancing direction when the valve is fully closed, the second expansion valve being configured so that the needle is released from sitting on the valve seat when the urging force of the spring in the needle advancing direction is overcome by a force pushing the needle in the needle retracting direction as generated by a counter-pressure valve-opening pressure difference, which is the difference between refrigerant pressure in a space (52a) on the needle retracting direction side of the valve seat and refrigerant pressure in a space (52b) on the needle advancing direction side of the valve seat.

11. The air conditioning apparatus (1) according to claim 10, wherein the urging force of the spring of the second expan-

sion valve (26) when the valve is fully closed is set so that the sum total of a maximum saturation pressure and the counter-pressure valve-opening pressure difference of the second expansion valve is equal to or less than the minimum value of the proof pressures of the components constituting the portion of the refrigerant circuit (10) from the second expansion valve to the liquid-side shut-off valve (27), the maximum saturation pressure being the refrigerant saturation pressure corresponding to the maximum value of atmospheric temperature in the location where the second expansion valve and the liquid-side shut-off valve are installed.

12. The air conditioning apparatus (1) according to claim 11, wherein the proof pressures of the components constituting the portion of the refrigerant circuit (10) from the second expansion valve (26) to the liquid-side shut-off valve (27) are pressure values obtained by multiplying the design pressures of the components constituting the portion of the refrigerant circuit from the second expansion valve to the liquid-side shut-off valve by a safety factor.

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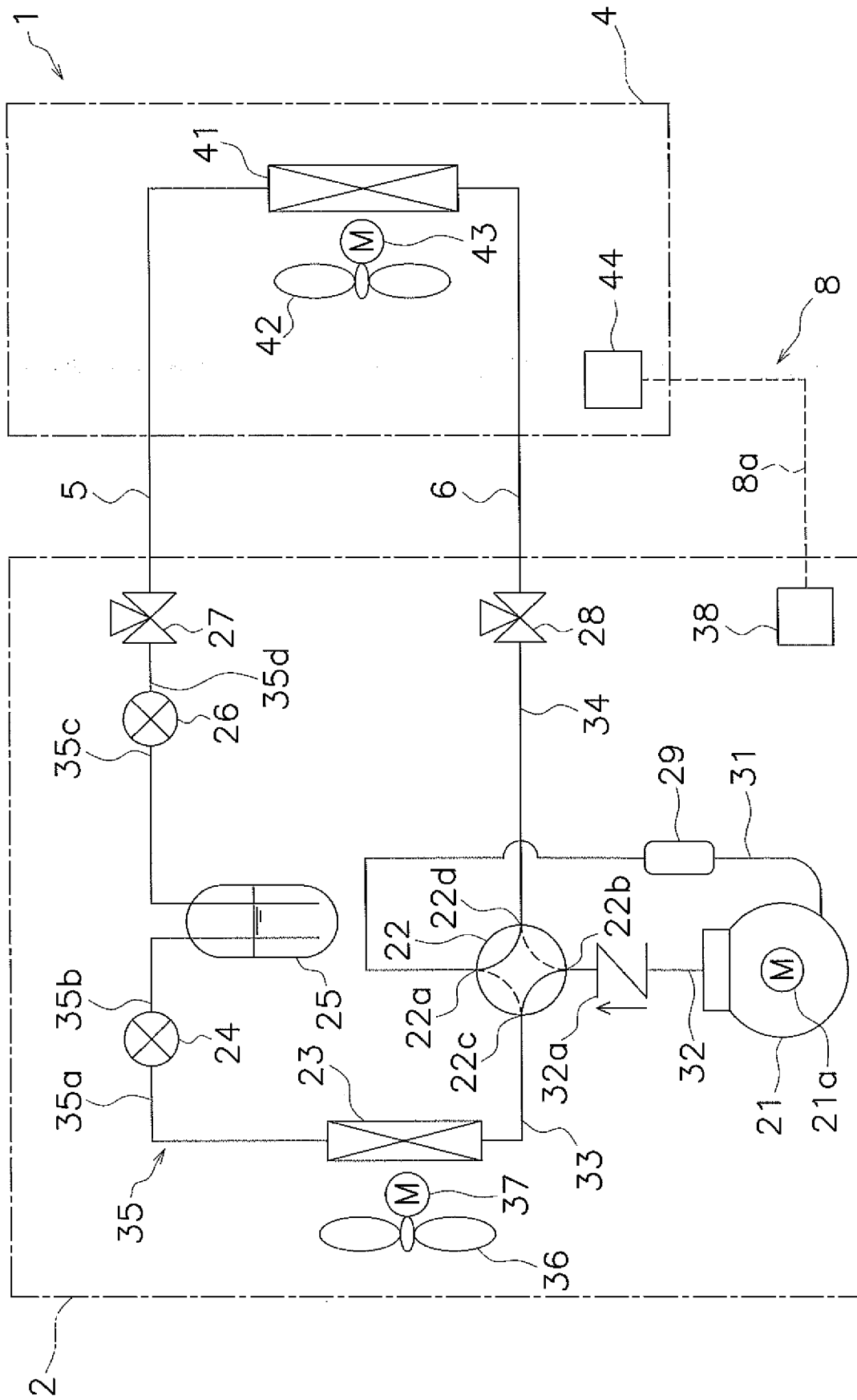


FIG. 1

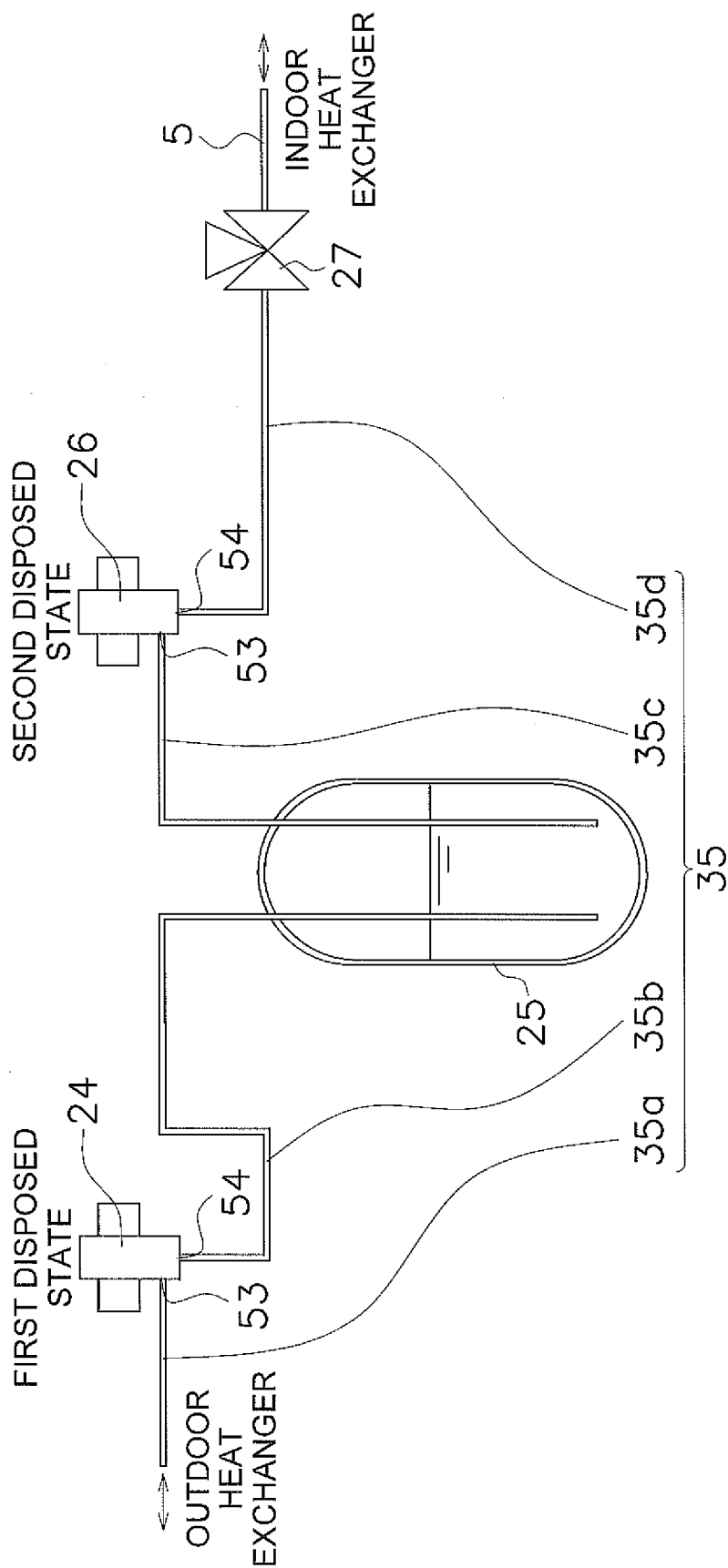


FIG. 2

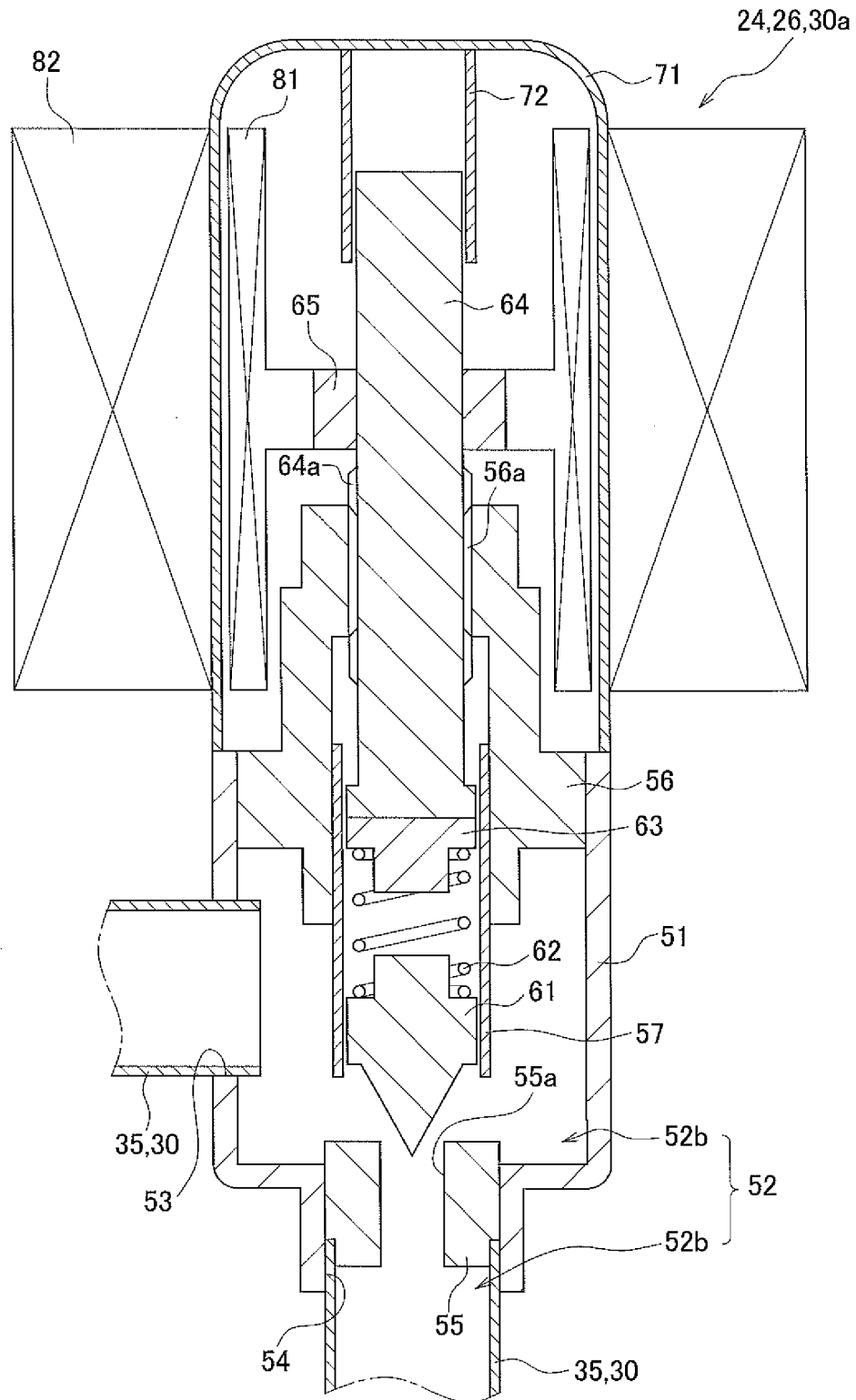


FIG. 3

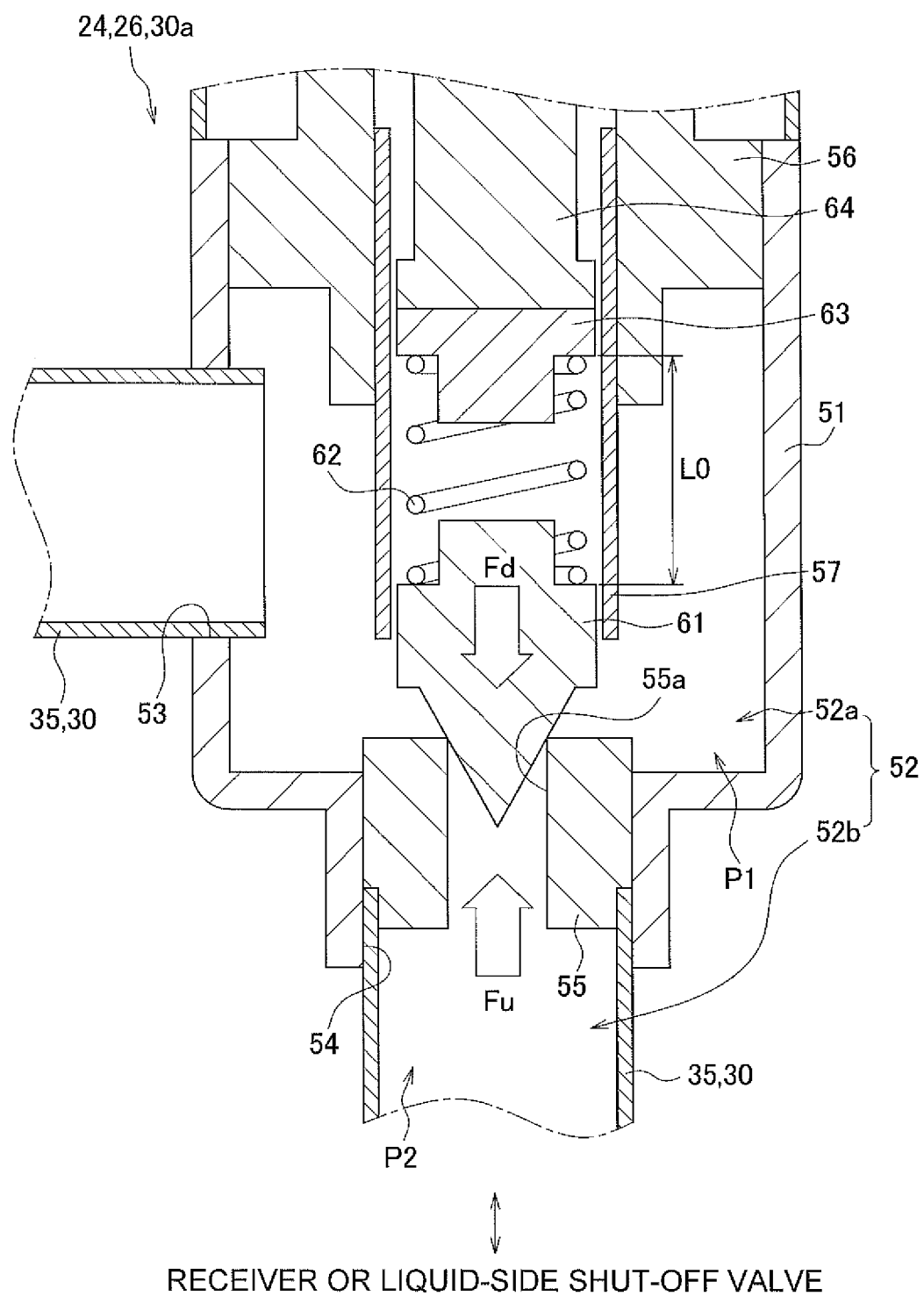


FIG. 4

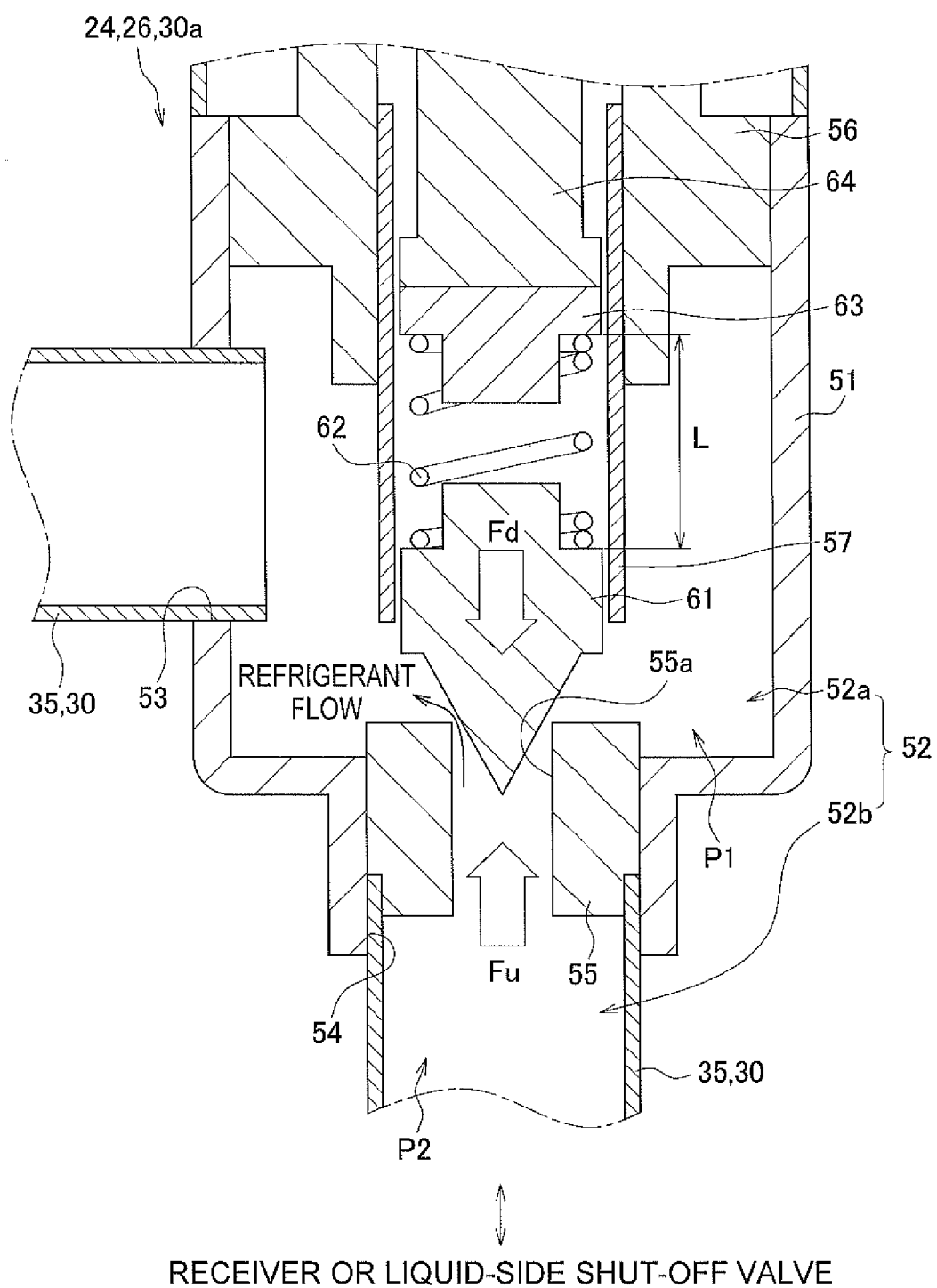


FIG. 5

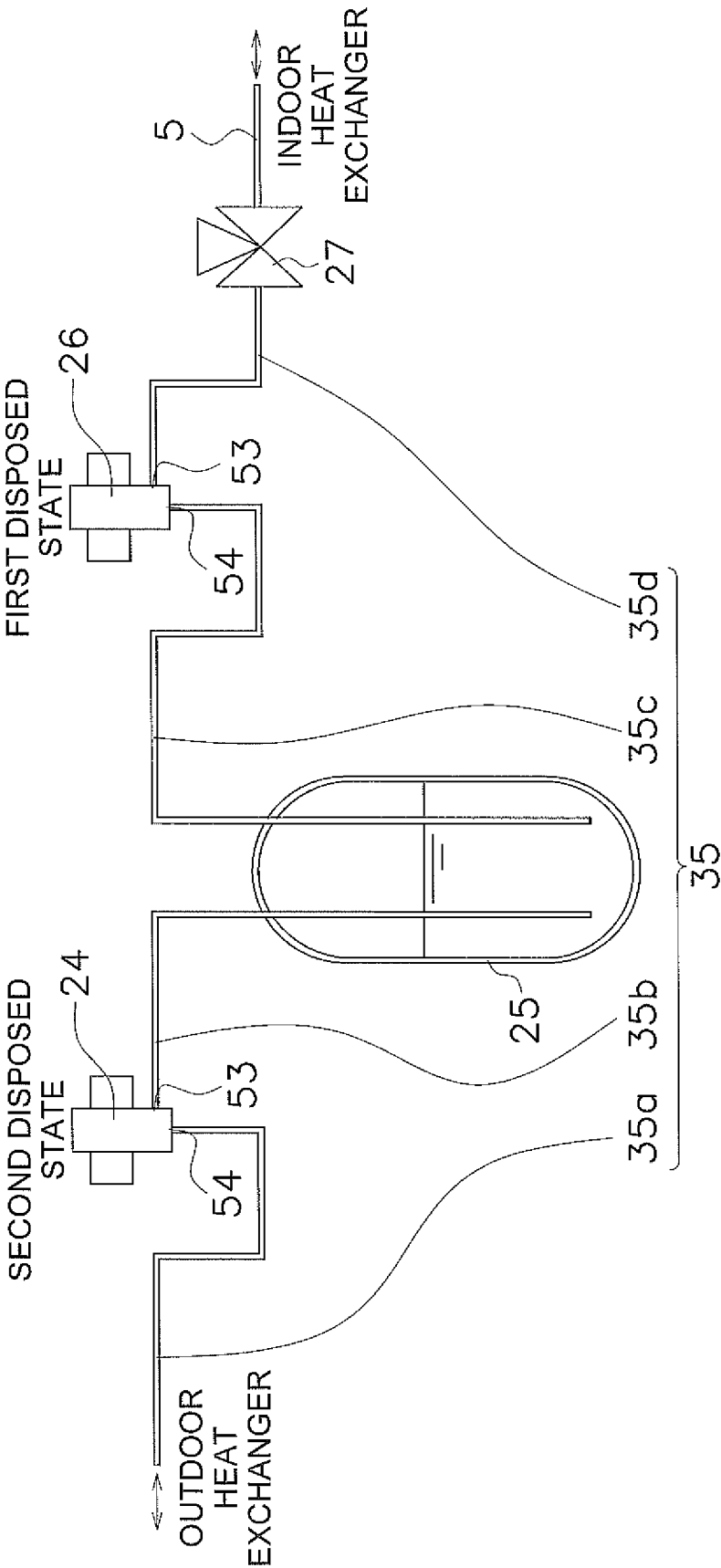


FIG. 6

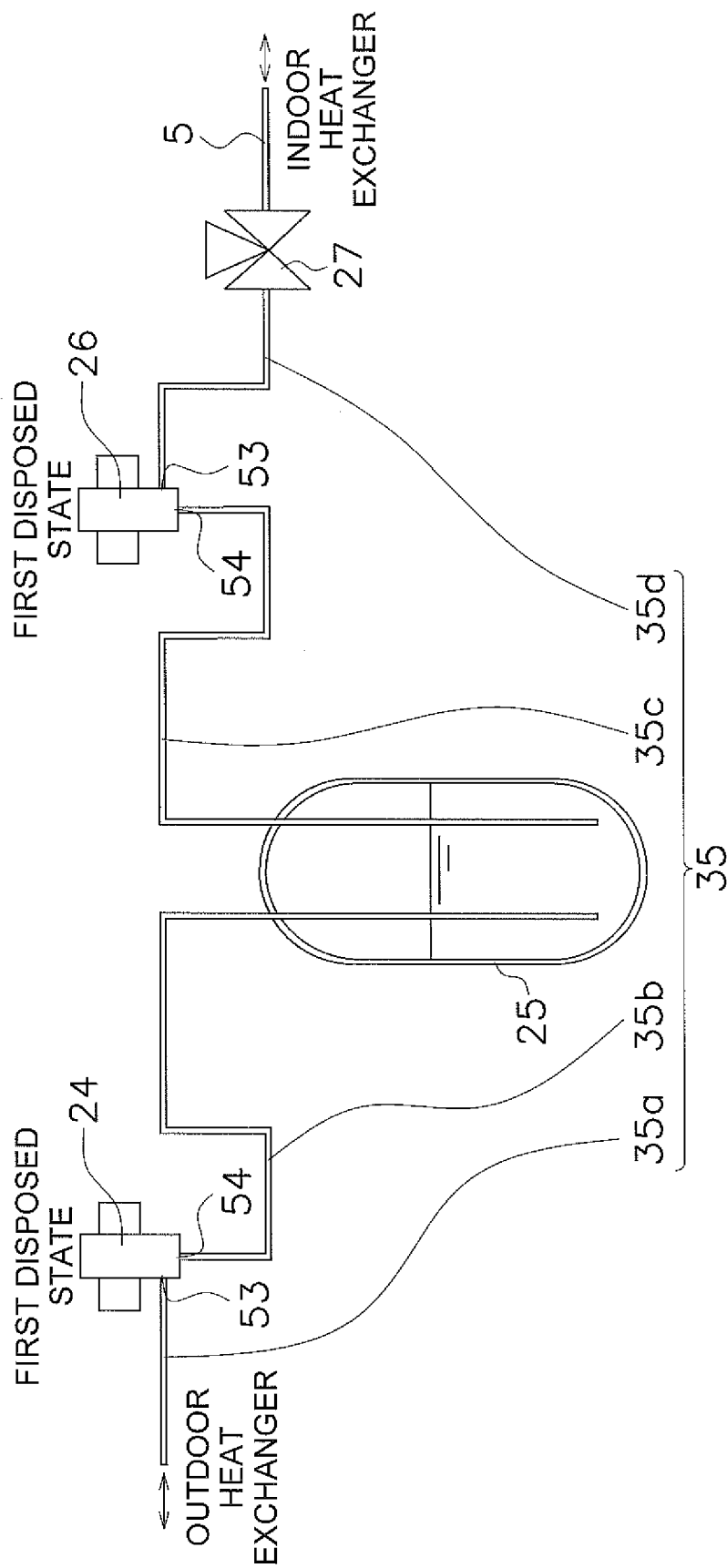


FIG. 7

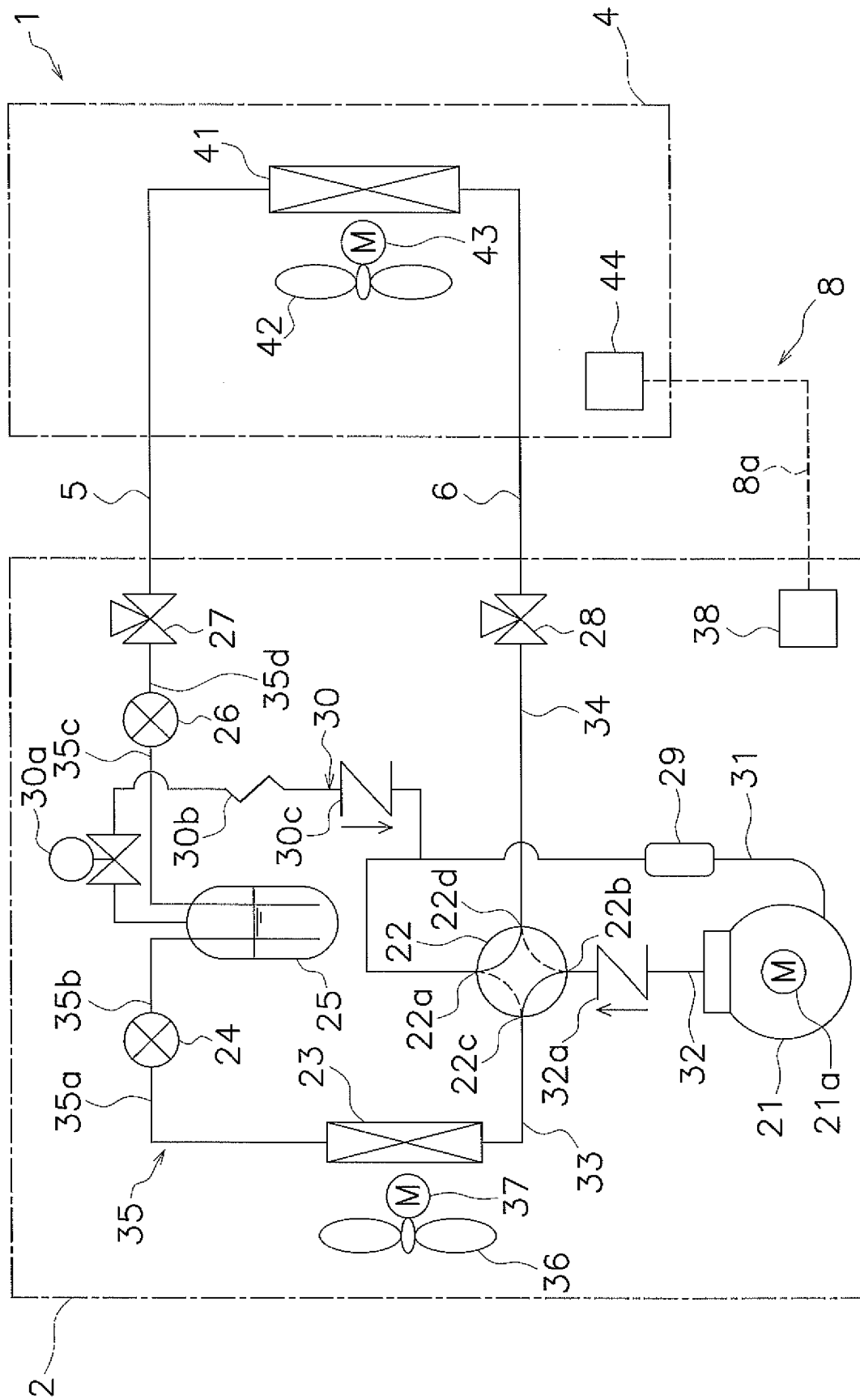


FIG. 8

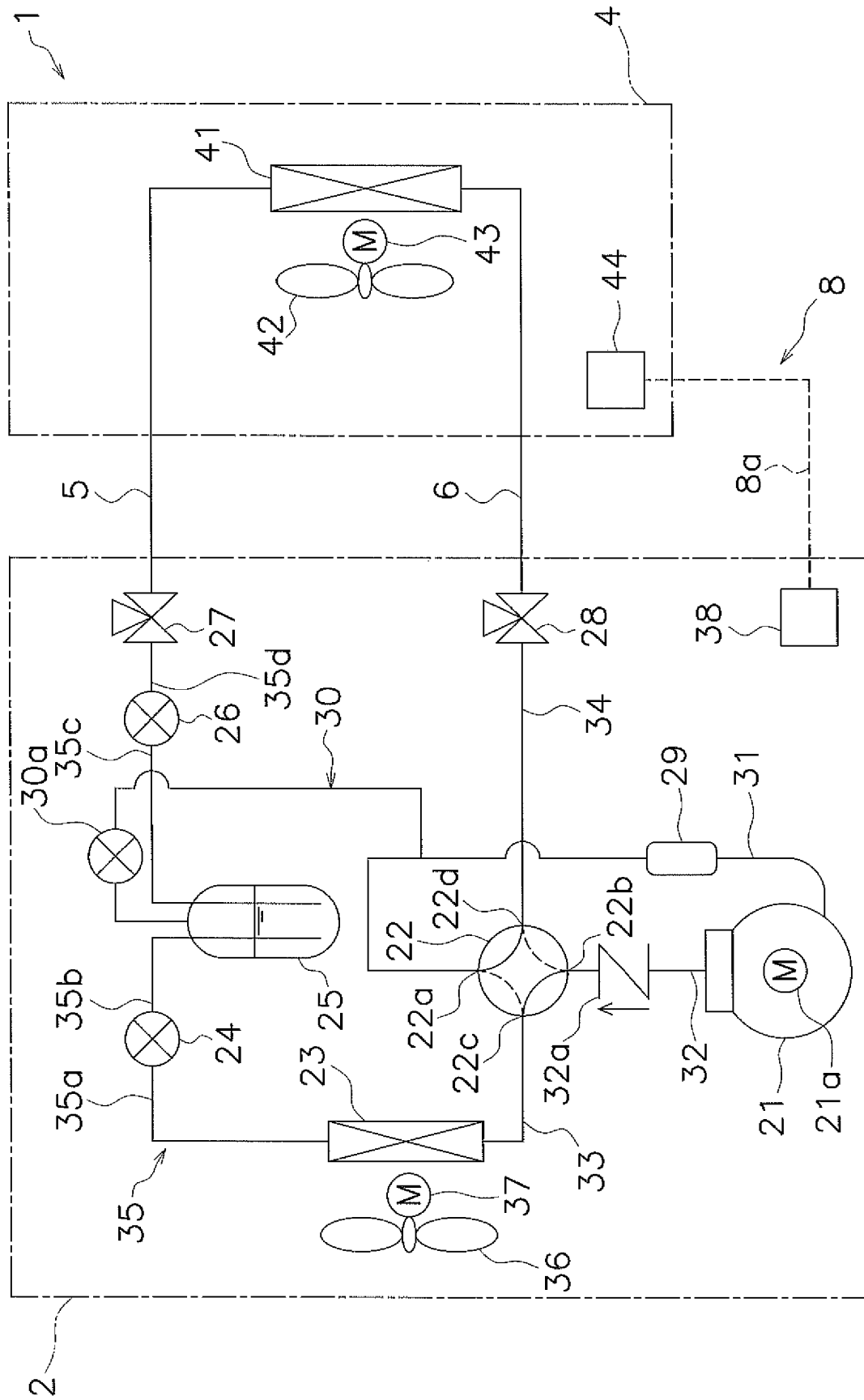


FIG. 9

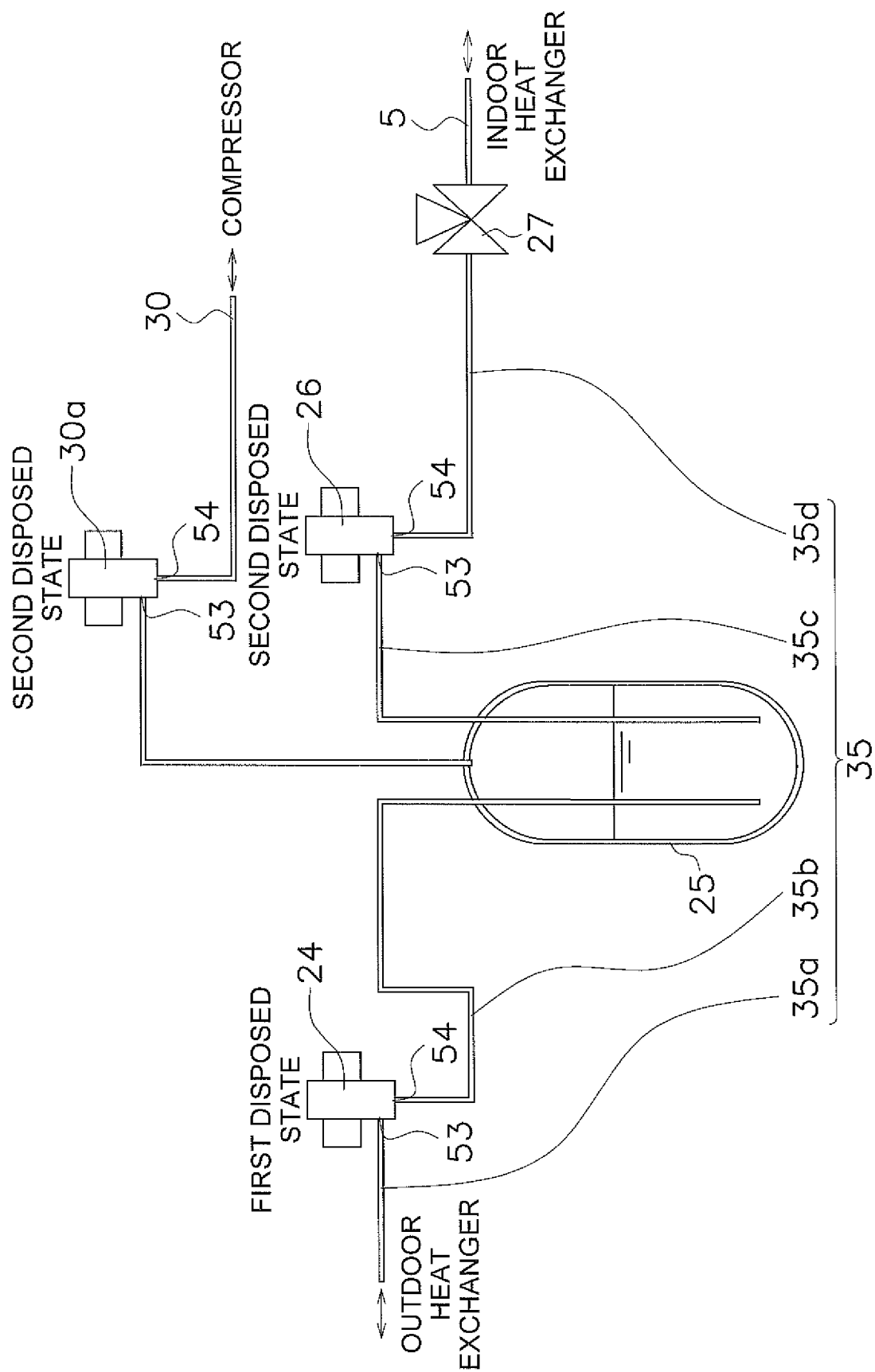


FIG. 10

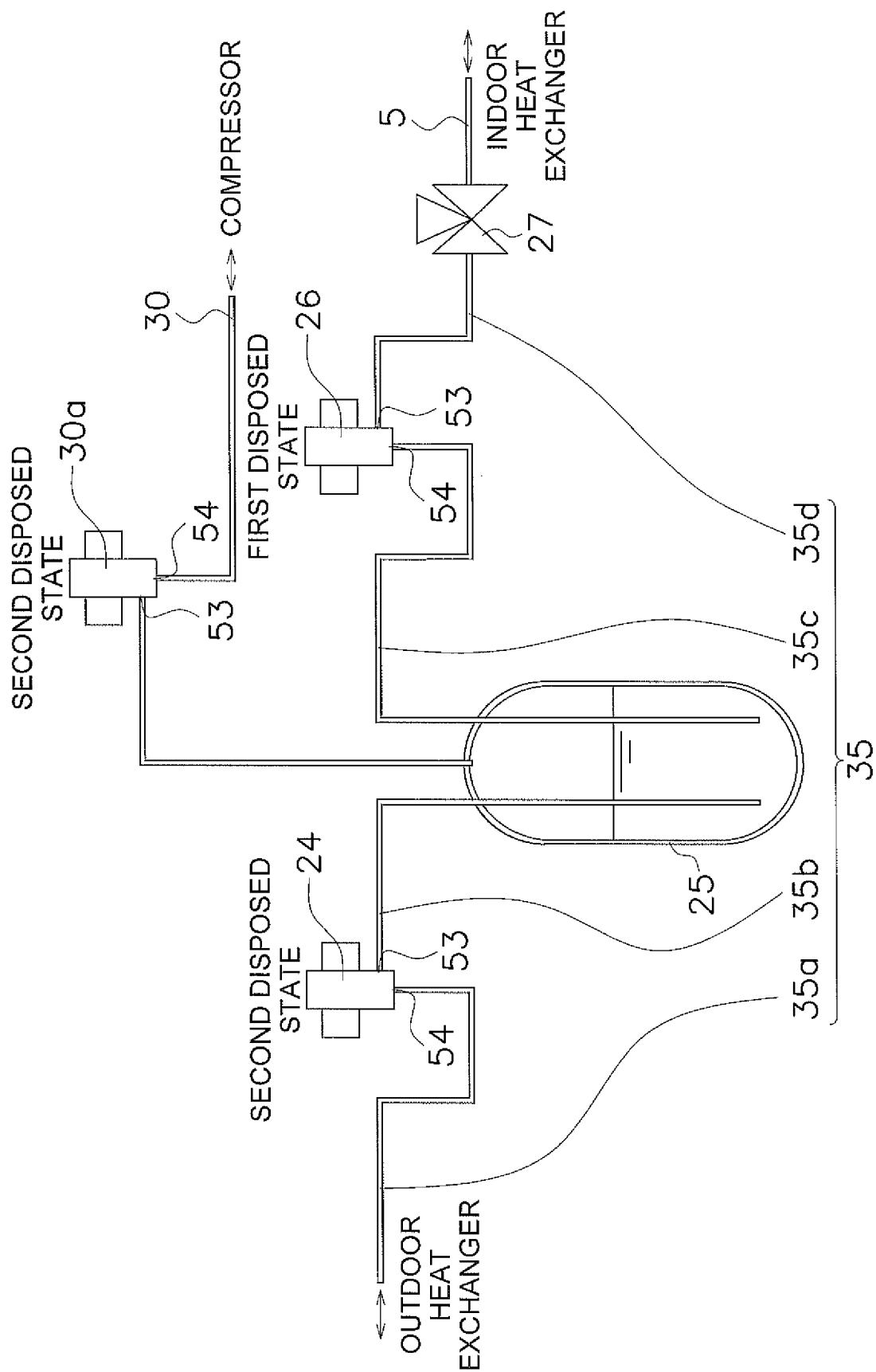


FIG. 11

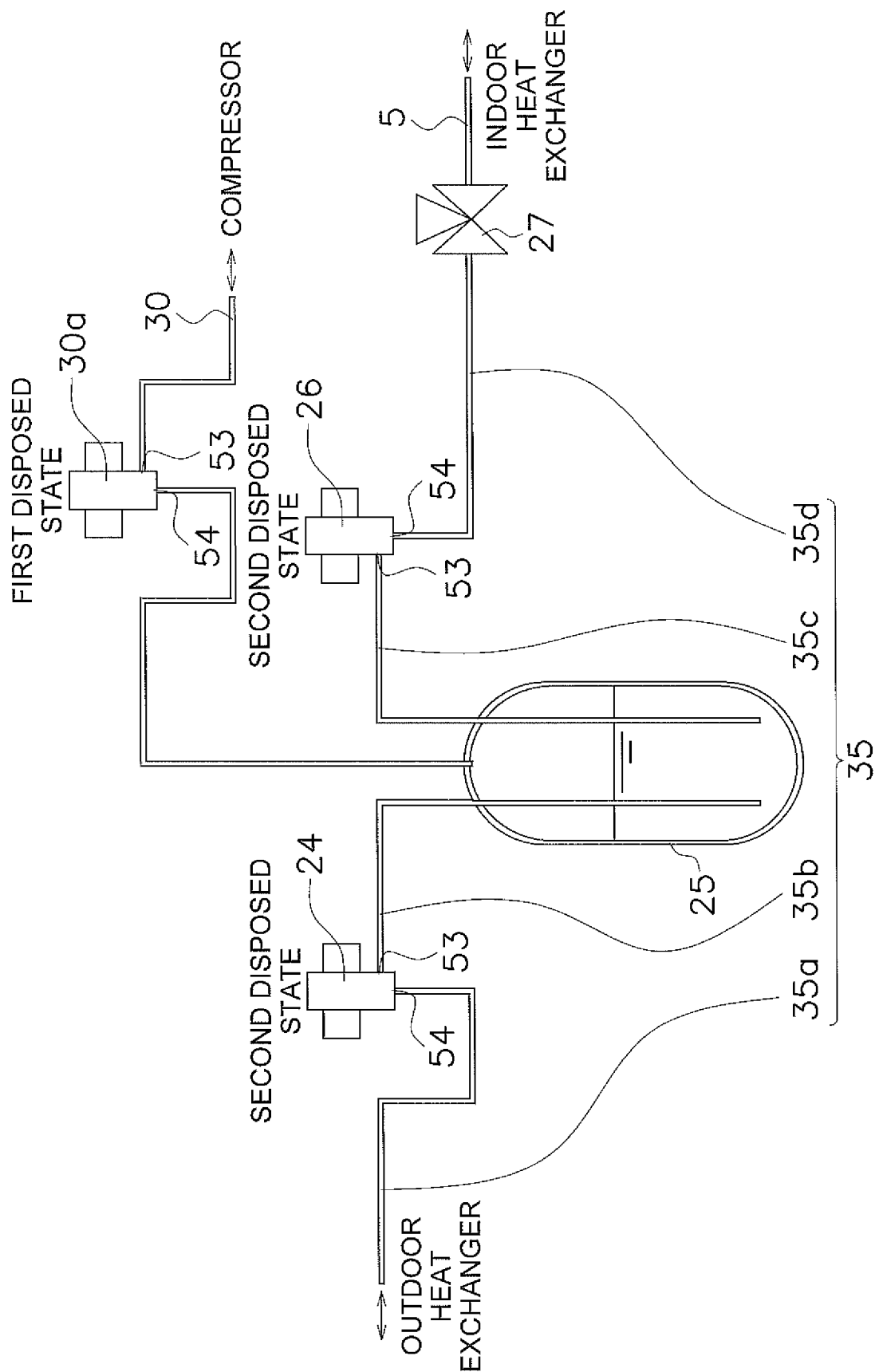


FIG. 12

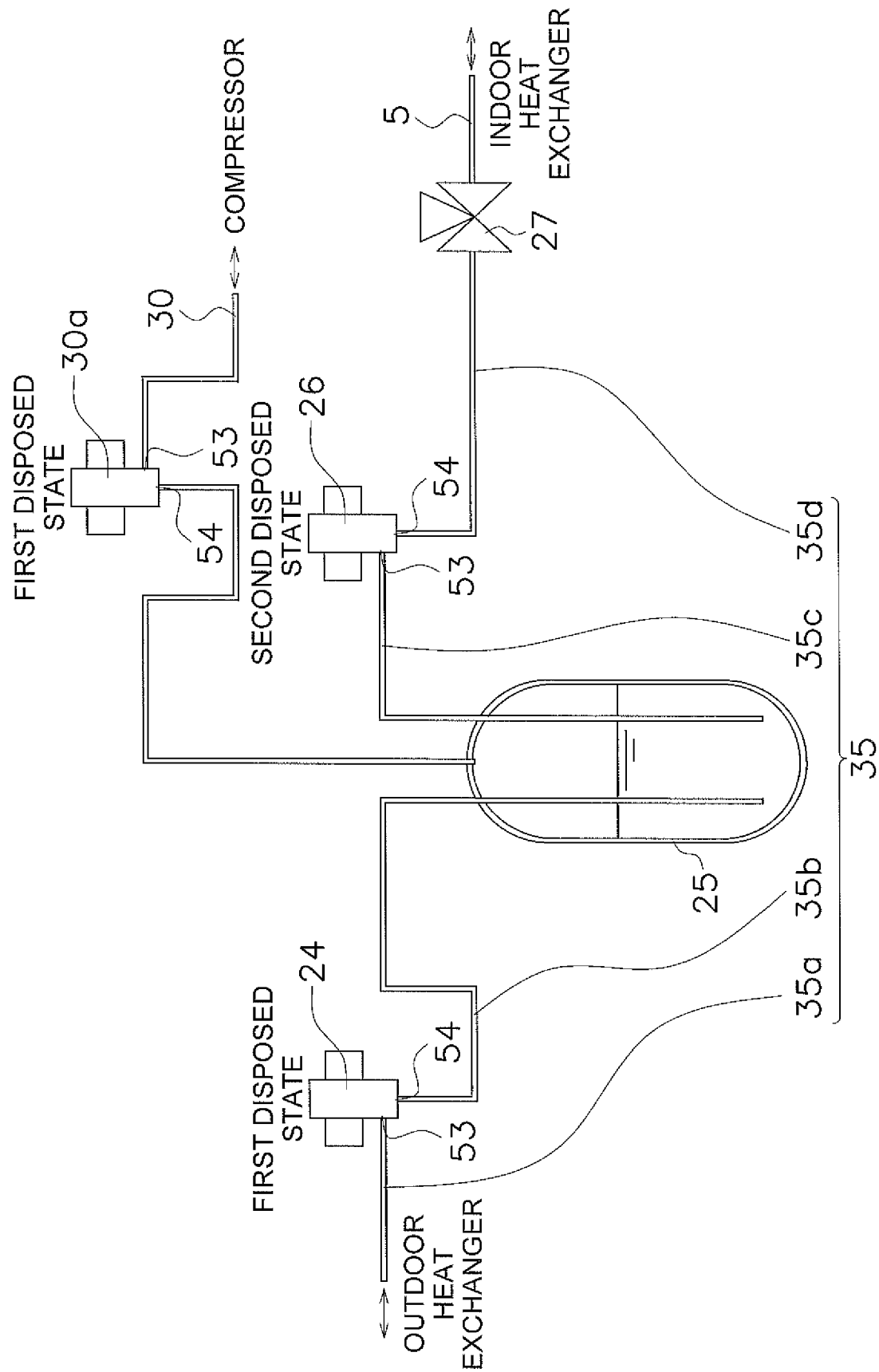


FIG. 13

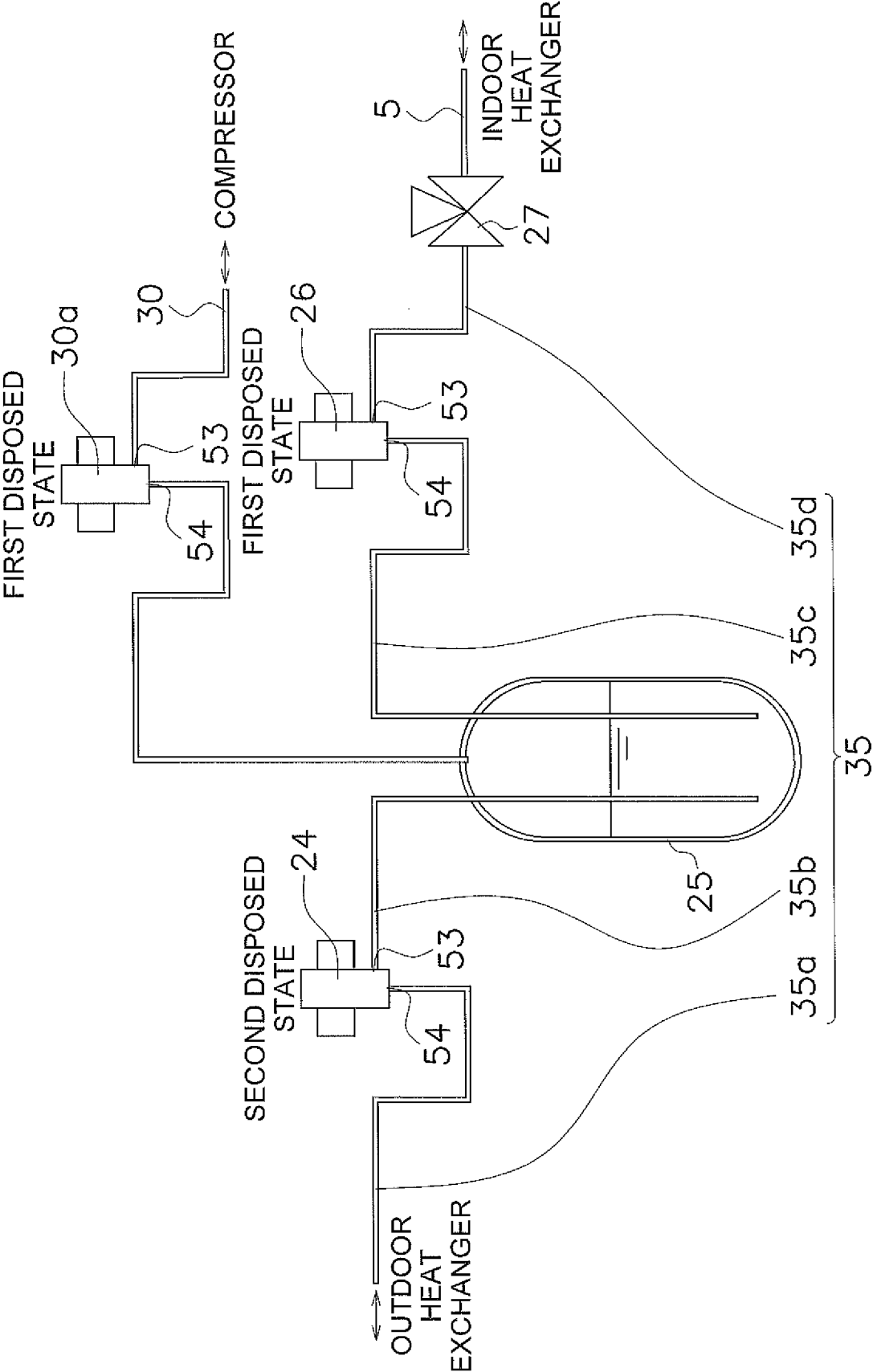


FIG. 14

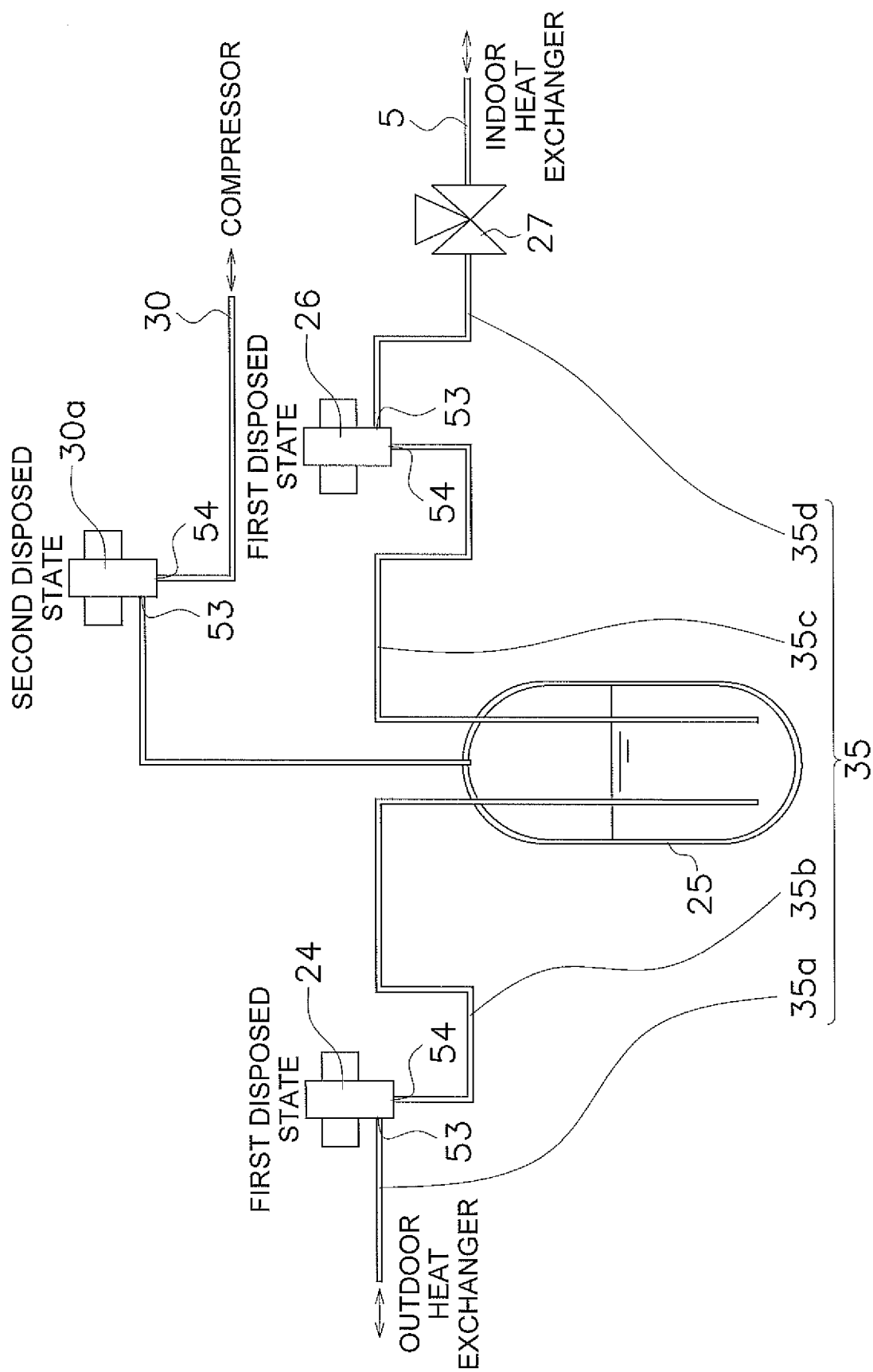


FIG. 15

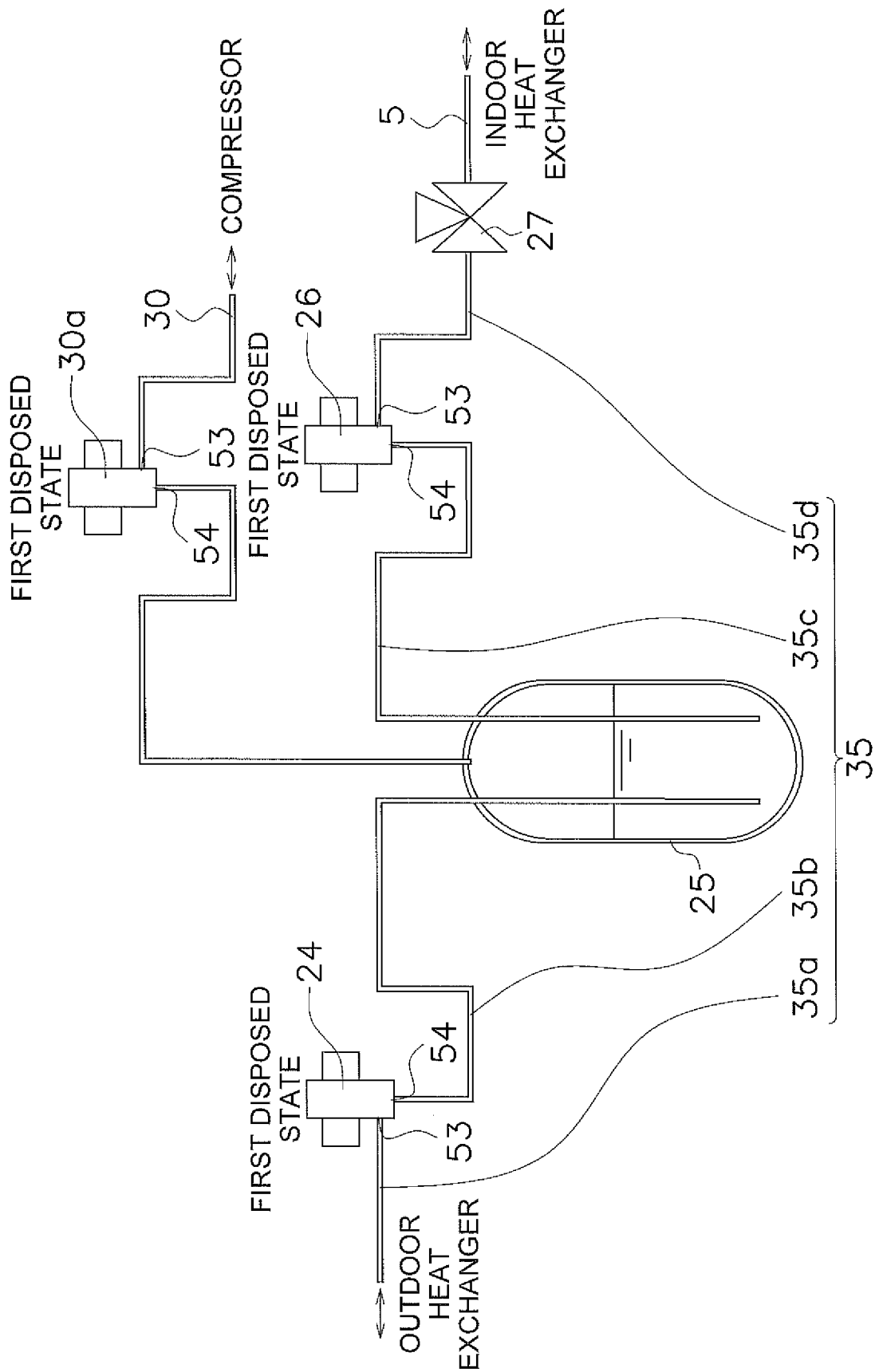


FIG. 16

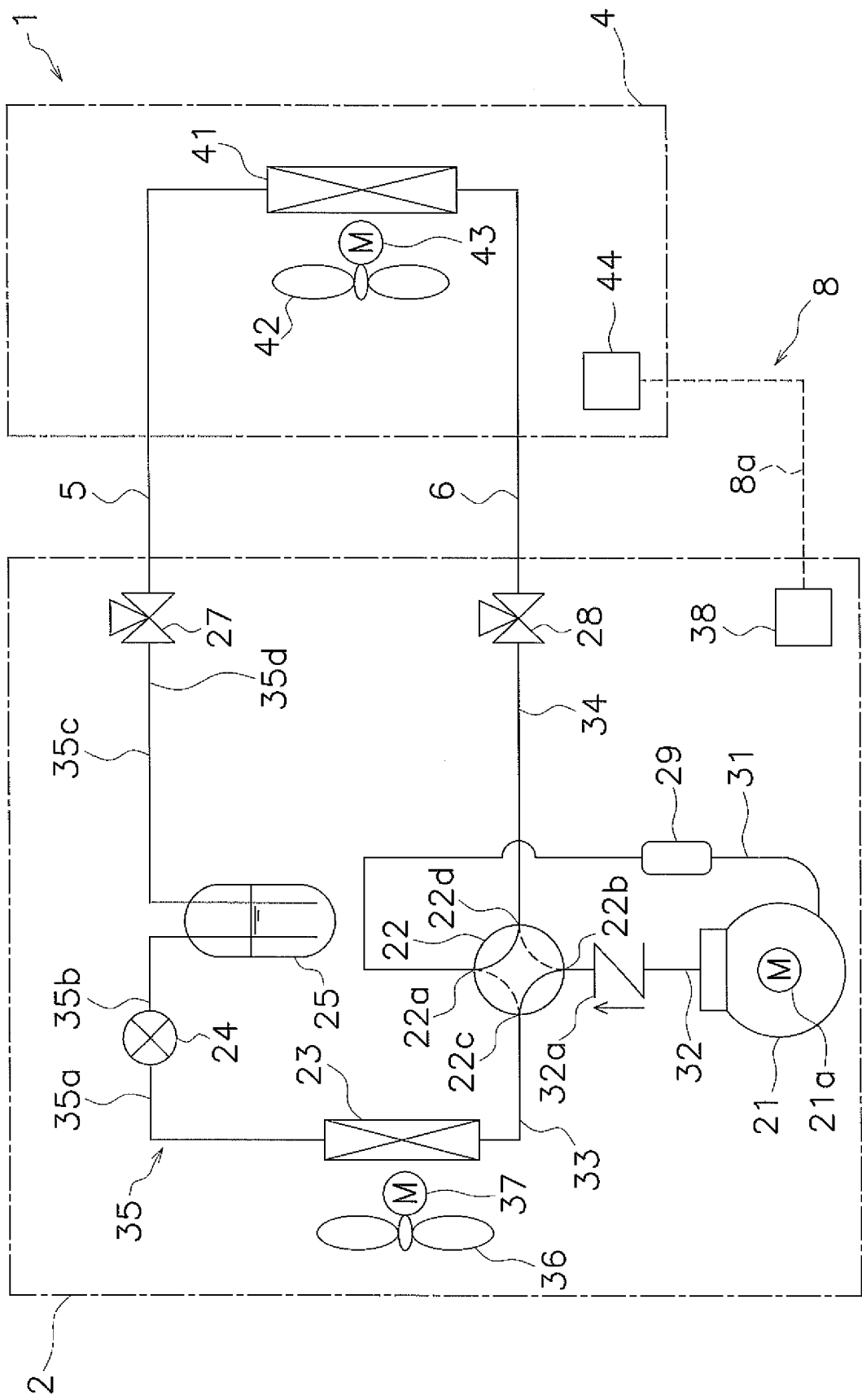


FIG. 17

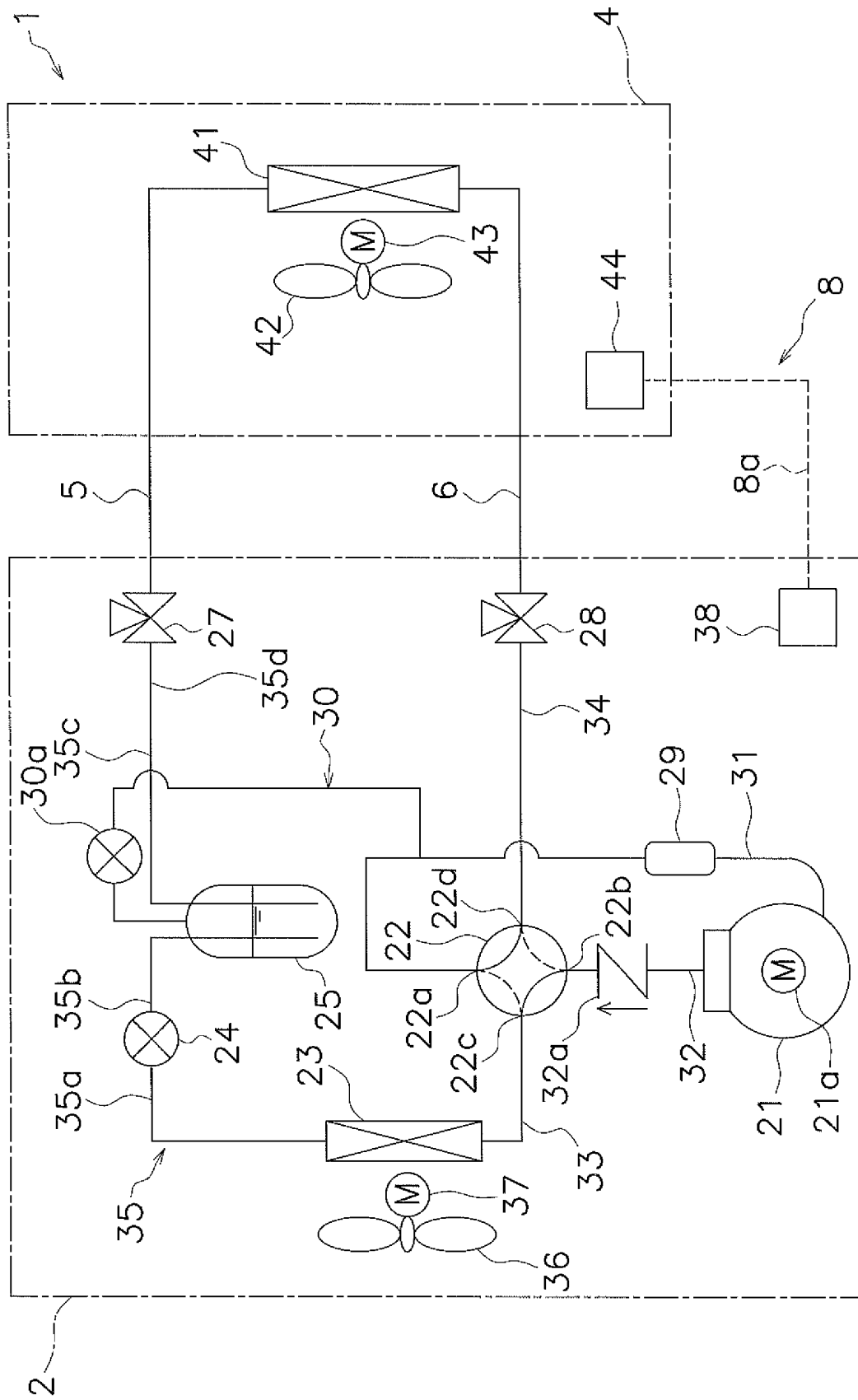


FIG. 18

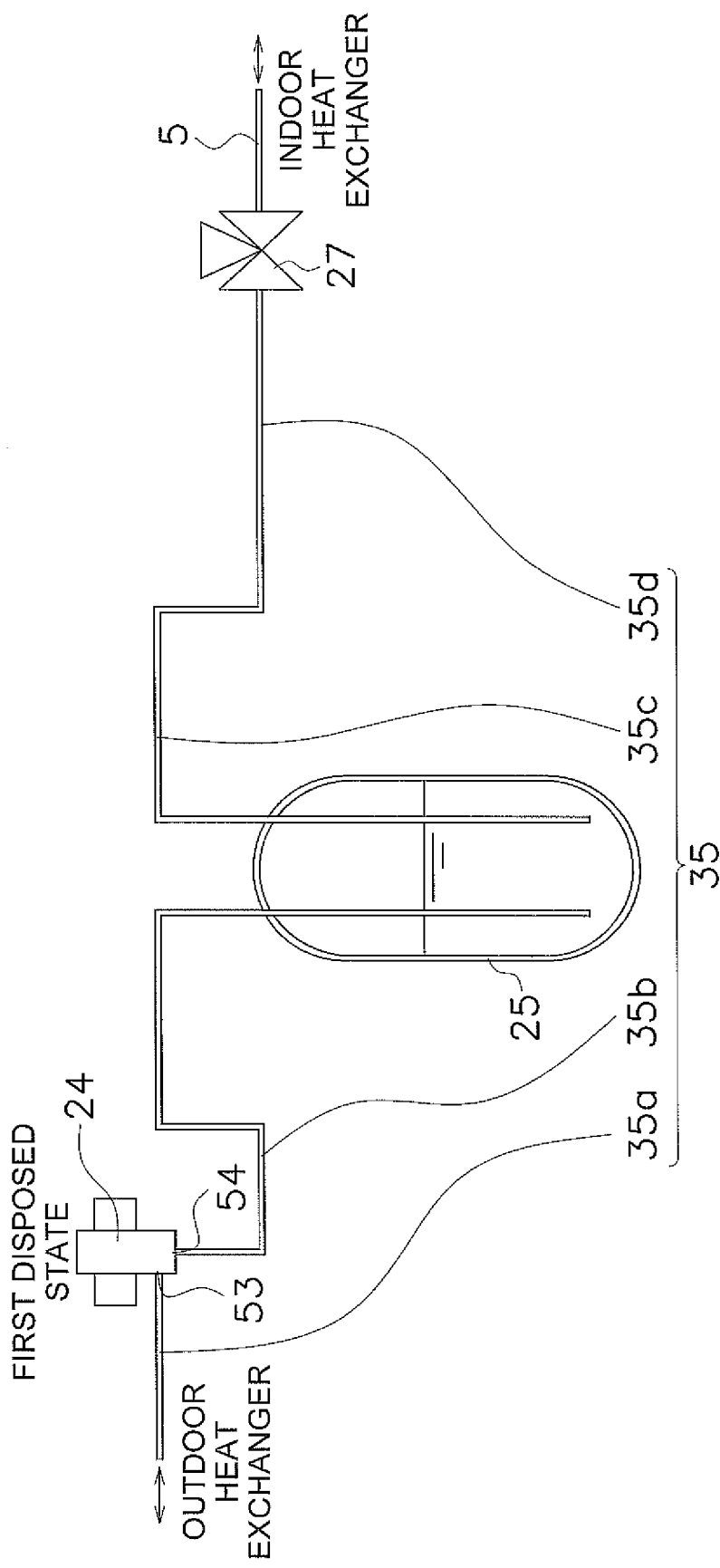


FIG. 19

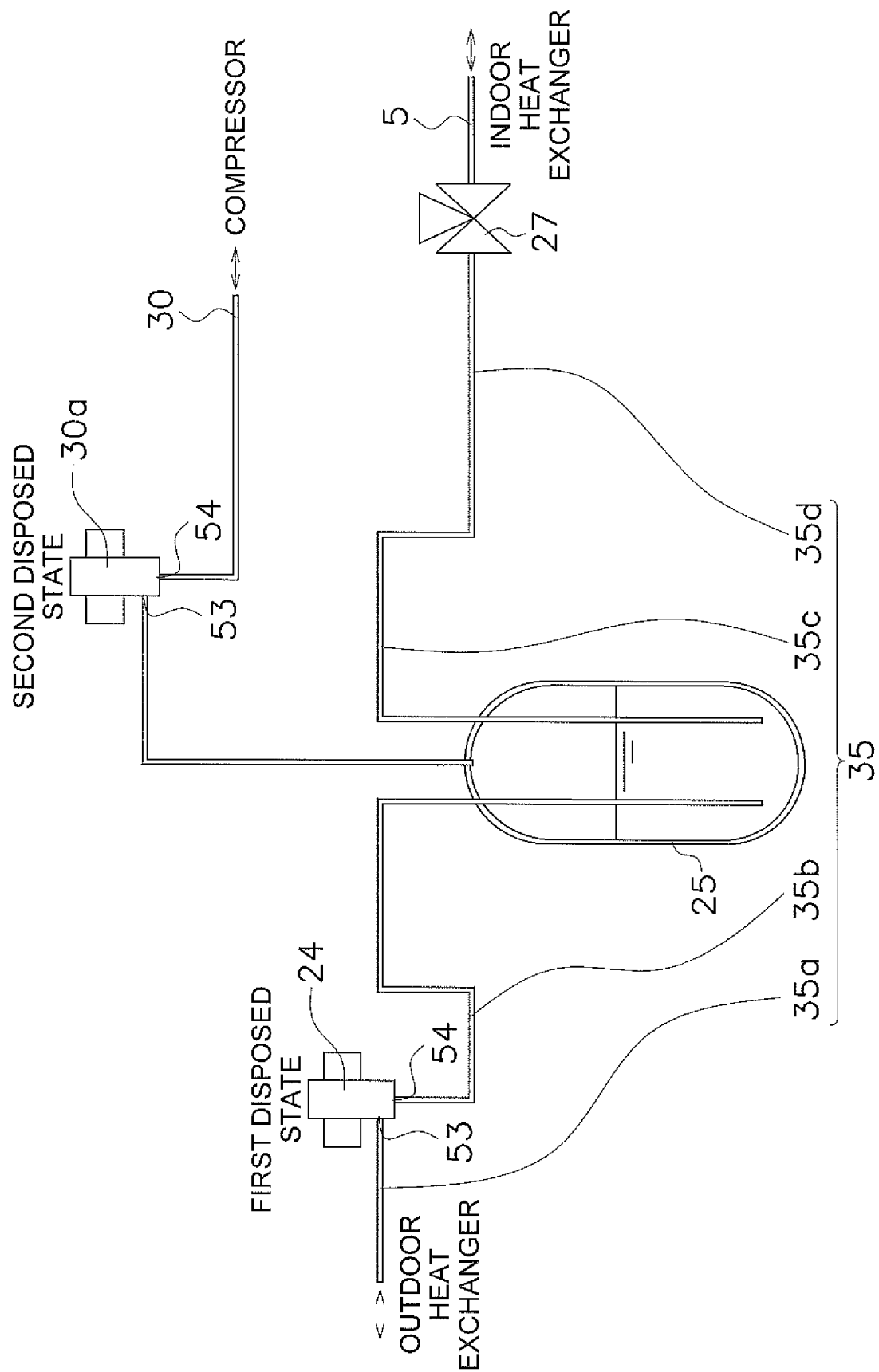


FIG. 20

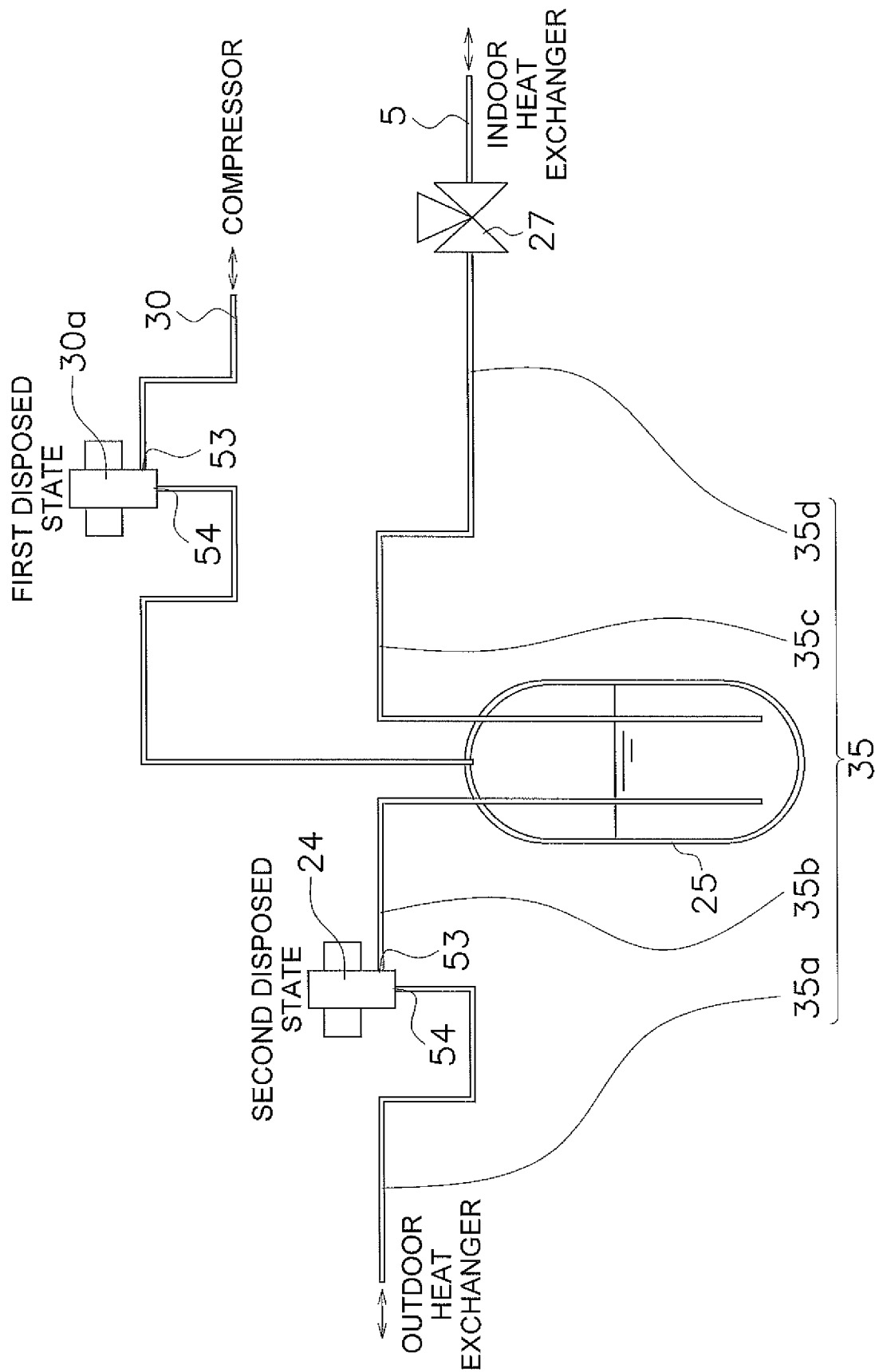


FIG. 21

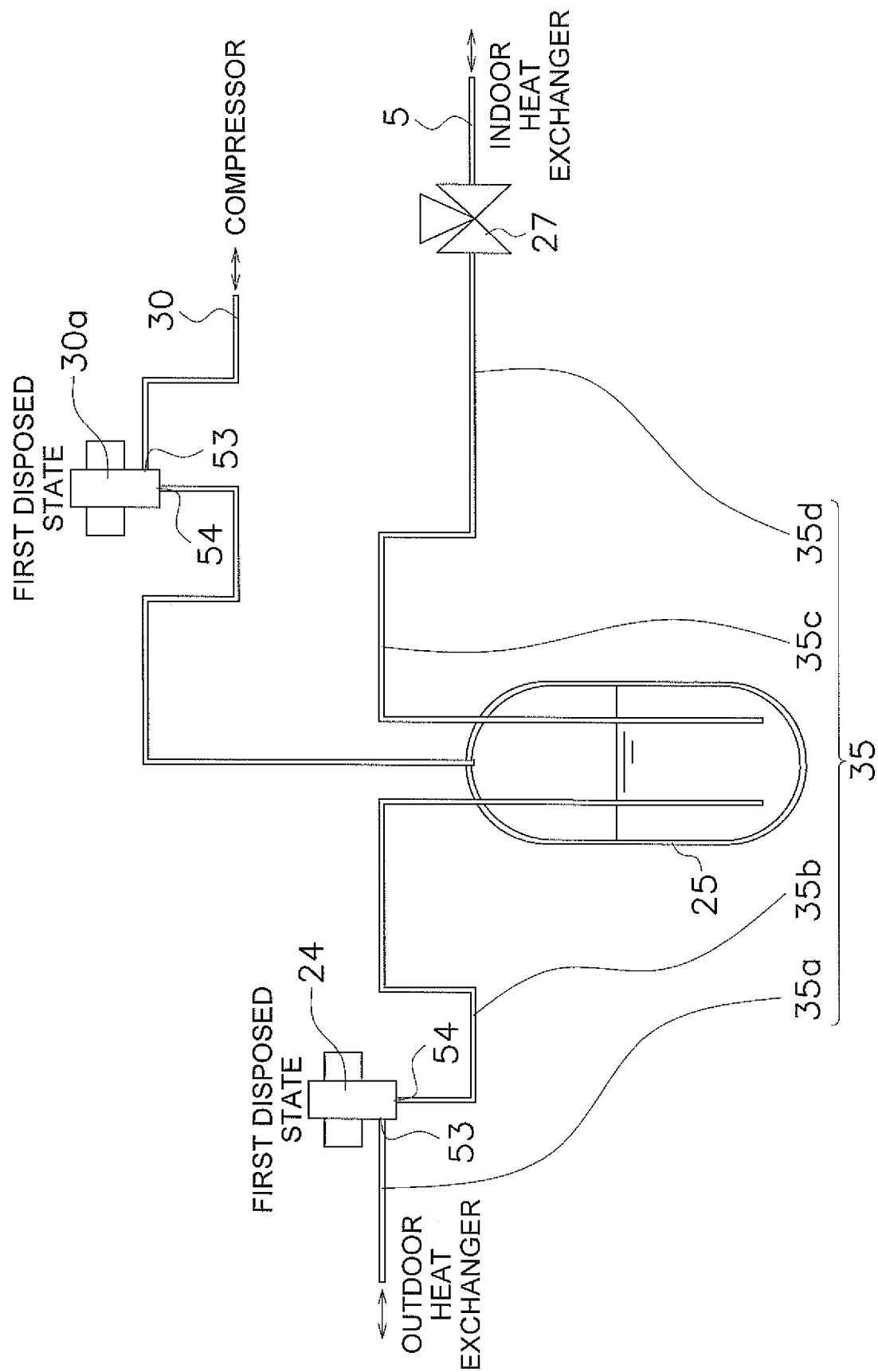


FIG. 22

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/064613

A. CLASSIFICATION OF SUBJECT MATTER

F25B41/04(2006.01)i, F16K31/04(2006.01)i, F25B1/00(2006.01)i, F25B13/00(2006.01)i, F25B41/00(2006.01)i, F25B41/06(2006.01)i, F25B43/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B41/04, F16K31/04, F25B1/00, F25B13/00, F25B41/00, F25B41/06, F25B43/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005-121333 A (Hitachi, Ltd.),	1, 3-4
Y	12 May 2005 (12.05.2005), paragraphs [0007] to [0058]; fig. 6 to 7 (Family: none)	1-12
X	WO 2007/083794 A1 (Sanyo Electric Co., Ltd.),	1, 3-4
Y	26 July 2007 (26.07.2007), paragraphs [0009] to [0039]; fig. 1 to 5 & US 2008/0276635 A1 & EP 1988345 A1 & CN 101484761 A & KR 10-2008-0085877 A	1-12
Y	JP 2001-133055 A (Daikin Industries, Ltd.), 18 May 2001 (18.05.2001), paragraphs [0015] to [0027]; fig. 1 to 2 (Family: none)	2, 5-12

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
12 August, 2014 (12.08.14)

Date of mailing of the international search report
19 August, 2014 (19.08.14)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/064613

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/049767 A2 (CARRIER CORP.), 28 April 2011 (28.04.2011), paragraphs [0047] to [0048]; fig. 1 & US 2012/0192579 A1 & EP 2491317 A & CN 102575886 A	2,5-12
Y	JP 2008-57828 A (Daikin Industries, Ltd.), 13 March 2008 (13.03.2008), paragraphs [0025] to [0027]; fig. 1 & US 2010/0275632 A1 & EP 2060861 A1 & WO 2008/026568 A1 & KR 10-2009-0042281 A & CN 101501421 A & AU 2007289778 A	2,5-12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H10132393 A [0002] [0134]