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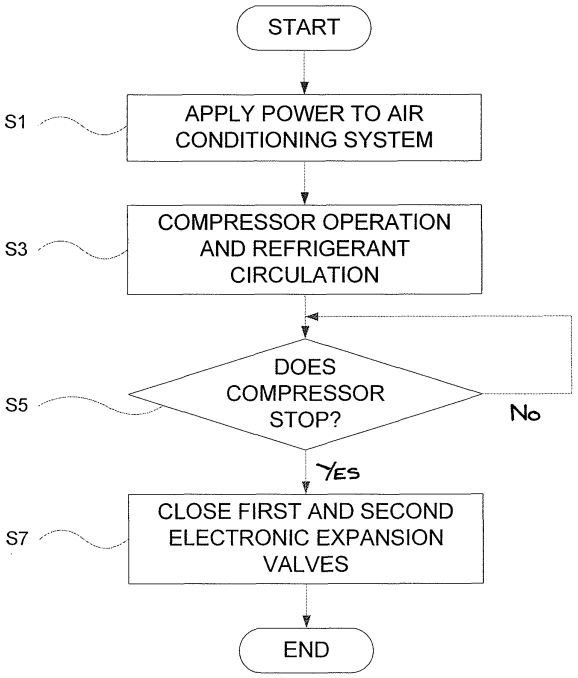
(54) Air conditioner

(57) An air conditioner is disclosed comprising a compressor, a plurality of heat exchangers, an accumulator and, at least one expansion valve connected in a refrigeration circuit operable to perform a cooling and/or heating operation. The air conditioner further comprises a control unit for controlling operation of the air conditioner wherein when the compressor stops, the control unit is configured so as to close at least one expansion valve to prevent refrigerant flowing into the accumulator.

Figure 3



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Description

[0001] The present invention relates to an air conditioner comprising a compressor, a plurality of heat exchangers, an accumulator and, at least one expansion valve connected in a refrigeration circuit operable to perform a cooling and/or heating cycle and, a control unit for controlling operation of the air conditioner.

[0002] An air conditioner generally controls the temperature of air within a building such as a house, an office or a factory by heating, cooling air and comprises a heat exchanger, a compressor, a condenser and an evaporator connected with the compressor.

[0003] A conventional air conditioner is described in Korean Patent Publication No. 2004-0074544. Such a conventional air conditioner comprises an accumulator to separate liquid and gaseous refrigerant supplied from an evaporator at low temperature and low pressure and allow the gaseous refrigerant to pass therethrough, a plurality of compressors to compress the low temperature and pressure gaseous refrigerant from the accumulator, a plurality of check valves provided at each compressor outlet to prevent a backflow of the refrigerant, a condenser to condense the gaseous refrigerant discharged from the compressor at high temperature and high pressure to a liquid state at middle temperature and high pressure by heat exchange with external air, an electric expansion valve to expand the liquid refrigerant at middle temperature and high pressure discharged from the condenser to a liquid refrigerant at low temperature and pressure, an evaporator to evaporate the liquid refrigerant at low temperature and pressure from the electric expansion valve into gaseous refrigerant at low temperature and low pressure through heat exchange with surrounding air, and a ventilating fan to supply the air cooled by the evaporating process of the evaporator indoors. The conventional air conditioner further comprises a fan motor ventilating external air to the condenser. When only one compressor operates among the plurality of compressors, the fan motor reduces the number of revolutions from 20% to 30% in companion with a case in which the plurality of the compressors operate.

[0004] Thus, the conventional air conditioner may increase the general efficiency of the air conditioning system by changing the fan motor velocity of the condenser according to the number of the compressors in operation.

[0005] Also, in a conventional air conditioner, heat exchangers such as the evaporator and the condenser are provided substantially above the accumulator. Hence, the conventional accumulator should be of sufficient size to accommodate the refrigerant contained within the heat exchangers in a case when the air conditioning system device stops operating. If the accumulator is not of sufficient size to accommodate the refrigerant, problems may occur when the compressor is restarted as the liquid refrigerant may be supplied in the direction of the compressor through the accumulator.

[0006] Accordingly, problems occur such as increasing volume and production costs because the accumulator provided in a conventional air conditioner must be of sufficient size to accommodate the refrigerant normally contained within the heat exchangers.

[0007] The present invention seeks to provide a system which overcomes or substantially alleviates the problems discussed above.

[0008] An air conditioner according to the present invention is characterised in that when the compressor stops, the control unit is configured so as to close at least one expansion valve to prevent refrigerant from flowing into the accumulator.

[0009] In a preferred embodiment, an expansion valve is located in the refrigeration circuit between each heat exchanger and the accumulator.

[0010] Preferably, the air conditioner comprises a single expansion valve in the refrigeration circuit between each pair of heat exchangers.

[0011] In one embodiment, a refrigerant flow check valve is located in the refrigeration circuit to prevent back flow of refrigerant into the compressor when the compressor is stopped.

[0012] Preferably, a pressure control valve is disposed between expansion valves, the control unit being configured to open the pressure control valve when the pressure of refrigerant in the refrigeration circuit between said expansion valves exceeds a predetermined pressure.

[0013] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of an air conditioner according to a first embodiment of the present invention;

Figure 2 is a control block diagram of the air conditioner according to the first embodiment of the present invention;

Figure 3 is a control flow chart of the air conditioner according to the first embodiment of the present invention;

Figure 4 is a schematic view of an air conditioner according to a second embodiment of the present invention; and

Figure 5 is a schematic view of an air conditioner according to a third embodiment of the present invention.

[0014] Referring to the drawings, there is shown in Figures 1 and 2 a first embodiment of an air conditioner comprising an air conditioning system 1 provided to control air temperature and a control unit 40 to control the air conditioning system 1.

[0015] The air conditioning system 1 comprises a compressor 11, heat exchangers 15,31 which exchange heat between a refrigerant supplied from the compressor 11 and surrounding air, electric expansion valves 17,33 provided between the heat exchangers 15,31 and an accumulator 19 provided between the heat exchangers 15,31

and the compressor 11. A refrigerant tube 7 forms a closed circuit such that the refrigerant circulates through the compressor 11, the heat exchangers 11,31 and the accumulator 19. The air conditioning system 1 further comprises a pressure control unit 21 provided to control the pressure of the refrigerant in the portion of refrigerant tube located between the electric expansion valves 17,33. A four-way valve 13 is provided to change the refrigerant flow direction through the heat exchangers 15,31 such that each heat exchanger 15,31 may operate alternately in either an air cooling or an air heating mode. This embodiment of the air conditioning system 1 comprises one indoor unit 30 provided in a building such as a house or an office and a factory to cool or heat the interior air and an outdoor unit 10 connected to the indoor unit 30. However, the air conditioning system 1 may be provided as a single body equipped in one casing. In this embodiment, the air conditioning system further comprises a receiver 27 provided between the plurality of electric expansion valves 17,33 to accommodate refrigerant and emit liquid refrigerant.

[0016] The heat exchangers 15,31 comprise a first heat exchanger 15 provided in the outdoor unit 10, and a second heat exchanger 31 provided in the indoor unit 30. Each heat exchanger 15,31 is provided with a ventilation fan 35 adjacent thereto to accelerate the heat exchange across the heat exchanger by forced convection.

[0017] When the air conditioning system 1 performs a cooling operation, the first heat exchanger 15 operates as a condenser to condense the refrigerant compressed from the compressor 11 and the second heat exchanger 31 operates as an evaporator to evaporate the refrigerant by absorbing heat from the surrounding air. When the air conditioning system 1 performs a heating operation, the first heat exchanger 15 operates as an evaporator to evaporate the refrigerant and the first heat exchanger 15 operates as a condenser to condense the refrigerant compressed from the compressor.

[0018] The second heat exchanger 31 may be provided as a plurality of heat exchangers according to the quantity of indoor units 30.

[0019] The electric expansion valves 17,33 comprise a first electric expansion valve 17 provided in the outdoor unit 10 and a second electric expansion valve 33 provided in the indoor unit 30.

[0020] The electric expansion valves 17,33 are provided in the refrigerant pipe 7 located between the first heat exchanger 15 and the second heat exchanger 31, the first electric expansion valve 17 being located proximate to the first heat exchanger 15 and the second electric expansion valve 33 being located proximate to the second heat exchanger 31.

[0021] When the air conditioning system 1 performs a cooling operation, the first electric expansion valve 17 opens completely such that the refrigerant passing therethrough does not expand and the second electric expansion valve 33 is controlled such that high temperature and high pressure refrigerant passing therethrough expands to a low temperature and low pressure refrigerant.

[0022] When the air conditioning system 1 performs a heating operation, the first electric expansion valve 33 is controlled such that high temperature and high pressure refrigerant passing therethrough expands to low temperature and low pressure refrigerant and the second electric expansion valve 33 opens completely such that the refrigerant passing therethrough does not expand.

[0023] The accumulator 19 accommodates the refrigerant transmitted from the heat exchangers 15,31 and the compressor 11. It may also be provided to prevent the supply of liquid refrigerant to the compressor 11. The accumulator 19 is located lower than the first and the second heat exchangers 15,31. In this case, the refrigerant in the refrigerant pipe 7 flows into the accumulator 19 due to gravity when the air conditioning system 1 stops operating. When this occurs, the first electronic expansion valve 17 and the second electronic expansion valve 33 are closed by the control unit 40 such that the refrigerant located between the first electronic expansion valve 17 and the second electronic expansion valve 33 does not flow to the accumulator 19 and so the size of the accumulator 19 may be reduced.

[0024] The four-way valve 13 controls the flow direction of the refrigerant in the air conditioning system to alternately select the cooling or heating operation. When the air conditioning system 1 performs a cooling operation, the refrigerant compressed by the compressor 11 is supplied to the first heat exchanger 15 by the four-way valve 15 and the refrigerant from the second heat exchanger 31 is supplied to the accumulator 19. When the air conditioning system 1 performs a heating operation, the refrigerant compressed by the compressor 11 is supplied by the four-way valve to the second heat exchanger 31 and the refrigerant from the first heat exchanger 15 is supplied to the accumulator 19.

[0025] The pressure control unit 21 is provided as a means to prevent the pressure of the refrigerant located between the electric expansion valves 17,33 from exceeding a predetermined pressure when the electric expansion valves 17,33 are closed by the control unit 40. This predetermined pressure is preferably but not necessarily lower than an endurable pressure of the refrigerant pipe 7 located between the electric expansion valves 17,33. The pressure control unit 21 comprises an auxiliary pipe 23 connected with respect to the refrigerant pipe 7 between the electric expansion valves 17,33 and the accumulator 19, and a relief valve 25 provided to the auxiliary pipe 23. However, the pressure control unit 21 is not limited to the auxiliary pipe 23 and the relief valve 25.

[0026] The auxiliary pipe 23 connects the refrigerant pipe 7 provided between the first and the second electric expansion valves 17,33 and the refrigerant pipe 7 provided between the four-way valve 13 and the accumulator 19. Alternatively, the auxiliary pipe 23 may be located to connect the refrigerant pipe 7 provided between the first and the second electric expansion valves 17,33 and

the refrigerant pipe 7 provided between the second electric expansion valve 33 and the second heat exchanger 31.

[0027] The relief valve 25 opens when the pressure of the refrigerant in the section of refrigerant pipe 7 between the first and the second electric expansion valves 17,33 increases more than the predetermined pressure. If this occurs, the refrigerant may pass to the accumulator 19.

[0028] The receiver 27 is located between the first and the second electric expansion valves 17,33 and allows the liquid refrigerant to flow through the first or the second electric expansion valve 17,33 such that the air conditioning system 1 operates in a stable manner.

[0029] The compressor 11, the first heat exchanger 15, the accumulator 19 and the first electric expansion valve 17 are located in the outdoor unit. As shown in Figure 1, the four-way valve 13, the pressure control unit 21 and the receiver 27 may also be located in the outdoor unit as well as the ventilation fan 35 adjacent to the first heat exchanger 15.

[0030] The second heat exchanger 31 and the second electric expansion valve 33 are located in the indoor unit as well as the ventilation fan 35 adjacent to the second heat exchanger 31.

[0031] The control unit 40 controls the first and second electric expansion valves 17,33 as previously described to prevent the refrigerant located between the first and second electric expansion valves 17,33 from flowing to the accumulator 19 when the air conditioning system 1 stops operating. The control unit 40 opens the first and second electric expansion valves 17,33 such that the first electric expansion valve 17 or the second electric expansion valve 33 may perform an expansion function when the air conditioning system 1 is operating.

[0032] With the above configuration, the control process of the air conditioner according to the first embodiment of the present invention is described hereafter with reference to the control flowchart of Figure 3.

[0033] First of all, power is applied to the air conditioning system 1 at operation S1. The compressor 11 then operates and the refrigerant circulates through the refrigerant pipe 7 at operation S3. Subsequently, the central process confirms whether the compressor 11 is operating at operation S5. This may occur on a periodical basis or a signal stopping the operation of the compressor 11 may be sensed. If the compressor stops operating the first and second expansion valves 17,33 are closed at operation S7 such that the refrigerant located between the first electric expansion valve 17 and the second electric expansion valve 33 cannot flow to the accumulator 19.

[0034] As described above, the air conditioner according to the first embodiment of the invention closes the electric expansion valves 17,33 to prevent the refrigerant accommodated between the electric expansion valves from flowing to the accumulator when the operation of the compressor stops. Thus, the size of the accumulator may be reduced as the refrigerant located between the first and the second electric expansion valves does not need to be accommodated in the accumulator.

[0035] Figure 4 is a schematic view of an air conditioner according to a second embodiment of the present invention. As shown therein, an air conditioning system 101 differs from the first embodiment in that the air conditioning system 101 further comprises a check valve 50 provided at the outlet of the compressor 11 to prevent the refrigerant flowing backwards to the compressor 11.

[0036] As shown in Figure 4 the check valve 50 is provided between the compressor 11 and the four-way valve 13 and prevents the backward flow of refrigerant from the first heat exchanger 15 or the second heat exchanger 31 to the compressor 11.

[0037] In this embodiment wherein the check valve 50 is provided, the control unit 40 closes one of either the first or second electric expansion valves 17,33 when the operation of the compressor 11 is stopped. The control unit 40 closes the second electric expansion valve 33 when the operation of the compressor 11 is stopped during the cooling operation and closes the first electric expansion valve 17 when the operation of the compressor 11 is stopped during the heating operation.

[0038] Thus, the air conditioner according to the second embodiment of the present invention may close the electric expansion valves when the compressor stops operating and prevent the refrigerant interposed between one of the electric expansion valves and the check valve as well as that interposed between the electric expansion valves from flowing to the accumulator thereby reducing the size of the accumulator.

[0039] Figure 5 is a schematic view of an air conditioner according to a third embodiment of the present invention. As shown therein, the air conditioner according to the third embodiment comprises an air conditioning system 201 provided to control air temperature and a control unit (not shown) controlling the air conditioning system 201.

[0040] The air conditioning system 201 comprises the compressor 11, heat exchangers 15,31 to heat-exchange refrigerant supplied from the compressor 11, an electric expansion valve 217 provided between the heat exchangers 15,31, an accumulator 19 provided between the heat exchangers 15,31 and the compressor 11, and the check valve 50 provided at a refrigerant outlet of the compressor 11 to prevent the refrigerant from flowing backwards to the compressor. The air conditioning unit 201 may further comprise the four-way valve 13 provided to change the refrigerant flow direction through the heat exchangers 15,31.

[0041] The electric expansion valve 217 is provided as a single unit different from the foregoing first and second embodiments. The detailed explanation about the function of the electric expansion valve 217 will be avoided because it is similar to the first embodiment.

[0042] During a cooling operation, the first heat exchanger 15 functions as the condenser to condense the refrigerant from the compressor 11 and the second heat exchanger 31 functions as the evaporator to evaporate and to absorb heat from surrounding air.

[0043] During a heating operation, the first heat exchanger 15 functions as the evaporator to evaporate and to absorb heat from surrounding air and the second heat exchanger 31 functions as the condenser to condense the refrigerant compressed from the compressor 11.

[0044] The explanation about the four-way valve 13 will be omitted because it is similar to the foregoing first embodiment.

[0045] The control unit (not shown) controls the electric expansion valve 217 such that the refrigerant located between the electric expansion valve 217 and the check valve 50 does not flow to the accumulator 19 when it is closed.

[0046] Thus, the air conditioner according to the third embodiment of the present invention may prevent the refrigerant located between the electric expansion valve 217 and the check valve 50 from flowing to the accumulator 19 if the control unit closes the electric expansion valve when the operation of the compressor stops. Accordingly, the size of the accumulator 19 may be reduced.

[0047] Further features shown in Figure 5 are omitted from the description as they are similar to the first and second embodiments.

[0048] Although embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles of the invention, the scope of which is defined in the claims and their equivalents and the foregoing description should be regarded as a description of preferred embodiments only.

Claims

1. An air conditioner comprising a compressor, a plurality of heat exchangers, an accumulator and, at least one expansion valve connected in a refrigeration circuit operable to perform a cooling and/or heating cycle and, a control unit for controlling operation of the air conditioner **characterised in that** when the compressor stops, the control unit is configured so as to close at least one expansion valve to prevent refrigerant from flowing into the accumulator.

2. An air conditioner according to claim 1 wherein an expansion valve is located in the refrigeration circuit between each heat exchanger and the accumulator.

3. An air conditioner according to claim 1 comprising a single expansion valve in the refrigeration circuit between each pair of heat exchangers.

4. An air conditioner according to any preceding claim wherein a refrigerant flow check valve is located in the refrigeration circuit to prevent back flow of refrigerant into the compressor when the compressor is stopped.

5. An air conditioner according to any of claims 1, 2 and 4 wherein a pressure control valve is disposed between expansion valves, the control unit being configured to open the pressure control valve when the pressure of refrigerant in the refrigeration circuit between said expansion valves exceeds a predetermined pressure.

6. A method of controlling an air conditioner comprising a compressor, a plurality of heat exchangers, an accumulator and, at least one expansion valve connected in a refrigeration circuit operable to perform a cooling and/or heating cycle and, a control unit for controlling operation of the air conditioner **characterised by** the step of closing at least one expansion valve when the compressor stops, to prevent refrigerant from flowing into the accumulator.

7. An air conditioner comprising a freezing device comprising a compressor, a plurality of heat exchangers to heat exchange a refrigerant supplied from the compressor, a plurality of electric expansion valves provided between the plurality of the heat exchangers and an accumulator provided between the heat exchanger and the compressor and a control unit controlling to close the plurality of the electric expansion valves to prevent the refrigerant located between the plurality of electric expansion valves from being accommodated in the accumulator when the operation of the compressor stops.

8. The air conditioner according to claim 7 wherein the freezing device further comprises a check valve provided in a refrigerant exit area of the compressor and preventing the refrigerant to flow backward to the compressors.

9. The air conditioner according to claims 7 or 8 wherein the freezing device further comprises a pressure control unit provided to control the pressure of the refrigerant accommodated between the plurality of the electric expansion valves.

10. The air conditioner according to claim 9 wherein the pressure control unit comprises a refrigerant pipe provided between the plurality of the electric expansion valves, an auxiliary pipe connected to the accumulator and a relief valve provided in the auxiliary pipe.

11. The air conditioner according to claim 7 wherein the freezing device further comprises a four way valve provided to change the refrigerant flow direction in the plurality of the heat exchangers to make an air cooling and an air heating operation possible.

12. The air conditioner according to claim 7 wherein the freezing device further comprises a receiver provid-

ed between the plurality of the electric expansion valves and accommodating the refrigerant and provided to discharge a liquid refrigerant.

13. The air conditioner according to claim 7 or claim 12 wherein the freezing device further comprises an outdoor unit comprising the compressor, one of the plurality of the heat exchangers and the accumulator and an indoor unit comprising at least another one of the plurality of the heat exchangers, one of the plurality of the electric expansion valve is equipped to the indoor unit and at least another one of the plurality of the electric expansion valves is equipped to the indoor unit.

14. An air conditioner comprising a freezing device comprising a compressor and a plurality of heat exchangers to heat exchange a refrigerant supplied from the compressor, an electric expansion valve provided between the plurality of the heat exchangers, an accumulator provided between the heat exchanger and the compressor, and a check valve provided in a refrigerant exit area of the compressor and preventing the refrigerant from flowing backward to the compressor, a control unit controlling to close the electric expansion valve to prevent the refrigerant located between the electric expansion valve and the check valve from being accommodated in the accumulator when the operation of the compressor stops.

15. The air conditioner according to claim 14 wherein the freezing device further comprises a four way valve provided to change the refrigerant flow direction in the plurality of the heat exchangers to make an air cooling and an air heating operation possible.

FIG. 1

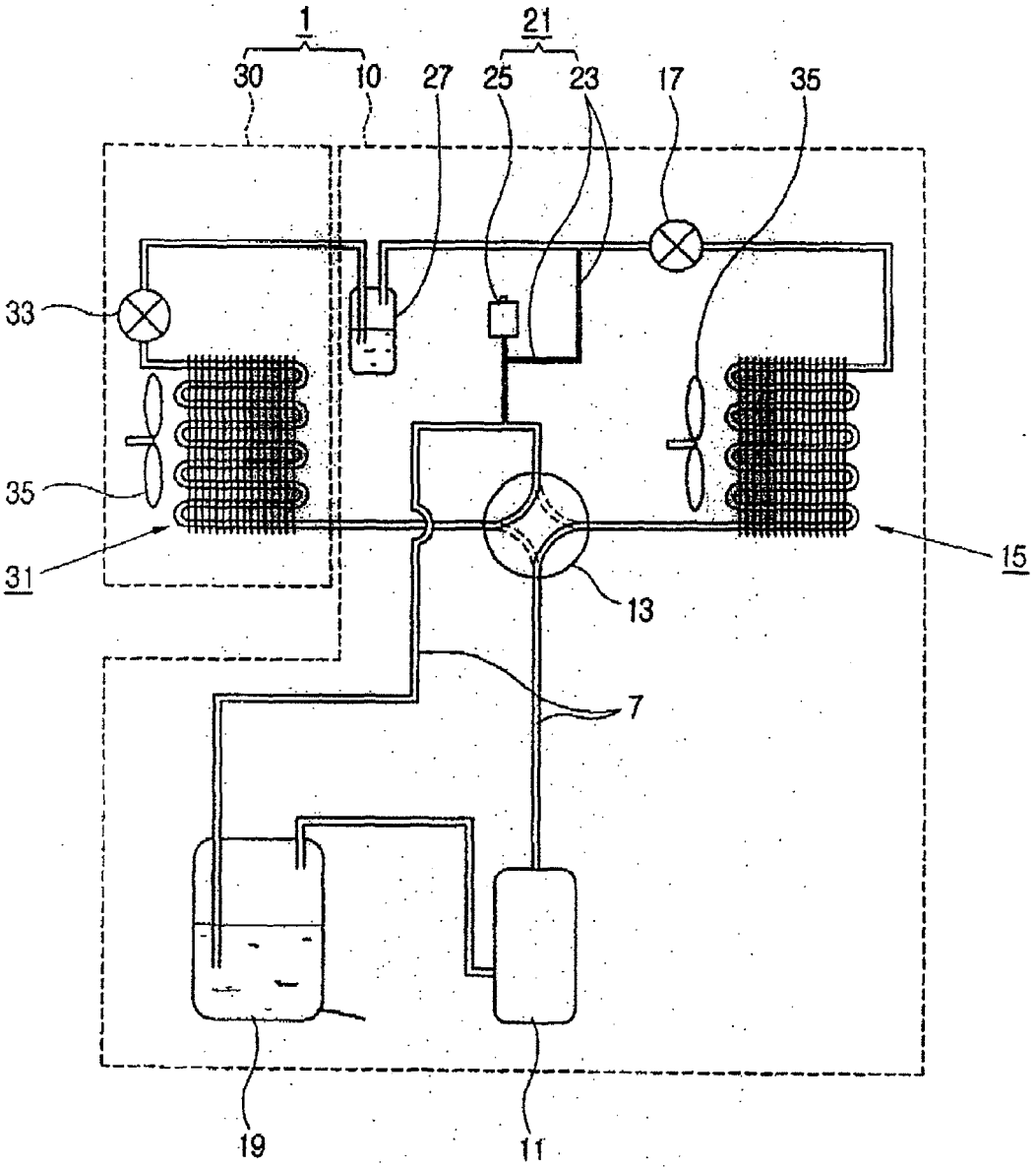

FIG. 2

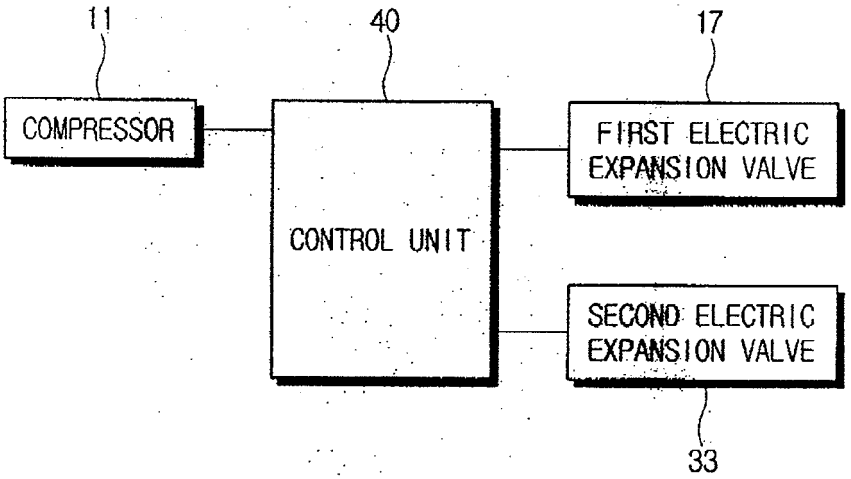
11
40
17
COMPRESSOR
CONTROL UNIT
FIRST ELECTRIC EXPANSION VALVE
SECOND ELECTRIC EXPANSION VALVE
33

Figure 3

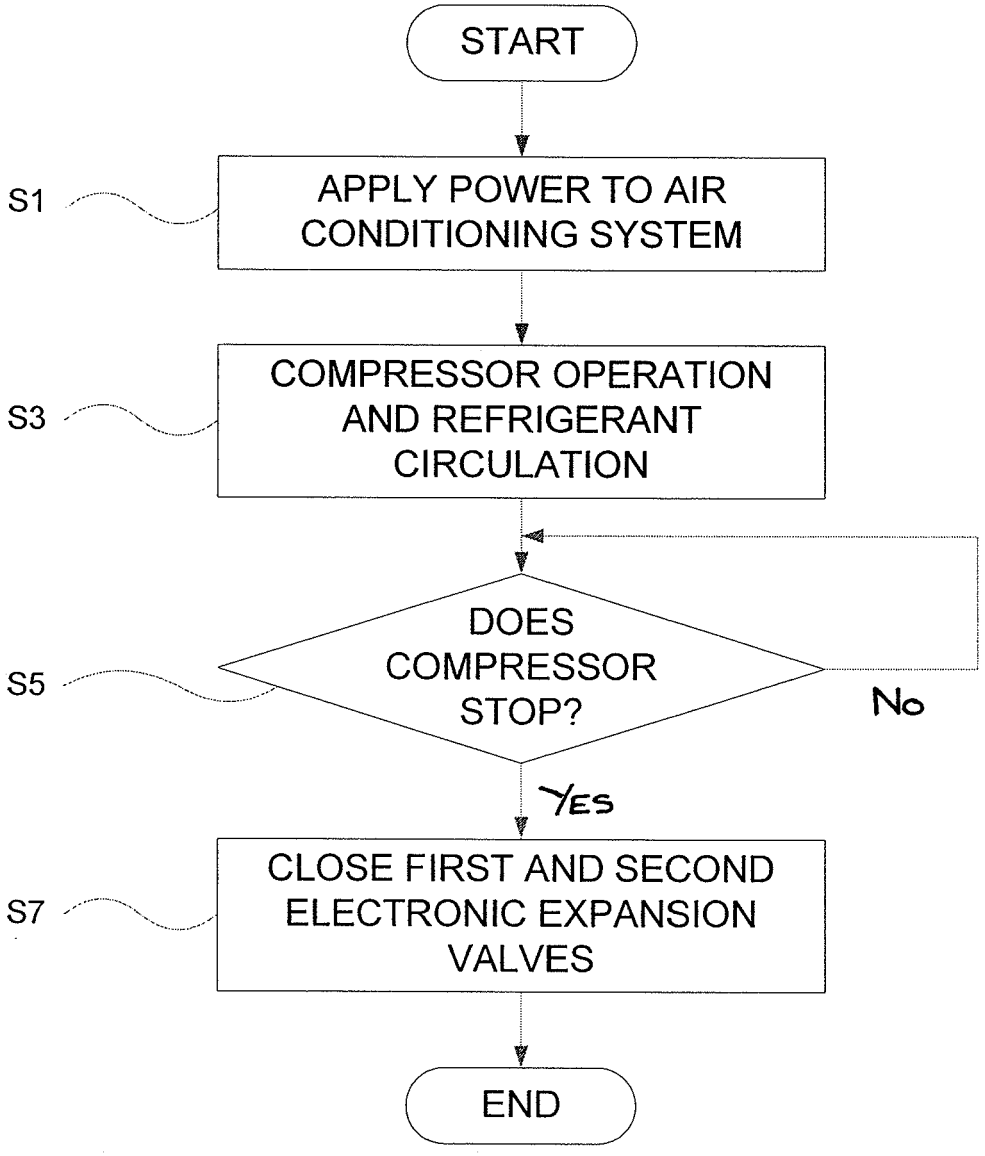
START
S1
APPLY POWER TO AIR CONDITIONING SYSTEM
S3
COMPRESSOR OPERATION AND REFRIGERANT CIRCULATION
S5
DOES COMPRESSOR STOP?
No
Yes
S7
CLOSE FIRST AND SECOND ELECTRONIC EXPANSION VALVES
END

FIG. 4

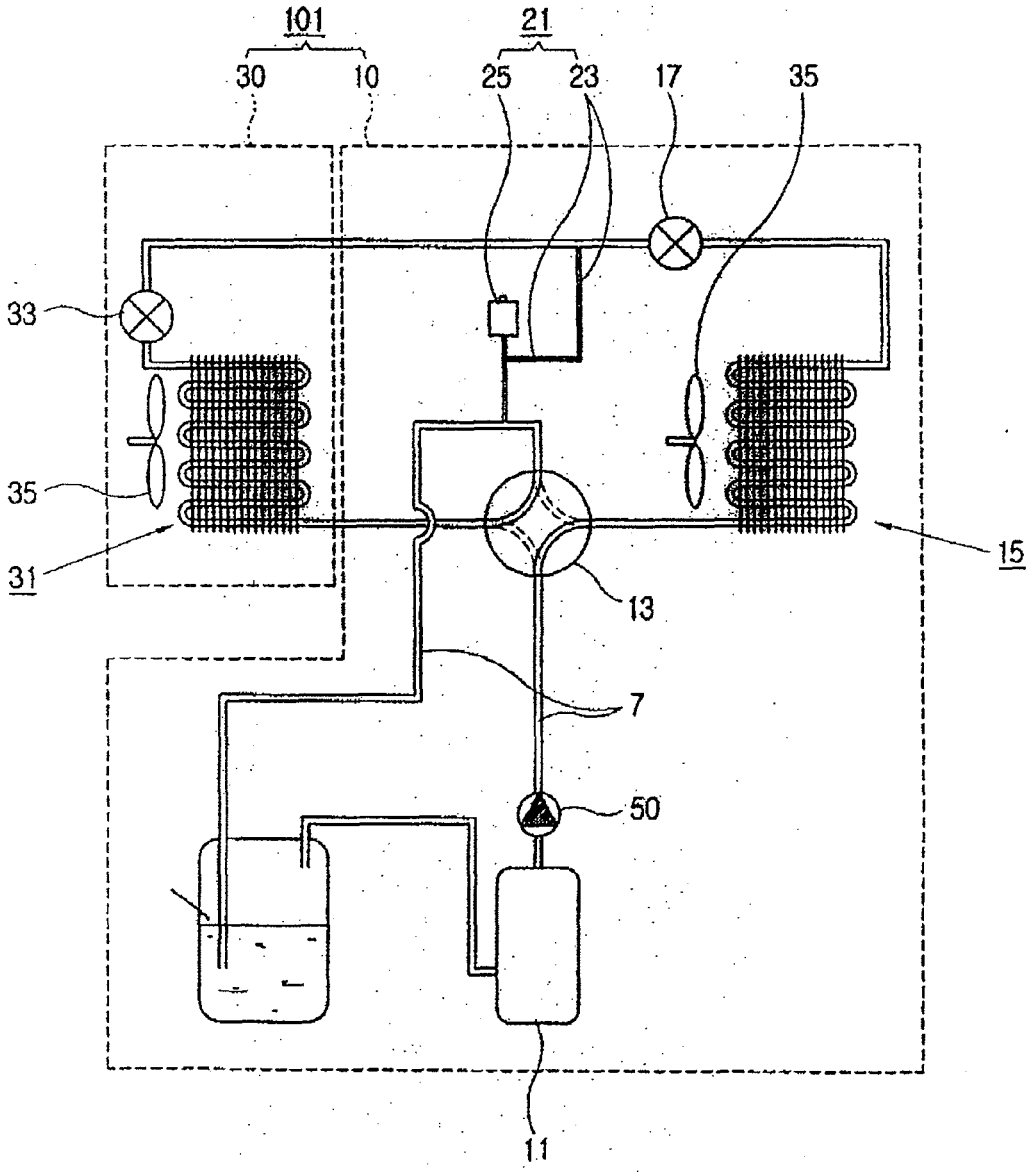

FIG. 5