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(11) **EP 1 580 496 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.09.2005 Bulletin 2005/39

(51) Int Cl.7: **F25B 5/04**, F25B 41/06,
F25B 41/04

(21) Application number: **04103085.9**

(22) Date of filing: **30.06.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
AL HR LT LV MK

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(30) Priority: **23.03.2004 KR 2004019700**

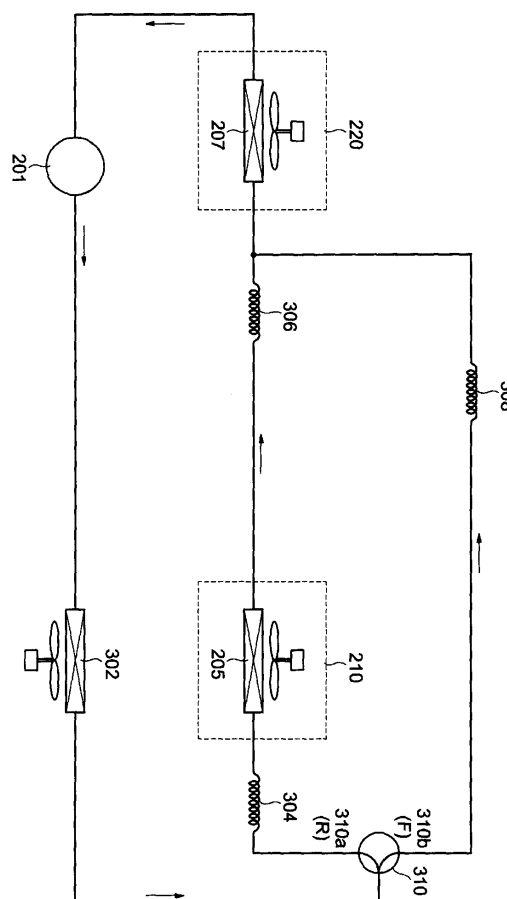
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(54) **Heat pump**

(57) A refrigerator and a control method thereof in which a smooth flow of a refrigerant can be provided through an effective control for a path change valve (310) when a flow path of the refrigerant is changed between two evaporators (205,207) equipped in the refrigerator by the path change valve (310). The refrigerator includes a refrigerating compartment evaporator (205), a freezing compartment evaporator (207), a first expansion device (304) adapted to expand a flow of a refrigerant to be introduced into the refrigerating compartment evaporator (205), a second expansion device (308) adapted to expand a flow of the refrigerant to be introduced into the freezing compartment evaporator (207), a path change device (310) adapted to change a flow path of the refrigerant between the first expansion device (304) and the second expansion device (308), and a control unit adapted to control the path change device so that, when the refrigerant flow path is changed from the second expansion device (308) to the first expansion device (304), a simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device (304) and the second expansion device (308) is maintained for a predetermined time.

FIG 1



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Description

[0001] The present invention relates to heat pump for cooling first and second spaces to respectively higher and lower temperatures.

[0002] Generally, refrigerators include a body containing freezing and refrigerating compartments divided by a wall. Separate doors are generally provided for the freezing and refrigerating compartments. An evaporator and a fan are located behind a wall at the back of the freezing compartment, in order to generate cold air which is supplied to the freezing compartment. Another evaporator and another fan are arranged behind a wall at the back of the refrigerating compartment, in order to generate cold air which is supplied to the refrigerating compartment. Thus, cold air is supplied to the freezing and refrigerating compartments independently. Such a system is called an "independent cooling system".

[0003] The independent cooling system is used because the freezing compartment needs to be cooled significantly more than the refrigerating compartment. In order to implement different temperatures in the freezing and refrigerating compartments, the evaporators of the freezing and refrigerating compartments must have different evaporation temperatures. To this end, expansion (pressure reduction) of a refrigerant at the upstream sides of each evaporator must be carried out in such a manner that the expansion degrees are different. Accordingly, separate expansion devices are installed for the evaporators.

[0004] The different evaporation temperatures of the evaporators for the freezing and refrigerating compartments means different refrigerant pressures in the evaporators. Such a refrigerant pressure difference causes the refrigerant to flow through one of the evaporators in a larger quantity so that the refrigerant may not flow smoothly through the other evaporator when the refrigerant flow path is changed.

[0005] A heat pump, according to the present invention, comprising:

a refrigerant circuit comprising:

first and second segments for cooling the first and second spaces respectively connected in series;

a bypass loop bypassing the first segment; and valve means having states for selectively directing refrigerant through:

- (a) the first segment but not the bypass loop,
- (b) the bypass loop but not the first segment, or
- (c) both the first segment and the bypass loop, and

a controller for controlling the valve means such that

when the valve means is transitioning between states (a) and (b), it is held in state (c) for a time.

[0006] Holding the valve means in state (c) improves the refrigerant flow when the valve means is changing from states (a) to (b).

[0007] The time during which state (c) is held may be predetermined.

[0008] The first segment preferably includes a first expansion device followed by a first evaporator followed by a second expansion device.

[0009] The bypass loop preferably includes a third expansion device.

[0010] The second segment preferably includes a second evaporator.

[0011] The refrigerant circuit preferably includes a compressor and condenser connected in series between the second segment and the valve means.

[0012] According to the present invention, there is also provided a refrigerator including a heat pump according to the present invention, wherein the first space is a refrigerating compartment and the second space is a freezing compartment.

[0013] Additional preferred and optional features are set forth in claims 8 to 13 appended hereto.

[0014] An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows the refrigerant circuit of a heat pump according to the present invention;

Figure 2 is a timing chart illustrating the operation of the 3-way valve in Figure 1;

Figure 3 is a block diagram of the control system of the heat pump of Figure 1;

Figure 4 is a flowchart illustrating a method of controlling the 3-way valve in Figure 1; and

Figure 5 is a flowchart illustrating a method of controlling the 3-way valve in Figure 1.

[0015] Referring to Figure 1, refrigerant, which is discharged from a compressor 201, is fed to a refrigerating compartment capillary tube 304 or a freezing compartment capillary tube 308 after passing through a condenser 302 according to the state of 3-way valve 310. When the 3-way valve 310 is operated such that a refrigerating compartment valve 310a thereof is closed and a freezing compartment valve 310b thereof is open, the refrigerant emerging from the condenser 302 is only fed to the freezing compartment evaporator 207 through the freezing compartment capillary tube 308. In this case, cooling is carried out in the freezing compartment 220 alone. On the other hand, when it is necessary to cool both the refrigerating compartment 210 and the freezing compartment 220, the 3-way valve 310 is operated to open the refrigerating compartment valve 310a and close the freezing compartment valve 310b. In this case, the refrigerant emerging from the condens-

er 302 is fed into the refrigerating compartment evaporator 205 and then into the freezing compartment evaporator 207 via the refrigerating compartment capillary tube 304 and a connecting capillary tube 306.

[0016] The state of the 3-way valve 310 is controlled by a stepping motor (not shown). That is, a refrigerant flow path, which communicates with at least one of the refrigerating compartment evaporator 205 and freezing compartment evaporator 207, is set by operation of the stepping motor.

[0017] The change of the refrigerant flow path caused by rotation of the stepping motor will now be described with reference to Figure 2.

[0018] Referring to Figure 2, different or no refrigerant flow paths are established by selectively opening one or other or both or none of the refrigerating compartment valve 310a and the freezing compartment valve 310b using the stepping motor. When the angular position of the stepping motor is 34°, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are closed so that no refrigerant flow path is established. When the stepping motor further rotates to about 95°, the freezing compartment valve 310b is opened while the refrigerating compartment valve 310b is still closed. In this state, a refrigerant flow path is established through the freezing compartment evaporator 207 via the freezing compartment capillary tube 308. A further rotation of the stepping motor to about 154° opens the refrigerating compartment valve 310b as well. When the stepping motor further rotates to about 195°, the freezing compartment valve 310b is closed while the refrigerating compartment valve 310a remains open. In this state, a refrigerant flow path is established only through the refrigerating compartment evaporator 205 via the refrigerating compartment capillary tube 304. A further rotation of the stepping motor to 215° closes the refrigerating compartment valve 310a as well. As a result, there is no refrigerant flow paths.

[0019] In this way, the establishment of a desired refrigerant flow path is effected by rotation of the stepping motor so as to control the openings and closings of the 3-way valve. As described above, at a certain angular position of the stepping motor, for example, about 154° in the case of Figure 2, there is a simultaneous opening stage t0 in which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are open. In this stage t0, the refrigerant can flow through the refrigerating compartment evaporator 205 and the freezing compartment evaporator 207. In the simultaneous opening stage t0, however, the refrigerant flows toward the freezing compartment evaporator 207 in a larger quantity because the pressure of the freezing compartment evaporator 207 is relatively higher than that of the refrigerating compartment evaporator 205. For this reason, when the operation mode of the refrigerator is changed from a mode for cooling the refrigerating compartment to a mode for cooling the freezing compartment alone (that is, the angular position of the

stepping motor is changed from 195° to 95° via an angular position of about 154°), the refrigerant concentrated to the freezing compartment evaporator 207 cannot be sufficiently supplied through the refrigerant flow path communicating with the refrigerating compartment evaporator 205. In order to solve this problem, where the operation mode of the refrigerator is changed from the refrigerating compartment mode to the freezing compartment only mode, the simultaneous opening stage t0, corresponding to the position of about 154°, is maintained for a relatively long period of time. As a result, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are open for a sufficient period of time to allow the refrigerant concentrated to the freezing compartment evaporator 207 to be sufficiently and smoothly supplied through the refrigerant flow path communicating with the refrigerating compartment evaporator 205.

[0020] In order to achieve such a control operation, the refrigerator includes the control system shown in Figure 3.

[0021] Referring to Figure 3, an input unit 354 and a temperature detecting unit 356 are connected to an input of a control unit 352 for controlling the operation of the refrigerator. The input unit 354 allows the user to set a desired target cooling temperature, a desired cooling mode and other operating conditions. The temperature detecting unit 356 detects the temperatures of the refrigerating compartment 210, the freezing compartment 220, the refrigerating compartment evaporator 205 and the freezing compartment evaporator 207 and other temperatures and informs the control unit 352 of the detected temperatures. Based on the detected temperatures, the control unit 352 controls the cooling operation of the refrigerator. The 3-way valve 310 is electrically connected to an output of the control unit 352, along with a compressor 201. The 3-way valve 310 and compressor 201 are controlled by the control unit 352 to implement a cooling mode and achieve a target cooling temperature set by the user. The operation of the control unit 352 will now be described with reference to Figures 4 and 5.

[0022] Referring to Figure 4, with the 3-way valve 310 rotated to the 195° position by the stepping motor, the refrigerating compartment valve 310a is open and the freezing compartment valve 310b is closed. In this state, the refrigerating compartment 210 is cooled (Step 402). After completion of the cooling of the refrigerating compartment 210, the control unit 352 determines whether or not the freezing compartment 220 needs cooling. Based on this determination, the control unit 352 determines whether or not the refrigerant flow path needs to be changed from the refrigerating compartment 210 to the freezing compartment 220 (Step 404). If it is necessary to change the refrigerant flow path from the refrigerating compartment 210 to the freezing compartment 220, the control unit 352 changes the angular position of the stepping motor from 195° to 154° (Step 406). This

procedure is an intermediate procedure involved in a procedure in which the stepping motor is rotated to 95°. In accordance with the intermediate procedure, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are open. Where the refrigerant flow path is to be changed from the refrigerating compartment 210 to the freezing compartment 220, the stepping motor is rotated to the 95° position without any delay in the intermediate procedure, thereby closing the refrigerating compartment valve 310a while opening only the freezing compartment valve 310b to cool only the freezing compartment 220 (Step 408). Thus, the time, for which both of the valves 310a, 310b are open, is minimized during the change of the refrigerant flow path from the refrigerating compartment 210 to the freezing compartment 220. Accordingly, it is possible to reduce the degree of concentration of the refrigerant from the refrigerating compartment evaporator 205 to the freezing compartment evaporator 207.

[0023] Referring to Figure 5, with the 3-way valve 310 rotated to the 95° angular position by the stepping motor, the refrigerating compartment valve 310a is closed and the freezing compartment valve 310b is open. In this state, the freezing compartment 220 is cooled (Step 502). After completion of the cooling of the freezing compartment 220, it is determined whether or not the refrigerating compartment 210 needs to be cooled. Based on this determination, it is then determined whether or not the refrigerant flow path needs to be changed from the freezing compartment 220 to the refrigerating compartment 210 (Step 504). When it is necessary to change the refrigerant flow path from the freezing compartment 220 to the refrigerating compartment 210, the angular position of the stepping motor is changed from 95° to 154° (Step 506). This procedure is an intermediate procedure involved in a procedure in which the stepping motor is rotated to 195°. In accordance with the intermediate procedure, a simultaneous opening stage, in which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are both open, is established. Where the refrigerant flow path is to be changed from the freezing compartment 220 to the refrigerating compartment 210, the simultaneous opening stage established in the intermediate procedure is continued for a predetermined time (for example, 10 seconds). That is, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are open for the predetermined time (Step 508). As both of the valves 310a and 310b are open for the predetermined time during the change of the refrigerant flow path from the freezing compartment 220 to the refrigerating compartment 210, as described above, the refrigerant concentrated to the freezing compartment evaporator 220 can sufficiently flow toward the refrigerating compartment evaporator 210.

[0024] When the change of the refrigerant flow path from the refrigerating compartment evaporator 210 to the freezing compartment 220 is carried out (that is,

when the stepping motor is rotated from 195° to 95°), there is an inevitable delay time caused by the mechanical characteristics of the stepping motor and 3-way valve 310 (for example, 3 seconds). Accordingly, the predetermined time, for which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are open, upon changing the refrigerant flow path from the freezing compartment 220 to the refrigerating compartment 210, is set to be longer than the inevitable delay time (for example, 10 seconds), in order to allow the refrigerant concentrated to the freezing compartment evaporator 220 to flow sufficiently toward the refrigerating compartment evaporator 210. After the elapsing of the predetermined time (10 seconds), the stepping motor is rotated to 195°, thereby closing the freezing compartment valve 310b while maintaining only the refrigerating compartment valve 310a in the open state. Thus, only the refrigerating compartment 210 is cooled (Step 510).

[0025] As apparent from the above description, in accordance with the refrigerator control method according to the present invention, it is possible to provide a smooth flow of refrigerant by effectively controlling the path change valve upon changing the refrigerant flow path between the evaporators.

[0026] Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible.

Claims

1. A heat pump for cooling first and second spaces to respectively higher and lower temperatures, the heat pump comprising:

a refrigerant circuit comprising:

first and second segments for cooling the first and second spaces respectively connected in series;
a bypass loop bypassing the first segment; and
valve means (310) having states for selectively directing refrigerant through:

- (a) the first segment but not the bypass loop,
- (b) the bypass loop but not the first segment, or
- (c) both the first segment and the bypass loop, and

a controller (352) for controlling the valve means (310) such that when the valve means (310) is transitioning between states (a) and (b), it is held in state (c) for a time.

2. A heat pump according to claim 1, wherein said time is predetermined.
3. A heat pump according to claim 1 or 2, wherein the first segment includes a first expansion device (304) followed by a first evaporator (205) followed by a second expansion device (306). 5
4. A heat pump according to claim 1, 2 or 3, wherein the bypass loop includes a third expansion device (308). 10
5. A heat pump according to any preceding claim, wherein the second segment includes a second evaporator (207). 15
6. A heat pump according to any preceding claim, wherein the refrigerant circuit includes a compressor (201) and condenser (302) connected in series between the second segment and the valve means (310). 20
7. A refrigerator including an heat pump according to any preceding claim, wherein the first space is a refrigerating compartment and the second space is a freezing compartment. 25
8. A refrigerator comprising:
 - a refrigerating compartment evaporator; 30
 - a freezing compartment evaporator;
 - a first expansion device adapted to expand a flow of a refrigerant to be introduced into the refrigerating compartment evaporator;
 - a second expansion device adapted to expand a flow of the refrigerant to be introduced into the freezing compartment evaporator; 35
 - a path change device adapted to change a flow path of the refrigerant between the first expansion device and the second expansion device; 40
 - and
 - a control unit adapted to control the path change device so that, when the refrigerant flow path is changed from the second expansion device to the first expansion device, a simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device and the second expansion device is maintained for a predetermined time. 45
9. The refrigerator according to claim 8, wherein:
 - the path change device comprises a 3-way valve adapted to change the refrigerant flow path in accordance with a rotation of a stepping motor; and 50
 - the control unit rotates the stepping motor to cause the refrigerant flow path to be changed from the second expansion device to the first expansion device, while temporarily stopping, for the predetermined time, the rotation of the stepping motor at a rotation angle thereof corresponding to the simultaneous opening stage.
10. A method for controlling a refrigerator including a refrigerating compartment evaporator, a freezing compartment evaporator, a first expansion device adapted to expand a flow of a refrigerant to be introduced into the refrigerating compartment evaporator, a second expansion device adapted to expand a flow of the refrigerant to be introduced into the freezing compartment evaporator, and a path change device adapted to change a flow path of the refrigerant between the first expansion device and the second expansion device, the method comprising the step of:
 - controlling the path change device when the refrigerant flow path is changed from the second expansion device to the first expansion device so that a simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device and the second expansion device is maintained for a predetermined time.
11. The method according to claim 10, wherein:
 - the path change device is a 3-way valve adapted to change the refrigerant flow path in accordance with a rotation of a stepping motor; and
 - the step of controlling the path change device comprises the step of rotating the stepping motor to cause the refrigerant flow path to be changed from the second expansion device to the first expansion device, while temporarily stopping, for the predetermined time, the rotation of the stepping motor at a rotation angle thereof corresponding to the simultaneous opening stage.
12. The method according to claim 10, further comprising the step of:
 - controlling the path change device when the refrigerant flow path is changed from the first expansion device to the second expansion device so that there is no time for maintaining the simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device and the second expansion device.
13. The method according to claim 10, wherein the predetermined time is longer than a time, for which the simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device

and the second expansion device is maintained due to mechanical characteristics of the path change valve when the refrigerant flow path is changed from the first expansion device to the second expansion device.

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FIG 1

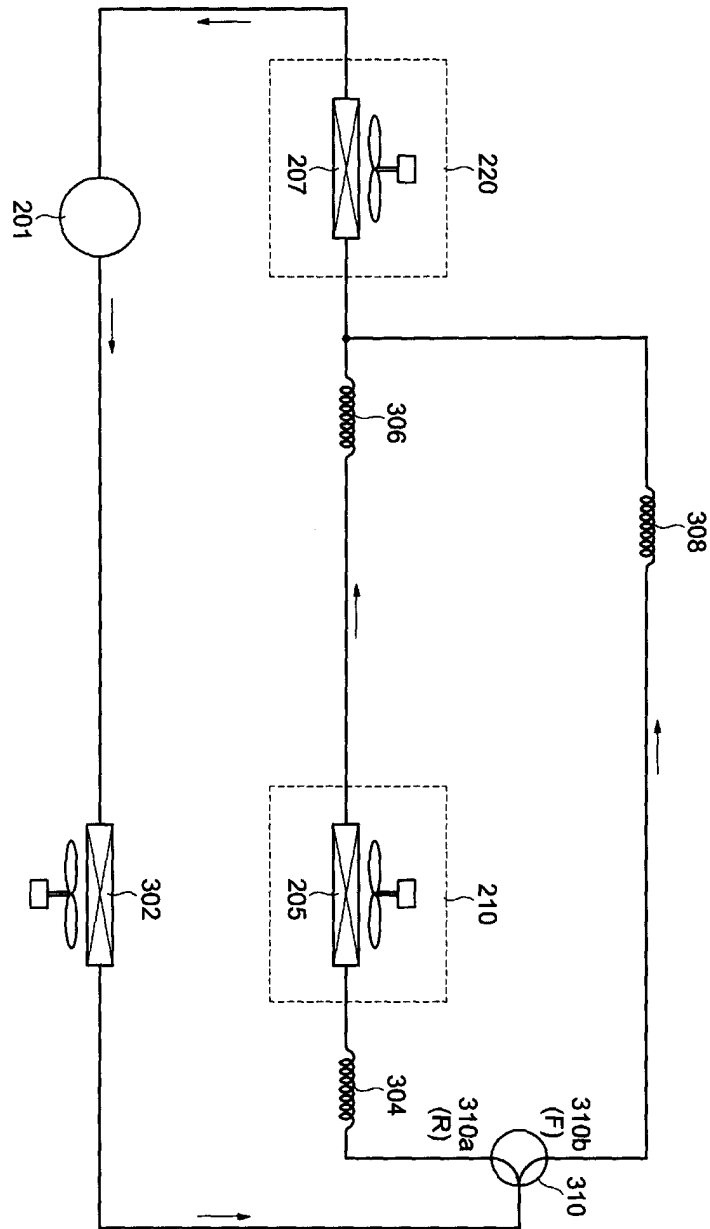


FIG 2

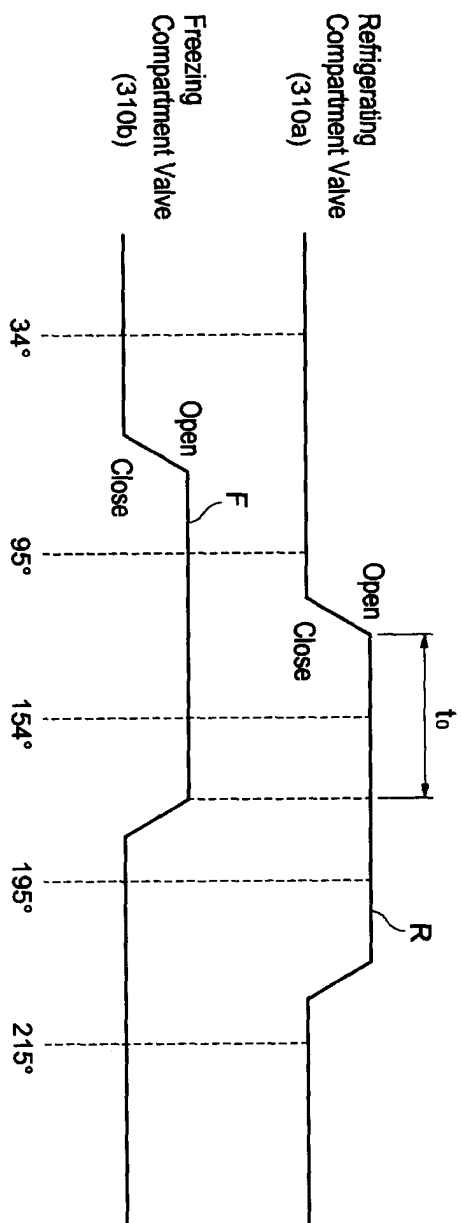


FIG 3

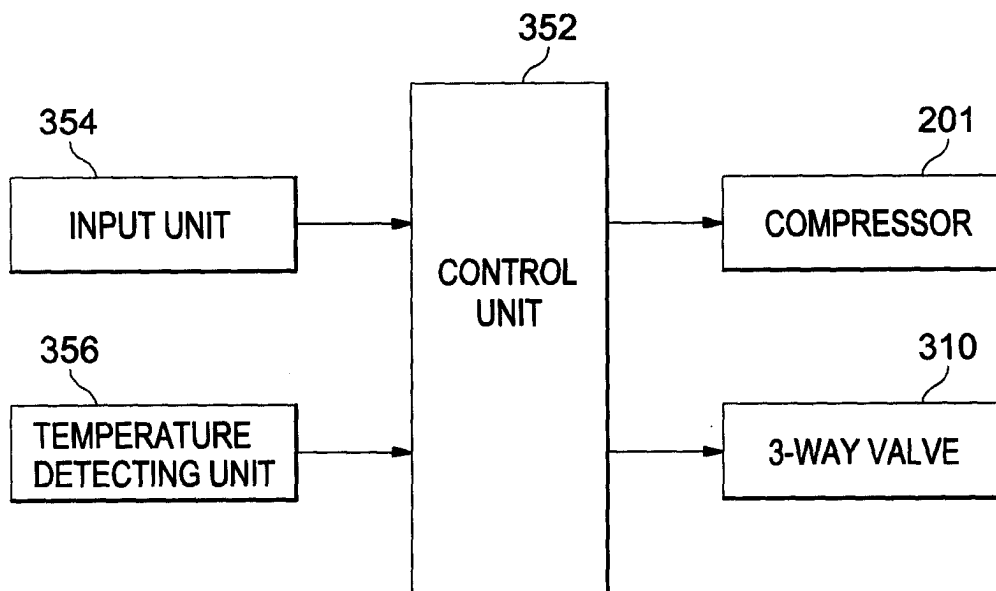


FIG 4

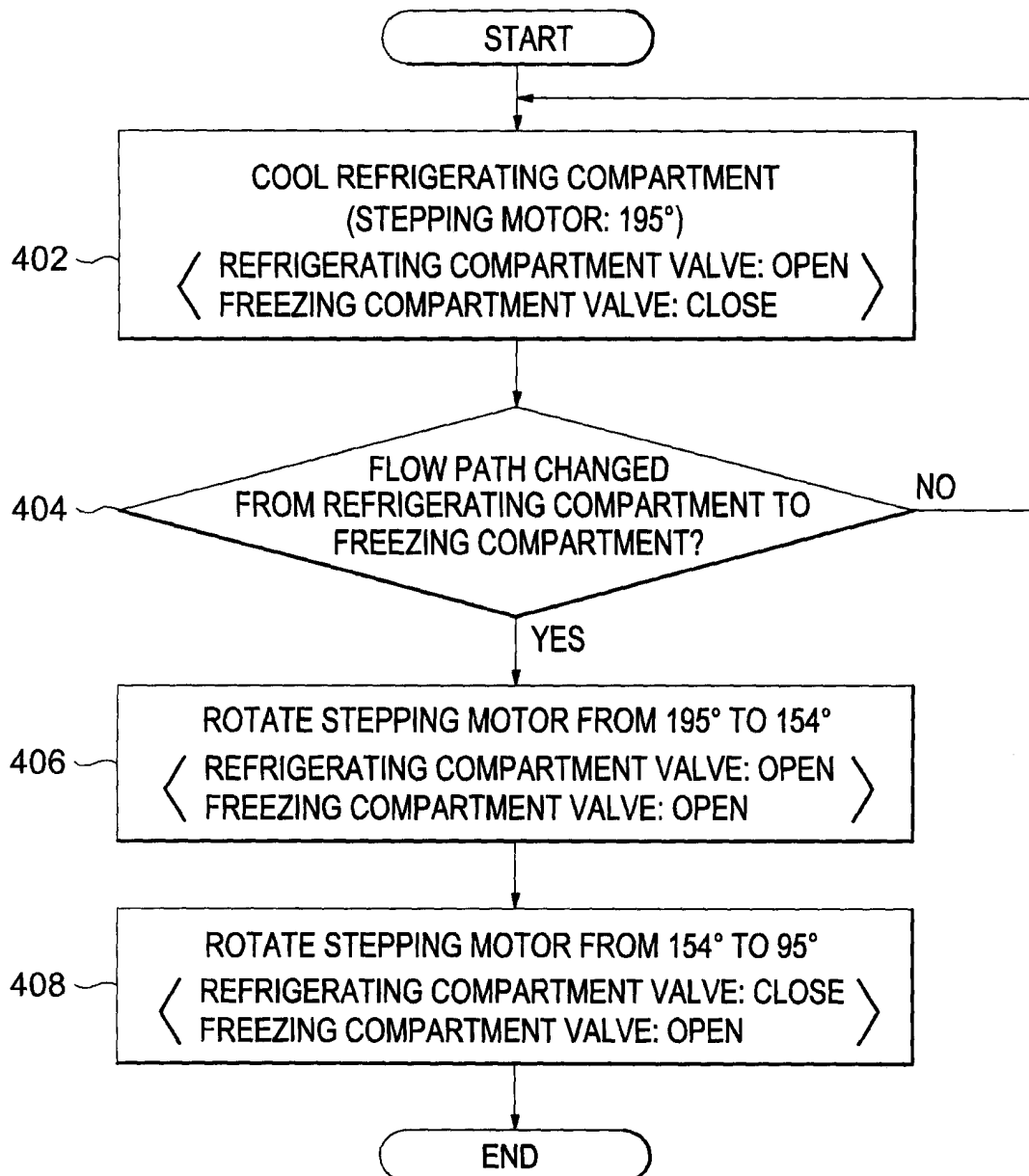


FIG 5

