(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 December 2009 (30.12.2009)

PCT

(10) International Publication Number
WO 2009/158612 A2

(51) International Patent Classification:
*F25B 47/02* (2006.01) *F25B 41/04* (2006.01)
*F25B 5/00* (2006.01)

(21) International Application Number:
PCT/US2009/048850

(22) International Filing Date:
26 June 2009 (26.06.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/076,236 27 June 2008 (27.06.2008) US

(71) Applicant *(for all designated States except US)*: **CARRIER CORPORATION** [US/US]; One Carrier Place, Farmington, CT 06034 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ZHANG, FeiHong** [CN/CN]; Room 601, No. 14, Lane 666, Rd, Taierzhuang, Pudong New Area, Shanghai (CN). **ZHANG, JianMing** [CN/CN]; No. 3239, Shenjiang Road, Pudong New Area, Shanghai (CN).

(74) Agent: **HABELT, William W.**; 250 South Clinton Street, Suite 300, Syracuse, NY 13202 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published**:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: HOT GAS DEFROST PROCESS

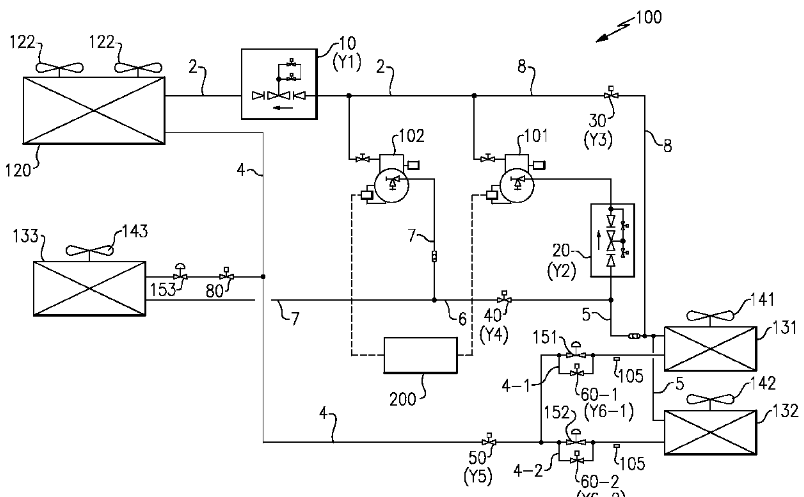


FIG.1

(57) **Abstract**: A hot gas defrost process is disclosed for defrosting an evaporator of a refrigeration system. In an exemplary embodiment, the hot gas defrost process includes the step of flooding at least one evaporator to be defrosted with liquid refrigerant prior to supplying a hot refrigerant vapor to the liquid flooded evaporator. In an exemplary embodiment, the hot gas process includes the step of suctioning down the refrigeration pressure within the evaporator upon termination of the supplying of the hot refrigerant vapor to the evaporator being defrosted.

WO 2009/158612 A2

# HOT GAS DEFROST PROCESS

## Cross-Reference to Related Application

**[0001]** This international patent application claims priority from and the benefit of provisional U.S. Patent Application serial number 61/076,236, filed June 27, 2008.

## Field of the Invention

**[0002]** This invention relates generally to refrigeration systems and, more particularly, to a hot gas defrost process for defrosting an evaporator of a commercial refrigeration system.

## Background of the Invention

**[0003]** Commercial refrigeration systems, such as the central refrigeration systems found in supermarket applications, include multiple refrigerant vapor compressors, centrally located, that provide refrigerant to a plurality of evaporators. Typically, the evaporators may be located at various locations throughout the store in connection with a number of refrigerated merchandisers for displaying refrigerated products, such as diary products, fresh poultry, fish, meat products and produce, or frozen products, such as frozen fish, poultry, meat products, ice cream, frozen confections and other frozen products, and even walk-in cold rooms and freezers.

**[0004]** Refrigeration systems of this type include the following basic components: a plurality of refrigerant vapor compressors, at least one condenser, a plurality of evaporators, interconnected in a refrigerant circuit, with an expansion device operatively associated with each evaporator. In operation, hot compressed refrigerant vapor discharges from the compressors into the refrigerant circuit and passes through the condenser in heat exchange relationship with a cooling medium, commonly ambient air. In traversing the condenser, the refrigerant vapor is condensed to a liquid. The warm, high pressure liquid refrigerant is thence distributed amongst the plurality of evaporators. Prior to entering a respective evaporator, the warm, high pressure liquid traverses the expansion device operatively associated with that respective evaporator and undergoes an expansion to a lower pressure vapor or liquid/vapor mixture. This lower temperature, low pressure liquid or liquid/vapor mixture thence flows through the evaporator in heat exchange relationship with air from the refrigerated space associated with the evaporator and absorbs heat from the air whereby the air is chilled and the refrigerant is evaporated. The low pressure vapor leaving the evaporators thence returns to the suction inlet of the compressor or a suction manifold supplying a plurality of compressors.

**[0005]** Over time frost and/or ice builds up on the respective heat exchange coils of the various evaporators. If the build up becomes excessive, air flow through the evaporator will be reduced as the air flow passage becomes more and more restricted, thereby causing a loss of refrigeration capacity. Consequently, it is customarily practice to defrost the heat exchange coils of the various evaporators, either on demand or at timed intervals, to melt frost and ice accumulated on the heat exchange coils. One method commonly employed to defrost the heat exchange coils of the evaporators is known as hot gas defrost.

**[0006]** In the hot gas defrost method, hot refrigerant vapor discharging from the compressors is redirected to evaporators to be defrosted, rather than passed through the condenser. This redirected hot refrigerant vapor passes through the heat exchange coil of the evaporator being defrosted in a reverse direction. The frost and/or ice accumulated on the heat exchange coil melts and the hot refrigerant vapor cools and condenses to a liquid before leaving the evaporator.

**Summary of the Invention**

**[0007]** In an aspect, this invention is directed at a hot gas defrost process for a refrigeration system having an evaporator to be defrosted, the process characterized by the step of flooding the evaporator to be defrosted with liquid refrigerant prior to supplying hot refrigerant vapor to the evaporator.

**[0008]** In an aspect, this invention is directed at a hot gas defrost process for a refrigeration system having an evaporator to be defrosted, the process characterized by the step of suctioning down a refrigerant pressure within the evaporator being defrosted following termination of supplying hot refrigerant vapor to the evaporator.

**[0009]** In an aspect, this invention is directed at a hot gas defrost process for a refrigeration system having at least a pair of compressors, at least a pair of evaporators and a condenser disposed in a refrigerant circuit, said hot gas defrost process comprising the steps of: flooding at least one evaporator to be defrosted with liquid refrigerant; supplying hot refrigerant vapor to the liquid flooded evaporator; suctioning down the refrigeration pressure within the evaporator upon termination of the supplying of hot refrigerant vapor to the evaporator being defrosted; and resetting the refrigeration system in condition for operation in a cooling mode.

**[0010]** In an aspect, this invention is directed at a refrigeration system including at least a pair of compressors, at least a pair of evaporators and a condenser disposed in a refrigerant circuit, the refrigeration system being selectively operable in a cooling mode of operation and a defrost mode of operation. The refrigeration system includes a plurality of flow control valves disposed in the refrigeration circuit, the flow control valves being selectively positionable in an open position and a closed position. One of the plurality of flow control valves is disposed in a refrigerant line interconnecting a refrigerant suction line to a first of the compressors in fluid flow communication with a refrigerant suction line to a second of the compressors.

**[0011]** In an aspect of the invention, a refrigeration system including a first compressor and a second compressor disposed in parallel relationship with respect to refrigerant flow, a condenser, a first evaporator and a second evaporator disposed in parallel relationship with respect to refrigerant flow, connected in a refrigerant circuit, a condenser fan operatively associated with the condenser, a first evaporator fan operatively associated with the first evaporator, a second evaporator fan operatively associated with the second evaporator, a first expansion device operatively associated with the first evaporator and a second expansion device operatively associated with the second evaporator, and a control system for selectively operating the refrigeration system in a cooling mode of operation and an evaporator defrost mode of operation. The control system includes: a first flow control valve disposed in the refrigerant circuit downstream with respect to refrigerant flow of the first and second compressors and upstream with respect to refrigerant flow of the condenser, a second flow control valve disposed in the refrigerant circuit in a suction line to the first compressor interconnecting the plurality of evaporators to a suction inlet of the first compressor, a third flow control valve disposed in a refrigerant line that extends in parallel relationship with respect to refrigerant flow with the first and second compressors from a location in the suction line to the first compressor upstream with respect to refrigerant flow of the second flow control valve, and a fourth flow control valve disposed in a refrigerant line interconnecting a suction line to the second compressor to the suction line to the first compressor at a location in the suction line to the first compressor upstream of the second flow control valve. The refrigeration system may also include a fifth flow control valve disposed in the refrigerant circuit downstream with respect to refrigerant flow of the condenser and upstream with respect to refrigerant flow of the plurality of evaporators, a sixth flow control valve disposed upstream with respect to refrigerant flow of the first evaporator in a refrigerant branch line bypassing the first expansion device, and a seventh flow control valve disposed upstream with respect to refrigerant flow of the second evaporator in a refrigerant branch line bypassing the second expansion device. The control system further includes a controller operative to control the opening and closing of each of the various flow control valves, to control operation of the first compressor and the second compressor, to control operation of the condenser fan, and to control operation of the first evaporator fan and the second evaporator fan.

**Brief Description of the Drawings**

**[0012]** FIG. 1 is a schematic diagram illustrating an exemplary embodiment of a refrigeration system equipped with a hot gas defrost system in accord with the invention;

**[0013]** FIG. 2 is a table presenting the status of various valves and other components within the refrigeration system shown in FIG. 1 at each of the steps of the hot gas defrost process of the invention;

**[0014]** FIG. 3 is a schematic diagram of the exemplary embodiment of the refrigeration system shown in FIG. 1 illustrating the status of various valves and other components within the refrigeration system during operation in a cooling mode;

**[0015]** FIG. 4 is a schematic diagram of the exemplary embodiment of the refrigeration system shown in FIG. 1 illustrating the status of various valves and other components within the refrigeration system during operation in a first step of the defrost mode;

**[0016]** FIG. 5 is a schematic diagram of the exemplary embodiment of the refrigeration system shown in FIG. 1 illustrating the status of various valves and other components within the refrigeration system during operation in a second step of the defrost mode;

**[0017]** FIG. 6 is a schematic diagram of the exemplary embodiment of the refrigeration system shown in FIG. 1 illustrating the status of various valves and other components within the refrigeration system during operation in a third step of the defrost mode; and

**[0018]** FIG. 7 is a schematic diagram of the exemplary embodiment of the refrigeration system shown in FIG. 1 illustrating the status of various valves and other components within the refrigeration system during operation in a fourth step of the defrost mode.

**Description of the Invention**

**[0019]** Referring initially to FIG. 1, there is depicted an exemplary embodiment of a refrigeration system 100 including a pair of refrigerant vapor compressors 101 and 102, a condenser 120, and a plurality of evaporators 131, 132 and 133, connected in a refrigerant circuit in a conventional manner. Operatively associated with each of the evaporators 131, 132, 133 is an expansion device 151, 152, 153, respectively, as in conventional practice. Each of the expansion devices 151, 152, 153 may, for example for purposes of illustration but not limitation, be a conventional thermostatic expansion valve. Also operatively associated with each of the evaporators 131, 132, 133 is an evaporator fan 141, 142, 143, respectively, for passing air to be cooled and supplied to a climate-controlled space, such as for example the display zone of a product merchandiser or cold room or the like, through its associated evaporator in heat exchange relationship with refrigerant from the refrigerant circuit, whereby the air is cooled and the refrigerant evaporated. One or more condenser fans 122 are provided in operative association with the condenser 120 for passing ambient air through the condenser in heat exchange relationship with the hot, high pressure refrigerant discharged from the compressors 101, 102, whereby the hot, high pressure refrigerant is cooled and condensed to a high pressure liquid.

**[0020]** The refrigeration system 100 also includes a plurality of flow control valves 10, 20, 30, 40, 50, 60-1 and 60-2 disposed at various locations in the refrigerant circuit for selectively opening or closing selected branches of the refrigerant circuit to refrigerant flow therethrough. The first flow control valve 10 is disposed in refrigerant line 2 of the refrigerant circuit downstream with respect to refrigerant flow of the point at which the refrigerant flows from the respective discharge outlets of the first and second compressors 101, 102 combine and upstream with respect to refrigerant flow of the condenser 120. The second flow control valve 20 is disposed in refrigerant suction line 5 upstream with respect to refrigerant flow of the suction inlet to the first compressor 101. The third flow control valve 30 is disposed in refrigerant vapor line 8. As seen in FIG. 1, the refrigerant vapor line 8 extends in parallel relationship with respect to refrigerant flow with the first and second compressors from a location in the suction line 5 to the first compressor 101 upstream with respect to refrigerant flow of the second flow control valve 20. The fourth flow control valve 40 is disposed in suction line 6 that interconnects suction line 5, which is in flow communication with the first compressor 101, in fluid flow communication with suction line 7, which is in flow communication with the second compressor 102. The fifth flow control valve 50 is disposed in refrigerant line 4 that interconnects the refrigerant outlet from the condenser 120 in refrigerant flow communication with the respective refrigerant inlets to the evaporators 131 and 132. The sixth flow control valve 60-1 is disposed in refrigerant line branch 4-1 intermediate the fifth flow control valve 50 and the evaporator 131. The seventh flow control valve 60-2 is disposed in refrigerant line branch 4-2 intermediate the fifth flow control valve 50 and the evaporator 132. Refrigerant line branch 4-1 provides a flow path bypassing the expansion valve 151 and the refrigerant line branch 4-2 provides a flow path bypassing the expansion valve 152. An additional flow control valve 80 may be disposed in the refrigerant branch line 4-3 upstream of the expansion valve 153. Each of the afore-mentioned flow control valves 10, 20, 30, 40, 50, 60-1, 60-2, 80 may comprise a solenoid valve having an open position in which fluid may pass through the valve and a closed position in which fluid can not flow through the valve.

**[0021]** The operation of the refrigeration system 100 may be switched from a cooling mode wherein the evaporators 131 and 132 cool air to be supplied to a temperature controlled space to a defrost mode wherein hot gas is used to defrost the evaporators 131 and 132, by selective positioning of the various valves 10, 20, 30, 40, 50, 60-1 and 60-2, and selective operation of the first compressor 101, the second compressor 102, the evaporator fans 141, 142 and the condenser fan(s) 122, in accord with the status schedule set forth in the table presented in FIG. 2. The refrigeration system 100 may include a controller 200, such as for example for a microprocessor controller, in operative association with each of the afore-mentioned valves, as well as other components of the system including the first and second compressors 101, 102, the evaporator fans 141, 142 and 143, and the condenser fan(s) 122, to selectively control the positioning of the various valves and the operational status of various system components to carry out the hot gas defrost process based upon processing of signals from the defrost sensors 105 operatively associated with the respective evaporators 131 and 132.

**[0022]** In the table presented in FIG. 2, it is to be understood that: "Comp 1" refers to the first compressor 101; "Comp 2" refers to the second compressor 102; "Y1" refers to the first flow control valve 10; "Y2" refers to the second flow control valve 20; "Y3" refers to the third flow control valve 30; "Y4" refers to the fourth flow control valve 40; "Y5" refers to the fifth flow control valve 50; "Y6-1" refers to the sixth flow control valve 60-1; "Y6-2" refers to the seventh flow control valve 60-2; "Cond Fan" refers to the condenser fan(s) 122; and "Evap Fan" refers to the evaporator fans 141 and 142 associated with the evaporators 131 and 132, respectively. Additionally, in FIGs. 3-7, the reference characters shown therein refer to the same components as those respective reference characters refer to in FIG. 1 and are described hereinbefore with respect to FIG. 1. As used in the table presented in FIG. 2 and throughout the application, "ON" means the subject component is in operation; "OFF" means the subject component is not in operation; "OPEN" means the subject valve is positioned as to permit fluid to flow therethrough; and "CLOSED" means the subject valve is positioned so as to block the flow of fluid therethrough.

**[0023]** Referring now to FIGs. 2 and 3 in particular, in operation of the refrigeration system 100 in the cooling mode (time t0 in FIG. 2), both the first compressor 101 and the second compressor 102 are ON, the condenser fan(s) 122 is ON, the evaporator fans 141, 142 are ON, flow control valves 10, 20, 50 are OPEN, and flow control valves 30, 40, 60-1, 60-2 are CLOSED. With flow control valve 10 open and flow control valve 30 closed, the hot, high pressure refrigerant vapor discharging from both the first and second compressors 101, 102 passes to the condenser through refrigerant line 2. With the flow control valve 4 closed, the first compressor 101 is supplied with suction pressure refrigerant from the evaporators 131, 132 through suction line 5 and the second compressor 102 is supplied with suction pressure refrigerant from the evaporator 133 through suction line 7. Thus, in the cooling mode, the compressors 101, 102 discharge to a common refrigerant line 2 and share the condenser 120 with the first compressor 101, the condenser 120 and the evaporators 131, 132 being connected in refrigerant flow communication in a first refrigerant loop, while the second compressor 102, the condenser 120 and the evaporator 133 being connected in refrigerant flow communication in a second refrigerant loop.

**[0024]** Referring now to FIGs. 2 and 4 in particular, in step 1 of operation of the refrigeration system 10 in the defrost mode (time t1 in FIG. 2), the first compressor 101 is OFF, the second compressor 102 in ON, the evaporator fans 141 and 142 are OFF, the condenser fan 122 is ON, flow control valves 10, 50, 60-1, 60-2 are open, and flow control valves 20, 30, 40 are closed. In this mode, the evaporators 131, 132 are flooded with liquid refrigerant from the condenser 120 flowing through refrigerant line 4 and branches 4-1 and 4-2 bypassing the expansion valves 151 and 152, flow control valves 50, 60-1 and 60-2 being in their open position.

**[0025]** Referring now to FIGs. 2 and 5 in particular, in step 2 of operation of the refrigeration system 10 in the defrost mode (time t2 in FIG. 2), hot gas, i.e. hot refrigerant vapor from the second compressor 102, is passed through the evaporators 131, 132 in a reverse direction. In this step of the defrost mode, the first compressor 101 remains OFF, the second compressor 102 is ON, the condenser fan(s) 122 and the evaporator fans 141, 142 are OFF, flow control valves 10, 20, 40 are closed, and flow control valves 30, 50, 60-1, 60-2 are OPEN. With the flow control valve 10 closed and the flow control valve 30 open, the hot refrigerant vapor discharging from the second compressor 102 passes through refrigerant vapor line 8 and through the respective heat exchange surface within the evaporators 131, 132 to melt frost and ice accumulated on the evaporator heat exchange surface. In this step, the first flow control valve 10 functions as a pressure valve. When the temperature sensed by the defrost sensor 105 associated with the evaporator 131 reaches a termination temperature, the flow control valve 60-1 will be closed. Similarly, when the temperature sensed by the defrost sensor 105 associated with the evaporator 132 reaches a termination temperature, the flow control valve 60-2 will be closed

**[0026]** Referring now to FIGs. 2 and 6 in particular, in step 3 of operation of the refrigeration system 10 in the defrost mode (time t3 in FIG. 2), the flow of hot gas is terminated by positioning the flow control valve 30 in is CLOSED position. Additionally, both the flow control valve 10 and the flow control valve 40 are positioned in their respective OPEN position. The first compressor 101 remains OFF, the second compressor is ON, the condenser fan(s) 122 are turned ON, while the evaporator fans 141, 142 remain OFF. In this step of the defrost process, flow control valves 10, 40, 60-1, 60-2 are OPEN and flow control valves 20, 30, 50 are CLOSED. With the refrigeration system 100 so configured, the second compressor 102 draws refrigerant from all the evaporators, including any refrigerant remaining in the evaporators 131, 132 and the refrigerant line 4 between the closed flow control valve 50 and the evaporators 131, 132.

**[0027]** Referring now to FIGs. 2 and 7 in particular, in step 4 of operation of the refrigeration system 10 in the defrost mode (time t4 in FIG. 2), the refrigeration system 100 is transitioned from the hot gas defrost mode back to the cooling mode. In this step, the second compressor 102 remains ON and the first compressor 101 is turned back ON. The condenser fan(s) is ON. The evaporator fans 141, 142 remain OFF for the first few minutes of the step 4 period and then are turned back ON for operation of the evaporators 131, 132 in the cooling mode. The flow control valves 10, 20 are OPEN and the flow control valves 30, 40, 60-1, 60-2 are closed. The flow control valve 50 remains in its CLOSED position for the first few minutes of the step 4 period and then is returned to its OPEN position when the evaporator fans 141, 142 are turned on. At the close of this transition step, the defrost process cycle has been completed and the refrigeration system 100 is returned to the cooling mode with the position status of the flow control valves and the operation status of other system components are all reset for operation of the refrigeration system 100 in the cooling mode.

**[0028]** Thus, the hot gas defrost process includes four steps: step 1 being liquid flooding of the evaporator(s) to be defrosted; step 2 being hot gas (hot refrigerant vapor) discharge to the evaporator(s) being defrosted; step 3 being drip time and pressure down to suction pressure of the evaporator(s) having been defrosted; and step 4 being cooling mode restarting. The liquid flooding of the evaporator(s) to be defrosted in the beginning of the defrost process fills the heat exchange coil(s) of the evaporator(s) to be defrosted with warm refrigerant liquid to prepare for the discharging of hot refrigerant vapor into those coils. The discharge of hot refrigerant vapor to heat exchange coil(s) of the evaporator(s) being defrosted is terminated when the temperature of the refrigerant line sensed by the defrost sensors 105 has reached a termination temperature. At this point, refrigerant is drawn out of the evaporator(s) having been defrosted to return the refrigerant pressure therein to suction pressure and permit drip down of liquid refrigerant to guard against wet running when the refrigeration system 100 is returned to operation in the cooling mode.

**We Claim:**

1. A hot gas defrost process for a refrigeration system having an evaporator to be defrosted said process characterized by the step of flooding the evaporator to be defrosted with liquid refrigerant prior to supplying a hot refrigerant vapor to the evaporator.

2. A hot gas defrost process for a refrigeration system having an evaporator to be defrosted said process characterized by the step of suctioning down a refrigerant pressure within the evaporator being defrosted following termination of supplying a hot refrigerant vapor to the evaporator.

3. A hot gas defrost process for a refrigeration system having at least a pair of compressors, at least a pair of evaporators and a condenser disposed in a refrigerant circuit, said hot gas defrost process comprising the steps of:

flooding at least one evaporator to be defrosted with liquid refrigerant;

supplying a hot refrigerant vapor to the liquid flooded evaporator;

suctioning down the refrigeration pressure within the evaporator upon termination of the supplying of the hot refrigerant vapor to the evaporator being defrosted; and

resetting the refrigeration system in condition for operation in a cooling mode.

4. A refrigeration system including at least a pair of compressors, at least a pair of evaporators and a condenser disposed in a refrigerant circuit, said refrigeration system selectively operable in a cooling mode of operation and a defrost mode of operation, said refrigeration system including a plurality of flow control valves disposed in said refrigeration circuit, said flow control valves selectively positionable in an open position and a closed position, said refrigeration system characterized by one of the plurality of flow control valves being disposed in a refrigerant line interconnecting a refrigerant suction line to a first of said at least a pair of compressors in fluid flow communication with a refrigerant suction line to a second of said at least a pair of compressors.

5. A refrigeration system including a first compressor and a second compressor disposed in parallel relationship with respect to refrigerant flow, a condenser, a first evaporator and a second evaporator disposed in parallel relationship with respect to refrigerant flow, connected in a refrigerant circuit, a condenser fan operatively associated with the condenser, a first evaporator fan operatively associated with the first evaporator, a second evaporator fan operatively associated with the second evaporator, a first expansion device operatively associated with the first evaporator and a second expansion device operatively associated with the second evaporator, and a control system for selectively operating the refrigeration system in a cooling mode of operation and an evaporator defrost mode of operation, characterized in that said control system comprises:

a first flow control valve disposed in the refrigerant circuit downstream with respect to refrigerant flow of the first and second compressors and upstream with respect to refrigerant flow of the condenser;

a second flow control valve disposed in the refrigerant circuit in a suction line to the first compressor interconnecting the plurality of evaporators to a suction inlet of the first compressor;

a third flow control valve disposed in a refrigerant line that extends in parallel relationship with respect to refrigerant flow with the first and second compressors from a location in the suction line to the first compressor upstream with respect to refrigerant flow of the second flow control valve; and

a fourth flow control valve disposed in a refrigerant line interconnecting a suction line to the second compressor to the suction line to the first compressor at a location in the suction line to the first compressor upstream of the second flow control valve.

6. A refrigeration system as recited in claim 5 further characterized in that said control system further comprises:

a fifth flow control valve disposed in the refrigerant circuit downstream with respect to refrigerant flow of the condenser and upstream with respect to refrigerant flow of the plurality of evaporators;

a sixth flow control valve disposed upstream with respect to refrigerant flow of the first evaporator in a refrigerant branch line bypassing the first expansion device; and

a seventh flow control valve disposed upstream with respect to refrigerant flow of the second evaporator in a refrigerant branch line bypassing the second expansion device.

7. A refrigeration system as recited in claim 6 further characterized in that said control system further comprises a controller operative to control the opening and closing of each of the first, second, third, fourth, fifth, sixth and seventh flow control valves, to control operation of the first compressor and the second compressor, to control operation of the condenser fan, and to control operation of the first evaporator fan and the second evaporator fan.

8. A refrigeration system as recited in claim 7 wherein said controller is operative, when operating the refrigeration system in a cooling mode, to power on the first compressor and the second compressor, the condenser fan, the first and second evaporator fans, open the first, second and fifth flow control valves, and close the third, fourth, sixth and seventh flow control valves.

9. A refrigeration system as recited in claim 7 wherein said controller is operative, when switching the refrigeration system from a cooling mode to a defrost mode, to power off the first compressor and the first and second evaporator fans, to power on the second compressor and the condenser fan, to open the first, fifth, sixth and seventh flow control valves, and to close the second, third and fourth flow control valve, whereby the first and second evaporators are flooded with liquid refrigerant.

10. A refrigeration system as recited in claim 7 wherein said controller is operative, when operating the refrigeration system in a defrost mode, to power on the second compressor, to power off the first compressor, the condenser fan and the first and second evaporator fans, to open the third, fifth, sixth and seventh flow control valves, and to close the first, second and fourth flow control valves, whereby hot gas from the second compressor is directed through the first and second evaporators.

11. A refrigeration system as recited in claim 7 wherein said controller is operative, when operating the refrigeration system n a defrost, to power on the second compressor and the condenser fan, to power off the first compressor and the first and second evaporator fans, to open the first, fourth, sixth and seven flow control valves, and to close the second, third and fifth flow control valves, whereby the flow of hot gas to the first and second evaporators is terminated and refrigerant is drawn from the first and second evaporators to suction down the refrigerant pressure within the first and second evaporators..

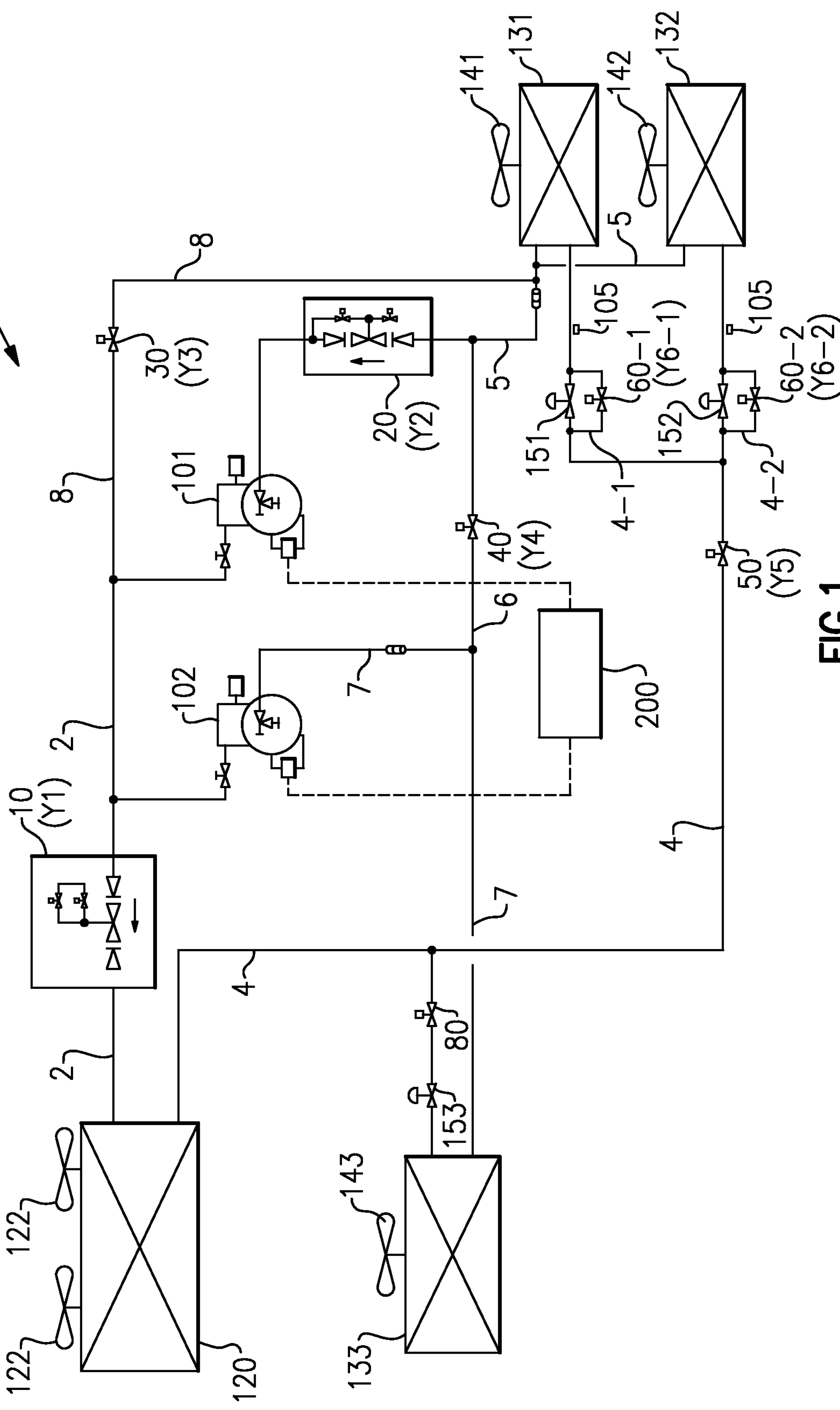
100
8
30
(Y3)
131
141
132
142
5
105
60–1
(Y6–1)
60–2
(Y6–2)
151
152
4–1
4–2
20
(Y2)
101
40
(Y4)
50
(Y5)
6
102
7
200
10
(Y1)
2
4
80
153
143
133
122
120

FIG.1

<table>
<tr><th rowspan="2">TIME</th><th rowspan="2">DESCRIPTION</th><th colspan="3">CHANNEL 1</th><th colspan="4">CHANNEL 2</th><th>CHANNEL 3</th><th>CHANNEL 4</th><th>CHANNEL 5</th></tr>
<tr><th>Y2</th><th>Y6-1, Y6-2</th><th>COMP 1</th><th>Y1</th><th>Y3</th><th>COMP 2</th><th>COND FAN</th><th>EVAP FAN</th><th>Y4</th><th>Y5</th></tr>
<tr><td>t0</td><td>PREPARATION FOR DEFROST</td><td>OPEN</td><td>CLOSE</td><td>ON</td><td rowspan="2">OPEN</td><td rowspan="2">CLOSE</td><td rowspan="2">ON</td><td rowspan="2">ON</td><td>ON</td><td rowspan="3">CLOSE</td><td rowspan="3">OPEN</td></tr>
<tr><td>t1</td><td>STEP1:LIQUID FLOODING TO THE EVAPORATOR 1 AND 2 VIA Y5 AND Y6</td><td rowspan="3">CLOSE</td><td rowspan="3">OPEN</td><td rowspan="3">OFF</td><td rowspan="4">OFF<br>A FEW MINUTES MORE</td></tr>
<tr><td>t2</td><td>STEP2: HOT GAS DEFROST</td><td>CLOSE</td><td>OPEN</td><td>FORCED ON</td><td>OFF</td></tr>
<tr><td>t3</td><td>STEP3:DRIP TIME AND PRESSURE SUCTION DOWN</td><td rowspan="3">OPEN</td><td rowspan="3">CLOSE</td><td rowspan="3">ON</td><td rowspan="3">ON</td><td>OPEN</td><td rowspan="2">CLOSE</td></tr>
<tr><td rowspan="2">t4</td><td rowspan="2">STEP34: RESTART COOLING MODE</td><td rowspan="2">OPEN</td><td rowspan="2">CLOSE</td><td rowspan="2">ON</td><td rowspan="2">CLOSE</td></tr>
<tr><td>ON</td><td>OPEN</td></tr>
</table>

FIG.2

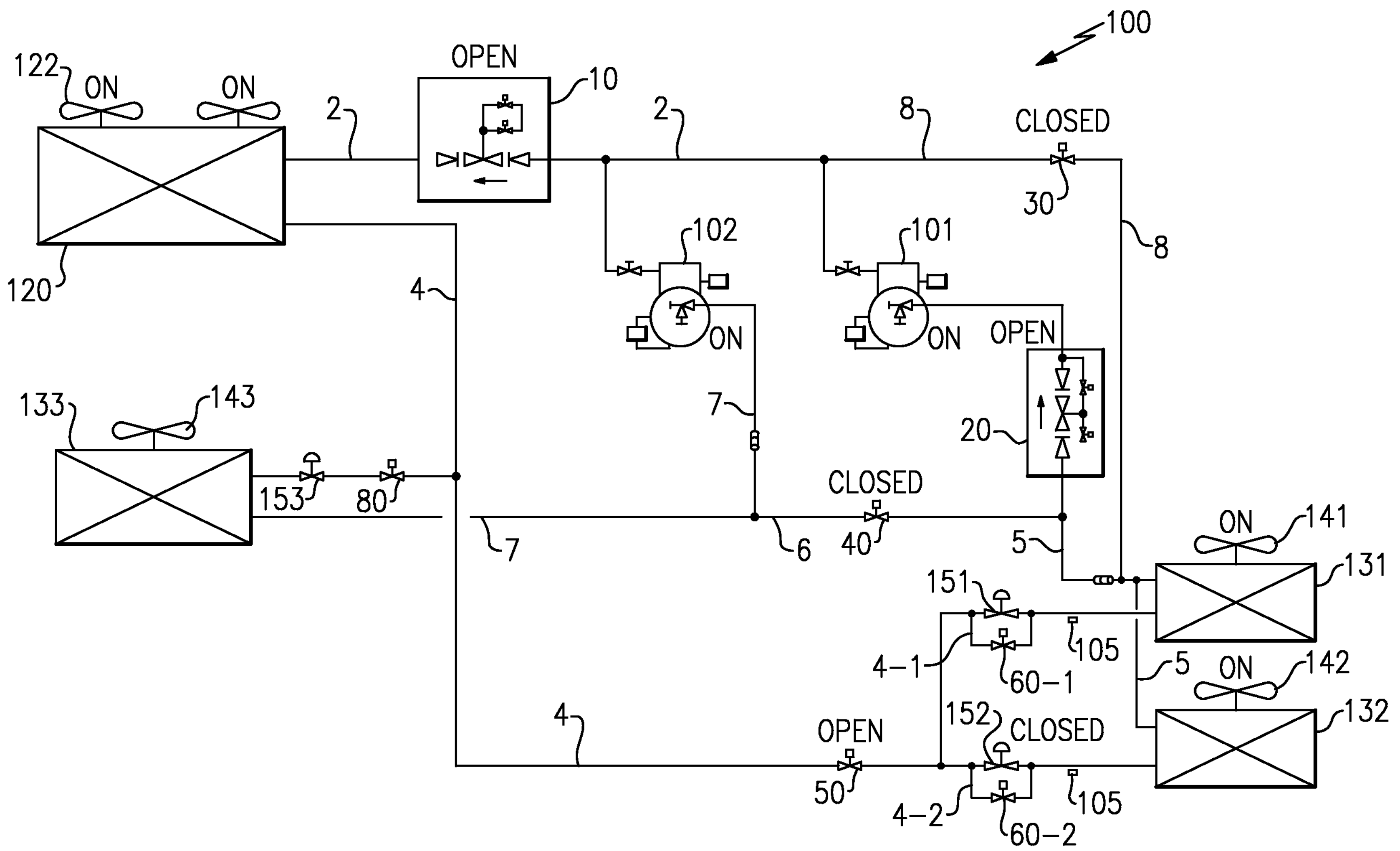
100
122
ON
ON
120
2
OPEN
10
2
8
CLOSED
30
8
102
ON
101
ON
OPEN
20
7
4
133
143
153
80
7
6
CLOSED
40
5
ON
141
131
151
105
4−1
60−1
5
ON
142
132
4
OPEN
50
152
CLOSED
105
4−2
60−2

FIG.3

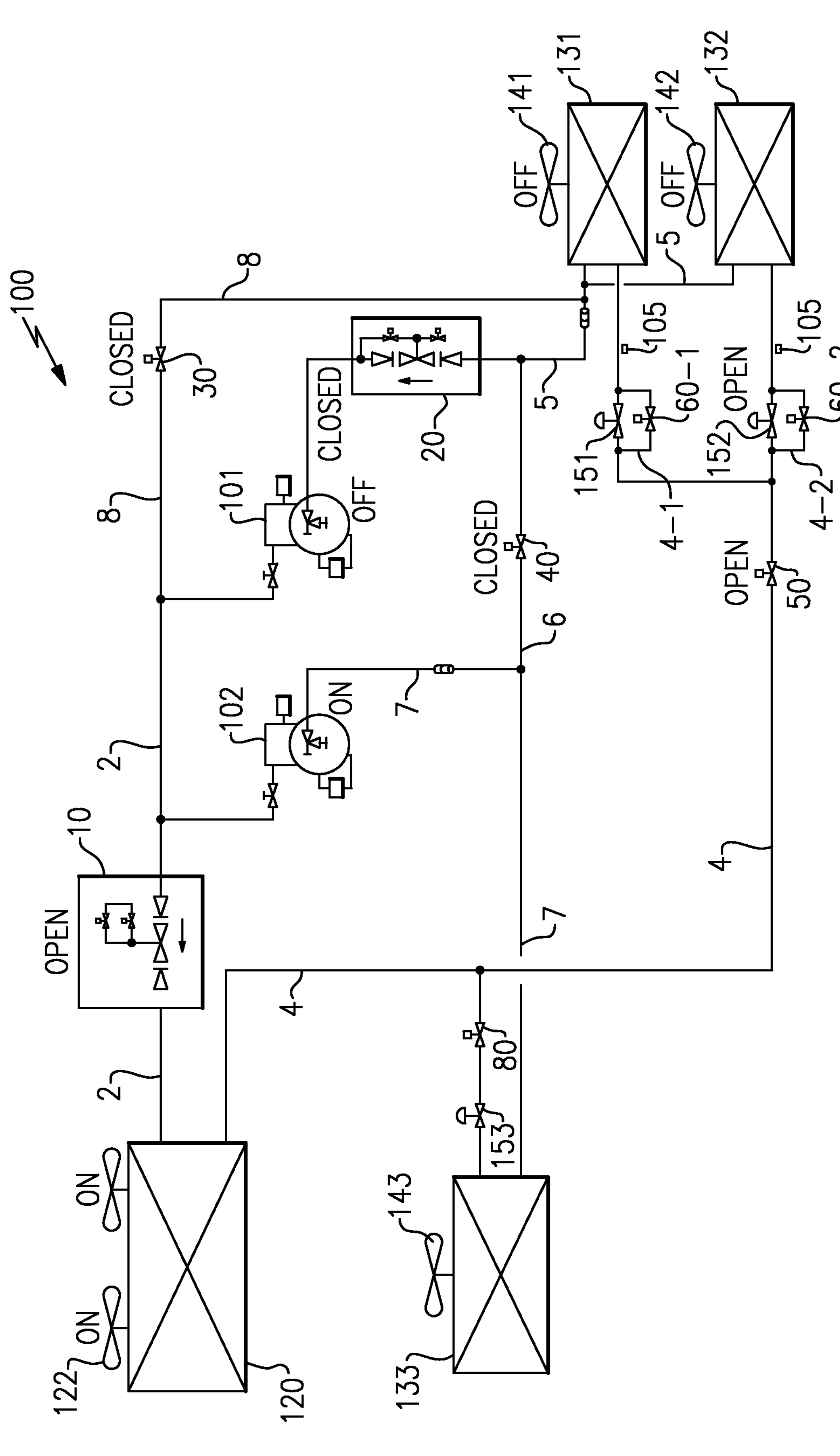
100
CLOSED
30
8
OPEN
10
2
101
OFF
102
ON
CLOSED
20
5
40
6
7
4
80
153
143
133
ON
122
120
131
141
132
142
105
60−1
60−2
151
152
4−1
4−2
50


FIG.4

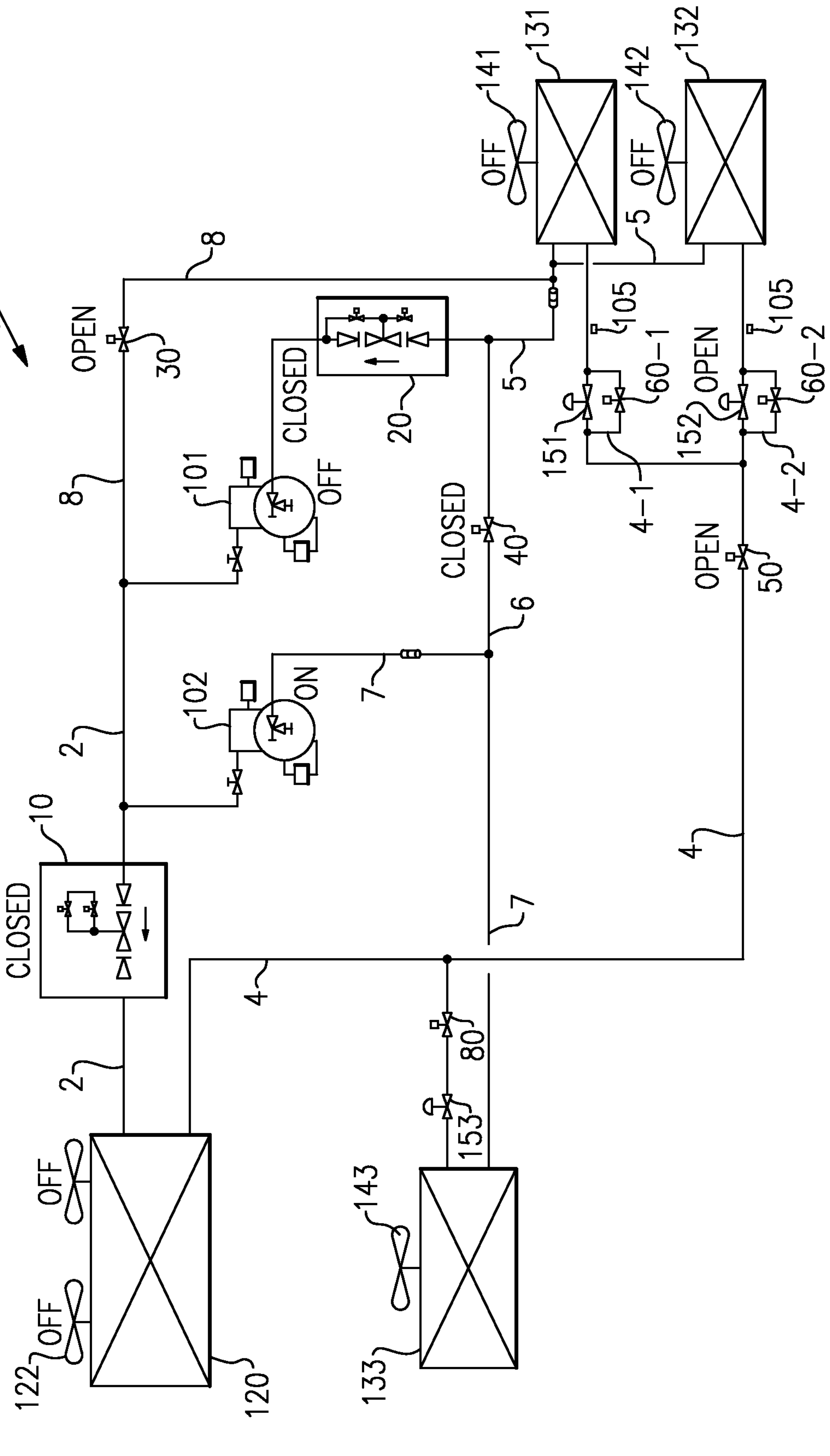
100
OPEN
30
8
141
131
OFF
142
132
OFF
5
105
105
CLOSED
20
5
60-1
OPEN
60-2
151
152
4-1
4-2
101
OFF
8
CLOSED
40
OPEN
50
6
102
ON
7
2
10
CLOSED
4
7
4
80
2
153
OFF
OFF
122
120
143
133

FIG.5

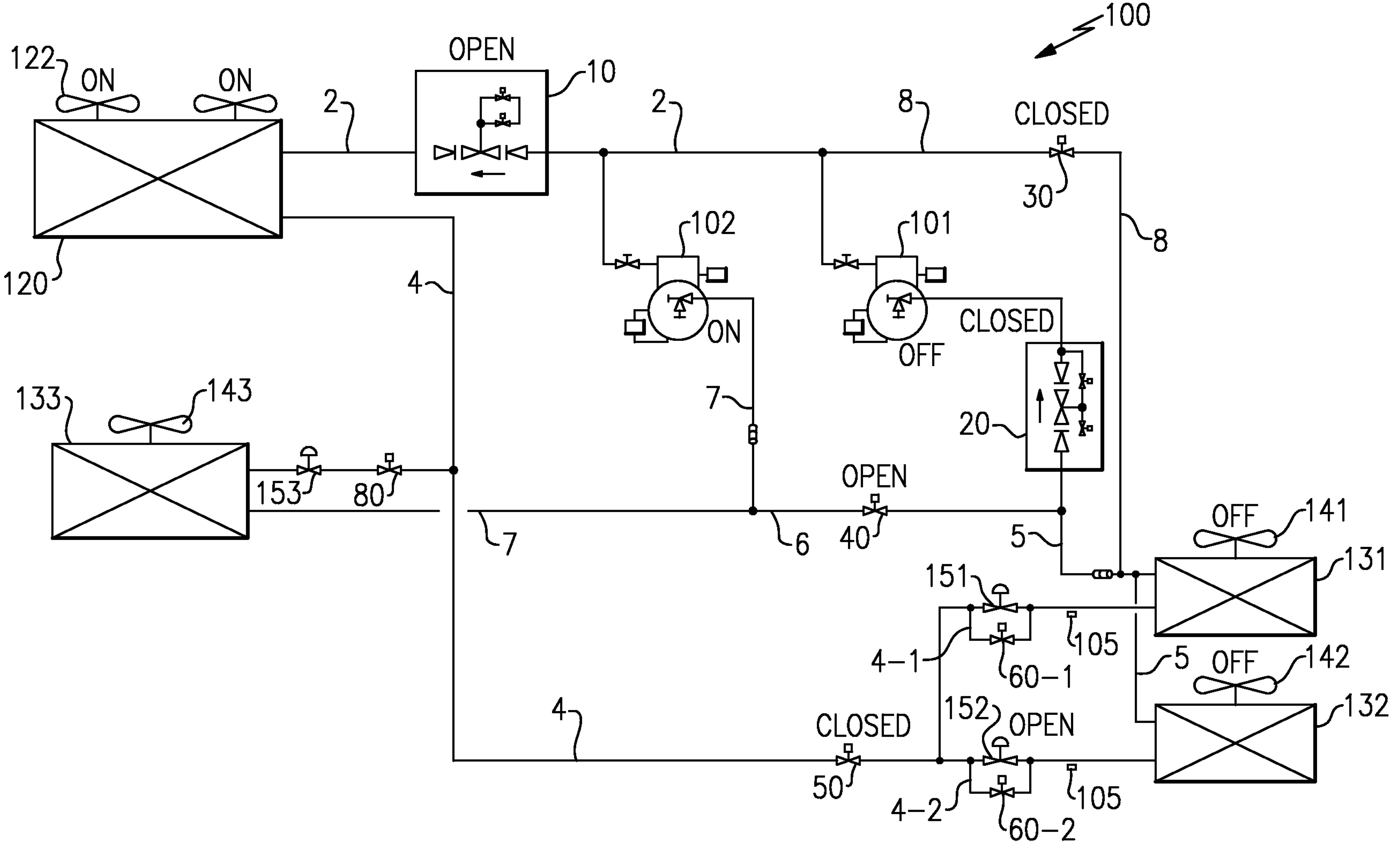
100
OPEN
10
122
ON
ON
2
2
8
CLOSED
30
8
120
102
101
4
ON
CLOSED
OFF
133
143
7
20
153
80
OPEN
7
6
40
5
OFF
141
131
151
105
4−1
60−1
5
OFF
142
4
152
OPEN
132
CLOSED
50
4−2
105
60−2

FIG.6

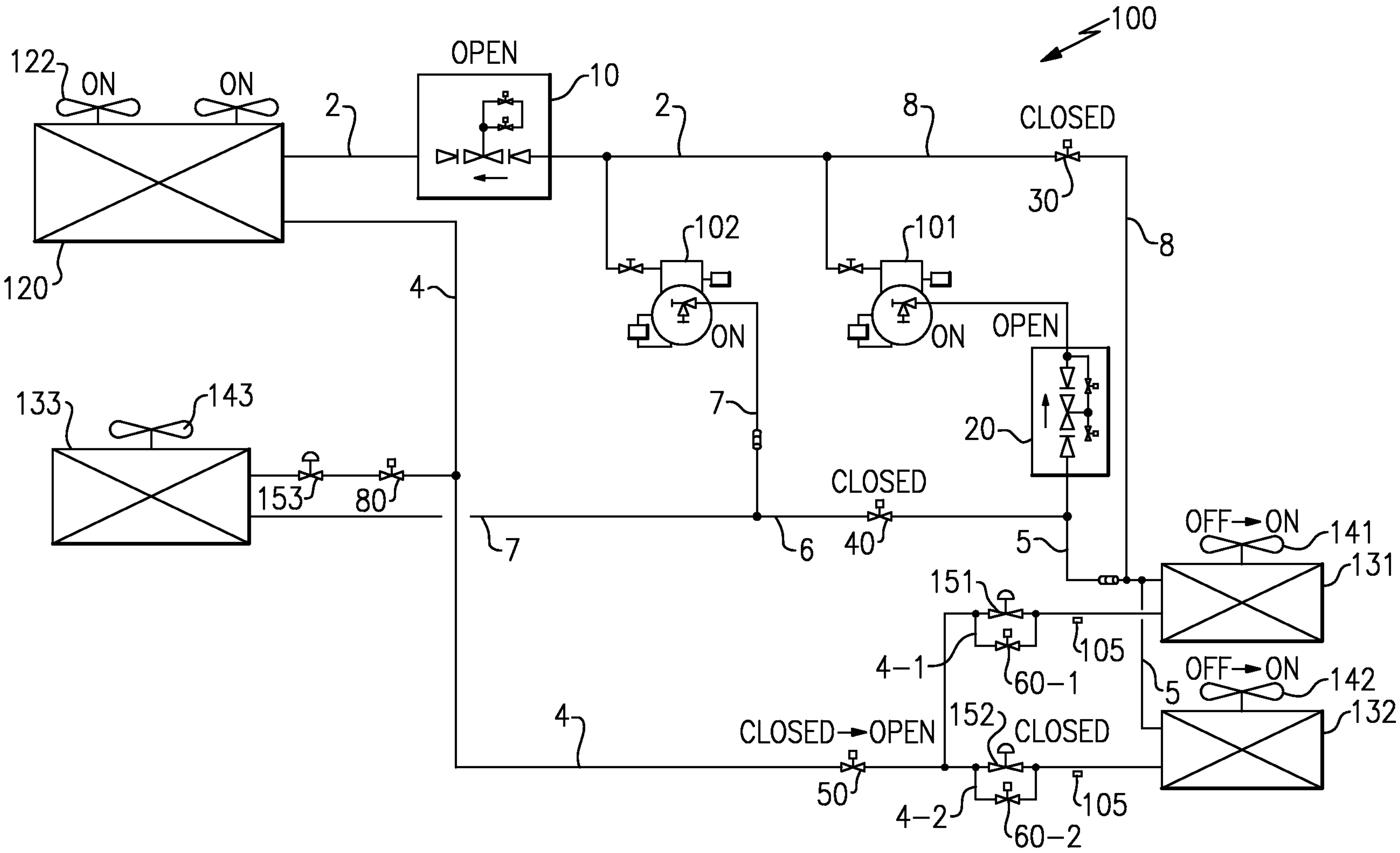
100
OPEN
10
122
ON
ON
2
2
8
CLOSED
30
8
120
102
101
ON
ON
4
OPEN
133
143
7
20
CLOSED
153
80
7
6
40
5
OFF→ON
141
131
151
105
4-1
60-1
5
OFF→ON
142
132
4
CLOSED→OPEN
152
CLOSED
50
105
4-2
60-2

FIG.7