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(54) **Heat pump**

(57) Disclosed is a heat pump including: a refrigeration cycle unit 1 that includes a compressor 10 for compressing a coolant, a first heat exchanger 14 for condensing the coolant compressed in the compressor, an expansion mechanism 16 for expanding the coolant condensed in the first heat exchanger, and a second heat exchanger 18 for evaporating the coolant expanded in the expansion mechanism 16; and a booster module 2

that is connected to the refrigeration cycle unit 1, wherein the booster module 2 separates a gaseous coolant from the coolant flowing from the first heat exchanger 14 to the expansion mechanism 16, compresses the separated gaseous coolant, and then has the compressed gaseous coolant flow between the compressor 10 and the first heat exchanger 14.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a heat pump, and more particularly to a heat pump that includes a compressor, a first heat exchanger, an expansion mechanism, and a second heat exchanger, through which a coolant is circulated, and allows the first heat exchanger to supply heat to a destination requiring heat.

2. Description of the Conventional Art

[0002] In general, a heat pump is an apparatus that cools/heats a room using a refrigeration cycle unit that includes a compressor, a first heat exchanger, an expansion mechanism, and a second heat exchanger to provide users with comfortable indoor environments.

[0003] The heat pump heats/cools a room by discharging air heated/cooled using the first heat exchanger or second heat exchanger to the room.

[0004] However, conventional heat pumps may fail to provide a sufficient cooling/heating performance corresponding to a change in ambient temperature, and thus a user may need to exchange an existing heat pump with a new one providing a larger capacity, or add another one.

SUMMARY OF THE INVENTION

[0005] An aspect of the present invention is to provide a heat pump that further includes a booster module to reinforce or increase the capacity of a refrigeration cycle unit.

[0006] Another aspect of the present invention is to provide a heat pump that may raise heating performance under a low temperature condition by injecting a gaseous coolant into a booster compressor of the booster module.

[0007] Still another aspect of the present invention is to provide a heat pump that may perform various operations according to loads and thus efficiently respond to the loads while minimizing consumption power.

[0008] In accordance with an aspect of the present invention, there is provided a heat pump including: a refrigeration cycle unit that includes a compressor for compressing a coolant, a first heat exchanger for condensing the coolant compressed in the compressor, an expansion mechanism for expanding the coolant condensed in the first heat exchanger, and a second heat exchanger for evaporating the coolant expanded in the expansion mechanism; and a booster module that is connected to the refrigeration cycle unit, wherein the booster module separates a gaseous coolant from the coolant flowing from the first heat exchanger to the expansion mechanism, compresses the separated gaseous coolant, and then has the compressed gaseous coolant flow between

the compressor and the first heat exchanger.

[0009] The booster module may include a first booster expansion mechanism that expands the coolant flowing in the first heat exchanger, a gas/liquid separator that separates the coolant expanded in the first booster expansion mechanism into a liquid coolant and a gaseous coolant, a second booster expansion mechanism that expands the gaseous coolant separated in the gas/liquid separator, and a booster compressor that compresses the coolant expanded in the second booster expansion mechanism.

[0010] The booster module may further include a booster suction pipe that guides the coolant evaporated in the second heat exchanger to be sucked into the booster compressor.

[0011] The booster module may further include a gas/liquid separator suction pipe that connects between the first booster expansion mechanism and the gas/liquid separator, a gaseous coolant discharging pipe that guides the gaseous coolant separated in the gas/liquid separator to the second booster expansion mechanism, a booster compressor suction pipe that allows the coolant expanded in the second booster expansion mechanism to be sucked into the booster compressor, and a booster compressor discharging pipe that guides the coolant discharged from the booster compressor to between the compressor and the first heat exchanger, wherein the booster suction pipe connects the booster compressor suction pipe to between the second heat exchanger and the compressor.

[0012] The booster module may further include a check valve that is provided over the booster suction pipe to prevent the coolant in the booster compressor suction pipe from being sucked through the booster suction pipe to the compressor.

[0013] The first boost expansion mechanism may be connected to the first heat exchanger via a first booster expansion mechanism suction pipe.

[0014] The gas/liquid separator may be connected to the expansion mechanism via a gas/liquid separator outlet pipe.

[0015] The compressor may be a capacity variable compressor and the booster compressor may be a constant speed compressor.

[0016] The booster compressor may have a smaller capacity than the compressor.

[0017] The heat pump may include a controller that controls the compressor, the booster compressor, and the second booster expansion mechanism based on an operation mode.

[0018] The controller may drive the compressor, stop the booster compressor, and close the second booster expansion mechanism under a general load mode.

[0019] The controller may turn off the compressor, drive the booster compressor, and close the second booster expansion mechanism under a partial load mode.

[0020] The controller may drive the compressor and

the booster compressor, and close the second booster expansion mechanism under a multi operation mode.

[0021] The controller may drive the compressor and booster compressor and open the second booster expansion mechanism under a gas injection mode.

[0022] The first heat exchanger may be a water coolant heat exchanger that performs heat exchange between water and a coolant, and connects to a room heating unit for room heating and a water heating unit for supplying hot water via a water circulation path.

[0023] Since the booster module is additionally coupled with the refrigeration cycle unit, the heat pump according to the present invention, as configured above, may simply raise a heating capacity in a cold geographical region that requires a sufficient heating capacity. Further, the heat pump may respond to various load conditions difficult to handle only with the compressor of the refrigeration cycle unit, thus capable of providing the optimum performance with lowest costs.

BRIEF DESCRIPTION OF THE DRAWING

[0024]

Fig. 1 is a view schematically illustrating a heat pump before a booster module is attached to a refrigeration cycle unit according to an embodiment of the present invention.

Fig. 2 is a view schematically illustrating a heat pump after a booster module has been attached to a refrigeration cycle unit according to an embodiment of the present invention.

Fig. 3 is schematically illustrating a heat pump wherein a water heating unit and a room heating unit are coupled with the refrigeration cycle unit according to an embodiment of the present invention.

Fig. 4 is a front view schematically illustrating a heat pump wherein a booster module is separated from a refrigeration cycle unit according to an embodiment of the present invention.

Fig. 5 is a front view schematically illustrating a heat pump wherein a booster module is attached to a refrigeration cycle unit according to an embodiment of the present invention.

Fig. 6 is a graph illustrating a P-H relationship in a heat pump according to an embodiment of the present invention, wherein a situation with a booster module is compared with a situation without a booster module.

Fig. 7 is a block diagram schematically illustrating a heat pump according to an embodiment of the present invention.

Fig. 8 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "general load mode".

Fig. 9 is a view schematically illustrating a heat pump according to an embodiment of the present inven-

tion, which depicts the flow of a coolant when the heat pump is subjected to a "partial load mode".

Fig. 10 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "multi operation mode".

Fig. 11 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "gas injection mode".

Fig. 12 is a view schematically illustrating a heat pump according to an embodiment of the present invention, wherein a booster module is mounted on a refrigeration cycle unit.

Fig. 13 is a view schematically illustrating a heat pump according to an embodiment, which depicts the flow of a coolant under a general load mode.

Fig. 14 is a view schematically illustrating a heat pump according to an embodiment, which depicts the flow of a coolant under a gas injection mode.

Fig. 15 is a view schematically illustrating a heat pump before a booster module is mounted on a refrigeration cycle unit according to an embodiment of the present invention.

Fig. 16 is a view schematically illustrating a heat pump after a booster module has been mounted on a refrigeration cycle unit according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Fig. 1 is a view schematically illustrating a heat pump before a booster module is attached to a refrigeration cycle unit according to an embodiment of the present invention, Fig. 2 is a view schematically illustrating a heat pump after a booster module has been attached to a refrigeration cycle unit according to an embodiment of the present invention, and Fig. 3 is schematically illustrating a heat pump wherein a water heating unit and a room heating unit are coupled with the refrigeration cycle unit according to an embodiment of the present invention.

[0026] The heat pump according to the embodiment of the present invention includes a refrigeration cycle unit 1 and a booster module 2.

[0027] The refrigeration cycle unit 1 may be used for room cooling/heating or water heating.

[0028] The booster module 2 may be provided to additionally increase room cooling/heating or water heating performance when the refrigeration cycle unit 1 fails to provide sufficient room cooling/heating or water heating performance, or a user wishes to raise the room cooling/heating or water heating performance.

[0029] As shown in Figs. 1 to 3, the refrigeration cycle unit 1 may include a compressor 10 that compresses a coolant, a first heat exchanger 14 that condenses the

coolant compressed in the compressor 10, an expansion mechanism 16 that expands the coolant condensed in the first heat exchanger 14, and a second heat exchanger 18 that evaporates the coolant expanded in the expansion mechanism 16.

[0030] The refrigeration cycle unit 1 may be provided for room cooling or heating, or both room cooling and heating.

[0031] The refrigeration cycle unit 1 may perform room heating by blowing air from a room to the first heat exchanger 14 and then discharging the air back to the room, and room cooling by blowing air from the room to the second heat exchanger 18 and then discharging the air back to the room.

[0032] That is, the refrigeration cycle unit 1 may perform a direct heat exchange between indoor air and one of the first heat exchanger 14 and the second heat exchanger 18. The refrigeration cycle unit 1 may include an indoor fan that circulates indoor air between the room and one of the first heat exchanger 14 and the second heat exchanger 18.

[0033] In the refrigeration cycle unit 1, one of the first heat exchanger 14 and the second heat exchanger 18 may be configured as a water coolant heat exchanger that performs heat exchange between water and a coolant. A cooling/heating coil around for heating or cooling mixed air of indoor air and outdoor air may be connected to the water coolant heat exchanger through a water circulation path so that the water cools/heats the cooling/heating coil while circulating the water coolant heat exchanger and the cooling/heating coil, the mixed air of the indoor air and the outdoor air is cooled/heated by the cooling/heating coil, and then discharged to the room.

[0034] That is, the water heat exchanged with the coolant in the refrigeration cycle unit 1 may be used in an air handling unit ("AHU") that cools/heats the mixed air of the indoor air and the outdoor air and discharges it to the room.

[0035] In the refrigeration cycle unit 1, one of the first heat exchanger 14 and the second heat exchanger 18 may be configured as a water coolant heat exchanger that performs heat exchange between water and a coolant. The water cooled or heated in the water coolant heat exchanger may be used for room cooling/heating or water heating.

[0036] In a case where the refrigeration cycle unit 1 is provided for room cooling, the second heat exchanger 18 may be configured as a water coolant heat exchanger, and a room cooling unit for room cooling may be connected to the water coolant heat exchanger through a water circulation path so that water cools the room cooling unit while circulating between the water coolant heat exchanger and the room cooling unit, and thus the room cooling unit may cool the room.

[0037] In a case where the refrigeration cycle unit 1 is provided for room heating, the first heat exchanger 14 may be configured as a water coolant heat exchanger, and a room heating unit for room heating may be con-

nected to the water coolant heat exchanger through a water circulation path so that water heats the room heating unit while circulating between the water coolant heat exchanger and the room heating unit, and thus the room heating unit may heat the room.

[0038] In a case where the refrigeration cycle unit 1 is provided for water heating, the first heat exchanger 14 may be configured as a water coolant heat exchanger, and a water heating unit for supplying hot water to the room may be connected to the water coolant heat exchanger through a water circulation path so that water heats the water heating unit while circulating between the water coolant heat exchanger and the water heating unit, and thus the water heating unit may supply hot water to the room.

[0039] In a case where the refrigeration cycle unit 1 is provided for room cooling/heating and water heating, the first heat exchanger 14 may be configured as a water coolant heat exchanger, and a room cooling/heating unit for room cooling/heating may be connected to the water coolant heat exchanger through a water circulation path so that water cools/heats the room cooling/heating unit while circulating between the water coolant heat exchanger and the room cooling/heating unit, or a water heating unit for supplying hot water to the room may be connected to the water coolant heat exchanger through a water circulation path so that water heats the water heating unit while circulating between the water coolant heat exchanger and the water heating unit.

[0040] That is, the water heat exchanged with the coolant in the refrigeration cycle unit 1 may be used for the room heating unit for room heating, the room cooling unit for room cooling, or the water heating unit for supplying hot water to the room.

[0041] Hereinafter, it is assumed that in the refrigeration cycle unit 1, the first heat exchanger 14 is configured as a water coolant heat exchanger, water heated in the first heat exchanger 14 is used for a water heating unit 4, and water heated or cooled in the first heat exchanger 14 is used for a room heating unit 5.

[0042] In the heat pump according to the embodiment of the present invention, the compressor 10, the first heat exchanger 14, the expansion mechanism 16, and the second heat exchanger 18 may be installed in the refrigeration cycle unit 1. The refrigeration cycle unit 1 may further include a room cooling/heating switching valve 12 that may perform switching between room heating and room cooling.

[0043] Under a room heating mode for room heating, the room cooling/heating switching valve 12 makes the coolant compressed in the compressor 10 flow to the first heat exchanger 14 and the coolant evaporated in the second heat exchanger 18 flow to the compressor 10 so that the coolant is condensed in the first heat exchanger 14 and evaporated in the second heat exchanger 18.

[0044] Under a room cooling mode for room cooling or defrosting mode for defrosting, the room cooling/heating switching valve 12 makes the coolant compressed in the

compressor 10 flow to the second heat exchanger 18 and the coolant evaporated in the first heat exchanger 14 flow to the compressor 10 so that the coolant is evaporated in the first heat exchanger 14 and condensed in the second heat exchanger 18.

[0045] The refrigeration cycle unit 1 may be configured as a single unit, or to have an indoor unit 6 and an outdoor unit 7.

[0046] In a case where the refrigeration cycle unit 1 is configured to have a single unit, the compressor 10, the room cooling/heating switching valve 12, the first heat exchanger 14, the expansion mechanism 16, and the second heat exchanger 18 may be installed in a single casing.

[0047] In a case where the refrigeration cycle unit 1 is configured to have the indoor unit 6 and the outdoor unit 7, the compressor 10, the room cooling/heating switching valve 12, the expansion mechanism 16, and the second heat exchanger 18 may be installed in the outdoor unit 7, the first heat exchanger 14 may be installed in the indoor unit 6, and the outdoor unit 7 and the indoor unit 6 may be connected to each other via a coolant pipe.

[0048] The compressor 10 may be connected to the room cooling/heating switching valve 12 via a compressor discharging pipe 11.

[0049] The compressor discharging pipe 11 may include a check valve 11' to prevent a coolant discharged from a booster compressor 90 as will be described later from flowing into the compressor 10.

[0050] The room cooling/heating switching valve 12 may be connected to the first heat exchanger 14 via a pipe 13 between the room cooling/heating switching valve 12 and the first heat exchanger 14, and to the compressor 10 via a compressor suction pipe 20.

[0051] The first heat exchanger 14 may be connected to the expansion mechanism 16 via a pipe 15 between the first heat exchanger 14 and the expansion mechanism 16.

[0052] The first heat exchanger 14 may be a water coolant heat exchanger performing heat exchanger between water and a coolant, and may include a heat radiation path that radiates heat while the coolant passes therethrough, a heat absorption path that absorbs heat while the water passes therethrough, and a heat transfer member between the heat radiation path and the heat absorption path.

[0053] The first heat exchanger 14 may be connected to a water circulation path 22 that forms a closed path along with the water heating unit 4 and the room heating unit 5.

[0054] The expansion mechanism 16 may be connected to the second heat exchanger 18 via a pipe 17 between the expansion mechanism 16 and the second heat exchanger 18.

[0055] The expansion mechanism 16 may be configured as an electronic expansion valve.

[0056] The second heat exchanger 18 may be connected to the room cooling/heating switching valve 12

via a pipe 19 between the second heat exchanger 18 and the room cooling/heating switching valve 12.

[0057] The second heat exchanger 18 may be configured as an air cooled heat exchanger that blows outdoor air to the second heat exchanger 18 to evaporate the coolant. The refrigeration cycle unit 1 may further include an outdoor fan (not shown) that blows outdoor air to the second heat exchanger 18.

[0058] The water circulation path 22 may couple the first heat exchanger 14 with the water heating unit 4 and the room heating unit 5 such that water heat exchanged with the coolant in the first heat exchanger 14 passes through at least one of the water heating unit 4 and the room heating unit 5 and then returns to the first heat exchanger 14.

[0059] The water circulation path 22 may include a refrigeration cycle unit pipe 23 located in the refrigeration cycle unit 1, a water heating pipe 24 that allows water heated in the first heat exchanger 14 to pass through the water heating unit 4, a room cooling/heating pipe 25 that allows water heated in the first heat exchanger 14 to pass the room heating unit 5, and a connection pipe 27 that couples the refrigeration cycle unit pipe 23 with the water heating pipe 24 and the room cooling/heating pipe 25.

[0060] The connection pipe 27 may include a water adjustment valve 28 that guides water heated or cooled in the first heat exchanger 14 to at least one of the water heating pipe 24 and the room cooling/heating pipe 25. The water heating pipe 24 and the room cooling/heating pipe 25 may be connected to the water adjustment valve 28 via the connection pipe 27.

[0061] Hereinafter, the refrigeration cycle unit 1, the water heating unit 4, and the room heating unit 5 will be described in greater detail.

[0062] The refrigeration cycle unit 1 may be an air to water heat pump ("AWHP"), and may include a flow switch 32 that senses the flow of water passing through the refrigeration cycle unit pipe 23, an expansion tank 33 that is positioned over the refrigeration cycle unit pipe 23 to be spaced from the flow switch 32, a water collection tank 34 that is connected to the refrigeration cycle unit pipe 23 and includes therein an auxiliary heater 35, and a circulation pump 36 that is positioned over the refrigeration cycle unit pipe 23 to pump the water for water circulation.

[0063] The expansion tank 33 may be a buffer that absorbs water heated while passing through the first heat exchanger 14 when the water is expanded beyond an appropriate level. The expansion tank 33 may be filled with nitrogen and may include a diaphragm that moves depending on the volume of water.

[0064] The water collection tank 34 may collect water, and the auxiliary heater 35 may be selectively operated when the defrosting operation is necessary or the first heat exchanger 14 does not reach a required performance level.

[0065] The circulation pump 36 circulates water among the refrigeration cycle unit 1, the water heating

unit 4, and the room heating unit 5, and may be provided downstream of the water collection tank 34 over the refrigeration cycle unit pipe 23.

[0066] The water heating unit 4 may supply hot water necessary for, for example, showering, bathing, or dish washing, and may include a hot water tank 41 for containing water and an auxiliary heater 42 for water heating installed in the hot water tank 41.

[0067] The hot water tank 41 may be connected to a cool water inlet 43 that introduces cool water to the hot water tank 41 and a hot water outlet 44 that discharges hot water out of the hot water tank 41.

[0068] A water heating pipe 24 is provided in the hot water tank 41 to heat water in the hot water tank 41.

[0069] The hot water outlet 44 may be connected to a hot water discharging device 45, such as a shower head.

[0070] A cool water inlet 46 may be connected to the hot water outlet 44 so that cool water may be discharged to the outside through the hot water discharging device 45.

[0071] The room heating unit 5 may include a floor cooling/heating unit 51 for cooling/heating the indoor floor, and an air cooling/heating unit 52 for cooling/heating indoor air.

[0072] The floor cooling/heating unit 51 may be configured as a meander line embedded in the indoor floor.

[0073] The air cooling/heating unit 52 may be configured as a fan coil unit or a radiator.

[0074] Water adjustment valves 53 and 54 may be positioned over the room cooling/heating pipe 25 to guide water to at least one of the floor cooling/heating unit 51 and the air cooling/heating unit 52. The floor cooling/heating unit 51 may be connected to the water adjustment valves 53 and 54 via an air cooling/heating pipe 55, and the air cooling/heating unit 52 may be connected to the water adjustment valves 53 and 54 via a floor cooling/heating pipe 56.

[0075] When the water adjustment valve 28 is subjected to a water heating mode for water heating upon driving the circulation pump 36, the water heated in the first heat exchanger 14 may pass through the refrigeration cycle unit pipe 23 and the connection pipe 27 to the water heating pipe 24 to heat the water in the hot water tank 41, and then return to the first heat exchanger 14 via the connection pipe 27 and the refrigeration cycle unit pipe 23.

[0076] When the water adjustment valve 28 is subjected to a room cooling/heating mode for room cooling/heating upon driving the circulation pump 36, the water heated or cooled in the first heat exchanger 14 may pass through the refrigeration cycle unit pipe 23 and the connection pipe 27 to the room cooling/heating pipe 25 to heat or cool at least one of the floor cooling/heating unit 51 and the air cooling/heating unit 52, and then return to the first heat exchanger 14 via the room cooling/heating pipe 25, the connection pipe 27, and the refrigeration cycle unit pipe 23.

[0077] When the water adjustment valves 53 and 54

are subjected to an air cooling/heating mode for air cooling/heating, the water heated or cooled in the first heat exchanger 14 may pass through the room cooling/heating pipe 25, the air cooling/heating unit 52, and the air cooling/heating pipe 55 and discharge through the room cooling/heating pipe 25, and when the water adjustment valves 53 and 54 are subjected to a floor cooling/heating mode for floor cooling/heating, the water heated in the first heat exchanger 14 may pass through the floor cooling/heating pipe 56, the floor cooling/heating unit 51, and the floor cooling/heating pipe 56, and discharge through the room cooling/heating pipe 25.

[0078] After installation of the refrigeration cycle unit 1, as necessary, the booster module 2 may be additionally provided to the refrigeration cycle unit 1.

[0079] The booster module 2 may be connected to the refrigeration cycle unit 1 to separate a gaseous coolant from the coolant flowing from the first heat exchanger 14 to the expansion mechanism 16, compress the separated gaseous coolant, and then make the compressed gaseous coolant flow between the compressor 10 and the first heat exchanger 14.

[0080] Independently from the compressor 10 included in the refrigeration cycle unit 1, the booster module 2 may compress the coolant by using a booster compressor 90 included in the booster module 2, as will be described later, and inject to the booster compressor 90 a gaseous coolant which has a pressure higher than the condensation pressure of the first heat exchanger 14 and lower than the evaporation pressure of the second heat exchanger 18, thus capable of raising operational efficiency.

[0081] The booster module 2 may include a first booster expansion mechanism 62 that expands the coolant condensed in the first heat exchanger 14, a gas/liquid separator 70 that separates the coolant expanded in the first booster expansion mechanism 62 into a liquid coolant and a gaseous coolant, a second booster expansion mechanism 80 that expands the gaseous coolant separated in the gas/liquid separator 70, and a booster compressor 90 that compresses the coolant expanded in the second booster expansion mechanism 80.

[0082] When the booster module 2 is installed in the heat pump according to the embodiment of the present invention, the pipe 13 connecting between the first heat exchanger 14 and the room cooling/heating switching valve 12 and the pipe 15 connecting between the first heat exchanger 14 and the expansion mechanism 16 may be separated into pipes 13A and 13B, and pipes 15A and 15B, respectively. The booster module 2 is connected to between the pipes 13A and 13B, and may be connected to between the pipes 15A and 15B.

[0083] The first booster expansion mechanism 62 may be connected to the first heat exchanger 14 via a first booster expansion mechanism suction pipe 64 that may be connected to one 15A of the separated pipes 15A and 15B.

[0084] The first booster expansion mechanism 62 may

be configured as an electronic expansion valve.

[0085] The gas/liquid separator 70 separates the coolant condensed in the first heat exchanger 14 into a gaseous coolant and a liquid coolant, and may be connected to the expansion mechanism 16 via a gas/liquid separator outlet pipe 72 that may be connected to the other 15B of the separated pipes 15A and 15B.

[0086] When opened, the second booster expansion mechanism 80 allows the gaseous coolant from the gas/liquid separator 70 to flow to the booster compressor 90, and when closed, the second booster expansion mechanism 80 stops the flow of the gaseous coolant from the gas/liquid separator 70 to the booster compressor 90. The second booster expansion mechanism 80 may expand the gaseous coolant flowing from the gas/liquid separator 70 to the booster compressor 90 upon adjusting the degree of opening.

[0087] The second booster expansion mechanism 80 may be configured as an electronic expansion valve.

[0088] The booster module 2 may include a gas/liquid separator suction pipe 74 connecting between the first booster expansion mechanism 62 and the gas/liquid separator 70.

[0089] That is, the first heat exchanger 14 and the expansion mechanism 16 may be connected to each other via the pipe 15 connecting between the first heat exchanger 14 and the expansion mechanism 16 before installation of the booster module 2, and via one 15A of the pipes 15A and 15B, the first booster expansion mechanism suction pipe 64, the first booster expansion mechanism 62, the gas/liquid separator suction pipe 74, the gas/liquid separator 70, the gas/liquid separator outlet pipe 72, and the other 15B of the separated pipes 15A and 15B, the pipe 15B after installation of the booster module 2.

[0090] The booster module 2 may further include a gaseous coolant discharging pipe 76 that guides the gaseous coolant separated in the gas/liquid separator 70 to the second booster expansion mechanism 80, a booster compressor suction pipe 92 that allows the coolant expanded in the second booster expansion mechanism 80 to be sucked to the booster compressor 90, and booster compressor discharging pipes 94 and 95 that guide the coolant discharged from the booster compressor 90 to between the first heat exchanger 14 and the compressor 10 of the refrigeration cycle unit 1.

[0091] The booster compressor discharging pipes 94 and 95 may include a first booster compressor discharging pipe 94 connecting between the pipes 13A and 13B and a second booster compressor discharging pipe 95 guiding the coolant discharged from the booster compressor 90 to the first booster compressor discharging pipe 94.

[0092] That is, the room cooling/heating switching valve 12 and the first heat exchanger 14 may be connected to each other via the pipe 13 connecting between the room cooling/heating switching valve 12 and the first heat exchanger 14 before installation of the booster mod-

ule 2, as shown in Fig. 1, and via one 13A of the pipes 13A and 13B, the first booster compressor discharging pipe 94, and the other 13B of the pipes 13A and 13B, after installation of the booster module 2, as shown in Fig. 2.

[0093] A check valve 95' may be provided over the booster compressor discharging pipes 94 and 95 to prevent the coolant compressed in the compressor 10 from flowing to the booster compressor 90. For example, the check valve 95' may be provided over the second booster compressor discharging pipe 95.

[0094] The booster module 2 may further include a bypass pipe 99 leading the coolant flowing out of the gas/liquid separator 70 via the gas/liquid separator outlet pipe 72 to the first booster expansion mechanism suction pipe 64. A check valve 99' may be provided over the third booster suction pipe 99 to prevent the coolant in the first booster expansion mechanism suction pipe 64 from flowing to the gas/liquid separator outlet pipe 72 through the third booster suction pipe 99, and the gaseous coolant flowing from the gas/liquid separator 70 to the booster compressor suction pipe 92 may be maximized.

[0095] The booster module 2 may compress the coolant evaporated in the second heat exchanger 18 using the booster compressor 90 and then have the compressed coolant flow between the compressor 10 and the first heat exchanger 14.

[0096] The booster module 2 may be configured so that the gaseous coolant separated in the gas/liquid separator 70 and the coolant evaporated in the second heat exchanger 18 may be together or selectively sucked to the booster compressor 90.

[0097] The booster module 2 may connect the booster compressor suction pipe 92 to between the second heat exchanger 18 and the compressor 10 through a booster suction pipe 96 to guide part of the coolant evaporated in the second heat exchanger 18 to the booster compressor suction pipe 92.

[0098] One end of the booster suction pipe 96 may be connected to the compressor suction pipe 20 and the other end may be connected to the booster compressor suction pipe 92.

[0099] The booster suction pipe 96 may include a first booster suction pipe 97 that is provided in the refrigeration cycle unit 1 to be connected to the compressor suction pipe 20, a second booster suction pipe 98 that is provided in the booster module 2 to be connected to the booster compressor suction pipe 92, and a third booster suction pipe 99 that connects between the first booster suction pipe 97 and the second booster suction pipe 98.

[0100] The booster module 2 may further include a check valve 96' that is provided over the booster suction pipe 96 to prevent the coolant in the booster compressor suction pipe 92 from being sucked to the compressor 10 through the booster suction pipe 96.

[0101] The check valve 96' may be provided over the second booster suction pipe 98.

[0102] Fig. 4 is a front view schematically illustrating a

heat pump wherein a booster module is separated from a refrigeration cycle unit according to an embodiment of the present invention, and Fig. 5 is a front view schematically illustrating a heat pump wherein a booster module is attached to a refrigeration cycle unit according to an embodiment of the present invention.

[0103] In a case where the refrigeration cycle unit 1 is configured as a single unit, the booster module 2 may be separated from or joined to the refrigeration cycle unit 1.

[0104] In a case where the refrigeration cycle unit 1 is configured to have an indoor unit 6 and an outdoor unit 7, the booster module 2 may be separated from the indoor unit 6 and the outdoor unit 7, or joined to one of the indoor unit 6 and the outdoor unit 7.

[0105] The refrigeration cycle unit 1 may be configured as a "separation type" as shown in Fig. 4, wherein the refrigeration cycle unit 1 is separated from the outdoor unit 7, or as an "integration type" as shown in Fig. 5, wherein the refrigeration cycle unit 1 is integrally mounted on the outdoor unit 7.

[0106] That is, the room heating unit 5 may be selectively mounted on the outdoor unit 7 as shown in Figs. 4 and 5.

[0107] Fig. 6 is a graph illustrating a P-H relationship in a heat pump according to an embodiment of the present invention, wherein a situation with a booster module is compared with a situation without a booster module.

[0108] Without the booster module 2, the coolant is subjected to a general procedure of compression, condensation, expansion, and evaporation—that is, "a→b'→c→f→a" as depicted in dashed lines in Fig. 4.

[0109] On the contrary, with the booster module 2, the coolant is subjected to a procedure of compression, condensation, expansion, expansion, and evaporation—that is, a→b→c→d→e→f→a as depicted in solid lines in Fig. 6. Part of the coolant discharged from the first heat exchanger 14 is subjected to expansion and compression in the booster module 2—that is, d→g→h→b as depicted in Fig. 6. When the booster module 2 is included, the heat pump may show a further improved overall efficiency with reduced compression work compared to when the booster module 2 is absent.

[0110] That is, the entire consumption power supplied to the compressor 10 and the booster compressor 90 may be reduced and the performance may be enhanced especially when the outdoor temperature is low. The situation with the booster module 2 may further lower the maximum management temperature of the compressor 10 and improve reliability of the compressor 10 than the situation without the booster module 2.

[0111] Fig. 7 is a block diagram schematically illustrating a heat pump according to an embodiment of the present invention, Fig. 8 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "general load mode", Fig. 9 is a view schematically illustrating a heat

pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "partial load mode", Fig. 10 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "multi operation mode", and Fig. 11 is a view schematically illustrating a heat pump according to an embodiment of the present invention, which depicts the flow of a coolant when the heat pump is subjected to a "gas injection mode".

[0112] The heat pump according to the embodiment of the present invention may include a manipulation unit 100 that inputs various instructions including operation/stop of the heat pump, a load sensor 110 that senses the load of the heat pump, and a controller 120 that controls the compressor 10, the expansion mechanism 16, the outdoor fan 22', the first booster expansion mechanism 62, the second booster expansion mechanism 80, and the booster compressor 90 based on the operation of the manipulation unit 100 and the sensing result of the load sensor 110.

[0113] The load sensor 110 may include a water temperature sensor that senses the load of the water heating unit 4 and the room heating unit 5.

[0114] The water temperature sensor may be provided at a side of the water circulation path 22 to sense the temperature of water circulating the first heat exchanger 14 and at least one of the water heating unit 4 and the room heating unit 5.

[0115] The water temperature sensor may be provided to sense the temperature of water passing through at least one of the water heating unit 4 and the room heating unit 5 and then returning to the first heat exchanger 14. For example, the water temperature sensor may be provided over the refrigeration cycle unit pipe 23.

[0116] The load sensor 110 may include an outdoor temperature sensor that determines whether the outdoor temperature is low or not.

[0117] The outdoor temperature sensor may be installed in the second heat exchanger 18 to sense the temperature of outdoor air blowing to the second heat exchanger 18.

[0118] When the load sensor 110 senses a load, the controller 120 may perform control under the partial load mode, the general load mode, and the multi operation mode, and when the load sensor 110 senses an "outdoor low temperature load", that is, determines that the outdoor temperature is low, the controller 120 may perform control under the gas injection mode.

[0119] If the temperature of water sensed by the load sensor 110 is less than a first predetermined temperature, the controller 120 may determine that the load of the heat pump is a partial load, if the temperature of water sensed by the load sensor 110 is not less than the first predetermined temperature and less than a second predetermined temperature higher than the first determined temperature by a predetermined value, the controller 120

may determine that the load of the heat pump is a general load, and if the temperature of water sensed by the load sensor 110 is not less than the second predetermined temperature, the controller 120 may determine that the load of the heat pump is a multi operation load (that is, overload).

[0120] If the outdoor temperature sensed by the load sensor 110 is not more than a predetermined temperature, the controller 120 may determine that the load of the heat pump is an outdoor low temperature load.

[0121] Depending on the operation mode, the controller 120 may control the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 at the same time. Various operation modes are possible according to the load. For example, in a case where the load is smaller than a general load, the controller 120 may operate the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 in the partial load mode, if the load is equal to the general load, the controller 120 may control the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 in the general load mode, if the load is larger than the general load, the controller 120 may control the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 in the multi operation mode, and if the load is the low temperature load, the controller 120 may control the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 in the gas injection mode.

[0122] The heat pump according to the embodiment of the present invention may configure the compressor 10 as a capacity variable compressor and the booster compressor 90 as a constant speed compressor, and have the booster compressor 90 smaller in capacity than the compressor 10 in order to efficiently respond to various loads.

[0123] Under the partial load mode, the controller 120 turns off the compressor 10, drives the booster compressor 90, and closes the second booster expansion mechanism 80. The controller 120 may fully open the first booster expansion mechanism 62 and adjust the expansion mechanism 16 at a predetermined degree of opening to allow the expansion mechanism 16 to expand the coolant.

[0124] The controller 120 may control the degree of opening of the expansion mechanism 16 so that the suction superheat of the booster compressor 90 reaches a predetermined value.

[0125] Under the above-mentioned control, as shown in Figs. 2 and 8, the coolant in the compressor suction pipe 19 may be sucked into the booster compressor 90 via the booster suction pipe 96 and the booster compressor suction pipe 92 without being introduced into the compressor 10, compressed in the booster compressor 90, and then flow into the first heat exchanger 14 via the first booster compressor discharging pipe 94 and the compressor discharging pipe 13.

[0126] The coolant flowing into the first heat exchanger 14 may be condensed in the first heat exchanger 14 to heat the water passing through the first heat exchanger 14, expanded in the expansion mechanism 16 while passing through the first booster expansion mechanism 62 and the gas/liquid separator 70, and then flow into the second heat exchanger 18.

[0127] The coolant flowing into the second heat exchanger 18 may be evaporated by the outdoor air blowing from the outdoor fan 22', and then recovered to the compressor suction pipe 19.

[0128] That is, the coolant may be subjected to compression, condensation, expansion, and evaporation while circulating the booster compressor 90, the first heat exchanger 14, the expansion mechanism 16, and the second heat exchanger 18, and thus the heat pump may respond to the partial load with lower consumption power than in case of driving the compressor 10.

[0129] Under the general load mode, the controller 120 drives the compressor 10, stops the booster compressor 90, and closes the second booster expansion mechanism 80. The controller 120 may fully open the first booster expansion mechanism 62 and adjust the expansion mechanism 16 at a predetermined degree of opening to allow the expansion mechanism 16 to expand the coolant.

[0130] The controller 120 may control the degree of opening of the expansion mechanism 16 so that the suction superheat of the compressor 10 reaches a predetermined value.

[0131] Under the above-mentioned control, the coolant in the compressor suction pipe 19 may be sucked and compressed in the compressor 10 without being introduced into the booster compressor 90 and then flow to the first heat exchanger 14 via the compressor discharging pipe 13, as shown in Figs. 2 and 9.

[0132] The coolant flowing to the first heat exchanger 14 may be condensed in the first heat exchanger 14 to heat the water passing through the first heat exchanger 14, expanded in the expansion mechanism 16 while passing through the first booster expansion mechanism 62 and the gas/liquid separator 70, and then flow to the second heat exchanger 18.

[0133] The coolant flowing to the second heat exchanger 18 may be evaporated by the outdoor air blowing from the outdoor fan 22' and then recover to the compressor suction pipe 19.

[0134] That is, the coolant may be subjected to compression, condensation, expansion, and evaporation while circulating the compressor 10, the first heat exchanger 14, the expansion mechanism 16, and the second heat exchanger 18, and thus the heat pump may respond to the general load that is larger than when the booster compressor 90 is driven.

[0135] Under the multi operation mode, the controller 120 drives the compressor 10 and the booster compressor 90, and closes the second booster expansion mechanism 80. The controller 120 may fully open the first

booster expansion mechanism 62 and adjust the expansion mechanism 16 at a predetermined degree of opening to allow the expansion mechanism 16 to expand the coolant.

[0136] The controller 120 may control the degree of opening of the expansion mechanism 16 so that the suction superheat of the compressor 10 reaches a predetermined value.

[0137] Under the above-mentioned control, the coolant in the compressor suction pipe 19 is partially sucked and compressed in the compressor 10 and then discharged through the compressor discharging pipe 13, and the remainder of the coolant is sucked via the booster suction pipe 96 and the booster compressor suction pipe 92 to the booster compressor 90 for compression, and the compressed coolant is discharged through the compressor discharging pipe 13 and mixed with the coolant discharged from the compressor 10, as shown in Figs. 2 and 10.

[0138] The coolant discharged through the compressor discharging pipe 13 flows in the first heat exchanger 14 for compression. The coolant is condensed in the first heat exchanger 14 to heat the water passing through the first heat exchanger 14, expanded in the expansion mechanism 16 while passing the first booster expansion mechanism 62 and the gas/liquid separator 70, and then flow into the second heat exchanger 18.

[0139] The coolant flowing into the second heat exchanger 18 may be evaporated by the outdoor air blowing from the outdoor fan 22' and then recovered to the compressor suction pipe 19.

[0140] That is, the coolant may be subjected to compression, condensation, expansion, and evaporation while circulating the compressor 10, the booster compressor 90, the first heat exchanger 14, the expansion mechanism 16, and the second heat exchanger 18, and thus the heat pump may respond to the larger load than in case of driving the booster compressor 90 alone or 10 alone.

[0141] Under the gas injection mode, the controller 120 may drive the compressor 10 and the booster compressor 90, and open the second booster expansion mechanism 80. The controller 120 may open the first booster expansion mechanism 62 and adjust the expansion mechanism 16 at a predetermined degree of opening to allow the expansion mechanism 16 to expand the coolant.

[0142] The controller 120 may control the degree of opening of the first booster expansion mechanism 62 and the degree of opening of the second booster expansion mechanism 80 such that the pressure of the coolant sucked into the booster compressor 90 is lower than the evaporation pressure of the second heat exchanger 18 and higher than the compression pressure of the first heat exchanger 14, and control the degree of opening of the expansion mechanism 16 such that the suction superheat of the compressor 10 reaches a predetermined value.

[0143] Under the above-mentioned control, the coolant in the compressor suction pipe 19 may be sucked and compressed in the compressor 10, discharged through the compressor discharging pipe 13, flowed and compressed into the first heat exchanger 14 to heat the water passing through the first heat exchanger 14, expanded in the first booster expansion mechanism 62, and introduced into the gas/liquid separator 70, as shown in Figs. 2 and 11. The coolant introduced in the gas/liquid separator 70 is separated into a gaseous coolant and a liquid coolant. The gaseous coolant may be discharged through the gaseous coolant discharging pipe 76 and the liquid coolant may be flowed into the expansion mechanism 16 through the gas/liquid separator outlet pipe 72 for expansion.

[0144] The coolant expanded in the expansion mechanism 16 may be flowed and evaporated in the second heat exchanger 18, recovered to the compressor suction pipe 19, compressed in the compressor 10, and then discharged through the compressor discharging pipe 13.

[0145] On the other hand, the coolant discharged through the gaseous coolant discharging pipe 76 is expanded in the second booster expansion mechanism 80, flowed into the booster compressor suction pipe 92, and then compressed in the booster compressor 90. The coolant compressed in the booster compressor 90 is discharged through the first booster compressor discharging pipe 94, flowed into the compressor discharging pipe 13, and mixed with the coolant discharged from the compressor 10.

[0146] That is, the coolant may be subjected to compression, condensation, expansion, expansion, and evaporation while circulating the compressor 10, the first heat exchanger 14, the first booster expansion mechanism 62, the expansion mechanism 16, and the second heat exchanger 18, and the gaseous coolant of the coolant condensed in the first heat exchanger 14 is expanded and then gas injected to the booster compressor 90. Thus, the heat pump may further raise efficiency and reduce compression work than in case of driving the booster compressor 90 and the compressor 10 without gas injection. The heat pump may provide improved performance particularly under low outdoor temperature.

[0147] Fig. 12 is a view schematically illustrating a heat pump according to an embodiment of the present invention, wherein a booster module is mounted on a refrigeration cycle unit, Fig. 13 is a view schematically illustrating a heat pump according to an embodiment, which depicts the flow of a coolant under a general load mode, and Fig. 14 is a view schematically illustrating a heat pump according to an embodiment, which depicts the flow of a coolant under a gas injection mode.

[0148] The heat pump according to the embodiment of the present invention is identical or similar in construction to the heat pump as described above except that the booster suction pipe 96 and the check valve 96' are absent.

[0149] The heat pump according to the embodiment

of the present invention may have a general load mode under which the compressor 10 is driven, the booster compressor 90 is not driven, and the second booster expansion mechanism 80 stop the gaseous coolant from passing therethrough, as shown in Fig. 12, and a gas injection mode under which the compressor 10 and the booster compressor 90 are driven and the second booster expansion mechanism 80 allows the gaseous coolant to pass therethrough, as shown in Fig. 14.

[0150] More specifically, if a low temperature load is sensed by the load sensor 110, the compressor 10 and the booster compressor 90 may be driven and the second booster expansion mechanism 80 allows the gaseous coolant to be passed, so that the compressor 10 may compress the coolant evaporated in the second heat exchanger 18 and the booster compressor 90 may compress the gaseous coolant separated in the gas/liquid separator 70.

[0151] On the other hand, unless a low temperature load is sensed by the load sensor 110, the compressor 10 may be driven while the booster compressor 90 may not be driven and the second booster expansion mechanism 80 may stop the gaseous coolant from being passed, so that the compressor 10 may compress the coolant evaporated in the compressor 10.

[0152] Fig. 15 is a view schematically illustrating a heat pump before a booster module is mounted on a refrigeration cycle unit according to an embodiment of the present invention, and Fig. 16 is a view schematically illustrating a heat pump after a booster module has been mounted on a refrigeration cycle unit according to an embodiment of the present invention.

[0153] The heat pump according to the embodiment of the present invention, which may be used only for room heating, does not include the room cooling/heating switching valve 12. The other constructions are identical or similar to those as described above.

[0154] In the refrigeration cycle unit 1, the compressor 10 may be connected to the first heat exchanger 14 via the compressor discharging pipe 11, the first heat exchanger 14 to the expansion mechanism 16 via the pipe 15 between the first heat exchanger 14 and the expansion mechanism 16, the expansion mechanism 16 to the second heat exchanger 18 via the pipe 17 between the expansion mechanism 16 and the second heat exchanger 18, and the second heat exchanger 18 to the compressor 10 via the compressor suction pipe 20'.

[0155] In the heat pump according to the embodiment of the present invention, upon mounting the booster module 2, the compressor discharging pipe 11 and the pipe 15 connecting between the first heat exchanger 14 and the expansion mechanism 16 may be separated into pipes 11A and 11B, and pipes 15A and 15B, respectively. The booster module 2 may be connected between the pipes 11A and 11B and pipes 15A and 15B.

[0156] In the booster module 2, booster compressor discharging pipes 94 and 95 may include a first booster compressor discharging pipe 94 that connects between

the separated pipes 11A and 11B and a second booster compressor discharging pipe 95 that guides the coolant discharged from the booster compressor 90 to the first booster compressor discharging pipe 94.

[0157] That is, the compressor 10 and the first heat exchanger 14 may be connected to each other via the compressor discharging pipe 11 before installation of the booster module 2, as shown in Fig. 14, and via the pipe 11A, the first booster compressor discharging pipe 94, and the pipe 11B after installation of the booster module 2, as shown in Fig. 15.

[0158] One of the booster suction pipe 96 may be connected to the compressor suction pipe 20' and the other end may be connected to the booster compressor suction pipe 92.

Claims

1. A heat pump comprising:

a refrigeration cycle unit 1 that includes a compressor 10 for compressing a coolant, a first heat exchanger 14 for condensing the coolant compressed in the compressor, an expansion mechanism 16 for expanding the coolant condensed in the first heat exchanger, and a second heat exchanger 18 for evaporating the coolant expanded in the expansion mechanism 16; and a booster module 2 that is connected to the refrigeration cycle unit 1, wherein the booster module 2 separates a gaseous coolant from the coolant flowing from the first heat exchanger 14 to the expansion mechanism 16, compresses the separated gaseous coolant, and then has the compressed gaseous coolant flow between the compressor 10 and the first heat exchanger 14.

2. The heat pump of claim 1, wherein the booster module 2 includes,

a first booster expansion mechanism 62 that expands the coolant flowing in the first heat exchanger 14,

a gas/liquid separator 70 that separates the coolant expanded in the first booster expansion mechanism 62 into a liquid coolant and a gaseous coolant,

a second booster expansion mechanism 80 that expands the gaseous coolant separated in the gas/liquid separator 70, and

a booster compressor 90 that compresses the coolant expanded in the second booster expansion mechanism 80.

3. The heat pump of claim 2, wherein the booster module 2 further includes,

a booster suction pipe 96 that guides the coolant evaporated in the second heat exchanger 18 to be sucked into the booster compressor 90.

4. The heat pump of claim 3, wherein the booster module 2 further includes,
a gas/liquid separator suction pipe 74 that connects between the first booster expansion mechanism 62 and the gas/liquid separator 70,
a gaseous coolant discharging pipe 76 that guides the gaseous coolant separated in the gas/liquid separator 70 to the second booster expansion mechanism 80,
a booster compressor suction pipe 92 that allows the coolant expanded in the second booster expansion mechanism 80 to be sucked into the booster compressor 90, and
a booster compressor discharging pipe 94 or 95 that guides the coolant discharged from the booster compressor 90 to between the compressor 10 and the first heat exchanger 14, wherein the booster suction pipe 96 connects the booster compressor suction pipe 92 to between the second heat exchanger 18 and the compressor 10.
5. The heat pump of claim 4, wherein the booster module 2 further includes,
a check valve 96' that is provided over the booster suction pipe 96 to prevent the coolant in the booster compressor suction pipe 92 from being sucked through the booster suction pipe 96 to the compressor 10.
6. The heat pump of claim 4, wherein the first booster expansion mechanism 62 is connected to the first heat exchanger 14 via a first booster expansion mechanism suction pipe 64.
7. The heat pump of claim 4, wherein the gas/liquid separator 70 is connected to the expansion mechanism 16 via a gas/liquid separator outlet pipe 72.
8. The heat pump of claim 3, wherein the compressor 10 is a capacity variable compressor and the booster compressor 90 is a constant speed compressor.
9. The heat pump of claim 3, wherein the booster compressor 90 has a smaller capacity than the compressor 10.
10. The heat pump of claim 3, wherein the heat pump includes a controller 120 that controls the compressor 10, the booster compressor 90, and the second booster expansion mechanism 80 based on an operation mode.
11. The heat pump of claim 10, wherein the controller 120 drives the compressor 10, stops the booster compressor 90, and closes the second booster expansion mechanism 80 under a general load mode.
12. The heat pump of claim 10, wherein the controller 120 turns off the compressor 10, drives the booster compressor 90, and closes the second booster expansion mechanism 80 under a partial load mode.
13. The heat pump of claim 10, wherein the controller 120 drives the compressor 10 and the booster compressor 90, and closes the second booster expansion mechanism 80 under a multi operation mode.
14. The heat pump of claim 10, wherein the controller 120 drives the compressor 10 and booster compressor 90 and opens the second booster expansion mechanism 80 under a gas injection mode.
15. The heat pump of claim 1, wherein the first heat exchanger 14 is a water coolant heat exchanger that perform heat exchange between water and a coolant, and connects to a room heating unit 5 for room heating and a water heating unit 4 for supplying hot water via a water circulation path 22.

FIG. 1

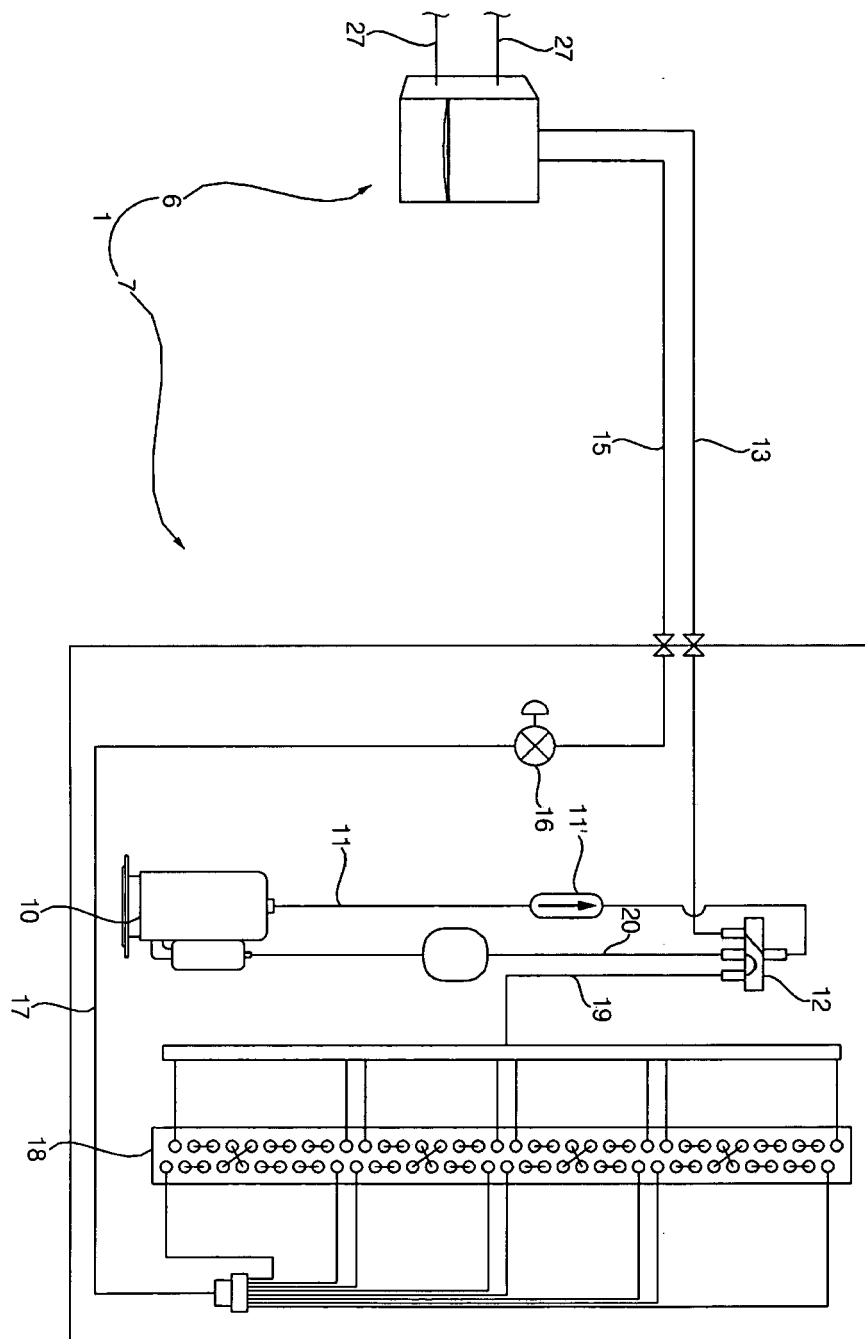


FIG. 2

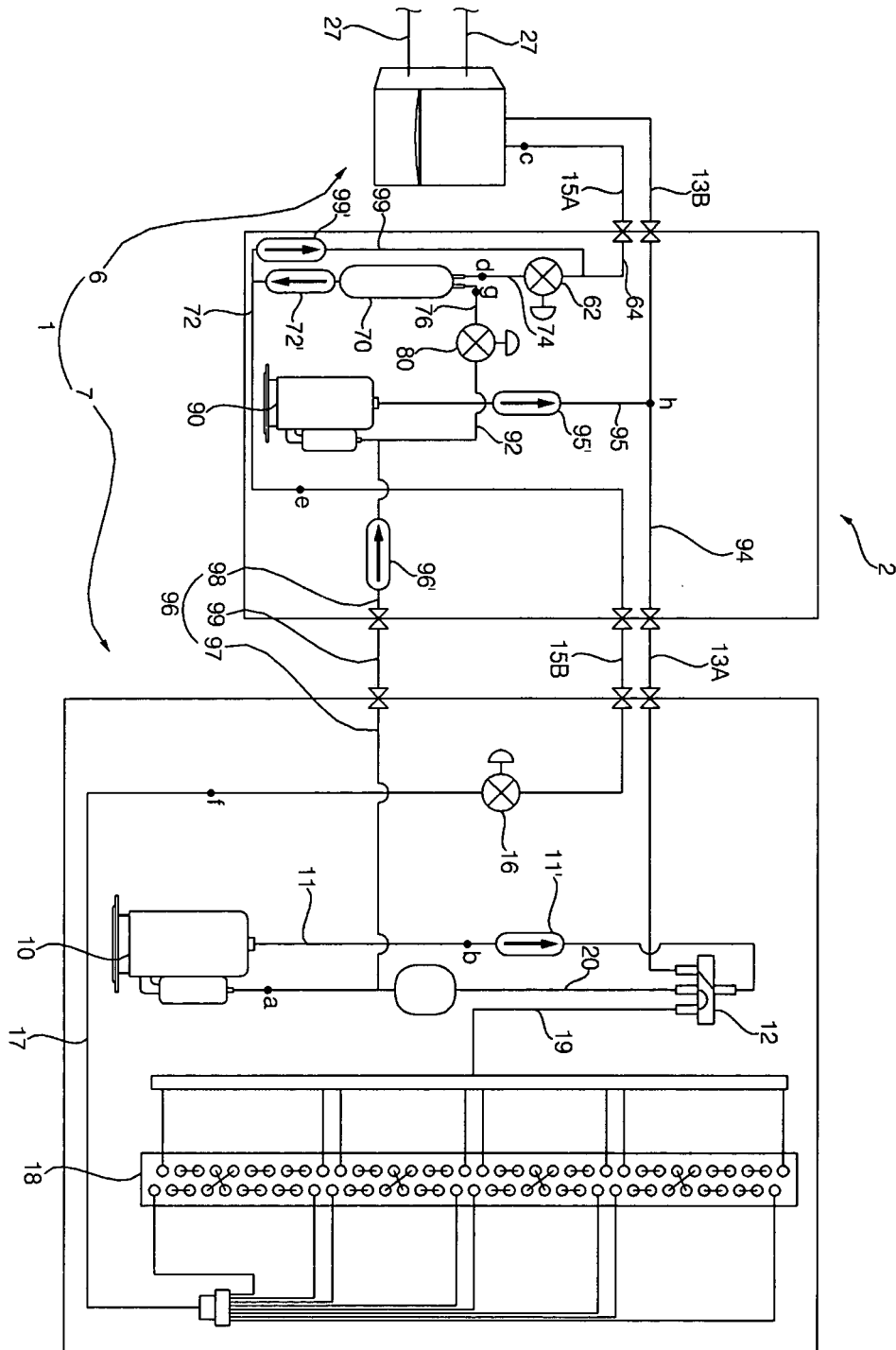


FIG. 3

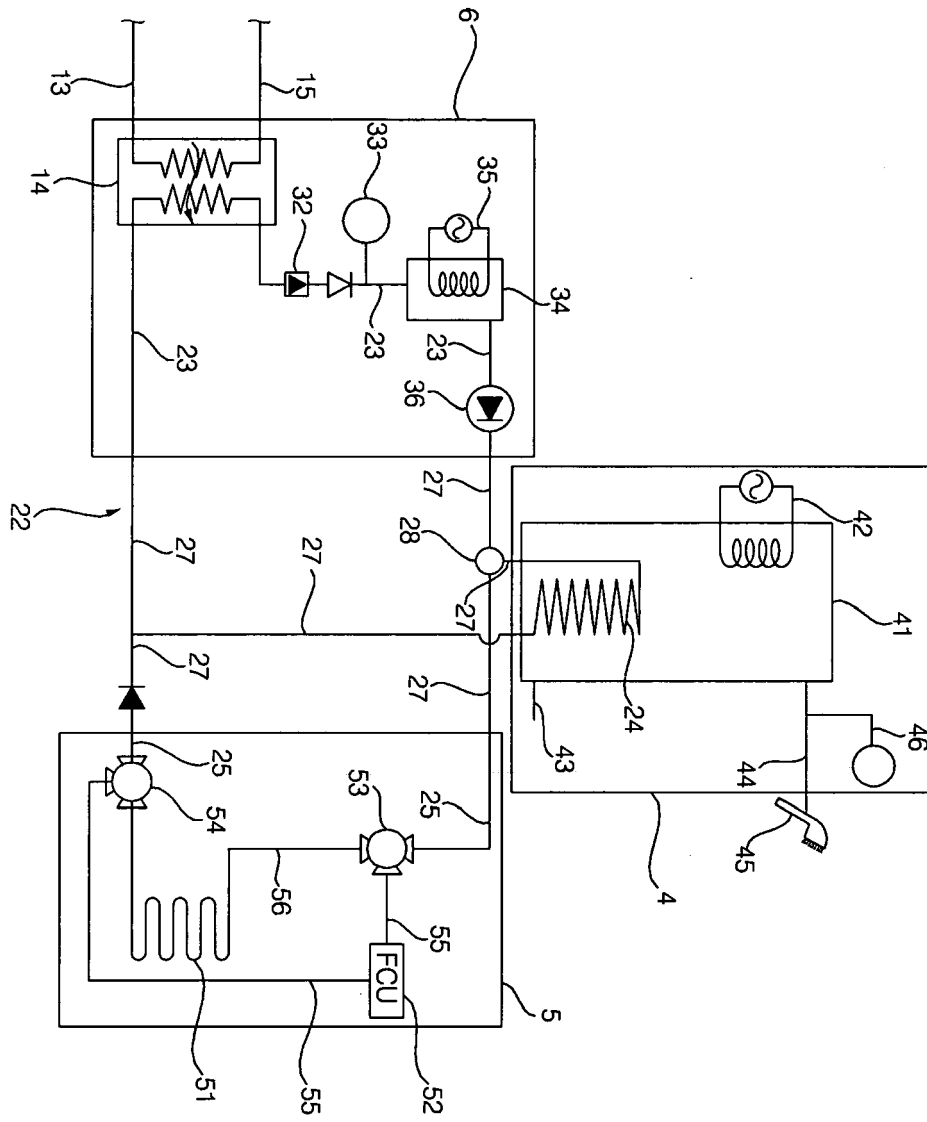


FIG. 4

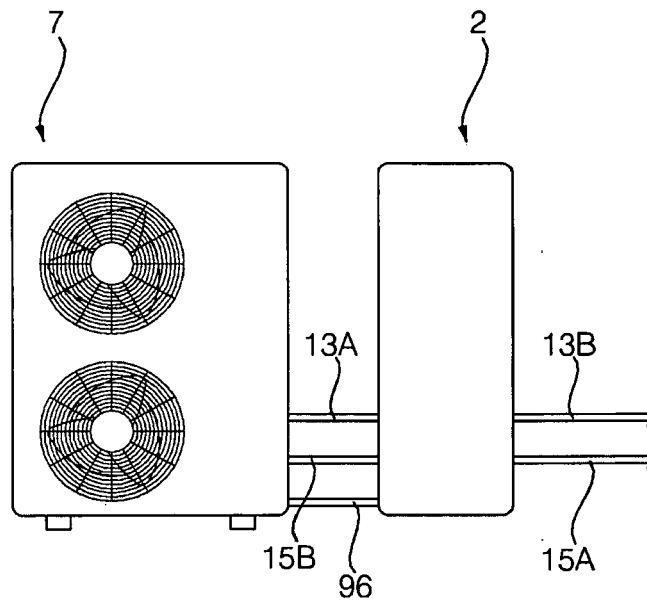


FIG. 5

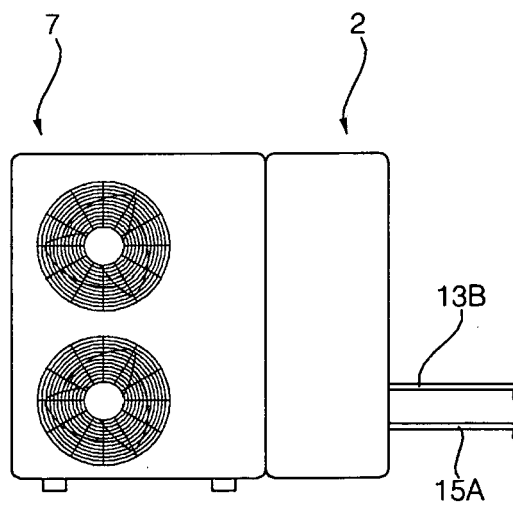


FIG. 6

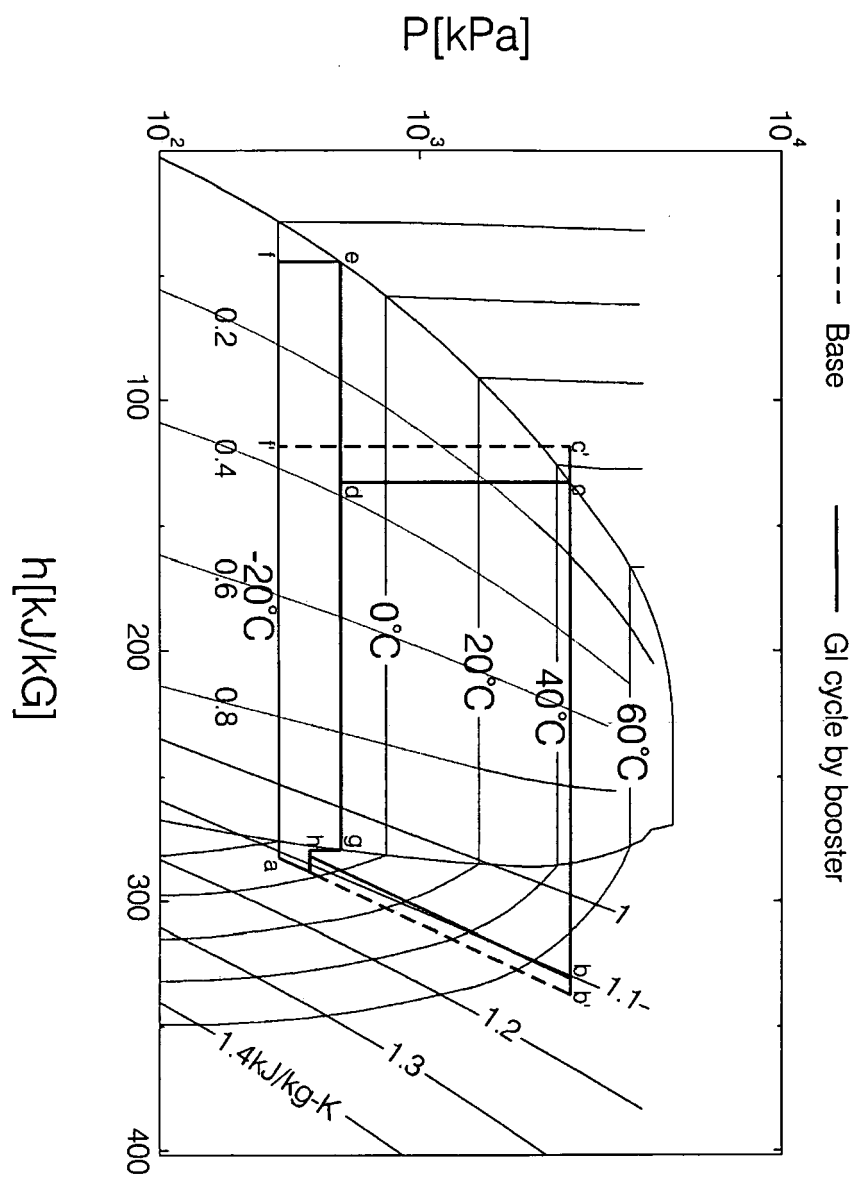


FIG. 7

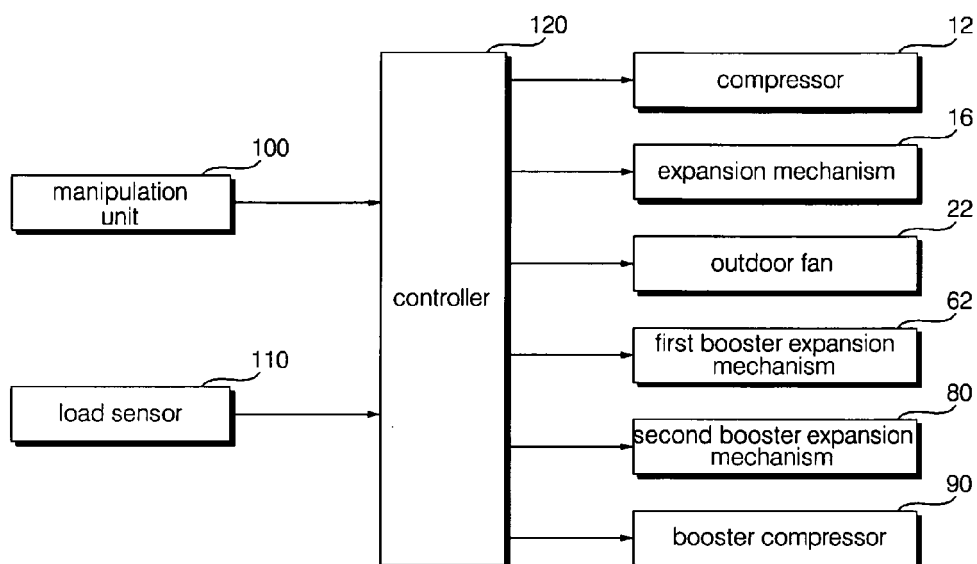


FIG. 8

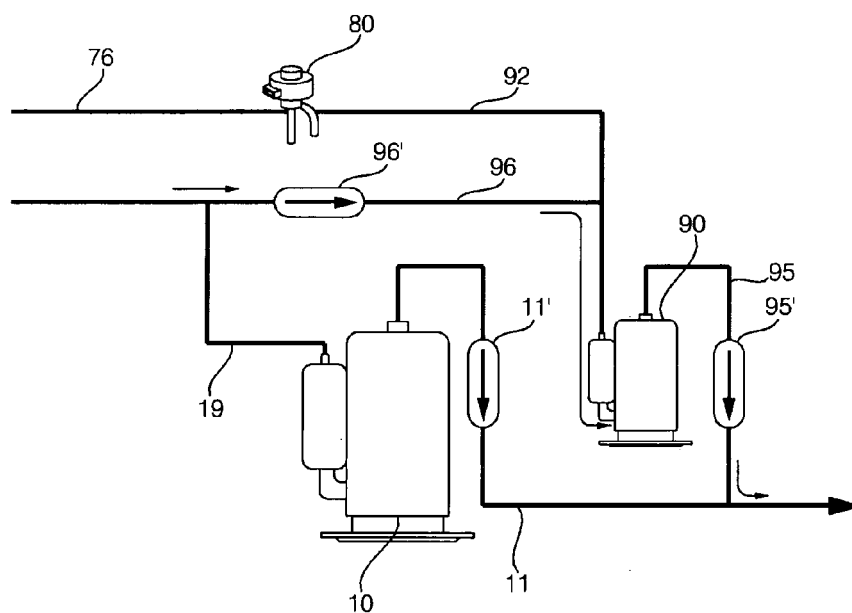


FIG. 9

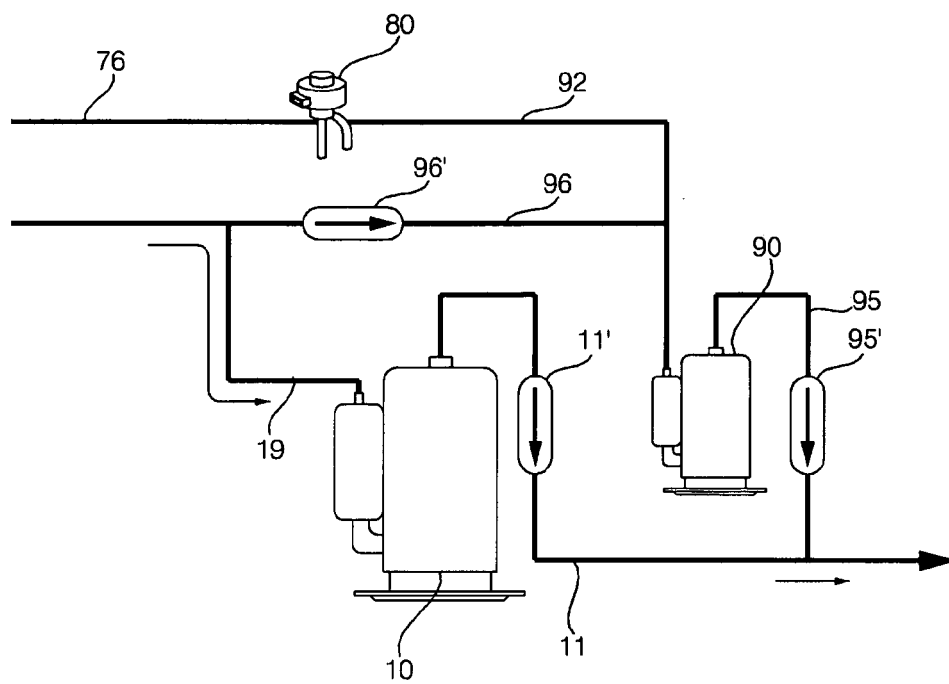


FIG. 10

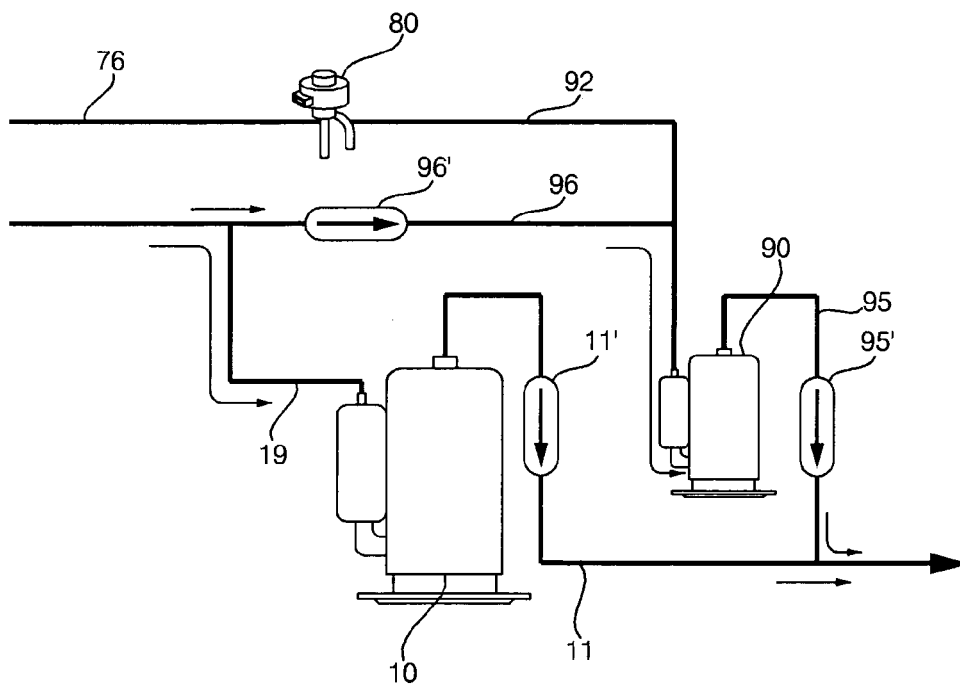


FIG. 11

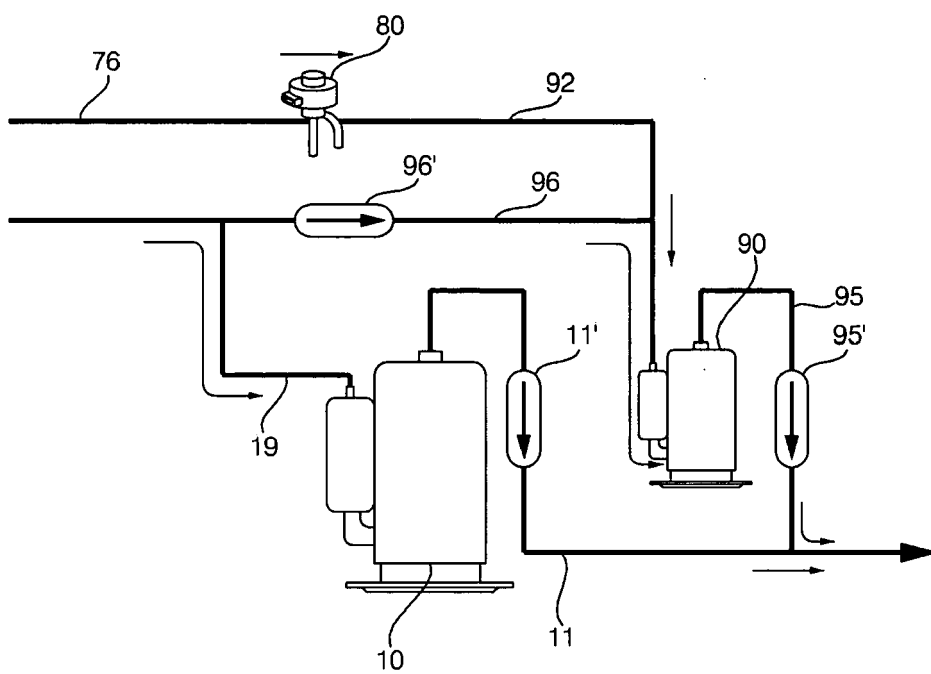


FIG. 12

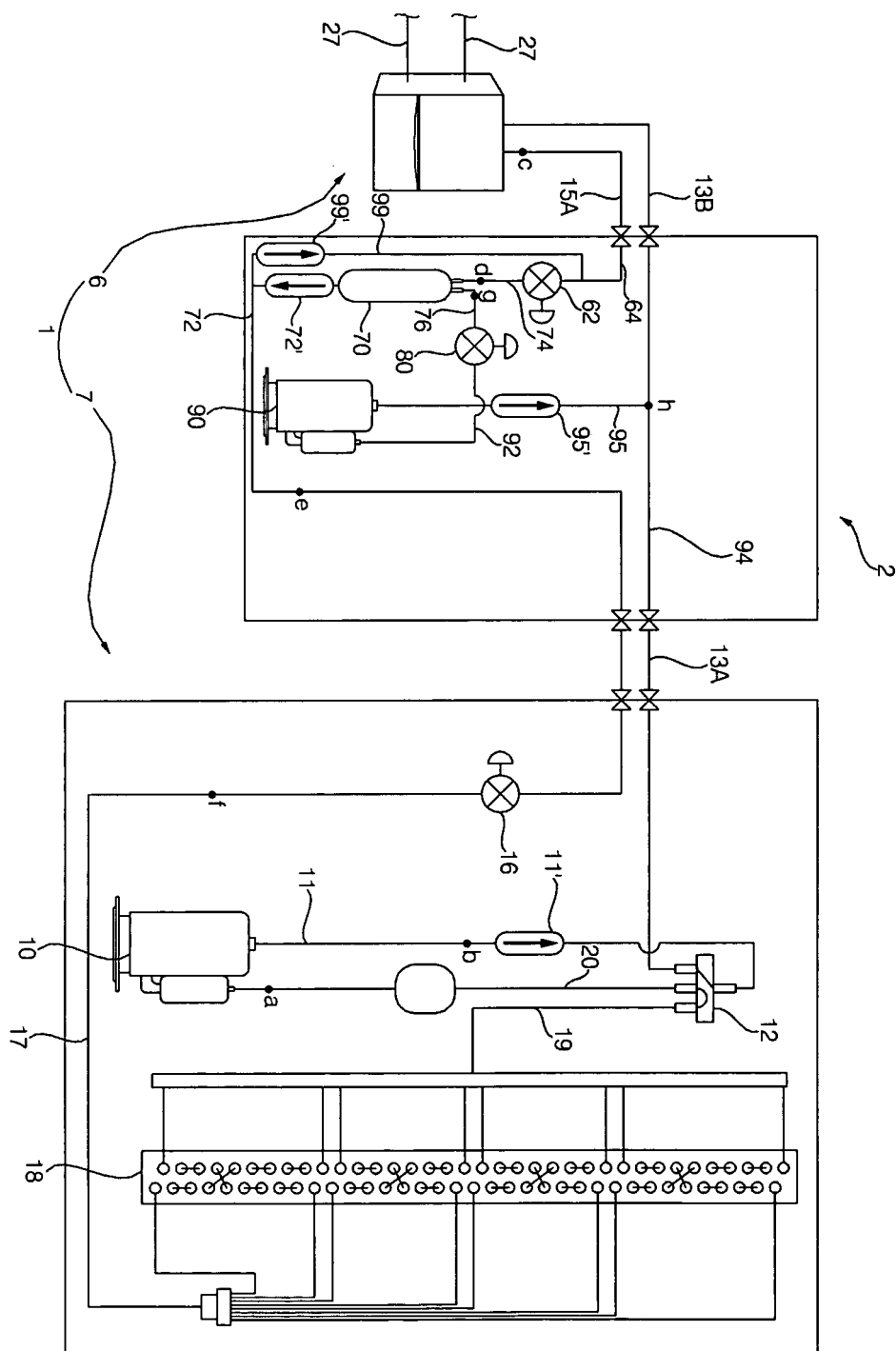


FIG. 13

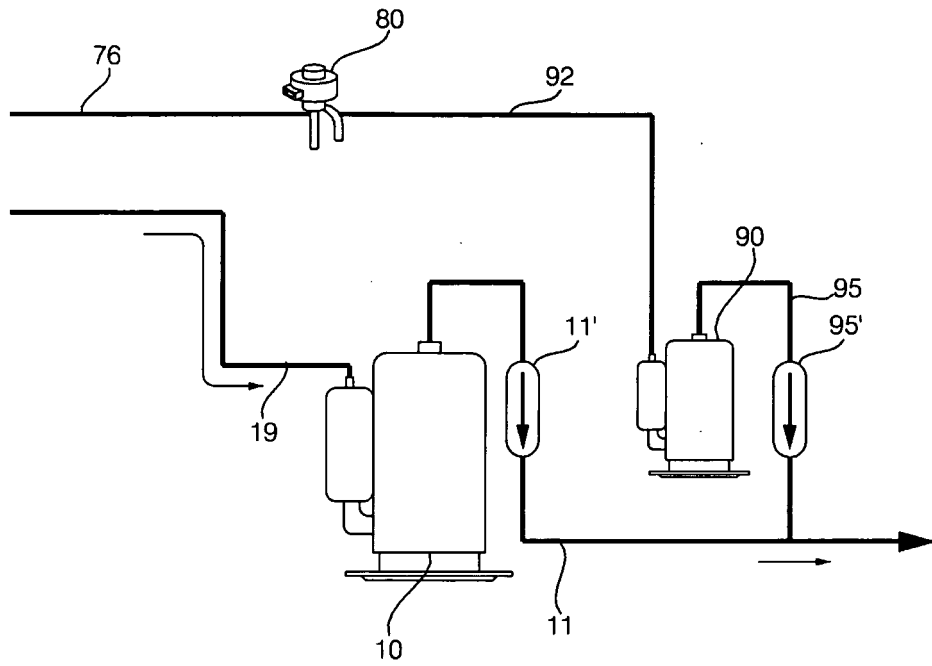


FIG. 14

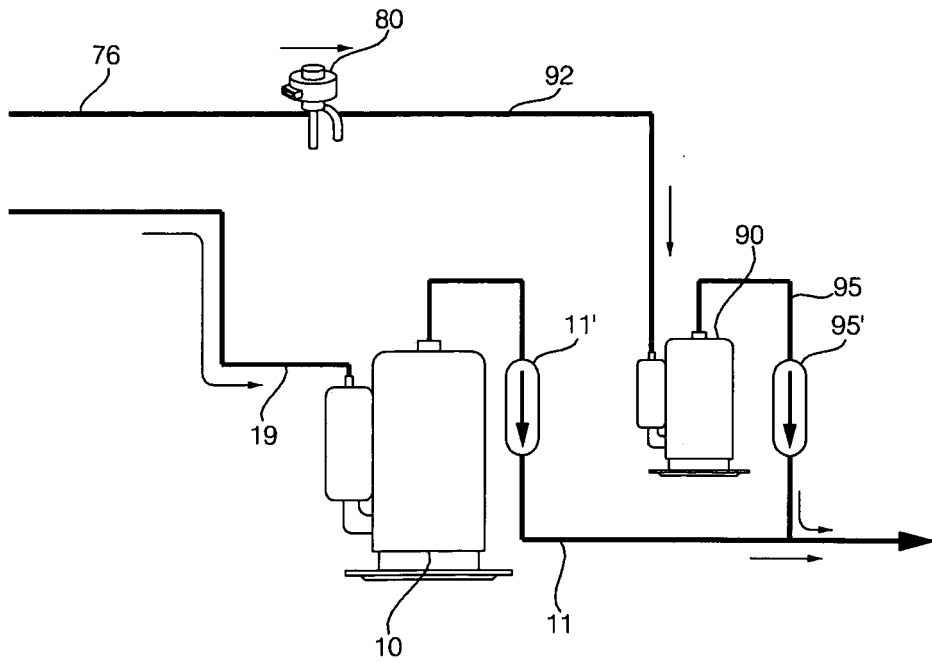


FIG. 15

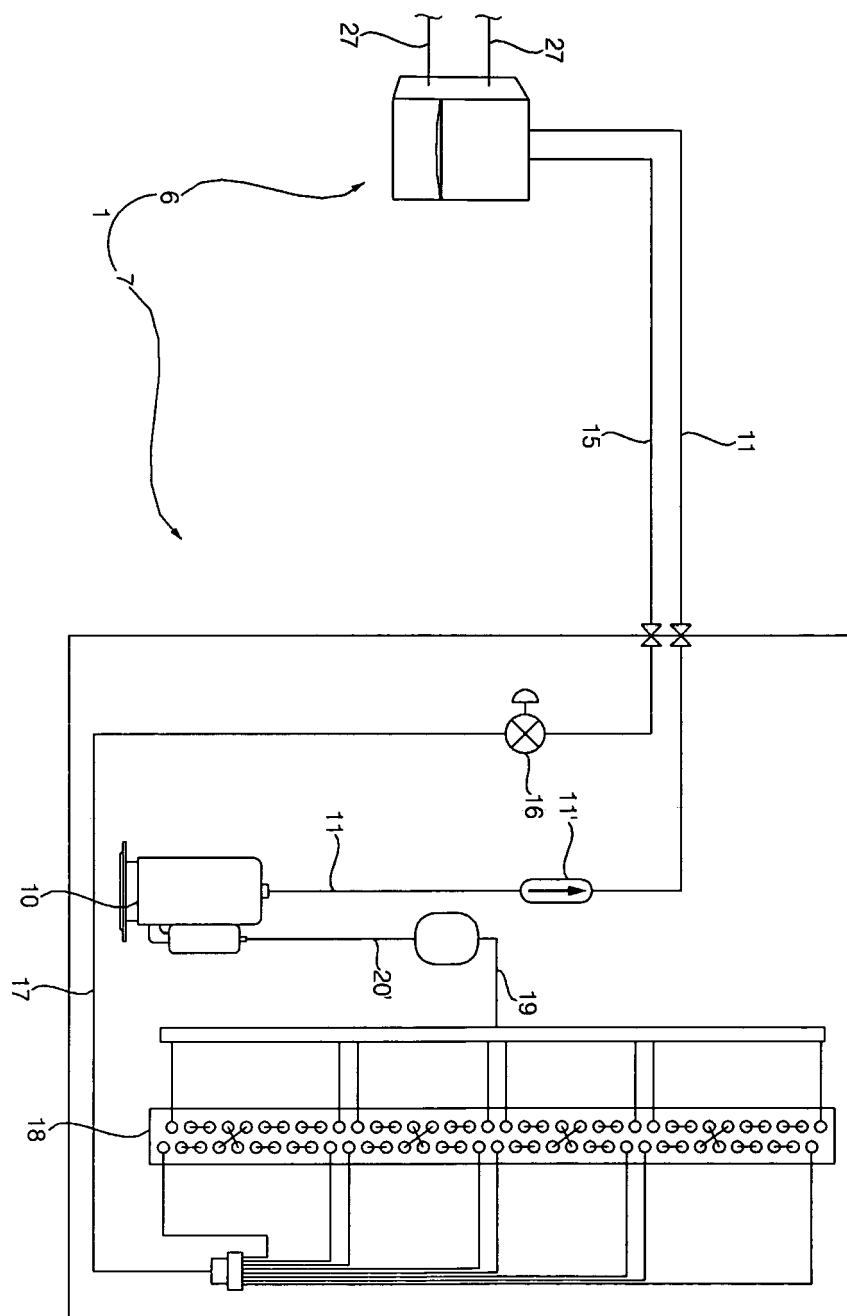


FIG. 16

