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(19) **United States**(12) **Patent Application Publication**
HIRAYAMA et al.(10) **Pub. No.: US 2025/0012518 A1**(43) **Pub. Date: Jan. 9, 2025**(54) **COMPOSITE HEAT EXCHANGER**(71) Applicant: **DENSO CORPORATION**, Kariya-city
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KATO, Kariya-city (JP)(21) Appl. No.: **18/886,515**(22) Filed: **Sep. 16, 2024****Related U.S. Application Data**(63) Continuation of application No. PCT/JP2023/
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F25B 40/02 (2006.01)(52) **U.S. Cl.**CPC **F28F 3/08** (2013.01); **F25B 39/00**
(2013.01); **F25B 40/02** (2013.01)(57) **ABSTRACT**

A composite heat exchanger is used in a vapor compression refrigeration cycle. The vapor compression refrigeration cycle includes: a compressor; a decompressor configured to decompress a high-pressure refrigerant discharged from the compressor; and an evaporator configured to evaporate a low-pressure refrigerant decompressed at the decompressor by exchanging heat between the low-pressure refrigerant and a first heat medium. The composite heat exchanger includes a condenser unit, a liquid storage unit temporarily storing a high-pressure liquid refrigerant, a sub-cooler unit sub-cooling the high-pressure liquid refrigerant through heat exchange with a second heat medium, and an internal heat exchanger unit exchanging heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and the low-pressure refrigerant. The condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together by a predetermined binding element and thereby form an integral structure.

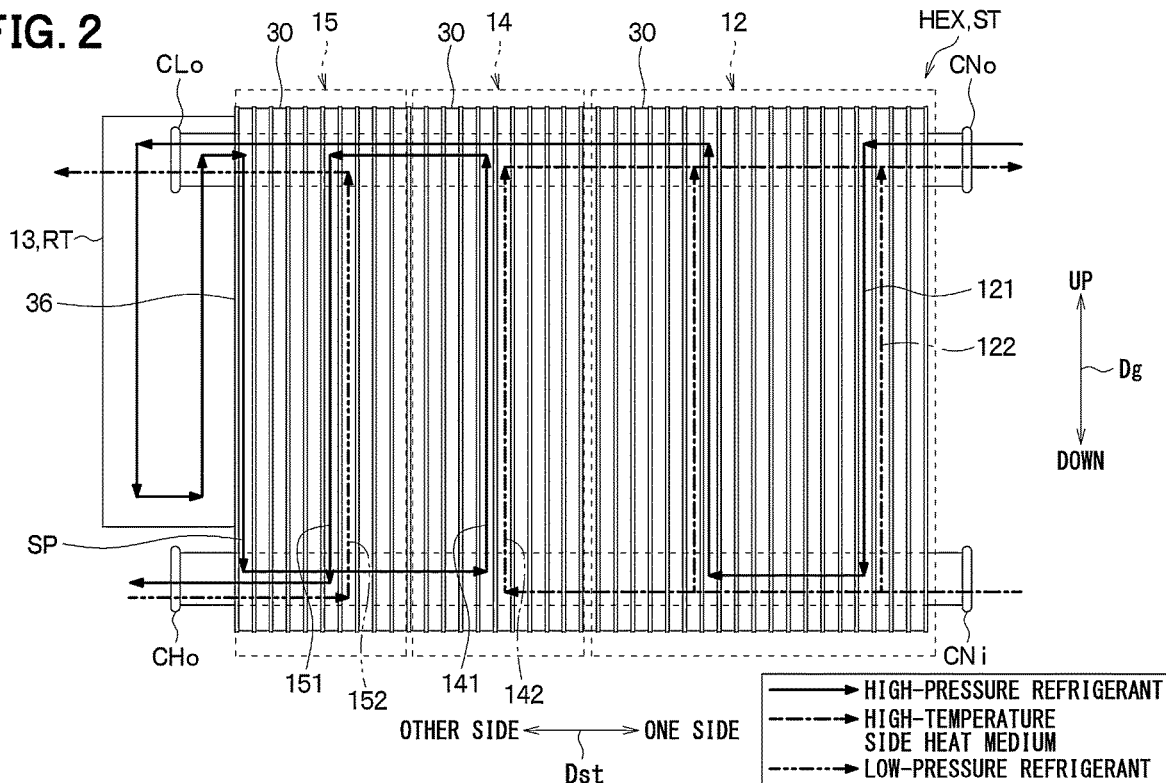
FIG. 2

FIG. 1

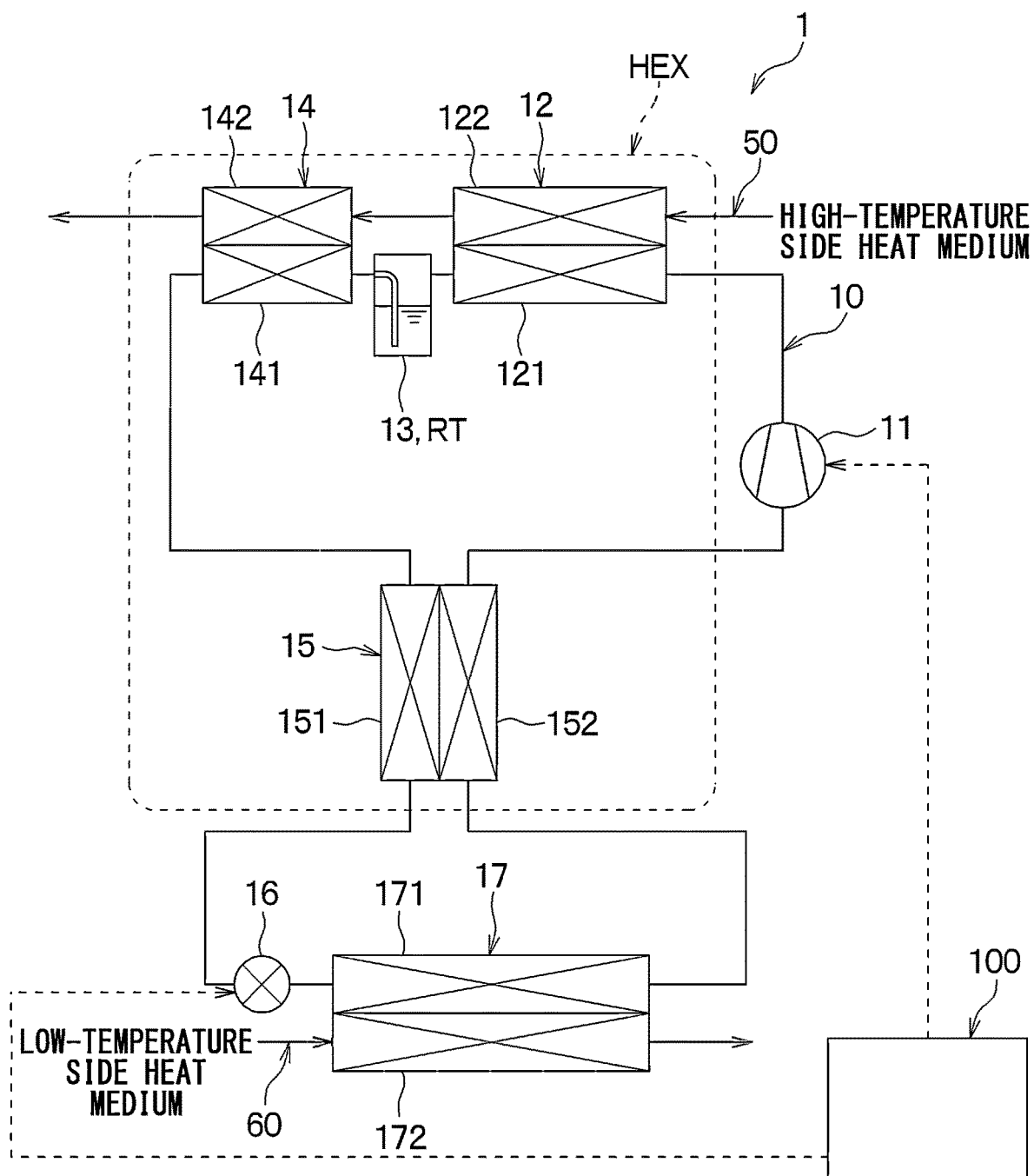


FIG. 2

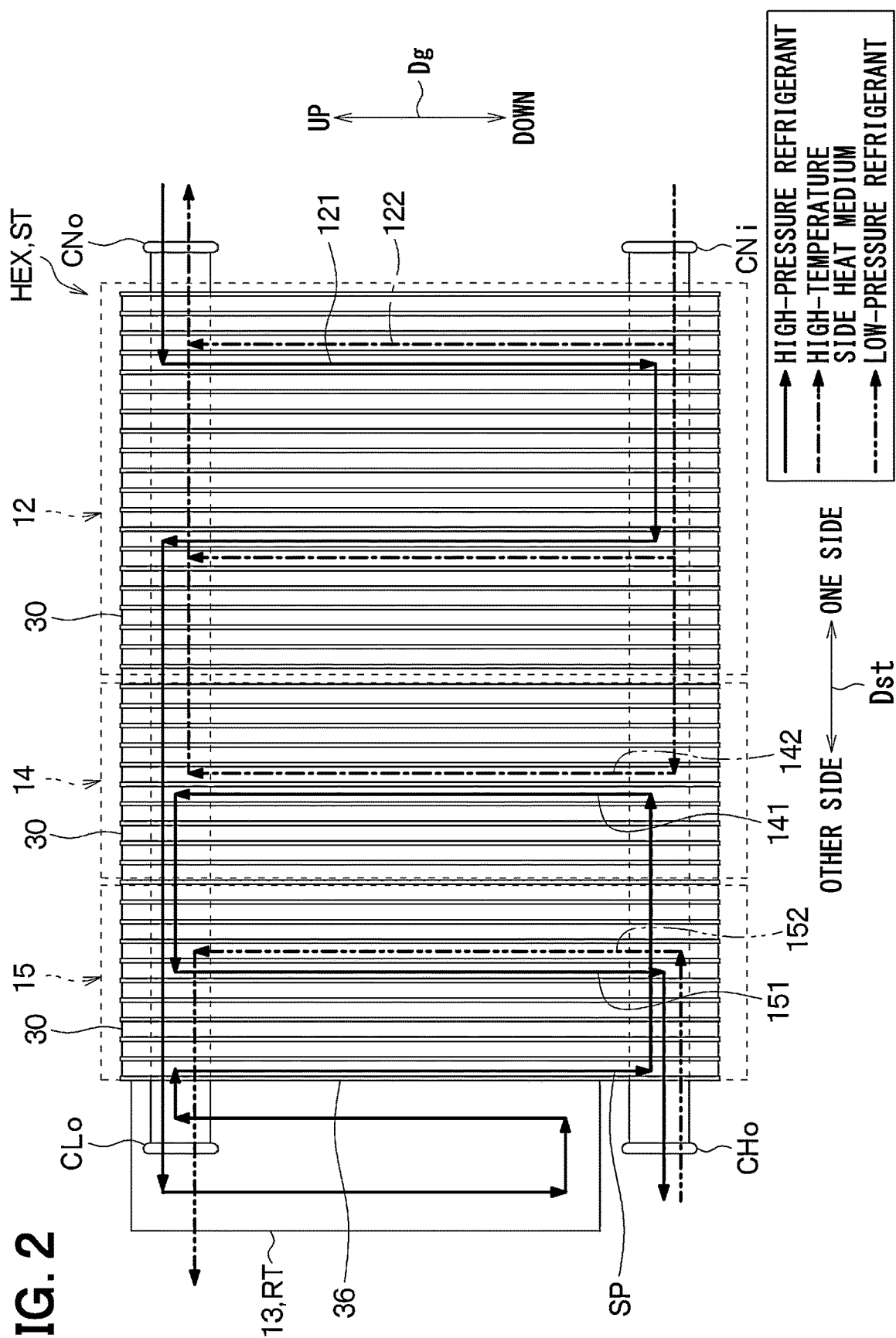


FIG. 3

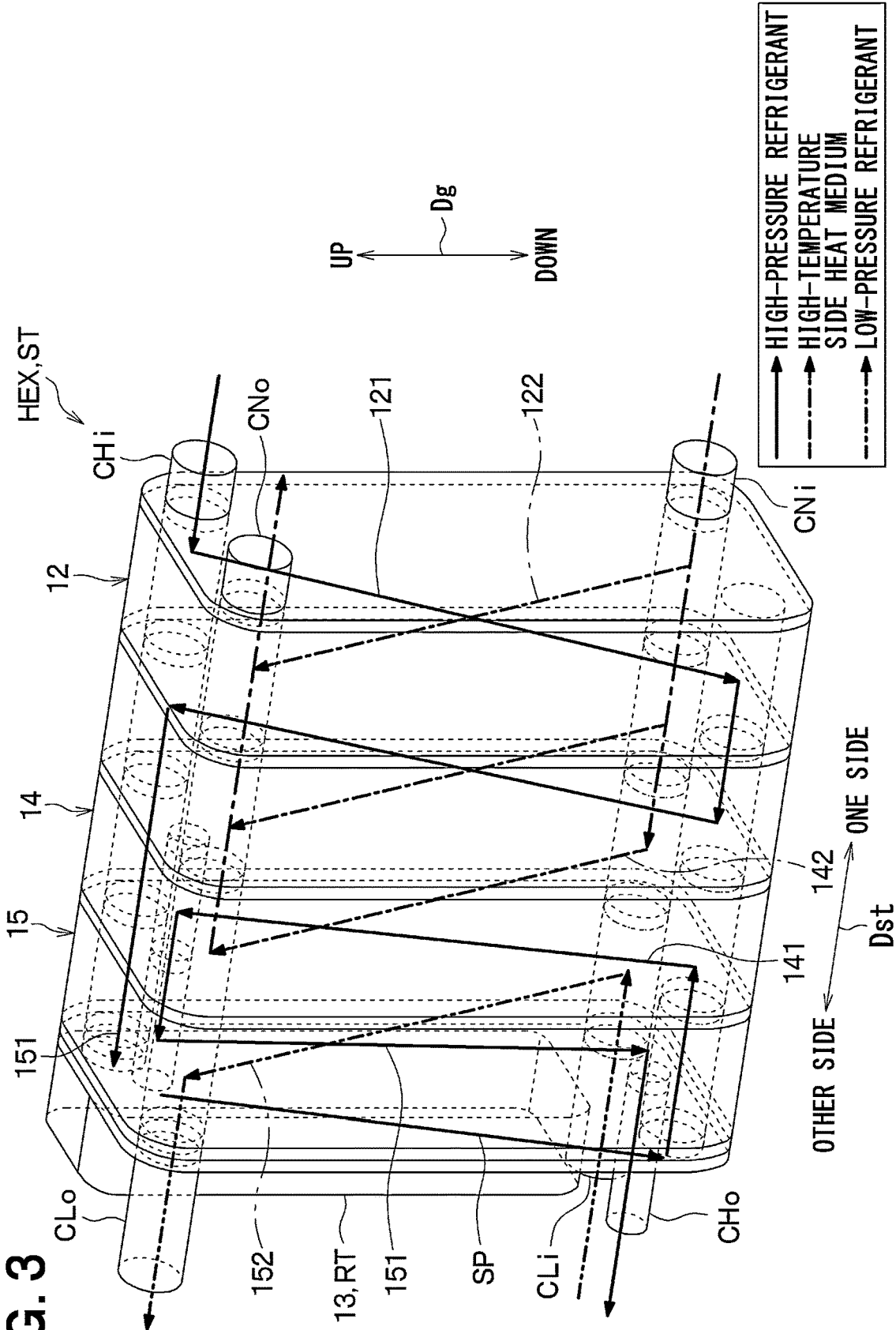


FIG. 5

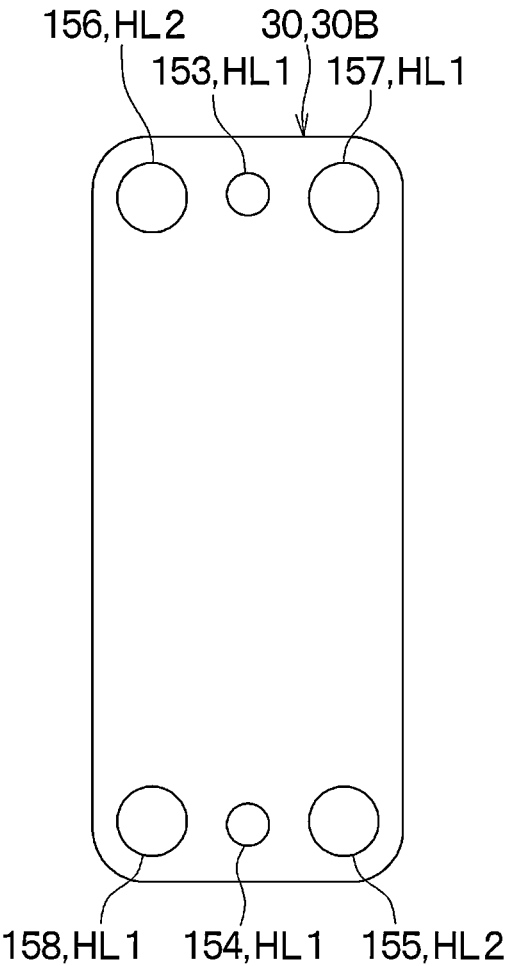


FIG. 6

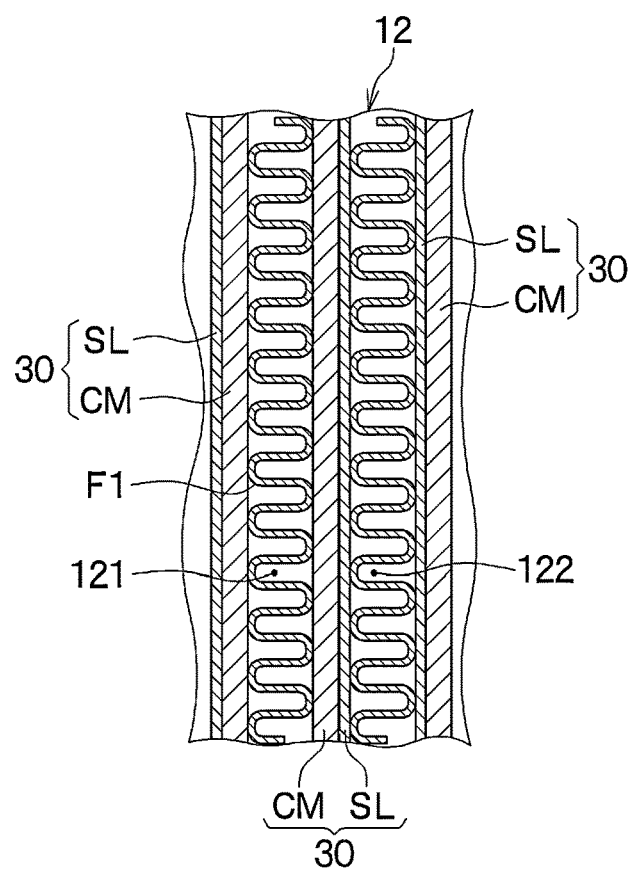


FIG. 7

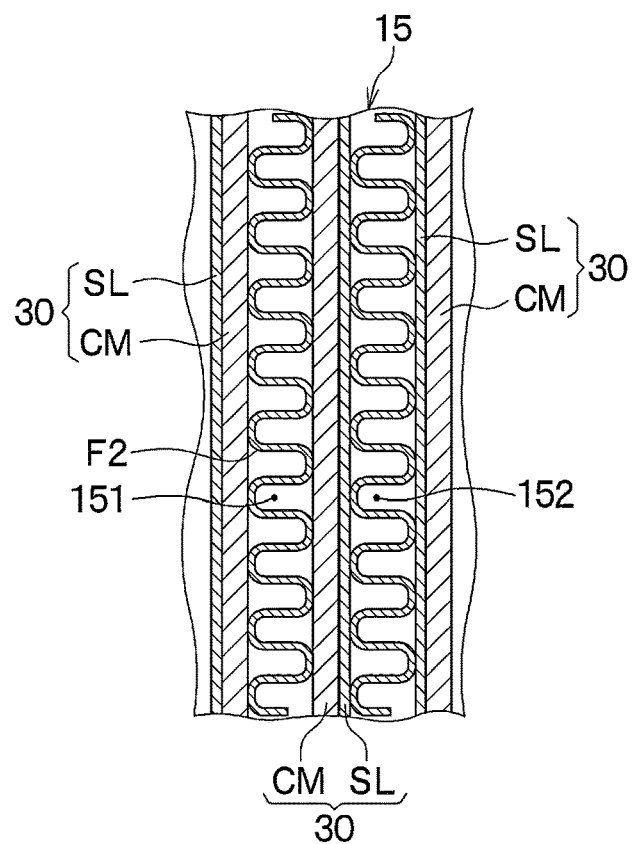


FIG. 8

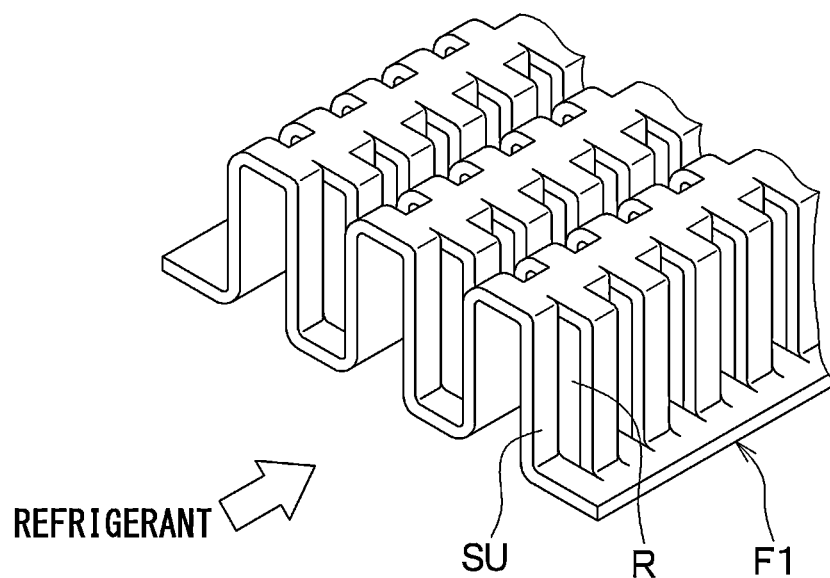
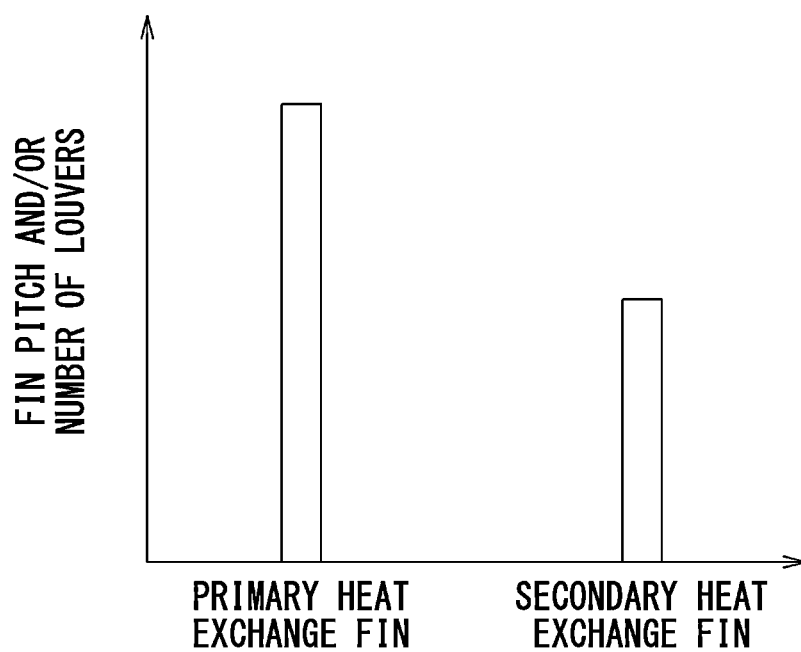
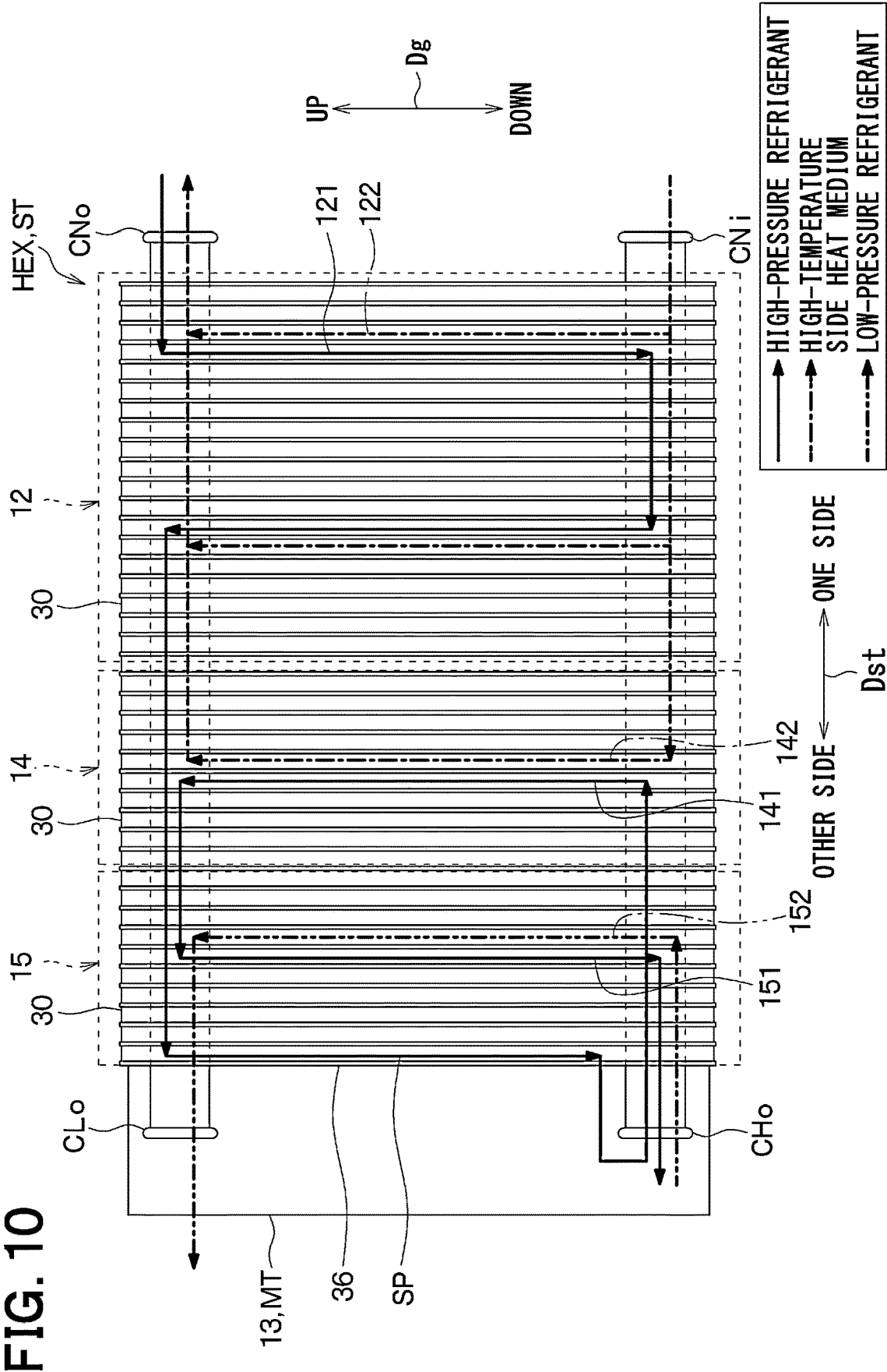


FIG. 9





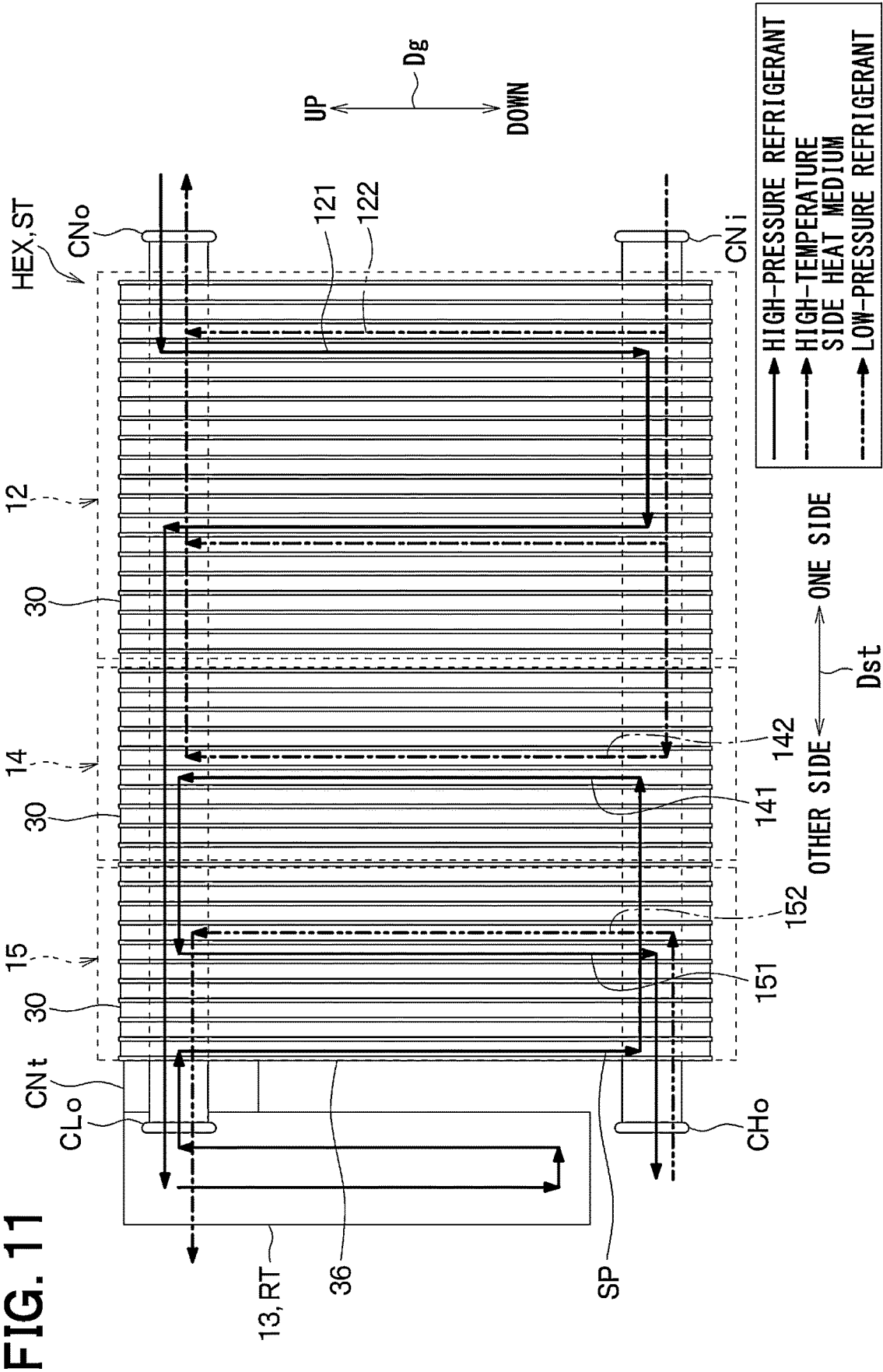
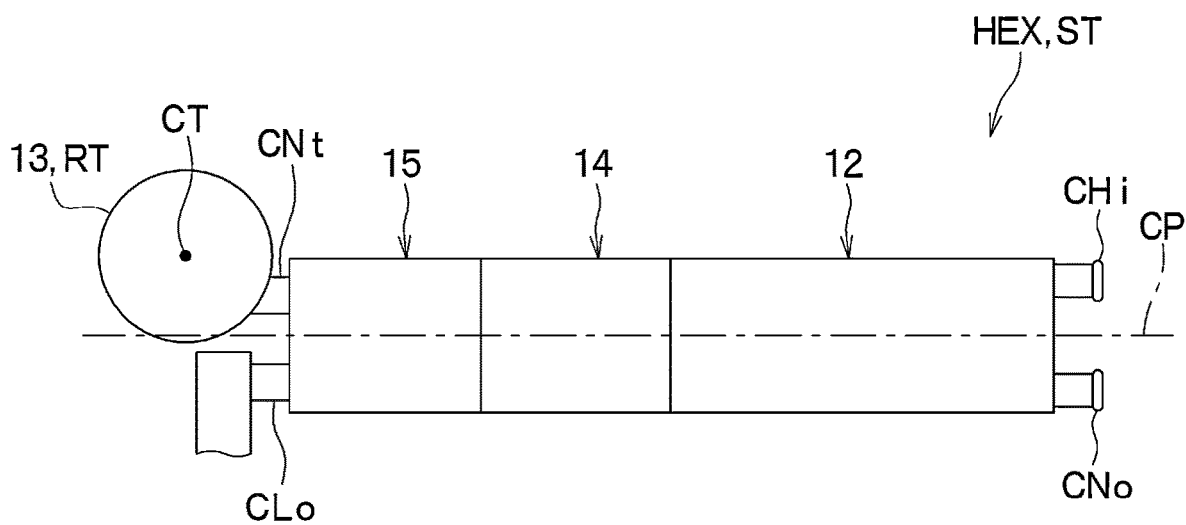
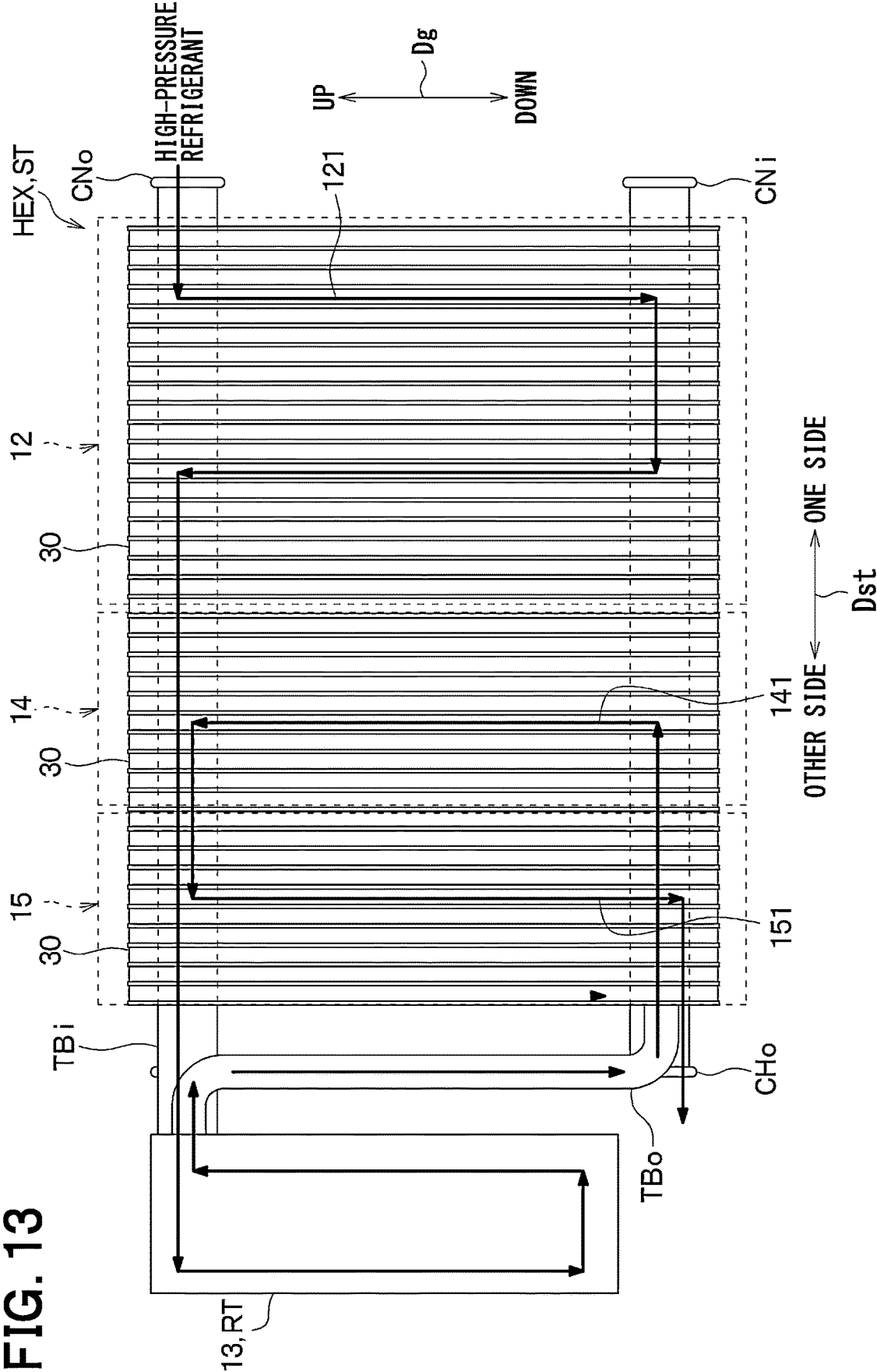


FIG. 12





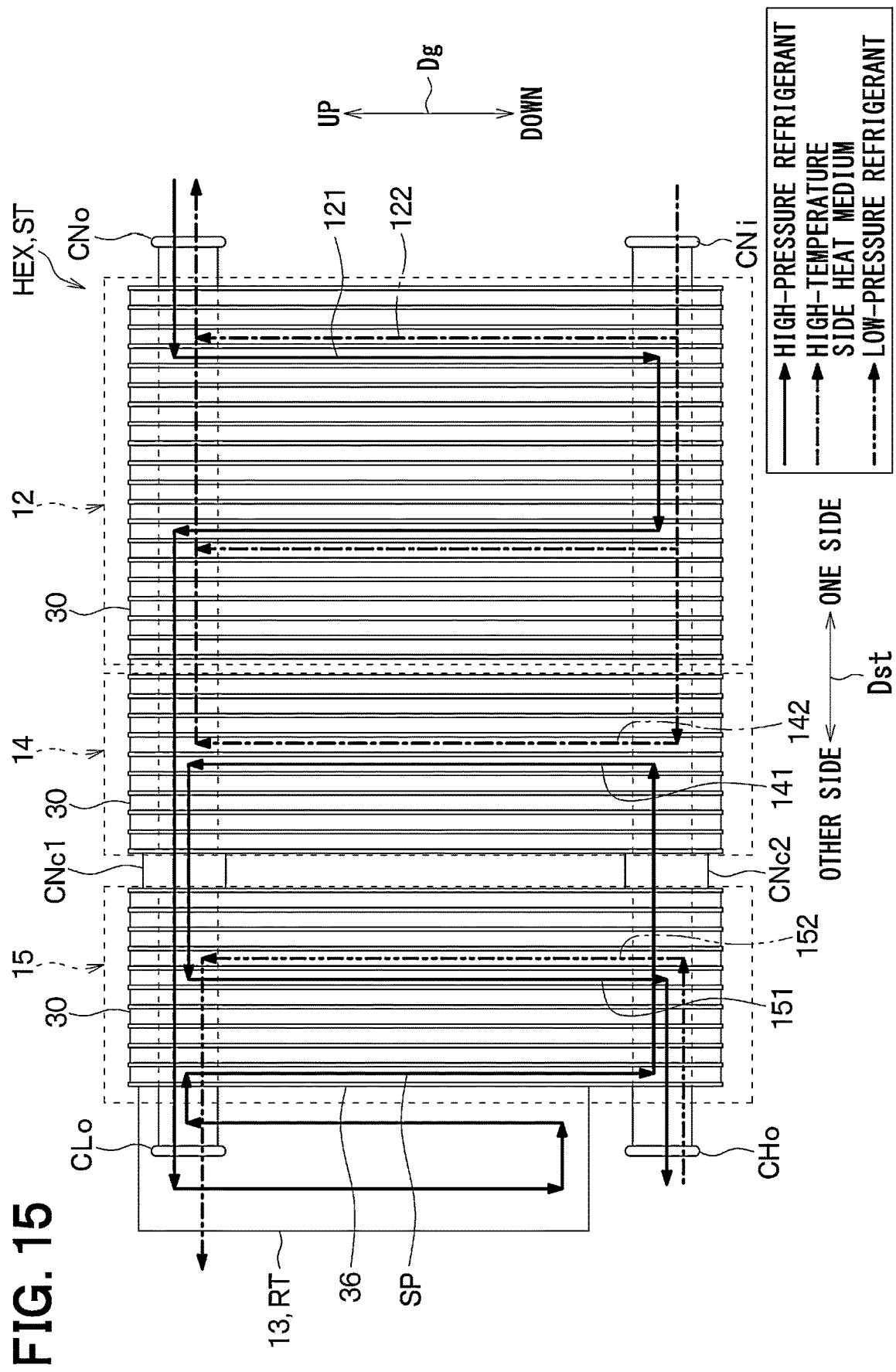
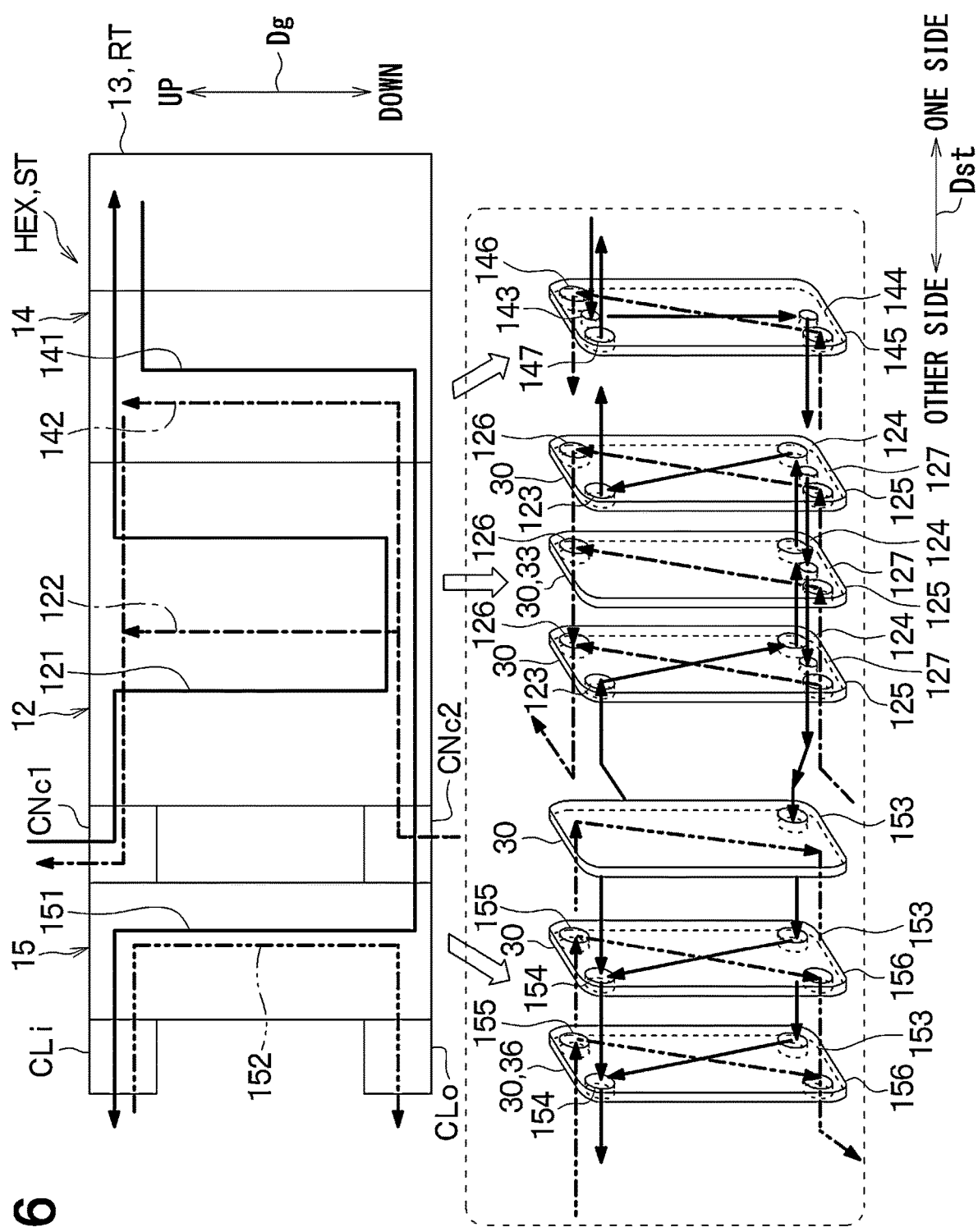


FIG. 16



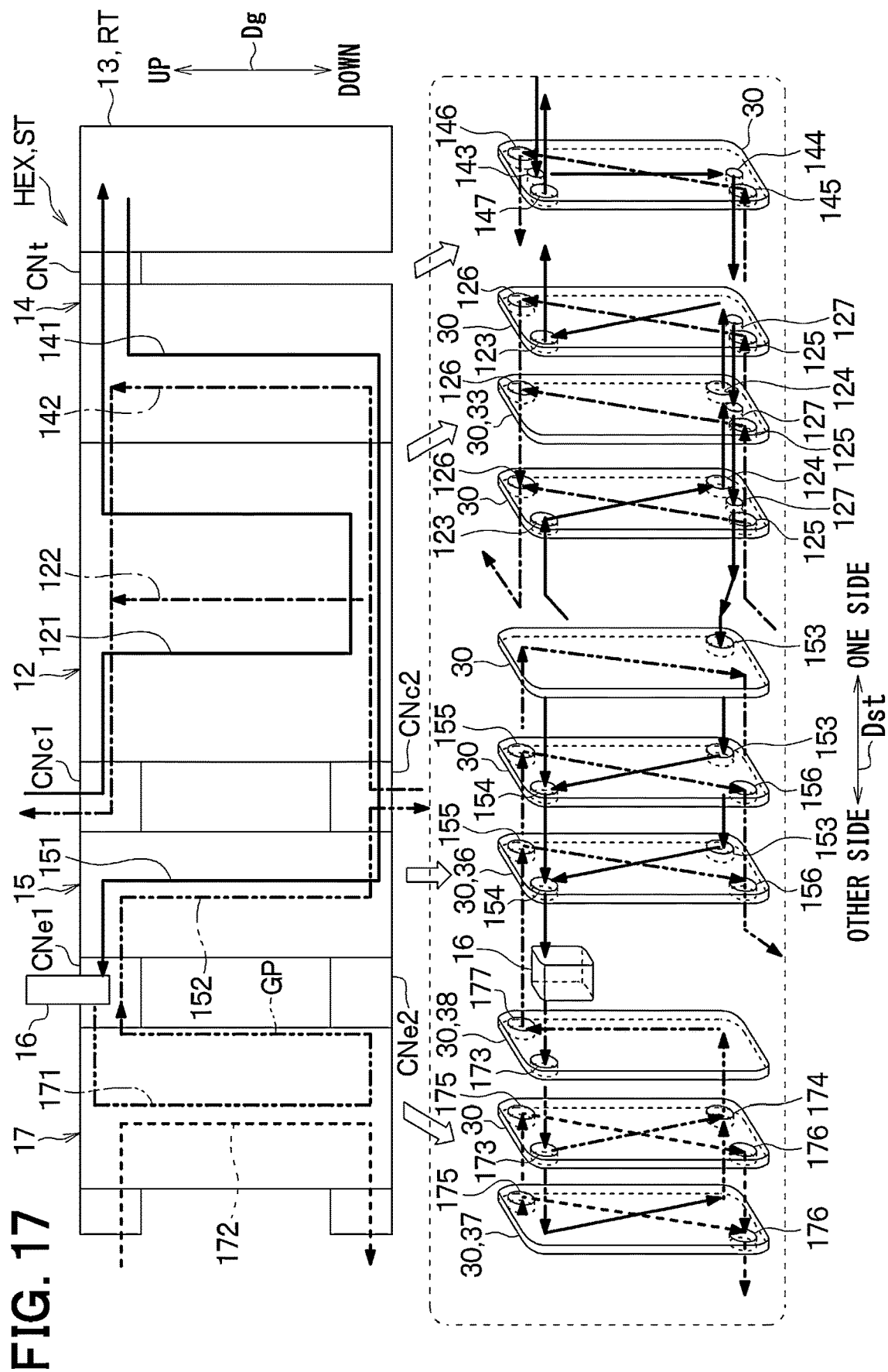


FIG. 18

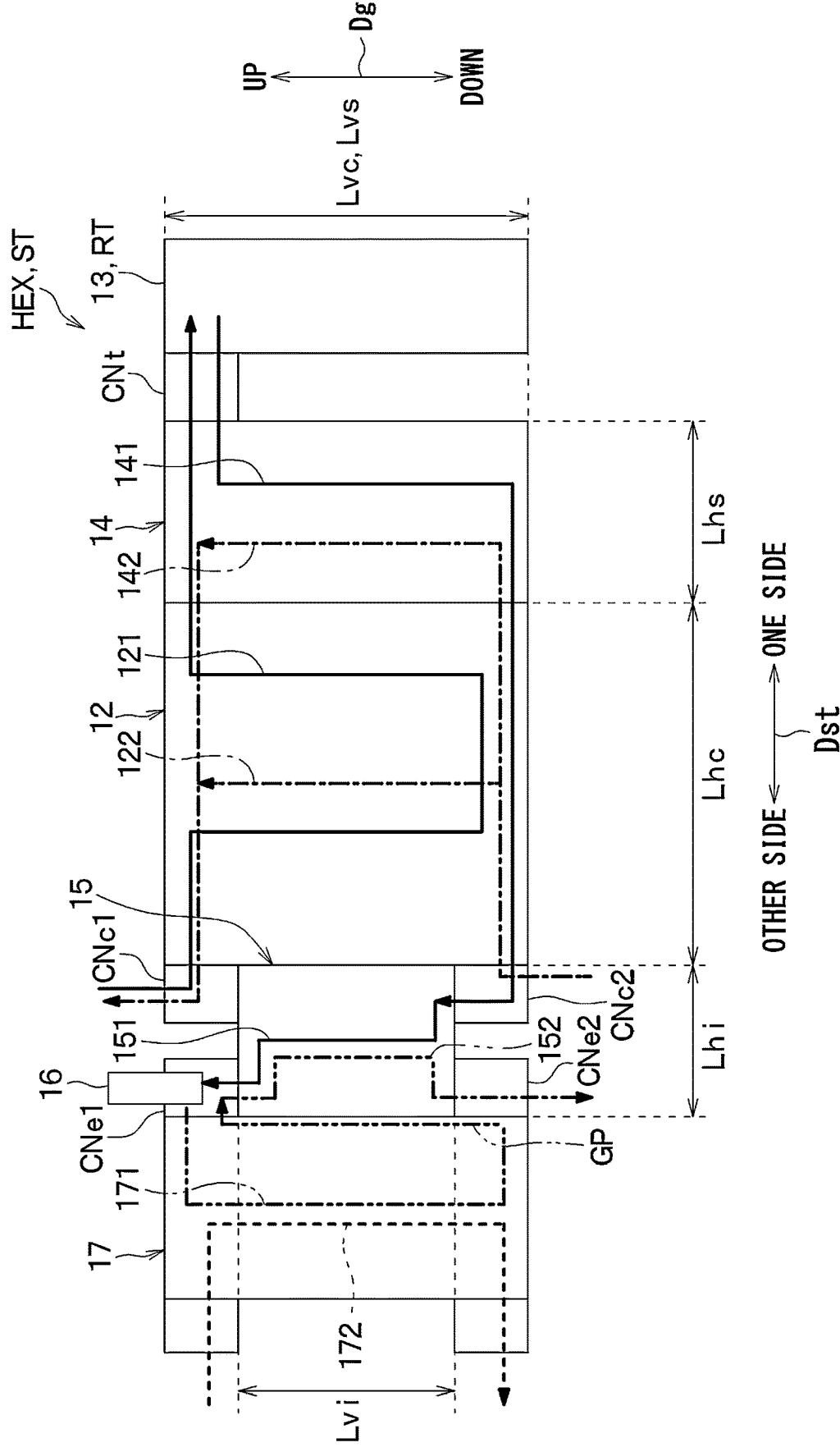


FIG. 19

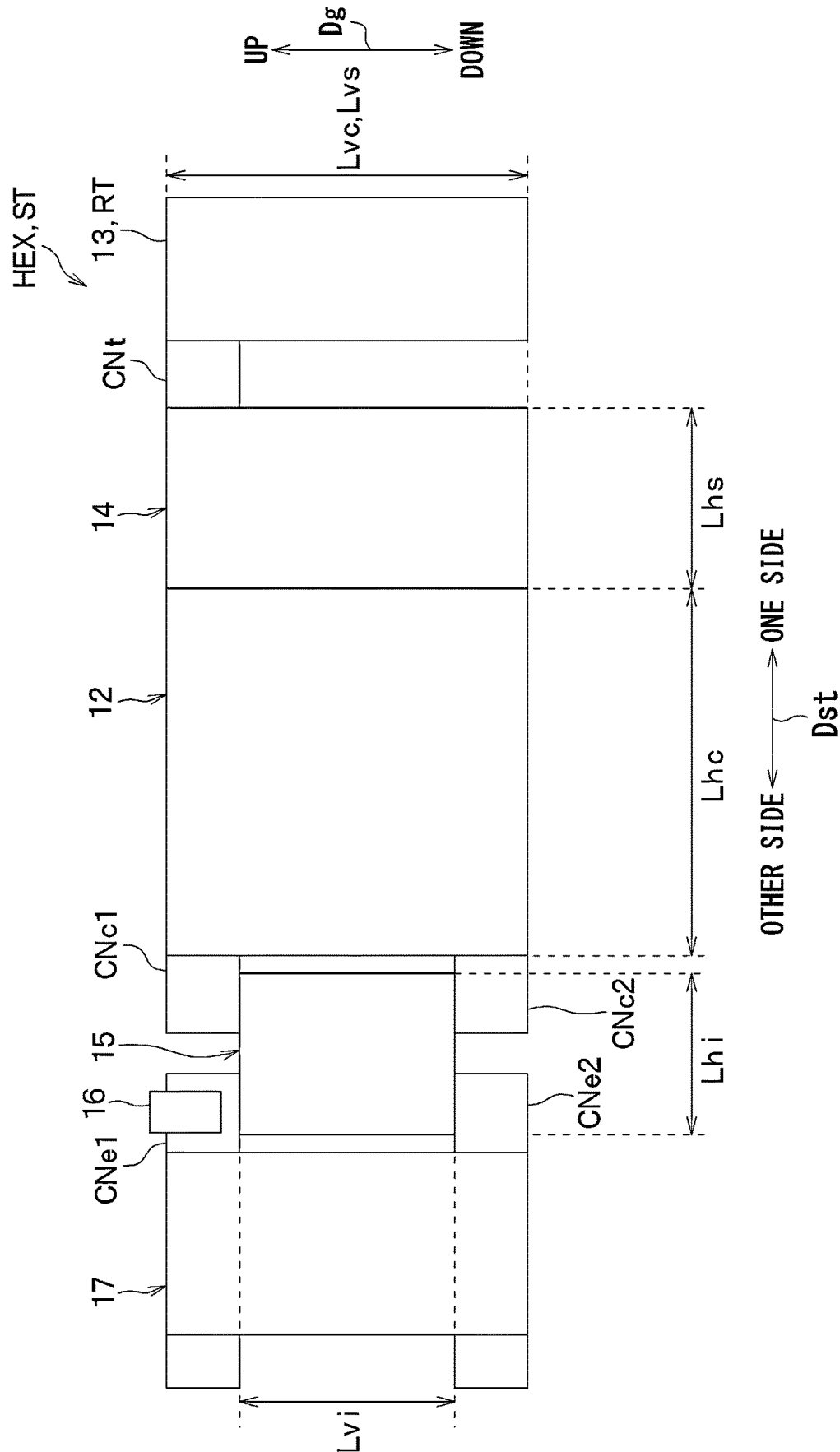


FIG. 20

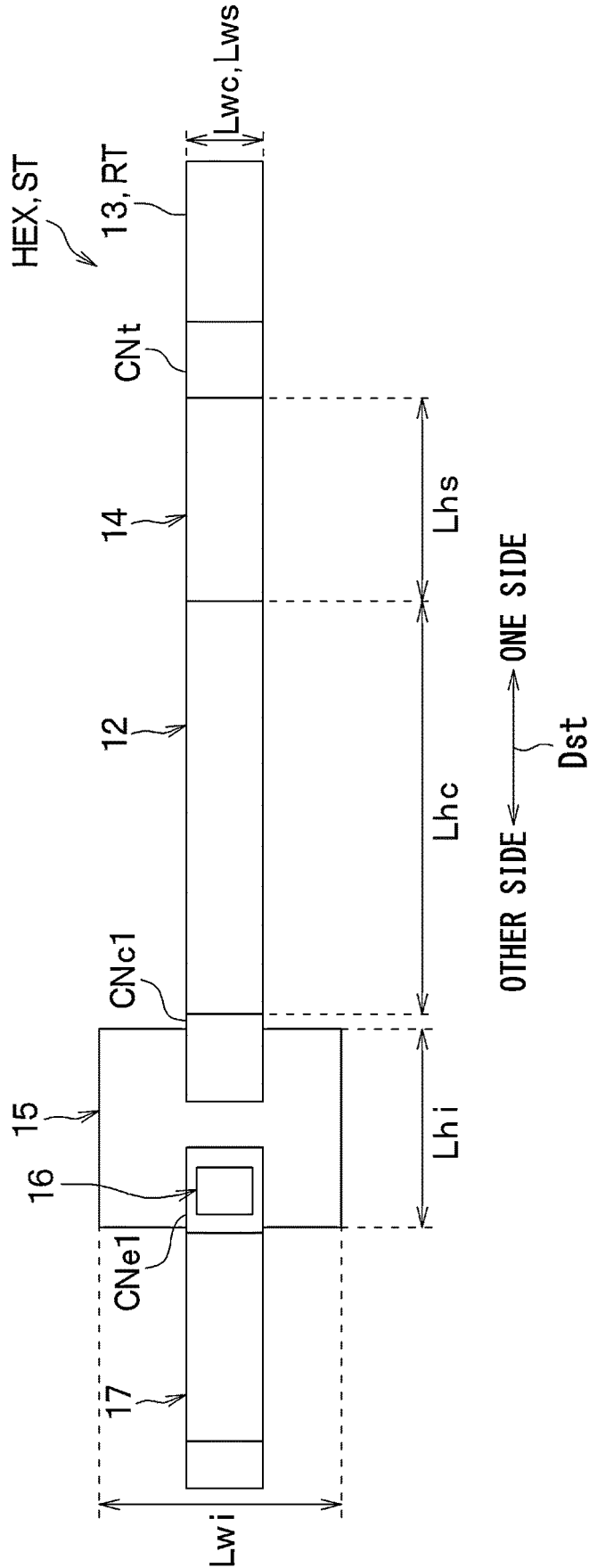


FIG. 21

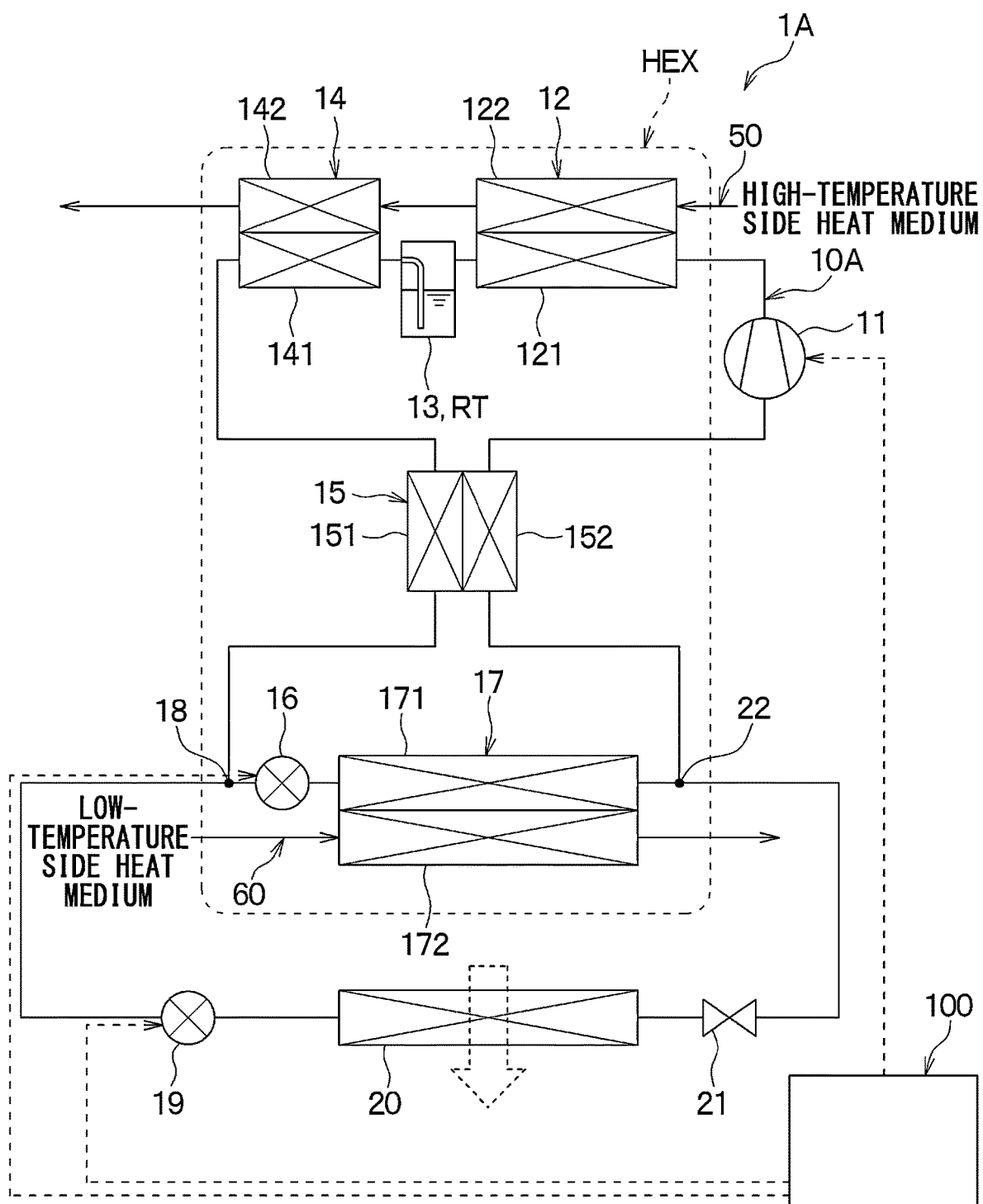


FIG. 22

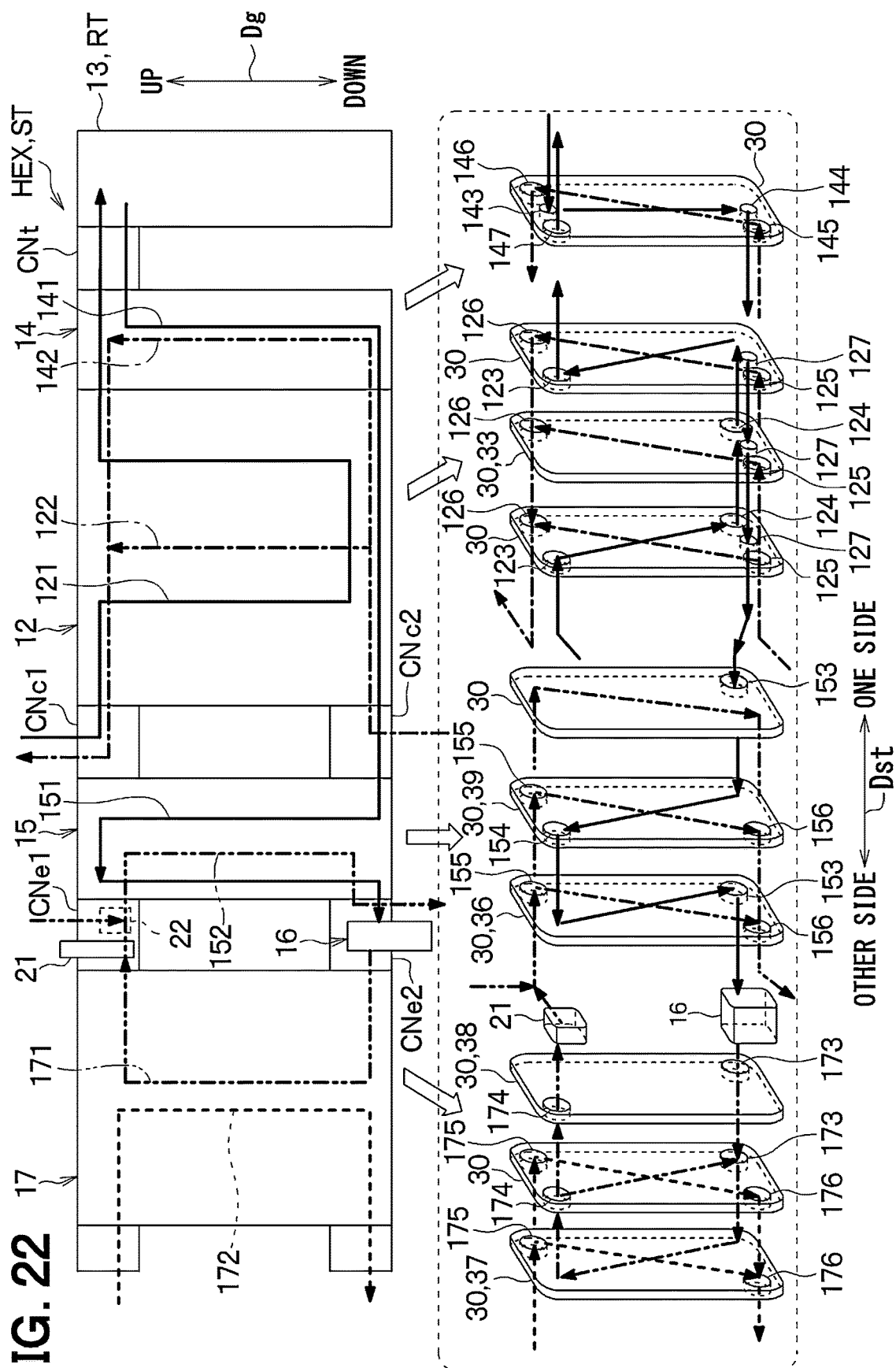


FIG. 23

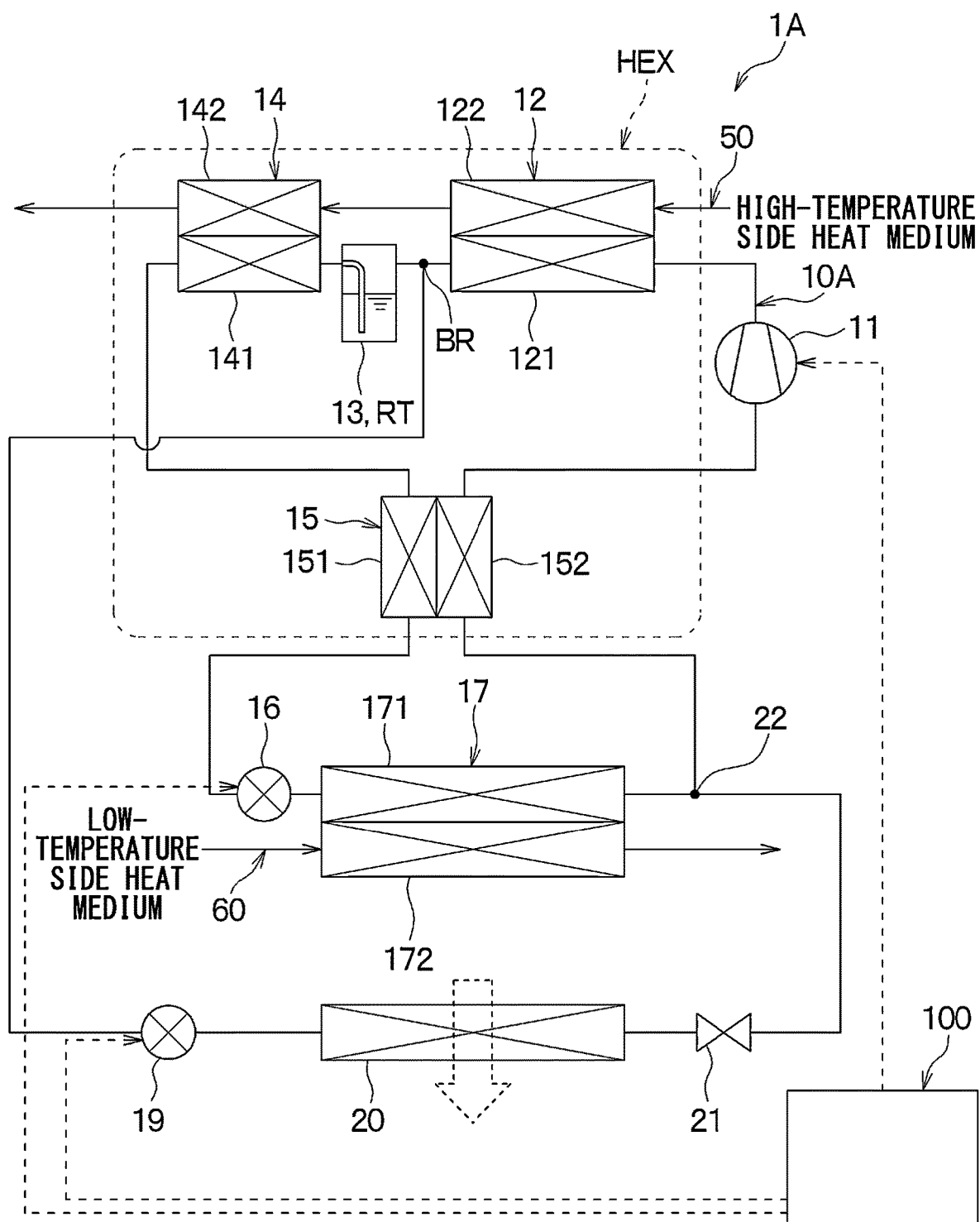


FIG. 25

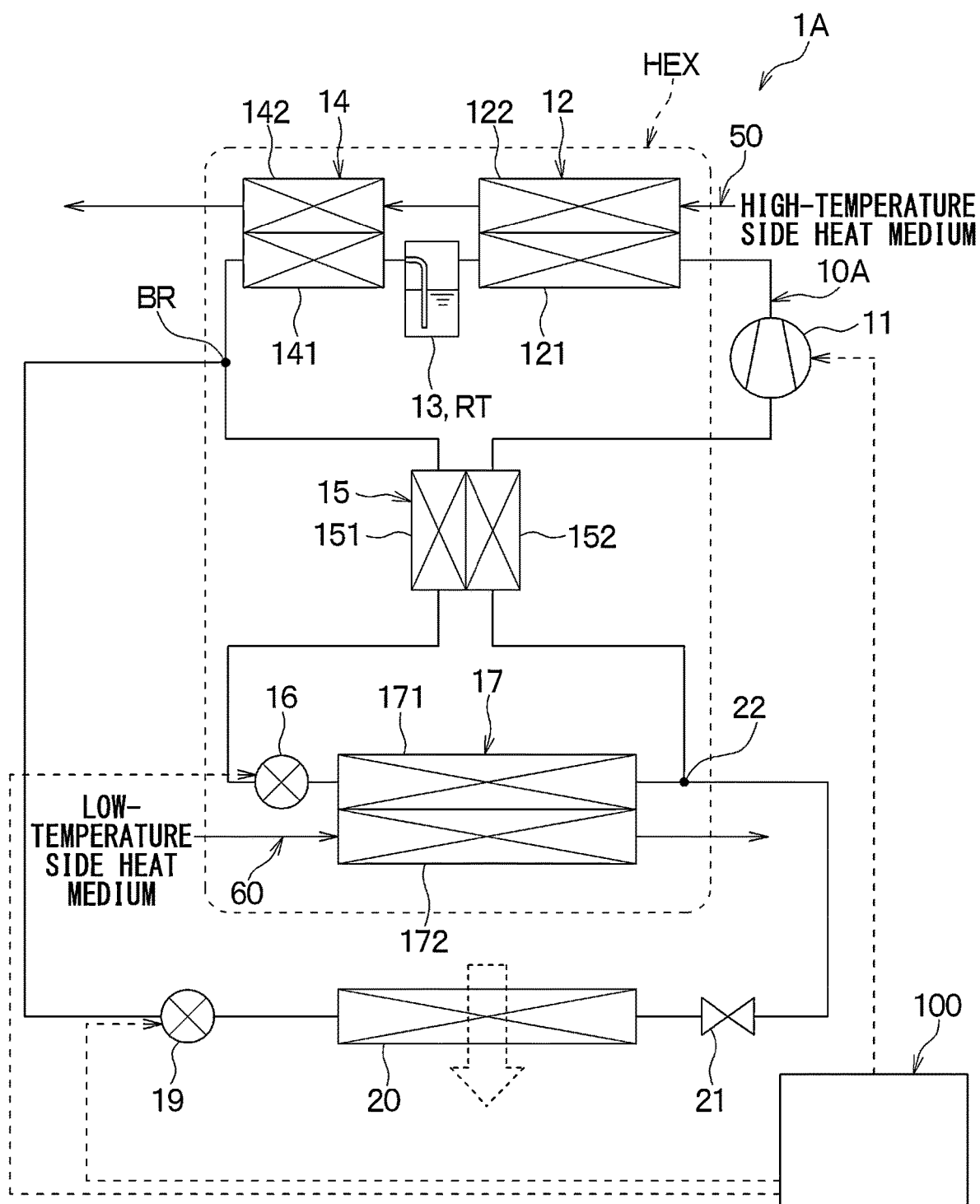
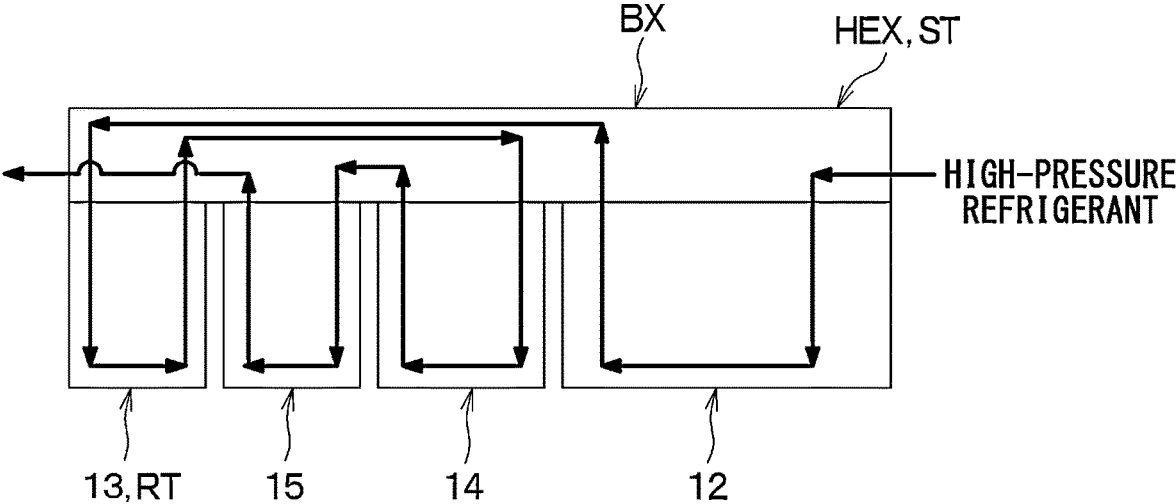


FIG. 27



COMPOSITE HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International Patent Application No. PCT/JP2023/010646 filed on Mar. 17, 2023, which designated the U.S. and claims the benefit of priority from Japanese Patent Application No. 2022-047473 filed on Mar. 23, 2022. The entire disclosures of all of the above applications are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a composite heat exchanger.

BACKGROUND

[0003] Previously, there has been proposed a heat exchanger that includes: a radiator which releases heat from a refrigerant; a liquid storage which stores a high-pressure liquid refrigerant contained in a high-pressure refrigerant passed through the radiator; and an internal heat exchanger which exchanges heat between the high-pressure liquid refrigerant and a low-pressure refrigerant to be suctioned into a compressor, and the radiator, the liquid storage and the internal heat exchanger are integrated together in a compact form.

[0004] Although the previously proposed composite heat exchanger described above includes the internal heat exchanger, the amount of heat released by the refrigerant at the radiator is not sufficient, making it difficult to sufficiently lower an enthalpy of the high-pressure refrigerant.

SUMMARY

[0005] According to one aspect of the present disclosure, there is provided a composite heat exchanger that includes: a condenser unit configured to condense a high-pressure refrigerant by exchanging heat between the high-pressure refrigerant and a heat medium; a liquid storage unit configured to temporarily store a high-pressure liquid refrigerant contained in the high-pressure refrigerant passed through the condenser unit; a sub-cooler unit configured to sub-cool the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit by exchanging heat between the high-pressure liquid refrigerant and the heat medium; and an internal heat exchanger unit configured to exchange heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and a low-pressure refrigerant discharged from an evaporator. The condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together and thereby form an integral structure.

BRIEF DESCRIPTION OF DRAWINGS

[0006] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0007] FIG. 1 is a schematic diagram of a refrigeration cycle apparatus including a composite heat exchanger of a first embodiment.

[0008] FIG. 2 is a schematic front view of the composite heat exchanger of the first embodiment.

[0009] FIG. 3 is a schematic perspective view of the composite heat exchanger of the first embodiment.

[0010] FIG. 4 is a schematic exploded perspective view of the composite heat exchanger of the first embodiment.

[0011] FIG. 5 is an explanatory diagram for explaining one example of a plate member used in the composite heat exchanger of the first embodiment.

[0012] FIG. 6 is an explanatory diagram for explaining an internal structure of a condenser unit.

[0013] FIG. 7 is an explanatory diagram for explaining an internal structure of an internal heat exchanger unit.

[0014] FIG. 8 is an explanatory diagram for explaining a primary heat exchange fin.

[0015] FIG. 9 is an explanatory diagram for explaining a difference between the primary heat exchange fin and a secondary heat exchange fin.

[0016] FIG. 10 is a schematic front view of a composite heat exchanger of a second embodiment.

[0017] FIG. 11 is a schematic front view of a composite heat exchanger of a third embodiment.

[0018] FIG. 12 is a schematic plan view of the composite heat exchanger of the third embodiment.

[0019] FIG. 13 is a schematic front view of a composite heat exchanger of a fourth embodiment.

[0020] FIG. 14 is a schematic front view of a composite heat exchanger of a modification of the fourth embodiment.

[0021] FIG. 15 is a schematic front view of a composite heat exchanger of a fifth embodiment.

[0022] FIG. 16 is an explanatory diagram for explaining a composite heat

[0023] exchanger of a sixth embodiment.

[0024] FIG. 17 is an explanatory diagram for explaining a composite heat

[0025] exchanger of a seventh embodiment.

[0026] FIG. 18 is a schematic front view of a composite heat exchanger of an

[0027] eighth embodiment.

[0028] FIG. 19 is a schematic front view of a composite heat exchanger of a ninth

[0029] embodiment.

[0030] FIG. 20 is a schematic plan view of the composite heat exchanger of the ninth embodiment.

[0031] FIG. 21 is a schematic diagram of a refrigeration cycle apparatus including a composite heat exchanger of a tenth embodiment.

[0032] FIG. 22 is an explanatory diagram for explaining the composite heat exchanger of the tenth embodiment.

[0033] FIG. 23 is a schematic diagram of a refrigeration cycle apparatus including a composite heat exchanger of an eleventh embodiment.

[0034] FIG. 24 is an explanatory diagram for explaining the composite heat exchanger of the eleventh embodiment.

[0035] FIG. 25 is a schematic diagram of a refrigeration cycle apparatus including a composite heat exchanger of a twelfth embodiment.

[0036] FIG. 26 is an explanatory diagram for explaining the composite heat exchanger of the twelfth embodiment.

[0037] FIG. 27 is an explanatory diagram for explaining a composite heat exchanger of a thirteenth embodiment.

DETAILED DESCRIPTION

[0038] Previously, there has been proposed a heat exchanger that includes: a radiator which releases heat from a refrigerant; a liquid storage which stores a high-pressure

liquid refrigerant contained in a high-pressure refrigerant passed through the radiator; and an internal heat exchanger which exchanges heat between the high-pressure liquid refrigerant and a low-pressure refrigerant to be suctioned into a compressor, and the radiator, the liquid storage and the internal heat exchanger are integrated together in a compact form.

[0039] Although the previously proposed composite heat exchanger described above includes the internal heat exchanger, the amount of heat released by the refrigerant at the radiator is not sufficient, making it difficult to sufficiently lower an enthalpy of the high-pressure refrigerant.

[0040] According to one aspect of the present disclosure, there is provided a composite heat exchanger configured to be used in a vapor compression refrigeration cycle that includes: a compressor; a decompressor configured to decompress a high-pressure refrigerant discharged from the compressor; and an evaporator configured to evaporate a low-pressure refrigerant decompressed at the decompressor by exchanging heat between the low-pressure refrigerant and a first heat medium. The composite heat exchanger includes: a condenser unit configured to condense the high-pressure refrigerant by exchanging heat between the high-pressure refrigerant and a second heat medium; a liquid storage unit configured to temporarily store a high-pressure liquid refrigerant contained in the high-pressure refrigerant passed through the condenser unit; a sub-cooler unit configured to sub-cool the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit by exchanging heat between the high-pressure liquid refrigerant and the second heat medium; and an internal heat exchanger unit configured to exchange heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and the low-pressure refrigerant discharged from the evaporator. The condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together by a predetermined binding element and thereby form an integral structure.

[0041] In the composite heat exchanger configured in the manner described above, the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit exchanges the heat with the second heat medium at the sub-cooler unit and is thereby sub-cooled and then exchanges the heat with the low-pressure refrigerant at the internal heat exchanger unit and is thereby further sub-cooled. This allows the enthalpy of the high-pressure refrigerant to be sufficiently lowered in the single heat exchanger. Particularly, in the composite heat exchanger of the present disclosure, the condenser unit, the sub-cooler unit and the internal heat exchanger unit are integrated together to form the integral structure. Therefore, the composite heat exchanger, which can sufficiently lower the enthalpy of the high-pressure refrigerant, can be realized in the compact form.

[0042] Hereinafter, embodiments of the present disclosure will be described with reference to the drawings. In the following embodiments, the same reference signs may be assigned to portions that are the same as or equivalent to those described in the preceding embodiment(s), and the description thereof may be omitted. Furthermore, when only a portion of any one of the components is described in the embodiment, the description of the component described in the preceding embodiment can be applied to the rest of the component. The following embodiments may be partially

combined with each other as long as the combination does not cause any trouble, even if not explicitly stated.

First Embodiment

[0043] The present embodiment will be described with reference to FIGS. 1 to 9. In the present embodiment, there will be described an example in which a composite heat exchanger HEX of the present disclosure is applied to a refrigeration cycle apparatus 1 for a vehicle. The refrigeration cycle apparatus 1 is installed to, for example, an electric vehicle that obtains a drive force for running the vehicle from an electric motor that is installed for running the vehicle.

[0044] The refrigeration cycle apparatus 1 includes a vapor compression refrigeration cycle 10, a high-temperature side circuit 50, a low-temperature side circuit 60 and a control device 100. The refrigeration cycle apparatus 1 makes heat exchange of a refrigerant flowing in the refrigeration cycle 10 with a high-temperature side heat medium flowing in the high-temperature side circuit 50 and a low-temperature side heat medium flowing in the low-temperature side circuit 60. In the present embodiment, the low-temperature side heat medium serves as a first heat medium, and the high-temperature side heat medium serves as a second heat medium.

[0045] The refrigeration cycle 10 includes a compressor 11, a condenser unit 12, a liquid storage unit 13, a sub-cooler unit 14, an internal heat exchanger unit 15, a decompression valve 16 and an evaporator 17. The refrigeration cycle 10 uses a refrigerant with a low global warming potential, such as HFO-1234yf. The refrigerant contains a refrigerating machine oil to lubricate the compressor 11. As the refrigerating machine oil, a refrigerating machine oil, which is compatible with a liquid phase refrigerant, such as PAG oil, is used. A portion of the refrigerating machine oil is circulated in the cycle of the refrigeration cycle 10 along with the refrigerant.

[0046] The compressor 11 is a device that compresses and discharges the refrigerant. The compressor 11 is an electric compressor that is driven by an electric power supplied from a battery (not shown). The operation of the compressor 11 is controlled by a control signal outputted from the control device 100.

[0047] The condenser unit 12 is connected to a refrigerant discharge outlet of the compressor 11. The condenser unit 12 is a radiator that exchanges heat between: the refrigerant, which is discharged from the compressor 11 and has the high temperature and the high pressure (hereinafter also referred to as a high-pressure refrigerant); and the high-temperature side heat medium, which flows in the high-temperature side circuit 50, thereby releasing the heat of the high-pressure refrigerant to the high-temperature side heat medium. When the high-pressure refrigerant passes through the condenser unit 12, the high-pressure refrigerant releases the heat to the high-temperature side heat medium and is thereby condensed. The condenser unit 12 includes a primary condenser passage 121, which conducts the high-pressure refrigerant discharged from the compressor 11, and a secondary condenser passage 122, which conducts the high-temperature side heat medium.

[0048] Here, the high-temperature side heat medium is a fluid that flows in the high-temperature side circuit 50. For example, a liquid or an antifreeze liquid, each of which contains ethylene glycol, is used as the high-temperature

side heat medium. The high-temperature side circuit 50 is a circuit which is used to release the heat from the high-temperature side heat medium to the outside and also heat a vehicle cabin by using the high-temperature side heat medium. Although not shown in the drawing, the high-temperature side circuit 50 includes a high-temperature side pump, an electric heater, a high-temperature side radiator and a heater core.

[0049] The liquid storage unit 13 is connected to a refrigerant outlet of the condenser unit 12. The liquid storage unit 13 stores excess refrigerant which is in excess in the refrigeration cycle 10. The liquid storage unit 13 separates the high-pressure refrigerant outputted from the condenser unit 12 into a gas refrigerant and a liquid refrigerant (high-pressure liquid refrigerant) and temporarily stores the high-pressure liquid refrigerant. The liquid storage unit 13 is formed by a receiver tank RT having a refrigerant inlet and a refrigerant outlet placed at an upper side thereof. The receiver tank RT is configured to allow the high-pressure liquid refrigerant stored therein to flow out from the upper side.

[0050] The sub-cooler unit 14 is connected to the refrigerant outlet of the liquid storage unit 13. The sub-cooler unit 14 sub-cools the high-pressure liquid refrigerant discharged from the liquid storage unit 13 by exchanging heat with the high-temperature side heat medium that is in a state where the high-temperature side heat medium is before flowing into the condenser unit 12. The sub-cooler unit 14 includes a primary sub-cooler passage 141, which conducts the high-pressure liquid refrigerant discharged from the liquid storage unit 13, and a secondary sub-cooler passage 142, which conducts the high-temperature side heat medium. In the present embodiment, each of the condenser unit 12 and the sub-cooler unit 14 forms a radiator that releases the heat from the high-pressure refrigerant discharged from the compressor 11.

[0051] The internal heat exchanger unit 15 is connected to a refrigerant outlet of the sub-cooler unit 14. The internal heat exchanger unit 15 exchanges heat between the high-pressure liquid refrigerant passed through the sub-cooler unit 14 and the low-pressure refrigerant passed through the evaporator 17 described later. The internal heat exchanger unit 15 has a primary heat exchanger passage 151, which conducts the high-pressure liquid refrigerant passed through the sub-cooler unit 14, and a secondary heat exchanger passage 152, which conducts the low-pressure refrigerant passed through the evaporator 17.

[0052] The decompression valve 16 is connected to a refrigerant outlet of the primary heat exchanger passage 151 of the internal heat exchanger unit 15. The decompression valve 16 is a decompressor that decompresses the high-pressure liquid refrigerant passed through the internal heat exchanger unit 15. The decompression valve 16 is an electric valve having a variable throttle. The operation of the decompression valve 16 is controlled by a control signal outputted from the control device 100 and includes a valve element and an electric actuator.

[0053] The evaporator 17 is connected to a refrigerant outlet of the decompression valve 16. The evaporator 17 is a chiller that evaporates the low-pressure refrigerant decompressed at the decompression valve 16 by exchanging heat between the low-pressure refrigerant and the low-temperature side heat medium. The evaporator 17 has a primary evaporator passage 171, which conducts the low-pressure

refrigerant decompressed at the decompression valve 16, and a secondary evaporator passage 172, which conducts the low-temperature side heat medium.

[0054] Here, the low-temperature side heat medium is a fluid that flows in the low-temperature side circuit 60. For example, a liquid or an antifreeze liquid, each of which contains ethylene glycol, is used as the low-temperature side heat medium. The low-temperature side circuit 60 is a circuit which is used to absorb the heat from the outside through the low-temperature side heat medium and also cools the vehicle cabin by using the low-temperature side heat medium. Although not shown in the drawing, the low-temperature side circuit 60 includes a low-temperature side pump, a low-temperature side radiator and a cooler core.

[0055] The secondary heat exchanger passage 152 of the internal heat exchanger unit 15 is connected to a refrigerant outlet of the evaporator 17. The low-pressure refrigerant passed through the evaporator 17 flows into the secondary heat exchanger passage 152 of the internal heat exchanger unit 15.

[0056] A refrigerant outlet of the secondary heat exchanger passage 152 of the internal heat exchanger unit 15 is connected to a refrigerant suction inlet of the compressor 11. Therefore, the low-pressure refrigerant passed through the internal heat exchanger unit 15 is suctioned into the compressor 11 and is compressed once again.

[0057] In the refrigeration cycle apparatus 1 configured in the above-described manner, in order to make a compact size thereof, the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14 and the internal heat exchanger unit 15 are integrated together as the composite heat exchanger HEX. Hereinafter, the composite heat exchanger HEX will be described with reference to FIGS. 2 to 9. The arrows indicating up and down in FIGS. 2 to 4 indicate the up-to-down direction Dg in a state where the composite heat exchanger HEX is installed to the vehicle.

[0058] As shown in FIG. 2, the composite heat exchanger HEX is formed as an integral structure ST, in which the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are joined together by a predetermined binding element (a brazing material in this example). In the composite heat exchanger HEX, the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are arranged in a predetermined direction in a row. In the structure ST, the sub-cooler unit 14 is placed between the condenser unit 12 and the internal heat exchanger unit 15. Thereby, the structure ST is configured to limit the heat transfer between the condenser unit 12 and the internal heat exchanger unit 15. The liquid storage unit 13 is placed at the outside of the structure ST. In the present embodiment, the liquid storage unit 13 is placed adjacent to a portion of the structure ST which forms the internal heat exchanger unit 15.

[0059] As shown in FIGS. 3 and 4, each of the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 is formed by stacking and joining a plurality of plate members 30. The condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are respectively formed as a heat exchanger unit of a stacked plate type. Specifically, the structure ST is formed entirely by stacking and joining the plurality of plate members 30. The structure ST is installed on the vehicle in a correspond-

ing orientation where a stacking direction Dst of the plurality of plate members 30 intersects the up-to-down direction Dg.

[0060] Each of the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 is formed by corresponding plate members 30 among the plurality of plate members 30, and the plurality of plate members 30 are made of a plurality of plate materials, respectively, each of which has at least a common plate thickness and common external dimensions. Specifically, each of the plurality of plate members 30 is formed from an elongated, rectangular plate material. Each of the plurality of plate members 30 has a bulge which is formed at an outer periphery of the plate member 30 and projects toward the one side in the stacking direction Dst. In the stacked state where the plurality of plate members 30 are stacked together, the plurality of plate members 30 are joined together by brazing the bulges of the plurality of plate members 30 together.

[0061] As shown in FIG. 4, when the plurality of plate members 30 are joined together in the stacked state where the plurality of plate members 30 are stacked together, the structure ST forms the primary condenser passage 121, the secondary condenser passage 122, the primary sub-cooler passage 141, the secondary sub-cooler passage 142, the primary heat exchanger passage 151 and the secondary heat exchanger passage 152.

[0062] Specifically, the primary condenser passage 121 is formed between each corresponding adjacent two of the plate members 30 stacked at one side of the structure ST in the stacking direction Dst. Also, the secondary condenser passage 122 is formed between each corresponding adjacent two of the plate members 30 stacked at the one side of the structure ST in the stacking direction Dst. The primary condenser passages (also collectively referred to as the primary condenser passage) 121 and the secondary condenser passages (also collectively referred to as the secondary condenser passage) 122 are alternately arranged. The condenser unit 12 is formed by alternately arranging the primary condenser passages 121 and the secondary condenser passages 122 in the stacking direction Dst.

[0063] Each corresponding one of the plate members 30, which form the condenser unit 12, has a primary condenser hole 123 and a secondary condenser hole 124, each of which conducts the high-pressure refrigerant in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the condenser unit 12, has a primary heat medium hole 125 and a secondary heat medium hole 126 each of which conducts the high-temperature side heat medium in the stacking direction Dst.

[0064] Among four corners of each corresponding one of the plate members 30, which form the condenser unit 12, two corners, which are diagonally opposed to each other, have the primary condenser hole 123 and the secondary condenser hole 124, respectively, and the remaining two corners have the primary heat medium hole 125 and the secondary heat medium hole 126, respectively. Specifically, the primary condenser hole 123 and the secondary heat medium hole 126 are formed at an upper side of the plate member 30, and the secondary condenser hole 124 and the primary heat medium hole 125 are formed at a lower side of the plate member 30.

[0065] The primary condenser holes 123 and the secondary condenser holes 124 form tank spaces, respectively, which distribute the high-pressure refrigerant to the primary

condenser passages 121 or collect the high-pressure refrigerant passed through the primary condenser passages 121. Among the plate members 30, which form the condenser unit 12, a first end member 31 and a first intermediate member 32, which are respectively placed at two opposite ends of the condenser unit 12 in the stacking direction Dst, have the primary condenser hole 123, the primary heat medium hole 125 and the secondary heat medium hole 126 but do not have the secondary condenser hole 124. Furthermore, among the plate members 30, which form the condenser unit 12, a second intermediate member 33, which is placed at an intermediate location of the condenser unit 12 in the stacking direction Dst, has the secondary condenser hole 124, the primary heat medium hole 125 and the secondary heat medium hole 126 but does not have the primary condenser hole 123. With the configuration described above, the passage of the high-pressure refrigerant at the condenser unit 12 becomes a U-turn passage.

[0066] The first end member 31 has: a high-pressure connector CHi, which is connected with a refrigerant pipe; an inlet connector CNi, which receives the high-temperature side heat medium; and an outlet connector CNo, which outputs the high-temperature side heat medium.

[0067] The primary heat medium holes 125 form a distributing space which distributes the high-temperature side heat medium to the secondary condenser passages 122. Furthermore, the secondary heat medium holes 126 form a collecting space which collects the high-temperature side heat medium passed through the secondary condenser passages 122.

[0068] In the condenser unit 12, an upstream side passage of the high-pressure refrigerant forms a down-flow passage, and a downstream side passage of the high-pressure refrigerant forms an up-flow passage. Furthermore, the passage of the high-temperature side heat medium in the condenser unit 12 forms an up-flow passage. With the configuration described above, the high-pressure refrigerant and the high-temperature side heat medium form counter flows, respectively, at the one side of the condenser unit 12 in the stacking direction Dst, and the high-pressure refrigerant and the high-temperature side heat medium form parallel flows, respectively, at the other side of the condenser unit 12 in the stacking direction Dst. Here, the term “down-flow passage” refers to a passage in which the fluid flows downward. Furthermore, the term “up-flow passage” refers to a passage in which the fluid flows upward.

[0069] Next, the primary sub-cooler passage 141 and the secondary sub-cooler passage 142, which form the sub-cooler unit 14, will be described. The primary sub-cooler passage 141 is formed between each corresponding adjacent two of the plate members 30 located between the condenser unit 12 and the internal heat exchanger unit 15 in the stacking direction Dst. Also, the secondary sub-cooler passage 142 is formed between each corresponding adjacent two of the plate members 30 located between the condenser unit 12 and the internal heat exchanger unit 15. The primary sub-cooler passages (also collectively referred to as the primary sub-cooler passage) 141 and the secondary sub-cooler passages (also collectively referred to as the secondary sub-cooler passage) 142 are alternately arranged. The sub-cooler unit 14 is formed by alternately arranging the primary sub-cooler passages 141 and the secondary sub-cooler passages 142 in the stacking direction Dst. In the

structure ST, the first intermediate member 32 partitions between the condenser unit 12 and the sub-cooler unit 14.

[0070] Each corresponding one of the plate members 30, which form the sub-cooler unit 14, has a primary sub-cooler hole 143 and a secondary sub-cooler hole 144 each of which conducts the high-pressure liquid refrigerant in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the sub-cooler unit 14, has a tertiary heat medium hole 145 and a quaternary heat medium hole 146 each of which conducts the high-temperature side heat medium in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the sub-cooler unit 14, has a primary communication hole 147 which forms a high-pressure inlet passage HPi that conducts the high-pressure refrigerant passed through the condenser unit 12 to the liquid storage unit 13.

[0071] Among four corners of each corresponding one of the plate members 30, which form the sub-cooler unit 14, two corners, which are diagonally opposed to each other, have the primary sub-cooler hole 143 and the primary communication hole 147, respectively, and the remaining two corners have the tertiary heat medium hole 145 and the quaternary heat medium hole 146, respectively. Furthermore, the secondary sub-cooler hole 144 is formed between the primary communication hole 147 and the quaternary heat medium hole 146. Specifically, the secondary sub-cooler hole 144, the quaternary heat medium hole 146 and the primary communication hole 147 are formed at the upper side of the plate member 30, and the primary sub-cooler hole 143 and the tertiary heat medium hole 145 are formed at the lower side of the plate member 30.

[0072] The primary sub-cooler holes 143 form a distributing space which distributes the high-pressure liquid refrigerant to the primary sub-cooler passages 141. Furthermore, the secondary sub-cooler holes 144 form a collecting space which collects the high-pressure liquid refrigerant passed through the primary sub-cooler passages 141. The primary sub-cooler holes 143 are formed at a position where the primary sub-cooler holes 143 overlap with the secondary condenser holes 124 in the stacking direction Dst.

[0073] The tertiary heat medium holes 145 form a distributing space which distributes the high-temperature side heat medium to the secondary sub-cooler passages 142. Furthermore, the quaternary heat medium holes 146 form a collecting space which collects the high-temperature side heat medium passed through the secondary sub-cooler passages 142. The tertiary heat medium holes 145 are formed at a position where the tertiary heat medium holes 145 overlap with the primary heat medium holes 125 in the stacking direction Dst so that the tertiary heat medium holes 145 communicate with the primary heat medium holes 125. The quaternary heat medium holes 146 are formed at a position where the quaternary heat medium holes 146 overlap with the secondary heat medium holes 126 in the stacking direction Dst so that the quaternary heat medium holes 146 communicate with the secondary heat medium holes 126.

[0074] The primary communication holes 147 are formed at a position where the primary communication holes 147 overlap with the primary condenser holes 123 in the stacking direction Dst so that the primary communication holes 147 communicate with the primary condenser holes 123 of the plate members 30 of the condenser unit 12 placed adjacent to the sub-cooler unit 14.

[0075] Among the plate members 30, which form the sub-cooler unit 14, a third intermediate member 34, which is placed at an end of the sub-cooler unit 14 facing the other side in the stacking direction Dst, has the primary sub-cooler hole 143, the secondary sub-cooler hole 144 and the primary communication hole 147 but does not have the tertiary heat medium hole 145 and the quaternary heat medium hole 146.

[0076] In the sub-cooler unit 14 configured in the above-described manner, each of the flow passage of the high-pressure liquid refrigerant and the passage of the high-temperature side heat medium forms an up-flow passage. Therefore, in the sub-cooler unit 14, the high-pressure liquid refrigerant and the high-temperature side heat medium form the parallel flows, respectively.

[0077] Next, the primary heat exchanger passage 151 and the secondary heat exchanger passage 152, which form the internal heat exchanger unit 15, will be described. The primary heat exchanger passage 151 is formed between each corresponding adjacent two of the plate members 30 stacked at the other side of the structure ST in the stacking direction Dst. Also, the secondary heat exchanger passage 152 is formed between each corresponding adjacent two of the plate members 30 stacked at the other side of the structure ST in the stacking direction Dst. The primary heat exchanger passages (also collectively referred to as the primary heat exchanger passage) 151 and the secondary heat exchanger passages (also collectively referred to as the secondary heat exchanger passage) 152 are alternately arranged. The internal heat exchanger unit 15 is formed by alternately arranging the primary heat exchanger passages 151 and the secondary heat exchanger passages 152 in the stacking direction Dst. In the structure ST, the third intermediate member 34 partitions between the sub-cooler unit 14 and the internal heat exchanger unit 15.

[0078] Each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has a primary heat exchanger hole 153 and a secondary heat exchanger hole 154 each of which conducts the high-pressure liquid refrigerant passed through the sub-cooler unit 14 in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has a primary low-pressure hole 155 and a secondary low-pressure hole 156, each of which conducts the low-pressure refrigerant in the stacking direction Dst. Each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has a secondary communication hole 157 which forms the high-pressure inlet passage HPi that conducts the high-pressure refrigerant passed through the sub-cooler unit 14 to the liquid storage unit 13. The secondary communication holes 157 are formed at a position where the secondary communication holes 157 overlap with the primary communication holes 147 in the stacking direction Dst so that the secondary communication holes 157 communicate with the primary communication holes 147.

[0079] Each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has a tertiary communication hole 158 which forms a high-pressure outlet passage HPo that conducts the high-pressure liquid refrigerant stored in the liquid storage unit 13 to the sub-cooler unit 14. The tertiary communication holes 158 are formed at a position where the tertiary communication holes 158 overlap with the primary sub-cooler holes 143 in the stack-

ing direction Dst so that the tertiary communication holes **158** communicate with the primary sub-cooler holes **143**.

[0080] Among four corners of each corresponding one of the plate members **30**, which form the internal heat exchanger unit **15**, two corners, which are diagonally opposed to each other, have the secondary communication hole **157** and the tertiary communication hole **158**, respectively, and the remaining two corners have the primary low-pressure hole **155** and the secondary low-pressure hole **156**, respectively. Furthermore, the primary heat exchanger hole **153** is formed between the secondary communication hole **157** and the secondary low-pressure hole **156**. The secondary heat exchanger hole **154** is formed between the tertiary communication hole **158** and the primary low-pressure hole **155**. Specifically, the primary heat exchanger hole **153**, the secondary low-pressure hole **156** and the secondary communication hole **157** are formed at the upper side of the plate member **30**, and the secondary heat exchanger hole **154**, the primary low-pressure hole **155** and the tertiary communication hole **158** are formed at the lower side of the plate member **30**.

[0081] The primary heat exchanger holes **153** form a distributing space which distributes the high-pressure liquid refrigerant passed through the sub-cooler unit **14** to the primary heat exchanger passages **151**. The primary heat exchanger holes **153** are formed at a position where the primary heat exchanger holes **153** overlap with the secondary sub-cooler holes **144** in the stacking direction Dst so that the primary heat exchanger holes **153** communicate with the secondary sub-cooler holes **144**. Furthermore, the secondary heat exchanger holes **154** form a collecting space which collects the high-pressure liquid refrigerant passed through the primary heat exchanger passages **151**.

[0082] The primary low-pressure holes **155** form a distributing space which distributes the low-pressure refrigerant to the secondary heat exchanger passages **152**. Furthermore, the secondary low-pressure holes **156** form a collecting space which collects the low-pressure refrigerant passed through the secondary heat exchanger passages **152**.

[0083] Among the plate members **30**, which form the internal heat exchanger unit **15**, a fourth intermediate member **35**, which is placed at the other side of the internal heat exchanger unit **15** in the stacking direction Dst, has the secondary heat exchanger hole **154**, the primary low-pressure hole **155**, the secondary low-pressure hole **156**, the secondary communication hole **157** and the tertiary communication hole **158** but does not have the primary heat exchanger hole **153**.

[0084] In the internal heat exchanger unit **15**, the passage of the high-pressure liquid refrigerant forms a down-flow passage, and the passage of the low-pressure refrigerant forms an up-flow passage. Therefore, in the internal heat exchanger unit **15**, the high-pressure liquid refrigerant and the low-pressure refrigerant form counter flows, respectively.

[0085] In the present embodiment, the receiver tank RT, which is the liquid storage unit **13**, is placed adjacent to a portion of the structure ST which forms the internal heat exchanger unit **15**. As described above, the secondary communication holes **157** are formed at the upper side of the internal heat exchanger unit **15**, and the tertiary communication holes **158** are formed at the lower side of the internal

heat exchanger unit **15**. Therefore, the receiver tank RT cannot be connected to the internal heat exchanger unit **15** without a modification.

[0086] With respect to this point, the structure ST of the present embodiment is formed such that the portion of the internal heat exchanger unit **15**, which is adjacent to the liquid storage unit **13**, guides the high-pressure refrigerant flowing in the high-pressure inlet passage HPI to the liquid storage unit **13** and conducts the high-pressure liquid refrigerant stored in the liquid storage unit **13** to the high-pressure outlet passage HPO.

[0087] Among the plate members **30**, which form the internal heat exchanger unit **15**, a second end member **36**, which is placed at the end of the internal heat exchanger unit **15** facing the other side in the stacking direction Dst, has a quaternary communication hole **159** that is connected to the refrigerant outlet of the liquid storage unit **13**. Furthermore, a side passage SP, which conducts the high-pressure liquid refrigerant passed through the quaternary communication hole **159** to the tertiary communication holes **158**, is formed between the second end member **36** and the fourth intermediate member **35**. The second end member **36** is the portion of the internal heat exchanger unit **15** which is adjacent to the liquid storage unit **13**. The quaternary communication hole **159** is formed at a position where the quaternary communication hole **159** overlaps with the primary heat exchanger holes **153** in the stacking direction Dst.

[0088] In the structure ST configured in the manner described above, the receiver tank RT, which is the liquid storage unit **13**, is integrally joined to the internal heat exchanger unit **15** by brazing. In other words, the composite heat exchanger HEX is integrally formed by joining the condenser unit **12**, the liquid storage unit **13**, the sub-cooler unit **14** and the internal heat exchanger unit **15** with the brazing material.

[0089] Specifically, the liquid storage unit **13** is joined to the second end member **36** of the internal heat exchanger unit **15**. Besides the liquid storage unit **13**, a high-pressure connector CHO, a low-pressure inlet connector CLi communicated with the primary low-pressure holes **155**, and a low-pressure outlet connector CLo communicated with the secondary low-pressure holes **156** are coupled to the second end member **36**. The liquid storage unit **13** is coupled to the second end member **36** of the internal heat exchanger unit **15** such that the liquid storage unit **13** does not interfere with the high-pressure connector CHO, the low-pressure inlet connector CLi and the low-pressure outlet connector CLo.

[0090] Here, it should be noted that the plurality of plate members **30** include a plurality of multi-hole members. Each of multi-hole members has: at least two high-temperature side passage holes HL1, which conduct the high-pressure refrigerant that includes the high-pressure liquid refrigerant; and at least one low-temperature side passage hole HL2, which conducts the high-temperature side heat medium or the low-pressure refrigerant. In each of the multi-hole members, at least one of the at least two high-temperature side passage holes HL1 is formed as a passage hole that conducts the high-pressure liquid refrigerant and is placed adjacent to a corresponding one of the at least one low-temperature side passage hole HL2. Furthermore, in each of the multi-hole members, the at least two high-temperature side passage holes HL1 include: a large-diameter hole that conducts the high-pressure refrigerant in a gas state or the high-pressure liquid refrigerant; and a small-diameter hole that has a

diameter smaller than a diameter of the large-diameter hole and conducts the high-pressure liquid refrigerant. The small-diameter hole is placed adjacent to the corresponding one of the at least one low-temperature side passage hole HL2.

[0091] Specifically, the plate members 30, which form the sub-cooler unit 14, include a plurality of primary plate members 30A which serve as the multi-hole members. Each of the primary plate members 30A has the primary sub-cooler hole 143, the secondary sub-cooler hole 144 and the primary communication hole 147 which serve as the high-temperature side passage holes HL1, respectively. Each of the primary plate members 30A also has the tertiary heat medium hole 145 and the quaternary heat medium hole 146 which serve as the low-temperature side passage holes HL2, respectively. The primary sub-cooler hole 143 and the primary communication hole 147 are the passage holes conducting the high-pressure refrigerant and are the large-diameter holes each of which has the diameter larger than the diameter of the secondary sub-cooler hole 144. The secondary sub-cooler hole 144 is the passage hole conducting the high-pressure liquid refrigerant and is the small-diameter hole having the diameter smaller than the diameter of the primary sub-cooler hole 143 and the diameter of the primary communication hole 147. In the primary plate member 30A, the secondary sub-cooler hole 144, which is the small-diameter hole, is placed adjacent to the quaternary heat medium hole 146 that conducts the high-temperature side heat medium.

[0092] Furthermore, the plate members 30, which form the internal heat exchanger unit 15, include a plurality of secondary plate members 30B which serve as the multi-hole members. As shown in FIG. 5, each of the secondary plate members 30B has the primary heat exchanger hole 153, the secondary heat exchanger hole 154, the secondary communication hole 157 and the tertiary communication hole 158 which serve as the high-temperature side passage holes HL1, respectively. Each of the secondary plate members 30B also has the primary low-pressure hole 155 and the secondary low-pressure hole 156 which serve as the low-temperature side passage holes HL2, respectively. The secondary communication hole 157 and the tertiary communication hole 158 are the passage holes conducting the high-pressure refrigerant and are the large-diameter holes each of which has the diameter larger than the diameter of the primary heat exchanger hole 153 and the diameter of the secondary heat exchanger hole 154. The primary heat exchanger hole 153 and the secondary heat exchanger hole 154 are the passage holes conducting the high-pressure liquid refrigerant and are the small-diameter holes each of which has the diameter smaller than the diameter of the secondary communication hole 157 and the diameter of the tertiary communication hole 158. In the secondary plate member 30B, the primary heat exchanger hole 153, which is the small-diameter hole, is placed adjacent to the secondary low-pressure hole 156, which conducts the low-pressure refrigerant, and the secondary heat exchanger hole 154, which is the small-diameter hole, is placed adjacent to the primary low-pressure hole 155.

[0093] FIG. 6 is an explanatory diagram for explaining an internal structure of the condenser unit 12. FIG. 7 is an explanatory diagram for explaining an internal structure of the internal heat exchanger unit 15. Since the internal structure of the sub-cooler unit 14 is substantially the same

as that of the condenser unit 12, indication of the sub-cooler unit 14 is omitted for the sake of simplicity.

[0094] Each of the plurality of plate members 30, which form the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15, is formed by cladding a brazing material on each of two opposite surfaces of a core material CM made of metal (e.g., an aluminum alloy).

[0095] Specifically, as shown in FIGS. 6 and 7, each of the plate members 30 has a sacrificial layer SL formed at one surface among the two opposite surfaces of the core material CM made of the aluminum alloy. The plate members 30 are joined together such that the one surface having the sacrificial layer SL of each corresponding one of the plate members 30 is opposed to and is joined to the one surface having the sacrificial layer SL of an adjacent one of the plate members 30, and the other surface lacking the sacrificial layer SL of each corresponding one of the plate members 30 is opposed to and is joined to the other surface lacking the sacrificial layer SL of an adjacent one of the plate members 30. The sacrificial layer SL is made of an aluminum alloy containing a predetermined percentage of a material (e.g., Zn) that has a potential lower than that of the core material CM.

[0096] As shown in FIG. 6, at the plate members 30, which form the condenser unit 12, the primary condenser passage 121 conducting the high-pressure refrigerant is formed between the other surface lacking the sacrificial layer SL of each corresponding plate member 30 and the other surface lacking the sacrificial layer SL of the adjacent plate member 30. Furthermore, the secondary condenser passage 122 conducting the high-temperature side heat medium is formed between the one surface having the sacrificial layer SL of each corresponding plate member 30 and the one surface having the sacrificial layer SL of the adjacent plate member 30. Although not depicted in the drawing, at the plate members 30, which form the sub-cooler unit 14, the primary sub-cooler passage 141 conducting the high-pressure refrigerant is formed between the other surface lacking the sacrificial layer SL of each corresponding plate member 30 and the other surface lacking the sacrificial layer SL of the adjacent plate member 30. Furthermore, the secondary sub-cooler passage 142 conducting the high-temperature side heat medium is formed between the one surface having the sacrificial layer SL of each corresponding plate member 30 and the one surface having the sacrificial layer SL of the adjacent plate member 30.

[0097] As shown in FIG. 7, at the plate members 30, which form the internal heat exchanger unit 15, the primary heat exchanger passage 151 conducting the high-pressure liquid refrigerant is formed between the other surface lacking the sacrificial layer SL of each corresponding plate member 30 and the other surface lacking the sacrificial layer SL of the adjacent plate member 30. Furthermore, the secondary heat exchanger passage 152 conducting the low-pressure refrigerant is formed between the one surface having the sacrificial layer SL of each corresponding plate member 30 and the one surface having the sacrificial layer SL of the adjacent plate member 30.

[0098] In the structure ST configured in the manner described above, the sacrificial layer SL corrodes preferentially over the core material CM. This makes it more difficult for the core material CM to corrode. In other words, the corrosion resistance of the structure ST is improved.

[0099] A primary heat exchange fin F1, which promotes heat exchange between the high-pressure refrigerant and the high-temperature side heat medium, is provided between each adjacent two of the plate members 30 of the condenser unit 12 and the sub-cooler unit 14. Furthermore, a secondary heat exchange fin F2, which promotes heat exchange between the high-pressure refrigerant and the low-pressure refrigerant, is provided between each adjacent two of the plate members 30 of the internal heat exchanger unit 15.

[0100] As shown in FIG. 8, each of the primary heat exchange fin F1 and the secondary heat exchange fin F2 is formed as, for example, an offset fin F. The offset fin F has a plurality of louvers R cut and raised on a corrugated substrate SU. Each of the secondary heat exchange fins F2 has a shape that is different from a shape of each of the primary heat exchange fins F1 to reduce a refrigerant pressure loss (pressure loss of the refrigerant) at the internal heat exchanger unit 15. For example, as shown in FIG. 9, at least one of a fin pitch, which is an interval between tops of the substrate SU, and the number of louvers R of the secondary heat exchange fin F2 is smaller than that of the primary heat exchange fin F1.

[0101] The refrigeration cycle apparatus 1, which includes the composite heat exchanger HEX configured in the manner described above, includes the control device 100 that controls the component devices of the refrigeration cycle apparatus 1. The control device 100 has: a microcomputer, which includes a processor and a memory; and peripheral circuits. The control device 100 executes various calculations and operations according to a control program stored in the memory. The memory of the control device 100 is a non-transitory tangible storage medium.

[0102] The compressor 11 and the decompression valve 16 are connected to an output side of the control device 100. Furthermore, although not depicted in the drawing, a group of sensors for air conditioning control and a group of sensors for device temperature control are connected to an input side of the control device 100. Furthermore, various operation switches are connected to the input side of the control device 100, and operation signals from the various operation switches are inputted to the input side of the control device 100.

[0103] The various operation switches include an air conditioning switch, a room temperature control switch, and the like. The air conditioning switch is a switch that is used to set whether or not cooling of the air is performed by an air conditioning unit. The room temperature control switch is a switch that is used to set a set temperature of the vehicle cabin.

[0104] The control device 100 operates the refrigeration cycle apparatus 1 based on the sensor outputs of the group of sensors for the air conditioning control and the group of sensors for the device temperature control and the operation signals from the various operation switches. The control device 100, for example, drives the compressor 11 and controls the decompression valve 16 into a throttled state. For example, the control device 100 determines a control signal, which is outputted to the decompression valve 16, such that a degree of superheat at the refrigerant suction inlet of the compressor 11 coincides with a predetermined target degree of superheat.

[0105] When the compressor 11 is driven, the high-pressure refrigerant, which is outputted from the compressor 11, flows into the condenser unit 12 of the composite heat

exchanger HEX. The high-pressure refrigerant, which flows into the condenser unit 12, releases heat to the high-temperature side heat medium which flows in the high-temperature side circuit 50. Therefore, the high-pressure refrigerant, which flows in the condenser unit 12, is cooled and is condensed.

[0106] Specifically, the high-pressure refrigerant, which flows into the condenser unit 12 from the one side in the stacking direction Dst, makes a U-turn in the condenser unit 12 and then flows into the liquid storage unit 13 after flowing through the high-pressure inlet passage HPi that extends through the sub-cooler unit 14 and the internal heat exchanger unit 15.

[0107] The high-pressure refrigerant is separated into a gas phase and a liquid phase in the liquid storage unit 13, and the refrigerant in the liquid phase, i.e., the high-pressure liquid refrigerant, which is in excess in the cycle, is stored in the liquid storage unit 13. The high-pressure liquid refrigerant, which is stored in the liquid storage unit 13, flows into the sub-cooler unit 14 through the side passage SP of the internal heat exchanger unit 15 and the high-pressure outlet passage HPo extending through the internal heat exchanger unit 15.

[0108] The high-pressure liquid refrigerant, which flows into the sub-cooler unit 14, exchanges heat with the high-temperature side heat medium and is thereby sub-cooled. The high-pressure liquid refrigerant, which passes through the sub-cooler unit 14, flows into the primary heat exchanger passage 151 of the internal heat exchanger unit 15. The high-pressure liquid refrigerant, which flows into the primary heat exchanger passage 151 of the internal heat exchanger unit 15, exchanges heat with the low-pressure refrigerant passed through the evaporator 17.

[0109] The high-pressure liquid refrigerant, which passes through the primary heat exchanger passage 151 of the internal heat exchanger unit 15, is decompressed at the decompression valve 16. The refrigerant decompressed at the decompression valve 16 flows into the evaporator 17 and absorbs heat from the low-temperature side heat medium flowing in the low-temperature side circuit 60 and evaporates. Thereby, the low-temperature side heat medium is cooled until the temperature of the low-temperature side heat medium reaches a desired temperature.

[0110] The low-pressure refrigerant passed through the evaporator 17 flows into the secondary heat exchanger passage 152 of the internal heat exchanger unit 15 and absorbs heat from the high-pressure liquid refrigerant. Then, the low-pressure refrigerant passed through the secondary heat exchanger passage 152 of the internal heat exchanger unit 15 flows into the refrigerant suction inlet of the compressor 11 and is compressed once again at the compressor 11.

[0111] The composite heat exchanger HEX described above includes the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14 and the internal heat exchanger unit 15. The condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are joined together by the predetermined binding element to form the integral structure ST.

[0112] In the composite heat exchanger HEX configured in the manner described above, the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit 13 exchanges the heat with the high-temperature side heat medium at the sub-cooler unit 14 and is thereby

sub-cooled and then exchanges the heat with the low-pressure refrigerant at the internal heat exchanger unit **15** and is thereby further sub-cooled. This allows the enthalpy of the high-pressure refrigerant to be sufficiently lowered in the single heat exchanger. Particularly, in the composite heat exchanger HEX of the present disclosure, the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15** are integrated together to form the integral structure ST. Therefore, the composite heat exchanger HEX, which can sufficiently lower the enthalpy of the high-pressure refrigerant, can be realized in a compact form.

[0113] Here, when the liquid storage unit **13** is held between the condenser unit **12** and the internal heat exchanger unit **15**, as in the previously proposed technology, interference among the condenser unit **12**, the internal heat exchanger unit **15** and the liquid storage unit **13** is likely to occur, reducing a degree of design freedom of the liquid storage unit **13**. This makes it difficult to properly separate the gas phase and the liquid phase of the high-pressure refrigerant at the liquid storage unit **13**.

[0114] In contrast, the composite heat exchanger HEX of the present embodiment has the liquid storage unit **13** located on the side of the structure ST. With this configuration, the interference between the structure ST and the liquid storage unit **13** is less likely to occur, thereby increasing the degree of design freedom of the liquid storage unit **13**. Thus, the sufficient separation performance for separating the high-pressure refrigerant into the gas phase and the liquid phase at the liquid storage unit **13** can be ensured.

[0115] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0116] (1) The structure ST has the configuration that limits the heat transfer between the condenser unit **12** and the internal heat exchanger unit **15**. With this configuration, unintended heat transfer between the condenser unit **12** and the internal heat exchanger unit **15** is limited, and thereby the enthalpy of the high-pressure refrigerant can be sufficiently reduced at the internal heat exchanger unit **15**.

[0117] (2) In the structure ST, the sub-cooler unit **14** is placed between the condenser unit **12** and the internal heat exchanger unit **15**. Thus, the configuration described above, in which the sub-cooler unit **14** is placed between the condenser unit **12** and the internal heat exchanger unit **15**, can limit the unintended heat transfer between the condenser unit **12** and the internal heat exchanger unit **15** without the need for a separate component, such as a thermal insulation material. In other words, it is possible to realize the structure that limits the unintended heat transfer between the condenser unit **12** and the internal heat exchanger unit **15** in a compact form. As a result, the heat exchange performance of the internal heat exchanger unit **15** is improved, and the enthalpy of the high-pressure refrigerant can be sufficiently reduced at the internal heat exchanger unit **15**.

[0118] (3) The liquid storage unit **13** is placed adjacent to the portion of the structure ST which forms the internal heat exchanger unit **15**. The structure ST is formed such that the high-pressure inlet passage HPi, which conducts the high-pressure refrigerant passed through the condenser unit **12** to the liquid storage unit **13**, extends through the sub-cooler unit **14** and the internal heat exchanger unit **15**. The structure ST is also formed such that the high-pressure outlet passage HPo, which conducts the high-pressure liquid refrigerant stored in the liquid storage unit **13** to the sub-cooler unit **14**,

extends through the internal heat exchanger unit **15**. The structure ST is formed such that the portion of the internal heat exchanger unit **15**, which is adjacent to the liquid storage unit **13**, conducts the high-pressure refrigerant flowing in the high-pressure inlet passage HPi to the liquid storage unit **13** and conducts the high-pressure liquid refrigerant stored in the liquid storage unit **13** to the high-pressure outlet passage HPo.

[0119] According to this configuration, the high-pressure inlet passage HPi, which conducts the high-pressure refrigerant passed through the condenser unit **12** to the liquid storage unit **13**, and the high-pressure outlet passage HPo, which conducts the high-pressure liquid refrigerant stored in the liquid storage unit **13** to the sub-cooler unit **14**, can be formed at the inside of the structure ST. Therefore, the composite heat exchanger HEX, in which the sub-cooler unit **14** is placed between the condenser unit **12** and the internal heat exchanger unit **15**, can be realized in the compact form.

[0120] (4) Specifically, the liquid storage unit **13** is directly joined to the portion of the structure ST which forms the internal heat exchanger unit **15**. When the liquid storage unit **13** and the internal heat exchanger unit **15** are integrally formed in the manner described above, the composite heat exchanger HEX can be realized in the compact form.

[0121] (5) The condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15** are formed by stacking and joining the plurality of plate members **30**. This makes it easier to realize the composite heat exchanger HEX with excellent heat exchange efficiency in the compact form.

[0122] (6) The plurality of plate members **30** include the plurality of multi-hole members. Each of the multi-hole members has: the at least two high-temperature side passage holes HL1, which conduct the high-pressure refrigerant that includes the high-pressure liquid refrigerant; and the at least one low-temperature side passage hole HL2, which conducts the high-temperature side heat medium or the low-pressure refrigerant. When the multi-hole members configured in the above-described manner are included in the plurality of plate members **30**, the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15** of the stacked plate type can be easily integrated together.

[0123] (7) In each of the multi-hole members, among the at least two high-temperature side passage holes HL1, the passage hole, which conducts the high-pressure liquid refrigerant, is placed adjacent to the corresponding one of the at least one low-temperature side passage hole HL2. This makes it easier to release the heat from the high-pressure liquid refrigerant to the high-temperature side heat medium and the low-pressure refrigerant, thereby enabling the sufficient reduction of the enthalpy of the high-pressure liquid refrigerant in the composite heat exchanger HEX. In other words, it is possible to limit heat damage, which is caused by unintended heat absorption by the high-pressure liquid refrigerant.

[0124] (8) Furthermore, the at least two high-temperature side passage holes HL1 of each of the multi-hole members include: the large-diameter hole, which conducts the high-pressure refrigerant in the gas state or the high-pressure liquid refrigerant; and the small-diameter hole, which has the diameter smaller than the diameter of the large-diameter hole and conducts the high-pressure liquid refrigerant, and

the small-diameter hole is placed adjacent to the corresponding one of the at least one low-temperature side passage hole HL2.

[0125] The configuration, in which the high-pressure refrigerant in the gas state passes through the large-diameter hole among the high-temperature side passage holes HL1, makes it possible to limit the pressure loss in the passage hole. In addition, the configuration, in which the high-pressure liquid refrigerant passes through the small-diameter hole among the high-temperature side passage holes HL1, makes it possible to limit an increase in the size of the multi-hole member. This contributes to the compact size of the composite heat exchanger HEX.

[0126] (9) The plate members 30 are joined together such that the one surface having the sacrificial layer SL of each corresponding one of the plate members 30 is opposed to and is joined to the one surface having the sacrificial layer SL of the adjacent one of the plate members 30, and the other surface lacking the sacrificial layer SL of each corresponding one of the plate members 30 is opposed to and is joined to the other surface lacking the sacrificial layer SL of the adjacent one of the plate members 30. Each of the primary condenser passage 121 conducting the high-pressure refrigerant, the primary sub-cooler passage 141 conducting the high-pressure liquid refrigerant stored in the liquid storage unit 13, and the primary heat exchanger passage 151 conducting the high-pressure liquid refrigerant passed through the sub-cooler unit 14 is formed between the other surface of each corresponding one of the plurality of plate members 30 and the other surface of the adjacent one of the plurality of plate members 30. Each of the secondary condenser passage 122 conducting the high-temperature side heat medium, the secondary sub-cooler passage 142 conducting the high-temperature side heat medium, and the secondary heat exchanger passage 152 conducting the low-pressure refrigerant is formed between the one surface of each corresponding one of the plurality of plate members 30 and the one surface of the adjacent one of the plurality of plate members 30.

[0127] As described above, each of the passages conducting the high-temperature side heat medium and the passage conducting the low-pressure refrigerant is formed between the one surface having the sacrificial layer SL of each corresponding one of the plurality of plate members 30 and the one surface having the sacrificial layer SL of the adjacent one of the plurality of plate members 30, and each of the passages conducting the high-pressure refrigerant or the high-pressure liquid refrigerant is formed between the other surface of each corresponding one of the plurality of plate members 30 and the other surface of the adjacent one of the plurality of plate members 30. In this way, it is possible to ensure the corrosion resistance and the pressure resistance. Particularly, by implementing the configuration where the low-pressure refrigerant is conducted between the one surface having the sacrificial layer SL of each corresponding one of the plurality of plate members 30 and the one surface having the sacrificial layer SL of the adjacent one of the plurality of plate members 30, the configuration of the plate members 30 used for the internal heat exchanger unit 15 can be made common with the configuration of the plate members 30 used for the condenser unit 12 and the sub-cooler unit 14. This makes it easier to design the structure ST that

includes the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 which are integrally formed.

[0128] (10) Each of the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 is formed by the corresponding plate members 30 among the plurality of plate members 30, and the plurality of plate members 30 are made of the plurality of plate materials, respectively, each of which has at least the common plate thickness and the common external dimensions. With this configuration, the configuration of the respective plate members 30 used for the internal heat exchanger unit 15 can be made common with the configuration of the respective plate members 30 used for the condenser unit 12 and the sub-cooler unit 14, and thereby the designing of the integral structure ST, which includes the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 integrally formed, is eased.

[0129] (11) Each of the condenser unit 12 and the sub-cooler unit 14 has the plurality of primary heat exchange fins F1 which promote the heat exchange between the high-pressure refrigerant and the high-temperature side heat medium. The internal heat exchanger unit 15 has the plurality of secondary heat exchange fins F2 which promote the heat exchange between the high-pressure liquid refrigerant and the low-pressure refrigerant. Each of the secondary heat exchange fins F2 has the shape that is different from the shape of each of the primary heat exchange fins F1 to reduce the refrigerant pressure loss at the internal heat exchanger unit 15.

[0130] Here, when the pressure loss of the low-pressure refrigerant in the internal heat exchanger unit 15 is large, the pressure of the refrigerant suctioned into the compressor 11 is decreased. In this case, the drive force of the compressor 11 is increased, and the coefficient of performance COP of the refrigeration cycle 10 is deteriorated. Here, COP stands for Coefficient of Performance.

[0131] In contrast, in the case where the secondary heat exchange fins F2 of the internal heat exchanger unit 15 are shaped to reduce the pressure loss of the refrigerant in the internal heat exchanger unit 15, the pressure loss of the low-pressure refrigerant in the internal heat exchanger unit 15 can be limited while ensuring the required heat exchange performance of the internal heat exchanger unit 15. Thus, the deterioration of the coefficient of performance COP of the refrigeration cycle 10 can be limited.

Modification of First Embodiment

[0132] In the plate members 30 of the first embodiment, the large-diameter holes are formed at the four corners of the plate member 30, and the small-diameter hole is formed between the large-diameter holes. However, the present disclosure is not limited to this configuration. Each corresponding one of the plate members 30 may, for example, have the large-diameter hole and the small-diameter hole at the two corners, respectively, of the upper side and the large-diameter hole and the small-diameter hole at the two corners, respectively, of the lower side in the plate member 30, and the large-diameter hole may be formed between the large-diameter hole and the small-diameter hole at each of the upper side and the lower side in the plate member 30. In this case, it is desirable that each small-diameter hole is placed adjacent to the corresponding low-temperature side passage hole HL2.

Second Embodiment

[0133] Next, a second embodiment will be described with reference to FIG. 10. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0134] The liquid storage unit 13 of the present embodiment is not the receiver tank RT but is a modulator tank MT, which has an inlet and outlet of the refrigerant at a lower side of the modulator tank MT. The modulator tank MT is configured to allow the high-pressure liquid refrigerant stored therein to flow out from the lower side.

[0135] As shown in FIG. 10, the liquid storage unit 13 is placed at the outside of the structure ST. In the present embodiment, the liquid storage unit 13 is placed adjacent to a portion of the structure ST which forms the internal heat exchanger unit 15.

[0136] Like in the first embodiment, the internal heat exchanger unit 15 has the secondary communication holes 157 formed at the upper side of the internal heat exchanger unit 15 and the tertiary communication holes 158 formed at the lower side of the internal heat exchanger unit 15. Therefore, the internal heat exchanger unit 15 cannot be connected to the modulator tank MT without a modification.

[0137] With respect to this point, the structure ST of the present embodiment is formed such that the portion of the internal heat exchanger unit 15, which is adjacent to the liquid storage unit 13, conducts the high-pressure refrigerant flowing in the high-pressure inlet passage HPi to the liquid storage unit 13 and conducts the high-pressure liquid refrigerant stored in the liquid storage unit 13 to the high-pressure outlet passage HPo.

[0138] Among the plate members 30, which form the internal heat exchanger unit 15, the second end member 36, which is placed at the end of the internal heat exchanger unit 15 facing the other side in the stacking direction Dst, has a communication hole that is connected to the refrigerant inlet of the modulator tank MT. Furthermore, a side passage SP, which conducts the high-pressure liquid refrigerant passed through the secondary communication hole 157 to this communication hole, is formed by the second end member 36.

[0139] In the structure ST configured in the manner described above, the modulator tank MT, which is the liquid storage unit 13, is integrally joined to the internal heat exchanger unit 15 by brazing. In other words, the composite heat exchanger HEX is integrally formed by joining the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14 and the internal heat exchanger unit 15 together with the brazing material.

[0140] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

Third Embodiment

[0141] Next, a third embodiment will be described with reference to FIGS. 11 and 12. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0142] As shown in FIG. 11, the liquid storage unit 13 is coupled to the portion of the structure ST, which forms the internal heat exchanger unit 15, through a tank connector CNT. Although not shown in the drawing, the tank connector CNT has: an inlet hole, which conducts the high-pressure refrigerant into the liquid storage unit 13; and an outlet hole, which conducts the high-pressure liquid refrigerant out of the liquid storage unit 13.

[0143] As shown in FIG. 12, the tank connector CNT is coupled to the second end member 36 of the internal heat exchanger unit 15 such that the tank connector CNT does not interfere with the low-pressure inlet connector CLi and the low-pressure outlet connector CLo.

[0144] The liquid storage unit 13 is arranged such that a center position CT of the liquid storage unit 13 does not overlap a center plane CP of the structure ST extending in a direction along which the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are arranged in the row. Specifically, the liquid storage unit 13 is positioned such that the center position CT of the liquid storage unit 13 is placed on an opposite side of the center plane CP which is opposite to the low-pressure inlet connector CLi and the low-pressure outlet connector CLo. The direction, along which the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are arranged in the row, coincides with the stacking direction Dst. The center plane CP is a plane formed by connecting a plurality of center points which are centered between a pair of outer surfaces of the internal heat exchanger unit 15, while the pair of outer surfaces of the internal heat exchanger unit 15 extend along the stacking direction Dst and the up-to-down direction Dg.

[0145] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

[0146] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0147] (1) The liquid storage unit 13 is arranged such that the center position CT of the liquid storage unit 13 does not overlap the center plane CP of the structure ST extending in the direction along which the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are arranged in the row. With this configuration, the components of the structure ST do not interfere with the liquid storage unit 13, so that the designing of the composite heat exchanger HEX is eased.

Modification of Third Embodiment

[0148] The liquid storage unit 13 of the third embodiment is coupled to the structure ST through the tank connector CNT. However, the present disclosure is not limited to this configuration. For example, the liquid storage unit 13 may be directly joined to the internal heat exchanger unit 15 as in the first embodiment.

Fourth Embodiment

[0149] Next, a fourth embodiment will be described with reference to FIG. 13. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0150] As shown in FIG. 13, the liquid storage unit 13 is coupled to the end portion of the structure ST, which faces the other side in the stacking direction Dst, through a refrigerant inlet pipe TBi and a refrigerant outlet pipe TBo. In the internal heat exchanger unit 15 of the present embodiment, the side passage SP is eliminated. Furthermore, the refrigerant inlet pipe TBi is coupled to the internal heat exchanger unit 15 to communicate with the secondary communication holes 157, and the refrigerant outlet pipe TBo is coupled to the internal heat exchanger unit 15 to communicate with the tertiary communication holes 158.

[0151] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

Modification of Fourth Embodiment

[0152] The liquid storage unit 13 of the fourth embodiment is coupled to the end portion of the structure ST, which faces the other side in the stacking direction Dst, through the refrigerant inlet pipe TBi and the refrigerant outlet pipe TBo. However, the present disclosure is not limited to this configuration. For example, as shown in FIG. 14, the liquid storage unit 13 may be coupled to the end portion of the structure ST facing the other side in the stacking direction Dst through the refrigerant inlet pipe TBi and may be coupled to an end portion of the structure ST facing the one side in the stacking direction Dst through the refrigerant outlet pipe TBo.

Fifth Embodiment

[0153] Next, a fifth embodiment will be described with reference to FIG. 15. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0154] In the composite heat exchanger HEX of the present embodiment, the internal heat exchanger unit 15 is coupled to one heat exchanger unit among the condenser unit 12 and the sub-cooler unit 14 through at least one coupler component in a state where the internal heat exchanger unit 15 is spaced from the one heat exchanger unit. Thereby, the structure ST is configured to limit the heat transfer between the one heat exchanger unit and the internal heat exchanger unit 15.

[0155] Specifically, in the composite heat exchanger HEX, as shown in FIG. 15, the sub-cooler unit 14 is placed between the condenser unit 12 and the internal heat exchanger unit 15. The internal heat exchanger unit 15 is coupled to the sub-cooler unit 14 through a first intermediate connector CNc1 and a second intermediate connector CNc2 which serve as the coupler components, respectively. The liquid storage unit 13 is directly joined to the portion of the structure ST which forms the internal heat exchanger unit 15.

[0156] Since the first intermediate connector CNc1 and the second intermediate connector CNc2 are interposed between the internal heat exchanger unit 15 and the sub-cooler unit 14, the internal heat exchanger unit 15 is coupled to the sub-cooler unit 14 in the state where the internal heat exchanger unit 15 is spaced from the sub-cooler unit 14. The

internal heat exchanger unit 15 and the sub-cooler unit 14 are separated from each other except for the portions thereof coupled to the first intermediate connector CNc1 and the second intermediate connector CNc2.

[0157] Although not shown in the drawing, the first intermediate connector CNc1 has: a connecting passage which communicates between the primary communication holes 147 and the secondary communication holes 157; and a connecting passage which communicates between the secondary sub-cooler passage 142 and the primary heat exchanger passage 151. Furthermore, the second intermediate connector CNc2 has a connecting passage which communicates between the tertiary communication holes 158 and the primary sub-cooler passage 141.

[0158] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

[0159] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0160] (1) The internal heat exchanger unit 15 is spaced from and is coupled to the one heat exchanger unit among the condenser unit 12 and the sub-cooler unit 14 through the coupler components in the state where the internal heat exchanger unit 15 is spaced from the one heat exchanger unit. Thus, the configuration described above, in which the internal heat exchanger unit 15 is coupled to the one heat exchanger unit among the condenser unit 12 and the sub-cooler unit 14 in the state where the internal heat exchanger unit 15 is spaced from the one heat exchanger unit, can limit the unintended heat transfer between the one heat exchanger unit and the internal heat exchanger unit 15. In other words, it is possible to realize the structure, which limits the unintended heat transfer between the one heat exchanger unit and the internal heat exchanger unit 15, in a compact form. As a result, the heat exchange performance of the internal heat exchanger unit 15 is improved, and the enthalpy of the high-pressure refrigerant can be sufficiently reduced at the internal heat exchanger unit 15.

[0161] In addition, the configuration described above, in which the internal heat exchanger unit 15 is coupled to the one heat exchanger unit through the coupler components, can implement the heat exchanger, which does not have the internal heat exchange function, by detaching the internal heat exchanger unit 15 from the heat exchanger. This makes it easier to add or remove the internal heat exchange function at the time of design and to increase the variations of the composite heat exchanger HEX.

[0162] Furthermore, the configuration described above, in which the internal heat exchanger unit 15 is coupled to the one heat exchanger unit through the coupler components, can mitigate the effect of thermal distortion on the coupling portions between the internal heat exchanger unit 15 and the one heat exchanger unit in comparison to a case where the internal heat exchanger unit 15 and the one heat exchanger unit are coupled in close contact with each other.

[0163] (2) In the structure ST, the sub-cooler unit 14 is placed between the condenser unit 12 and the internal heat exchanger unit 15. The internal heat exchanger unit 15 is coupled to the sub-cooler unit 14 in the state where the

internal heat exchanger unit 15 is spaced from the sub-cooler unit 14. Thus, the configuration described above, in which the sub-cooler unit 14 is placed between the condenser unit 12 and the internal heat exchanger unit 15, can limit the unintended heat transfer between the condenser unit 12 and the internal heat exchanger unit 15 without the need for a separate component, such as a thermal insulation material.

[0164] (3) The liquid storage unit 13 is directly joined to the portion of the structure ST which forms the internal heat exchanger unit 15. When the liquid storage unit 13 and the internal heat exchanger unit 15 are integrally formed in the manner described above, the composite heat exchanger HEX can be realized in the compact form.

Sixth Embodiment

[0165] Next, a sixth embodiment will be described with reference to FIG. 16. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0166] In the composite heat exchanger HEX of the present embodiment, the internal heat exchanger unit 15 is coupled to the condenser unit 12 through coupler components in a state where the internal heat exchanger unit 15 is spaced from the condenser unit 12. Thereby, the structure ST is configured to limit the heat transfer between the condenser unit 12 and the internal heat exchanger unit 15.

[0167] Specifically, in the structure ST, as shown in FIG. 16, the condenser unit 12 is placed between the sub-cooler unit 14 and the internal heat exchanger unit 15. The internal heat exchanger unit 15 is coupled to the condenser unit 12 through the first intermediate connector CNc1 and the second intermediate connector CNc2 which serve as the coupler components, respectively. The liquid storage unit 13 is directly joined to a portion of the structure ST which forms the sub-cooler unit 14.

[0168] Each corresponding one of the plate members 30, which form the condenser unit 12, has the primary condenser hole 123 and the secondary condenser hole 124, each of which conducts the high-pressure refrigerant in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the condenser unit 12, has the primary heat medium hole 125 and the secondary heat medium hole 126 each of which conducts the high-temperature side heat medium in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the condenser unit 12, has a sub-cooler communication hole 127 which conducts the high-pressure liquid refrigerant passed through the sub-cooler unit 14.

[0169] Among four corners of each corresponding one of the plate members 30, which form the condenser unit 12, two corners, which are diagonally opposed to each other, have the primary condenser hole 123 and the secondary condenser hole 124, respectively, and the remaining two corners have the primary heat medium hole 125 and the secondary heat medium hole 126, respectively. Specifically, the primary condenser hole 123 and the secondary heat medium hole 126 are formed at the upper side of the plate member 30, and the secondary condenser hole 124, the primary heat medium hole 125 and the sub-cooler communication hole 127 are formed at the lower side of the plate member 30.

[0170] The sub-cooler communication hole 127 is formed between the secondary condenser hole 124 and the primary heat medium hole 125. A diameter of the sub-cooler com-

munication hole 127 is smaller than a diameter of the primary condenser hole 123 and a diameter of the secondary condenser hole 124. In the present embodiment, the primary condenser hole 123, the secondary condenser hole 124 and the sub-cooler communication hole 127 serve as the high-temperature side passage holes HL1, respectively, and the primary heat medium hole 125 and the secondary heat medium hole 126 serve as the low-temperature side passage holes HL2, respectively. Furthermore, the primary condenser hole 123 and the secondary condenser hole 124 serve as the large-diameter holes, respectively, and the sub-cooler communication hole 127 serves as the small-diameter hole.

[0171] Among the plate members 30, which form the condenser unit 12, the second intermediate member 33, which is placed at the intermediate location of the condenser unit 12 in the stacking direction Dst, has the secondary condenser hole 124, the primary heat medium hole 125, the secondary heat medium hole 126 and the sub-cooler communication hole 127 but does not have the primary condenser hole 123. With the configuration described above, the passage of the high-pressure refrigerant at the condenser unit 12 becomes a U-turn passage. Among the plate members 30, which form the condenser unit 12, the first end member 31, which is placed at the end of the condenser unit 12 facing the other side in the stacking direction Dst, is provided with the first intermediate connector CNc1 and the second intermediate connector CNc2. The first intermediate connector CNc1 and the second intermediate connector CNc2 also function as connectors, which input the high-pressure refrigerant and input and output the high-temperature side heat medium.

[0172] In the condenser unit 12, an upstream side passage of the high-pressure refrigerant forms a down-flow passage, and a downstream side passage of the high-pressure refrigerant forms an up-flow passage. Furthermore, the passage of the high-temperature side heat medium in the condenser unit 12 forms an up-flow passage. With the configuration described above, the high-pressure refrigerant and the high-temperature side heat medium form counter flows, respectively, at the one side of the condenser unit 12 in the stacking direction Dst, and the high-pressure refrigerant and the high-temperature side heat medium form parallel flows, respectively, at the other side of the condenser unit 12 in the stacking direction Dst.

[0173] Next, the plate members 30, which form the sub-cooler unit 14, will be described. Each corresponding one of the plate members 30, which form the sub-cooler unit 14, has the primary sub-cooler hole 143 and the secondary sub-cooler hole 144. Furthermore, each corresponding one of the plate members 30, which form the sub-cooler unit 14, has the tertiary heat medium hole 145 and the quaternary heat medium hole 146 each of which conducts the high-temperature side heat medium in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the sub-cooler unit 14, has the primary communication hole 147 which forms the high-pressure inlet passage HPi that conducts the high-pressure refrigerant passed through the condenser unit 12 to the liquid storage unit 13.

[0174] Among four corners of each corresponding one of the plate members 30, which form the sub-cooler unit 14, two corners, which are diagonally opposed to each other, have the tertiary heat medium hole 145 and the quaternary heat medium hole 146, respectively, and one of the remain-

ing two corners has the primary communication hole 147. Furthermore, the primary sub-cooler hole 143 is formed between the primary communication hole 147 and the quaternary heat medium hole 146. The secondary sub-cooler hole 144 is formed at a location adjacent to the tertiary heat medium hole 145. Specifically, the primary sub-cooler hole 143, the quaternary heat medium hole 146 and the primary communication hole 147 are formed at the upper side of the plate member 30, and the secondary sub-cooler hole 144 and the tertiary heat medium hole 145 are formed at the lower side of the plate member 30.

[0175] The tertiary heat medium holes 145 are formed at a position where the tertiary heat medium holes 145 overlap with the primary heat medium holes 125 in the stacking direction Dst so that the tertiary heat medium holes 145 communicate with the primary heat medium holes 125. The quaternary heat medium holes 146 are formed at a position where the quaternary heat medium holes 146 overlap with the secondary heat medium holes 126 in the stacking direction Dst so that the quaternary heat medium holes 146 communicate with the secondary heat medium holes 126. Furthermore, the secondary sub-cooler holes 144 are formed at a position where the secondary sub-cooler holes 144 overlap with the sub-cooler communication holes 127 in the stacking direction Dst so that the secondary sub-cooler holes 144 communicate with the sub-cooler communication holes 127.

[0176] In the present embodiment, the primary sub-cooler hole 143, the secondary sub-cooler hole 144 and the primary communication hole 147 serve as the high-temperature side passage holes HL1, respectively, and the tertiary heat medium hole 145 and the quaternary heat medium hole 146 serve as the low-temperature side passage holes HL2, respectively. Furthermore, the primary communication hole 147 serves as the large-diameter hole, and the primary sub-cooler hole 143 and the secondary sub-cooler hole 144 serve as the small-diameter holes, respectively.

[0177] In the sub-cooler unit 14 configured in the above-described manner, the flow passage of the high-pressure liquid refrigerant forms a down-flow passage, and the passage of the high-temperature side heat medium forms an up-flow passage. Therefore, in the sub-cooler unit 14, the high-pressure liquid refrigerant and the high-temperature side heat medium form the counter flows, respectively.

[0178] Next, the plate members 30, which form the internal heat exchanger unit 15, will be described. Each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has the primary heat exchanger hole 153 and the secondary heat exchanger hole 154 each of which conducts the high-pressure liquid refrigerant passed through the sub-cooler unit 14 in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has the primary low-pressure hole 155 and the secondary low-pressure hole 156, each of which conducts the low-pressure refrigerant in the stacking direction Dst.

[0179] Among four corners of each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, two corners, which are diagonally opposed to each other, have the primary heat exchanger hole 153 and the secondary heat exchanger hole 154, respectively, and the remaining two corners have the primary low-pressure hole 155 and the secondary low-pressure hole 156, respectively. Specifically, the secondary heat exchanger

hole 154 and the primary low-pressure hole 155 are formed at the upper side of the plate member 30, and the primary heat exchanger hole 153 and the secondary low-pressure hole 156 are formed at the lower side of the plate member 30.

[0180] Among the plate members 30, which form the internal heat exchanger unit 15, the second end member 36, which is placed at the end of the internal heat exchanger unit 15 facing the other side in the stacking direction Dst, is coupled with the low-pressure inlet connector CLi, which is communicated with the primary low-pressure holes 155, and the low-pressure outlet connector CLo, which is communicated with the secondary low-pressure holes 156.

[0181] In the internal heat exchanger unit 15, the passage of the high-pressure liquid refrigerant forms an up-flow passage, and the passage of the low-pressure refrigerant forms a down-flow passage. Therefore, in the internal heat exchanger unit 15, the high-pressure liquid refrigerant and the low-pressure refrigerant form counter flows, respectively.

[0182] In the present embodiment, the receiver tank RT, which is the liquid storage unit 13, is placed adjacent to the portion of the structure ST which forms the sub-cooler unit 14. In the sub-cooler unit 14, the primary sub-cooler hole 143 and the primary communication hole 147 are formed at the upper side of the plate member 30. Therefore, the sub-cooler unit 14 can be coupled to the receiver tank RT without providing the side passage SP described in the first embodiment.

[0183] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

[0184] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0185] (1) In the structure ST, the condenser unit 12 is placed between the sub-cooler unit 14 and the internal heat exchanger unit 15. The internal heat exchanger unit 15 is coupled to the condenser unit 12 in the state where the internal heat exchanger unit 15 is spaced from the condenser unit 12. Thus, the configuration described above, in which the internal heat exchanger unit 15 is coupled to the condenser unit 12 in the state where the internal heat exchanger unit 15 is spaced from the condenser unit 12, can limit the unintended heat transfer between the condenser unit 12 and the internal heat exchanger unit 15 without the need for a separate component, such as a thermal insulation material.

[0186] (2) The liquid storage unit 13 is directly joined to the portion of the structure ST which forms the sub-cooler unit 14. When the liquid storage unit 13 and the sub-cooler unit 14 are integrally formed in the manner described above, the composite heat exchanger HEX can be realized in the compact form.

Seventh Embodiment

[0187] Next, a seventh embodiment will be described with reference to FIG. 17. In the present embodiment, points, which are different from the sixth embodiment, will be mainly described.

[0188] As shown in FIG. 17, in the composite heat exchanger HEX, the liquid storage unit 13 is coupled to the portion of the structure ST, which forms the sub-cooler unit 14, through the tank connector CNt. Here, it should be noted that, as in the sixth embodiment, the liquid storage unit 13 may be directly joined to the portion of the structure ST which forms the sub-cooler unit 14.

[0189] Furthermore, in the composite heat exchanger HEX, the condenser unit 12 is placed between the internal heat exchanger unit 15 and the sub-cooler unit 14, and the evaporator 17 is coupled to the internal heat exchanger unit 15 through coupling connectors. Specifically, the evaporator 17 is coupled to the end of the internal heat exchanger unit 15, which faces the other side in the stacking direction Dst, through a first coupling connector CNe1 and a second coupling connector CNe2.

[0190] The first coupling connector CNe1 and the second coupling connector CNe2 are connectors that couple between the internal heat exchanger unit 15 and the evaporator 17. The first coupling connector CNe1 functions as a connector that conducts the low-pressure refrigerant from the evaporator 17 to the internal heat exchanger unit 15. The decompression valve 16, which decompresses the high-pressure liquid refrigerant passed through the internal heat exchanger unit 15, is formed integrally with the first coupling connector CNe1. Therefore, the low-pressure refrigerant, which is decompressed at the decompression valve 16, flows into the evaporator 17. The second coupling connector CNe2 may be omitted because it does not have a passage which conducts the refrigerant.

[0191] Like the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15, the evaporator 17 is formed by stacking and joining a plurality of plate members 30. In the evaporator 17, the plate members 30 are joined together in a state where the plate members 30 are stacked together to form the primary evaporator passages (also collectively referred to as the primary evaporator passage) 171 and the secondary evaporator passages (also collectively referred to as the secondary evaporator passage) 172. The primary evaporator passages 171 and the secondary evaporator passages 172 are alternately arranged.

[0192] Each corresponding one of the plate members 30, which form the evaporator 17, has a primary evaporator hole 173 and a secondary evaporator hole 174, each of which conducts the low-pressure refrigerant in the stacking direction Dst. Furthermore, each corresponding one of the plate members 30, which form the evaporator 17, has a primary low-temperature hole 175 and a secondary low-temperature hole 176 each of which conducts the low-temperature side heat medium in the stacking direction Dst.

[0193] Among four corners of each corresponding one of the plate members 30, which form the evaporator 17, two corners, which are diagonally opposed to each other, have the primary evaporator hole 173 and the secondary evaporator hole 174, respectively, and the remaining two corners have the primary low-temperature hole 175 and the secondary low-temperature hole 176, respectively. Specifically, the primary evaporator hole 173 and the primary low-temperature hole 175 are formed at the upper side of the plate member 30, and the secondary evaporator hole 174 and the secondary low-temperature hole 176 are formed at the lower side of the plate member 30.

[0194] Among the plate members 30, which form the evaporator 17, an other-end member 37, which is placed at

an end of the evaporator 17 facing the other side in the stacking direction Dst, has the primary low-temperature hole 175 and the secondary low-temperature hole 176 but does not have the primary evaporator hole 173 and the secondary evaporator hole 174.

[0195] Among the plate members 30, which form the evaporator 17, a one-end member 38, which is placed at the end of the evaporator 17 facing the one side in the stacking direction Dst, has the primary evaporator hole 173 and the secondary evaporator hole 174 but does not have the primary low-temperature hole 175 and the secondary low-temperature hole 176. In place of the primary low-temperature hole 175, the one-end member 38 has an evaporator communication hole 177, which is communicated with the primary low-pressure holes 155 of the internal heat exchanger unit 15. Furthermore, in the evaporator 17, a guide passage GP is formed adjacent to the one-end member 38 to conduct the refrigerant passed through the secondary evaporator holes 174 to the evaporator communication hole 177.

[0196] In the evaporator 17 of the present embodiment, each of the passage of the low-pressure refrigerant and the passage of the low-temperature side heat medium is formed as a down-flow passage. Therefore, in the evaporator 17, the low-pressure refrigerant and the low-temperature side heat medium form the parallel flows, respectively.

[0197] The rest of the configuration of the present embodiment is the same as that of the sixth embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the sixth embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the sixth embodiment.

[0198] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0199] (1) The evaporator 17 is coupled to the internal heat exchanger unit 15 through the first coupling connector CNe1 and the second coupling connector CNe2. With the configuration described above, the condenser unit 12, the sub-cooler unit 14, the internal heat exchanger unit 15 and the evaporator 17 can be formed by the single heat exchanger. As a result, it is easier to reduce the costs of the refrigeration cycle 10 by reducing the number of components thereof and to realize the refrigeration cycle 10 in a compact form.

Eighth Embodiment

[0200] Next, an eighth embodiment will be described with reference to FIG. 18. In the present embodiment, points, which are different from the seventh embodiment, will be mainly described.

[0201] In the composite heat exchanger HEX of the present embodiment, one of a vertical dimension and a horizontal dimension of the internal heat exchanger unit 15 measured at a front surface of the internal heat exchanger unit 15 is smaller than both of: a larger one of a vertical dimension and a horizontal dimension of the condenser unit 12 measured at a front surface of the condenser unit 12; and a larger one of a vertical dimension and a horizontal dimension of the sub-cooler unit 14 measured at a front surface of the sub-cooler unit 14. Here, the front surface is defined as a surface that connects an upper surface and a bottom surface and extends in the direction along which the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger

unit **15** are arranged in the row. Furthermore, in the present embodiment, the up-to-down direction Dg is defined as vertical, and the direction (i.e., the horizontal direction), along which the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15** are arranged in the row, is defined as horizontal. The vertical dimension Lv is a dimension measured in the up-to-down direction Dg . Furthermore, the horizontal dimension Lh is a dimension measured in the horizontal direction.

[0202] Specifically, as shown in FIG. **18**, the horizontal dimension Lhc of the condenser unit **12** is larger than the vertical dimension Lvc of the condenser unit **12** at the front surface of the condenser unit **12**. The vertical dimension Lvs of the sub-cooler unit **14** is larger than the horizontal dimension Lhs of the sub-cooler unit **14** at the front surface of the sub-cooler unit **14**. The vertical dimension Lvc of the condenser unit **12** and the vertical dimension Lvs of the sub-cooler unit **14** are substantially equal to each other. The vertical dimension Lvi of the internal heat exchanger unit **15** is larger than the horizontal dimension Lhi of the internal heat exchanger unit **15** at the front surface of the internal heat exchanger unit **15**. The vertical dimension Lvi of the internal heat exchanger unit **15** is smaller than the vertical dimension Lvc of the condenser unit **12** and the vertical dimension Lvs of the sub-cooler unit **14**. Furthermore, the horizontal dimension Lhi of the internal heat exchanger unit **15** is smaller than the vertical dimension Lvc of the condenser unit **12** and the vertical dimension Lvs of the sub-cooler unit **14**. Although not shown in the drawing, a depth dimension (i.e., a front-to-back dimension) of the internal heat exchanger unit **15** is substantially equal to a depth dimension of the condenser unit **12** and a depth dimension of the sub-cooler unit **14**.

[0203] In the composite heat exchanger HEX of the present embodiment, the vertical dimension Lvi of the internal heat exchanger unit **15** is smaller than a distance between the first coupling connector $CNe1$ and the second coupling connector $CNe2$ to enable placement of the internal heat exchanger unit **15** between the first coupling connector $CNe1$ and the second coupling connector $CNe2$.

[0204] Furthermore, in the composite heat exchanger HEX, the horizontal dimension Lhi of the internal heat exchanger unit **15** is set such that the first coupling connector $CNe1$ and the first intermediate connector $CNe1$ are adjacent to each other, and the second coupling connector $CNe2$ and the second intermediate connector $CNe2$ are adjacent to each other. Each of the first coupling connector $CNe1$ and the second coupling connector $CNe2$ may be in contact with or spaced from the corresponding adjacent one of the first intermediate connector $CNe1$ and the second intermediate connector $CNe2$.

[0205] Here, the plate members **30**, which form the internal heat exchanger unit **15**, are made of a plurality of plate materials, respectively, each of which has at least different external dimensions that are different from those of each of a plurality of plate materials that are used to form the plate members **30** of the condenser unit **12** and the sub-cooler unit **14**.

[0206] The rest of the configuration of the present embodiment is the same as that of the seventh embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the seventh embodiment described above and are achieved by

the common configuration or equivalent configuration that is common to or equivalent to the seventh embodiment.

[0207] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0208] (1) One of the vertical dimension and the horizontal dimension of the internal heat exchanger unit **15** measured at the front surface of the internal heat exchanger unit **15** is smaller than both of: the larger one of the vertical dimension and the horizontal dimension of the condenser unit **12** measured at the front surface of the condenser unit **12**; and the larger one of the vertical dimension and the horizontal dimension of the sub-cooler unit **14** measured at the front surface of the sub-cooler unit **14**. When the internal heat exchanger unit **15** is formed in the compact form as described above, it will be easier to realize the composite heat exchanger HEX in the compact form. In addition, the pressure loss in the internal heat exchanger unit **15** can be limited, and thereby the deterioration of the coefficient of performance COP of the refrigeration cycle **10** can be limited.

[0209] (2) Specifically, a larger one of the vertical dimension and the horizontal dimension of the internal heat exchanger unit **15** measured at the front surface of the internal heat exchanger unit **15** is smaller than both of: the larger one of the vertical dimension and the horizontal dimension of the condenser unit **12** measured at the front surface of the condenser unit **12**; and the larger one of the vertical dimension and the horizontal dimension of the sub-cooler unit **14** measured at the front surface of the sub-cooler unit **14**. With this configuration, while the composite heat exchanger HEX is formed in the compact form, the pressure loss in the internal heat exchanger unit **15** can be limited, and thereby the coefficient of performance COP of the refrigeration cycle **10** can be improved.

Modification of Eighth Embodiment

[0210] In the composite heat exchanger HEX of the eighth embodiment, the evaporator **17** is coupled to the internal heat exchanger unit **15**. However, the present disclosure is not limited to this configuration. That is, the configuration, in which the evaporator **17** is not coupled to the internal heat exchanger unit **15**, may be realized.

Ninth Embodiment

[0211] Next, a ninth embodiment will be described with reference to FIGS. **19** and **20**. In the present embodiment, points, which are different from the eighth embodiment, will be mainly described.

[0212] As shown in FIG. **19**, the vertical dimension Lvc of the condenser unit **12** is substantially the same as the vertical dimension Lvs of the sub-cooler unit **14**. Furthermore, the vertical dimension Lvi and the horizontal dimension Lhi of the internal heat exchanger unit **15** are smaller than the vertical dimension Lvc of the condenser unit **12** and the vertical dimension Lvs of the sub-cooler unit **14**.

[0213] As shown in FIG. **20**, a depth dimension (i.e., a front-to-back dimension) Lwc of the condenser unit **12** is substantially the same as a depth dimension Lws of the sub-cooler unit **14**. Furthermore, a depth dimension Lwi of the internal heat exchanger unit **15** is larger than the depth dimension Lwc of the condenser unit **12** and the depth dimension Lws of the sub-cooler unit **14**.

[0214] The rest of the configuration of the present embodiment is the same as that of the eighth embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the eighth embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the eighth embodiment.

[0215] Furthermore, the composite heat exchanger HEX of the present embodiment has the following advantageous features.

[0216] (1) The internal heat exchanger unit 15 has the depth dimension that is larger than the depth dimension of the condenser unit 12 and the depth dimension of the sub-cooler unit 14. With this configuration, the sufficient heat exchange surface area for exchanging the heat between the high-pressure liquid refrigerant and the low-pressure refrigerant in the internal heat exchanger unit 15 can be ensured, and thereby it is possible to make the composite heat exchanger HEX in the compact form while ensuring the sufficient performance of the internal heat exchanger unit 15.

Tenth Embodiment

[0217] Next, a tenth embodiment will be described with reference to FIGS. 21 and 22. In the present embodiment, points, which are different from the seventh embodiment, will be mainly described.

[0218] In the present embodiment, there will be described an example, in which the composite heat exchanger HEX of the present disclosure is applied to a refrigeration cycle apparatus 1A that includes an air conditioning evaporator 20 in addition to the evaporator 17 described in the first embodiment.

[0219] As shown in FIG. 21, in the refrigeration cycle 10A, a first three-way valve 18, which splits a flow of the refrigerant, is placed between the primary heat exchanger passage 151 of the internal heat exchanger unit 15 and the decompression valve 16. The first three-way valve 18 has one refrigerant inlet and two refrigerant outlets. The primary heat exchanger passage 151 of the internal heat exchanger unit 15 is connected to the refrigerant inlet of the first three-way valve 18. The decompression valve 16 is connected to one of the two refrigerant outlets of the first three-way valve 18. An air conditioning decompression valve 19 is connected to the other one of the two refrigerant outlets of the first three-way valve 18. With the configuration described above, in the refrigeration cycle 10A, the high-pressure liquid refrigerant passed through the primary heat exchanger passage 151 of the internal heat exchanger unit 15 flows into the decompression valve 16 and the air conditioning decompression valve 19.

[0220] The air conditioning decompression valve 19 is a decompressor that decompresses the high-pressure liquid refrigerant passed through the internal heat exchanger unit 15. The air conditioning decompression valve 19 is an electric valve having a variable throttle. The operation of the air conditioning decompression valve 19 is controlled by a control signal outputted from the control device 100 and includes a valve element and an electric actuator.

[0221] The air conditioning evaporator 20 is connected to a refrigerant outlet of the air conditioning decompression valve 19. The air conditioning evaporator 20 is a heat absorber that exchanges heat between the low-pressure refrigerant decompressed at the air conditioning decompression valve 19 and the air to be blown into the vehicle cabin

and thereby evaporates the low-pressure refrigerant. The air conditioning evaporator 20 has a primary evaporator passage 171, which conducts the low-pressure refrigerant decompressed at the decompression valve 16, and a secondary evaporator passage 172, which conducts the low-temperature side heat medium. The air conditioning evaporator 20 is a fin-and-tube heat exchanger.

[0222] An evaporator pressure regulator valve 21 is connected to a refrigerant outlet of the air conditioning evaporator 20. The evaporator pressure regulator valve 21 is a regulator valve that adjusts the pressure at the refrigerant outlet of the air conditioning evaporator 20 such that the pressure at the refrigerant outlet of the air conditioning evaporator 20 is kept equal to or higher than a predetermined pressure.

[0223] A second three-way valve 22, which merges the low-pressure refrigerant passed through the evaporator pressure regulator valve 21 and the low-pressure refrigerant passed through the evaporator 17, is placed at a refrigerant outlet side of the evaporator pressure regulator valve 21. The second three-way valve 22 has two refrigerant inlets and one refrigerant outlet. The evaporator pressure regulator valve 21 is connected to one of the refrigerant inlets of the second three-way valve 22. The evaporator 17 is connected to the other one of the refrigerant inlets of the second three-way valve 22. The compressor 11 is connected to the refrigerant outlet of the second three-way valve 22. With the configuration described above, in the refrigeration cycle 10A, the low-pressure refrigerant passed through the evaporator pressure regulator valve 21 and the low-pressure refrigerant passed through the evaporator 17 are suctioned into and are compressed once again by the compressor 11.

[0224] In the refrigeration cycle apparatus 1A configured in the above-described manner, in order to make a compact size thereof, the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14, the internal heat exchanger unit 15, the decompression valve 16 and the evaporator 17 are integrated together as the composite heat exchanger HEX. Hereinafter, the composite heat exchanger HEX will be described with reference to FIG. 22.

[0225] As shown in FIG. 22, in the composite heat exchanger HEX, the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14, the internal heat exchanger unit 15, the decompression valve 16 and the evaporator 17 are integrated in the same arrangement form as in the seventh embodiment. The composite heat exchanger HEX of the present embodiment differs from the composite heat exchanger HEX of the seventh embodiment with respect to the configuration of the internal heat exchanger unit 15 and the configuration of the evaporator 17.

[0226] Each corresponding one of the plate members 30, which form the internal heat exchanger unit 15, has the primary heat exchanger hole 153, the secondary heat exchanger hole 154, the primary low-pressure hole 155 and the secondary low-pressure hole 156. The secondary heat exchanger hole 154 and the primary low-pressure hole 155 are formed at the upper side of the plate member 30, and the primary heat exchanger hole 153 and the secondary low-pressure hole 156 are formed at the lower side of the plate member 30.

[0227] The primary heat exchanger holes 153 and the secondary heat exchanger holes 154 form tank spaces, respectively, which distribute the high-pressure liquid refrigerant to the primary heat exchanger passages 151 or collect

the high-pressure liquid refrigerant passed through the primary heat exchanger passages 151. Among the plate members 30, which form the internal heat exchanger unit 15, an internal member 39, which is placed at an intermediate location of the internal heat exchanger unit 15 in the stacking direction Dst, has the secondary heat exchanger hole 154, the primary low-pressure hole 155 and the secondary low-pressure hole 156 but does not have the primary heat exchanger hole 153. With the configuration described above, the passage of the high-pressure liquid refrigerant at the internal heat exchanger unit 15 becomes a U-turn passage.

[0228] In the internal heat exchanger unit 15, an upstream side passage of the high-pressure liquid refrigerant forms an up-flow passage, and a downstream side passage of the high-pressure liquid refrigerant forms a down-flow passage. Furthermore, the passage of the low-pressure refrigerant at the internal heat exchanger unit 15 forms a down-flow passage. With the configuration described above, the high-pressure liquid refrigerant and the low-pressure refrigerant form counter flows, respectively, at the one side of the internal heat exchanger unit 15 in the stacking direction Dst, and the high-pressure liquid refrigerant and the low-pressure refrigerant form parallel flows, respectively, at the other side of the internal heat exchanger unit 15 in the stacking direction Dst.

[0229] The evaporator 17 is coupled to the end of the internal heat exchanger unit 15, which faces the other side in the stacking direction Dst, through the first coupling connector CNe1 and the second coupling connector CNe2.

[0230] The first coupling connector CNe1 and the second coupling connector CNe2 are connectors that couple between the internal heat exchanger unit 15 and the evaporator 17. The first coupling connector CNe1 functions as a connector that conducts the low-pressure refrigerant from the evaporator 17 to the internal heat exchanger unit 15. The first coupling connector CNe1 is configured to function as the second three-way valve 22. Furthermore, the first coupling connector CNe1 has the evaporator pressure regulator valve 21 that is formed integrally with the first coupling connector CNe1.

[0231] The second coupling connector CNe2 has the decompression valve 16 that is formed integrally with the second coupling connector CNe2 and decompresses the high-pressure liquid refrigerant passed through the internal heat exchanger unit 15. Therefore, the low-pressure refrigerant, which is decompressed at the decompression valve 16, flows into the evaporator 17.

[0232] Each corresponding one of the plate members 30, which form the evaporator 17, has the primary evaporator hole 173, the secondary evaporator hole 174, the primary low-temperature hole 175 and the secondary low-temperature hole 176. The secondary evaporator hole 174 and the primary low-temperature hole 175 are formed at the upper side of the plate member 30, and the primary evaporator hole 173 and the secondary low-temperature hole 176 are formed at the lower side of the plate member 30.

[0233] In the evaporator 17 of the present embodiment, the passage of the low-pressure refrigerant forms an up-flow passage, and the passage of the low-temperature side heat medium forms a down-flow passage. Therefore, in the evaporator 17, the low-pressure refrigerant and the low-temperature side heat medium form the counter flows, respectively.

[0234] The rest of the configuration of the present embodiment is the same as that of the seventh embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the seventh embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the seventh embodiment.

Eleventh Embodiment

[0235] Next, an eleventh embodiment will be described with reference to FIGS. 23 and 24. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0236] In the present embodiment, there will be described an example, in which the composite heat exchanger HEX of the present disclosure is applied to a refrigeration cycle apparatus 1A that includes the air conditioning evaporator 20 in addition to the evaporator 17.

[0237] As shown in FIG. 23, in the refrigeration cycle 10A, a branch BR, which splits a flow of the refrigerant, is placed between the primary condenser passage 121 of the condenser unit 12 and the liquid storage unit 13. With this configuration, the refrigerant passed through the condenser unit 12 is divided and is distributed to the liquid storage unit 13 and the air conditioning decompression valve 19.

[0238] In the refrigeration cycle apparatus 1A configured in the above-described manner, in order to make a compact size thereof, the condenser unit 12, the liquid storage unit 13, the sub-cooler unit 14 and the internal heat exchanger unit 15 are integrated together as the composite heat exchanger HEX. Hereinafter, the composite heat exchanger HEX will be described with reference to FIG. 24.

[0239] As shown in FIG. 24, the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are joined together by the predetermined binding element and thereby form the integral structure ST. A branch connector CHd, which conducts a portion of the refrigerant passed through the condenser unit 12 to the air conditioning decompression valve 19, is provided to the condenser unit 12. The branch connector CHd is provided to the end portion of the condenser unit 12 which faces the other side in the stacking direction Dst.

[0240] Furthermore, in the composite heat exchanger HEX of the present embodiment, at least one heat exchanger unit among the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 is configured such that one of the vertical dimension and the horizontal dimension of the at least one heat exchanger unit measured at the front surface of the at least one heat exchanger unit is smaller than a largest dimension among the vertical dimension and the horizontal dimension of remaining one or more heat exchanger units among the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15.

[0241] Specifically, in the composite heat exchanger HEX, the vertical dimension Lvc of the condenser unit 12 measured at the front surface of the condenser unit 12 is the largest dimension among the vertical dimension and the horizontal dimension of each of the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15. The vertical dimension Lvs of the sub-cooler unit 14 measured at the front surface of the sub-cooler unit 14 is smaller than the vertical dimension Lvc of the condenser unit 12. Furthermore, the vertical dimension Lvi of the internal heat exchanger unit 15 measured at the front surface of the

internal heat exchanger unit **15** is substantially the same as the vertical dimension L_{vs} of the sub-cooler unit **14** but is smaller than the vertical dimension L_{vc} of the condenser unit **12**.

[0242] In the composite heat exchanger HEX of the present embodiment, since the vertical dimension L_{vs} of the sub-cooler unit **14** and the vertical dimension L_{vi} of the internal heat exchanger unit **15** are smaller than the vertical dimension L_{vc} of the condenser unit **12**, the upper portion of the sub-cooler unit **14** and the branch connector CHd will not interfere with each other. With this configuration, the composite heat exchanger HEX can be realized in the compact form.

[0243] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

Twelfth Embodiment

[0244] Next, a twelfth embodiment will be described with reference to FIGS. 25 and 26. In the present embodiment, points, which are different from the first embodiment, will be mainly described. In the present embodiment, there will be described an example, in which the composite heat exchanger HEX of the present disclosure is applied to the refrigeration cycle apparatus **1A** that includes the air conditioning evaporator **20** in addition to the evaporator **17**.

[0245] As shown in FIG. 25, in the refrigeration cycle **10A**, a branch BR, which splits a flow of the refrigerant, is placed between the sub-cooler unit **14** and the internal heat exchanger unit **15**. With this configuration, the refrigerant passed through the sub-cooler unit **14** is divided and is distributed to the internal heat exchanger unit **15** and the air conditioning decompression valve **19**.

[0246] In the refrigeration cycle apparatus **1A** configured in the above-described manner, in order to make a compact size thereof, the condenser unit **12**, the liquid storage unit **13**, the sub-cooler unit **14** and the internal heat exchanger unit **15** are integrated together as the composite heat exchanger HEX. Hereinafter, the composite heat exchanger HEX will be described with reference to FIG. 26.

[0247] As shown in FIG. 26, the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15** are joined together by the predetermined binding element and thereby form the integral structure ST. A branch connector CHd, which conducts a portion of the refrigerant passed through the sub-cooler unit **14** to the air conditioning decompression valve **19**, is provided to the sub-cooler unit **14**. The branch connector CHd is provided to the end portion of the sub-cooler unit **14** which faces the other side in the stacking direction Dst.

[0248] In the composite heat exchanger HEX of the present embodiment, the vertical dimension L_{vc} of the condenser unit **12** measured at the front surface of the condenser unit **12** and the vertical dimension L_{vs} of the sub-cooler unit **14** measured at the front surface of the sub-cooler unit **14** serve as the largest dimension among the vertical dimension and the horizontal dimension of each of the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15**. Furthermore, the vertical dimension L_{vi} of the internal heat exchanger unit **15** measured at the front surface

of the internal heat exchanger unit **15** is smaller than the vertical dimension L_{vc} of the condenser unit **12** and the vertical dimension L_{vs} of the sub-cooler unit **14**.

[0249] In the composite heat exchanger HEX of the present embodiment, since the vertical dimension L_{vi} of the internal heat exchanger unit **15** is smaller than the vertical dimension L_{vc} of the condenser unit **12** and the vertical dimension L_v of the sub-cooler unit **14**, the upper portion of the internal heat exchanger unit **15** and the branch connector CHd do not interfere with each other. With this configuration, the composite heat exchanger HEX can be realized in the compact form.

[0250] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

Modification of Twelfth Embodiment

[0251] In the composite heat exchanger HEX, for example, one of the vertical dimension and the horizontal dimension of the condenser unit **12** measured at the front surface of the condenser unit **12** may be smaller than a largest dimension among the vertical dimension and the horizontal dimension of the sub-cooler unit **14** measured at the front surface of the sub-cooler unit **14** and the vertical dimension and the horizontal dimension of the internal heat exchanger unit **15** measured at the front surface of the internal heat exchanger unit **15**. Furthermore, the composite heat exchanger HEX may be formed to include the evaporator **17** in addition to the condenser unit **12**, the sub-cooler unit **14** and the internal heat exchanger unit **15**.

Thirteenth Embodiment

[0252] Next, a thirteenth embodiment will be described with reference to FIG. 27. In the present embodiment, points, which are different from the first embodiment, will be mainly described.

[0253] As shown in FIG. 27, the composite heat exchanger HEX includes a passage box BX to conduct the refrigerant through the condenser unit **12**, the liquid storage unit **13**, the sub-cooler unit **14** and the internal heat exchanger unit **15** in this order. The passage box BX is not a refrigerant pipe and can be realized by, for example, forming a plurality of passage holes at a metal block. The passage box BX is installed at a lateral surface of the composite heat exchanger HEX. The passage box BX may be installed at a top surface or a bottom surface of the composite heat exchanger HEX.

[0254] The rest of the configuration of the present embodiment is the same as that of the first embodiment. The composite heat exchanger HEX of the present embodiment can achieve the advantages, which are similar to those of the first embodiment described above and are achieved by the common configuration or equivalent configuration that is common to or equivalent to the first embodiment.

Modification of Thirteenth Embodiment

[0255] In the thirteenth embodiment, the passage box BX is coupled to the structure ST, in which the sub-cooler unit **14** is placed between the condenser unit **12** and the internal heat exchanger unit **15**. However, the composite heat

exchanger HEX is not limited to this configuration. The composite heat exchanger HEX may be configured such that the passage box BX is coupled to the structure ST, in which, for example, the condenser unit 12 is placed between the sub-cooler unit 14 and the internal heat exchanger unit 15. Furthermore, the composite heat exchanger HEX may be configured such that the passage box BX is coupled to the structure ST, which includes the condenser unit 12, the sub-cooler unit 14, the internal heat exchanger unit 15 and the evaporator 17.

Other Embodiments

[0256] Although the representative embodiments of the present disclosure have been described above, the present disclosure is not limited to the above-described embodiments and can be variously modified, for example, as follows.

[0257] In the composite heat exchanger HEX of each of the first to seventh embodiments, the plurality of plate members 30, which form the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15, are made of the plurality of plate materials, respectively, each of which has at least the common plate thickness and the common external dimensions. However, the present disclosure is not limited to this configuration. The plurality of plate members 30, which form the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15, may be made of the plurality of plate materials, respectively, while at least some or more of the plurality of plate materials have at least a different plate thickness or different external dimensions that are different from that of the rest of the plurality of plate materials. Furthermore, the internal heat exchanger unit 15 may be formed by stacking and joining the plurality of plate members 30, each of which does not have the sacrificial layer SL.

[0258] Although it is desirable that each of the secondary heat exchange fins F2 has the shape that is different from the shape of each of the primary heat exchange fins F1 to reduce the refrigerant pressure loss at the internal heat exchanger unit 15, the present disclosure is not limited to this configuration. The shape of each of the primary heat exchange fins F1 and the shape of each of the secondary heat exchange fins F2 may be identical to each other.

[0259] As described in the above embodiments, it is desirable that the structure ST is configured to limit the heat transfer between the condenser unit 12 and the internal heat exchanger unit 15. However, the present disclosure is not limited to this configuration. The structure ST may be configured such that the condenser unit 12 and the internal heat exchanger unit 15 are directly joined together to allow the heat transfer between the condenser unit 12 and the internal heat exchanger unit 15. Furthermore, the structure ST may be configured such that the internal heat exchanger unit 15 is placed between the condenser unit 12 and the sub-cooler unit 14.

[0260] The composite heat exchanger HEX of the embodiments described above is configured such that the evaporator 17 is integrated with the structure ST, in which the condenser unit 12 is placed between the internal heat exchanger unit 15 and the sub-cooler unit 14. However, the present disclosure is not limited to this configuration. The composite heat exchanger HEX may be configured such that the evaporator 17 is integrated with the structure ST, in which, for example,

the sub-cooler unit 14 is placed between the condenser unit 12 and the internal heat exchanger unit 15.

[0261] The composite heat exchanger HEX described above is exemplified such that the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are formed as the heat exchanger of the stacked plate type in which the plurality of plate members 30 are stacked together. However, the present disclosure is not limited to this configuration. The composite heat exchanger HEX may be configured, for example, as a multi-tube heat exchanger which includes a shell and a plurality of heat transfer tubes. The condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 may be coupled to each other through connectors.

[0262] In the composite heat exchanger HEX described in the above embodiments, the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15 are arranged in the predetermined direction in the row. However, the present disclosure is not limited to this configuration. For example, the composite heat exchanger HEX may be configured such that among the condenser unit 12, the sub-cooler unit 14 and the internal heat exchanger unit 15, the front surface of one heat exchanger unit is opposed to the front surface of another heat exchanger unit.

[0263] As in the embodiments described above, it is desirable to arrange the liquid storage unit 13 such that the center position CT of the liquid storage unit 13 does not overlap the center plane CP of the structure ST. However, the present disclosure is not limited to this configuration. The liquid storage unit 13 may be arranged such that the center position CT of the liquid storage unit 13 overlaps the center plane CP of the structure ST.

[0264] In the embodiments described above, there is discussed the example where the composite heat exchanger HEX is applied to the refrigeration cycle apparatus 1 of the vehicle. However, the application of the composite heat exchanger HEX is not limited to the mobile systems, but can also be applied to stationary or portable systems, for example. The cycle configuration of the refrigeration cycle 10 and the refrigeration cycle apparatus 1, to which the composite heat exchanger HEX is applied, may be different from those described above.

[0265] Needless to say, in the above-described embodiments, the components of the embodiment(s) are not necessarily essential except when it is clearly indicated that they are essential and when they are clearly considered to be essential in principle.

[0266] In the above-described embodiments, when the numerical values, such as the number, numerical value, quantity, range, etc. of the components of the embodiment(s) are mentioned, the numerical values are not limited to those described in the embodiment(s) except when it is clearly indicated that the numeric values are essential and when the numeric values are clearly considered to be essential in principle.

[0267] In the above-described embodiments, when a shape, a positional relationship, etc. of the component(s) is mentioned, the shape, positional relationship, etc. are not limited to those described in the embodiment(s) unless otherwise specified or limited in principle to the those described in the embodiment(s).

What is claimed is:

1. A composite heat exchanger configured to be used in a vapor compression refrigeration cycle that includes: a com-

pressor; a decompressor configured to decompress a high-pressure refrigerant discharged from the compressor; and an evaporator configured to evaporate a low-pressure refrigerant decompressed at the decompressor by exchanging heat between the low-pressure refrigerant and a first heat medium, the composite heat exchanger comprising:

- a condenser unit configured to condense the high-pressure refrigerant by exchanging heat between the high-pressure refrigerant and a second heat medium;
- a liquid storage unit configured to temporarily store a high-pressure liquid refrigerant contained in the high-pressure refrigerant passed through the condenser unit;
- a sub-cooler unit configured to sub-cool the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit by exchanging heat between the high-pressure liquid refrigerant and the second heat medium; and
- an internal heat exchanger unit configured to exchange heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and the low-pressure refrigerant discharged from the evaporator, wherein:
 - the condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together by a predetermined binding element and thereby form an integral structure;
 - in the integral structure, the sub-cooler unit is placed between the condenser unit and the internal heat exchanger unit; and
 - the liquid storage unit is placed adjacent to a portion of the integral structure which forms the internal heat exchanger unit.

2. The composite heat exchanger according to claim 1, wherein the integral structure is configured to limit heat transfer between the condenser unit and the internal heat exchanger unit.

3. The composite heat exchanger according to claim 1, wherein:

- in the integral structure, a high-pressure inlet passage, which is configured to conduct the high-pressure refrigerant passed through the condenser unit to the liquid storage unit, extends through the sub-cooler unit and the internal heat exchanger unit, and a high-pressure outlet passage, which is configured to conduct the high-pressure liquid refrigerant stored in the liquid storage unit to the sub-cooler unit, extends through the internal heat exchanger unit; and

- in the integral structure, a portion of the internal heat exchanger unit, which is adjacent to the liquid storage unit, is configured to conduct the high-pressure refrigerant flowing in the high-pressure inlet passage to the liquid storage unit and also conduct the high-pressure liquid refrigerant stored in the liquid storage unit to the high-pressure outlet passage.

4. The composite heat exchanger according to claim 1, wherein the internal heat exchanger unit is coupled to one heat exchanger unit among the condenser unit and the sub-cooler unit through at least one coupler component in a state where the internal heat exchanger unit is spaced from the one heat exchanger unit.

5. The composite heat exchanger according to claim 4, wherein:

- the internal heat exchanger unit is coupled to the sub-cooler unit in a state where the internal heat exchanger unit is spaced from the sub-cooler unit.

6. The composite heat exchanger according to claim 1, wherein the liquid storage unit is directly joined to a portion of the integral structure which forms the internal heat exchanger unit.

7. The composite heat exchanger according to claim 1, wherein the internal heat exchanger unit and at least one of the condenser unit and the sub-cooler unit are formed by a plurality of plate members which are stacked and joined together.

8. The composite heat exchanger according to claim 7, wherein the plurality of plate members include a plurality of multi-hole members each of which has:

- at least two high-temperature side passage holes which are configured to conduct the high-pressure refrigerant that includes the high-pressure liquid refrigerant; and
- at least one low-temperature side passage hole which is configured to conduct the second heat medium or the low-pressure refrigerant.

9. The composite heat exchanger according to claim 8, wherein in each of the plurality of multi-hole members, one of the at least two high-temperature side passage holes is formed as a passage hole that is configured to conduct the high-pressure liquid refrigerant and is placed adjacent to a corresponding one of the at least one low-temperature side passage hole.

10. The composite heat exchanger according to claim 8, wherein in each of the plurality of multi-hole members, the at least two high-temperature side passage holes include:

- a large-diameter hole that is configured to conduct the high-pressure refrigerant in a gas state or the high-pressure liquid refrigerant; and
- a small-diameter hole that has a diameter smaller than a diameter of the large-diameter hole and is configured to conduct the high-pressure liquid refrigerant, wherein the small-diameter hole is placed adjacent to a corresponding one of the at least one low-temperature side passage hole.

11. The composite heat exchanger according to claim 7, wherein:

- each of the plurality of plate members has a sacrificial layer at one surface and lacks the sacrificial layer at another surface opposite to the one surface;

- the one surface having the sacrificial layer of each corresponding one of the plurality of plate members is opposed to and is joined to the one surface having the sacrificial layer of an adjacent one of the plurality of plate members, and the another surface lacking the sacrificial layer of each corresponding one of the plurality of plate members is opposed to and is joined to the another surface lacking the sacrificial layer of an adjacent one of the plurality of plate members;

- each of a primary condenser passage configured to conduct the high-pressure refrigerant discharged from the compressor, a primary sub-cooler passage configured to conduct the high-pressure liquid refrigerant stored in the liquid storage unit, and a primary heat exchanger passage configured to conduct the high-pressure liquid refrigerant passed through the sub-cooler unit is formed between the another surface of each corresponding one of the plurality of plate members and the another surface of the adjacent one of the plurality of plate members; and

- each of a secondary condenser passage configured to conduct the second heat medium, a secondary sub-

cooler passage configured to conduct the second heat medium, and a secondary heat exchanger passage configured to conduct the low-pressure refrigerant is formed between the one surface of each corresponding one of the plurality of plate members and the one surface of the adjacent one of the plurality of plate members.

12. The composite heat exchanger according to claim 7, wherein each of the condenser unit, the sub-cooler unit and the internal heat exchanger unit is formed by corresponding plate members among the plurality of plate members, and the plurality of plate members are made of a plurality of plate materials, respectively, each of which has at least a common plate thickness and common external dimensions.

13. The composite heat exchanger according to claim 1, wherein:

each of the condenser unit and the sub-cooler unit has a plurality of primary heat exchange fins which are configured to promote heat exchange between the high-pressure refrigerant and the second heat medium;

the internal heat exchanger unit has a plurality of secondary heat exchange fins which are configured to promote heat exchange between the high-pressure liquid refrigerant and the low-pressure refrigerant; and

each of the plurality of secondary heat exchange fins has a shape that is different from a shape of each of the plurality of primary heat exchange fins to reduce a refrigerant pressure loss at the internal heat exchanger unit.

14. The composite heat exchanger according to claim 1, wherein the liquid storage unit is arranged such that a center position of the liquid storage unit does not overlap a center plane of the integral structure extending in a direction along which the condenser unit, the sub-cooler unit and the internal heat exchanger unit are arranged in a row.

15. A composite heat exchanger configured to be used in a vapor compression refrigeration cycle that includes: a compressor; a decompressor configured to decompress a high-pressure refrigerant discharged from the compressor; and an evaporator configured to evaporate a low-pressure refrigerant decompressed at the decompressor by exchanging heat between the low-pressure refrigerant and a first heat medium, the composite heat exchanger comprising:

a condenser unit configured to condense the high-pressure refrigerant by exchanging heat between the high-pressure refrigerant and a second heat medium;

a liquid storage unit configured to temporarily store a high-pressure liquid refrigerant contained in the high-pressure refrigerant passed through the condenser unit;

a sub-cooler unit configured to sub-cool the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit by exchanging heat between the high-pressure liquid refrigerant and the second heat medium; and

an internal heat exchanger unit configured to exchange heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and the low-pressure refrigerant discharged from the evaporator, wherein:

the condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together by a predetermined binding element and thereby form an integral structure;

the internal heat exchanger unit is coupled to one heat exchanger unit among the condenser unit and the

sub-cooler unit through at least one coupler component in a state where the internal heat exchanger unit is spaced from the one heat exchanger unit;

in the integral structure, the condenser unit is placed between the sub-cooler unit and the internal heat exchanger unit; and

the internal heat exchanger unit is coupled to the condenser unit in a state where the internal heat exchanger unit is spaced from the condenser unit.

16. The composite heat exchanger according to claim 15, wherein the liquid storage unit is placed adjacent to a portion of the integral structure which forms the sub-cooler unit.

17. The composite heat exchanger according to claim 15, wherein the liquid storage unit is directly joined to a portion of the integral structure which forms the sub-cooler unit.

18. The composite heat exchanger according to claim 15, wherein one of a vertical dimension and a horizontal dimension of the internal heat exchanger unit measured at a front surface of the internal heat exchanger unit is smaller than both of:

a larger one of a vertical dimension and a horizontal dimension of the condenser unit measured at a front surface of the condenser unit; and

a larger one of a vertical dimension and a horizontal dimension of the sub-cooler unit measured at a front surface of the sub-cooler unit.

19. The composite heat exchanger according to claim 15, wherein a larger one of a vertical dimension and a horizontal dimension of the internal heat exchanger unit measured at a front surface of the internal heat exchanger unit is smaller than both of:

a larger one of a vertical dimension and a horizontal dimension of the condenser unit measured at a front surface of the condenser unit; and

a larger one of a vertical dimension and a horizontal dimension of the sub-cooler unit measured at a front surface of the sub-cooler unit.

20. The composite heat exchanger according to claim 15, wherein at least one heat exchanger unit among the condenser unit, the sub-cooler unit and the internal heat exchanger unit is configured such that one of a vertical dimension and a horizontal dimension of the at least one heat exchanger unit measured at a front surface of the at least one heat exchanger unit is smaller than a largest dimension among a vertical dimension and a horizontal dimension of remaining one or more heat exchanger units measured at a front surface of the remaining one or more heat exchanger units among the condenser unit, the sub-cooler unit and the internal heat exchanger unit.

21. The composite heat exchanger according to claim 15, wherein the internal heat exchanger unit is coupled to the evaporator through at least one coupling connector.

22. A composite heat exchanger configured to be used in a vapor compression refrigeration cycle that includes: a compressor; a decompressor configured to decompress a high-pressure refrigerant discharged from the compressor; and an evaporator configured to evaporate a low-pressure refrigerant decompressed at the decompressor by exchanging heat between the low-pressure refrigerant and a first heat medium, the composite heat exchanger comprising:

a condenser unit configured to condense the high-pressure refrigerant by exchanging heat between the high-pressure refrigerant and a second heat medium;

a liquid storage unit configured to temporarily store a high-pressure liquid refrigerant contained in the high-pressure refrigerant passed through the condenser unit;

a sub-cooler unit configured to sub-cool the high-pressure liquid refrigerant stored in and outputted from the liquid storage unit by exchanging heat between the high-pressure liquid refrigerant and the second heat medium; and

an internal heat exchanger unit configured to exchange heat between the high-pressure liquid refrigerant passed through the sub-cooler unit and the low-pressure refrigerant discharged from the evaporator, wherein:

the condenser unit, the sub-cooler unit and the internal heat exchanger unit are joined together by a predetermined binding element and thereby form an integral structure;

the internal heat exchanger unit and at least one of the condenser unit and the sub-cooler unit are formed by a plurality of plate members which are stacked and joined together;

the plurality of plate members include a plurality of multi-hole members each of which has:

at least two high-temperature side passage holes which are configured to conduct the high-pressure refrigerant that includes the high-pressure liquid refrigerant; and

at least one low-temperature side passage hole which is configured to conduct the second heat medium or the low-pressure refrigerant.

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