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(54) **HEAT EXCHANGER, AND REFRIGERATION CYCLE DEVICE**

(57) Providing a heat exchanger in which a liquid refrigerant tends to be distributed to a plurality of first spaces without unevenness, and a refrigeration cycle apparatus including the same. A first heat exchanger (11) includes a plurality of flat tubes and a first header (40). The first header has a first member (100a), a second member (100b), and a third sub-member (130). The first member forms a plurality of first spaces (S1) into which the flat tubes are inserted. The second member forms a second space (S2) into which the refrigerant flows. The third sub-member is provided between the first space and the second space. The third sub-member is provided with a flow division opening (132). The flow division opening allows the first space and the second space to communicate with each other. The refrigerant flows from the second space into the first space through the flow division opening. When viewed along an insertion direction (D1) of the flat tube with respect to the first space, the flow division opening is at least partially close to one end portion (144) of the second space in a width direction (D2) of the flat tube.

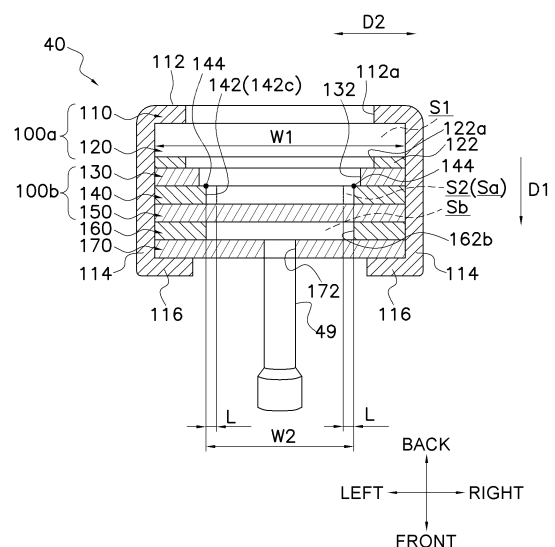


FIG. 7

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Conventionally, as in PTL 1 (Japanese Unexamined Patent Application Publication No. 2021-12018), there is a known heat exchanger that uses flat tubes as heat transfer tubes and, in a header that includes a plurality of spaces (referred to as first spaces) into which the flat tubes are inserted, a space (referred to as a second space) into which a refrigerant guided to the first spaces flows, and a first plate provided between the first space and the second space, has a structure in which an opening is formed in the first plate to allow the first space and the second space to communicate with each other and distribute the refrigerant from the second space to the first space.

[0003] In PTL 1 (Japanese Unexamined Patent Application Publication No. 2021-12018), when viewed along an insertion direction of the flat tube with respect to the first space, an opening is provided at a central portion of the second space in which the refrigerant is present in the width direction of the flat tube, and thus the refrigerant is divided from the second space to the first space.

SUMMARY

<Technical Problem>

[0004] However, the discloser of this application has found that, in a case where the dryness of the refrigerant flowing into the second space increases when the heat exchanger having the structure in PTL 1 (Japanese Unexamined Patent Application Publication No. 2021-12018) is used, a difference may occur in the amounts of liquid refrigerant and gas refrigerant flowing through each flat tube, and the efficiency may decrease. From such a viewpoint, the discloser of this application has found that there is room for further improvement in the efficiency of the heat exchanger.

<Solution to Problem>

[0005] A heat exchanger according to a first aspect includes a plurality of flat tubes and a header. The header includes a first member, a second member, and a first plate. The first member forms a plurality of first spaces into which the flat tubes are inserted. The second member forms a second space into which a refrigerant flows. The first plate is provided between the first space and the second space. The first plate is provided with an opening. The opening allows the first space and the second space to communicate with each other. The refrigerant flows

from the second space into the first space through the opening. When viewed along the insertion direction of the flat tube with respect to the first space, the opening is arranged, at least partially, close to one end portion of the second space in a width direction of the flat tube.

[0006] In the heat exchanger according to the first aspect, since the opening formed in the first plate is arranged close to the end portion of the second space, the liquid refrigerant, which is likely to flow in the vicinity of the end portion of the second space in the width direction of the flat tube, may be easily distributed to the plurality of first spaces without unevenness.

[0007] A heat exchanger according to a second aspect is the heat exchanger according to the first aspect, wherein when viewed along the insertion direction of the flat tube with respect to the first space, the opening is arranged, at least partially, close to both end portions of the second space in the width direction of the flat tube.

[0008] In the heat exchanger according to the second aspect, the opening formed in the first plate is arranged close to both the end portions of the second space, and thus the liquid refrigerant, which is likely to flow in the vicinity of the end portions of the second space in the width direction of the flat tube, may be easily distributed to the plurality of first spaces without unevenness.

[0009] A heat exchanger according to a third aspect is the heat exchanger according to the first aspect or the second aspect, wherein a width of the second space is a first width. In the width direction, the opening is arranged, at least partially, between an end portion of the second space and a position by 15% of the first width inside the second space from the end portion.

[0010] In the heat exchanger according to the third aspect, the liquid refrigerant, which is likely to flow in the vicinity of the end portion of the second space in the width direction of the flat tube, may be easily distributed to the plurality of first spaces without unevenness.

[0011] A heat exchanger according to a fourth aspect is the heat exchanger according to any one of the first aspect to the third aspect, wherein, when viewed along the insertion direction of the flat tube with respect to the first space, the opening partially overlaps with one end portion of the second space in the width direction of the flat tube.

[0012] In the heat exchanger according to the fourth aspect, the opening formed in the first plate is arranged to overlap with the end portion of the second space, and thus the liquid refrigerant, which is likely to flow in the vicinity of the end portion of the second space in the width direction of the flat tube, may be easily distributed to the plurality of first spaces without unevenness.

[0013] A heat exchanger according to a fifth aspect is the heat exchanger according to the fourth aspect, wherein when viewed along the insertion direction, the opening partially overlaps with both the end portions of the second space in the width direction.

[0014] In the heat exchanger according to the fifth aspect, the opening formed in the first plate is arranged

to overlap with both the end portions of the second space, and thus the liquid refrigerant, which is likely to flow in the vicinity of the end portions of the second space in the width direction of the flat tube, may be easily distributed to the plurality of first spaces without unevenness.

[0015] A heat exchanger according to a sixth aspect is the heat exchanger according to the fifth aspect, wherein when viewed along the insertion direction, the opening overlaps with the entire second space in the width direction.

[0016] In the heat exchanger according to the sixth aspect, the liquid refrigerant flowing through the end portion of the second space in the width direction of the flat tube may be easily distributed to the plurality of first spaces without unevenness.

[0017] A heat exchanger according to a seventh aspect is the heat exchanger according to any one of the first aspect to the sixth aspect, wherein when viewed along the insertion direction, the second member forms a main space and a sub-space. The main space includes a refrigerant inlet and a refrigerant outlet. The refrigerant moves from the refrigerant inlet to the refrigerant outlet in the main space. The sub-space guides the refrigerant having reached the refrigerant outlet of the main space to a vicinity of the refrigerant inlet of the main space. The opening communicates with the main space as the second space.

[0018] In the heat exchanger according to the seventh aspect, since the loop structure having the main space and the sub-space is employed for dividing the flow of the refrigerant, the refrigerant may be easily distributed to the plurality of first spaces without unevenness especially.

[0019] A heat exchanger according to an eighth aspect is the heat exchanger according to any one of the first aspect to the seventh aspect, wherein in the width direction, the width of the first space is larger than the width of the second space.

[0020] In the heat exchanger according to the eighth aspect, since the width of the first space is larger than the width of the second space, the liquid refrigerant flowing through the end portion of the second space may be easily divided to the first spaces via the opening of the first plate without unevenness.

[0021] A heat exchanger according to a ninth aspect is the heat exchanger according to any one of the first aspect to the eighth aspect, wherein the width of the opening in the thickness direction of the flat tube is equal to or more than 1 mm.

[0022] In the heat exchanger according to the ninth aspect, as the width of the opening in the thickness direction of the flat tube is equal to or more than 1 mm, it is possible to suppress the occurrence of an issue in which it is difficult for the liquid refrigerant to flow through the opening.

[0023] A heat exchanger according to a tenth aspect is the heat exchanger according to any one of the first aspect to the ninth aspect, wherein one of the flat tube is inserted into each of the first spaces. One or more of the

openings are provided for each of the first spaces.

[0024] In the heat exchanger according to the tenth aspect, one of the flat tube is inserted corresponding to each of the first spaces, and the refrigerant from the second space is guided to each of the first spaces via the opening, and therefore, unevenness in the amount of refrigerant flowing into each of the flat tubes may be easily suppressed, as compared with a case where the plurality of flat tubes is inserted into each of the first spaces and the refrigerant having flowed into each of the first spaces is distributed to the plurality of flat tubes.

[0025] A heat exchanger according to an eleventh aspect is the heat exchanger according to any one of the first aspect to the tenth aspect, wherein the plurality of flat tubes includes at least a first flat tube and a plurality of second flat tubes. In the heat exchanger, the refrigerant having flowed through the first flat tube passes through a first portion of the header, into which the plurality of second flat tubes is inserted, and flows into the plurality of second flat tubes. At least in the first portion of the header, when viewed along the insertion direction, the opening is arranged, at least partially, close to one end portion of the second space in the width direction.

[0026] In a case where the refrigerant with a high liquid content exchanges heat while flowing through the first flat tube, the dryness of the refrigerant becomes high when the refrigerant turns back at the header and flows into the plurality of second flat tubes. In such a case, in the heat exchanger of the related art, a difference may occur in the amounts of the liquid refrigerant and the gas refrigerant flowing through each of the second flat tubes, and the efficiency of heat exchange may decrease.

[0027] In contrast, in this heat exchanger, as the liquid refrigerant may be easily distributed to the plurality of first spaces in the first portion of the header without unevenness, the amounts of the liquid refrigerant and the gas refrigerant flowing through the respective second flat tubes may be easily equalized.

[0028] A refrigeration cycle apparatus according to a twelfth aspect includes: the heat exchanger according to any one of the first aspect to the eleventh aspect configured to function as an evaporator; a compressor configured to compresses the refrigerant; a radiator configured to cool the refrigerant discharged from the compressor; and an expansion device configured to expands the refrigerant flowing out of the radiator to the heat exchanger.

[0029] In the refrigeration cycle apparatus according to the twelfth aspect, unevenness in the amount of refrigerant flowing into each of the flat tubes of the heat exchanger may be easily suppressed, and a highly-efficient refrigeration cycle apparatus may be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Fig. 1 is a schematic configuration diagram of an air

conditioning apparatus according to an example of a refrigeration cycle apparatus.

Fig. 2 is a schematic perspective view of a first heat exchanger of the air conditioning apparatus of Fig. 1 according to an embodiment of the heat exchanger.

Fig. 3 is a partially enlarged view of a heat exchange unit of the first heat exchanger in Fig. 2.

Fig. 4 is a schematic view illustrating a state in which fins are attached to flat tubes in the heat exchange unit of the first heat exchanger in Fig. 3.

Fig. 5 is a schematic configuration diagram of the first heat exchanger in Fig. 2.

Fig. 6 is an exploded perspective view of a first header according to an embodiment of the first heat exchanger in Fig. 2.

Fig. 7 is a cross-sectional view of a first sub-member to a seventh sub-member of the first header taken along an insertion direction of the flat tubes to the first header.

Fig. 8 is a diagram schematically illustrating the flow of the refrigerant in a first portion of the first header illustrated in Fig. 6 in a case where the first heat exchanger in Fig. 2 functions as an evaporator of the refrigerant.

Fig. 9 is a diagram illustrating the flow of the refrigerant in a case where an opening is provided at a central portion of the second space in the width direction of the flat tube as in a conventional heat exchanger when the opening of the first plate is viewed along the insertion direction of the flat tube with respect to the first space.

Fig. 10 is a schematic view of the inside of the first header of Fig. 6 as viewed in the longitudinal direction of the first header, illustrating a first example of the arrangement state of the first space, the second space, and the flow division opening of the first plate.

Fig. 11 is a schematic view of the inside of the first header of Fig. 6 as viewed in the longitudinal direction of the first header, illustrating a second example of the arrangement state of the first space, the second space, and the flow division opening of the first plate.

Fig. 12 is a schematic view of the inside of the first header of Fig. 6 as viewed in the longitudinal direction of the first header, illustrating a third example of the arrangement state of the first space, the second space and the flow division opening of the first plate.

Fig. 13 is a schematic view of the inside of the first header of Fig. 6 as viewed in the longitudinal direction of the first header, illustrating a fourth example of the arrangement state of the first space, the second space, and the flow division opening of the first plate.

Fig. 14 is a schematic perspective view of the first heat exchanger according to a modification A.

Fig. 15 is a diagram illustrating the flow of the refrigerant when the first heat exchanger of Fig. 14 functions as an evaporator.

Fig. 16 is a schematic perspective view of the first

heat exchanger according to another example of the modification A.

Fig. 17 is a diagram illustrating the flow of the refrigerant when the first heat exchanger of Fig. 16 functions as an evaporator.

Fig. 18 is an exploded perspective view of the first header according to a modification D of the first heat exchanger in Fig. 2.

Fig. 19 is a cross-sectional view of the first sub-member to the sixth sub-member of the first header of Fig. 18 taken along the insertion direction of the flat tubes with respect to the first header.

Fig. 20 is a schematic view of the inside of the first header of Fig. 18 as viewed in the longitudinal direction of the first header, illustrating a first example of the arrangement state of the first space, the second space and the flow division opening of the first plate.

Fig. 21 is a schematic view of the inside of the first header of Fig. 18 as viewed in the longitudinal direction of the first header, illustrating a second example of the arrangement state of the first space, the second space, and the flow division opening of the first plate.

Fig. 22 is a schematic view of the inside of the first header of Fig. 18 as viewed in the longitudinal direction of the first header, illustrating a third example of the arrangement state of the first space, the second space, and the flow division opening of the first plate.

DESCRIPTION OF EMBODIMENTS

[0031] Hereinafter, embodiments of a heat exchanger according to the present disclosure and a refrigeration cycle apparatus according to the present disclosure using the heat exchanger will be described.

(1) Refrigeration Cycle Apparatus

[0032] An air conditioning apparatus 1 according to an embodiment of a refrigeration cycle apparatus according to the present disclosure will be described with reference to the drawings.

[0033] The air conditioning apparatus 1 is an apparatus capable of cooling and heating a space to be air-conditioned by performing a vapor compression refrigeration cycle. The type of the refrigeration cycle apparatus according to the present disclosure is not limited to the air conditioning apparatus and may be, for example, a hot water supply apparatus, a floor heater, or the like.

[0034] As illustrated in Fig. 1, the air conditioning apparatus 1 mainly includes a heat source unit 2, utilization units 3a, 3b, a liquid-refrigerant connection pipe 4, a gas-refrigerant connection pipe 5, and a control unit 50. The control unit 50 controls operations of constituent devices of the heat source unit 2 and the utilization units 3a, 3b.

[0035] The liquid-refrigerant connection pipe 4 and the gas-refrigerant connection pipe 5 connect the heat source unit 2 and the utilization units 3a, 3b. In the air

conditioning apparatus 1, the heat source unit 2 and the utilization units 3a, 3b are connected via the refrigerant connection pipes 4, 5, thereby configuring a refrigerant circuit 6 (see Fig. 1). In the refrigerant circuit 6, a compressor 8, a flow direction switching mechanism 10, a first heat exchanger 11, a first expansion mechanism 12, a first closing valve 13, a second closing valve 14, second expansion mechanisms 31a, 31b, and second heat exchangers 32a, 32a, which will be described below, are connected by refrigerant pipes as illustrated in Fig. 1. The first heat exchanger 11 is an example of a heat exchanger according to the present disclosure.

[0036] In Fig. 1, the air conditioning apparatus 1 includes the one heat source unit 2 and the two utilization units 3a, 3b, but the number of units is merely an example. The air conditioning apparatus 1 may include a plurality of heat source units or may include one utilization unit or three or more utilization units. Further, the air conditioning apparatus 1 may be an integrated air conditioning apparatus in which a heat source unit and a utilization unit are integrally formed.

[0037] In the refrigerant circuit 6, a refrigerant having a small global warming potential such as R290 or CO₂ is enclosed. However, the type of refrigerant is not limited to R290, CO₂, or the like, and may be R32, R410A, R1234yf, R1234ze(E), or the like.

(2) Detailed Configuration of Air Conditioning Apparatus

[0038] The heat source unit 2, the utilization units 3a, 3b, the liquid-refrigerant connection pipe 4, the gas-refrigerant connection pipe 5, and the control unit 50 of the air conditioning apparatus 1 will be described below.

(2-1) Heat Source Unit

[0039] The heat source unit 2 is, but is not limited thereto, is installed outdoors, for example, on the roof of the building or around the outer wall of the building where the air conditioning apparatus 1 is installed.

[0040] The heat source unit 2 according to the present embodiment is a top-blowing type unit that takes in air from the side of a housing (not illustrated) that houses various devices of the heat source unit 2, and blows out the air that has exchanged heat with the refrigerant from above the housing. However, the type of the heat source unit 2 is not limited to the top-blowing type, and may be a side-blowing type in which the air having exchanged heat with the refrigerant is blown out from the side of the housing.

[0041] The heat source unit 2 mainly includes an accumulator 7, the compressor 8, the flow direction switching mechanism 10, the first heat exchanger 11, the first expansion mechanism 12, the first closing valve 13, the second closing valve 14, and a first fan 15 (see Fig. 1).

[0042] The heat source unit 2 includes a suction pipe 17, a discharge pipe 18, a first gas refrigerant pipe 19, a liquid refrigerant pipe 20, and a second gas refrigerant

pipe 21 (see Fig. 1). The suction pipe 17 connects the flow direction switching mechanism 10 and the suction side of the compressor 8. The suction pipe 17 is provided with the accumulator 7. The discharge pipe 18 connects the discharge side of the compressor 8 and the flow direction switching mechanism 10. The first gas refrigerant pipe 19 connects the flow direction switching mechanism 10 and the gas end of the first heat exchanger 11. The liquid refrigerant pipe 20 connects the liquid end of the first heat exchanger 11 and the first closing valve 13. The first expansion mechanism 12 is provided in the liquid refrigerant pipe 20. The second gas refrigerant pipe 21 connects the flow direction switching mechanism 10 and the second closing valve 14.

(2-1-1) Compressor

[0043] The compressor 8 is a device that suctions the low-pressure refrigerant in the refrigeration cycle that flows in from the suction pipe 17, compresses the refrigerant to raise the pressure to a high pressure in the refrigeration cycle, and discharges the refrigerant to the discharge pipe 18. The compressor 8 is, for example, a positive displacement compressor, but may be another type (a centrifugal compressor).

(2-1-2) Flow Direction Switching Mechanism

[0044] The flow direction switching mechanism 10 is a mechanism that switches the flow direction of the refrigerant in the refrigerant circuit 6. According to the present embodiment, the flow direction switching mechanism 10 is a four-way switching valve.

[0045] During the cooling operation and the defrosting operation, the flow direction switching mechanism 10 communicates the suction pipe 17 with the second gas refrigerant pipe 21 and communicates the discharge pipe 18 with the first gas refrigerant pipe 19 (such a connection state of the pipes by the flow direction switching mechanism 10 is referred to as a first state), thereby switching the flow direction of the refrigerant in the refrigerant circuit 6 (see the solid lines in Fig. 1) so that the refrigerant discharged by the compressor 8 is sent to the first heat exchanger 11.

[0046] During the heating operation, the flow direction switching mechanism 10 communicates the suction pipe 17 with the first gas refrigerant pipe 19 and communicates the discharge pipe 18 with the second gas refrigerant pipe 21 (such a connection state of the pipes by the flow direction switching mechanism 10 is referred to as a second state), thereby switching the flow direction of the refrigerant in the refrigerant circuit 6 (see the broken line in Fig. 1) so that the refrigerant discharged by the compressor 8 is sent to the second heat exchangers 32a, 32b.

[0047] The flow direction switching mechanism 10 is not limited to a four-way switching valve and may be configured so as to be able to switch the flow direction of the refrigerant as described above by combining a

plurality of electromagnetic valves and refrigerant pipes.

(2-1-3) First Heat Exchanger

[0048] The first heat exchanger 11 functions as a radiator (condenser) during the cooling operation or defrosting operation and functions as an evaporator (heat absorber) during the heating operation. The first heat exchanger 11 is an example of a heat exchanger in the claims.

[0049] The structure of the first heat exchanger 11 and the flow of the refrigerant in the first heat exchanger 11 will be described below.

(2-1-4) First Expansion Mechanism

[0050] The first expansion mechanism 12 is a mechanism that expands the refrigerant flowing between the first heat exchanger 11 and the second heat exchangers 32a, 32b of the utilization units 3a, 3b in the refrigerant circuit 6. The first expansion mechanism 12 is, for example, an electronic expansion valve whose opening degree is adjustable. The opening degree of the first expansion mechanism 12 is adjusted by the control unit 50 in accordance with the operating condition.

(2-1-5) First Fan

[0051] The first fan 15 generates an airflow and supplies air to the first heat exchanger 11. The first fan 15 generates a flow of air that flows into the heat source unit 2 from the outside of the housing, passes through the first heat exchanger 11, and flows out of the housing. The first fan 15 is, for example, a propeller fan. However, the type of the first fan 15 is not limited to a propeller fan, and may be another type of fan.

(2-2) Utilization Unit

[0052] The utilization units 3a, 3b are installed in the space to be air-conditioned or in the vicinity of the space to be air-conditioned (for example, in the attic space of the space to be air-conditioned).

[0053] The utilization unit 3a mainly includes a second expansion mechanism 31a, a second heat exchanger 32a, and a second fan 33a (see Fig. 1). The utilization unit 3b mainly includes a second expansion mechanism 31b, a second heat exchanger 32b, and a second fan 33b (see Fig. 1).

(2-2-1) Second Expansion Mechanism

[0054] The second expansion mechanisms 31a, 31b are mechanisms that expand the refrigerant flowing between the first heat exchanger 11 and the second heat exchangers 32a, 32b of the utilization units 3a, 3b in the refrigerant circuit 6. The second expansion mechanisms 31a, 31b are, for example, an electronic expansion valve

whose opening degree is adjustable. The opening degree of the second expansion mechanisms 31a, 31b is adjusted by the control unit 50 in accordance with the operating condition.

(2-2-2) Second Heat Exchanger

[0055] The second heat exchangers 32a, 32b function as a heat absorber (evaporator) to cool the indoor air during the cooling operation and function as a radiator (condenser) of the refrigerant to heat the indoor air during the heating operation.

[0056] The liquid side of the second heat exchangers 32a, 32b is connected to the liquid-refrigerant connection pipe 4 via a refrigerant pipe, and the gas side of the second heat exchangers 32a, 32b is connected to the gas-refrigerant connection pipe 5 via a refrigerant pipe. The second heat exchangers 32a, 32b are, for example, cross-fin type fin-and-tube heat exchangers including a plurality of heat transfer tubes (not illustrated) and a plurality of fins (not illustrated).

[0057] Here, the second heat exchangers 32a, 32b exchange heat between the refrigerant and air, but the second heat exchanger of the utilization unit may be a heat exchanger that exchanges heat between the refrigerant and water.

(2-2-3) Second Fan

[0058] The second fans 33a, 33b generate a flow of air that flows into the utilization units 3a, 3b from the outside (air-conditioning target space) of a housing (not illustrated) that houses various devices of the utilization units 3a, 3b therein, passes through the second heat exchangers 32a, 32b, and flows out of the housing (air-conditioning target space). The second fans 33a, 33b are, for example, centrifugal fans.

(2-3) Refrigerant Connection Pipe

[0059] The refrigerant connection pipes 4, 5 are refrigerant pipes constructed on site when the air conditioning apparatus 1 is installed. One end of the liquid-refrigerant connection pipe 4 is connected to the first closing valve 13 of the heat source unit 2, and the other end of the liquid-refrigerant connection pipe 4 is connected to the refrigerant pipe connected to the liquid side of the second heat exchangers 32a, 32b of the utilization units 3a, 3b (see Fig. 1). One end of the gas-refrigerant connection pipe 5 is connected to the second closing valve 14 of the heat source unit 2, and the other end of the gas-refrigerant connection pipe 5 is connected to the refrigerant pipe connected to the gas side of the second heat exchangers 32a, 32b of the utilization units 3a, 3b (see Fig. 1).

(2-4) Control Unit

[0060] The control unit 50 is configured by communicably connecting control boards (not illustrated) including a CPU, a ROM, a RAM, and the like, which are provided in the heat source unit 2 and the utilization units 3a, 3b. In Fig. 1, for the sake of simplicity, the control unit 50 is illustrated at a position away from the heat source unit 2 and the utilization units 3a, 3b.

[0061] As indicated by a broken line in Fig. 1, the control unit 50 is electrically connected to constituent devices of the air conditioning apparatus 1. To be specific, the control unit 50 is electrically connected to, for example, the compressor 8, the flow direction switching mechanism 10, the first expansion mechanism 12, the first fan 15, the second expansion mechanisms 31a, 31b and the second fans 33a, 33b. The control unit 50 is also electrically connected to various sensors (not illustrated) provided in the heat source unit 2 and the utilization units 3a, 3b.

[0062] The control unit 50 executes a program for controlling the air conditioning apparatus 1 (the CPU executes a program stored in the ROM) to control constituent devices of the air conditioning apparatus 1 based on an operation from a remote controller (not illustrated), measurement values of various sensors (not illustrated), and the like.

[0063] The control unit 50 controls the constituent devices of the air conditioning apparatus 1 to cause the air conditioning apparatus 1 to execute a cooling operation or a heating operation. Further, when a predetermined condition is satisfied during the heating operation of the air conditioning apparatus 1, the control unit 50 switches the operation of the air conditioning apparatus 1 to the defrosting operation. The operation of the air conditioning apparatus 1 during each operation will be described below.

(3) Operation of Air Conditioning Apparatus

[0064] The cooling operation, the heating operation, and the defrosting operation of the air conditioning apparatus 1 will be described. The defrosting operation is an operation for melting frost or ice stuck to the first heat exchanger 11, which is performed by temporarily interrupting the heating operation during the heating operation.

[0065] During the cooling operation and the defrosting operation, the refrigerant circulates in the refrigerant circuit 6 through the compressor 8, the first heat exchanger 11, the first expansion mechanism 12, the second expansion mechanisms 31a, 31b, the second heat exchangers 32a, 32b, and the accumulator 7 in this order.

[0066] During the heating operation, the refrigerant circulates in the refrigerant circuit 6 through the compressor 8, the second heat exchangers 32a, 32b, the second expansion mechanisms 31a, 31b, the first expansion mechanism 12, the first heat exchanger 11, and the

accumulator 7 in this order.

[0067] An operation of the air conditioning apparatus 1 during the cooling operation will be described.

[0068] During the cooling operation, the connection state of the pipes by the flow direction switching mechanism 10 is switched to the first state described above. The gas refrigerant at a low pressure (hereinafter simply referred to as a low pressure) in the refrigeration cycle is suctioned into the compressor 8 from the suction pipe 17. The gas refrigerant is compressed by the compressor 8 to a high pressure (hereinafter simply referred to as a high pressure) in the refrigeration cycle, and is then discharged to the discharge pipe 18. The high-pressure gas refrigerant discharged to the discharge pipe 18 is sent to the first heat exchanger 11 through the flow direction switching mechanism 10. The high-pressure gas refrigerant sent to the first heat exchanger 11 radiates heat by exchanging heat with the air supplied by the first fan 15 in the first heat exchanger 11 functioning as a radiator of the refrigerant, and becomes a high-pressure liquid refrigerant. The high-pressure liquid refrigerant having radiated heat in the first heat exchanger 11 is sent to the second expansion mechanisms 31a, 31b through the first expansion mechanism 12, the first closing valve 13, and the liquid-refrigerant connection pipe 4. The refrigerant sent to the second expansion mechanisms 31a, 31b is decompressed to a low pressure by the second expansion mechanisms 31a, 31b, and becomes a low-pressure refrigerant in a gas-liquid two-phase state. The low-pressure refrigerant in a gas-liquid two-phase state decompressed by the second expansion mechanisms 31a, 31b is sent to the second heat exchangers 32a, 32b. The low-pressure refrigerant in a gas-liquid two-phase state sent to the second heat exchangers 32a, 32b exchanges heat with the air supplied by the second fans 33a, 33b and evaporated in the second heat exchanger 32a, 32b. The air cooled in the second heat exchangers 32a, 32b is blown out to the space to be air-conditioned. The low-pressure gas refrigerant evaporated in the second heat exchangers 32a, 32b passes through the gas-refrigerant connection pipe 5, the second closing valve 14, the flow direction switching mechanism 10, and the accumulator 7, and is again suctioned into the compressor 8.

[0069] During the cooling operation, the control unit 50 performs, for example, the following control. The mode of control by the control unit 50 described here is an example, and the control is not limited thereto.

[0070] The control unit 50 controls the opening degree of the electronic expansion valve as an example of each of the second expansion mechanisms 31a, 31b so that the degree of superheating of the refrigerant at the outlet of each of the second heat exchangers 32a, 32b becomes a target degree of superheating based on a measurement value of a sensor (not illustrated). Further, the control unit 50 controls the operating capacity of the compressor 8 so that the evaporation temperature approaches the target evaporation temperature.

[0071] The operation of the air conditioning apparatus

1 during the heating operation will be described.

[0072] During the heating operation, the connection state of the pipes by the flow direction switching mechanism 10 is switched to the above-described second state. The low-pressure gas refrigerant suctioned into the compressor 8 from the suction pipe 17 is compressed to a high pressure by the compressor 8, and then discharged to the discharge pipe 18. The high-pressure gas refrigerant discharged to the discharge pipe 18 is sent to the second heat exchangers 32a, 32b through the flow direction switching mechanism 10, the second closing valve 14, and the gas-refrigerant connection pipe 5. The high-pressure gas refrigerant sent to the second heat exchangers 32a, 32b exchanges heat with the air supplied by the second fans 33a, 33b in the second heat exchanger 32a, 32b to radiate heat, and becomes a high-pressure liquid refrigerant or a refrigerant in a gas-liquid two-phase state. The air heated by heat-exchanging with the refrigerant in the second heat exchangers 32a, 32b is blown out to the space to be air-conditioned. The high-pressure refrigerant that has radiated heat in the second heat exchangers 32a, 32b is sent to the first expansion mechanism 12 through the second expansion mechanisms 31a, 31b, the liquid-refrigerant connection pipe 4, and the first closing valve 13. The refrigerant sent to the first expansion mechanism 12 is decompressed by the first expansion mechanism 12 and becomes a low-pressure refrigerant in a gas-liquid two-phase state. The low-pressure refrigerant in a gas-liquid two-phase state decompressed by the first expansion mechanism 12 is sent to the first heat exchanger 11. The low-pressure refrigerant in a gas-liquid two-phase state sent to the first heat exchanger 11 is evaporated by heat exchange with the air supplied by the first fan 15 in the first heat exchanger 11 functioning as an evaporator of the refrigerant, and becomes a low-pressure gas refrigerant. The low-pressure refrigerant evaporated in the first heat exchanger 11 passes through the flow direction switching mechanism 10 and the accumulator 7 and is suctioned into the compressor 8 again.

[0073] During the heating operation, the control unit 50 performs, for example, the following control. The mode of control by the control unit 50 described here is an example, and the control is not limited thereto.

[0074] The control unit 50 controls the opening degree of the electronic expansion valve as an example of the first expansion mechanism 12 so that the degree of superheating of the refrigerant at the outlet of the first heat exchanger 11 becomes a target degree of superheating based on a measurement value of a sensor (not illustrated). Further, the control unit 50 controls the operating capacity of the compressor 8 so that the evaporation temperature approaches the target evaporation temperature. Further, the control unit 50 controls the opening degree and the like of an electronic expansion valve as an example of the first expansion mechanism 12 so that the dryness of the refrigerant at the inlet of the first heat exchanger 11 becomes a predetermined value.

[0075] When the start condition of the defrosting operation is satisfied during the heating operation, the

control unit 50 temporarily switches the operation of the air conditioning apparatus 1 from the heating operation to the defrosting operation to defrost the first heat exchanger 11, and causes the first heat exchanger 11 to function as a radiator. Further, when a termination condition of the defrosting operation is satisfied, the control unit 50 terminates the defrosting operation and returns the operation of the air conditioning apparatus 1 to the heating operation. The description for the control contents of the control unit 50 during the defrosting operation will be omitted.

(4) First Heat Exchanger

[0076] A configuration of the first heat exchanger 11 according to an embodiment of the heat exchanger according to the present disclosure will be described with reference to the drawings.

[0077] Fig. 2 is a schematic perspective view of the first heat exchanger 11. Fig. 3 is a partially enlarged view of a heat exchange unit 27, which will be described below, of the first heat exchanger 11. Fig. 4 is a schematic view illustrating a state in which fins 29, which will be described below, are attached to flat tubes 28 in the heat exchange unit 27. Fig. 5 is a schematic configuration diagram of the first heat exchanger 11. Fig. 5 also illustrates how the refrigerant flows when the first heat exchanger 11 functions as an evaporator of the refrigerant. In the first heat exchanger 11 according to the present embodiment, as illustrated in Fig. 2, the flat tubes 28 are bent at two positions to form a substantially U-shape, but in Fig. 5, the flat tubes 28 are illustrated in a straight line.

[0078] Furthermore, in the following description, expressions such as "up", "down", "left", "right", "front (front surface)", and "back (back surface)" may be used to describe a direction or a position. These expressions follow the directions of the arrows drawn in Fig. 2 unless otherwise specified. These expressions representing directions and positions are used for convenience of description, and unless otherwise specified, the directions and positions of the entire first heat exchanger 11 and the components of the first heat exchanger 11 are not specified by the directions and positions of the expressions.

[0079] In the first heat exchanger 11, heat is exchanged between the refrigerant flowing inside and the air supplied by the first fan 15.

[0080] As illustrated in FIGS. 4 and 5, the first heat exchanger 11 mainly includes a flow divider 22, the plurality of flat tubes 28, the fin 29 attached to the flat tube 28, a first header 40 (an example of a header in the claims), and a second header 70. According to the present embodiment, all of the flow divider 22, the flat tube 28, the fin 29, the first header 40, and the second header 70 of the first heat exchanger 11 are made of aluminum or an aluminum alloy.

[0081] The flat tubes 28 and the fins 29 attached to the

flat tubes 28 form the heat exchange unit 27 (see FIGS. 2 and 3). The first heat exchanger 11 includes one row of the heat exchange unit 27. However, the first heat exchanger 11 may include a plurality of rows of the heat exchange units 27 (the flat tubes 28) arranged in an air flow direction. In the first heat exchanger 11, the air flows through a ventilation path formed by the flat tubes 28 and the fins 29 of the heat exchange unit 27, and thus heat is exchanged between the refrigerant flowing through the flat tube 28 and the air flowing through the ventilation path. Although not limited, the heat exchange unit 27 is partitioned into, for example, a first heat exchange unit 27a, a second heat exchange unit 27b, a third heat exchange unit 27c, a fourth heat exchange unit 27d, and a fifth heat exchange unit 27e that are arranged in the vertical direction (see Fig. 2).

(4-1) Flow Divider

[0082] The flow divider 22 is a mechanism that divides the flow of refrigerant. The flow divider 22 is also a mechanism that merges the refrigerants. A liquid refrigerant pipe 20 is connected to the flow divider 22. The flow divider 22 includes a plurality of flow division pipes 22a to 22e, divides the refrigerant flowing from the liquid refrigerant pipe 20 into the plurality of flow division pipes 22a to 22e, and guides the refrigerant to a plurality of spaces formed in the first header 40. Further, the flow divider 22 merges the refrigerant flowing in from the first header 40 via the flow division pipes 22a to 22e and guides the refrigerant to the liquid refrigerant pipe 20.

[0083] The connection between the flow divider 22 and the first header 40 will be described in detail. Connection pipes 49a to 49e communicating with an internal space 23 of the first header 40 are connected to the first header 40. As illustrated in Fig. 5, each of the connection pipes 49a to 49e is connected to a plurality of sub-spaces 23a to 23e, which will be described below, corresponding to each of the plurality of heat exchange units 27a to 27e. The flow division pipes 22a to 22e are connected to the connection pipes 49a to 49e, respectively. As a result, the internal space 23 (the sub-spaces 23a to 23e) of the first header 40 and the liquid refrigerant pipe 20 are connected via the flow division pipes 22a to 22e and the connection pipes 49a to 49e.

(4-2) Flat Tube

[0084] The first heat exchanger 11 includes the plurality of flat tubes 28. The flat tube 28 is a thin flat heat transfer tube. As illustrated in Fig. 3, each of the flat tubes 28 includes flat surfaces 28a serving as heat transfer surfaces at both ends in the thickness direction (the vertical direction in the installed state of the air conditioning apparatus 1 according to the present disclosure). As illustrated in Fig. 3, a plurality of refrigerant passages 28b through which the refrigerant flows is formed in the flat tube 28 along the direction in which the flat tube 28

extends. The flat tube 28 is, for example, a flat multi-hole tube in which a large number of the refrigerant passages 28b having small passage areas through which the refrigerant flows are formed. According to the present embodiment, the plurality of refrigerant passages 28b of each of the flat tube 28 are provided side by side in the air flow direction.

[0085] In the first heat exchanger 11, as illustrated in Fig. 5, the flat tubes 28 extending in the horizontal direction between the first header 40 side and the second header 70 side are arranged in a plurality of stages at predetermined intervals in the vertical direction. Hereinafter, the direction in which the plurality of flat tubes 28 is arranged may be referred to as a stage direction. Although the shape is not limited, according to the present embodiment, the flat tubes 28 extending between the first header 40 side and the second header 70 side are bent at two positions, and the heat exchange unit 27 configured by the flat tubes 28 is formed in a substantially U-shape in plan view (see Fig. 2). However, the flat tubes 28 may be bent at one position or three or more positions, or may include no bent portion.

(4-3) Fin

[0086] The plurality of fins 29 are members to increase the heat transfer area of the first heat exchanger 11. Each of the fins 29 is a plate-shaped member extending in the stage direction (the vertical direction according to the present embodiment).

[0087] As illustrated in Fig. 4, each of the fins 29 is formed with a plurality of notches 29a extending along the insertion direction of the flat tubes 28 so that the plurality of flat tubes 28 may be inserted. The notch 29a extends in the extending direction of the fin 29 and a direction orthogonal to the thickness direction of the fin 29. In a state in which the first heat exchanger 11 is installed in the heat source unit 2, the notches 29a formed in the respective fins 29 extend in the horizontal direction. The shape of the notch 29a of the fin 29 substantially corresponds to the outer shape of the cross-section of the flat tube 28. The notches 29a are formed in the fin 29 at intervals corresponding to the arrangement intervals of the flat tubes 28. In the first heat exchanger 11, the plurality of fins 29 is arranged side by side along the direction in which the flat tubes 28 extend. When the flat tube 28 is inserted into each of the plurality of notches 29a of the plurality of fins 29, a space between the adjacent flat tubes 28 is partitioned into a plurality of ventilation paths through which the air flows.

[0088] Each of the fins 29 includes a communication portion 29b communicating in the vertical direction on the upstream side or the downstream side in the air flow direction with respect to the flat tube 28. In the present embodiment, the communication portion 29b of the fin 29 is positioned on the windward side with respect to the flat tube 28.

(4-4) First Header and Second Header

[0089] The first header 40 and the second header 70 are hollow members having a space therein. The first header 40 and the second header 70 have functions to distribute the refrigerant flowing in from the outside of the first heat exchanger 11 to the connected flat tubes 28, merge the refrigerant flowing in from the connected flat tubes 28, and cause the refrigerant to flow out to the outside of the first heat exchanger 11.

[0090] According to the present embodiment, the first heat exchanger 11 is provided in a casing (not illustrated) of the heat source unit 2 such that the longitudinal direction of the first header 40 and the second header 70 substantially coincides with the vertical direction.

(4-4-1) Second Header

[0091] The second header 70 is a hollow member and has an internal space 25 as illustrated in Fig. 5.

[0092] A connection pipe 19a is attached to the second header 70. The connection pipe 19a is a pipe to which the first gas refrigerant pipe 19 is connected. Further, one end of each of the plurality of flat tubes 28 is connected to the second header 70. The internal space 25 of the second header 70 communicates via the connection pipe 19a with the first gas refrigerant pipe 19 connected to the connection pipe 19a. In addition, the internal space 25 of the second header 70 communicates with the refrigerant passage 28b of the connected flat tube 28.

[0093] When the first heat exchanger 11 functions as a radiator (during the cooling operation or the defrosting operation), the second header 70 distributes the refrigerant that flows through the first gas refrigerant pipe 19 and flows into the internal space 25 via the connection pipe 19a to the flat tubes 28 connected to the second header 70. When the first heat exchanger 11 functions as an evaporator (during the heating operation), the second header 70 has a function to merge the refrigerant flowing into the internal space 25 from the flat tubes 28 connected to the second header 70 and guide the merged refrigerant to the connection pipe 19a.

(4-4-2) First Header

[0094] The first header 40 is a hollow member and has the internal space 23 as illustrated in Fig. 5.

[0095] The internal space 23 of the first header 40 is partitioned into the plurality of sub-spaces 23a to 23e (see Fig. 5). The sub-spaces 23a to 23e correspond to the heat exchange units 27a to 27e, respectively. How to divide the internal space 23 may be appropriately changed in accordance with how to flow the refrigerant in the first heat exchanger 11.

[0096] The sub-spaces 23a, 23b, 23c, 23d, 23e are arranged in this order from the top in the vertical direction. The sub-spaces 23a to 23e do not communicate with each other in the internal space 23 of the first header 40.

Hereinafter, the portions of the first header 40 in which the sub-space 23a, the sub-space 23b, the sub-space 23c, the sub-space 23d, and the sub-space 23e are formed are referred to as a first portion 42a, a second portion 42b, a third portion 42c, a fourth portion 42d, and a fifth portion 42e, respectively (see Fig. 5).

[0097] The sub-spaces 23a to 23e communicate with the connection pipes 49a to 49e attached to the portions 42a to 42e, respectively. As described above, the flow division pipes 22a to 22e of the flow divider 22 are connected to the connection pipes 49a to 49e, respectively. One end of the one or more flat tubes 28 is connected to each of the sub-spaces 23a to 23e of the first header 40. The sub-spaces 23a to 23e of the first header 40 communicate with the liquid refrigerant pipe 20 via the connection pipes 49a to 49e and the flow division pipes 22a to 22e connected to the connection pipe 49a to 49e, respectively. In addition, each of the sub-spaces 23a to 23e of the first header 40 communicates with the refrigerant passage 28b of the connected flat tube 28.

[0098] When the first heat exchanger 11 functions as a radiator, the refrigerant having reached the sub-spaces 23a to 23e through the flat tubes 28 flows to the liquid refrigerant pipe 20 through the connection pipes 49a to 49e and the flow divider 22 connected to the respective sub-spaces 23a to 23e. When the first heat exchanger 11 functions as an evaporator, the refrigerant flowing into the sub-spaces 23a to 23e through the liquid refrigerant pipe 20, the flow divider 22, and the connection pipes 49a to 49e is further divided in the respective sub-spaces 23a to 23e and guided to each of the flat tubes 28.

[0099] The structure of the first header 40 will be described in detail below.

(4-5) Flow of Refrigerant in First Heat Exchanger

[0100] When the first heat exchanger 11 functions as an evaporator of the refrigerant, the refrigerant in a gas-liquid two-phase state flowing into the flow divider 22 from the liquid refrigerant pipe 20 flows into each of the sub-spaces 23a to 23e of the first header 40 via the flow division pipes 22a to 22e and the connection pipes 49a to 49e connected thereto. The refrigerant having flowed into each of the sub-spaces 23a to 23e flows through each of the flat tubes 28 connected to the sub-spaces 23a to 23e. The refrigerant flowing through each of the flat tubes 28 exchanges heat with the air, evaporates, becomes a gas-phase refrigerant, and flows into the internal space 25 of the second header 70. The refrigerant that has flowed into and merged with the internal space 25 of the second header 70 flows into the first gas refrigerant pipe 19 via the connection pipe 19a.

[0101] When the first heat exchanger 11 functions as a radiator of the refrigerant, the refrigerant flows in a direction opposite to the direction when the first heat exchanger 11 functions as an evaporator of the refrigerant. To be specific, the gas-phase refrigerant discharged from the compressor 8 and flowing through the first gas refrigerant

pipe 19 flows into the internal space 25 of the second header 70 via the connection pipe 19a. The refrigerant that has flowed into the internal space 25 of the second header 70 is divided and flows into the flat tubes 28. The refrigerant that has flowed into the flat tubes 28 dissipates heat when passing through the flat tubes 28, and flows into the sub-spaces 23a to 23e of the first header 40. The refrigerants that have flowed into the sub-spaces 23a to 23e respectively flow through the connection pipes 49a to 49e and the flow division pipes 22a to 22e, merge at the flow divider 22, and flow out to the liquid refrigerant pipe 20.

(4-6) Details of First Header

[0102] The structure of the first header 40 will be described in detail with reference to FIGS. 6 and 7.

[0103] Fig. 6 is a schematic exploded perspective view of the first header 40. Note that Fig. 6 illustrates only a part of the first header 40 (a portion forming the first portion 42a of the first header 40 and an upper portion of the second portion 42b of the first header 40). Two-dot chain line arrows in Fig. 6 indicate the refrigerant flow when the first heat exchanger 11 functions as a refrigerant evaporator (during the heating operation of the air conditioning apparatus 1).

[0104] Fig. 7 is a cross-sectional view of each of a first sub-member 110 to a seventh sub-member 170 of the first header 40, which will be described below, taken along a first direction D1 (the insertion direction of the flat tube 28 with respect to the first header 40) at a predetermined position.

[0105] The first header 40 includes the first sub-member 110 to the seventh sub-member 170. The first sub-member 110, the second sub-member 120, the third sub-member 130, the fourth sub-member 140, the fifth sub-member 150, the sixth sub-member 160, and the seventh sub-member 170 are stacked in this order along the first direction D1 in which the flat tubes 28 are inserted with respect to the first header 40. Here, as indicated by arrows in Fig. 6, in the direction in which the sub-members 110 to 170 are arranged, the side on which the first sub-member 110 is provided (the side on which the flat tube 28 is inserted) is referred to as a back side, and the side on which the seventh sub-member 170 is provided (the side on which the connection pipes 49a to 49e are inserted) is referred to as a front side.

[0106] The first header 40 is formed by brazing the first sub-member 110 to the seventh sub-member 170 to each other, and the internal space 23 (the sub-spaces 23a to 23e) is formed inside. The first header 40 formed by stacking the first sub-member 110 to the seventh sub-member 170 is configured to have a substantially quadrangular outer shape in a plan view.

[0107] The plate thickness of each of the first sub-member 110, the third sub-member 130, the fourth sub-member 140, the fifth sub-member 150, the sixth sub-member 160, and the seventh sub-member 170 is

approximately several millimeters (for example, 3 mm or less).

[0108] The first sub-member 110 and the second sub-member 120 constitute a first member 100a in the claims. The third sub-member 130, the fourth sub-member 140, and the fifth sub-member 150 constitute a second member 100b in the claims. The third sub-member 130 is an example of the first part in the claims. Here, the third sub-member 130 forms a part of the second member 100b and functions as the first part, but such a configuration is merely an example. The first part may be formed as a separate member from the second member 100b.

(4-6-1) First Sub-Member

[0109] As illustrated in Fig. 6, the first sub-member 110 is a member in which a flat tube connection opening 112a into which the flat tube 28 is inserted is formed. Fig. 7 is a cross-sectional view of the first sub-member 110 taken along the first direction D1 at a position where the flat tube connection opening 112a is formed in the stage direction. Furthermore, the first sub-member 110 is a member that forms the outer periphery of the first header 40 together with the seventh sub-member 170. The first sub-member 110 preferably has a clad layer having a brazing material formed on the surface thereof.

[0110] As illustrated in FIGS. 6 and 7, the first sub-member 110 includes a flat tube connection plate 112, a pair of outer wall portions 114, and a pair of claw portions 116. Although the manufacturing method is not limited, the first sub-member 110 according to the present embodiment is formed by bending a single sheet metal obtained by rolling. When the first sub-member 110 is manufactured by such a method, the plate thickness of each portion of the first sub-member 110 is uniform.

[0111] The flat tube connection plate 112 is a flat plate-shaped portion extending in the vertical direction. As illustrated in Fig. 6, the plurality of flat tube connection openings 112a arranged side by side in the vertical direction is formed in the flat tube connection plate 112. Each of the flat tube connection openings 112a penetrates through the flat tube connection plate 112 in the thickness direction (the first direction D1) of the flat tube connection plate 112. The flat tube 28 is joined by brazing in a state in which one end of the flat tube 28 is inserted into the flat tube connection opening 112a so as to completely pass therethrough. In the brazed and joined state, the entire inner peripheral surface of the flat tube connection opening 112a and the entire outer peripheral surface of the flat tube 28 are in contact with each other.

[0112] As illustrated in Fig. 7, each of the pair of outer wall portions 114 is a flat plate-shaped portion that extends toward the front side from left and right end portions of the flat tube connection plate 112 (from both end portions in a second direction D2 orthogonal to the first direction D1).

[0113] As illustrated in Fig. 7, each of the pair of claw

portions 116 is a portion extending in a direction approaching each other from the front end portion of each of the outer wall portions 114. In a state where the second sub-member 120 to the seventh sub-member 170 are provided on the inner side of the first sub-member 110 in a plan view, the pair of claw portions 116 are bent so as to approach each other and be pressed against the front surface of the seventh sub-member 170. As a result, the first sub-member 110 to the seventh sub-member 170 are temporarily fixed. In this state, brazing is performed in a furnace or the like, whereby the first sub-member 110 to the seventh sub-member 170 are fixed to each other by brazing.

(4-6-2) Second Sub-Member

[0114] As illustrated in Fig. 6, the second sub-member 120 includes a plate-shaped base portion 122 and a plurality of protruding portions 124 protruding from the base portion 122 toward the flat tube connection plate 112. A clad layer having a brazing material may be formed on the surface of the second sub-member 120.

[0115] The base portion 122 is a flat plate-shaped member that extends parallel to the flat tube connection plate 112 and has a plate thickness direction in the direction in which the flat tubes 28 extend. The width of the base portion 122 in the left-right direction is the same as the width of the inner surface of the flat tube connection plate 112 in the left-right direction. The base portion 122 is provided with the plurality of protruding portions 124 arranged side by side in the vertical direction. In addition, a communication hole 122a is formed between the adjacent protruding portions 124 of the base portion 122. The plurality of communication holes 122a is provided in the base portion 122 so as to be arranged side by side in the vertical direction. Each of the communication holes 122a corresponds to one of the flat tubes 28 on a one-to-one basis, and has a shape that is substantially overlapped with an end portion of the flat tube 28 when viewed from the back side.

[0116] Fig. 7 is a cross-sectional view of the second sub-member 120 taken along the first direction D1 at a position where the communication hole 122a is formed in the stage direction.

[0117] The plurality of protruding portions 124 is formed so as to extend horizontally from between the adjacent communication holes 122a of the base portion 122 toward the back side until coming into contact with the front surface of the flat tube connection plate 112. Accordingly, a first space S1 is formed by being surrounded by the front surface of the flat tube connection plate 112 of the first sub-member 110, the outer wall portion 114 of the first sub-member 110, the protruding portions 124 vertically adjacent to each other in the second sub-member 120, and a portion other than the communication hole 122a of the back surface of the base portion 122 of the second sub-member 120. Since the plurality of protruding portions 124 and the plurality of

communication holes 122a are provided in the base portion 122 along the vertical direction, the plurality of first spaces S1 is formed so as to be arranged side by side in the longitudinal direction of the first header 40. Each of the plurality of first spaces S1 is a space independent of the other first spaces S1. The corresponding single flat tube 28 is inserted into each of the first spaces S1, and an end portion of the flat tube 28 is arranged in each of the first spaces S1. The first sub-member 110 and the second sub-member 120, which form the first space S1, constitute the first member 100a.

(4-6-3) Third Sub-Member

[0118] The third sub-member 130 is an example of a first plate in the claims.

[0119] The third sub-member 130 is stacked such that the back surface thereof is in contact with the front surface of the base portion 122 of the second sub-member 120. The horizontal length of the third sub-member 130 is the same as the horizontal length of the second sub-member 120. The third sub-member 130 preferably has a clad layer having a brazing material formed on the surface thereof.

[0120] The third sub-member 130 is a plate-like member extending in the vertical direction and the left-right direction. The third sub-member 130 is provided with a plurality of flow division openings 132. The flow division opening 132 is an example of an opening of the first plate in the claims. Fig. 7 is a cross-sectional view of the third sub-member 130 taken along the first direction D1 at a position where the flow division opening 132 is formed in the stage direction.

[0121] The plurality of flow division openings 132 is arranged side by side in the vertical direction. The plurality of flow division openings 132 penetrates the third sub-member 130 in the plate thickness direction (the first direction D1). According to the present embodiment, the shape of the flow division opening 132 is a rectangular shape when viewed along the first direction D1. However, the shape of the flow division opening 132 when viewed along the first direction D1 may be a shape other than a rectangular shape, such as a circular shape. Note that, in order to ensure a sufficient amount of refrigerant flowing through the flow division opening 132, it is preferable that a width W_o (see Fig. 6) of the flow division opening in the thickness direction of the flat tube 28 be equal to or more than 1 mm. Each of the flow division openings 132 is at least partially overlapped with each of the communication holes 122a of the second sub-member 120 when viewed from the back side, and is in a state of communicating with each other.

[0122] The position and size of each of the flow division openings 132 in the left-right direction (the width direction of the flat tube 28) will be described below.

[0123] The third sub-member 130 is a member provided between the plurality of first spaces S1 described above and second spaces S2 described below. The

second space S2 is one space formed for each of the first portion 42a to the fifth portion 42e of the first header 40 (in the example illustrated in Fig. 5, the five second spaces S2 are formed in the first header 40). Each of the second spaces S2 is adjacent to a predetermined number of the two or more first spaces S1 across the third sub-member 130 in the first direction D1. The number of the first spaces S1 adjacent to each of the second spaces S2 across the third sub-member 130 may be the same or may be different from each other. Each of the second spaces S2 is a space into which the refrigerant flows from the liquid refrigerant pipe 20 via the flow divider 22, the corresponding flow division pipes 22a to 22e, and the corresponding connection pipes 49a to 49e when the first heat exchanger 11 is used as an evaporator.

[0124] Each of the flow division openings 132 of the third sub-member 130 is an opening that allows the first space S1 and the second space S2 to communicate with each other. At least the one flow division opening 132 is provided for each of the first spaces S1. When the first heat exchanger 11 functions as an evaporator, the refrigerant flowing into the second space S2 from the liquid refrigerant pipe 20 is divided and flows into the plurality of flow division openings 132 opened to the second space S2, and flows into the first space S1 corresponding to each of the flow division openings 132.

(4-6-4) Fourth Sub-Member

[0125] The fourth sub-member 140 is a member stacked so as to be in contact with the front surface of the third sub-member 130. The horizontal length of the fourth sub-member 140 is the same as the horizontal length of the third sub-member 130. A clad layer having a brazing material may be formed on the surface of the fourth sub-member 140.

[0126] The fourth sub-member 140 has a flat plate shape extending in the vertical direction and the left-right direction. In the fourth sub-member 140, one first penetration portion 142 is formed for each of the first portion 42a to the fifth portion 42e of the first header 40.

[0127] Each of the first penetration portions 142 is an opening formed in a central portion of the fourth sub-member 140 in the left-right direction so as to penetrate the fourth sub-member 140 in the plate thickness direction (the first direction D1). Each of the first penetration portions 142 includes an introduction portion 142a, a nozzle portion 142b, and an ascending portion 142c. The introduction portion 142a, the nozzle portion 142b, and the ascending portion 142c are provided at a central portion of the fourth sub-member 140 in the left-right direction so as to be arranged in this order from the bottom in the vertical direction. The introduction portion 142a of the first penetration portion 142 is wider in the left-right direction than the nozzle portion 142b and the ascending portion 142c of the first penetration portion 142. The ascending portion 142c of the first penetration portion 142 is wider than the nozzle portion 142b of the

first penetration portion 142. Fig. 7 is a cross-sectional view of the fourth sub-member 140 taken along the first direction D1 at a position where the ascending portion 142c of the first penetration portion 142 is present in the stage direction.

[0128] The fourth sub-member 140 is sandwiched between the front surface of the third sub-member 130 and the back surface of the fifth sub-member 150 described below. The ascending portion 142c of the first penetration portion 142 of the fourth sub-member 140, which is sandwiched between the front surface of the third sub-member 130 and the back surface of the fifth sub-member 150 described below, functions as the second space S2 in the claims. The third sub-member 130, the fourth sub-member 140, and the fifth sub-member 150 constitute the second member 100b that forms the second space S2. In the second direction D2, as illustrated in Fig. 7, a width W1 of the first space S1 is preferably larger than a width W2 of the second space S2.

[0129] The introduction portion 142a of the first penetration portion 142 faces the front surface of the third sub-member 130 and is not overlapped with the flow division opening 132 when viewed from the back side, and the space formed by the introduction portion 142a of the first penetration portion 142 and the flow division opening 132 do not directly communicate with each other. When viewed from the back side, the introduction portion 142a of the first penetration portion 142 is overlapped with a second connection opening 152c of the fifth sub-member 150 described below and communicates with the second connection opening 152c. Since the back side of the introduction portion 142a of the first penetration portion 142 is closed by the third sub-member 130, the gas-phase refrigerant and the liquid-phase refrigerant flowing into the introduction portion 142a of the first penetration portion 142 hit the third sub-member 130 and get mixed, and the refrigerant in a state where the gas-phase refrigerant and the liquid-phase refrigerant are mixed is sent to the nozzle portion 142b of the first penetration portion 142.

[0130] The nozzle portion 142b of the first penetration portion 142 faces the front surface of the third sub-member 130 and, when viewed from the back side, is not overlapped with the flow division opening 132 and does not communicate with the flow division opening 132. In addition, the nozzle portion 142b of the first penetration portion 142 faces the back surface of the fifth sub-member 150 described below and, when viewed from the back side, is not overlapped with the second connection opening 152c, a return opening 152a, and a forward opening 152b described below and does not directly communicate with the second connection opening 152c, the return opening 152a, and the forward opening 152b. When the first heat exchanger 11 functions as an evaporator, the refrigerant flowing into the introduction portion 142a of the first penetration portion 142 is accelerated when passing through the nozzle portion 142b of the first penetration portion 142, and flows into the ascending

portion 142c of the first penetration portion 142. In other words, the nozzle portion 142b of the first penetration portion 142 blows up the refrigerant flowing into the introduction portion 142a of the first penetration portion 142 to the ascending portion 142c of the first penetration portion 142 when the first heat exchanger 11 functions as an evaporator.

[0131] The ascending portion 142c of the first penetration portion 142 (in other words, the second space S2 surrounded by the front surface of the third sub-member 130, the back surface of the fifth sub-member 150, and the left and right edge portions of the ascending portion 142c of the first penetration portion 142) faces the front surface of the third sub-member 130 and, when viewed from the back side, is overlapped with the plurality of flow division openings 132 and communicates with the plurality of flow division openings 132. The mode of the overlap between the flow division opening 132 and the second space S2 will be described below.

[0132] The ascending portion 142c of the first penetration portion 142 faces the back surface of the fifth sub-member 150 described below and, when viewed from the back side, is not overlapped with the second connection opening 152c but is overlapped with the return opening 152a and the forward opening 152b. The functions of the return opening 152a and the forward opening 152b will be described below.

[0133] The ascending portion 142c of the first penetration portion 142 is sandwiched between the front surface of the third sub-member 130 and the back surface of the fifth sub-member 150 described below so that a main space Sa is formed by being surrounded by the front surface of the third sub-member 130, the back surface of the fifth sub-member 150 described below, and the left and right edge portions of the ascending portion 142c of the first penetration portion 142. The main space Sa is a space in which the refrigerant moves so as to blow up along the longitudinal direction of the first header 40 when the first heat exchanger 11 is used as an evaporator. When the first heat exchanger 11 is used as an evaporator, the nozzle portion 142b of the first penetration portion 142 functions as a refrigerant inlet, and the forward opening 152b of the fifth sub-member 150 functions as a refrigerant outlet. When the first heat exchanger 11 is used as an evaporator, the refrigerant flowing into the main space Sa from the nozzle portion 142b of the first penetration portion 142 as a refrigerant inlet moves to the forward opening 152b of the fifth sub-member 150 while being divided to the plurality of flow division openings 132. The refrigerant that has moved to the forward opening 152b of the fifth sub-member 150 without being divided to the flow division openings 132 flows into a sub-space Sb described below. The refrigerant that has flowed into the sub-space Sb (the refrigerant that has reached the forward opening 152b of the fifth sub-member 150, which is a refrigerant outlet of the main space Sa) moves downward in the sub-space Sb, and is guided from the return opening 152a of the fifth sub-member 150

to the vicinity of the nozzle portion 142b of the first penetration portion 142, which is a refrigerant inlet of the main space Sa. The main space Sa here is the same space as the second space S2 in the claims.

[0134] The connection pipes 49a to 49e for supplying the refrigerant to the introduction portion 142a of the first penetration portion 142 when the first heat exchanger 11 is used as an evaporator are connected to the seventh sub-member 170 described below at the same height position as the introduction portion 142a of the corresponding first penetration portion 142 (provided in the portions 42a to 42e including the sub-spaces 23a to 23e to which the connection pipes 49a to 49e supply the refrigerant) and at the center position in the left-right direction of the introduction portion 142a. In addition, the center of the introduction portion 142a in the left-right direction of each of the first penetration portions 142 is arranged on a straight line in the vertical direction together with the center of the nozzle portion 142b and the center of the ascending portion 142c in the left-right direction of each of the first penetration portions 142. Therefore, the refrigerant flowing through the connection pipes 49a to 49e flows into the center of the introduction portion 142a in the left-right direction via a connection opening 172 described below, a first connection opening 174a, and the second connection opening 152c, and blows up vertically upward from the introduction portion 142a toward the ascending portion 142c via the nozzle portion 142b without moving in the left-right direction or without moving much in the left-right direction. With such a configuration, it is easy to suppress the occurrence of a phenomenon in which the refrigerant is supplied from the nozzle portion 142b of the first penetration portion 142 to the main space Sa (the second space S2) unevenly in the left-right direction.

(4-6-5) Fifth Sub-Member

[0135] The fifth sub-member 150 is a member stacked so as to be in contact with the front surface of the fourth sub-member 140. The horizontal length of the fifth sub-member 150 is the same as the horizontal length of the fourth sub-member 140. The fifth sub-member 150 preferably has a clad layer having a brazing material formed on the surface thereof.

[0136] The fifth sub-member 150 has a flat plate shape extending in the vertical direction and the left-right direction. In the fifth sub-member 150, the one second connection opening 152c, the one return opening 152a, and the one forward opening 152b are formed for each of the first portion 42a to the fifth portion 42e of the first header 40. The second connection opening 152c, the return opening 152a, and the forward opening 152b are openings independent of each other and formed at positions away from each other in the vertical direction (stage direction). The second connection opening 152c, the return opening 152a, and the forward opening 152b are all openings that penetrate the fifth sub-member

150 in the plate thickness direction (the first direction D1). Fig. 7 is a cross-sectional view of the fifth sub-member 150 taken along the first direction D1 at a position where the second connection opening 152c, the return opening 152a, and the forward opening 152b do not exist in the stage direction.

[0137] When viewed from the back side, the second connection opening 152c is overlapped with the introduction portion 142a of the first penetration portion 142 of the fourth sub-member 140 and communicates with each other. When viewed from the back side, the second connection opening 152c is overlapped with a first connection opening 162a of the sixth sub-member 160 described below and communicates with each other. When viewed from the back side, the second connection opening 152c is not overlapped with the nozzle portion 142b and the ascending portion 142c of the first penetration portion 142 of the fourth sub-member 140 and does not directly communicate therewith. In addition, when viewed from the back side, the second connection opening 152c is not overlapped with and does not communicate with a descending opening 162b of the sixth sub-member 160 described below.

[0138] When viewed from the back side, the return opening 152a is overlapped with the ascending portion 142c (the second space S2) of the first penetration portion 142 in a lower end vicinity portion of the ascending portion 142c of the first penetration portion 142 of the fourth sub-member 140 (the vicinity of the nozzle portion 142b of the first penetration portion 142), and communicates with the lower end vicinity portion of the ascending portion 142c (the vicinity of the refrigerant inlet of the second space S2).

[0139] When viewed from the back side, the forward opening 152b is overlapped with an upper end vicinity portion of the ascending portion 142c of the first penetration portion 142 of the fourth sub-member 140 and communicates with the upper end vicinity portion of the ascending portion 142c. The forward opening 152b functions as a refrigerant outlet of the main space Sa described above.

(4-6-6) Sixth Sub-Member

[0140] The sixth sub-member 160 is a member stacked so as to be in contact with the front surface of the fifth sub-member 150. The horizontal length of the sixth sub-member 160 is the same as the horizontal length of the fifth sub-member 150. A clad layer having a brazing material may be formed on the surface of the sixth sub-member 160.

[0141] The sixth sub-member 160 has a flat plate shape extending in the vertical direction and the left-right direction. In the sixth sub-member 160, the one first connection opening 162a and the one descending opening 162b are formed for each of the first portion 42a to the fifth portion 42e of the first header 40.

[0142] The first connection opening 162a and the descending opening 162b are openings independent of each other and formed at positions away from each other in the vertical direction (stage direction). Both the first connection opening 162a and the descending opening 162b are openings that penetrate the sixth sub-member 160 in the plate thickness direction (the first direction D1). Fig. 7 is a cross-sectional view of the sixth sub-member 160 taken along the first direction D1 at a position where the descending opening 162b exists in the stage direction.

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ending opening 162b are openings independent of each other and formed at positions away from each other in the vertical direction (stage direction). Both the first connection opening 162a and the descending opening 162b are openings that penetrate the sixth sub-member 160 in the plate thickness direction (the first direction D1). Fig. 7 is a cross-sectional view of the sixth sub-member 160 taken along the first direction D1 at a position where the descending opening 162b exists in the stage direction.

[0143] When viewed from the back side, the first connection opening 162a is overlapped with the second connection opening 152c of the fifth sub-member 150 and communicates with the second connection opening 152c. When viewed from the back side, the first connection opening 162a is overlapped with a connection opening 172 of the seventh sub-member 170 described below and communicates with the connection opening 172.

[0144] When viewed from the back side, the descending opening 162b is overlapped with the return opening 152a and the forward opening 152b of the fifth sub-member 150 and communicates with the return opening 152a and the forward opening 152b. When viewed from the back side, the descending opening 162b is not overlapped with the connection opening 172 of the seventh sub-member 170 described below and does not directly communicate with each other.

[0145] The descending opening 162b is sandwiched between the front surface of the fifth sub-member 150 and the back surface of the seventh sub-member 170 so that the sub-space Sb is formed by being surrounded by the front surface of the fifth sub-member 150, the back surface of the seventh sub-member 170, and the left and right edge portions of the first connection opening 162a of the sixth sub-member 160. As described above, the sub-space Sb guides the refrigerant that has reached the refrigerant outlet (the forward opening 152b of the fifth sub-member 150) of the main space Sa (the second space S2) to the vicinity of the nozzle portion 142b of the first penetration portion 142 as the refrigerant inlet of the main space Sa. The refrigerant guided from the sub-space Sb to the main space Sa moves upward toward the forward opening 152b of the fifth sub-member 150 while being divided into the plurality of flow division openings 132 together with the refrigerant flowing into the main space Sa from the nozzle portion 142b of the first penetration portion 142.

(4-6-7) Seventh Sub-Member

[0146] The seventh sub-member 170 is a member stacked so as to be in contact with the front surface of the sixth sub-member 160. The horizontal length of the seventh sub-member 170 is the same as that of the sixth sub-member 160. The seventh sub-member 170 preferably has a clad layer having a brazing material formed on the surface thereof.

[0147] The seventh sub-member 170 has a flat plate shape extending in the vertical direction and the left-right

direction. In the seventh sub-member 170, the one connection opening 172 is formed for each of the first portion 42a to the fifth portion 42e of the first header 40. The connection opening 172 is an opening that penetrates the seventh sub-member 170 in the plate thickness direction (the first direction D1). Fig. 7 is a cross-sectional view of the seventh sub-member 170 taken along the first direction D1 at a position where the connection opening 172 exists in the stage direction.

[0148] When viewed from the back side, the connection opening 172 is overlapped with a part of the first connection opening 162a of the sixth sub-member 160 and communicates with the first connection opening 162a. When viewed from the back side, the connection opening 172 is not overlapped with the descending opening 162b of the sixth sub-member 160 and does not directly communicate with the descending opening 162b.

[0149] The connection opening 172 formed in the seventh sub-member 170 is an opening into which any one of the connection pipes 49a to 49e (a connection pipe 49) is inserted and connected. When the first heat exchanger 11 functions as an evaporator of the refrigerant, the refrigerant flowing through the respective connection pipes 49a to 49e is sent to the introduction portion 142a of the first penetration portion 142 via the first connection opening 162a of the sixth sub-member 160 and the second connection opening 152c of the fifth sub-member 150.

(5) Flow of Refrigerant in First Header when First Heat Exchanger Functions as Evaporator

[0150] The flow of the refrigerant in the first header 40 when the first heat exchanger 11 functions as an evaporator of the refrigerant will be described.

[0151] The liquid refrigerant or the refrigerant in a gas-liquid two-phase state, which is divided and flowed into the plurality of flow division pipes 22a to 22e in the flow divider 22, flows through the corresponding connection pipes 49a to 49e, passes through the connection opening 172 of the seventh sub-member 170, and flows into the portions 42a to 42e (the sub-spaces 23a to 23e) of the first header 40.

[0152] Hereinafter, the flow of the refrigerant particularly in the first portion 42a of the first header 40 will be described with reference to Fig. 8. Fig. 8 is a diagram schematically illustrating the flow of the refrigerant in the first portion 42a of the first header 40 when the first heat exchanger 11 functions as an evaporator of the refrigerant. The flow of the refrigerant in the second portion 42b to the fifth portion 42e of the first header 40 will not be described.

[0153] The refrigerant flowing through the connection pipe 49a passes through the connection opening 172 provided for the first portion 42a and flows into the first connection opening 162a also provided for the first portion 42a. The refrigerant that has flowed into the first connection opening 162a passes through the second

connection opening 152c provided for the first portion 42a and flows into the introduction portion 142a of the first penetration portion 142 of the fourth sub-member 140 provided for the first portion 42a.

[0154] The refrigerant flowing into the introduction portion 142a of the first penetration portion 142 is accelerated when passing through the nozzle portion 142b of the first penetration portion 142 as the refrigerant inlet of the main space Sa, and ascends in the ascending portion 142c (the main space Sa, the second space S2) of the first penetration portion 142 (see Fig. 8). Since the ascending portion 142c is narrower in the left-right direction than the introduction portion 142a, the refrigerant flowing into the main space Sa may easily reach the flow division opening 132 located in the vicinity of the upper end of the main space Sa even when the amount of the refrigerant circulating in the refrigerant circuit 6 is small. The refrigerant that has flowed into the main space Sa flows toward the vicinity of the upper end of the main space Sa while being divided to flow into the respective flow division openings 132 (see Fig. 8). The refrigerant that has flowed into each of the flow division openings 132 flows into the corresponding first space S1 and flows through the flat tube 28 inserted into the first space S1. The refrigerant that has reached the vicinity of the upper end of the main space Sa passes through the forward opening 152b of the fifth sub-member 150 as the refrigerant outlet of the main space Sa and flows into the descending opening 162b (the sub-space Sb) (see Fig. 8). The refrigerant that has reached the sub-space Sb descends and is returned via the return opening 152a to the vicinity of the nozzle portion 142b of the first penetration portion 142, which serves as a refrigerant inlet of the main space Sa (the space above the nozzle portion 142b of the first penetration portion 142), which is the lower vicinity of the main space Sa. In this way, the refrigerant may be circulated by the main space Sa (the second space S2), the forward opening 152b, the sub-space Sb, and the return opening 152a, and therefore, even when some of the refrigerant does not branch and does not flow through any of the flow division openings 132 while flowing upward in the main space Sa, the refrigerant may be returned to the main space Sa again via the sub-space Sb, and thus uneven flow to the flat tubes 28 may be easily suppressed.

(6) Arrangement of Flow Division Opening

[0155] Further, the arrangement of the flow division opening 132 for suppressing uneven flow to the flat tubes 28 when the first heat exchanger 11 is used as an evaporator will be described.

[0156] First, with reference to Fig. 9, a description will be given of a problem in a case where an opening is, as in a conventional heat exchanger, provided only in the central portion of the second space S2 where the refrigerant is present in the width direction (the second direction D2) of the flat tube 28 when viewed along the insertion direction (the first direction D1) of the flat tube 28 with

respect to the first space S1 and the refrigerant is divided from the second space S2 to the first space S1.

[0157] Fig. 9 is a diagram of a member A corresponding to the third sub-member 130 when viewed along the first direction D1, and the member A is drawn by a solid line. A circle drawn by a solid line is an opening Op corresponding to the flow division opening 132 formed in the third sub-member 130. However, in Fig. 9, the opening Op is provided at the center of the second space S2 in the second direction D2, which is the width direction of the flat tube 28, unlike the flow division opening 132 described below in detail. In Fig. 9, the first penetration portion 142 of the fourth sub-member 140 is drawn by a broken line.

[0158] For example, when the dryness of the refrigerant flowing into the second space S2 is relatively small (when the amount of the gas-phase refrigerant is small), the bubble flow and the slug flow tend to be dominant in the mode of the refrigerant flow in the second space S2, and even in a case where the opening Op is formed at the position illustrated in Fig. 9, an uneven flow to the flat tube 28 is relatively unlikely to be a problem.

[0159] On the other hand, when the dryness of the refrigerant flowing into the second space S2 is relatively high (when the amount of the gas-phase refrigerant is large), the churn flow and the annular flow tend to be dominant in the mode of the refrigerant flow in the second space S2. In this case, as illustrated in Fig. 9, since the liquid-phase refrigerant tends to flow in the vicinity of the end portions of the second space S2 in the left-right direction as indicated by hatching of the oblique lines, there is likely to be a problem of an uneven flow such that the liquid-phase refrigerant tends to relatively increase at the openings Op provided at both end portions in the stage direction, and the liquid-phase refrigerant tends to relatively decrease at the opening Op provided at the central portion in the stage direction in particular, among the openings Op that are opened to the one second space S2.

[0160] For example, when a refrigerant having a low global warming potential, such as R290 or CO₂, which is increasingly employed from the viewpoint of environmental protection, is used as the refrigerant, an operating condition in which a refrigerant having a high dryness flows into the first heat exchanger 11 is often selected. Therefore, when R290 or CO₂ is used as a refrigerant, a problem of an uneven flow is likely to occur.

[0161] Further, when a refrigerant having a small global warming potential such as R290 or CO₂ is used, the gas concentration is smaller than that of a conventional refrigerant such as R32 or R410A, and therefore the pressure loss in the heat exchanger tends to increase. Further, as R290 has a large gas-liquid speed difference, among the openings Op opened to the one second space S2, the flat tube communicating with the opening Op provided at the central portion in the stage direction is likely to be overheated in particular, and a problem of deterioration in performances is likely to occur.

[0162] In addition, when the heat exchanger is increased in size and the circulation amount of the refrigerant flowing through each section of the heat exchange unit is decreased, the ratio of the pressure loss in the header to the total pressure loss of the heat exchanger is increased, the variation in the header pressure loss becomes dominant, and the uneven flow is likely to lead to a decrease in performance.

[0163] In view of such a problem, in the first heat exchanger 11 according to the present disclosure, when viewed along the insertion direction (the first direction D1) of the flat tube 28 with respect to the first space S1, the flow division opening 132 is at least partially close to one end portion 144 of the second space S2 in the width direction (the second direction D2) of the flat tube 28.

[0164] The end portion 144 of the second space S2 means the position of an inner edge portion in the left-right direction (the second direction D2) of the ascending portion 142c of the first penetration portion 142 of the fourth sub-member 140 that forms the second space S2 (see Fig. 7).

[0165] Further, the flow division opening 132 being at least partially close to the one end portion 144 of the second space S2 in the width direction (the second direction D2) of the flat tube 28 means that a part of the flow division opening 132 is present in the range of a length L in the direction approaching the other end portion 144 from the one end portion 144 in the second direction D2.

[0166] The discloser of this application has found that the above-described uneven flow may be suppressed by at least partially providing the flow division opening 132 between the end portion 144 of the second space S2 and the position of a width by 15% of the width W2 inside the second space S2 from the end portion 144 in the second direction D2 (by setting the above-described length L to 15% of the width W2). In other words, it has been found that the above-described uneven flow is easily suppressed by, in the second direction D2, overlapping at least a part of a region between the end portion 144 of the second space S2 and the position of a width by 15% of the width W2 inside the second space S2 from the end portion 144 with at least a part of the flow division opening 132. Further, the discloser of this application has found that the above-described uneven flow is particularly likely to be suppressed by at least partially providing the flow division opening 132 between the end portion 144 of the second space S2 and the position of a width by 10% of the width W2 inside the second space S2 from the end portion 144 in the second direction D2 (by setting the length L to 10% of the width W2).

[0167] An arrangement example of the flow division opening 132 will be described with reference to FIGS. 10 to 13.

[0168] Fig. 10 is a schematic view (a schematic view from above) of the inside of the first header 40 viewed in the longitudinal direction of the first header 40 and illustrates a first example of the arrangement state of the first

space S1, the second space S2, and the flow division opening 132 of the third sub-member 130. Fig. 11 is a schematic view (a schematic view from above) of the first header 40 viewed in the longitudinal direction and illustrates a second example of the arrangement state of the first space S1, the second space S2, and the flow division opening 132 of the third sub-member 130. Fig. 12 is a schematic view (a schematic view from above) of the first header 40 viewed in the longitudinal direction and illustrates a third example of the arrangement state of the first space S1, the second space S2, and the flow division opening 132 of the third sub-member 130. Fig. 13 is a schematic view (a schematic view from above) of the first header 40 viewed in the longitudinal direction and illustrates a fourth example of the arrangement state of the first space S1, the second space S2, and the flow division opening 132 of the third sub-member 130.

[0169] In FIGS. 10 to 13, a portion hatched with rising diagonal lines from bottom left to top right represents the second space S2, a portion hatched with falling diagonal lines from top left to bottom right represents the first space S1, and a portion hatched with dots represents the position of the flow division opening 132.

[0170] In the example of Fig. 10, when viewed along the first direction D1, the flow division opening 132 is partially overlapped with the one end portion 144 of the second space S2 in the second direction D2. The partial overlap of the flow division opening 132 with the one end portion 144 of the second space S2 in the second direction D2 means that the flow division opening 132 is present at the position of the one end portion 144 in the second direction D2. In particular, in the example of Fig. 10, the flow division opening 132 is partially overlapped with both the end portions 144 of the second space S2 in the second direction D2. Further, in the example of Fig. 10, when viewed along the first direction D1, the flow division opening 132 is overlapped with the entire second space S2 in the second direction D2. In other words, when viewed along the first direction D1, the flow division opening 132 is overlapped with both the end portions 144 of the second space S2 in the second direction D2, and the width of the flow division opening 132 in the second direction D2 is equal to or more than the width of the second space S2 in the second direction D2.

[0171] In the second example (see Fig. 11) different from the examples illustrated in FIGS. 7 and 10, the flow division opening 132 is at least partially arranged close to both the end portions 144 in the second direction D2. For example, according to the second example, in the second direction D2, the flow division opening 132 is at least partially provided between both the end portions 144 of the second space S2 and the positions of a width by 15% of the width W2 inside the second space S2 from the respective end portions 144.

[0172] Further, in the third example (see Fig. 12), there is the plurality of (for example, two in the example of Fig. 12) flow division openings 132 that allows the second space S2 and the one first space S1 to communicate with

each other. In the example of Fig. 12, when viewed along the first direction D1, each of the flow division openings 132 is partially overlapped with the one end portion 144 of the second space S2 in the second direction D2. In other words, the pair of flow division openings 132 is partially overlapped with both the end portions 144 in the second direction D2.

[0173] In still another fourth example (see Fig. 13), there is the plurality of (for example, two in the example of Fig. 12) flow division openings 132 that allows the second space S2 and the one first space S1 to communicate with each other. In the example of Fig. 12, when viewed along the first direction D1, the one flow division opening 132 is partially overlapped with one of the end portions 144 of the second space S2 in the second direction D2, and the other flow division opening 132 is at least partially arranged close to one of the end portions 144 in the second direction D2. For example, also in the fourth example, in the second direction D2, the flow division opening 132 is at least partially provided between both the end portions 144 of the second space S2 and the positions of a width by 15% of the width W2 inside the second space S2 from the respective end portions 144.

[0174] Although not illustrated, for example, there may be the three or more flow division openings 132 that allow the second space S2 and the one first space S1 to communicate with each other, and at least the one flow division opening 132 may not be arranged close to any of the two end portions 144 in the second direction D2.

[0175] Further, although not illustrated in the drawings, for example, there may be the single flow division opening 132 that allows the second space S2 and the one first space S1 to communicate with each other, and the single flow division opening 132 may be arranged close to or overlapped with only one of the two end portions 144 in the second direction D2.

[0176] Here, it is assumed that the flow division openings 132 having the same shape are formed at the same position in the second direction D2 with respect to all the first spaces S1, but the invention is not limited thereto. For each of the first spaces S1, the flow division opening 132 may be formed at a different position in the second direction D2, and/or the flow division opening 132 having a different shape may be formed.

(7) Features of First Heat Exchanger and Air Conditioning Apparatus according to Present Embodiment

[0177] (7-1)

The first heat exchanger 11 according to the present embodiment includes the plurality of flat tubes 28 and the first header 40 as an example of a header. The first header 40 includes the first member 100a, the second member 100b, and the third sub-member 130 as a first plate. The first member 100a forms the plurality of first spaces S1 into which the flat tubes 28 are inserted. The second member 100b forms the second space S2 into

which the refrigerant flows. The third sub-member 130 is provided between the first space S1 and the second space S2. The third sub-member 130 is provided with the flow division opening 132. The flow division opening 132 allows the first space S1 and the second space S2 to communicate with each other. The refrigerant flows from the second space S2 into the first space S1 through the flow division opening 132. When viewed along the insertion direction (the first direction D1) of the flat tube 28 with respect to the first space S1, the flow division opening 132 is arranged, at least partially, close to the one end portion 144 of the second space S2 in the width direction (the second direction D2) of the flat tube 28.

[0178] In the first heat exchanger 11, since the flow division opening 132 formed in the third sub-member 130 is arranged close to the end portion 144 of the second space S2, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the second direction D2, may be easily distributed to the plurality of first spaces S1 without unevenness.

[0179] (7-2)

In the first heat exchanger 11 according to the present embodiment, when viewed along the first direction D1, the flow division opening 132 is at least partially arranged close to both the end portions 144 of the second space S2 in the second direction D2.

[0180] In the first heat exchanger 11, the flow division opening 132 formed in the third sub-member 130 is arranged close to both the end portions 144 of the second space S2, and therefore, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the second direction D2 of the flat tube 28, may be easily distributed to the plurality of first spaces S1 without unevenness.

[0181] (7-3)

In the first heat exchanger 11 according to the present embodiment, the width of the second space S2 is the width W2 (a first width in the claims). In the second direction D2, the flow division opening 132 is arranged, at least partially, between the end portion 144 of the second space S2 and the position by 15% of the width W2 inside the second space S2 from the end portion 144.

[0182] In the first heat exchanger 11, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the width direction (the second direction D2) of the flat tube 28, may be easily distributed to the plurality of first spaces without unevenness. Therefore, a difference is unlikely to occur in the amounts of liquid refrigerant and gas refrigerant flowing through each of the flat tubes 28 of the first header.

[0183] (7-4)

In the first heat exchanger 11 (illustrated in FIGS. 10, 12, 13) according to the present embodiment, when viewed along the first direction D1, the flow division opening 132 is partially overlapped with the one end portion 144 of the second space S2 in the second direction D2.

[0184] In the first heat exchanger 11, since the flow division opening 132 formed in the third sub-member 130

is arranged to overlap with the end portion 144 of the second space S2, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the second direction D2 of the flat tube 28, may be easily distributed to the plurality of first spaces S1 without unevenness.

[0185] (7-5)

In the first heat exchanger 11 (illustrated in FIGS. 10, 12) according to the present embodiment, when viewed along the first direction D1, the flow division opening 132 partially overlaps with both the end portions 144 of the second space S2 in the second direction D2.

[0186] In the first heat exchanger 11, the flow division opening 132 formed in the third sub-member 130 is arranged to be overlap with both the end portions 144 of the second space S2, and therefore, the liquid refrigerant flowing through the end portion 144 of the second space S2 in the second direction D2 of the flat tube 28 may be easily distributed to the plurality of first spaces S1 without unevenness.

[0187] (7-6)

In the first heat exchanger 11 (illustrated in Fig. 10) according to the present embodiment, when viewed along the first direction D1, the flow division opening 132 overlaps with the entire second space S2 in the second direction D2.

[0188] In the first heat exchanger 11, the liquid refrigerant flowing through the end portion of the second space S2 in the second direction D2 of the flat tube 28 may be easily distributed to the plurality of first spaces S1 without unevenness.

[0189] (7-7)

In the first heat exchanger 11 according to the present embodiment, when viewed along the first direction D1, the second member 100b forms the main space Sa and the sub-space Sb. The main space Sa includes the refrigerant inlet (the nozzle portion 142b of the first penetration portion 142) and the refrigerant outlet (the forward opening 152b). In the main space Sa, the refrigerant moves from the refrigerant inlet to the refrigerant outlet. The sub-space Sb guides the refrigerant having reached the refrigerant outlet of the main space Sa to the vicinity of the refrigerant inlet of the main space Sa. The flow division opening 132 communicates with the main space Sa as the second space S2.

[0190] In the first heat exchanger 11, since the loop structure including the main space Sa and the sub-space Sb is adopted for dividing the flow of the refrigerant, the refrigerant may be easily distributed to the plurality of first spaces S1 without unevenness especially.

[0191] (7-8)

In the first heat exchanger 11 according to the present embodiment, the width W1 of the first space S1 is larger than the width W2 of the second space S2 in the second direction D2.

[0192] In the first heat exchanger 11, since the width W1 of the first space S1 is larger than the width W2 of the second space S2, and therefore, the liquid refrigerant

flowing through the end portion 144 of the second space S2 may be easily divided to the first space S1 via the flow division opening 132 of the third sub-member 130 without unevenness.

[0193] However, the width W1 of the first space S1 may be equal to or less than the width W2 of the second space S2.

[0194] (7-9)

In the first heat exchanger 11 according to the present embodiment, the width W₀ of the flow division opening 132 is equal to or more than 1 mm in the thickness direction of the flat tube 28.

[0195] In the first heat exchanger 11, since the width of the flow division opening 132 in the thickness direction of the flat tube 28 is equal to or more than 1 mm, it is possible to suppress the occurrence of an issue in which it is difficult for the liquid refrigerant to flow through the flow division opening 132.

[0196] (7-10)

In the first heat exchanger 11 according to the present embodiment, one of the flat tube 28 is inserted into each of the first spaces S1. One or more of the flow division openings 132 are provided for each of the first spaces S1.

[0197] In the first heat exchanger 11, one of the flat tube 28 is inserted corresponding to each of the first spaces S1, and the refrigerant from the second space S2 is guided to each of the first spaces S1 via the flow division opening 132, and therefore, unevenness in the amount of refrigerant flowing into each of the flat tubes 28 may be easily suppressed, as compared with a case where the plurality of flat tubes 28 is inserted into each of the first spaces S1 and the refrigerant having flowed into each of the first spaces S1 is distributed to the plurality of flat tubes 28.

[0198] However, the structure is not limited thereto, and the first header 40 may have a structure in which the plurality of flat tubes 28 is inserted into one of the first space S1, and the refrigerant flowing into the first space S1 via the flow division opening 132 may be divided into the plurality of flat tubes 28.

[0199] (7-11)

The air conditioning apparatus 1 as an example of a refrigeration cycle apparatus includes the first heat exchanger 11 that functions as an evaporator, the compressor 8 that compresses the refrigerant, the second heat exchangers 32a, 32b as radiators that cool the refrigerant discharged from the compressor 8, and the expansion device (the first expansion mechanism 12, the second expansion mechanism 31a, the second expansion mechanism 31b) that expand the refrigerant flowing out of the radiator to the first heat exchanger 11.

[0200] In the air conditioning apparatus 1, unevenness of the amount of refrigerant flowing into each of the flat tubes 28 of the first heat exchanger 11 may be easily suppressed, and a highly-efficient air conditioning apparatus may be achieved.

(8) Modification

[0201] Modifications of the above-described embodiments will be described below. The modifications described below may be appropriately combined as long as there is no contradiction.

(8-1) Modification A

[0202] According to the above embodiment, the first heat exchanger 11 in which the refrigerant flows through the heat exchange unit 27 from one side to the other side has been described; however, the first heat exchanger may be a heat exchanger in which the refrigerant flows back through the heat exchange unit 27 as long as the header portion that distributes the refrigerant in a liquid phase or gas-liquid two phase to the flat tubes 28 when the first heat exchanger is used as an evaporator has the configuration according to the above embodiment.

[0203] For example, when different refrigerants are used in heat exchangers of the same size, the optimum refrigerant paths are different due to a difference in the physical properties of the refrigerants, and therefore, depending on the refrigerant, it is necessary to improve the flow dividing performance at high dryness.

[0204] An example of a refrigerant path different from that of the above-described embodiment and a portion in which the internal structure of the header having the structure described in (4-6) and (6) in the above-described embodiment is employed when the refrigerant path is employed will be described.

[0205] The number of sections in the vertical direction of the heat exchange unit 27 of each of the first heat exchangers, the number of the flat tubes 28 included in each section of the heat exchange unit 27, the way in which the refrigerant flows in the heat exchange unit 27, and the like, described in the following examples are merely examples for description, and do not limit the present disclosure.

[0206] In a first heat exchanger 11A according to an example of FIGS. 14 and 15, a second header 70A is partitioned into two upper and lower portions 70Aa, 70Ab. The portion 70Aa is connected to the connection pipe 19a to which the first gas refrigerant pipe 19 is connected. The portion 70Ab is connected to a connection pipe 20a to which the liquid refrigerant pipe 20 is connected. The heat exchange unit 27 is partitioned into the four heat exchange units 27a to 27d. The heat exchange units 27a, 27b are connected to the portion 70Aa of the second header 70A. The heat exchange units 27c, 27d are connected to the portion 70Ab of the second header 70A. A first header 40A is vertically partitioned into four portions 42Aa to 42Ad, which is the same number as the number of the heat exchange units 27a to 27d, and each of the heat exchange units 27a to 27d is connected to a corresponding one of the portions 42Aa to 42Ad. The portion 42Aa of the first header and the portion 42Ac of the first header are connected to each other with a pipe 41a. The

portion 42Ab of the second header and the portion 42Ad of the first header are connected to each other with a pipe 41b.

[0207] When the first heat exchanger 11A functions as an evaporator, the refrigerant flows as follows. First, the liquid refrigerant or the two-phase refrigerant flowing through the liquid refrigerant pipe 20 flows into the portion 70Ab of the second header 70A via the connection pipe 20a. The refrigerant having flowed into the portion 70Ab of the second header 70A is divided to the flat tubes 28 of the heat exchange units 27c, 27d. The refrigerant that has flowed through the flat tube 28 of the heat exchange unit 27c flows into the inside of the portion 42Ac of the first header 40A, and the refrigerant that has flowed through the flat tube 28 of the heat exchange unit 27d flows into the inside of the portion 42Ad of the first header 40A. The refrigerant that has flowed into the portion 42Ac of the first header 40A flows into the portion 42Aa of the first header 40A via the pipe 41a, and the refrigerant that has flowed into the portion 42Ad of the first header 40A flows into the portion 42Ab of the first header 40A via the pipe 41a. The refrigerant that has flowed into the portion 42Aa of the first header 40A is divided to the flat tubes 28 of the heat exchange unit 27a. The refrigerant that has flowed into the portion 42Ab of the first header 40A is divided to the flat tubes 28 of the heat exchange unit 27b. The refrigerant that has flowed through the flat tubes 28 of the heat exchange units 27a, 27b flows into the portion 70Aa of the second header 70A, merges, and flows out to the first gas refrigerant pipe 19 via the connection pipe 19a connected to the portion 70Aa of the second header 70A.

[0208] In such a configuration, by adopting the internal structure of the header having the structure described in (4-6) and (6) in the above embodiment for the portion 70Ab of the second header 70A and the portions 42Aa, 42Ab of the first header 40A, the liquid refrigerant and the gas refrigerant may be easily distributed to the flat tubes 28 of the heat exchange units 27a, 27b without unevenness.

[0209] When the first heat exchanger 11A functions as an evaporator, the refrigerant having exchanged heat in the heat exchange units 27c, 27d flows into the portions 42Aa, 42Ab of the first header 40A. Therefore, the refrigerant having a relatively high dryness is likely to flow into the portions 42Aa, 42Ab of the first header 40A. Therefore, by adopting the arrangement of the distribution opening as described in (6) of the above embodiment in the portions 42Aa, 42Ab of the first header 40A (as described above, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the second direction D2, may be easily distributed to the plurality of first spaces S1 without unevenness), the amounts of the liquid refrigerant and the gas refrigerant flowing into the flat tubes 28 of the heat exchange units 27a, 27b are likely to be equalized.

[0210] In a case where the dryness of the refrigerant flowing into the portion 70Ab of the second header 70A is low and an uneven flow is unlikely to occur at the time of

flow division, the arrangement of the distribution opening as described in (6) of the above embodiment may not be adopted in the portion 70Ab of the second header 70A.

[0211] The portion 70Aa of the second header 70A and the portions 42Ac, 42Ad of the first header 40A may appropriately adopt a structure capable of realizing the above-described flow of the refrigerant. A detailed description is omitted here.

[0212] In a first heat exchanger 11B according to an example of FIGS. 16 and 17, the second header 70B is vertically partitioned into five portions 70Ba to 70Be. The portion 70Be is connected to the connection pipe 20a to which the liquid refrigerant pipe 20 is connected. The portion 70Ba of the second header 70B is connected to the portion 70Bc of the second header 70B with a pipe 71a. The portion 70Bb of the second header 70B is connected to the portion 70Bd of the second header 70B with a pipe 71b. The first header 40B is vertically partitioned into five portions 42Ba to 42Be. The portion 42Ba is connected to the connection pipe 19a to which the first gas refrigerant pipe 19 is connected. The portion 42Bb is connected to the portion 42Bd of the first header 40B with the pipe 41a. The portion 42Bc of the first header 40B is connected to the portion 42Be of the first header 40B with the pipe 41b. The heat exchange unit 27 is divided into six heat exchange units 27a to 27f. Each of the portions 70Ba to 70Bd of the second header 70B is connected to a corresponding one of the heat exchange units 27a to 27d. The two heat exchange units 27e to 27f are connected to the portion 70Be of the second header 70B. The two heat exchange units 27a to 27b are connected to the portion 42Ba of the first header 40B. Each of the portions 42Bb to 42Be of the first header 40B is connected to a corresponding one of the heat exchange units 27b to 27e.

[0213] When the first heat exchanger 11A functions as an evaporator, the refrigerant flows as follows. First, the liquid refrigerant or the two-phase refrigerant flowing through the liquid refrigerant pipe 20 flows into the portion 70Be of the second header 70B via the connection pipe 20a. The refrigerant having flowed into the portion 70Be of the second header 70B is divided to the flat tubes 28 of the heat exchange units 27e, 27f. The refrigerant that has flowed through the flat tube 28 of the heat exchange unit 27e flows into the portion 42Bd of the first header 40B, and the refrigerant that has flowed through the flat tube 28 of the heat exchange unit 27f flows into the portion 42Be of the first header 40B. The refrigerant that has flowed into the portion 42Bd of the first header 40B flows into the portion 42Bb of the first header 40B via the pipe 41a, and the refrigerant that has flowed into the portion 42Bf of the first header 40B flows into the portion 42Bc of the first header 40B via the pipe 41b. The refrigerant that has flowed into the portion 42Bb of the first header 40B is divided to the flat tubes 28 of the heat exchange unit 27c. The refrigerant that has flowed into the portion 42Bc of the first header 40B is divided to the flat tubes 28 of the heat exchange unit 27d. The refrigerant that has flowed

through the flat tube 28 of the heat exchange unit 27c flows into the portion 70Bc of the second header 70B. The refrigerant that has flowed through the flat tube 28 of the heat exchange unit 27d flows into the portion 70Bd of the second header 70B. The refrigerant that has flowed into the portion 70Bc of the second header 70B flows into the portion 70Ba of the second header 70B via the pipe 71a, and the refrigerant that has flowed into the portion 70Bd of the second header 70B flows into the portion 70Bb of the second header 70B via the pipe 71b. The refrigerant flowing into the portion 70Ba of the second header 70B is divided to the flat tubes 28 of the heat exchange unit 27a. The refrigerant flowing into the portion 70Bb of the second header 70B is divided to the flat tubes 28 of the heat exchange unit 27b. The refrigerant that has flowed through the flat tubes 28 of the heat exchange units 27a, 27b flows into the portion 42Ba of the first header 40B, merges, and flows out to the first gas refrigerant pipe 19 via the connection pipe 19a connected to the portion 42Ba of the first header 40B.

[0214] In such a configuration, by adopting the internal structure of the header having the structure described in (4-6) and (6) in the above embodiment for the portion 70Be of the second header 70B, the portions 42Bb, 42Bc of the first header 40B, and the portions 70Ba, 70Bb of the second header 70B, the liquid refrigerant and the gas refrigerant may be easily distributed to the flat tubes 28 of the heat exchange unit 27 without unevenness.

[0215] When the first heat exchanger 11B functions as an evaporator, the refrigerant having exchanged heat in the heat exchange unit 27 flows into the portions 42Bb, 42Bc of the first header 40B and the portions 70Ba, 70Bb of the second header 70B. Therefore, the refrigerant having a relatively high dryness is likely to flow into the portions 42Bb, 42Bc of the first header 40B and the portions 70Ba, 70Bb of the second header 70B. Therefore, by adopting the arrangement of the distribution opening as described in (6) of the above embodiment (as described above, the liquid refrigerant, which is likely to flow in the vicinity of the end portion 144 of the second space S2 in the second direction D2, may easily distributed to the plurality of first spaces S1 without unevenness), the amounts of the liquid refrigerant and the gas refrigerant distributed and flowing into the flat tubes 28 are likely to be equalized.

[0216] The arrangement of the distribution opening as described in (6) of the above embodiment may not be adopted in a portion such as the portion 70Be of the second header 70B where the dryness of the refrigerant that flows in is low and an uneven flow is unlikely to occur at the time of flow division.

[0217] The portions 70Bc, 70Bd of the second header 70B and the portions 42Ba, 42Bd, 42Bf of the first header 40B may appropriately adopt a structure capable of realizing the above-described flow of the refrigerant. A detailed description is omitted here.

[0218] In summary, in the above-described first heat exchangers 11A, 11B, the plurality of flat tubes 28 in-

cludes at least a first flat tube and a plurality of second flat tubes. In the heat exchanger, the refrigerant that has flowed through the first flat tube passes through a first portion of the header into which the plurality of second flat tubes is inserted, and flows into the plurality of second flat tubes.

[0219] For example, in the first heat exchanger 11A, the flat tubes 28 of the heat exchange units 27c, 27d are the first flat tubes, the flat tubes 28 of the heat exchange units 27a, 27b are the plurality of second flat tubes, and the portions 42Aa, 42Ab of the first header 40A are the first portion of the header.

[0220] Further, for example, in the first heat exchanger 11B, the flat tubes 28 of the heat exchange units 27e, 27f are the first flat tubes, the flat tubes 28 of the heat exchange units 27c, 27d are the plurality of second flat tubes, and the portions 42Bb, 42Bc of the first header 40B are the first portion of the header. Further, for example, in the first heat exchanger 11B, the flat tubes 28 of the heat exchange units 27c, 27d are also the first flat tubes, and in this case, the flat tubes 28 of the heat exchange units 27a, 27d are the plurality of second flat tubes, and the portions 70Ba, 70Bb of the second header 70 are the first portion of the header.

[0221] The first portion of the header in the first heat exchangers 11A, 11B described above preferably has the structure or configuration described in (4-6) and (6) of the above embodiment.

[0222] In a case where the refrigerant with a high liquid content exchanges heat while flowing through the first flat tube, the dryness of the refrigerant becomes high when the refrigerant turns back at the header and flows into the plurality of second flat tubes. In such a case, in the conventional heat exchanger, a difference may occur in the amounts of the liquid refrigerant and the gas refrigerant flowing through each of the second flat tubes, and the efficiency of heat exchange may decrease.

[0223] In contrast, in the first heat exchangers 11A, 11B, the liquid refrigerant is easily distributed to the plurality of first spaces in the first portion of the header without unevenness, and thus the amounts of the liquid refrigerant and the gas refrigerant flowing through the respective second flat tubes are easily equalized.

(8-2) Modification B

[0224] In the above embodiment, the first header 40 has been described as a header formed by stacking the first sub-member 110 to the seventh sub-member 170, but the structure of the first header 40 is not limited to such a structure. For example, the first header 40 may be formed in the above-described structure by arranging a partition plate provided with an appropriate opening inside a tubular header.

(8-3) Modification C

[0225] In the above-described embodiment, the main

space Sa and the sub-space Sb are formed in the first header 40, but the present invention is not limited thereto. For example, the first header 40 may have only a structure corresponding to the main space Sa that does not communicate with the return opening 152a and the forward opening 152b without the sub-space Sb (without a loop structure in which the refrigerant circulates).

(8-4) Modification D

[0226] In the above-described embodiment, the case where the structure for circulating the refrigerant is formed by the plurality of plate-shaped portions mainly including the fourth sub-member 140 to the sixth sub-member 160 has been described as an example.

[0227] In contrast to this, instead of the first header 40, a first header 40A that adopts a structure in which the refrigerant may circulate in one plate-shaped portion instead of a plurality of plate-shaped portions may be adopted.

[0228] Fig. 18 is an exploded perspective view of the first header 40A. Fig. 19 is a cross-sectional view of a first sub-member 110A to a sixth sub-member 160A of the first header 40A taken along the insertion direction (the first direction D1) of the flat tubes 28 with respect to the first header 40A. In Fig. 18, a two-dot chain line arrow indicates a refrigerant flow when the first heat exchanger 11 functions as an evaporator of the refrigerant.

[0229] The first header 40A includes the first sub-member 110A, the second sub-member 120A, the third sub-member 130A, the fourth sub-member 140A, the fifth sub-member 150A, and the sixth sub-member 160A.

[0230] PTL 1 (Japanese Unexamined Patent Application Publication No. 2021-12018) also discloses a structure similar to that of the first header 40A, and therefore, here, main differences from the above-described embodiment and differences between PTL 1 (Japanese Unexamined Patent Application Publication No. 2021-12018) and the present disclosure will be mainly described.

[0231] Fig. 19 is a cross-sectional view of the first sub-member 110A taken along the first direction D1 at a position where a flat tube connection opening (similar to the flat tube connection opening 112a of the first sub-member 110 according to the first embodiment) is formed in the stage direction. Since the function and structure of the first sub-member 110A are the same as those of the first sub-member 110 according to the above-described embodiment, a detailed description thereof will be omitted.

[0232] The second sub-member 120A is a flat plate-shaped member and is provided with a plurality of first openings 122Aa. Fig. 19 is a cross-sectional view of the second sub-member 120A taken along the first direction D1 at a position where the first opening 122Aa is formed in the stage direction. The plurality of first openings 122Aa is arranged side by side in the vertical direction (step direction) and penetrate the second sub-member

120A in the plate thickness direction. The plurality of first openings 122Aa is formed at positions corresponding to the flat tube connection openings 112a of the first sub-member 110A in the vertical direction (stage direction). Each of the first openings 122Aa is an opening larger than the flat tube connection opening 112a of the first sub-member 110A.

[0233] The third sub-member 130A is a flat plate-shaped member and is provided with a plurality of second openings 132Aa. Fig. 19 is a cross-sectional view of the third sub-member 130A taken along the first direction D1 at a position where the second opening 132Aa is formed in the stage direction. The plurality of second openings 132Aa is arranged side by side in the vertical direction (step direction) and penetrate the third sub-member 130A in the plate thickness direction. The plurality of second openings 132Aa is formed at the positions corresponding to the first openings 122Aa of the second sub-member 120A in the vertical direction (stage direction). The width of each of the second openings 132Aa is designed to be slightly narrower than the width of the flat tube 28. As a result, the flat tube 28 that is inserted into the flat tube connection opening 112a and passes through the first opening 122Aa comes into contact with the front surface of the third sub-member 130A. Thus, the position of the flat tube 28 may be adjusted. According to the present modification, the flat tube 28 is inserted into the space formed by the first sub-member 110A to the third sub-member 130A. In other words, according to the present modification, the first sub-member 110A to the third sub-member 130A are an example of the first member that forms the first space S1. In Fig. 18, the first member is denoted by the reference numeral "100Aa".

[0234] The fourth sub-member 140A is an example of the first plate. The fourth sub-member 140A is a flat plate-shaped member. In Fig. 18, the fourth sub-member 140A is provided, on the left side, with a plurality of flow division openings 142Aa arranged along the stage direction, which penetrate in the plate thickness direction and is provided, on a right side, with a plurality of descending-side openings 142Ab penetrating in the plate thickness direction. The function of the flow division opening 142Aa is similar to that of the flow division opening 132 in the above embodiment. The function of the descending-side opening 142Ab will be described below. Fig. 19 is a cross-sectional view of the fourth sub-member 140A taken along the first direction D1 at a position where the flow division opening 142Aa is formed and the descending-side opening 142Ab is not formed in the stage direction.

[0235] The fifth sub-member 150A is a flat plate-shaped member, and as in Fig. 18, is provided with a first penetration portion C1 corresponding to the first penetration portion 142 in the above embodiment on the left side, a return opening C2 and a forward opening C3 corresponding to the return opening 152a and the forward opening 152b in the above embodiment at the center portion in the left-right direction, and a descending opening C4 corresponding to the descending opening

162b in the above embodiment on the right side in the left-right direction. In other words, while the first penetration portion 142, the return opening 152a, the forward opening 152b, and the descending opening 162b are formed in the three sub-members in the above-described embodiment, they are formed in the fifth sub-member 150A according to the present modification. Fig. 19 is a cross-sectional view of the fifth sub-member 150A taken along the first direction D1 at a position where the first penetration portion C1 and the forward opening C3 are formed in the stage direction.

[0236] In the first header 40A, when the first heat exchanger 11 functions as an evaporator, the refrigerant flowing into an introduction portion of the first penetration portion C1 is blown up from a nozzle portion C1i (refrigerant inlet) of the first penetration portion C1, and ascends in an ascending portion (in other words, the main space Sa (the second space S2)) of the first penetration portion C1 while being divided to the flow division opening 142Aa. The refrigerant that has risen to the forward opening C3 (refrigerant outlet) without being divided to the flow division openings 142Aa passes through the forward opening C3, flows into the descending opening C4 (the sub-space Sb), and moves downward. However, the descending opening C4 does not communicate to the lower end thereof, and is a discontinuous opening. Therefore, at the discontinuous position, the refrigerant flows through the descending-side opening 142Ab provided at the corresponding position of the fourth sub-member 140A, and moves in the sub-space Sb to the communication position with the return opening C2. The refrigerant that has reached the lower end of the sub-space Sb passes through the return opening C2 and is returned to the vicinity of the refrigerant inlet (the nozzle portion C1i of the first penetration portion C1) of the main space Sa.

[0237] The sixth sub-member 160A is a member similar to the seventh sub-member 170 in the embodiment described above. A connection opening 162Ai is provided in the sixth sub-member 160A so as to penetrate in the plate thickness direction. When viewed from the back side, the connection opening 162A is provided to be overlapped with a central portion in the left-right direction of the introduction portion of the first penetration portion C1.

[0238] According to the present embodiment, the fourth sub-member 140A to the sixth sub-member 160A function as the second member that forms the second space S2. In Fig. 18, the second member is denoted by the reference numeral "100Ab". Here, the fourth sub-member 140 forms a part of the second member 100Ab and functions as the first member, but such a configuration is merely an example. The first member may be formed as a separate member from the second member 100Ab.

[0239] Also, in the first header 40A according to the present modification, when viewed along the insertion direction (the first direction D1) of the flat tube 28 with

respect to the first space S1, the flow division opening 142Aa is at least partially arranged close to one end portion 154A of the second space S2 in the width direction (the second direction D2) of the flat tube 28.

[0240] The end portion 154A of the second space S2 means the position of the inner edge portion in the left-right direction (the second direction D2) of the ascending portion of the first penetration portion C1 of the fifth sub-member 150A that forms the second space S2.

[0241] In addition, the flow division opening 142Aa being at least partially arranged close to the one end portion 154A of the second space S2 in the width direction (the second direction D2) of the flat tube 28 means that a part of the flow division opening 142Aa is present in a range of the length L in a direction approaching the other end portion 154A from the one end portion 154A in the second direction D2.

[0242] Also in this case, the discloser of this application has found that the above-described uneven flow may be suppressed by at least partially providing the flow division opening 142Aa between the end portion 154A of the second space S2 and the position of a width by 15% of the width W2 inside the second space S2 from the end portion 154A in the second direction D2 (by setting the above-described length L to 15% of the width W2). In other words, it has been found that the above-described uneven flow is easily suppressed by, in the second direction D2, overlapping at least a part of a region between the end portion 154A of the second space S2 and the position of a width by 15% of the width W2 inside the second space S2 from the end portion 154A with at least a part of the flow division opening 142Aa. Further, the discloser of this application has found that the above-described uneven flow is easily suppressed in particular by at least partially providing the flow division opening 142Aa between the end portion 154A of the second space S2 and the position of a width by 10% of the width W2 inside the second space S2 from the end portion 154A in the second direction D2 (by setting the length L to 10% of the width W2).

[0243] An arrangement example of the flow division opening 142Aa will be described with reference to FIGS. 20 to 22.

[0244] Fig. 20 is a schematic view of the inside of the first header 40A viewed in the longitudinal direction of the first header 40A (a schematic view from above), and depicts a first example of the arrangement state of the first space S1, the second space S2, and the flow division opening 142Aa of the fourth sub-member 140. Fig. 21 is a schematic view of the inside of the first header 40A viewed in the longitudinal direction of the first header 40A (a schematic view from above), and depicts a second example of the arrangement state of the first space S1, the second space S2, and the flow division opening 142Aa of the fourth sub-member 140. Fig. 22 is a schematic view of the inside of the first header 40A viewed in the longitudinal direction of the first header 40A (a schematic view from above), and depicts a third example of

the arrangement state of the first space S1, the second space S2, and the flow division opening 142Aa of the fourth sub-member 140.

[0245] In FIGS. 20 to 22, a portion hatched with rising diagonal lines from bottom left to top right represents the second space S2, a portion hatched with falling diagonal lines from top left to bottom right represents the first space S1, and a portion hatched with dots represents the position of the flow division opening 132.

[0246] In the example of Fig. 20 (also illustrated in Fig. 19), when viewed along the first direction D1, the flow division opening 142Aa is overlapped with both the end portions 154A of the second space S2 in the second direction D2, and the width of the flow division opening 142Aa in the second direction D2 is equal to or more than the width of the second space S2 in the second direction D2.

[0247] In the example of Fig. 21, when viewed along the first direction D1, the flow division opening 142Aa is arranged close to both the end portions 154A of the second space S2 in the second direction D2. For example, in the second example, in the second direction D2, the flow division opening 142Aa is at least partially arranged between both the end portions 154A of the second space S2 and the positions of a width by 15% of the width W2 inside the second space S2 from the respective end portions 154A.

[0248] In the example of Fig. 22, there is the plurality of (for example, two in the example of Fig. 17) flow division openings 142Aa that allows the second space S2 and the one first space S1 to communicate with each other. In the example of Fig. 22, when viewed along the first direction D1, each of the flow division openings 142Aa is partially overlapped with the one end portion 154A of the second space S2 in the second direction D2. In other words, the pair of flow division openings 142Aa is partially overlapped with both the end portions 154A in the second direction D2.

[0249] As in the above-described embodiment, there are various modifications for the arrangement of the flow division opening 142Aa.

[0250] Although the embodiment according to the present disclosure has been described above, it is understood that various modifications may be made to forms and details without departing from the spirit and scope of the present disclosure described in the scope of claims.

REFERENCE SIGNS LIST

[0251]

- 1 AIR CONDITIONING APPARATUS (REFRIGERATION CYCLE APPARATUS)
- 8 COMPRESSOR
- 11 FIRST HEAT EXCHANGER (HEAT EXCHANGER, EVAPORATOR)
- 11A FIRST HEAT EXCHANGER (HEAT EXCHANGER, EVAPORATOR)

11B FIRST HEAT EXCHANGER (HEAT EXCHANGER, EVAPORATOR)

12 FIRST EXPANSION MECHANISM (EXPANSION DEVICE)

28 FLAT TUBE

31a SECOND EXPANSION MECHANISM (EXPANSION DEVICE)

31b SECOND EXPANSION MECHANISM (EXPANSION DEVICE)

32a SECOND HEAT EXCHANGER (RADIATOR)

32b SECOND HEAT EXCHANGER (RADIATOR)

40 FIRST HEADER (HEADER)

42Aa PORTION (FIRST PORTION)

42Ab PORTION (FIRST PORTION)

42Bb PORTION (FIRST PORTION)

42Bc PORTION (FIRST PORTION)

70Ba PORTION (FIRST PORTION)

70Bb PORTION (FIRST PORTION)

70 SECOND HEADER (HEADER)

100a FIRST MEMBER

100b SECOND MEMBER

100Aa FIRST MEMBER

100Ab SECOND MEMBER

130 THIRD SUB-MEMBER (FIRST PLATE)

132 FLOW DIVISION OPENING (OPENING)

140A FOURTH SUB-MEMBER (FIRST PLATE)

142b NOZZLE PORTION (REFRIGERANT INLET OF MAIN SPACE)

142Aa FLOW DIVISION OPENING (OPENING)

144 END PORTION

152b FORWARD OPENING (REFRIGERANT OUTLET OF MAIN SPACE)

154A END PORTION

C1i NOZZLE PORTION (REFRIGERANT INLET OF MAIN SPACE)

C3 FORWARD OPENING (REFRIGERANT OUTLET OF MAIN SPACE)

D1 FIRST DIRECTION (INSERTION DIRECTION)

D2 SECOND DIRECTION (WIDTH DIRECTION)

S1 FIRST SPACE

S2 SECOND SPACE

Sa MAIN SPACE

Sb SUB-SPACE

W1 WIDTH OF FIRST SPACE

W2 WIDTH OF SECOND SPACE (FIRST WIDTH)

Wo WIDTH OF FLOW DIVISION OPENING IN THICKNESS DIRECTION OF FLAT TUBE

CITATION LIST

PATENT LITERATURE

[0252] PTL 1: Japanese Unexamined Patent Application Publication No. 2021-12018

Claims

1. A heat exchanger (11, 11A, 11B) comprising:
 - a plurality of flat tubes (28); and
 - a header (40, 40A, 40B, 70B) including a first member (100a, 100Aa) forming a plurality of first spaces (S1) into which the flat tubes are inserted, a second member (100b, 100Ab) forming a second space (S2) into which a refrigerant flows, and a first plate (130, 140A) provided between the first space and the second space, wherein
 - the first plate is provided with an opening (132, 142Aa) that allows the first space and the second space to communicate with each other and passes the refrigerant flowing from the second space into the first space, and
 - when viewed along an insertion direction (D1) of the flat tube with respect to the first space, the opening is arranged, at least partially, close to one end portion (144, 154A) of the second space in a width direction (D2) of the flat tube.
2. The heat exchanger according to claim 1, wherein when viewed along the insertion direction, the opening is arranged, at least partially, close to both end portions of the second space in the width direction.
3. The heat exchanger according to claim 1 or 2, wherein
 - a width of the second space is a first width (W2), and
 - in the width direction, the opening is arranged, at least partially, between an end portion of the second space and a position by 15% of the first width inside the second space from the end portion.
4. The heat exchanger according to any one of claims 1 to 3, wherein when viewed along the insertion direction, the opening partially overlaps with one end portion of the second space in the width direction.
5. The heat exchanger according to claim 4, wherein when viewed along the insertion direction, the opening partially overlaps with both the end portions of the second space in the width direction.
6. The heat exchanger according to claim 5, wherein when viewed along the insertion direction, the opening overlaps with the entire second space in the width direction.
7. The heat exchanger according to any one of claims 1 to 6, wherein
 - the second member forms
 - a main space (Sa) which includes a refrigerant inlet (142b, C1i) and a refrigerant outlet (152b, C3) and in which the refrigerant moves from the refrigerant inlet to the refrigerant outlet, and
 - a sub-space (Sb) that guides the refrigerant having reached the refrigerant outlet of the main space to a vicinity of the refrigerant inlet of the main space, and
 - the opening communicates with the main space as the second space.
8. The heat exchanger according to any one of claims 1 to 7, wherein a width (W1) of the first space is larger than a width (W2) of the second space in the width direction.
9. The heat exchanger according to any one of claims 1 to 8, wherein a width (Wo) of the opening is equal to or more than 1 mm in a thickness direction of the flat tube.
10. The heat exchanger according to any one of claims 1 to 9, wherein
 - one of the flat tube is inserted into each of the first spaces, and
 - one or more of the openings are provided for each of the first spaces.
11. The heat exchanger (11A, 11B) according to any one of claims 1 to 10, wherein
 - the plurality of flat tubes includes at least a first flat tube and a plurality of second flat tubes, in the heat exchanger, the refrigerant having flown through the first flat tube passes through a first portion (42Aa, 42Ab, 42Bb, 42Bc, 70Ba, 70Bb) of the header, into which the plurality of second flat tubes is inserted, and flows into the plurality of second flat tubes, and
 - at least in the first portion of the header, when viewed along the insertion direction, the opening is arranged, at least partially, close to one end portion of the second space in the width direction.
12. A refrigeration cycle apparatus (1) comprising:
 - the heat exchanger (11, 11A, 11B) according to any one of claims 1 to 11 configured to function as an evaporator;
 - a compressor (8) configured to compress the refrigerant;
 - a radiator (32a, 32b) configured to cool the refrigerant discharged from the compressor; and
 - an expansion device (12, 31a, 31b) configured

to expand the refrigerant flowing out of the radiator to the heat exchanger.

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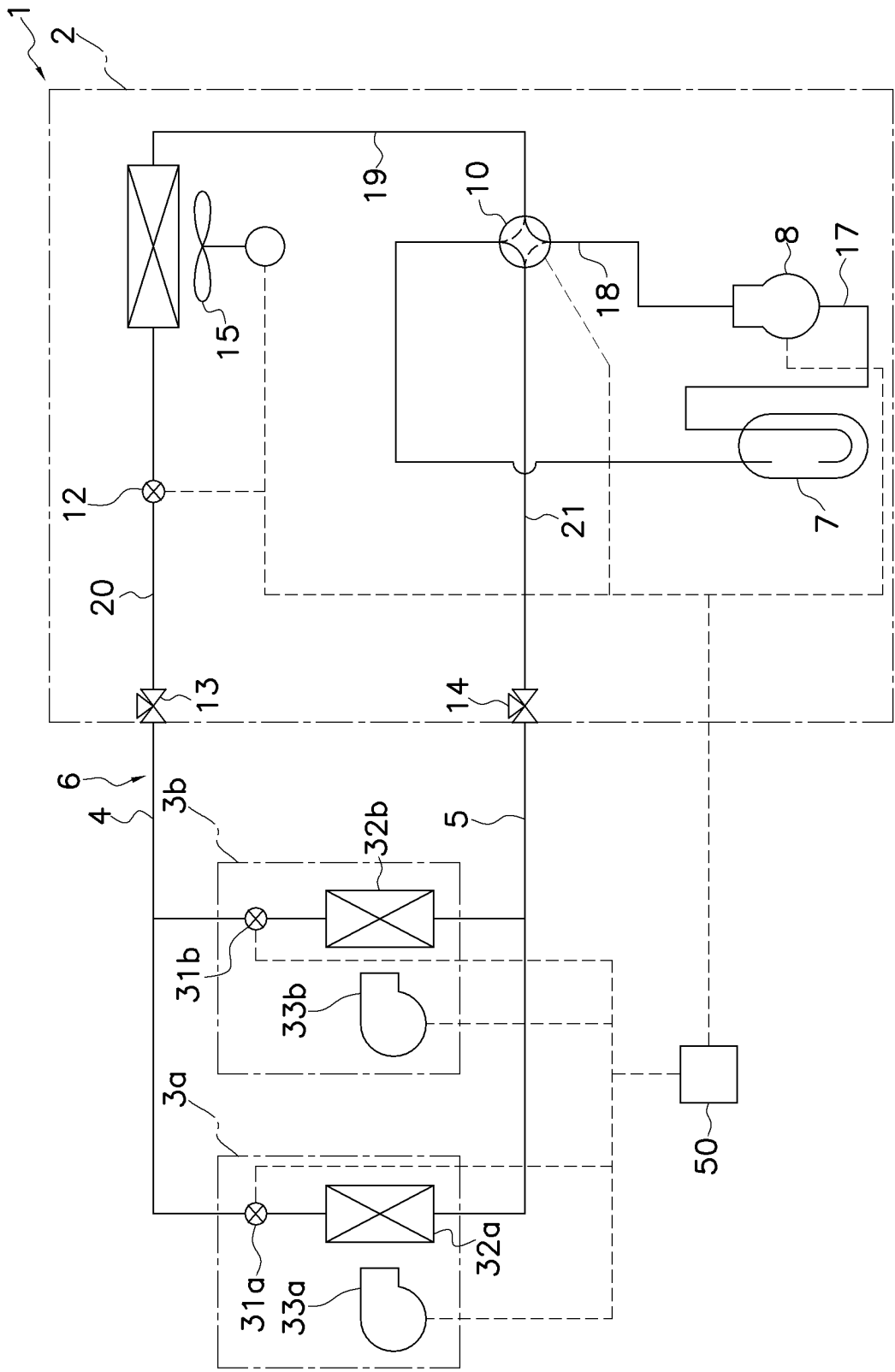


FIG. 1

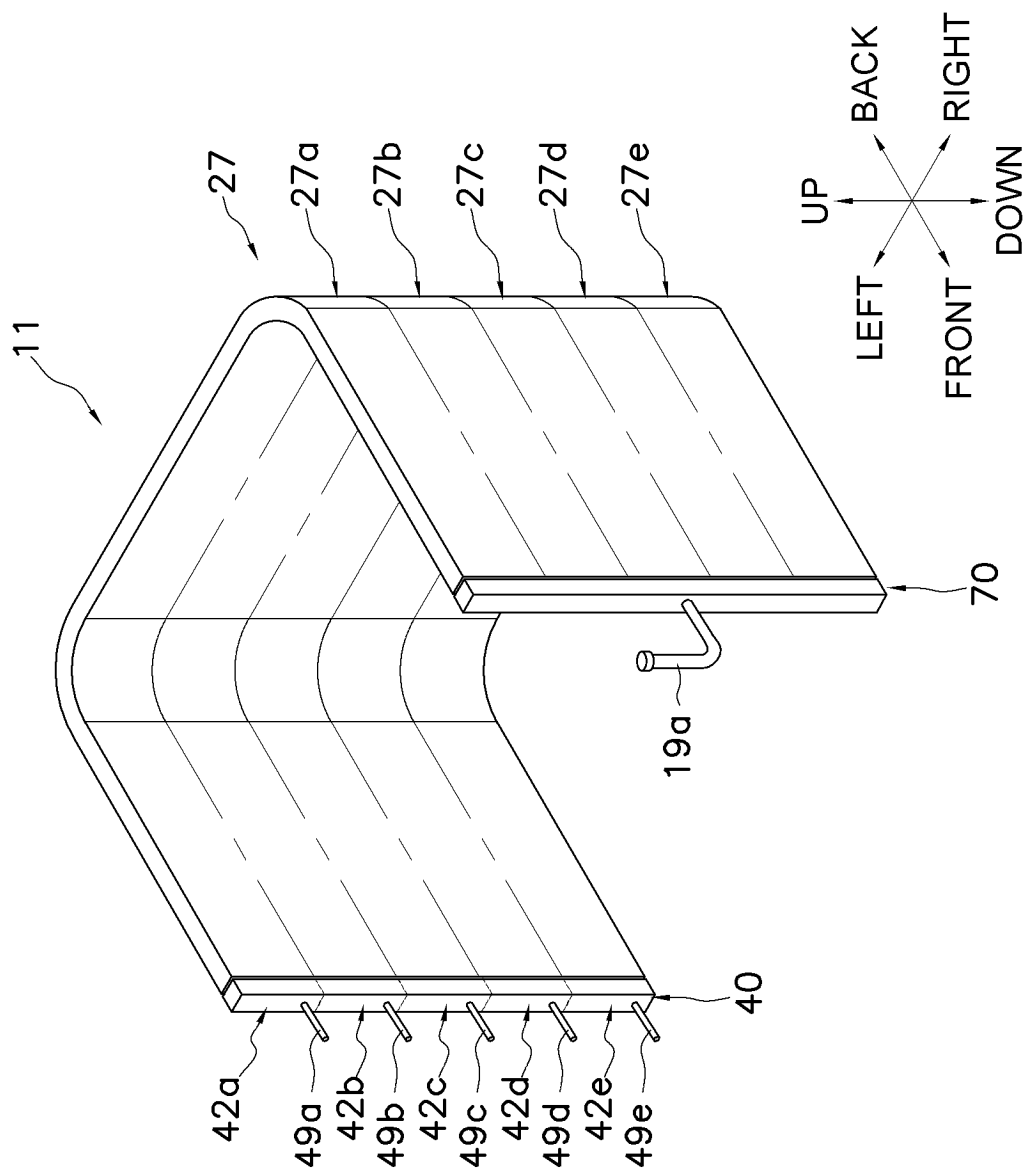


FIG. 2

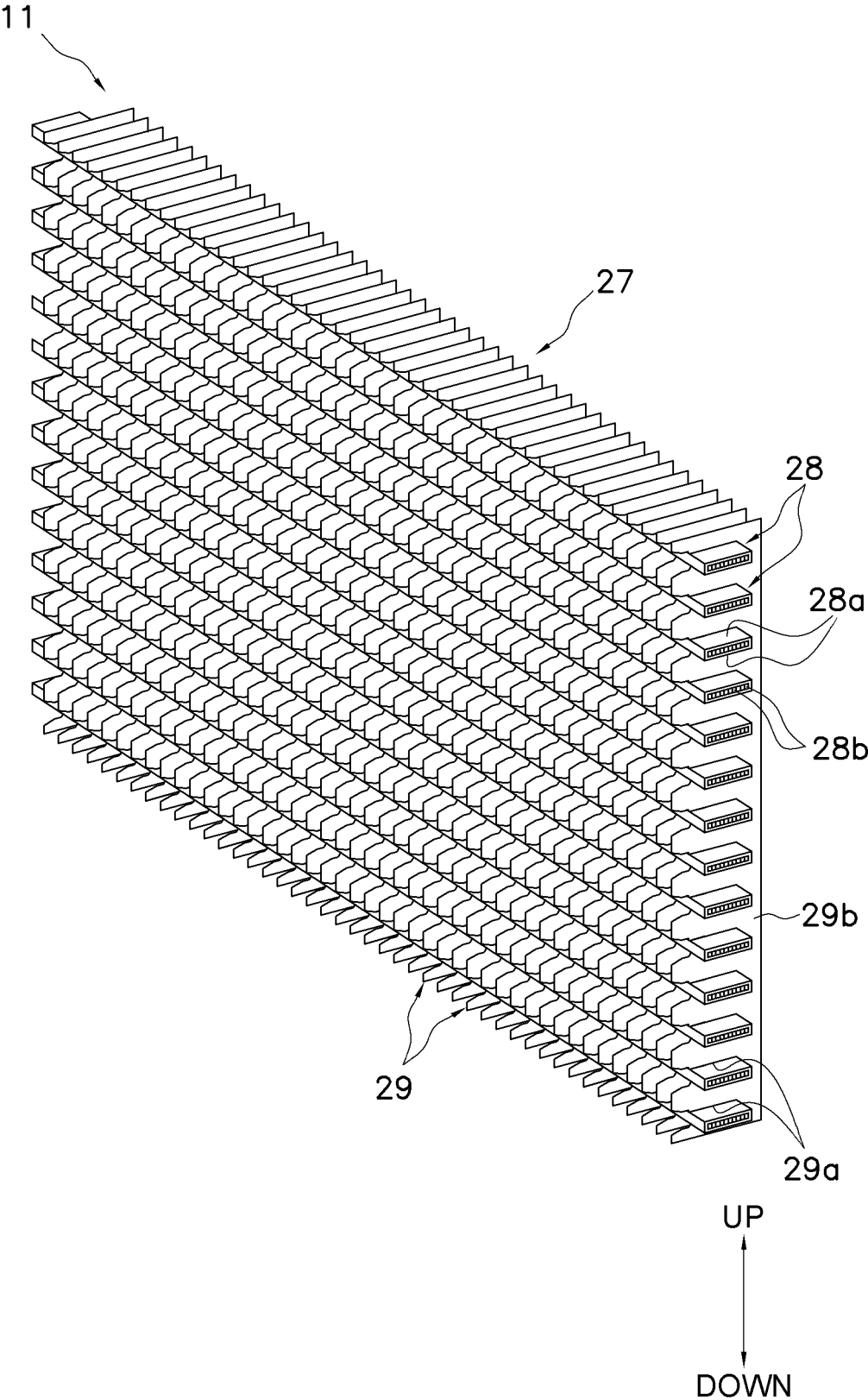


FIG. 3

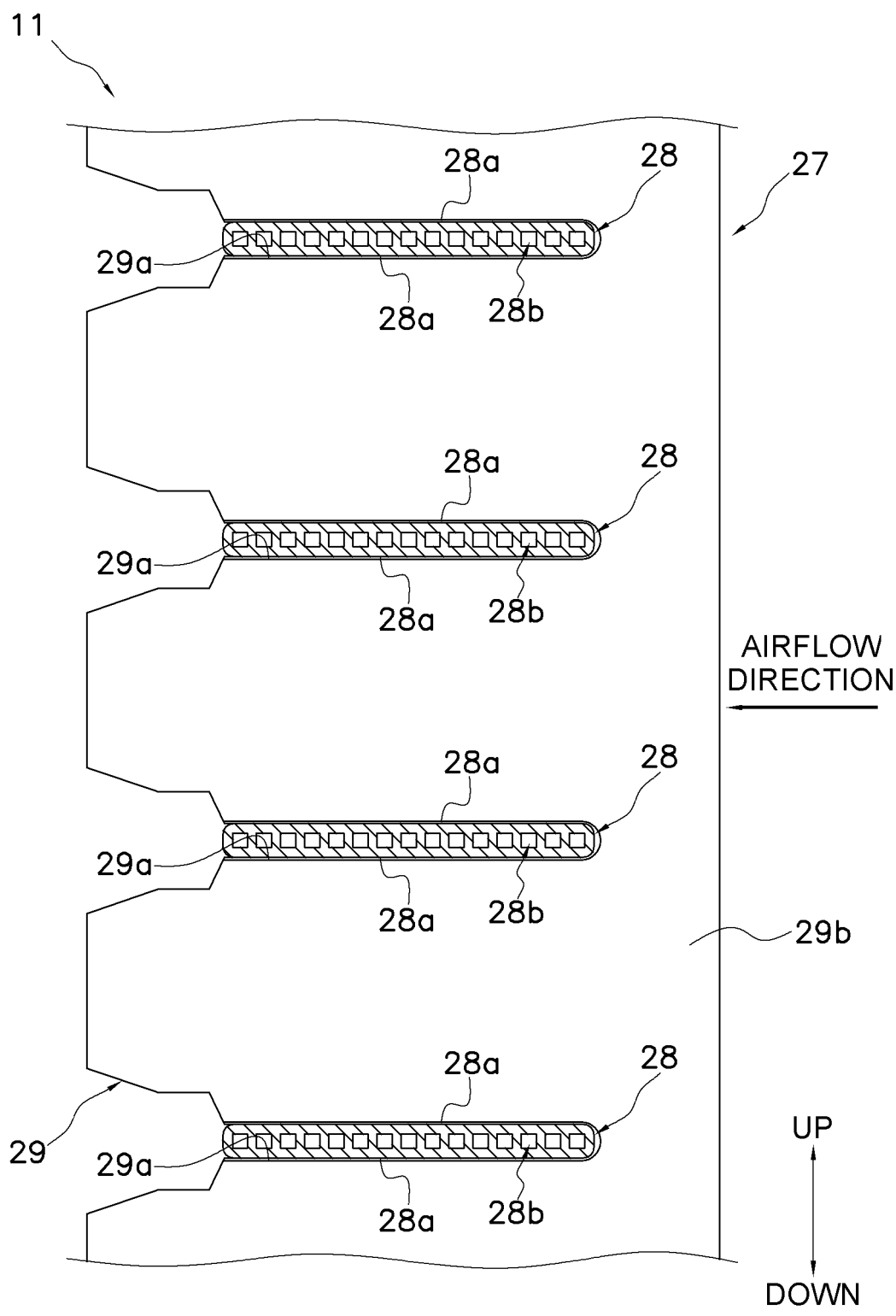


FIG. 4

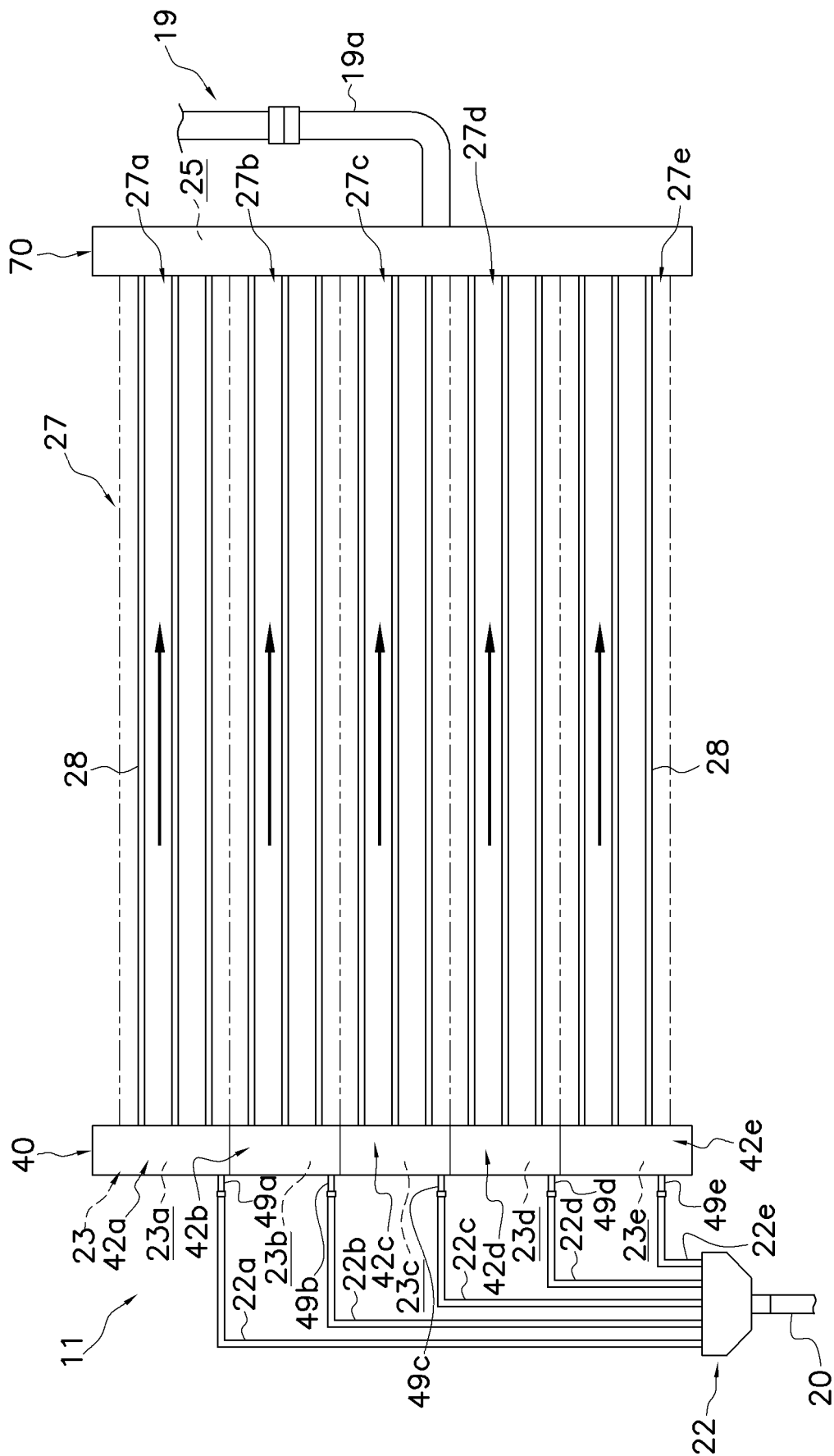


FIG. 5

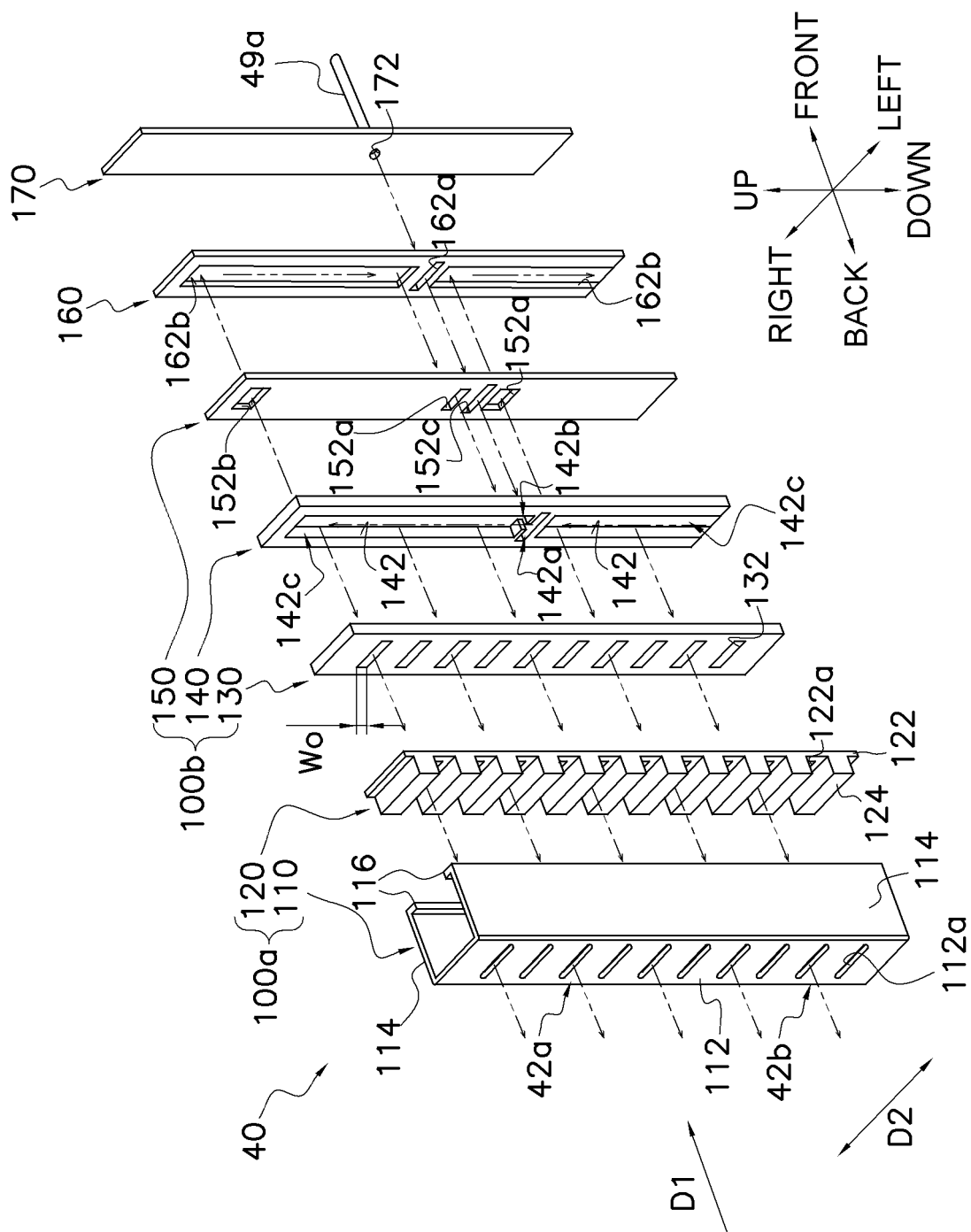


FIG. 6

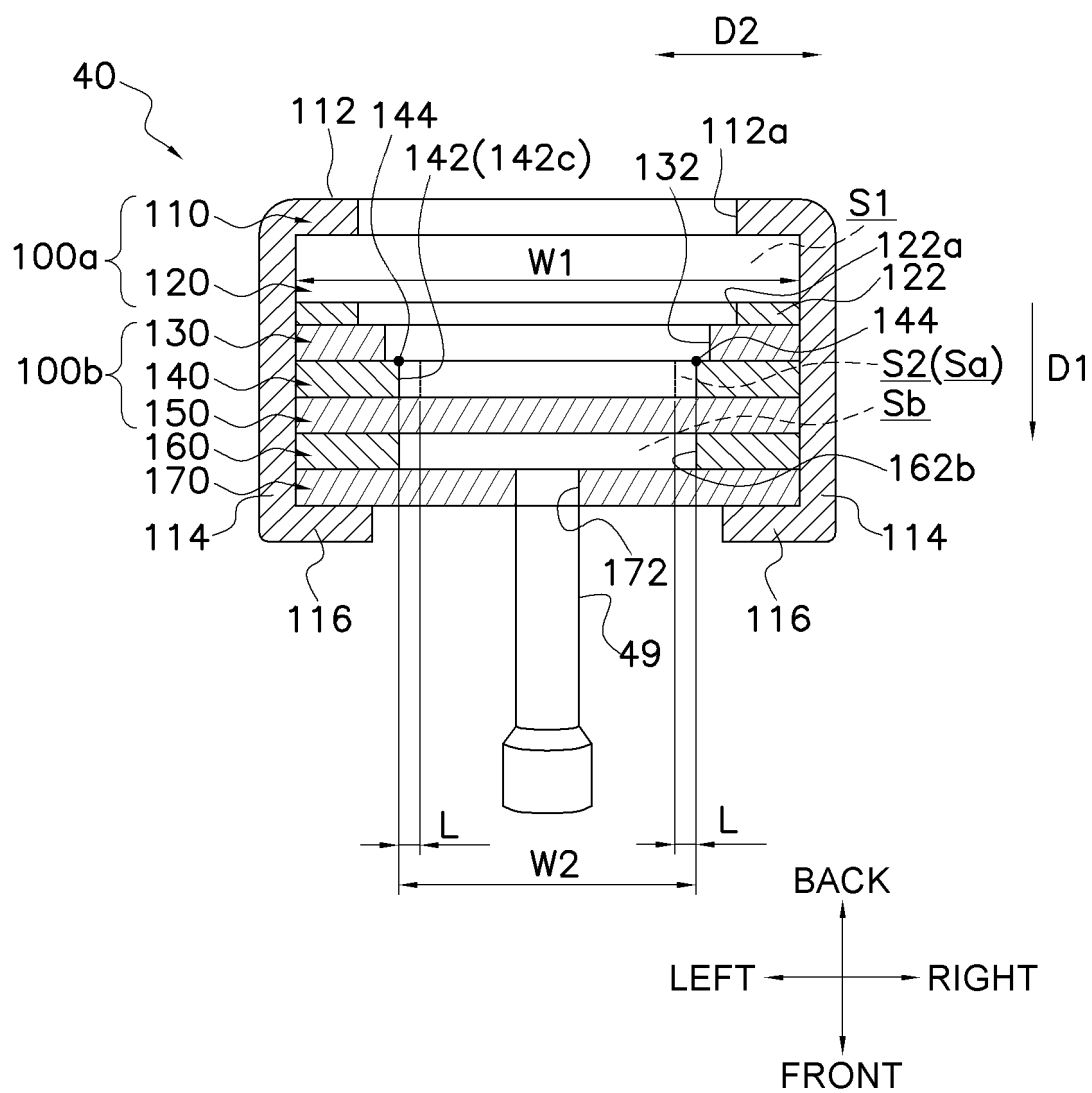


FIG. 7

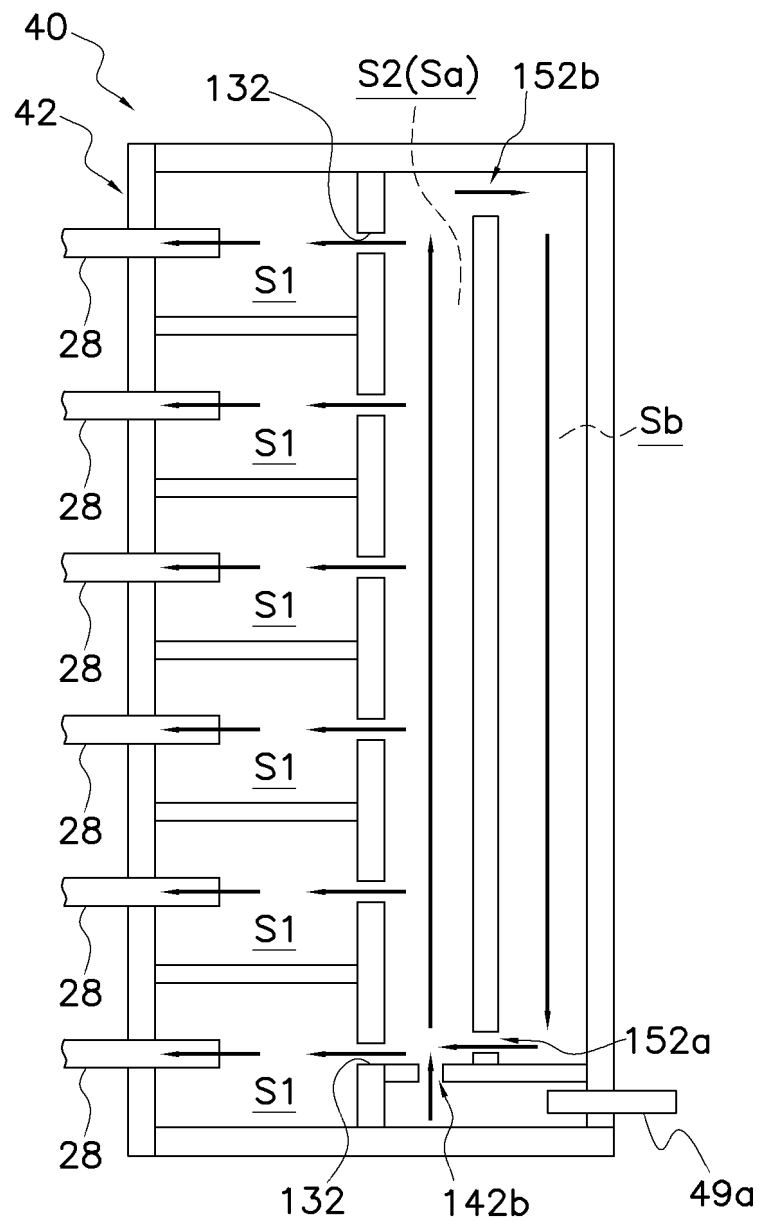


FIG. 8

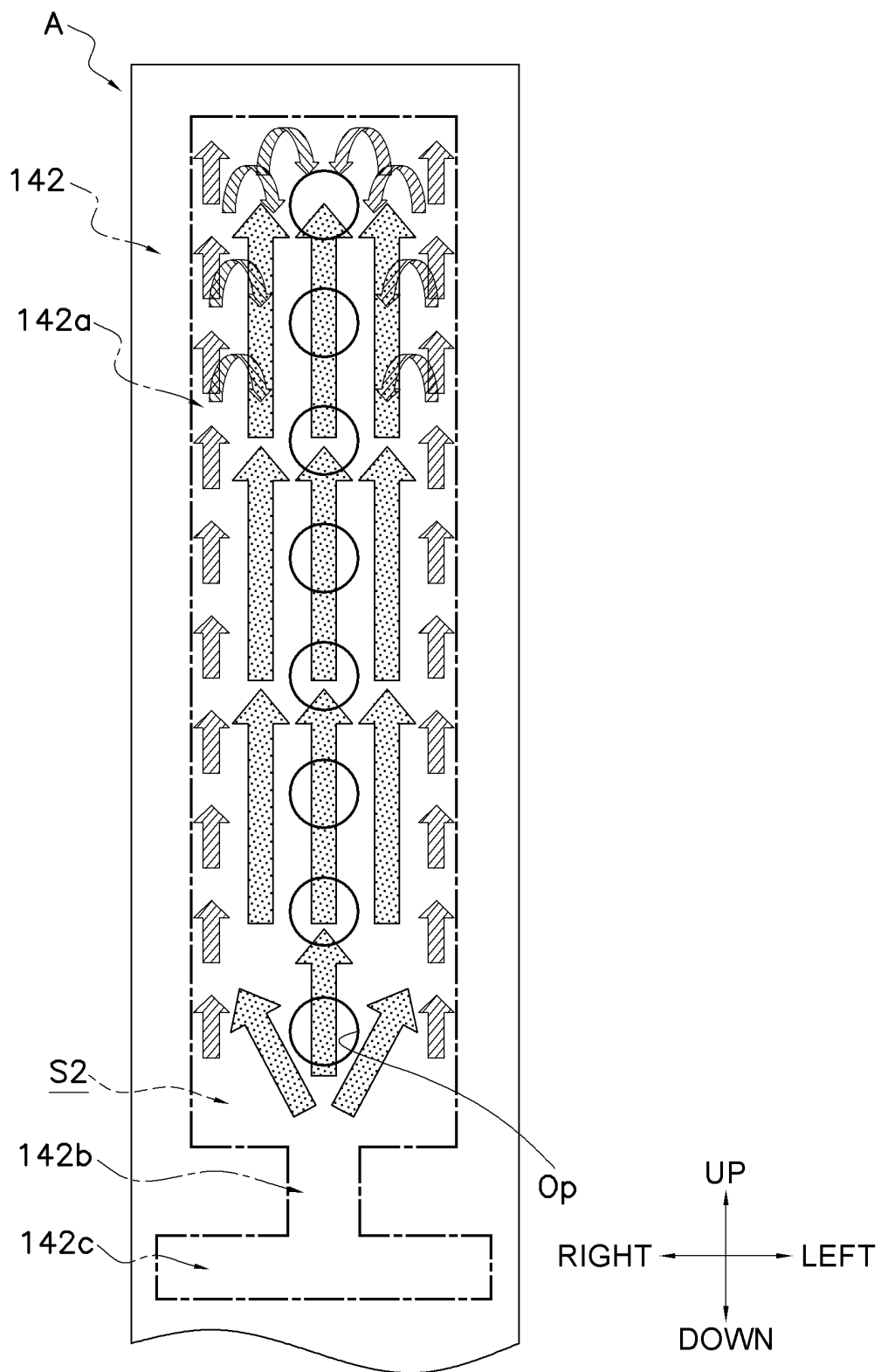


FIG. 9

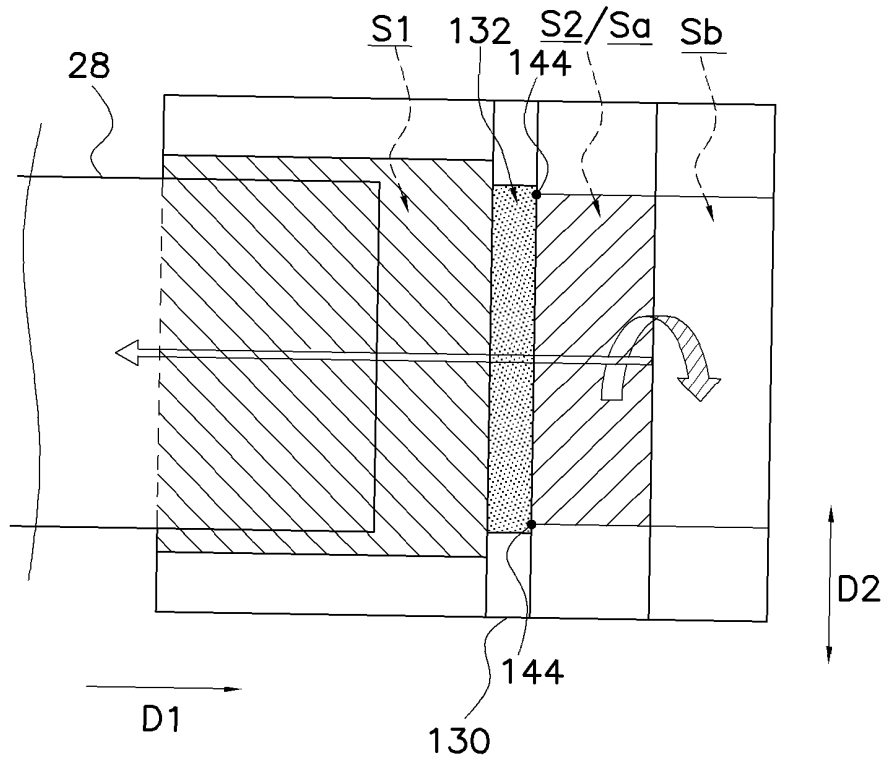


FIG. 10

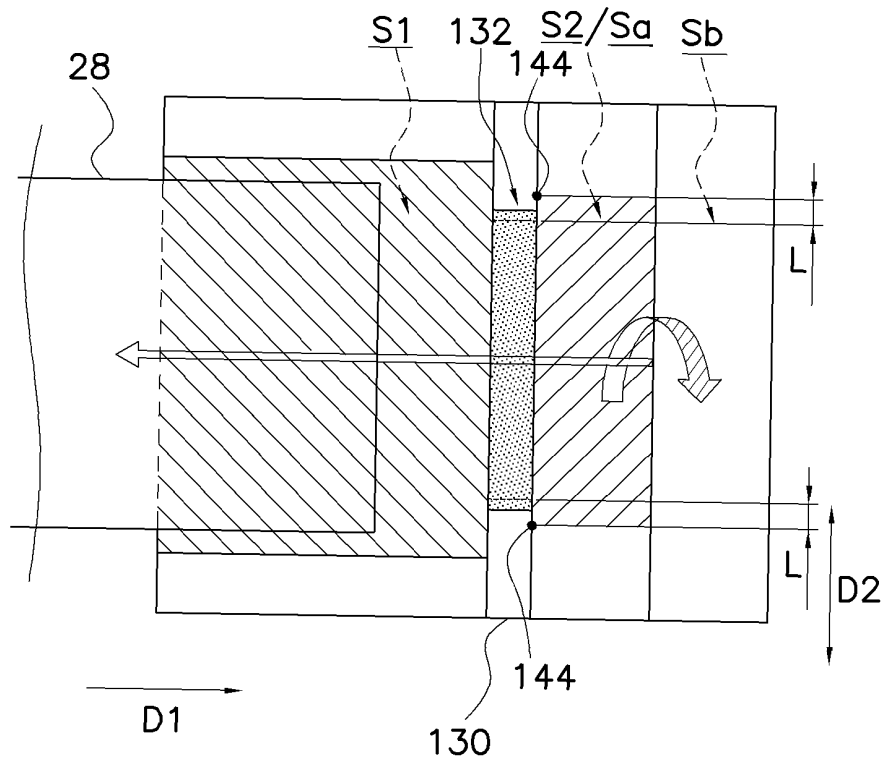


FIG. 11

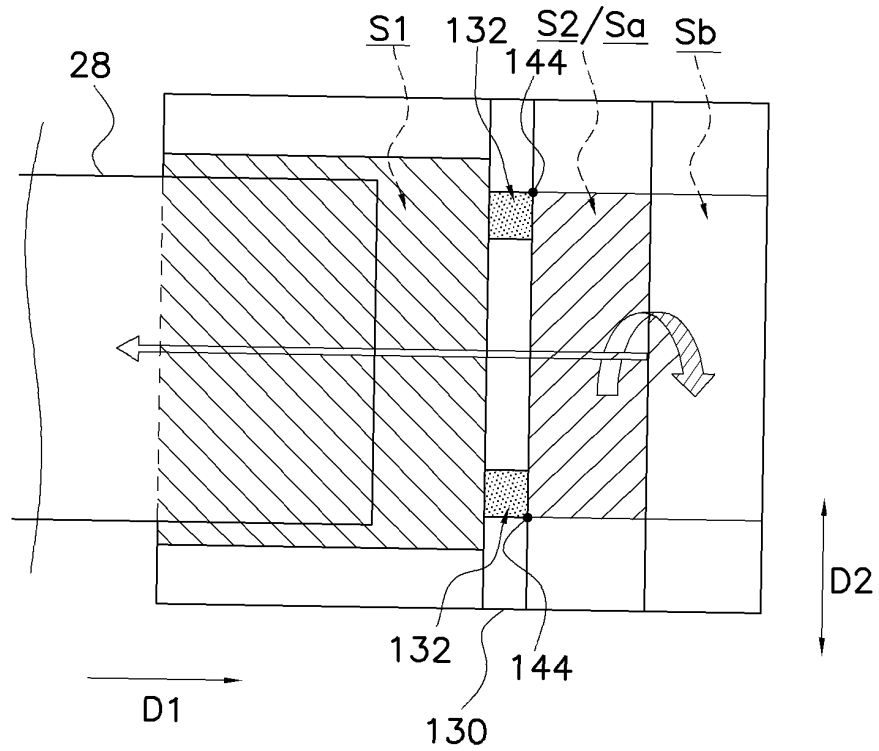


FIG. 12

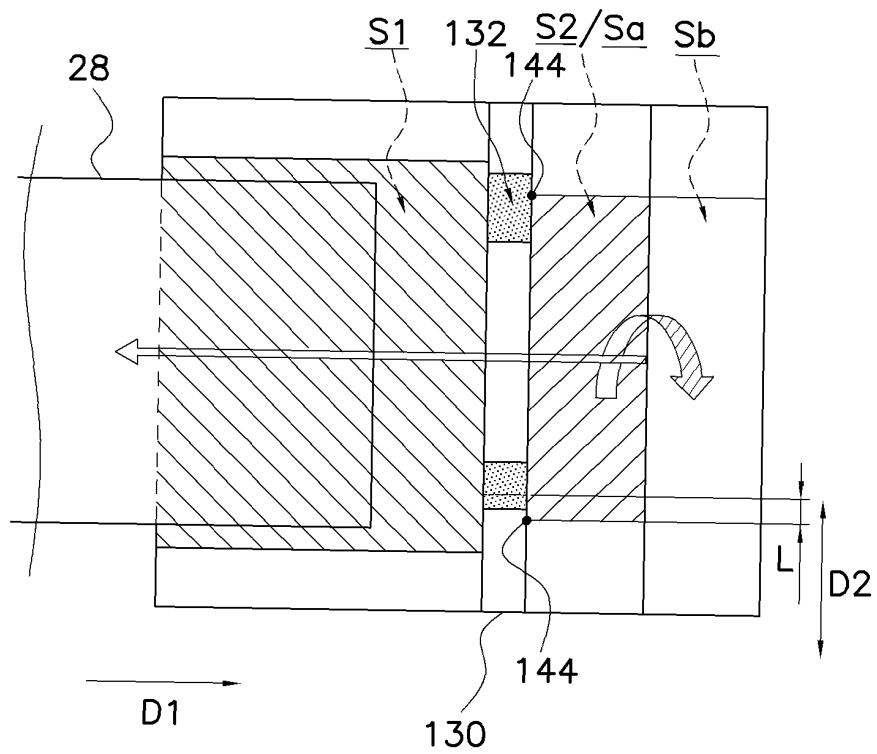


FIG. 13

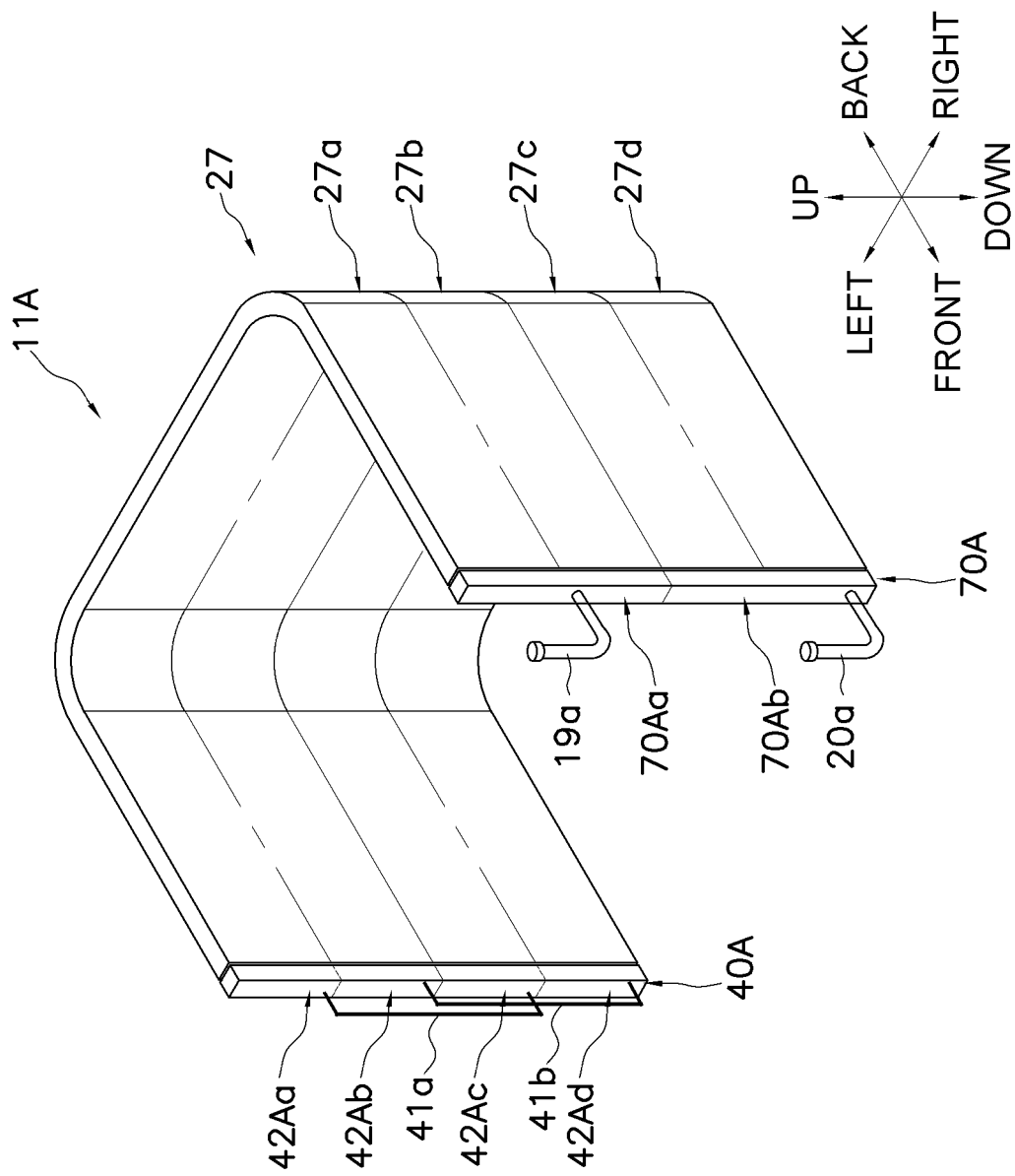


FIG. 14

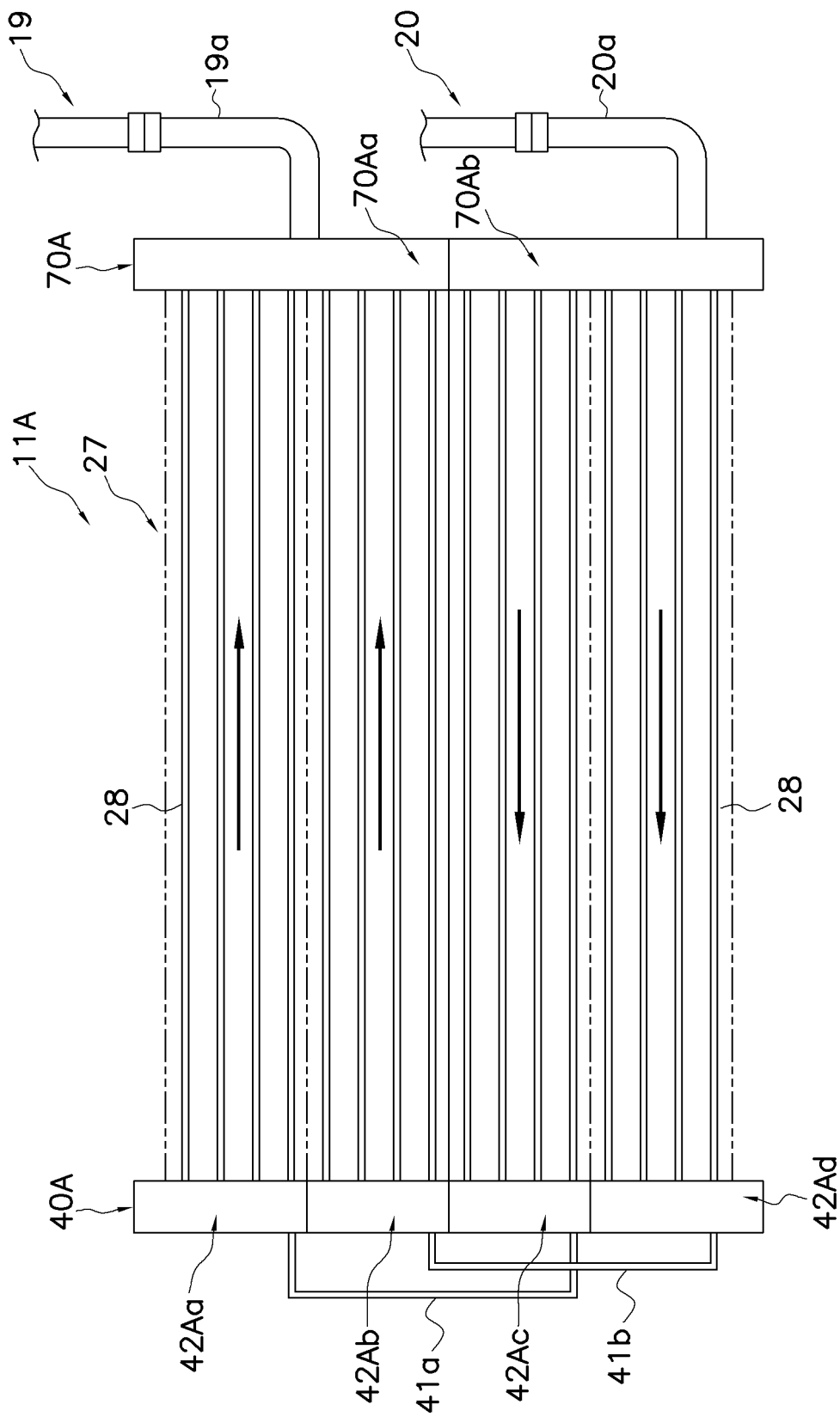


FIG. 15

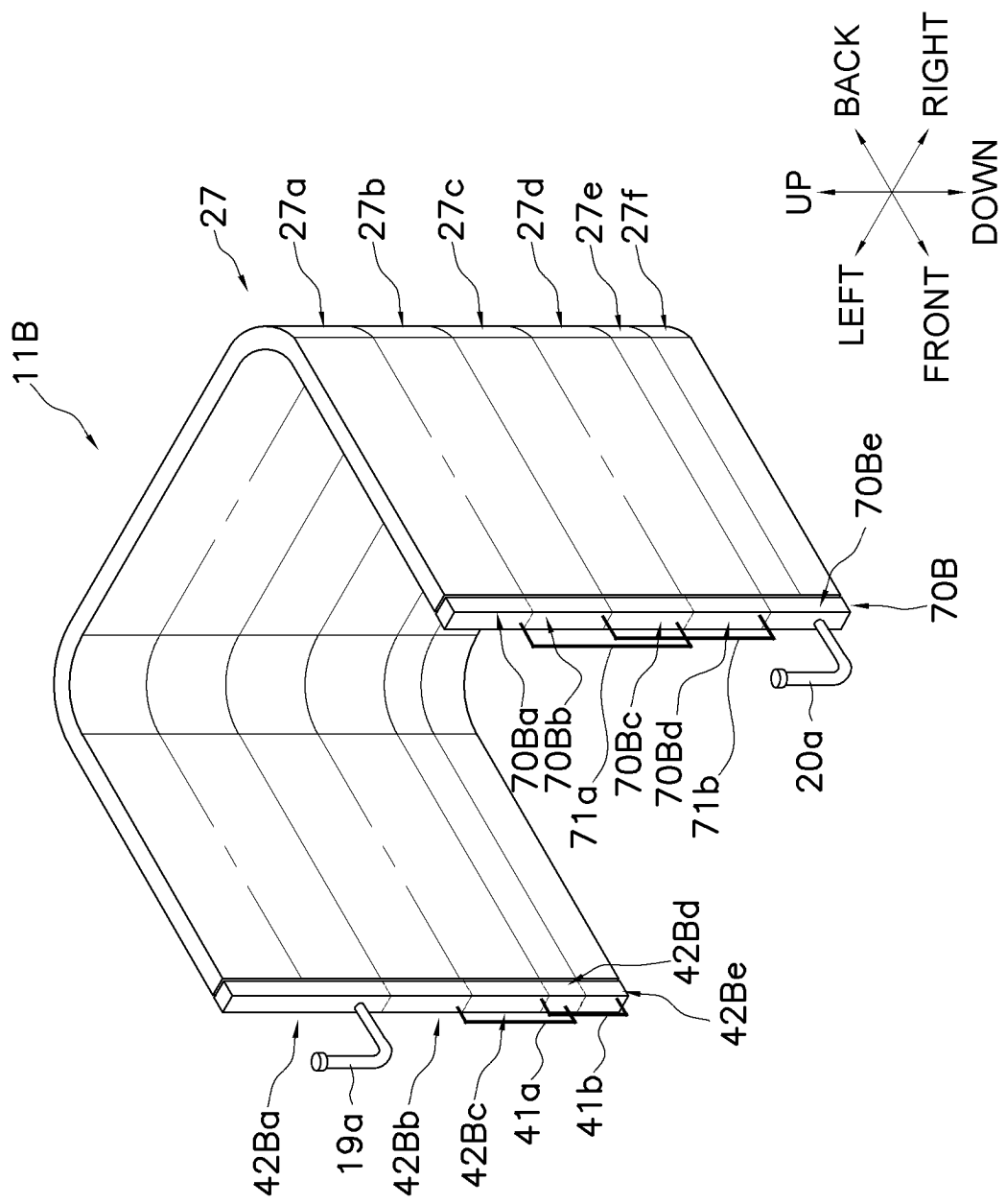


FIG. 16

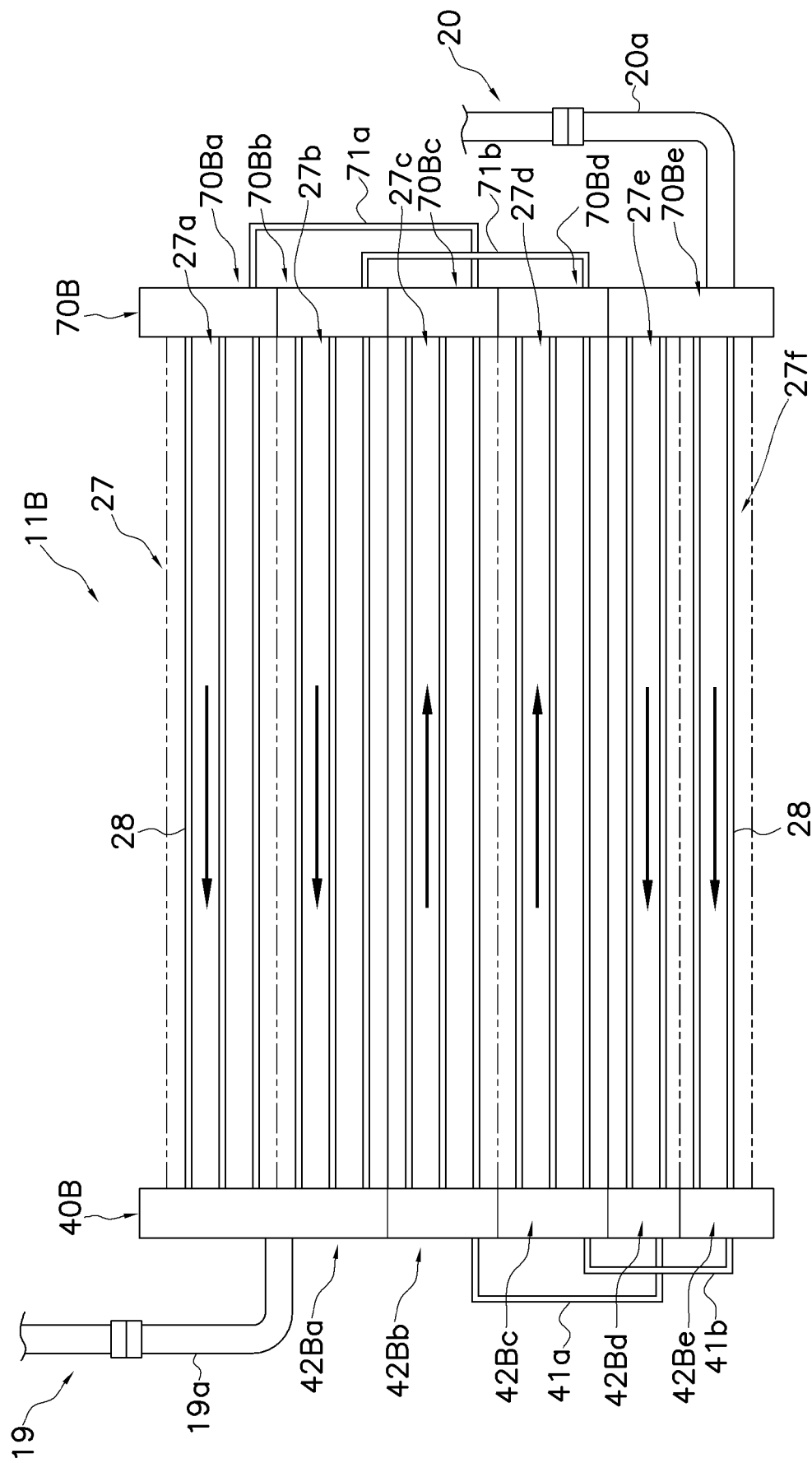


FIG. 17

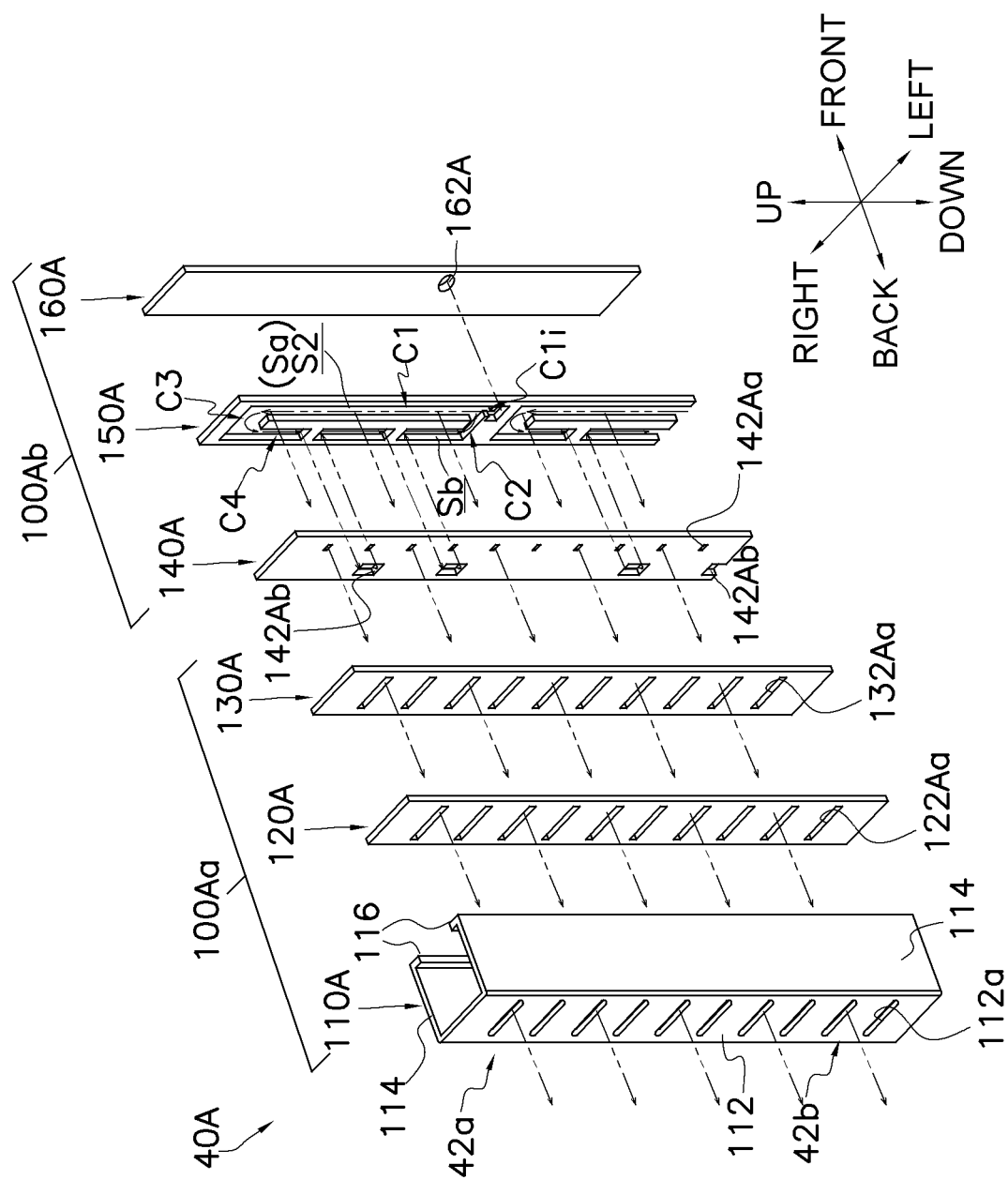


FIG. 18

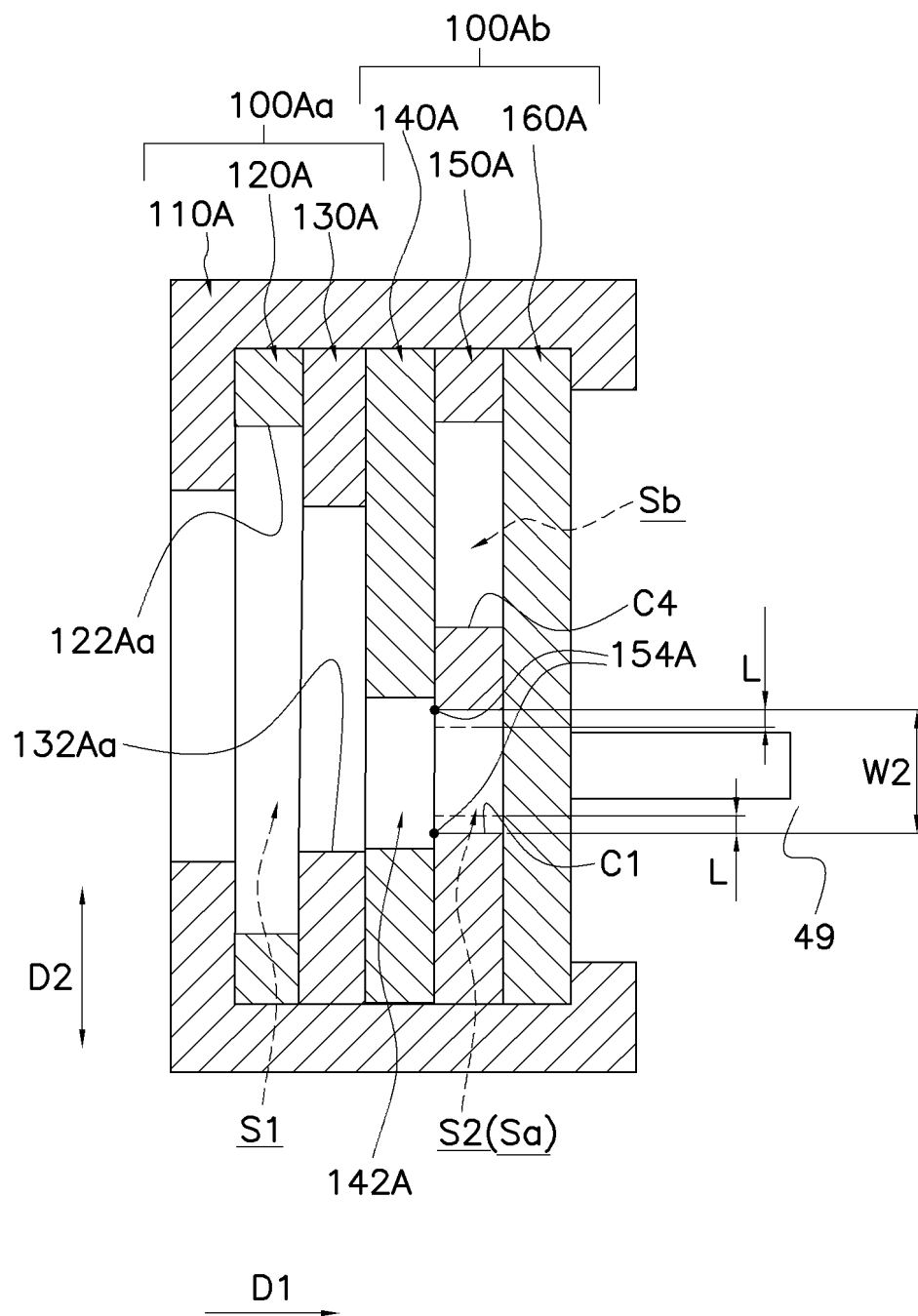


FIG. 19

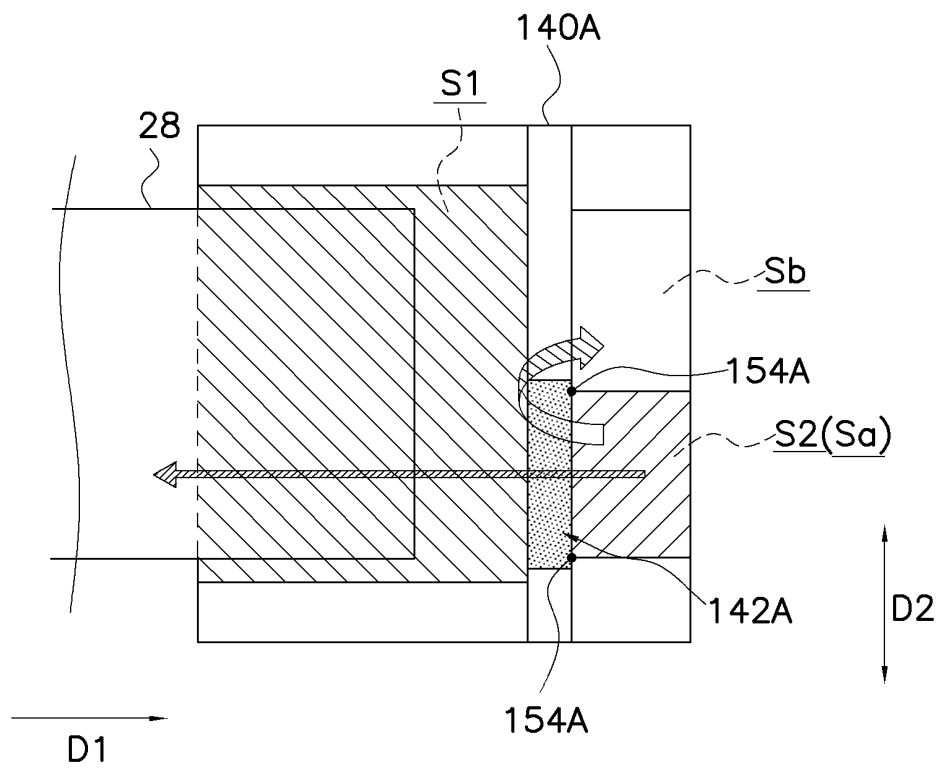


FIG. 20

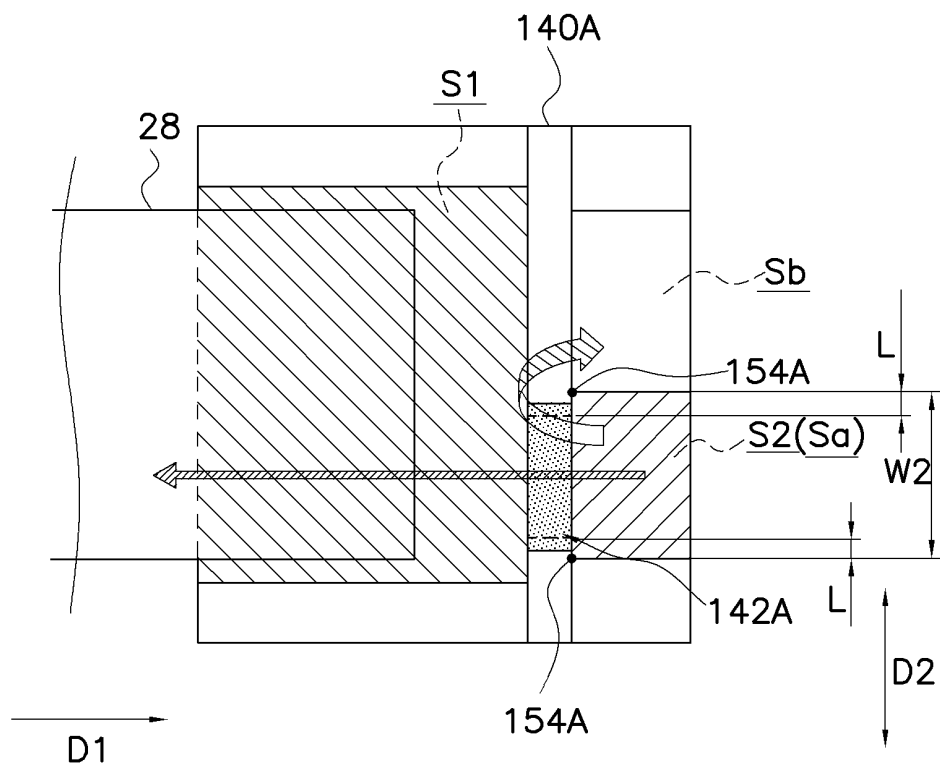


FIG. 21

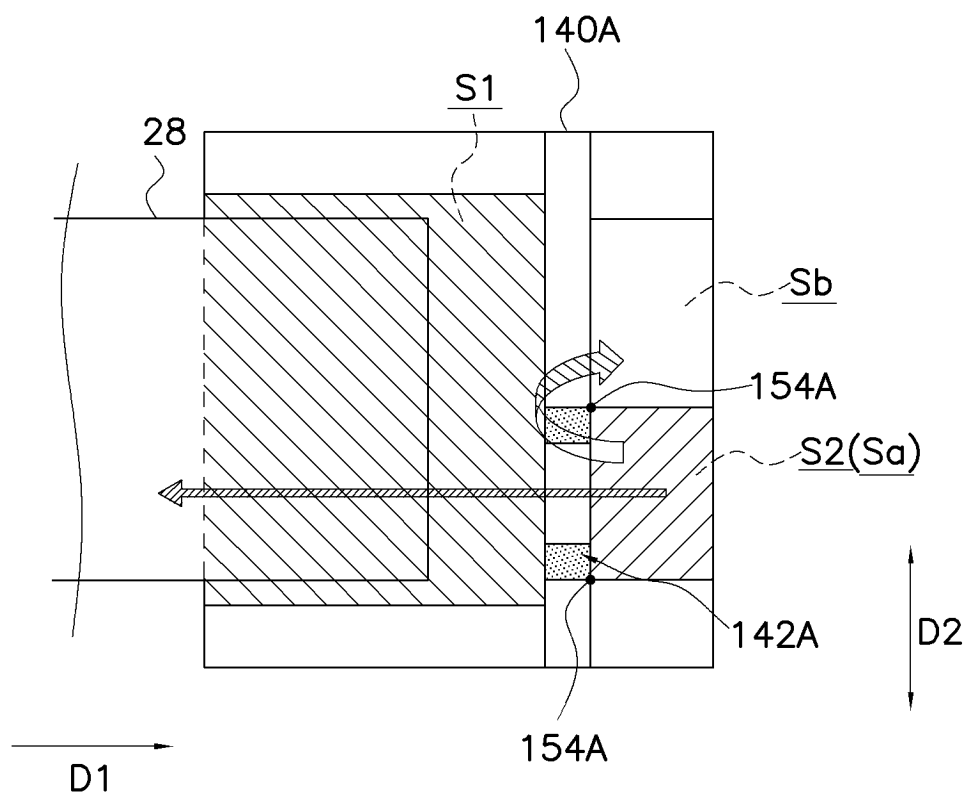


FIG. 22

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/009039

A. CLASSIFICATION OF SUBJECT MATTER

F28F 9/02(2006.01)i; **F24F 1/14**(2011.01)i; **F24F 1/0067**(2019.01)i; **F25B 39/02**(2006.01)i; **F28D 1/047**(2006.01)i;
F28F 9/22(2006.01)i

FI: F28F9/02 301J; F24F1/0067; F24F1/14; F25B39/02 G; F28D1/047 Z; F28F9/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F9/02; F24F1/14; F24F1/0067; F25B39/02; F28D1/047; F28F9/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2024
 Registered utility model specifications of Japan 1996-2024
 Published registered utility model applications of Japan 1994-2024

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020/066462 A1 (DAIKIN INDUSTRIES, LTD.) 02 April 2020 (2020-04-02) paragraphs [0033]-[0083], fig. 1-13	1-6, 8-10, 12
Y		7, 11
Y	JP 2021-8974 A (DAIKIN INDUSTRIES, LTD.) 28 January 2021 (2021-01-28) paragraphs [0193]-[0291], fig. 31-45	7
Y	WO 2020/203589 A1 (DAIKIN INDUSTRIES, LTD.) 08 October 2020 (2020-10-08) paragraphs [0090]-[0091], fig. 5-6	11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 10 May 2024	Date of mailing of the international search report 21 May 2024
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/009039

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				EP	3839404	A1	
				CN	112752944	A	

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				WO	2020/262666	A1	
				EP	3992549	A1	
				CN	114041033	A	JP
				JP	2021-17908	A	

WO	2020/203589	A1	08 October 2020	JP	2020-165644	A	

REFERENCES CITED IN THE DESCRIPTION

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- JP 2021012018 A [0002] [0003] [0004] [0230] [0252]