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(54) REFRIGERANT EVAPORATOR

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(57) **ABSTRACT**

A refrigerant evaporator includes: a first heat exchange part in which refrigerant flows; a second heat exchange part in which the refrigerant flows; a first tank arranged below the first heat exchange part to distribute the refrigerant to the first heat exchange part; a second tank arranged below the second heat exchange part to collect the refrigerant flowing through the second heat exchange part; and a third tank joined to the first tank and the second tank to introduce the refrigerant collected by the second tank to the first tank. A clearance is defined among the first tank, the second tank, and the third tank. At least one of a joint portion between the first tank and the third tank and a joint portion between the second tank and the third tank defines a drainage passage to discharge water trapped in the clearance.

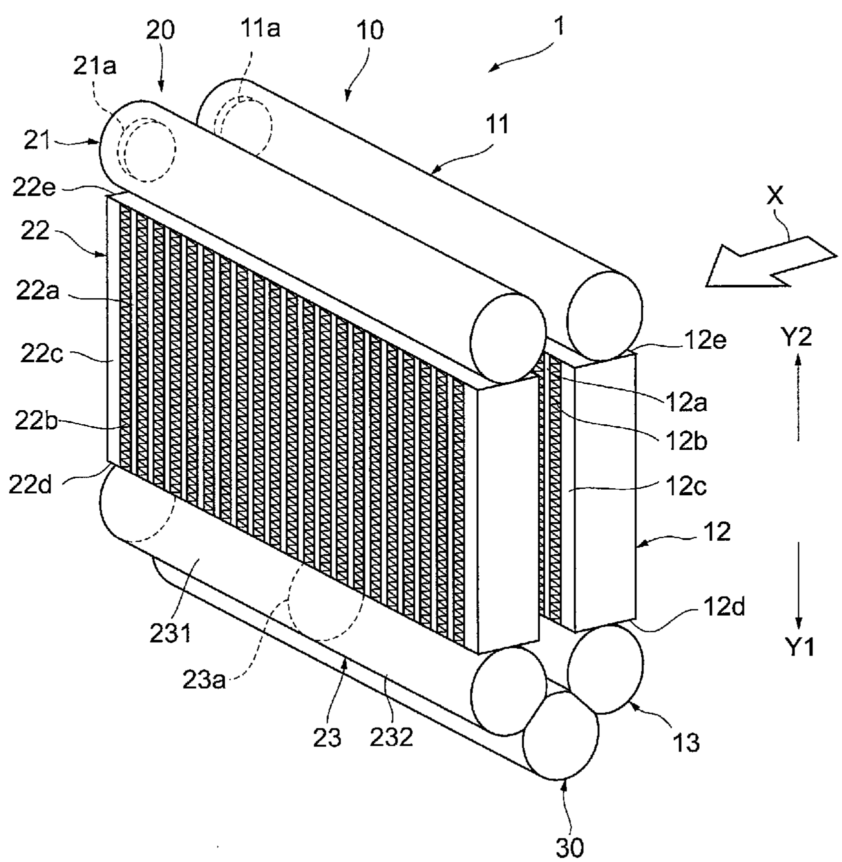
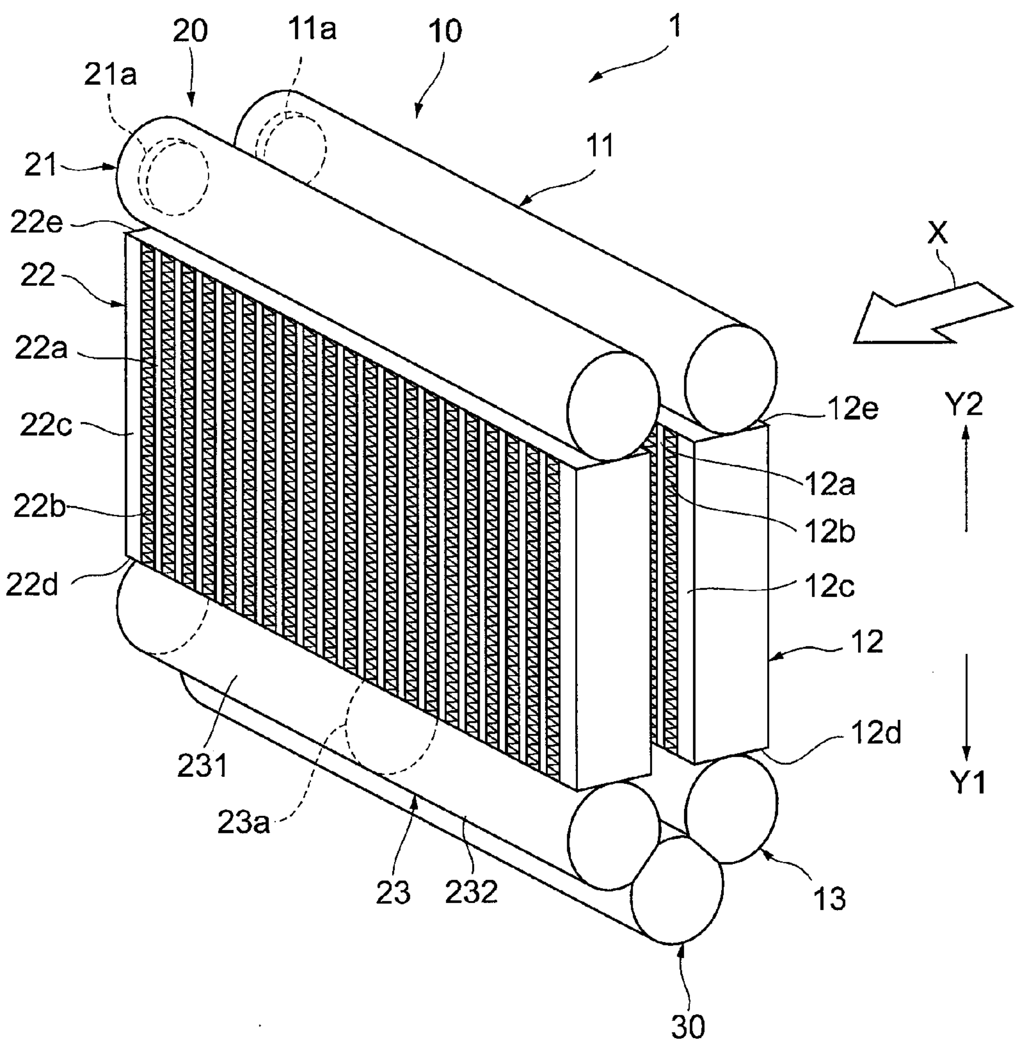
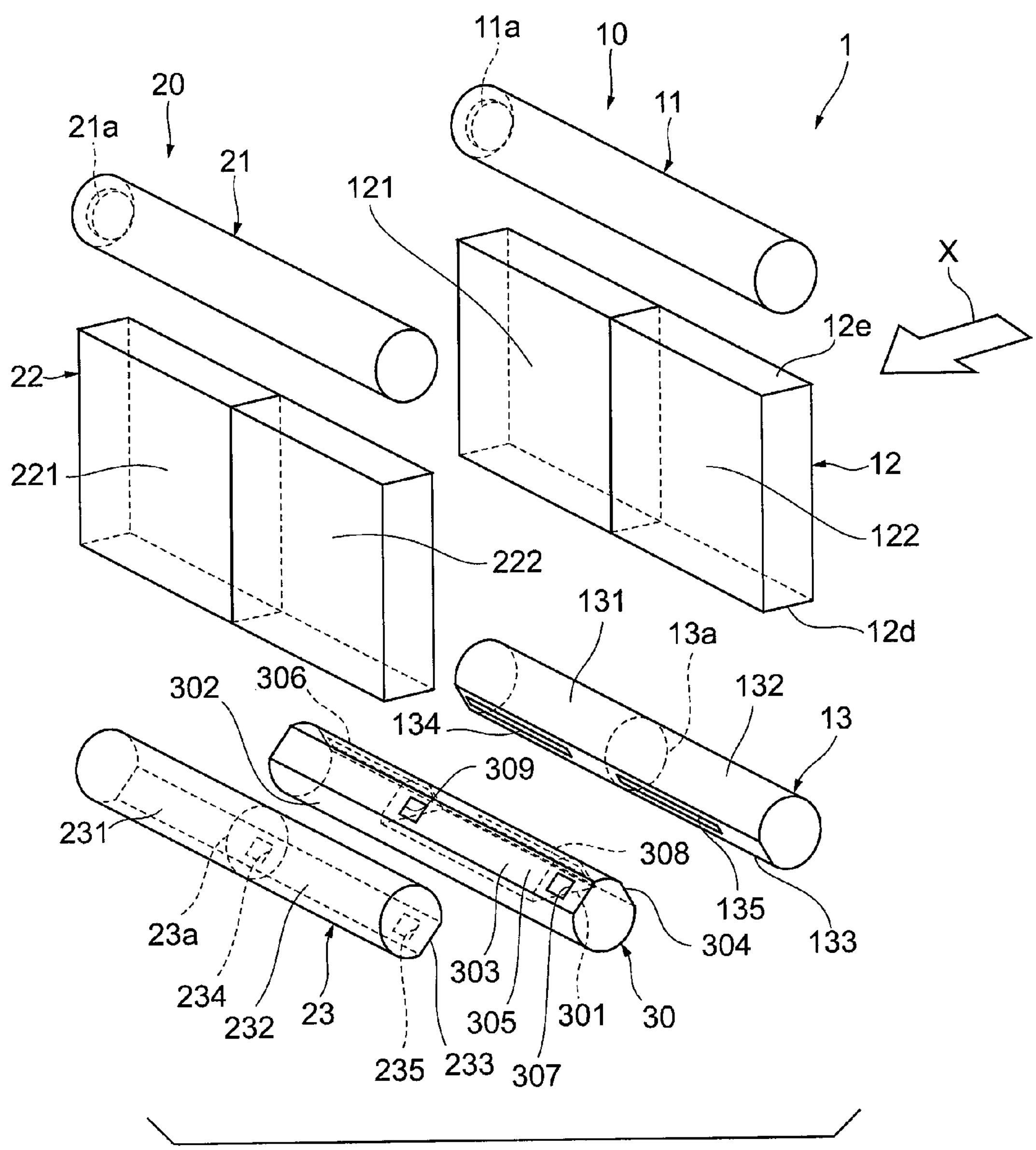


FIG. 1



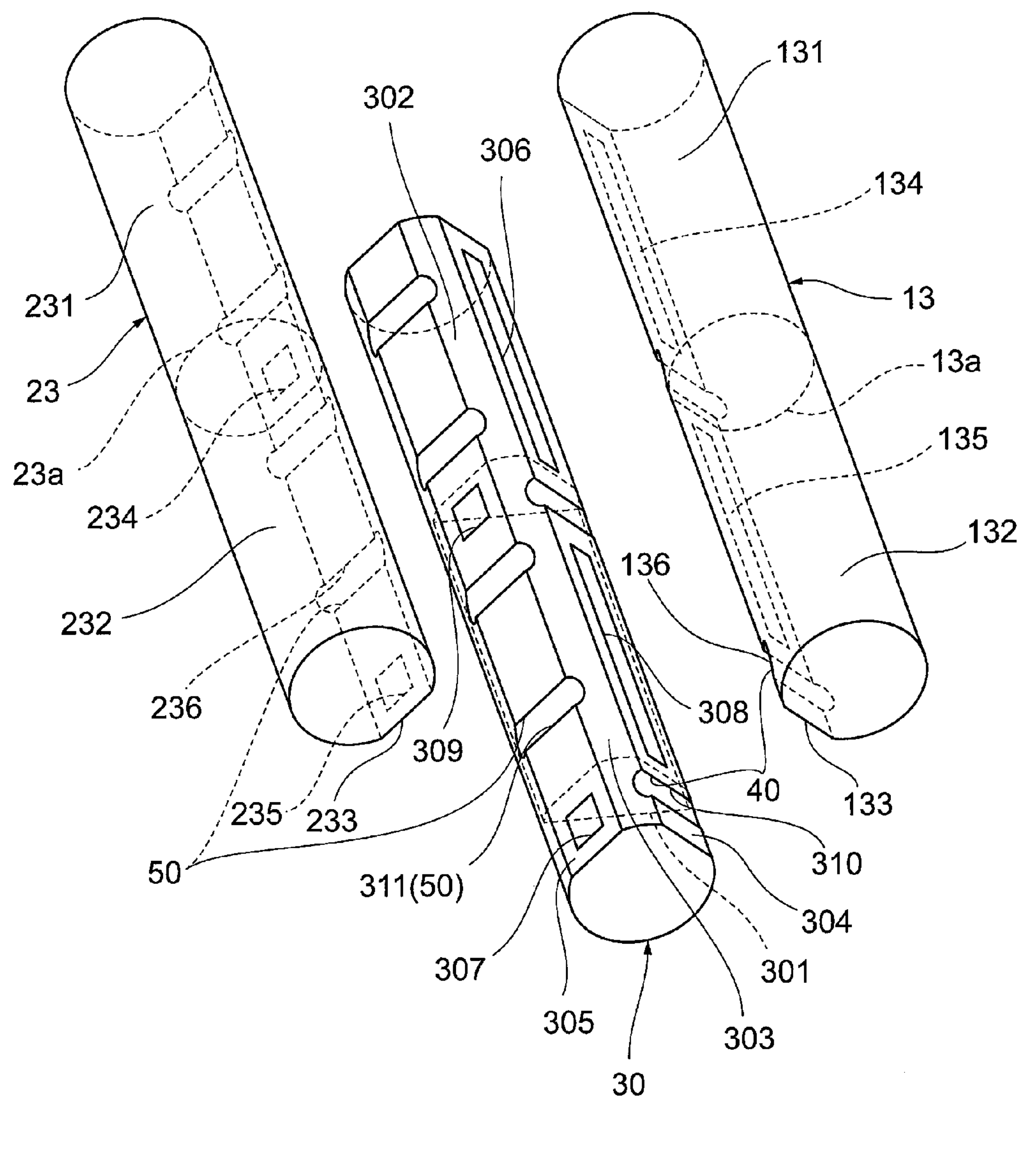
20
11a
10
1
21a
21
11
22e
22
X
22a
22c
12e
Y2
12a
22b
12b
22d
12c
12
231
12d
Y1
23a
23
232
13
30

FIG. 2



1
10
11a
11
20
21a
21
121
X
12e
22
12
221
122
222
12d
131
13a
132
13
134
302
306
309
231
308
135
133
23a
304
303
234
232
23
305
301
30
235
233
307

FIG. 3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134
231
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23
13a
23a
234
135
232
132
136
236
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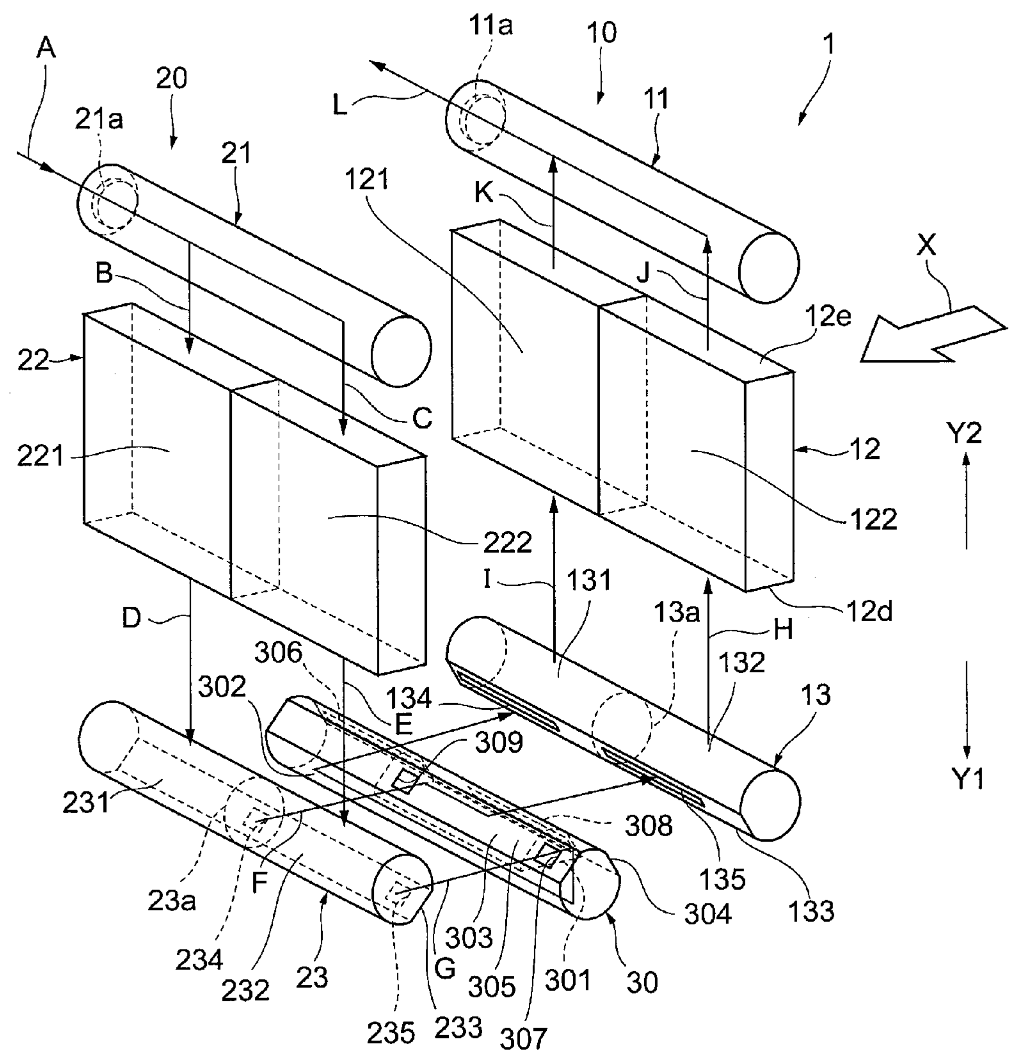
40
133
235
233
310
50
311(50)
304
307
301
305
303
30

FIG. 4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21a
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B
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221
C
222
D
306
302
134
E
309
231
23a
F
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235
G
233
303
305
307
301
30
304
308
135
133
13
132
13a
H
I
131
12d
122
12
Y2
Y1
X
12e
J
K
121
11
10
11a
L
1

FIG. 5

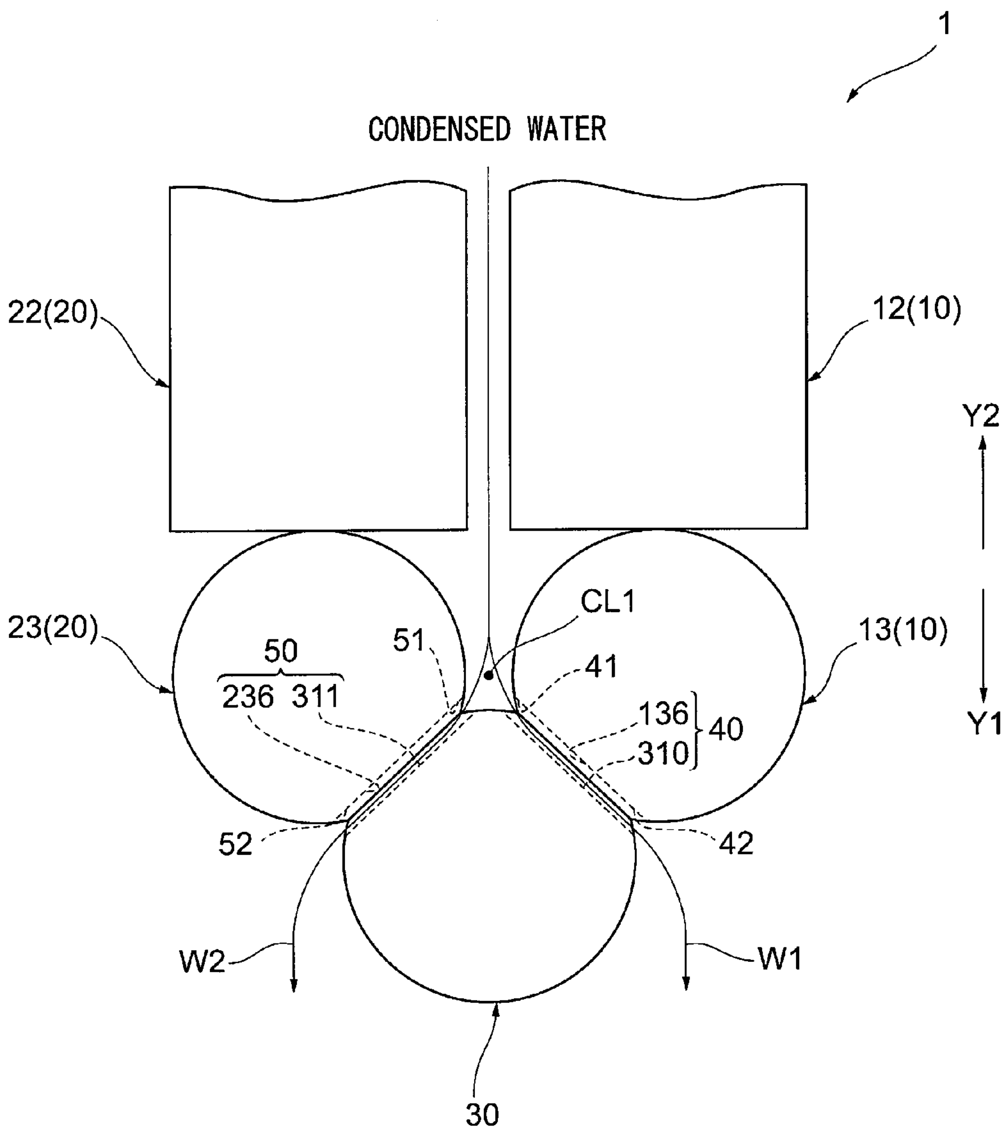

1
CONDENSED WATER
22(20)
12(10)
Y2
Y1
23(20)
13(10)
CL1
50
236 311
51
41
136
310
40
52
42
W2
W1
30

FIG. 6

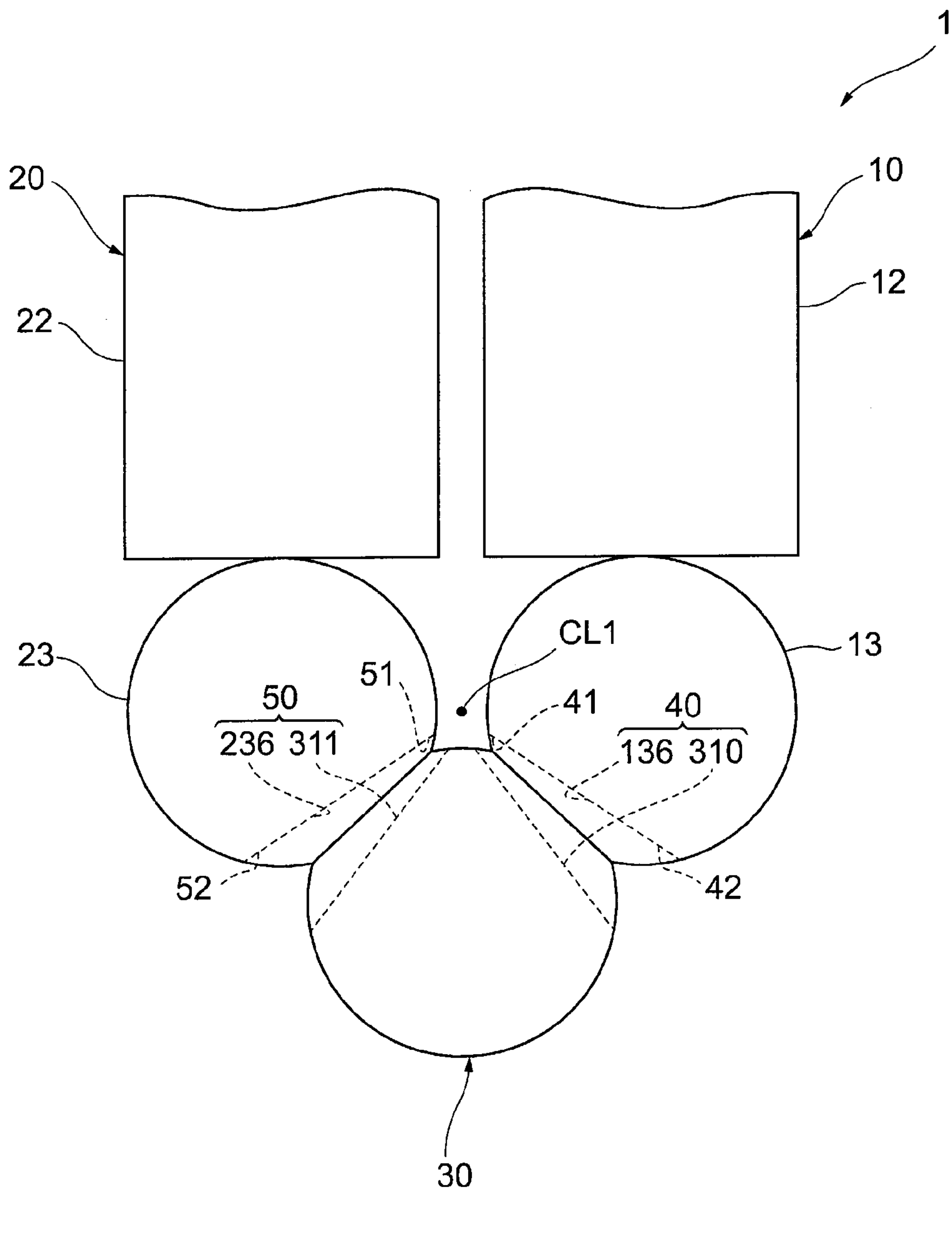


FIG. 7

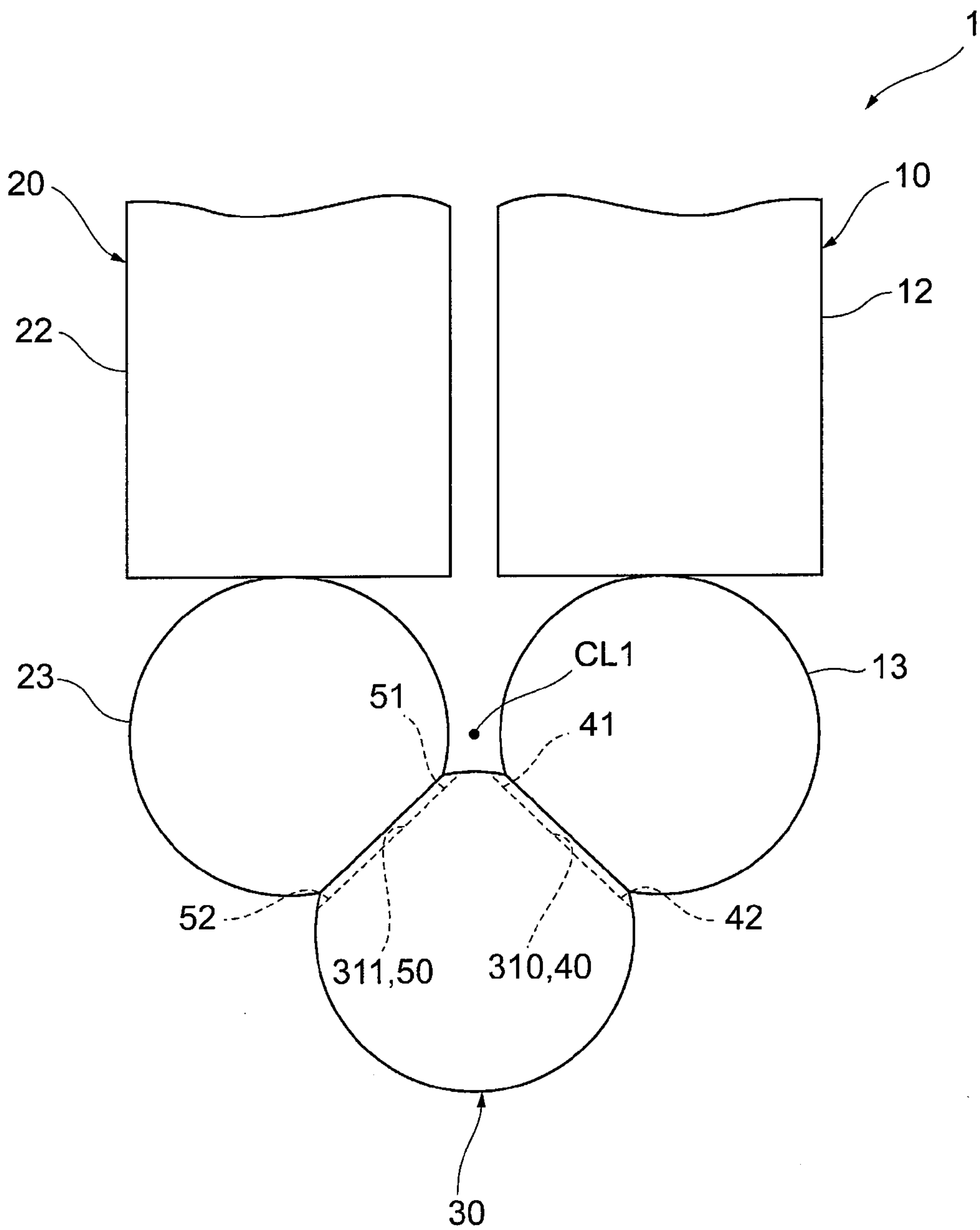


FIG. 8

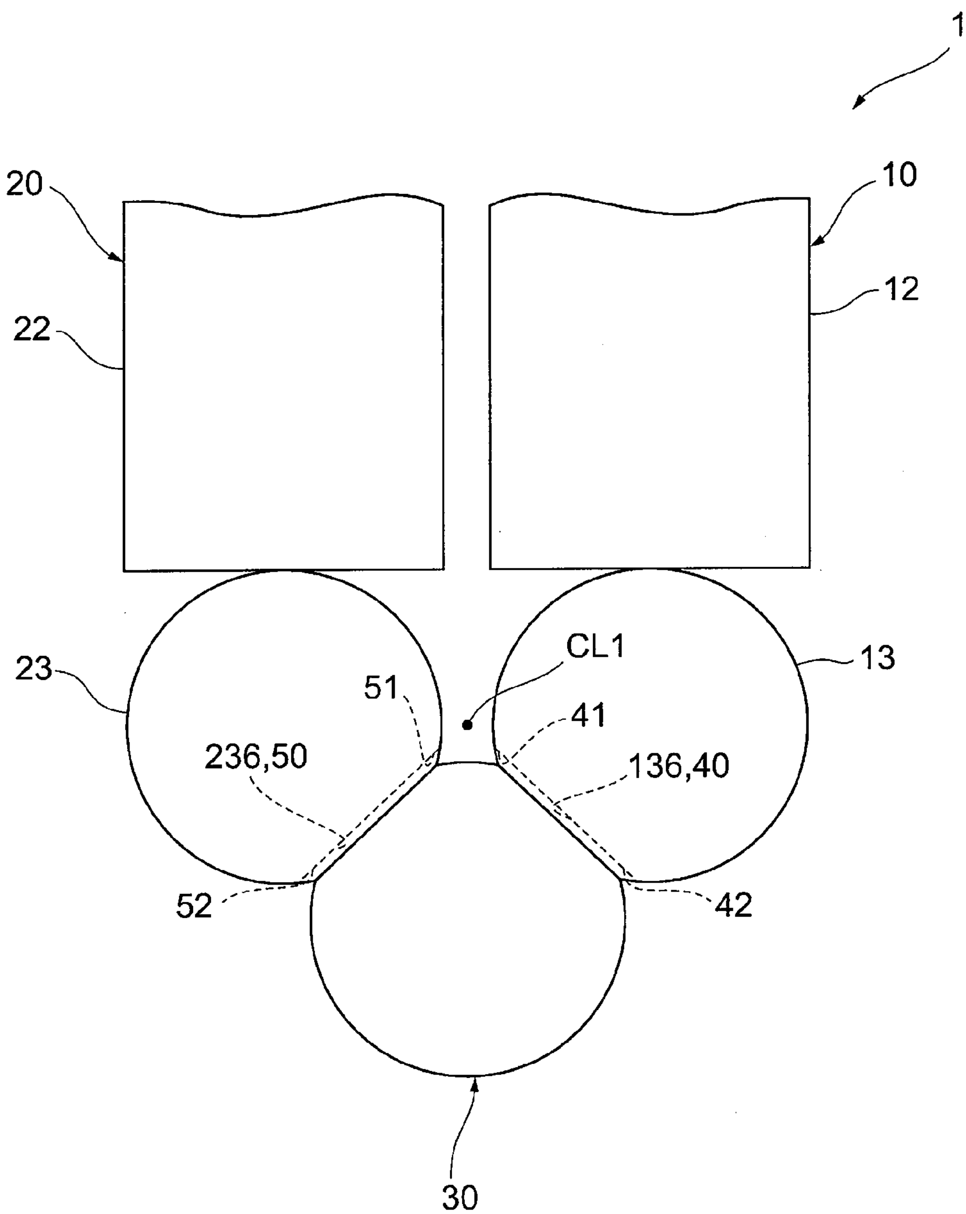


FIG. 9

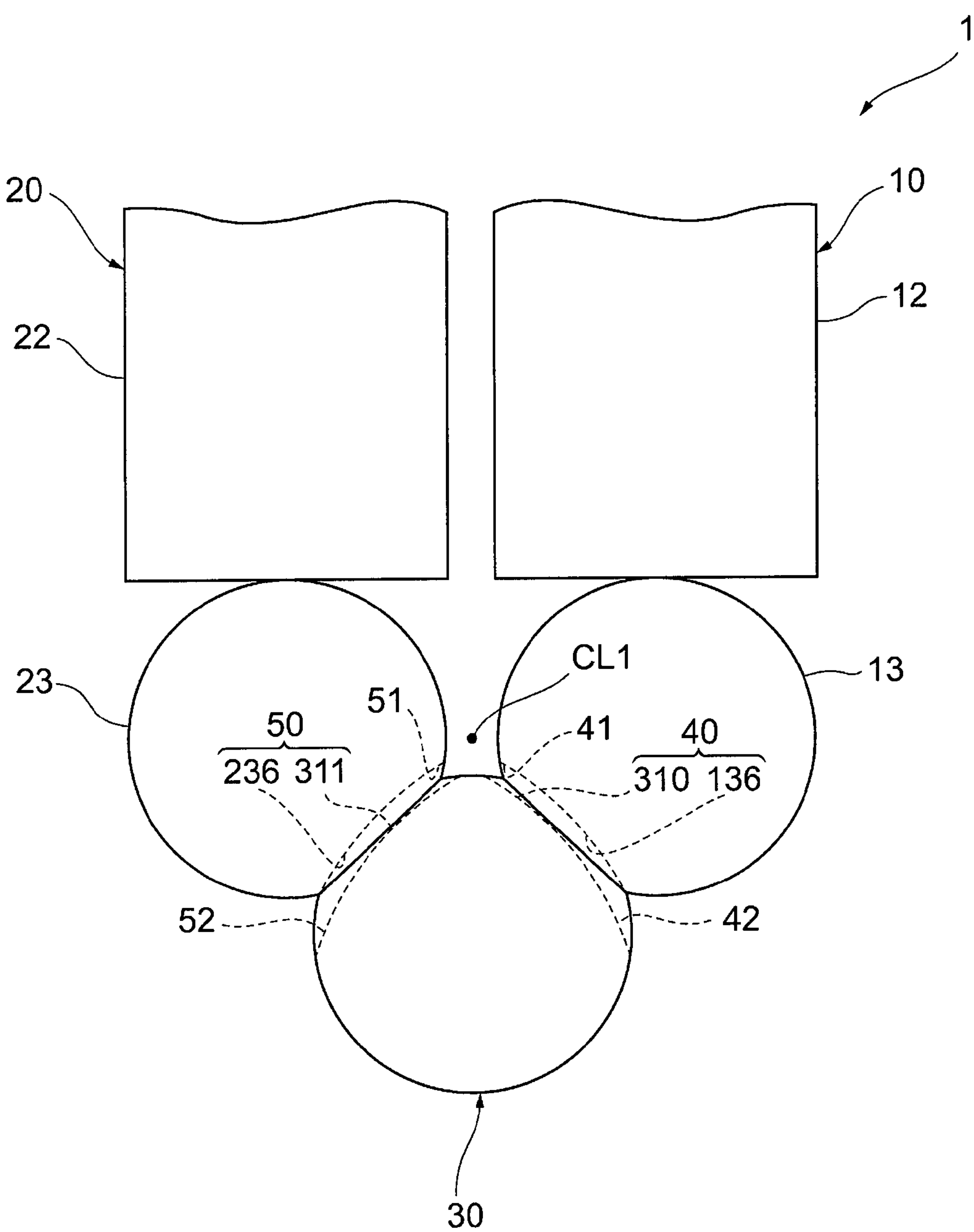
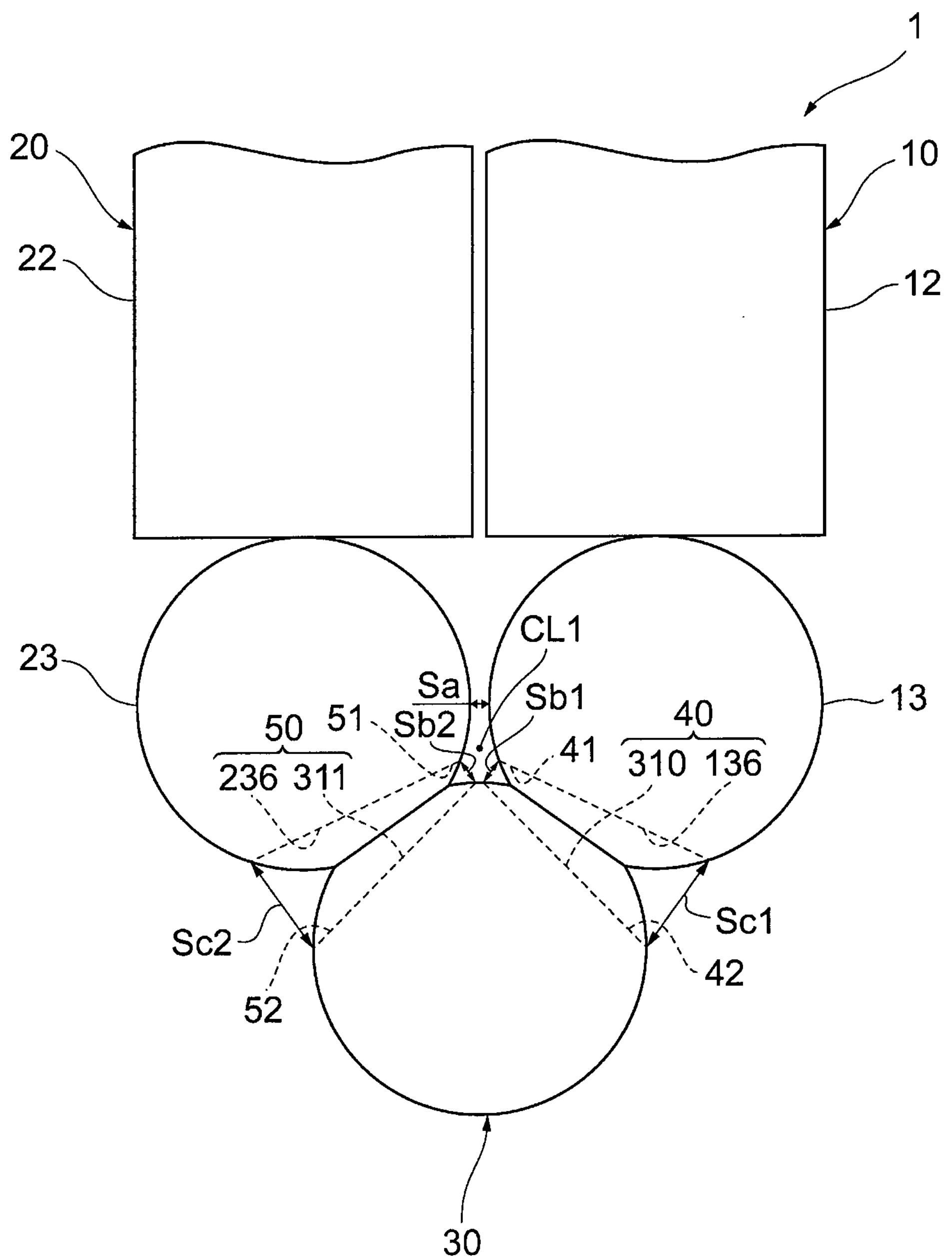


FIG. 10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20
10
22
12
23
13
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Sa
Sb1
Sb2
50
51
40
41
236 311
310 136
Sc2
Sc1
52
42
30

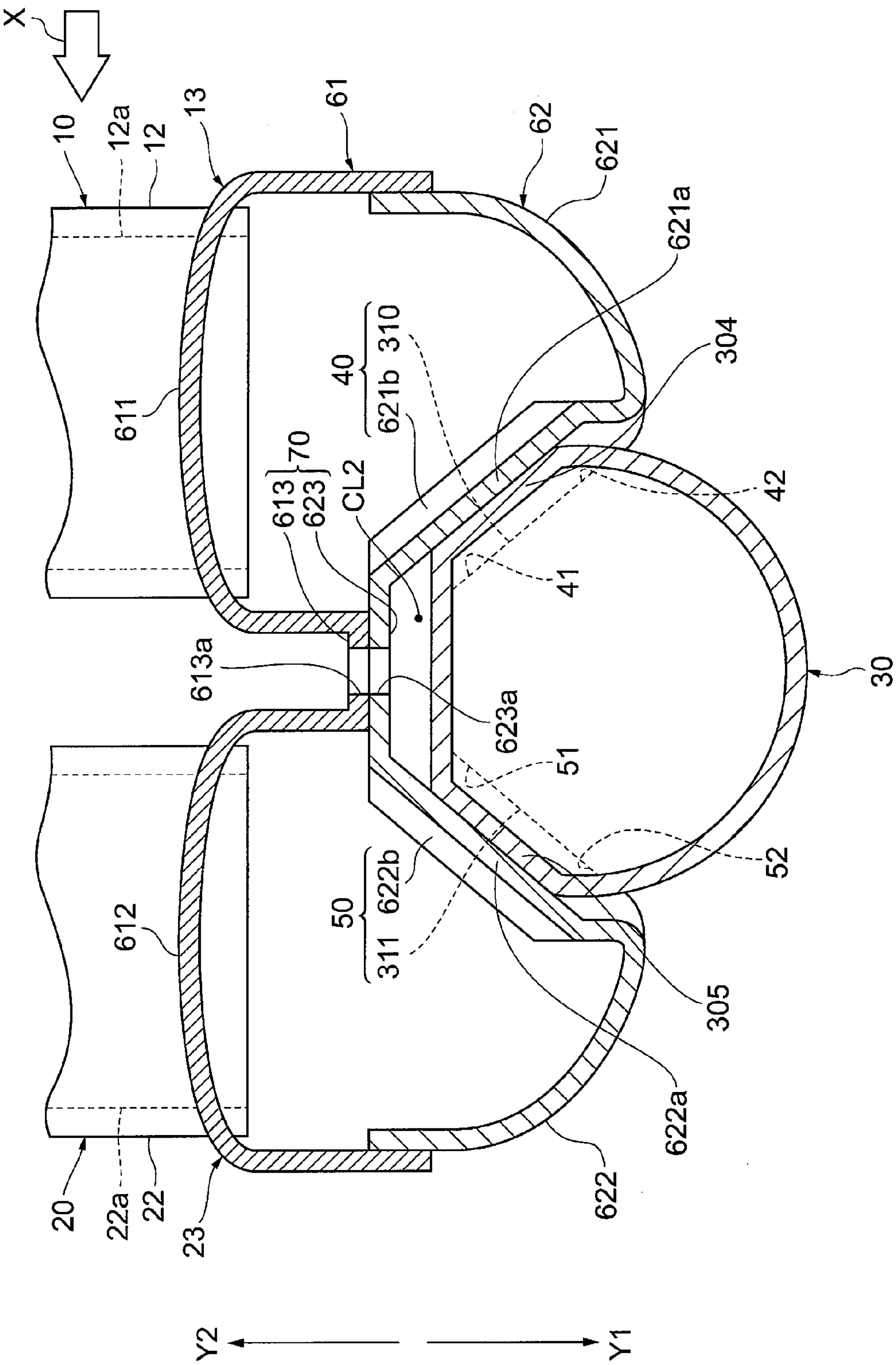
X
1
10
12a
12
13
61
62
621
621a
611
40
621b
310
304
70
613
623
CL2
42
41
613a
623a
30
51
52
612
50
622b
311
305
622a
20
22a
22
23
622
Y2
Y1

FIG. 11

REFRIGERANT EVAPORATOR

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is based on Japanese Patent Application No. 2015-38169 filed on Feb. 27, 2015 and Japanese Patent Application No. 2016-32052 filed on Feb. 23, 2016, the disclosures of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a refrigerant evaporator in which heat is exchanged between a fluid to be cooled and a refrigerant.

BACKGROUND ART

[0003] Patent Literature 1 describes a refrigerant evaporator. The refrigerant evaporator described in Patent Literature 1 includes a first heat exchange part and a second heat exchange part in which heat is exchanged with air that is a fluid to be cooled. The first heat exchange part and the second heat exchange part are arranged to oppose in a flowing direction of air. The first heat exchange part is divided into a first core part and a second core part in a direction perpendicular to the flowing direction of air. The second heat exchange part is also divided into a first core part and a second core part in a direction perpendicular to the flowing direction of air. The first core part of the first heat exchange part opposes the first core part of the second heat exchange part in the flowing direction of air. The second core part of the first heat exchange part opposes the second core part of the second heat exchange part in the flowing direction of air. The refrigerant evaporator described in Patent Literature 1 includes a pair of tanks disposed at the respective ends of the first heat exchange part in the vertical direction, and a pair of tanks disposed at the respective ends of the second heat exchange part in the vertical direction. Moreover, the refrigerant evaporator described in Patent Literature 1 includes a switch tank between the tank disposed below the first heat exchange part in the vertical direction and the tank disposed below the second heat exchange part in the vertical direction.

[0004] In the refrigerant evaporator described in Patent Literature 1, refrigerant flows from the tank above the second heat exchange part in the vertical direction to the first core part and the second core part of the second heat exchange part. The refrigerant flowing into the first core part of the second heat exchange part flows from the tank below the second heat exchange part in the vertical direction through the switch tank and the tank below the first heat exchange part in the vertical direction into the second core part of the first heat exchange part. The refrigerant flowing into the second core part of the second heat exchange part flows from the tank below the second heat exchange part in the vertical direction through the switch tank and the tank below the first heat exchange part in the vertical direction into the first core part of the first heat exchange part. The refrigerant flowing into the first core part of the first heat exchange part, and the refrigerant flowing into the second core part of the first heat exchange part are discharged through the tank above the first heat exchange part in the vertical direction.

PRIOR ART LITERATURES

Patent Literature

[0005] Patent Literature 1:JP 2013-185723A

SUMMARY OF INVENTION

[0006] In the refrigerant evaporator described in Patent Literature 1, water is condescend on the external surfaces of the first heat exchange part and the second heat exchange part, due to the heat exchange between refrigerant and air, and the condensed water flows downward in the vertical direction. If a clearance is formed among the tank below the first heat exchange part in the vertical direction, the tank below the second heat exchange part in the vertical direction, and the switch tank, the condensed water may stay in the clearance. If the water freezes, the freezing causes a crack, because the volume of water is increased to damage each tank.

[0007] It is an object of the present disclosure to provide a refrigerant evaporator in which a crack caused by freezing is restricted.

[0008] According to an aspect of the present disclosure, a refrigerant evaporator in which heat is exchanged between a fluid to be cooled and a refrigerant includes: a first heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant; a second heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant, the second heat exchange part being arranged to oppose the first heat exchange part; a first tank arranged below the first heat exchange part to distribute the refrigerant to the first heat exchange part; a second tank arranged below the second heat exchange part to collect the refrigerant flowing through the second heat exchange part; and a third tank joined to the first tank and the second tank to introduce the refrigerant collected by the second tank to the first tank. A clearance is defined among the first tank, the second tank, and the third tank. At least one of a joint portion between the first tank and the third tank, and a joint portion between the second tank and the third tank defines a drainage passage to discharge water trapped in the clearance.

[0009] According to an aspect of the present disclosure, a refrigerant evaporator in which heat is exchanged between a fluid to be cooled and a refrigerant includes: a first heat exchange part in which the refrigerant flows to perform heat exchange between the fluid to be cooled and the refrigerant; a second heat exchange part in which the refrigerant flows to perform heat exchange between the fluid to be cooled and the refrigerant, the second heat exchange part being arranged to oppose the first heat exchange part; a first tank arranged below the first heat exchange part to distribute the refrigerant to the first heat exchange part; a second tank arranged below the second heat exchange part to collect the refrigerant flowing through the second heat exchange part; a connection part that connects the first tank and the second tank to each other; and a third tank joined to the first tank and the second tank to introduce the refrigerant collected by the second tank to the first tank. At least one opening is defined in the connection part. At least one of a joint portion between the first tank and the third tank and a joint portion between the second tank and the third tank defines a drainage passage located on a lower side of the opening of the connection part to discharge water passing through the opening.

[0010] When the condensed water generated on the external surfaces of the first heat exchange part and the second heat exchange part flows into the clearance defined among the first tank, the second tank and the third tank, the condensed water is discharged outside through the drainage passage. Therefore, since the condensed water hardly stays in the clearance among the first tank, the second tank and the third tank, a crack caused by a freeze of the condensed water can be restricted.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. **1** is a perspective view illustrating a refrigerant evaporator according to a first embodiment.

[0012] FIG. **2** is an exploded perspective view illustrating the refrigerant evaporator of the first embodiment.

[0013] FIG. **3** is an exploded perspective view illustrating a windward distribution tank, a leeward collection tank, and a switch tank of the refrigerant evaporator of the first embodiment.

[0014] FIG. **4** is a schematic perspective view illustrating a flow of refrigerant in the refrigerant evaporator of the first embodiment.

[0015] FIG. **5** is a side view illustrating a structure of a drainage passage of the refrigerant evaporator of the first embodiment.

[0016] FIG. **6** is a side view illustrating a structure of a drainage passage of a refrigerant evaporator according to a first modification of the first embodiment.

[0017] FIG. **7** is a side view illustrating a structure of a drainage passage of a refrigerant evaporator according to a second modification of the first embodiment.

[0018] FIG. **8** is a side view illustrating a structure of a drainage passage of a refrigerant evaporator according to a third modification of the first embodiment.

[0019] FIG. **9** is a side view illustrating a structure of a drainage passage of a refrigerant evaporator according to a fourth modification of the first embodiment.

[0020] FIG. **10** is a side view illustrating a structure of a drainage passage of a refrigerant evaporator according to a fifth modification of the first embodiment.

[0021] FIG. **11** is a sectional view illustrating a windward distribution tank, a leeward collection tank, and a switch tank of a refrigerant evaporator according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

First embodiment

[0022] Hereafter, a refrigerant evaporator of a first embodiment of is described. The refrigerant evaporator **1** of this embodiment shown in FIG. **1** is used for a refrigeration cycle for an air-conditioner for a vehicle, which conditions air in the cabin. Specifically, the refrigerant evaporator **1** is a cooling heat exchanger for cooling air by absorbing heat from air to be sent to the cabin to evaporate the liquid phase refrigerant. The refrigeration cycle includes a compressor, a radiator, an expansion valve, which are not illustrated but well known, in addition to the refrigerant evaporator **1**.

[0023] As shown in FIG. **1** and FIG. **2**, the refrigerant evaporator **1** includes two evaporation parts **10** and **20** and a switch tank **30**. The evaporation part **10** is arranged on the upstream side and the evaporation part **20** is arranged on the downstream side in an air flowing direction X. In this embodiment, the air flowing direction X is a direction perpendicular to a vertical direction Y**1**, Y**2**. Hereafter, the evaporation part **10** arranged upstream in the air flowing direction X is called as “the windward side evaporation part **10**.” Moreover, the evaporation part **20** arranged downstream in the air flowing direction X is called as “the leeward side evaporation part **20**.”

[0024] The windward side evaporation part **10** has a windward side collection tank **11**, a windward side heat exchange part **12**, and a windward side distribution tank **13**. The windward side collection tank **11**, the windward side heat exchange part **12**, and the windward side distribution tank **13** are arranged in this order downward in the vertical direction Y**1**.

[0025] The windward side heat exchange part **12** has a rectangular parallelepiped shape. The windward side heat exchange part **12** is arranged so that the air flowing direction X corresponds to the thickness direction. The windward side distribution tank **13** is attached to a lower-side end surface **12***d* of the windward side heat exchange part **12** in the vertical direction Y**1**. The windward side collection tank **11** is attached to an upper-side end surface **12***e* of the windward side heat exchange part **12** in the vertical direction Y**2**. The windward side heat exchange part **12** includes plural tubes **12***a* and plural fins **12***b* alternately stacked with each other in the horizontal direction. In FIG. **2**, illustration of the tube **12***a* and the fin **12***b* is omitted. The tube **12***a* is arranged to extend in the vertical direction Y**1**, Y**2**, and has a flat shape in the cross-section. A passage for flowing refrigerant is formed in the tube **12***a*. The fin **12***b* is what is called a corrugated fin formed by bending a thin metal plate. The fin **12***b* is arranged between the tubes **12***a* adjacent to each other in the horizontal direction, and is joined to the external surface of the tube **12***a*. As shown in FIG. **2**, the windward side heat exchange part **12** is divided into a first windward side core part **121** and a second windward side core part **122** in the stacking direction of the tube **12***a* and the fin **12***b*. Moreover, as shown in FIG. **1**, the windward side heat exchange part **12** has a side plate **12***c* on the both ends in the stacking direction of the tube **12***a* and the fin **12***b*. The side plate **12***c* is a component for reinforcing the windward side heat exchange part **12**.

[0026] The windward side distribution tank **13** is a cylindrical component in which a passage for refrigerant is defined. The both ends of the windward side distribution tank **13** in the axial direction are closed. As shown in FIG. **2**, the windward side distribution tank **13** has a partition board **13***a* at the central part in the axial direction. The partition board **13***a* divides the internal passage of the windward side distribution tank **13** into a first distribution part **131** and a second distribution part **132**. Plural through holes, which are not illustrated, are defined in the external surface of the windward side distribution tank **13**, and the lower end of the tube **12***a* in the vertical direction Y**1** is inserted into the through hole. The internal passage of the first distribution part **131** is communicated to the tube **12***a* of the first windward side core part **121** by the through hole, and the internal passage of the second distribution part **132** is communicated to the tube **12***a* of the second windward side core part **122** by the through hole. That is, the first distribution part **131** distributes refrigerant to the tubes **12***a* of the first windward side core part **121**. Moreover, the second distribution part **132** distributes refrigerant to the tubes **12***a* of the second windward side core part **122**.

[0027] As shown in FIG. **3**, a joint portion **133** having a plane shape is formed on the external surface of the windward side distribution tank **13** to extend in the axial direction. The joint portion **133** is a portion to which the switch tank **30** is joined. The joint portion **133** has a through hole **134** passing through to the internal passage of the first distribution part **131**. The through hole **134** is a passage for leading the refrigerant from the switch tank **30** to the first distribution part **131**. Moreover, the joint portion **133** has a through hole **135** passing through to the internal passage of the second distribution part **132**. The through hole **135** is a passage for leading the refrigerant from the switch tank **30** to the second distribution part **132**.

[0028] As shown in FIG. **1** and FIG. **2**, the windward side collection tank **11** is a cylindrical component in which a passage is defined for refrigerant. One end part of the windward side collection tank **11** in the axial direction is closed. The other end part of the windward side collection tank **11** in the axial direction defines a refrigerant outlet **11***a*. The refrigerant outlet **11** a is connected to the intake side of the non-illustrated compressor. Moreover, non-illustrated plural through holes are formed in the external surface of the windward side collection tank **11**, and the upper end of the tube **12***a* in the vertical direction Y**2** is inserted into the through hole. The internal passage of the windward side collection tank **11** is communicated to the tube **12***a* of the first windward side core part **121** and the tube **12***a* of the second windward side core part **122** by the respective through holes. That is, the refrigerant which flows through the tube **12***a* of the first windward side core part **121**, and the refrigerant which flows through the tube **12***a* of the second windward side core part **122** are brought together into the windward side collection tank **11**. The refrigerant collected in the windward side collection tank **11** is introduced into the compressor through the refrigerant outlet **11***a*.

[0029] The leeward side evaporation part **20** has a leeward side distribution tank **21**, a leeward side heat exchange part **22**, and a leeward side collection tank **23**. The leeward side distribution tank **21**, the leeward side heat exchange part **22**, and the leeward side collection tank **23** are arranged in this order downward in the vertical direction Y**1**.

[0030] The leeward side heat exchange part **22** has the structure approximately the same as the windward side heat exchange part **12**. That is, the leeward side heat exchange part **22** has a rectangular parallelepiped shape, and is arranged so that the air flowing direction X corresponds to the thickness direction. The leeward side heat exchange part **22** includes plural tubes **22***a* and plural fins **22***b* alternately stacked with each other in the horizontal direction, and has a side plate **22***c* on the both ends in the stacking direction of the tube **22***a* and the fin **22***b*. The leeward side collection tank **23** is attached to a lower end surface **22***d* of the leeward side heat exchange part **22** in the vertical direction Y**1**. The leeward side distribution tank **21** is attached to an upper end surface **22***e* of the leeward side heat exchange part **22** in the vertical direction Y**2**. Moreover, as shown in FIG. **2**, the leeward side heat exchange part **22** is divided into a first leeward side core part **221** opposing the first windward side core part **121** and a second leeward side core part **222** opposing the second windward side core part **122** in the air flowing direction X.

[0031] The leeward side distribution tank **21** is a cylindrical component which has a passage for refrigerant inside. One end part of the leeward side distribution tank **21** in the axial direction is closed. The other end part of the leeward side distribution tank **21** in the axial direction defines a refrigerant inlet **21***a*. Low-pressure refrigerant decompressed by the non-illustrated expansion valve flows into the refrigerant inlet **21***a*. Moreover, non-illustrated plural through holes are formed in the external surface of the leeward side distribution tank **21**, and the upper end of the tube **22***a* in the vertical direction Y**2** is inserted into the through hole. The internal passage of the leeward side distribution tank **21** is communicated to the tube **22***a* of the first leeward side core part **221** and the tube **22***a* of the second leeward side core part **222** by the through hole. That is, the refrigerant which flowed into the leeward side distribution tank **21** from the refrigerant inlet **21***a* is distributed to the tube **22***a* of the first leeward side core part **221** and the tube **22***a* of the second leeward side core part **222**.

[0032] The leeward side collection tank **23** is a cylindrical component which has a passage for refrigerant inside. The both ends of the leeward side collection tank **23** in the axial direction are closed. The leeward side collection tank **23** has a partition board **23***a* at the central part in the axial direction. As shown in FIG. **2**, the partition board **23***a* divides the internal passage of the leeward side collection tank **23** into a first collection part **231** and a second collection part **232**. Moreover, non-illustrated plural through holes are formed in the external surface of the leeward side collection tank **23**, and the lower end of the tube **22***a* in the vertical direction Y**1** is inserted into the through hole. Due to the through hole, the internal passage of the first collection part **231** is communicated to the tube **22***a* of the first leeward side core part **221**, and the internal passage of the second collection part **232** is communicated to the tube **22***a* of the second leeward side core part **222**. That is, the refrigerant which flows through the tubes **22***a* of the first leeward side core part **221** is brought together in the first collection part **231**. Moreover, the refrigerant which flows through the tubes **22***a* of the second leeward side core part **222** is brought together in the second collection part **232**.

[0033] As shown in FIG. **3**, the external surface of the leeward side collection tank **23** defines a joint portion **233** having a plane shape to extend in the axial direction. The joint portion **233** is a portion to which the switch tank **30** is joined. The joint portion **233** has a through hole **234** passing through to the internal passage of the first collection part **231**. The through hole **234** is a passage for introducing the refrigerant from the first collection part **231** to the switch tank **30**. Moreover, the joint portion **233** has a through hole **235** passing through to the internal passage of the second collection part **232**. The through hole **235** is a passage for introducing the refrigerant from the second collection part **232** to the switch tank **30**.

[0034] In this embodiment, the leeward side collection tank **23** corresponds to a first tank, and the windward side heat exchange part **12** corresponds to a second tank. Moreover, the leeward side heat exchange part **22** corresponds to a first heat exchange part, and the windward side heat exchange part **12** corresponds to a second heat exchange part.

[0035] The switch tank **30** is arranged between the windward side distribution tank **13** and the leeward side collection tank **23**. In this embodiment, the switch tank **30** corresponds to a third tank. The switch tank **30** is a cylindrical component which has a passage for refrigerant inside. A partition component **301** is disposed inside the switch tank

30. The partition component 301 divides the interior space of the switch tank 30 to a first refrigerant passage 302 and a second refrigerant passage 303.

[0036] As shown in FIG. 3, the external surface of the switch tank 30 defines a joint portion 304 having a plane shape to which the joint portion 133 of the windward side distribution tank 13 is joined, and a joint portion 305 having a plane shape to which the joint portion 233 of the leeward side collection tank 23 is joined.

[0037] A through hole 306 passing through to the first refrigerant passage 302 is formed in the joint portion 304. The through hole 306 is located to be connected with the through hole 134 of the windward side distribution tank 13. A through hole 307 passing through to the first refrigerant passage 302 is formed in the joint portion 305. The through hole 307 is located to be connected with the through hole 235 of the leeward side collection tank 23. That is, the refrigerant brought together in the second collection part 232 of the leeward side collection tank 23 flows into the first refrigerant passage 302 through the through hole 235 of the leeward side collection tank 23 and the through hole 307 of the switch tank 30. The refrigerant which flowed into the first refrigerant passage 302 is led to the first distribution part 131 of the windward side distribution tank 13 through the through hole 306 of the switch tank 30 and the through hole 134 of the windward side distribution tank 13.

[0038] A through hole 308 passing through to the second refrigerant passage 303 is formed in the joint portion 304. The through hole 308 is located to be connected with the through hole 135 of the windward side distribution tank 13. A through hole 309 passing through to the second refrigerant passage 303 is formed in the joint portion 305. The through hole 309 is located to be connected with the through hole 234 of the leeward side collection tank 23. That is, the refrigerant brought together in the first collection part 231 of the leeward side collection tank 23 flows into the second refrigerant passage 303 through the through hole 234 of the leeward side collection tank 23 and the through hole 309 of the switch tank 30. The refrigerant which flowed into the second refrigerant passage 303 is led to the second distribution part 132 of the windward side distribution tank 13 through the through hole 308 of the switch tank 30 and the through hole 135 of the windward side distribution tank 13.

[0039] Thus, the switch tank 30 functions as a portion which introduces the refrigerant collected in the leeward side collection tank 23 to the windward side distribution tank 13. Moreover, the switch tank 30 functions as a portion which exchanges the flows of refrigerant in the leeward side heat exchange part 22 and the flows of refrigerant in the windward side heat exchange part 12 with each other in the stacking direction of the tubes 12*a*, 22*a*.

[0040] Next, the flow of refrigerant in the refrigerant evaporator 1 and a method of cooling air are explained.

[0041] The refrigerant decompressed by the non-illustrated expansion valve is introduced into the leeward side distribution tank 21 from the refrigerant inlet 21*a*, as shown in an arrow A in FIG. 4. The refrigerant is distributed in the leeward side distribution tank 21, as shown by arrows B and C, to flow into the first leeward side core part 221 and the second leeward side core part 222 of the leeward side distribution tank 21.

[0042] The refrigerant which flowed into the first leeward side core part 221 and the second leeward side core part 222 flows through inside of each tube 22*a* downward in the vertical direction Y1. At this time, the refrigerant which flows through the inside of the tube 22*a* performs heat exchange with air flowing outside of the tube 22*a* in the air flowing direction X. Thereby, a part of the refrigerant is evaporated to absorb heat from air, such that the air is cooled.

[0043] The refrigerant which flows through the tubes 22*a* of the first leeward side core part 221 is brought together in the first collection part 231 of the leeward side collection tank 23, as shown in an arrow D. The refrigerant brought together in the first collection part 231 flows into the second distribution part 132 of the windward side distribution tank 13 through the second refrigerant passage 303 of the switch tank 30, as shown in an arrow F. The refrigerant which flowed into the second distribution part 132 flows into the second windward side core part 122, as shown in an arrow H.

[0044] The refrigerant which flows through the tubes 22*a* of the second leeward side core part 222 is brought together in the second collection part 232 of the leeward side collection tank 23, as shown in an arrow E. The refrigerant brought together in the second collection part 232 flows into the first distribution part 131 of the windward side distribution tank 13 through the first refrigerant passage 302 of the switch tank 30, as shown in an arrow G. The refrigerant which flowed into the first distribution part 131 flows into the first windward side core part 121, as shown in an arrow I.

[0045] The refrigerant which flowed into the first windward side core part 121 and the second windward side core part 122 flows through the inside of the respective tube 22*a* upward in the vertical direction Y2. At this time, the refrigerant which flows through the inside of the tube 22*a* performs heat exchange with air which flows outside of the tube 22*a* in the air flowing direction X. Thereby, a part of the refrigerant is evaporated to absorb heat from air, such that the air is cooled.

[0046] The refrigerant which flows through the first windward side core part 121 and the second windward side core part 122 is brought together in the windward side collection tank 11, as shown in arrows K and J. The refrigerant brought together in the windward side collection tank 11 is supplied to the intake side of the non-illustrated compressor from the refrigerant outlet 11*a* of the windward side collection tank 11, as shown in an arrow L.

[0047] If water is condensed on the external surfaces of the windward side heat exchange part 12 and the leeward side heat exchange part 22 due to the heat exchange between refrigerant and air, the condensed water flows downward in the vertical direction Y1. As shown in FIG. 5, the condensed water may stay in a clearance CL1 among the windward side distribution tank 13, the leeward side collection tank 23, and the switch tank 30. If the condensed water staying in the clearance CL1 is frozen by a temperature fall, each of the tanks 13, 23, and 30 may be damaged, because the volume of water is increased, as what is called a freeze crack.

[0048] According to the present embodiment, the refrigerant evaporator 1 has a drainage structure for discharging the condensed water staying in the clearance CL1. Next, the details of the drainage structure are explained.

[0049] As shown in FIG. 3, plural drain grooves 310 are formed in the joint portion 304 of the switch tank 30 along the slope surface of the joint portion 304. Moreover, a drain groove 136 is formed in the joint portion 133 of the windward side distribution tank **13** at the position corresponding to the drain groove **310** of the joint portion **304** of the switch tank **30**. As shown in FIG. **5**, a straight-shaped drainage passage **40** is defined by a space surrounded by the drain groove **310** formed in the joint portion **304** of the switch tank **30** and the drain groove **136** formed in the joint portion **133** of the windward side distribution tank **13**. One end part of the drainage passage **40** defines an inflow port **41** communicated to the clearance CL**1**. The other end part of the drainage passage **40** defines an outlet port **42** open to the lower space of the windward side distribution tank **13** in the vertical direction Y**1**. The outlet port **42** is located on the lower side of the clearance CL**1** in the vertical direction Y**1**.

[0050] As shown in FIG. **3**, plural drain grooves **311** are formed in the joint portion **305** of the switch tank **30** along the slope surface of the joint portion **305**. Moreover, a drain groove **236** is formed in the joint portion **233** of the leeward side collection tank **23** at the position corresponding to the drain groove **311** of the joint portion **305** of the switch tank **30**. As shown in FIG. **5**, a straight-shaped drainage passage **50** is defined by a space surrounded by the drain groove **311** formed in the joint portion **305** of the switch tank **30** and the drain groove **236** formed in the joint portion **233** of the leeward side collection tank **23**. One end part of the drainage passage **50** defines an inflow port **51** communicated to the clearance CL**1**. The other end part of the drainage passage **50** defines an outlet port **52** open to the lower space of the leeward side collection tank **23** in the vertical direction Y**1**. The outlet port **52** is located on the lower side of the clearance CL**1** in the vertical direction Y**1**.

[0051] In FIG. **2** and FIG. **4**, each illustration of the drain groove **310**, **311** of the switch tank **30**, the drain groove **136** of the windward side distribution tank **13**, and the drain groove **236** of the leeward side collection tank **23** is omitted.

[0052] According to the refrigerant evaporator **1** of this embodiment explained above, the operation and advantage described in following (1) and (2) can be acquired.

[0053] (1) As shown in arrows W1 and W2 in FIG. **5**, the condensed water can be discharged from the clearance CL1 outside through the drainage passage **40** or/and the drainage passage **50**. Therefore, a freeze crack resulting from the freeze of condensed water can be restricted since it is difficult for the condensed water to stay in the clearance CL**1**.

[0054] (2) The outlet port **42** of the drainage passage **40** and the outlet port **52** of the drainage passage **50** are positioned on the lower side of the clearance CL**1** in the vertical direction Y**1**. Since the condensed water trapped by the clearance CL**1** becomes easy to be discharged, a freeze crack can be more certainly restricted.

(First Modification)

[0055] Next, a first modification of the refrigerant evaporator **1** of the first embodiment is explained.

[0056] As shown in FIG. **6**, in the refrigerant evaporator **1** of this modification, the cross-section area of the outlet port **42** of the drainage passage **40** is larger than the cross-section area of the inflow port **41** of the drainage passage **40**. Similarly, the cross-section area of the outlet port **52** of the drainage passage **50** is larger than the cross-section area of the inflow port **51** of the drainage passage **50**. Since the condensed water trapped by the clearance CL**1** becomes easier to be discharged according to such a structure, a freeze crack can be controlled effectively. The same action and effect can be acquired when the cross-section area of the outlet port **42** is more than or equal to the cross-section area of the inflow port **41**. The same action and effect can be acquired when the cross-section area of the outlet port **52** is more than or equal to the cross-section area of the inflow port **51**. **[0047]**

(Second Modification)

[0057] Next, a second modification of the refrigerant evaporator **1** of the first embodiment is explained.

[0058] As shown in FIG. **7**, the drainage passage **40**, **50** may be defined of only the drain groove **310**, **311** formed in the switch tank **30**. Moreover, as shown in FIG. **8**, the drainage passage **40** may be defined of only the drain groove **136** formed in the windward side distribution tank **13**. Furthermore, the drainage passage **50** may be defined of only the drain groove **236** formed in the leeward side collection tank **23**. In short, the drainage passage for discharging the water trapped by the clearance CL**1** is defined by at least one of the joint portion **133**, **304** between the windward side distribution tank **13** and the switch tank **30**, and the joint portion **233**, **305** between the leeward side collection tank **23** and the switch tank **30** shown in FIG. **2**.

(Third Modification)

[0059] Next, a third modification of the refrigerant evaporator **1** of the first embodiment is explained.

[0060] As shown in FIG. **9**, the drainage passage **40**, **50** may have a curved shape. In addition, the form of the drainage passage **40**, **50** can be suitably changed, without being limited to the form shown in FIG. **5** to FIG. **9**.

(Fourth Modification)

[0061] Next, a fourth modification of the refrigerant evaporator **1** of the first embodiment is explained.

[0062] As shown in FIG. **10**, in the refrigerant evaporator **1** of this modification, the cross-section area of the narrowest clearance between the windward side distribution tank **13** and the windward side collection tank **23** is set as "Sa." Moreover, the cross-section area of the inflow port **41** of the drainage passage **40** is set as "Sb**1**", and the cross-section area of the outlet port **42** of the drainage passage **40** is set as "Sc**1**." Furthermore, the cross-section area of the inflow port **51** of the drainage passage **50** is set as "Sb**2**", and the cross-section area of the outlet port **52** of the drainage passage **50** is set as "Sc**2**."

[0063] These cross-section areas Sa, Sb**1**, Sb**2**, Sc**1**, and Sc**2** are set to satisfy the following relation formulas f1 and f2.

$$Sa<Sb1\leq Sc1 \tag{f1}$$

$$Sa<Sb2\leq Sc2 \tag{f2}$$

[0064] Accordingly, since the condensed water which flows into the clearance CL**1** from the narrowest portion between the windward side distribution tank **13** and the windward side collection tank **23** can be easily drained, a freeze crack can be controlled effectively.

[0065] In addition, in case where the refrigerant evaporator **1** is arranged with the slanting posture, if the drainage passage, among the drainage passage **40** and the drainage passage **50**, arranged on the lower side in the vertical direction satisfies the formulas, the same operation and advantage can be acquired. The slanting posture represents an orientation in which the longitudinal direction of the tubes **12***a* and **22***a* intersects the vertical direction.

Second Embodiment

[0066] Next, a second embodiment of the refrigerant evaporator **1** is described hereafter focusing on differences from the first embodiment.

[0067] As shown in FIG. **11**, the windward side distribution tank **13** and the leeward side collection tank **23** of this embodiment are formed integrally with each other. Specifically, the windward side distribution tank **13** and the leeward side collection tank **23** are configured to have a core plate **61** and a tank portion **62**.

[0068] The tube **12***a* of the windward side heat exchange part **12** and the tube **22***a* of the leeward side heat exchange part **22** are inserted and joined to the core plate **61**. The core plate **61** is formed to have approximately W-shaped cross-section. In detail, the core plate **61** has a windward side tube bonded surface **611** and a leeward side tube bonded surface **612**. The tube **12***a* of the windward side heat exchange part **12** is inserted and joined to the windward side tube bonded surface **611**. The tube **22***a* of the leeward side heat exchange part **22** is inserted and joined to the leeward side tube bonded surface **612**. The core plate **61** has a core plate side projection part **613** arranged between the two tube bonded surfaces **611**, **612**. The core plate side projection part **613** is projected away from the heat exchange part **12**, **22** relative to the two tube bonded surfaces **611**, **612**. The core plate side projection part **613** has plural openings **613***a* arranged in the longitudinal direction, that is a direction perpendicular to both of the air flowing direction X and the vertical direction Y**1**, Y**2**.

[0069] The tank portion **62** defines a tank space with the core plate **61**. The tank space represents the first distribution part **131** and the second distribution part **132** of the windward side distribution tank **31**, and the first collection part **231** and the second collection part **232** of the leeward side collection tank **23**, shown in FIG. **2**. The tank portion **62** is formed to have approximately W-shaped cross-section. In detail, the tank portion **62** has a windward side tank the portion **621** and a leeward side tank portion **622**. The windward side tank portion **621** defines the first distribution part **131** and the second distribution part **132** with the windward side tube bonded surface **611**. The leeward side tank portion **622** defines the first collection part **231** and the second collection part **232** with the leeward side tube bonded surface **612**. The tank portion **62** has a tank portion side projection part **623** arranged between the two tank portions **621** and **622**. The tank portion side projection part **623** is projected toward the windward side heat exchange part **12** and the leeward side heat exchange part **22** relative to the two tank portions **621**, **622**. The tank portion side projection part **623** has plural openings **623***a* arranged in the longitudinal direction, that is, a direction perpendicular to both of the air flowing direction X and the vertical direction Y**1**, Y**2**.

[0070] The core plate side projection part **613** of the core plate **61** and the tank portion side projection part **623** of the tank portion **62** are joined to each other. The space formed of the core plate **61** and the tank portion **62** is divided into the windward side distribution tank **13** and the leeward side collection tank **23**. In other words, the core plate side projection part **613** and the tank portion side projection part **623** operate as a connection part **70** which connects the windward side distribution tank **13** and the leeward side collection tank **23** to each other.

[0071] The opening **613***a* and the opening **623***a* are arranged at least partially overlap with each other. Thereby, the opening **613***a* and the opening **623***a* function as a drainage hole to drain water condensed, due to heat exchange between refrigerant and air, on the external surfaces of the windward side heat exchange part **12** and the leeward side heat exchange part **22**.

[0072] A space CL**2** is defined between the upper part of the switch tank **30** and the tank portion **62**. The space CL**2** is communicated to a space where the windward side heat exchange part **12** and the leeward side heat exchange part **22** are arranged through the opening **613***a* and the opening **623***a*. The space CL**2** is located below the opening **613***a* and the opening **623***a* in the vertical direction Y**1**.

[0073] The external surface of the tank portion **62** located on the outer side when attached to the core plate **61** has the joint portion **621***a* and the joint portion **622***a*. The joint portion **621***a* is a portion joined to the joint portion **304** of the switch tank **30**. The joint portion **622***a* is a portion joined to the joint portion **305** of the switch tank **30**.

[0074] The drain groove **621***b* is formed on the joint portion **621***a* at the position corresponding to the drain groove **310** of the joint portion **304** of the switch tank **30**. The straight-shaped drainage passage **40** is defined by the space surrounded by the drain groove **310** formed in the joint portion **304** of the switch tank **30**, and the drain groove **621***b*. The drainage passage **40** is formed on the lower side of the opening **613***a*, **623***a* of the connection part **70**. The inflow port **41** communicated to the space CL**2** is formed at the end part of the drainage passage **40**. The outlet port **42** open to the lower space of the windward side distribution tank **13** in the vertical direction Y**1** is formed at the other end part of the drainage passage **40**. The outlet port **42** is arranged on the lower side of the space CL**2** in the vertical direction Y**1**. The space where the windward side heat exchange part **12** and the leeward side heat exchange part **22** are arranged is communicated to the drainage passage **40** through the opening **613***a*, the opening **623***a*, and the space CL**2**.

[0075] The drain groove **622***b* is formed in the joint portion **622***a* at the position corresponding to the drain groove **311** of the joint portion **305** of the switch tank **30**. The straight-shaped drainage passage **50** is defined by the space surrounded by the drain groove **311** formed in the joint portion **305** of the switch tank **30**, and the drain groove **622***b*. The drainage passage **50** is formed on the lower side of the opening **613***a*, **623***a* of the connection part **70**. The inflow port **51** communicated to the space CL**2** is formed at the end part of the drainage passage **50**. The outlet port **52** open to the lower space of the leeward side collection tank **23** in the vertical direction Y**1** is formed at the other end part of the drainage passage **50**. The outlet port **52** is arranged on the lower side of the space CL**2** in the vertical direction Y**1**. The space where the windward side heat exchange part **12** and the leeward side heat exchange part **22** are arranged is communicated to the drainage passage **50** through the opening **613***a*, the opening **623***a*, and the space CL**2**.

[0076] A cross-section area of at least one of the inflow port **41** of the drainage passage **40** and the inflow port **51** of the drainage passage **50** is larger than each opening area of the opening **613***a* and the opening **623***a*. Thereby, the condensed water which flows into the space CL**2** from the opening **613***a* and the opening **623***a* can be easily drained. Moreover, considering the viewpoint of the drainage property of condensed water, it is desirable to set the cross-section area of the outlet port **42** of the drainage passage **40** to be larger than the cross-section area of the inflow port **41** of the drainage passage **40**. Similarly, it is desirable to set the cross-section area of the outlet port **52** of the drainage passage **50** to be larger than the cross-section area of the inflow port **51** of the drainage passage **50**.

[0077] In addition, although illustration is omitted, similarly to the first embodiment, the joint portion **621***a* has a through hole used as a passage for introducing the refrigerant from the switch tank **30** to the first distribution part **131**, and a through hole used as a passage for introducing the refrigerant from the switch tank **30** to the second distribution part **132**. Similarly, although illustration is omitted, the joint portion **622***a* has a through hole used as a passage for introducing the refrigerant from the first collection part **231** to the switch tank **30**, and a through hole used as a passage for introducing the refrigerant from the second collection part **232** to the switch tank **30**.

[0078] According to the refrigerant evaporator **1** of this embodiment explained above, operation and advantage described in following (3) and (4) can be acquired.

[0079] (3) According to the refrigerant evaporator **1** of this embodiment, when water condensed, due to heat exchange between refrigerant and air, on the external surfaces of the windward side heat exchange part **12** and the leeward side heat exchange part **22**, the condensed water flows downward in the vertical direction Y**1**, and passes through the opening **613***a* and the opening **623***a*. The condensed water which passed through the opening **613***a* and the opening **623***a* flows into the space CL**2**, and is discharged outside through the drainage passage **40** and the drainage passage **50**. Thereby, a freeze crack can be more certainly restricted.

[0080] (4) A cross-section area of at least one of the inflow port **41** of the drainage passage **40** and the inflow port **51** of the drainage passage **50** is larger than each opening area of the opening **613***a* and the opening **623***a*. Thus, the condensed water can be easily discharged.

Other Embodiment

[0081] The refrigerant evaporator **1** of each embodiment may have only either one of the drainage passage **40** and the drainage passage **50**.

[0082] The fluid to be cooled in the refrigerant evaporator **1** is not limited to air, and appropriate fluid can be used.

[0083] It should be appreciated that the present disclosure is not limited to the embodiments described above and can be modified appropriately within the scope of the present disclosure. The scope of the present disclosure is not limited to the range exemplified with the structure of the embodiment. The range of the present disclosure is shown by the appended claims, and also includes all the changes in the equivalence. For example, each element, its arrangement, material, condition, shape, size and the like in each embodiment is not limited to the example, and is suitably modified. It is possible to combine the elements of the embodiments, provided it is technically possible.

What is claimed is:

1. A refrigerant evaporator in which heat is exchanged between a fluid to be cooled and a refrigerant, the refrigerant evaporator comprising:

a first heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant;

a second heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant, the second heat exchange part being arranged to oppose the first heat exchange part;

a first tank arranged below the first heat exchange part to distribute the refrigerant to the first heat exchange part;

a second tank arranged below the second heat exchange part to collect the refrigerant flowing through the second heat exchange part; and

a third tank joined to the first tank and the second tank to introduce the refrigerant collected by the second tank to the first tank, wherein

a clearance is defined among the first tank, the second tank, and the third tank, and

each of a joint portion between the first tank and the third tank and a joint portion between the second tank and the third tank defines a drainage passage to discharge water trapped in the clearance.

2. The refrigerant evaporator according to claim **1**, wherein

the drainage passage has an outlet port located below the clearance.

3. The refrigerant evaporator according to claim **1**, wherein

the drainage passage is an arc-shaped water passage.

4. The refrigerant evaporator according to claim **1**, wherein

the drainage passage is a straight-shaped water passage.

5. The refrigerant evaporator according to claim **1**, wherein

a cross-section area of an outlet port of the drainage passage is more than or equal to a cross-section area of an inflow port of the drainage passage.

6. The refrigerant evaporator according to claim **1**, wherein

a cross-section area of an inflow port of the drainage passage is larger than a cross-section area of a narrowest clearance between the first tank and the second tank.

7. A refrigerant evaporator in which heat is exchanged between a fluid to be cooled and a refrigerant, the refrigerant evaporator comprising:

a first heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant;

a second heat exchange part in which the refrigerant flows to exchange heat between the fluid to be cooled and the refrigerant, the second heat exchange part being arranged to oppose the first heat exchange part;

a first tank arranged below the first heat exchange part to distribute the refrigerant to the first heat exchange part;

a second tank arranged below the second heat exchange part to collect the refrigerant flowing through the second heat exchange part;

a connection part that connects the first tank and the second tank to each other; and

a third tank joined to the first tank and the second tank to introduce the refrigerant collected by the second tank to the first tank, wherein

at least one opening is defined in the connection part, and

each of a joint portion between the first tank and the third tank and a joint portion between the second tank and the third tank defines a drainage passage located below the opening of the connection part to discharge water passing through the opening.

8. The refrigerant evaporator according to claim **7**, wherein

a cross-section area of an inflow port of the drainage passage is larger than an opening area of the opening.

9. The refrigerant evaporator according to claim **1**, wherein

the drainage passage defined in the joint portion between the first tank and the third tank has an inflow port communicated with the clearance, and

the drainage passage defined in the joint portion between the second tank and the third tank has an inflow port communicated with the clearance.

10. The refrigerant evaporator according to claim **7**, wherein

the drainage passage defined in the joint portion between the first tank and the third tank has an inflow port communicated with a lower space of the opening, and

the drainage passage defined in the joint portion between the second tank and the third tank has an inflow port communicated with the lower space of the opening.

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