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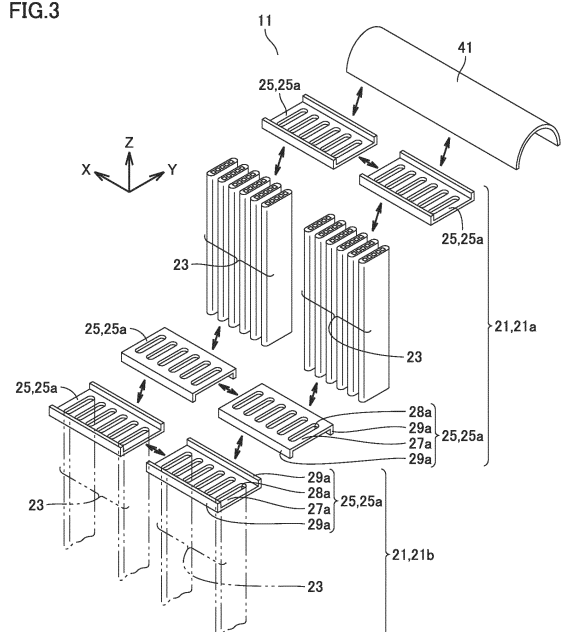
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE APPARATUS EQUIPPED WITH SAME**

(57) An outdoor heat exchanger (11) includes a first heat exchange module (21a) and a second heat exchange module (21b), as heat exchange modules (21) each including a plurality of heat transfer tubes (23) and a securing connector (25) that holds the heat transfer tubes (23). The securing connector (25) has a holder plate (27a) holding one end of each of the heat transfer tubes (23), and a pair of side plates (29a) extending from the holder plate (27a) away from the heat transfer tubes (23). The pair of side plates (29a) of the securing connector (25) of the first heat exchange module (21a) is joined to the pair of side plates (29a) of the securing connector (25) of the second heat exchange module (21b). The securing connectors (25) of both of the first heat exchange module (21a) and the second heat exchange module (21b) define a space, and the heat transfer tubes (23) of the first heat exchange module (21a) and the heat transfer tubes (23) of the second heat exchange module (21b) communicate with the space.

FIG.3



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Conventionally, as a heat exchanger, there has been provided a heat exchanger that adopts a fin-less structure in which no fins are disposed in heat transfer tubes. In this type of heat exchanger, it is necessary to dispose more heat transfer tubes in order to ensure a heat transfer area. It is necessary to narrow the pitch for disposing the heat transfer tubes in order to accommodate the heat transfer tubes within a limited volume.

[0003] When the pitch for disposing the heat transfer tubes is narrowed, it is conceivable that the heat transfer tubes may be curved due to thermal stress, an assembly error, or the like, for example, during the manufacturing of the heat exchanger, and adjacent heat transfer tubes may contact with each other. In order to prevent the heat transfer tubes from contacting with each other, for example, PTL 1 proposes a heat exchanger including a plurality of heat transfer tubes and an auxiliary member attached to the heat transfer tubes for maintaining the pitch of the heat transfer tubes.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2018-162953

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In a conventional heat exchanger in which many heat transfer tubes are disposed, there remains room for improvement in suppressing variations in the amounts of refrigerants flowing through the heat transfer tubes.

[0006] The present disclosure has been made in order to solve such a problem, and one object thereof is to provide a heat exchanger that reduces variations in the amounts of refrigerants flowing through heat transfer tubes, and another object thereof is to provide a refrigeration cycle apparatus to which such a heat exchanger is applied.

SOLUTION TO PROBLEM

[0007] A heat exchanger in accordance with the present disclosure is a heat exchanger including a plurality of heat exchange modules, the plurality of heat ex-

change modules each including a plurality of heat transfer tubes and a securing connector that holds the plurality of heat transfer tubes, the plurality of heat exchange modules being connected together by the securing connector of each of the plurality of heat exchange modules. The securing connector includes a holder plate and a pair of side plates. The holder plate holds the plurality of heat transfer tubes that are disposed to be spaced from each other, the plurality of heat transfer tubes each having one end inserted through the holder plate. The pair of side plates extends from the holder plate away from the heat transfer tubes, the pair of side plates extending along the one end of each of the plurality of heat transfer tubes, the one end being located between the side plates. The plurality of heat exchange modules include a first heat exchange module and a second heat exchange module. In the first heat exchange module, the plurality of heat transfer tubes are disposed in a first direction to be spaced from each other. In the second heat exchange module, the plurality of heat transfer tubes are disposed in the first direction to be spaced from each other, the second heat exchange module being connected to the first heat exchange module in a second direction crossing the first direction. In the first heat exchange module and the second heat exchange module connected with each other, the holder plate of the securing connector in the first heat exchange module is spaced from and faces the holder plate of the securing connector in the second heat exchange module. The pair of side plates of the securing connector in the first heat exchange module is joined to the pair of side plates of the securing connector in the second heat exchange module. The securing connector in the first heat exchange module and the securing connector in the second heat exchange module define a space, and the plurality of heat transfer tubes in the first heat exchange module and the plurality of heat transfer tubes in the second heat exchange module communicate with the space and face each other.

[0008] A refrigeration cycle apparatus in accordance with the present disclosure is a refrigeration cycle apparatus including the heat exchanger described above.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the heat exchanger in accordance with the present disclosure, in the space defined by the securing connectors connecting the first heat exchange module and the second heat exchange module, refrigerants that have flowed through the plurality of heat transfer tubes are mixed. Thereby, even when there are variations in the amounts of the refrigerants distributed to the heat transfer tubes after flowing into the heat exchanger, the refrigerants are mixed in that space, and thereby the amounts of the refrigerants flowing through the heat transfer tubes are equalized. As a result, the heat exchanger can have an improved heat transfer performance.

[0010] The refrigeration cycle apparatus in accordance

with the present disclosure includes the heat exchanger described above. This can contribute to an improved heat transfer performance as a refrigeration cycle apparatus.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a view showing a refrigerant circuit of a refrigeration cycle apparatus including an outdoor heat exchanger in accordance with each embodiment.

Fig. 2 is a front view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with a first embodiment.

Fig. 3 is an exploded perspective view showing an assembly structure of the heat exchange modules in the same embodiment.

Fig. 4 is a partial perspective view showing a heat exchange module including fins as a variation in the same embodiment.

Fig. 5 is a partial perspective view showing a structure of a heat exchange module in an outdoor heat exchanger in accordance with a second embodiment.

Fig. 6 is a partial perspective view showing a structure of a heat exchange module in an outdoor heat exchanger in accordance with a third embodiment.

Fig. 7 is a partial perspective view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with a fourth embodiment.

Fig. 8 is a first partial perspective view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with a fifth embodiment.

Fig. 9 is a second partial perspective view showing a structure of the heat exchange modules in the outdoor heat exchanger in the same embodiment.

Fig. 10 is a partial perspective view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with a sixth embodiment.

Fig. 11 is a partial front view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with a seventh embodiment.

Fig. 12 is a first front view showing a structure of heat exchange modules in an outdoor heat exchanger in accordance with an eighth embodiment.

Fig. 13 is a second front view showing a structure of the heat exchange modules in the outdoor heat exchanger in the same embodiment.

DESCRIPTION OF EMBODIMENTS

[0012] First, a description will be given of one example of a refrigerant circuit of a refrigeration cycle apparatus including a heat exchanger (an outdoor heat exchanger) in accordance with each embodiment. As shown in Fig. 1, a refrigeration cycle apparatus 1 includes a compressor 3, an indoor heat exchanger 5, a fan 7, an expansion

valve 9, an outdoor heat exchanger 11, a propeller fan 13, a four-way valve 15, and a refrigerant pipe 17 connecting these elements. The structure of outdoor heat exchanger 11 will be described in detail in each embodiment.

[0013] Next, a heating operation will be described first as an operation of refrigeration cycle apparatus 1 described above. Solid lines indicate the flow of refrigerant in the case of the heating operation. By driving compressor 3, high-temperature and high-pressure gas refrigerant is discharged from compressor 3. The discharged high-temperature and high-pressure gas refrigerant (single phase) flows into indoor heat exchanger 5 through four-way valve 15.

[0014] In indoor heat exchanger 5, heat exchange is performed between the gas refrigerant that has flowed therein and air fed therein by fan 7. The high-temperature and high-pressure gas refrigerant condenses into high-pressure liquid refrigerant (single phase). The heat exchanged air is fed into a room from indoor heat exchanger 5, to heat the interior of the room. The high-pressure liquid refrigerant fed from indoor heat exchanger 5 is turned into two-phase refrigerant including low-pressure gas refrigerant and liquid refrigerant by expansion valve 9.

[0015] The two-phase refrigerant flows into outdoor heat exchanger 11. Outdoor heat exchanger 11 functions as an evaporator. In outdoor heat exchanger 11, heat exchange is performed between the two-phase refrigerant that has flowed therein and air supplied by propeller fan 13. In the two-phase refrigerant, the liquid refrigerant evaporates into low-pressure gas refrigerant (single phase), which is fed from outdoor heat exchanger 11.

[0016] As described later, in the case of the heating operation, the refrigerant flows into a second header 43 located at the bottom of outdoor heat exchanger 11, flows through heat transfer tubes 23, and thereafter is fed from a first header 41 located at the top of outdoor heat exchanger 11 (see Fig. 2).

[0017] The low-pressure gas refrigerant fed from outdoor heat exchanger 11 flows into compressor 3 through four-way valve 15. The low-pressure gas refrigerant that has flowed into compressor 3 is compressed into high-temperature and high-pressure gas refrigerant, which is discharged from compressor 3 again. This cycle is subsequently repeated.

[0018] A cooling operation will be described next. By driving compressor 3, high-temperature and high-pressure gas refrigerant is discharged from compressor 3. The discharged high-temperature and high-pressure gas refrigerant (single phase) flows into outdoor heat exchanger 11 through four-way valve 15. Outdoor heat exchanger 11 functions as a condenser. In outdoor heat exchanger 11, heat exchange is performed between the refrigerant that has flowed therein and air supplied by propeller fan 13. The high-temperature and high-pressure gas refrigerant condenses into high-pressure liquid refrigerant (single phase).

[0019] In the case of the cooling operation, the refrigerant

erant flows into first header 41 located at the top of outdoor heat exchanger 11, flows through heat transfer tubes 23, and thereafter is fed from second header 43 located at the bottom of outdoor heat exchanger 11 (see Fig. 2).

[0020] The high-pressure liquid refrigerant fed from outdoor heat exchanger 11 is turned into two-phase refrigerant including low-pressure gas refrigerant and liquid refrigerant by expansion valve 9. The two-phase refrigerant flows into indoor heat exchanger 5. In indoor heat exchanger 5, heat exchange is performed between the two-phase refrigerant that has flowed therein and air fed into indoor heat exchanger 5 by fan 7. In the two-phase refrigerant, the liquid refrigerant evaporates into low-pressure gas refrigerant (single phase). The heat exchanged air is fed into the room from indoor heat exchanger 5, to cool the interior of the room.

[0021] The low-pressure gas refrigerant fed from indoor heat exchanger 5 flows into compressor 3 through four-way valve 15. The low-pressure gas refrigerant that has flowed into compressor 3 is compressed into high-temperature and high-pressure gas refrigerant, which is discharged from compressor 3 again. This cycle is subsequently repeated.

[0022] Outdoor heat exchanger 11 applied to refrigeration cycle apparatus 1 described above includes a plurality of heat exchange modules connected with each other. In the following, outdoor heat exchanger 11 in accordance with each embodiment will be specifically described.

First Embodiment

[0023] A description will be given of one example of an outdoor heat exchanger in accordance with a first embodiment. For convenience of description, an X axis direction, a Y axis direction, and a Z axis direction perpendicular to one another are used. The X axis direction is defined as a direction substantially perpendicular to an air flow direction. The Y axis direction is defined as a direction substantially parallel to the air flow direction. The Z axis direction is defined as a direction substantially parallel to a gravity direction.

[0024] As shown in Figs. 2 and 3, outdoor heat exchanger 11 includes a plurality of heat exchange modules 21, the plurality of heat exchange modules 21 each including a plurality of heat transfer tubes 23 and a securing connector 25 that holds the plurality of heat transfer tubes 23, the plurality of heat exchange modules 21 being connected together by securing connector 25 of each of the plurality of heat exchange modules 21.

[0025] First header 41 is connected to uppermost heat exchange module 21 of the plurality of heat exchange modules 21. Second header 43 is connected to lowermost heat exchange module 21 of the plurality of heat exchange modules 21.

[0026] Here, heat transfer tubes 23 of the plurality of heat exchange modules 21 are disposed substantially

parallel to the Z axis direction. That is, heat transfer tubes 23 are disposed along the gravity direction. Further, in the plurality of heat exchange modules 21, a fin-less structure in which no fins are disposed in heat transfer tubes 23 is adopted as an example.

[0027] The structure of heat exchange modules 21 will be described in more detail. Outdoor heat exchanger 11 has a first heat exchange module 21a as one heat exchange module 21, and a second heat exchange module 21b as another heat exchange module 21. First heat exchange module 21a and second heat exchange module 21b are connected by securing connectors 25 (25a). Securing connector 25a linearly extends in one direction.

[0028] In each of first heat exchange module 21a and second heat exchange module 21b, the plurality of heat transfer tubes 23 disposed in the X axis direction to be spaced from each other are held by securing connector 25a disposed at one end of each of heat transfer tubes 23. As heat transfer tube 23, a flat tube is applied. Securing connector 25a includes a holder plate 27a and a pair of side plates 29a.

[0029] In holder plate 27a, insertion holes 28a are formed, through each of which one end of each of the plurality of heat transfer tubes 23 is inserted, and each of which holds heat transfer tube 23. The pair of side plates 29a extends from holder plate 27a away from heat transfer tubes 23. The pair of side plates 29a extends along the one end of each of the plurality of heat transfer tubes 23, the one end being located between side plates 29a disposed to be spaced in the Y axis direction.

[0030] In first heat exchange module 21a and second heat exchange module 21b connected with each other, holder plate 27a in securing connector 25a of first heat exchange module 21a is spaced from and faces holder plate 27a in securing connector 25a of second heat exchange module 21b.

[0031] The pair of side plates 29a in securing connector 25a of first heat exchange module 21a is joined to the pair of side plates 29a in securing connector 25a of second heat exchange module 21b. The pair of side plates 29a of first heat exchange module 21a is joined to the pair of side plates 29a of second heat exchange module 21b by brazing, for example.

[0032] Securing connector 25a of first heat exchange module 21a and securing connector 25a of second heat exchange module 21b define a space (region), and heat transfer tubes 23 of first heat exchange module 21a and heat transfer tubes 23 of second heat exchange module 21b communicate with the space and face each other.

[0033] That is, in the space defined by securing connectors 25a, there is no member interposed between the plurality of heat transfer tubes 23 of first heat exchange module 21a and the plurality of heat transfer tubes 23 of second heat exchange module 21b that face each other, and the space in which refrigerants are to be mixed extends therebetween. All of the plurality of heat transfer tubes 23 held by securing connector 25a face all of the plurality of heat transfer tubes 23 held by securing con-

nector 25a, with no member being interposed between.

[0034] Securing connector 25a is attached to the other end of each of heat transfer tubes 23 of first heat exchange module 21a. This securing connector 25a is joined to first header 41. It should be noted that the other end of each of heat transfer tubes 23 of first heat exchange module 21a may be directly inserted into first header 41 with no securing connector 25a being interposed therebetween. Outdoor heat exchanger 11 in accordance with the first embodiment is configured as described above.

[0035] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be described. As shown in Figs. 1 and 3, first, in the case of the heating operation, the refrigerant that has been discharged from compressor 3 and flowed through indoor heat exchanger 5 flows into second header 43 located at the bottom of outdoor heat exchanger 11 through expansion valve 9. The refrigerant that has flowed into second header 43 flows through heat transfer tubes 23 along the (positive) Z axis direction, and flows into the space defined by securing connectors 25 connecting heat exchange modules 21.

[0036] In the space defined by securing connectors 25, the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into first header 41 located at the top of outdoor heat exchanger 11. The refrigerant that has flowed into first header 41 is fed from outdoor heat exchanger 11 and flows into compressor 3.

[0037] On the other hand, in the case of the cooling operation, the refrigerant that has been discharged from compressor 3 flows into first header 41 located at the top of outdoor heat exchanger 11. The refrigerant that has flowed into first header 41 flows through heat transfer tubes 23 along the (negative) Z axis direction, and flows into the space defined by securing connectors 25 connecting heat exchange modules 21.

[0038] In the space defined by securing connectors 25, the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11. The refrigerant that has flowed into second header 43 is fed from outdoor heat exchanger 11 and flows into compressor 3 through expansion valve 9 and indoor heat exchanger 5.

[0039] Next, a method for manufacturing outdoor heat exchanger 11 described above will be briefly described. First, the plurality of heat exchange modules 21, first header 41, and second header 43 constituting outdoor heat exchanger 11 are prepared. Then, the plurality of heat exchange modules 21 and the like are mechanically fastened using jigs, for example.

[0040] Subsequently, with the plurality of heat exchange modules 21 and the like being mechanically fastened, the plurality of heat exchange modules 21 and the

like are joined by brazing, for example. On this occasion, the pairs of side plates 29a of securing connectors 25 that face each other in the Z axis direction are joined. Further, the pairs of side plates 29a of securing connectors 25 that face each other in the X axis direction are joined, and holder plates 27a thereof are joined. By removing the jigs thereafter, the main part of outdoor heat exchanger 11 shown in Fig. 2 is completed.

[0041] Outdoor heat exchanger 11 described above includes the plurality of heat exchange modules 21, the plurality of heat exchange modules 21 each including the plurality of heat transfer tubes 23 and securing connector 25 that holds the plurality of heat transfer tubes 23, the plurality of heat exchange modules 21 being connected together by securing connector 25 of each of the plurality of heat exchange modules 21. First header 41 is connected to the top of heat exchange modules 21. Second header 43 is connected to the bottom of heat exchange modules 21.

[0042] The plurality of heat transfer tubes 23 are held by securing connector 25. This can prevent heat transfer tubes 23 from being curved due to thermal stress, an assembly error, or the like, for example, during the manufacturing of the heat exchanger.

[0043] Further, in the space defined by securing connectors 25, the refrigerants that have flowed through heat transfer tubes 23 are mixed. Thereby, even when there are variations in the amounts of the refrigerants distributed from first header 41 or second header 43 to heat transfer tubes 23, the refrigerants are mixed in that space. By repeating this process, the amounts of the refrigerants flowing through heat transfer tubes 23 are equalized. As a result, outdoor heat exchanger 11 can have an improved heat transfer performance, when compared with a conventional heat exchanger.

[0044] It should be noted that, in heat exchange modules 21 of outdoor heat exchanger 11 described above, the fin-less structure in which no fins are disposed in heat transfer tubes 23 has been described as an example. Heat exchange module 21 is not limited to the one having the fin-less structure, and heat exchange module 21 may be the one in which fins are disposed. Fig. 4 shows heat transfer tubes 23 in which plate-shaped fins 51 extending in the Z axis direction are disposed at both ends in the Y axis direction (on the positive side and the negative side) of flat-shaped heat transfer tubes 23. Further, instead of such plate-shaped fins 51, for example, corrugated fins (not shown) may be disposed in the heat transfer tubes.

50 Second Embodiment

[0045] A description will be given of one example of an outdoor heat exchanger in accordance with a second embodiment. As shown in Fig. 5, draining grooves 33 are formed in securing connector 25 that connects one heat exchange module and another heat exchange module. Draining grooves 33 are formed from portions corresponding to ends in the (positive and negative) Y axis

direction of each heat transfer tube inserted into holder plate 27a, along the Y axis direction, toward sides on which side plates 29a are located. Since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Fig. 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0046] Next, as the flow of the refrigerant in outdoor heat exchanger 11 described above, the flow of the refrigerant in the case of the heating operation will be described. As described above, when the heating operation of refrigeration cycle apparatus 1 is performed, outdoor heat exchanger 11 functions as an evaporator. On this occasion, low-temperature two-phase refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, flows through heat transfer tubes 23, and thereafter is fed from first header 41 located at the top of outdoor heat exchanger 11.

[0047] Since the low-temperature refrigerant flows into heat transfer tubes 23 of heat exchange module 21, frost is likely to form on surfaces of heat transfer tubes 23. If the frost builds up between adjacent heat transfer tubes 23, heat exchange may not be performed sufficiently between the air fed by propeller fan 13 and the refrigerant flowing through heat transfer tubes 23.

[0048] In order to avoid such a defect in advance, refrigeration cycle apparatus 1 performs a defrosting operation for melting the frost built up on heat transfer tubes 23. In the defrosting operation, the high-temperature and high-pressure refrigerant discharged from compressor 3 is fed into outdoor heat exchanger 11. As the high-temperature and high-pressure refrigerant is fed into heat transfer tubes 23 of outdoor heat exchanger 11, the frost built up on heat transfer tubes 23 melts into water droplets. The water droplets move on heat transfer tubes 23, reach holder plate 27a of securing connector 25, flow through draining grooves 33, and fall downward.

[0049] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance described above, the following effect is obtained. That is, in outdoor heat exchanger 11 described above, draining grooves 33 are formed in securing connector 25 that holds heat transfer tubes 23 and connects heat exchange modules 21 with each other. Thereby, the water droplets melting during the defrosting operation can fall downward from draining grooves 33, and can be suppressed from remaining on heat transfer tubes 23 and the like. As a result, it is possible to suppress the water droplets remaining on heat transfer tubes 23 and the like from being frozen again after the heating operation is resumed, and damaging heat transfer tubes 23 and the like.

Third Embodiment

[0050] A description will be given of one example of an outdoor heat exchanger in accordance with a third em-

bodiment. As shown in Fig. 6, inclinations are provided in holder plate 27a of securing connector 25 that connects one heat exchange module and another heat exchange module. Each inclination is inclined downward in the Z axis direction (downward in the gravity direction). Since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Fig. 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0051] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be described. As already described, when the heating operation of refrigeration cycle apparatus 1 is performed, the low-temperature two-phase refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, flows through heat transfer tubes 23, and thereafter is fed from first header 41 located at the top of outdoor heat exchanger 11.

[0052] Since the low-temperature refrigerant flows into heat transfer tubes 23 of heat exchange module 21, frost is likely to form on the surfaces of heat transfer tubes 23. If the frost builds up between adjacent heat transfer tubes 23, heat exchange may not be performed sufficiently between the air fed by propeller fan 13 and the refrigerant flowing through heat transfer tubes 23.

[0053] Accordingly, as described above, refrigeration cycle apparatus 1 performs the defrosting operation for melting the frost built up on heat transfer tubes 23. In the defrosting operation, the high-temperature and high-pressure refrigerant discharged from compressor 3 is fed into outdoor heat exchanger 11. As the high-temperature and high-pressure refrigerant is fed into heat transfer tubes 23 of outdoor heat exchanger 11, the frost built up on heat transfer tubes 23 melts into water droplets. The water droplets move on heat transfer tubes 23, flow along holder plate 27a of securing connector 25, and fall downward from the inclinations.

[0054] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance described above, the following effect is obtained. That is, in outdoor heat exchanger 11 described above, the inclinations are formed in holder plate 27a of securing connector 25 that holds heat transfer tubes 23 and connects heat exchange modules 21 with each other. Thereby, the water droplets melting during the defrosting operation can fall from the inclinations, and can be suppressed from remaining on heat transfer tubes 23 and the like. As a result, it is possible to suppress the water droplets remaining on heat transfer tubes 23 and the like from being frozen again after the heating operation is resumed, and damaging heat transfer tubes 23 and the like.

Fourth Embodiment

[0055] As an outdoor heat exchanger, there is provided an outdoor heat exchanger that adopts a structure in

which the heat exchanger is curved to ensure a heat transfer area within a limited installation area. Here, a description will be given of one example of an outdoor heat exchanger including securing connectors that can be applied to the portion of the curved heat exchanger.

[0056] As shown in Fig. 7, outdoor heat exchanger 11 includes a third heat exchange module 21c and a fourth heat exchange module 21d that are each curved, as heat exchange modules 21. Third heat exchange module 21c and fourth heat exchange module 21d are connected by securing connectors 25 (25b).

[0057] Securing connectors 25b are curved to correspond to curved third heat exchange module 21c and fourth heat exchange module 21d. It should be noted that, since the configuration other than that is the same as the configuration of the outdoor heat exchanger shown in Fig. 2 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0058] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be described. As described in the first embodiment, in the case of the heating operation, the refrigerant that has flowed into second header 43 flows through heat transfer tubes 23 along the (positive) Z axis direction, and flows into the space defined by securing connectors 25 (25b) connecting heat exchange modules 21 (see Figs. 2 and 7).

[0059] In the space defined by securing connectors 25 (25b), the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into first header 41 located at the top of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0060] On the other hand, in the case of the cooling operation, the refrigerant that has flowed into first header 41 flows through heat transfer tubes 23 along the (negative) Z axis direction, and flows into the space defined by securing connectors 25 (25b) connecting heat exchange modules 21 (see Figs. 2 and 7).

[0061] In the space defined by securing connectors 25 (25b), the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0062] Outdoor heat exchanger 11 described above has third heat exchange module 21c and fourth heat exchange module 21d that are each curved, as heat exchange modules 21. Curved third heat exchange module 21c and curved fourth heat exchange module 21d are connected by curved securing connectors 25b.

[0063] In the space defined by securing connectors 25b, the refrigerants that have flowed through heat transfer tubes 23 of third heat exchange module 21c (fourth heat exchange module 21d) are mixed. The mixed refrigerant flows through heat transfer tubes 23 of fourth

heat exchange module 21d (third heat exchange module 21c).

[0064] Thereby, even when there are variations in the amounts of the refrigerants distributed from first header 41 or second header 43 to heat transfer tubes 23 of curved third heat exchange module 21c or fourth heat exchange module 21d, the refrigerants are mixed in that space. By repeating this process, the amounts of the refrigerants flowing through heat transfer tubes 23 are equalized. As a result, this can contribute to an improved heat transfer performance of outdoor heat exchanger 11.

Fifth Embodiment

[0065] Here, a description will be given of one example of an outdoor heat exchanger including heat exchange modules in which heat transfer tubes are disposed along both of the air flow direction and a direction crossing the air flow direction.

[0066] As shown in Fig. 8, in each of first heat exchange module 21a and second heat exchange module 21b, the plurality of heat transfer tubes 23 disposed in the X axis direction to be spaced from each other are disposed on a windward side and on a leeward side along the Y axis direction (air flow direction). The positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the windward side and the positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the leeward side are set at the same positions. One end of each of these heat transfer tubes 23 is held by securing connector 25a.

[0067] It should be noted that, since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Figs. 2 and 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0068] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be described. As already described, in the case of the heating operation, the refrigerant that has flowed into second header 43 flows through heat transfer tubes 23 along the (positive) Z axis direction, and flows into the space defined by securing connectors 25 (25a) connecting heat exchange modules 21 (see Figs. 2 and 8).

[0069] In the space defined by securing connectors 25 (25a), the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into first header 41 located at the top of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0070] On the other hand, in the case of the cooling operation, the refrigerant that has flowed into first header 41 flows through heat transfer tubes 23 along the (negative) Z axis direction, and flows into the space defined by securing connectors 25 (25a) connecting heat exchange modules 21 (see Figs. 2 and 7).

[0071] In the space defined by securing connectors 25 (25a), the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0072] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance already described, the following effect is obtained. That is, in heat exchange module 21 of outdoor heat exchanger 11 described above, the plurality of heat transfer tubes 23 disposed in the X axis direction to be spaced from each other are disposed on the windward side and on the leeward side along the Y axis direction (air flow direction). Thereby, the heat transfer area in the air flow direction can be expanded. In addition, such heat exchange modules 21 are connected by securing connectors 25. Thereby, as described in the first embodiment, the amounts of the refrigerants flowing through heat transfer tubes 23 are equalized, and outdoor heat exchanger 11 can have an improved heat transfer performance.

[0073] It should be noted that the above description has been given of a case where, in outdoor heat exchanger 11 described above, the positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the windward side and the positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the leeward side are set at the same positions. Other than that, the positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the windward side may be offset from the positions in the X axis direction of the plurality of heat transfer tubes 23 disposed on the leeward side, as shown in Fig. 9. That is, with respect to the pitch of the plurality of heat transfer tubes 23 disposed on the windward side (the spacing in the X axis direction), the pitch of the plurality of heat transfer tubes 23 disposed on the leeward side (the spacing in the X axis direction) may be offset by half a pitch, for example.

[0074] In this case, air that has passed between heat transfer tubes 23 disposed on the windward side is likely to collide with heat transfer tubes 23 disposed on the leeward side. Thereby, heat exchange is performed more effectively between the air and the refrigerant flowing through heat transfer tubes 23 disposed on the leeward side, which can contribute to an improved heat transfer performance.

Sixth Embodiment

[0075] A description will be given of one example of an outdoor heat exchanger in accordance with a sixth embodiment. As shown in Fig. 10, a pair of partition walls 31a is provided in securing connector 25 (25a) that connects one heat exchange module (first heat exchange module 21a) and another heat exchange module (second heat exchange module 21b).

[0076] The pair of partition walls 31a extends from holder plate 27a away from heat transfer tubes 23. The pair of partition walls 31a is disposed to face each other to be spaced in the X axis direction. The pair of partition walls 31a is disposed to connect between the pair of side plates 29a. The pair of partition walls 31a in securing connector 25a of first heat exchange module 21a is joined to the pair of partition walls 31a in securing connector 25a of second heat exchange module 21b.

[0077] It should be noted that, since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Figs. 2 and 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0078] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be described. As already described, in the case of the heating operation, the refrigerant that has flowed into second header 43 flows through heat transfer tubes 23 along the (positive) Z axis direction, and flows into the space defined by securing connectors 25 (25a) connecting heat exchange modules 21 (see Figs. 2 and 10).

[0079] In the space defined by securing connectors 25 (25a), the refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into first header 41 located at the top of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0080] On the other hand, in the case of the cooling operation, the refrigerant that has flowed into first header 41 flows through heat transfer tubes 23 along the (negative) Z axis direction, and flows into the space defined by securing connectors 25 (25a) connecting heat exchange modules 21 (see Figs. 2 and 7).

[0081] In the space defined by securing connectors 25 (25a), that refrigerants that have flowed through heat transfer tubes 23 are mixed. The mixed refrigerant flows through heat transfer tubes 23 again. Finally, the refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, and is fed from outdoor heat exchanger 11.

[0082] When the refrigerant flows into the space defined by securing connectors 25 (25a) connecting heat exchange modules 21, the pressure of the refrigerant that has flowed into the space acts outward on securing connectors 25a.

[0083] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance described above, the following effect is obtained. That is, in outdoor heat exchanger 11 described above, the pairs of side plates 29a in securing connectors 25 (25a) of first heat exchange module 21a and second heat exchange module 21b are joined, and in addition, the pairs of partition walls 31a of securing connectors 25 (25a) thereof are joined.

[0084] Thereby, securing connectors 25 (25a) joined

to each other have an improved mechanical strength. As a result, it is possible to improve pressure resistance to the pressure of the refrigerant that has flowed into the space defined by securing connectors 25 (25a).

[0085] Further, since securing connectors 25 (25a) joined to each other have an improved mechanical strength, they can also have a resistance to external impact.

Seventh Embodiment

[0086] A description will be given of one example of an outdoor heat exchanger in accordance with a seventh embodiment. As shown in Fig. 11, outdoor heat exchanger 11 has first heat exchange module 21a and a fifth heat exchange module 21e, as heat exchange modules 21. First heat exchange module 21a and fifth heat exchange module 21e are disposed along the X axis direction, and are joined to each other by securing connectors 25.

[0087] An arrangement pitch of heat transfer tubes 23 in first heat exchange module 21a is set to a pitch P1. An arrangement pitch of heat transfer tubes 23 in fifth heat exchange module 21e is set to pitch P1. An arrangement pitch between first heat exchange module 21a and fifth heat exchange module 21e is set to a pitch P2 larger than pitch P1. That is, pitch P2 between heat exchange modules 21 is set to a value larger than that of pitch P1 within each heat exchange module 21.

[0088] Here, the arrangement pitch between first heat exchange module 21a and fifth heat exchange module 21e corresponds to a spacing between heat transfer tube 23 closest to fifth heat exchange module 21e, of the plurality of heat transfer tubes 23 in first heat exchange module 21a, and heat transfer tube 23 closest to first heat exchange module 21a, of the plurality of heat transfer tubes 23 in fifth heat exchange module 21e.

[0089] It should be noted that, since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Figs. 2 and 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0090] Next, the flow of the refrigerant in outdoor heat exchanger 11 described above will be briefly described. As described in the first embodiment, in the case of the heating operation, the refrigerant that has flowed into second header 43 flows through heat transfer tubes 23 and the space defined by securing connectors 25, flows into first header 41, and is fed from outdoor heat exchanger 11.

[0091] On the other hand, in the case of the cooling operation, the refrigerant that has flowed into first header 41 flows through heat transfer tubes 23 and the space defined by securing connectors 25, flows into second header 43, and is fed from outdoor heat exchanger 11.

[0092] Next, a method for manufacturing outdoor heat exchanger 11 described above will be described. First, the plurality of heat exchange modules 21, first header

41, and second header 43 constituting outdoor heat exchanger 11 are prepared. Then, the plurality of heat exchange modules 21 and the like, including first heat exchange module 21a and fifth heat exchange module 21e, are mechanically fastened using jigs, for example. On this occasion, first heat exchange module 21a and fifth heat exchange module 21e are disposed along the X axis direction and are mechanically fastened.

[0093] Subsequently, with the plurality of heat exchange modules 21 and the like being mechanically fastened, the plurality of heat exchange modules 21 and the like are joined by brazing, for example. On this occasion, in first heat exchange module 21a and fifth heat exchange module 21e, the pair of side plates 29a of securing connector 25 in first heat exchange module 21a is joined to the pair of side plates 29a of the securing connector in fifth heat exchange module 21e. Further, holder plate 27a of securing connector 25 in first heat exchange module 21a is joined to holder plate 27a in fifth heat exchange module 21e. By removing the jigs thereafter, the main part of outdoor heat exchanger 11 shown in Fig. 2 is completed.

[0094] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance already described, the following effect is obtained. That is, in outdoor heat exchanger 11 described above, pitch P2 between heat exchange modules 21 is set to a value larger than that of pitch P1 within each heat exchange module 21.

[0095] Thereby, when mechanically fastening the plurality of heat exchange modules 21 and the like, including first heat exchange module 21a and fifth heat exchange module 21e, gripping margins for holding securing connectors 25 with the jigs can be ensured between first heat exchange module 21a and fifth heat exchange module 21e. As a result, manufacturing of outdoor heat exchanger 11 is facilitated, which can contribute to improved productivity.

Eighth Embodiment

[0096] A description will be given of one example of an outdoor heat exchanger in accordance with an eighth embodiment. As shown in Fig. 12, outdoor heat exchanger 11 has the plurality of heat exchange modules 21 including first heat exchange module 21a and second heat exchange module 21b. First heat exchange module 21a and second heat exchange module 21b are disposed along the Z axis direction, and are joined to each other by securing connectors 25. Second heat exchange module 21b is disposed under first heat exchange module 21a.

[0097] The arrangement pitch of heat transfer tubes 23 in first heat exchange module 21a is set to pitch P1. An arrangement pitch of heat transfer tubes 23 in second heat exchange module 21b is set to a pitch P3. Pitch P3 is set to a value larger than that of pitch P1. That is, pitch P3 in second heat exchange module 21b disposed at a

lower part of heat exchange modules 21 is larger than pitch P1 in first heat exchange module 21a disposed above second heat exchange module 21b.

[0098] It should be noted that, since the configuration other than that is the same as the configuration of outdoor heat exchanger 11 shown in Figs. 2 and 3 and the like, identical members will be designated by the same reference numerals, and the description thereof will not be repeated except when necessary.

[0099] Next, as the flow of the refrigerant in outdoor heat exchanger 11 described above, the flow of the refrigerant in the case of the heating operation will be described. As described in the first embodiment, when the heating operation of refrigeration cycle apparatus 1 is performed, outdoor heat exchanger 11 functions as an evaporator. On this occasion, the low-temperature two-phase refrigerant flows into second header 43 located at the bottom of outdoor heat exchanger 11, flows through heat transfer tubes 23, and thereafter is fed from first header 41 located at the top of outdoor heat exchanger 11.

[0100] Since the low-temperature refrigerant flows into heat transfer tubes 23 of heat exchange module 21, frost is likely to form on the surfaces of heat transfer tubes 23.

[0101] If the frost builds up between adjacent heat transfer tubes 23, heat exchange may not be performed sufficiently between the air fed by propeller fan 13 and the refrigerant flowing through heat transfer tubes 23. In order to avoid such a defect, refrigeration cycle apparatus 1 performs the defrosting operation for melting the frost built up on heat transfer tubes 23. In the heating operation, this defrosting operation is performed as appropriate.

[0102] In outdoor heat exchanger 11 described above, in addition to the effect of improving the heat transfer performance already described, the following effect is obtained.

[0103] In the defrosting operation, the frost built up on heat transfer tubes 23 melts into water droplets, and the water droplets move on heat transfer tubes 23 and flow toward the lower part of heat exchange modules 21. When the defrosting operation and the heating operation are repeated, it is conceivable that the water droplets that have flowed into the lower part of heat exchange modules 21 are frozen again when the heating operation is resumed after the defrosting operation.

[0104] In outdoor heat exchanger 11 described above, pitch P3 in second heat exchange module 21b is set to a value larger than that of pitch P1 in first heat exchange module 21a. Thereby, even if the water droplets are frozen again, it is possible to suppress blockage of a gap between adjacent heat transfer tubes 23 in second heat exchange module 21b located at the lower part of heat exchange modules 21 due to refreezing. As a result, it is possible to cause air (wind) to flow between heat transfer tubes 23 adjacent to each other, and thereby to maintain heat exchange performance of outdoor heat exchanger 11.

(Variation)

[0105] A description will be given of one example of an outdoor heat exchanger in which the amounts of air fed into heat exchange modules are equalized will be described, as an outdoor heat exchanger in accordance with a variation. As described in the beginning, in outdoor heat exchanger 11, heat exchange is performed between the air fed into each heat exchange module by propeller fan 13 (see Fig. 1) and the refrigerant flowing through the heat transfer tubes of each heat exchange module. The amount of air fed into each heat exchange module depends on the speed at which the air flows (wind speed). The wind speed decreases with distance from the rotation shaft of propeller fan 13.

[0106] As shown in Fig. 13, outdoor heat exchanger 11 in accordance with the variation has the plurality of heat exchange modules 21 including a sixth heat exchange module 21f and a seventh heat exchange module 21g. An arrangement pitch of heat transfer tubes 23 in sixth heat exchange module 21f is set to a pitch P4. An arrangement pitch of heat transfer tubes 23 in seventh heat exchange module 21g is set to a pitch P5. Pitch P4 is set to a value larger than that of pitch P5.

[0107] Sixth heat exchange module 21f with a large arrangement pitch (pitch P4) is disposed at a position (region) where a relatively small amount of air is fed therein, in the outdoor heat exchanger. Seventh heat exchange module 21g with a small arrangement pitch (pitch P5) is disposed at a position (region) where a relatively large amount of air is fed therein, in the outdoor heat exchanger.

[0108] In Fig. 13, a region obtained by projecting a region in which propeller fan 13 (see Fig. 1) rotates onto heat exchange module 21 facing the propeller fan is indicated by a dotted-line frame FA. The amount of air fed into the heat exchange module located inside dotted-line frame FA is larger than the amount of air fed into the heat exchange module located outside dotted-line frame FA.

[0109] Seventh heat exchange module 21g is disposed inside dotted-line frame FA. Sixth heat exchange module 21f is disposed outside dotted-line frame FA. Here, sixth heat exchange module 21f is disposed at portions of four corners in outdoor heat exchanger 11.

[0110] According to outdoor heat exchanger 11 in accordance with the variation, in seventh heat exchange module 21g (21) where a relatively large amount of air is fed into outdoor heat exchanger 11, the arrangement pitch (pitch P5) of heat transfer tubes 23 is small, and in sixth heat exchange module 21f (21) into which a relatively small amount of air is fed, the arrangement pitch (pitch P4) of heat transfer tubes 23 is large.

[0111] Accordingly, in seventh heat exchange module 21g (21) into which a relatively large amount of air is fed, air flow resistance increases, and the air is less likely to flow between heat transfer tubes 23. On the other hand, in sixth heat exchange module 21f (21) into which a relatively small amount of air is fed, air flow resistance de-

creases, and the air is more likely to flow between heat transfer tubes 23.

[0112] This reduces the difference between the amount of air flow flowing through seventh heat exchange module 21g (21) into which a relatively large amount of air is fed and the amount of air flow flowing through sixth heat exchange module 21f(21) into which a relatively small amount of air is fed, and the amounts of air flow flowing through heat exchange modules 21 can be equalized. As a result, outdoor heat exchanger 11 can have an improved heat exchange amount.

[0113] It should be noted that the above descriptions have been given of the cases where, in each outdoor heat exchanger 11 described above, heat transfer tubes 23 of each heat exchange module 21 are disposed substantially parallel to the gravity direction (vertical direction). Outdoor heat exchanger 11 is not limited thereto, and heat transfer tubes 23 of each heat exchange module 21 may be disposed to cross the gravity direction. For example, outdoor heat exchanger 11 may have heat transfer tubes 23 disposed in a horizontal direction.

[0114] The outdoor heat exchangers described in the embodiments can be combined as necessary in various ways.

[0115] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive. The present disclosure is defined by the scope of the claims, rather than the scope described above, and is intended to include any modifications within the scope and meaning equivalent to the scope of the claims.

INDUSTRIAL APPLICABILITY

[0116] The present disclosure is effectively utilized for a heat exchanger including a plurality of heat exchange modules having a plurality of heat transfer tubes disposed therein, the heat exchange modules each having a fin-less structure.

REFERENCE SIGNS LIST

[0117] 1: refrigeration cycle apparatus; 3: compressor; 5: indoor heat exchanger; 7: indoor fan; 9: expansion valve; 11: outdoor heat exchanger; 13: propeller fan; 15: four-way valve; 17: refrigerant pipe; 21: heat exchange module; 21a: first heat exchange module; 21b: second heat exchange module; 21c: third heat exchange module; 21d: fourth heat exchange module; 21e: fifth heat exchange module; 21f: sixth heat exchange module; 21g: seventh heat exchange module; 23: heat transfer tube; 25: securing connector; 25a: securing connector; 27a: holder plate; 28a: insertion hole; 29a: pair of side plates; 31a: pair of partition walls; 25b: securing connector; 27b: holder plate; 28b: insertion hole; 29b: pair of side plates; 33: draining groove; 35: inclination; 41: first header; 43: second header; 51: plate-shaped fin; P1, P2, P3, P4, P5: pitch; FA: region.

Claims

1. A heat exchanger comprising a plurality of heat exchange modules, the plurality of heat exchange modules each comprising a plurality of heat transfer tubes and a securing connector that holds the plurality of heat transfer tubes, the plurality of heat exchange modules being connected together by the securing connector of each of the plurality of heat exchange modules,

the securing connector comprising:

a holder plate holding the plurality of heat transfer tubes that are disposed to be spaced from each other, the plurality of heat transfer tubes each having one end inserted through the holder plate; and
a pair of side plates extending from the holder plate away from the heat transfer tubes, the pair of side plates extending along the one end of each of the plurality of heat transfer tubes, the one end being located between the side plates,

the plurality of heat exchange modules comprising:

a first heat exchange module in which the plurality of heat transfer tubes are disposed in a first direction to be spaced from each other; and
a second heat exchange module in which the plurality of heat transfer tubes are disposed in the first direction to be spaced from each other, the second heat exchange module being connected to the first heat exchange module in a second direction crossing the first direction, wherein

in the first heat exchange module and the second heat exchange module connected with each other,
the holder plate of the securing connector in the first heat exchange module is spaced from and faces the holder plate of the securing connector in the second heat exchange module,
the pair of side plates of the securing connector in the first heat exchange module is joined to the pair of side plates of the securing connector in the second heat exchange module, and
the securing connector in the first heat exchange module and the securing connector in the second heat exchange module define a region, and
the plurality of heat transfer tubes in the first heat exchange module and the plurality of heat transfer tubes in the second heat exchange module communicate with the region and face each other.

- er.
2. The heat exchanger according to claim 1, wherein the plurality of heat exchange modules each have a fin-less structure without fins. 5
 3. The heat exchanger according to claim 1 or 2, wherein a draining groove for draining moisture adhering to the heat transfer tubes is formed in the securing connector. 10
 4. The heat exchanger according to any one of claims 1 to 3, wherein an inclination for draining moisture adhering to the heat transfer tubes toward a direction away from the heat transfer tubes is provided in the securing connector. 15
 5. The heat exchanger according to any one of claims 1 to 4, wherein 20

the plurality of heat exchange modules comprises

a third heat exchange module in which the plurality of heat transfer tubes are disposed to be bent from the first direction and to be spaced from each other, and 25

a fourth heat exchange module in which the plurality of heat transfer tubes are disposed to be bent from the first direction and to be spaced from each other, the fourth heat exchange module being connected to the third heat exchange module, and 30

in the third heat exchange module and the fourth heat exchange module connected with each other, 35

the securing connector bent to correspond to the heat transfer tubes disposed to be bent in the third heat exchange module is joined to the securing connector bent to correspond to the heat transfer tubes disposed to be bent in the fourth heat exchange module. 40
 6. The heat exchanger according to any one of claims 1 to 5, wherein 45

in the first heat exchange module, the plurality of heat transfer tubes disposed in the first direction to be spaced from each other are disposed on a windward side and on a leeward side along an air flow direction corresponding to a third direction crossing the first direction and the second direction, 50

in the second heat exchange module, the plurality of heat transfer tubes disposed in the first direction to be spaced from each other are disposed on the windward side and on the leeward side along the air flow direction corresponding to the third direction, 55

in the first heat exchange module and the second heat exchange module connected with each other, 60

the securing connector holding the one end of each of the plurality of heat transfer tubes disposed on the windward side and on the leeward side in the first heat exchange module is joined to the securing connector holding the one end of each of the plurality of heat transfer tubes disposed on the windward side and on the leeward side in the second heat exchange module. 65
 7. The heat exchanger according to any one of claims 1 to 6, wherein 70

the securing connector comprises a pair of partition walls extending from the holder plate away from the heat transfer tubes, the pair of partition walls being disposed to face each other to be spaced in the first direction, and to connect between the side plates, and 75

in the first heat exchange module and the second heat exchange module connected with each other, the pair of partition walls of the securing connector in the first heat exchange module is further joined to the pair of partition walls of the securing connector in the second heat exchange module. 80
 8. The heat exchanger according to any one of claims 1 to 7, wherein 85

the plurality of heat exchange modules comprises a fifth heat exchange module in which the plurality of heat transfer tubes are disposed in the first direction to be spaced from each other, the fifth heat exchange module being connected to the first heat exchange module in the first direction, and 90

in the first heat exchange module and the fifth heat exchange module connected with each other, 95

an inter-module pitch between a heat transfer tube closest to the fifth heat exchange module, of the plurality of heat transfer tubes in the first heat exchange module, and a heat transfer tube closest to the first heat exchange module, of the plurality of heat transfer tubes in the fifth heat exchange module, is larger than an intra-module pitch of the plurality of heat transfer tubes in the first heat exchange module. 100
 9. The heat exchanger according to any one of claims 1 to 8, wherein a first intra-module pitch of the plurality of heat transfer tubes in the first heat exchange module is smaller than a second intra-module pitch 105

of the plurality of heat transfer tubes in the second heat exchange module.

10. The heat exchanger according to any one of claims 1 to 9, wherein

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the second direction is a gravity direction, and the first heat exchange module is connected above the second heat exchange module.

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11. A refrigeration cycle apparatus comprising the heat exchanger according to any one of claims 1 to 10.

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FIG.1

→ FLOW OF REFRIGERANT DURING HEATING OPERATION
 ----> FLOW OF REFRIGERANT DURING COOLING OPERATION

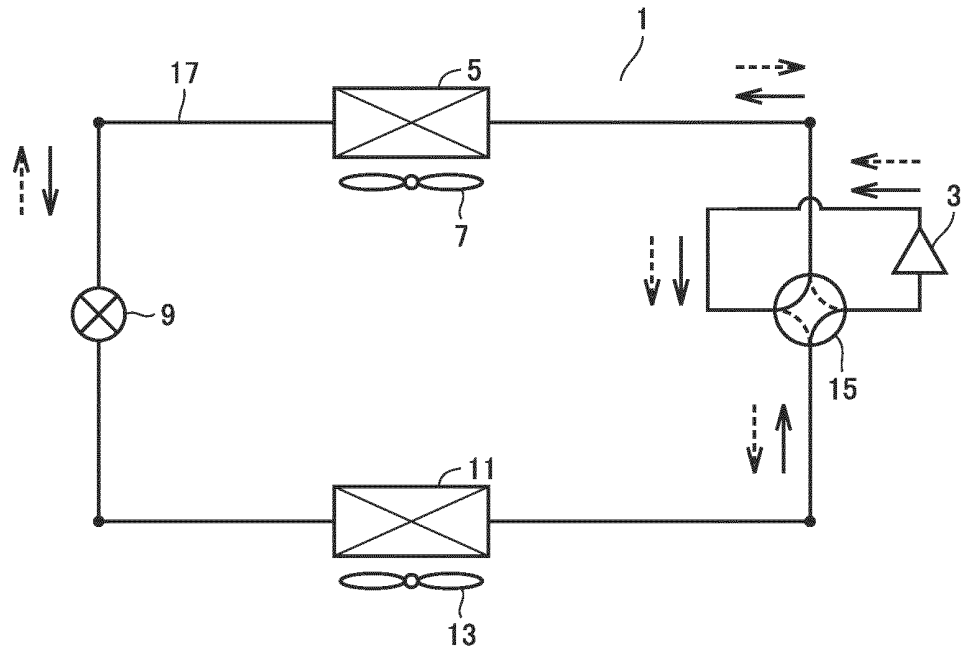


FIG.2

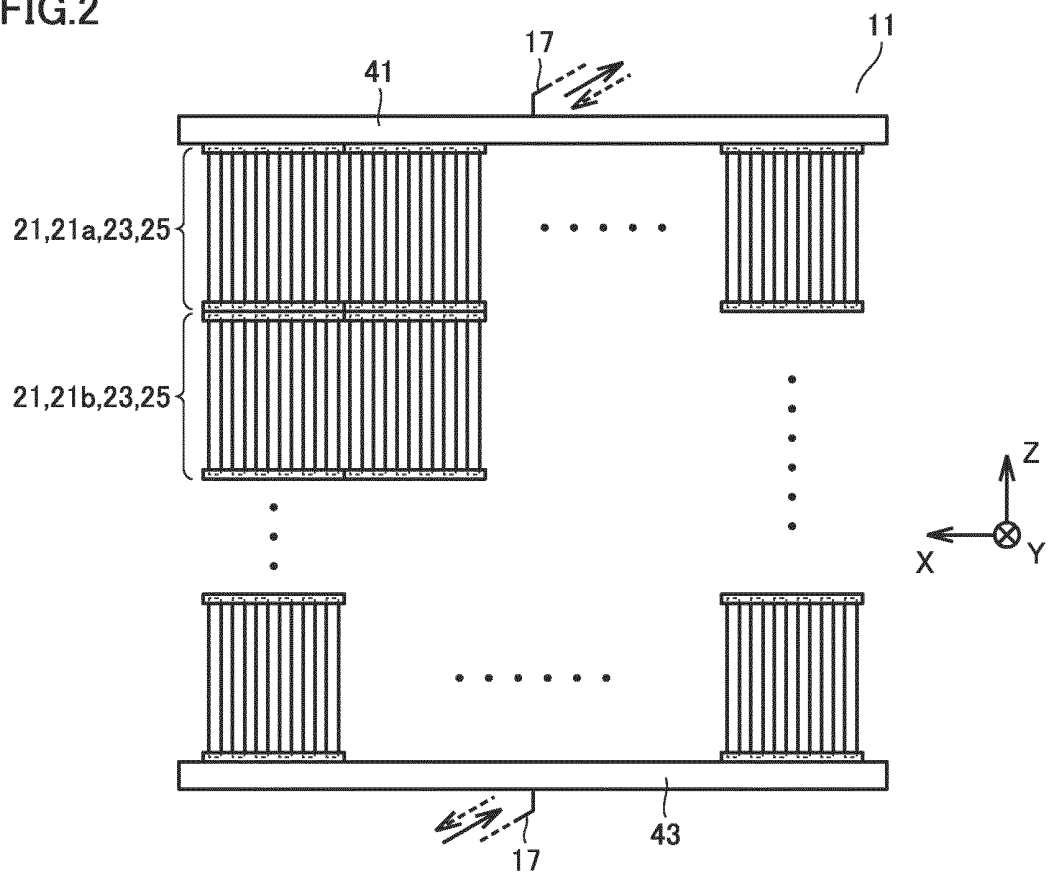


FIG.3

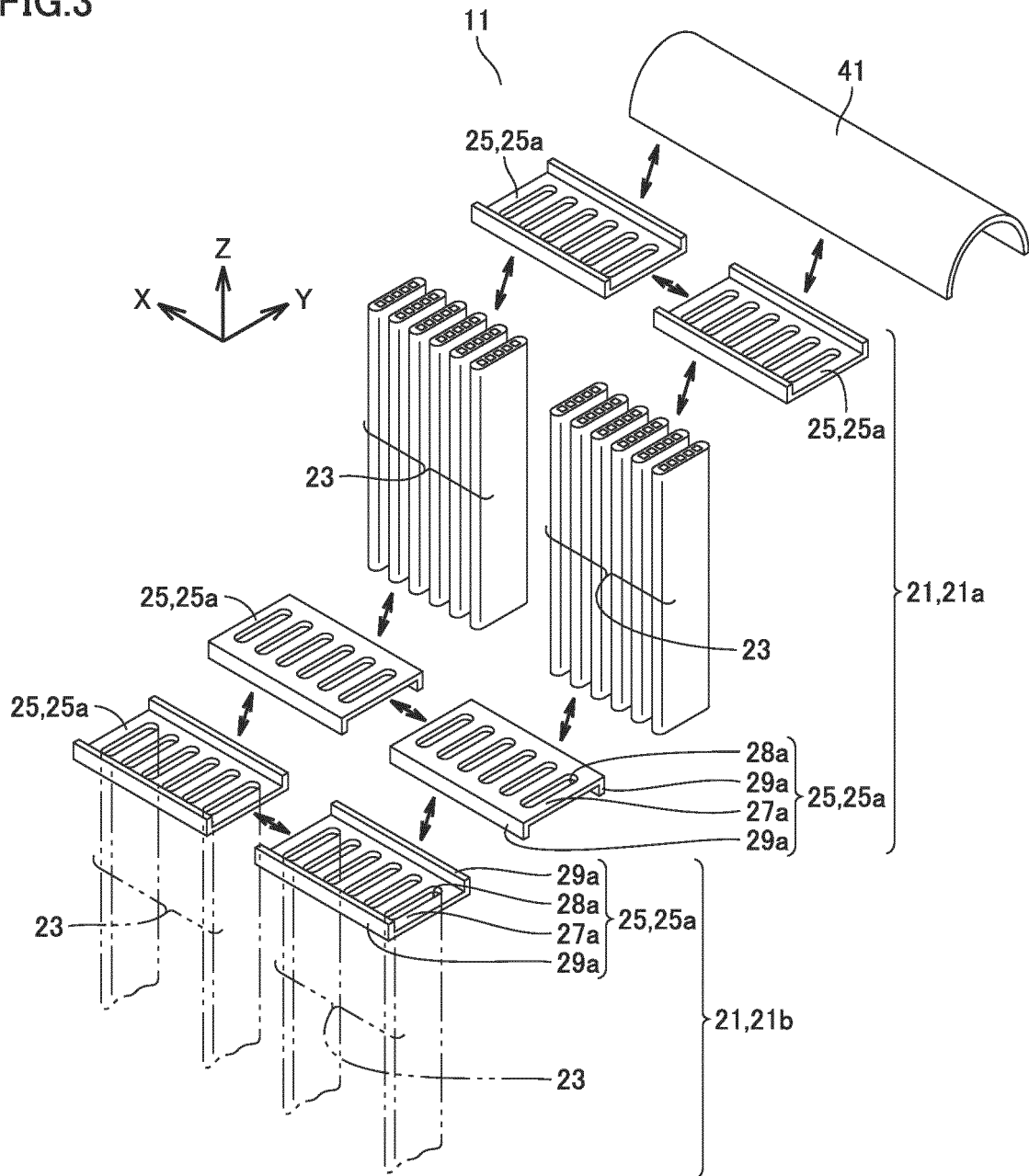


FIG.4

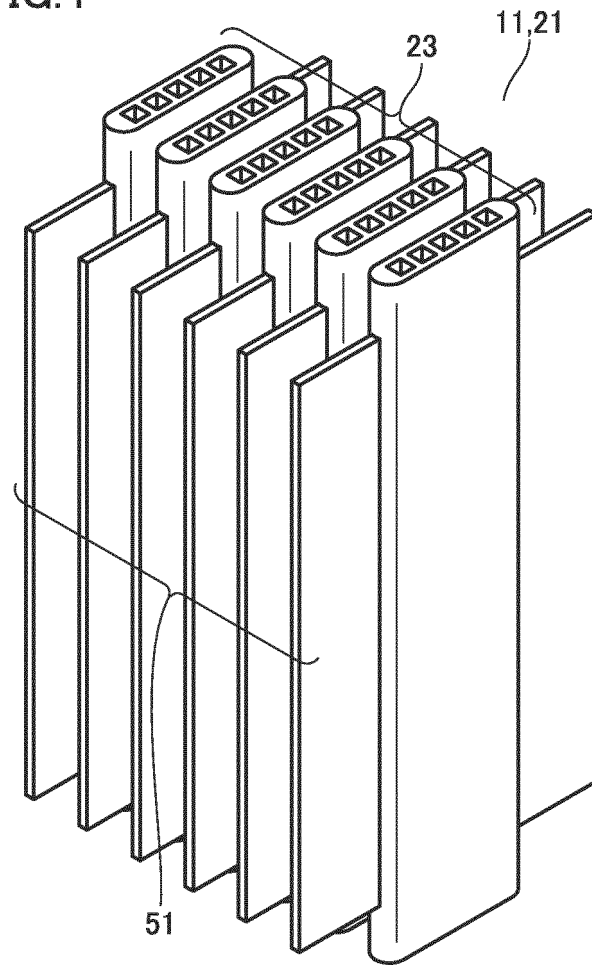


FIG.5

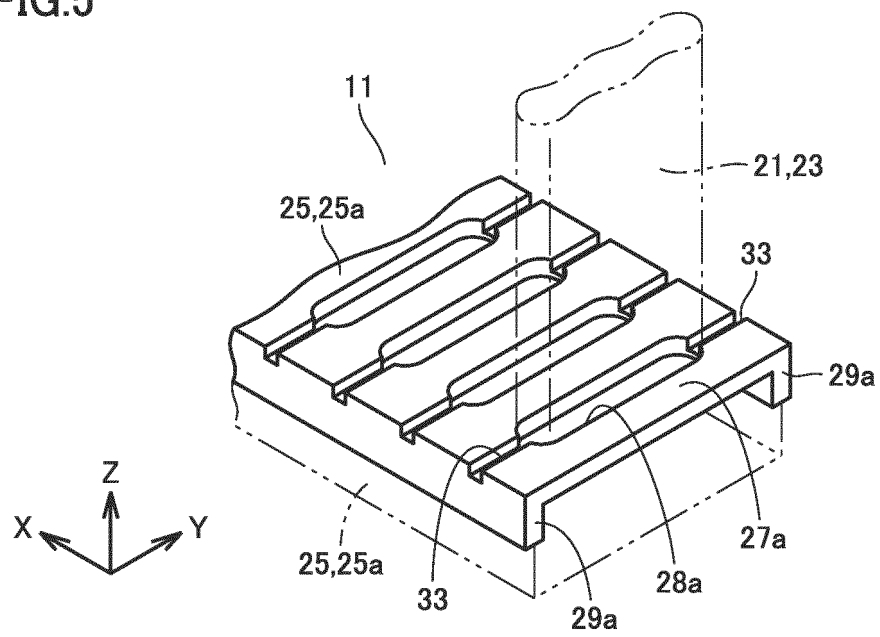


FIG.6

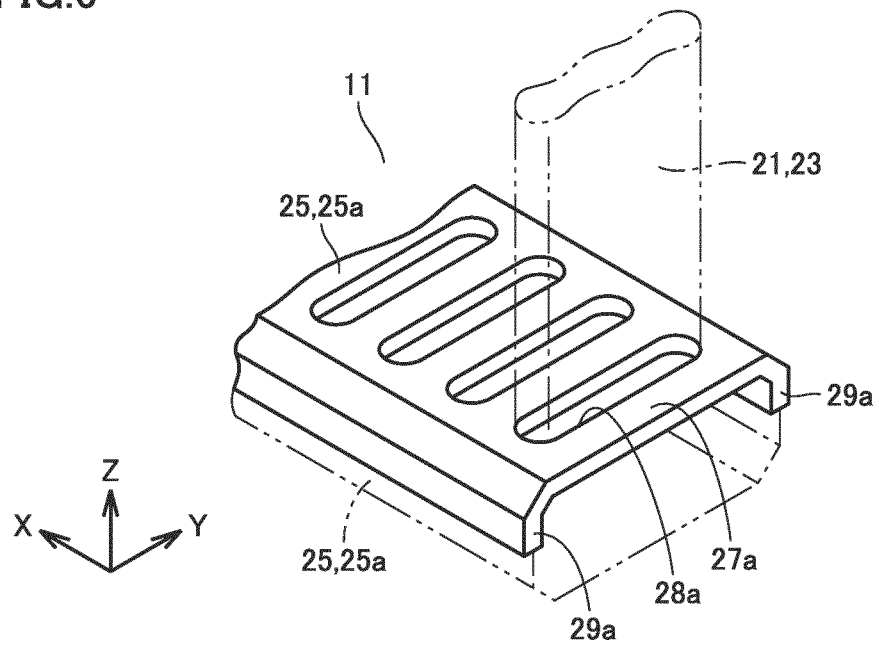


FIG.7

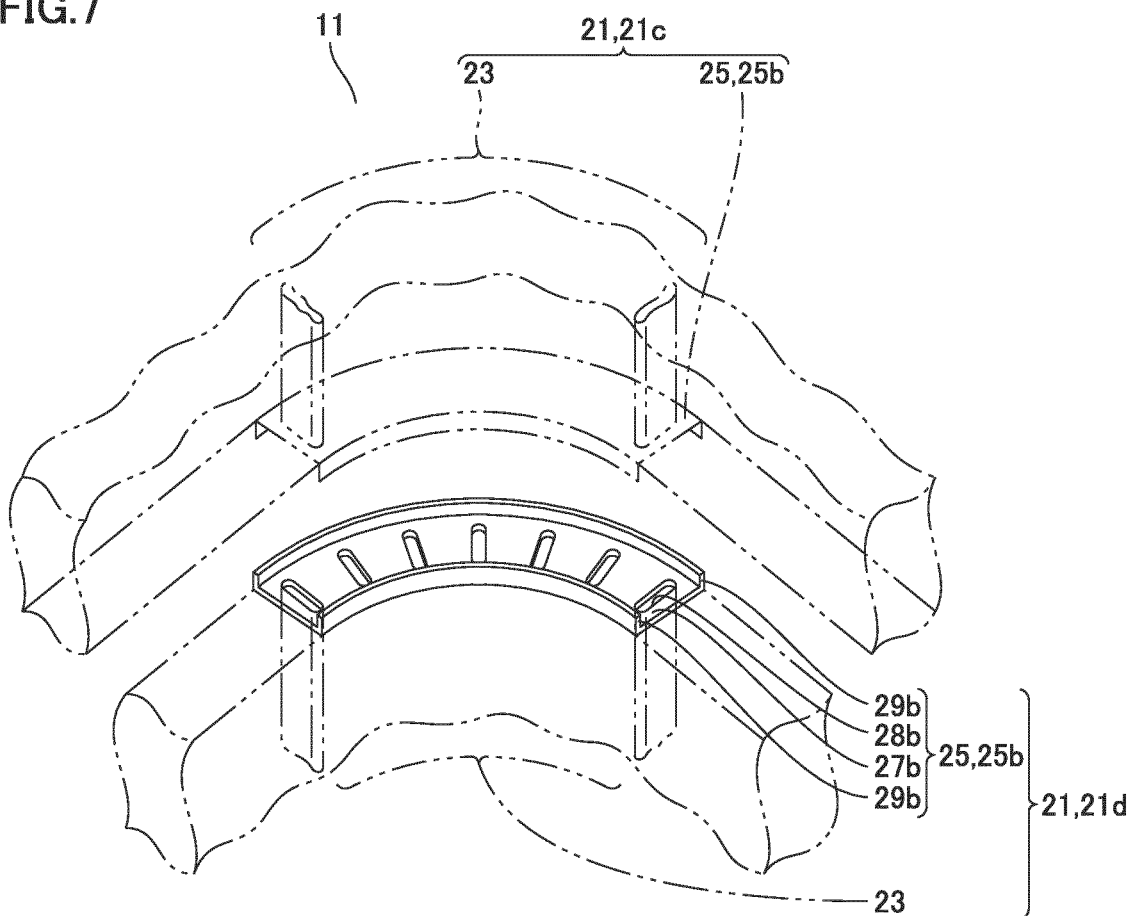


FIG.8

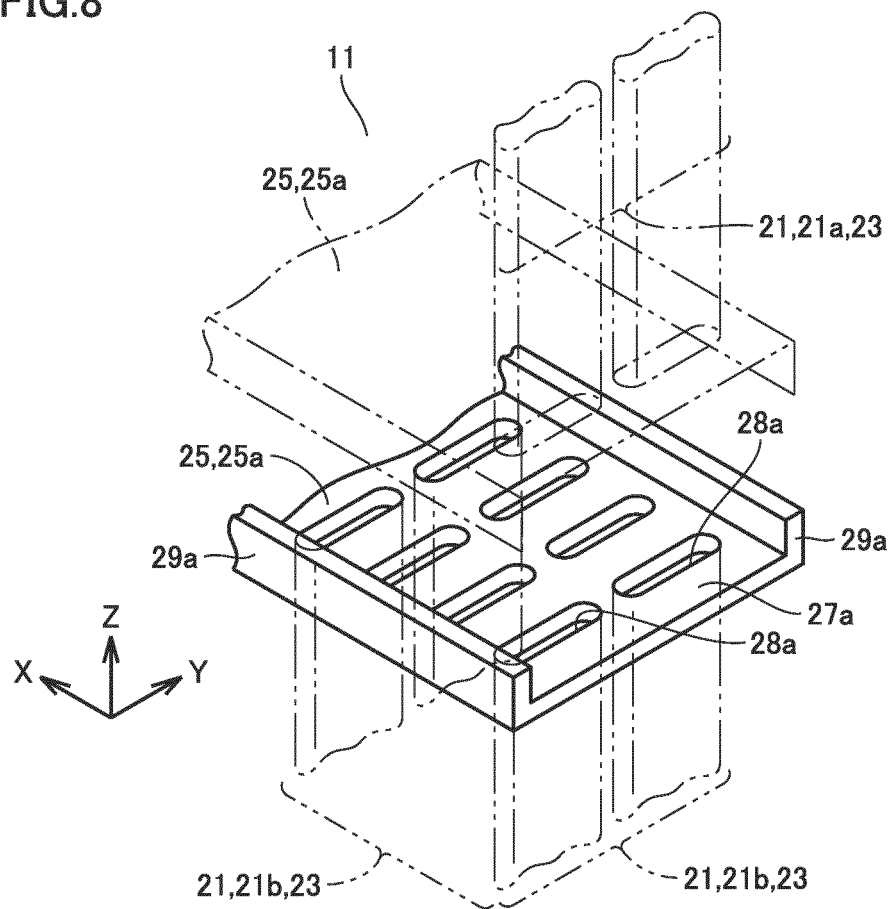


FIG.9

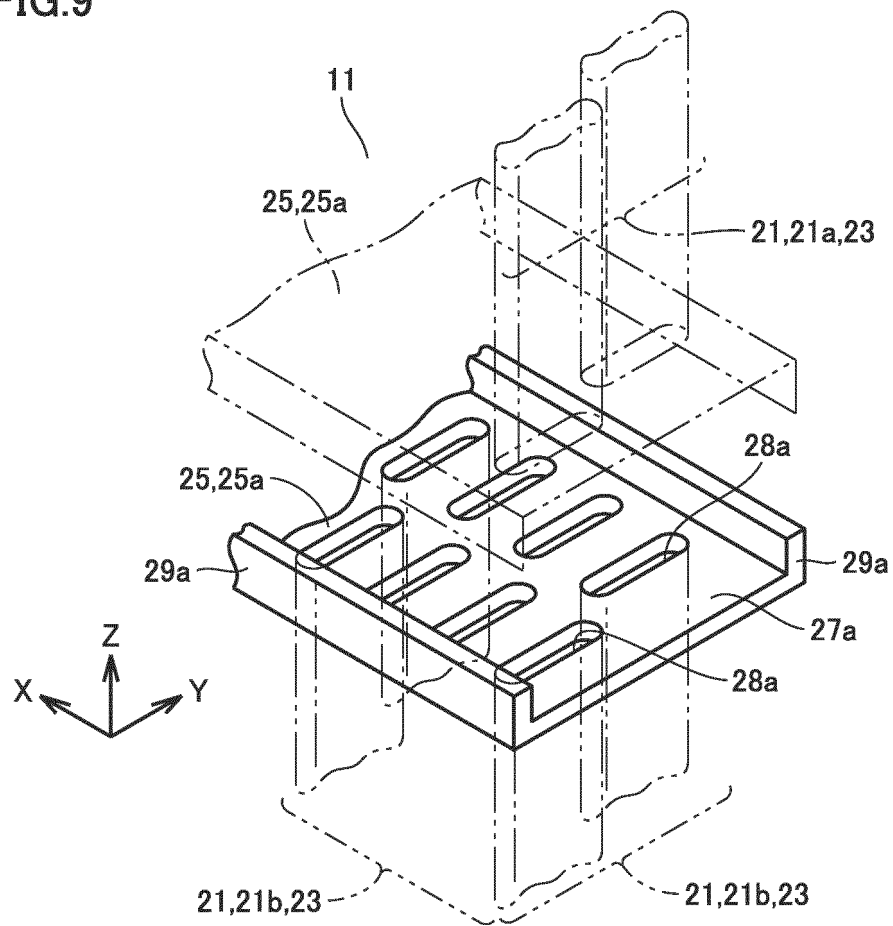


FIG.10

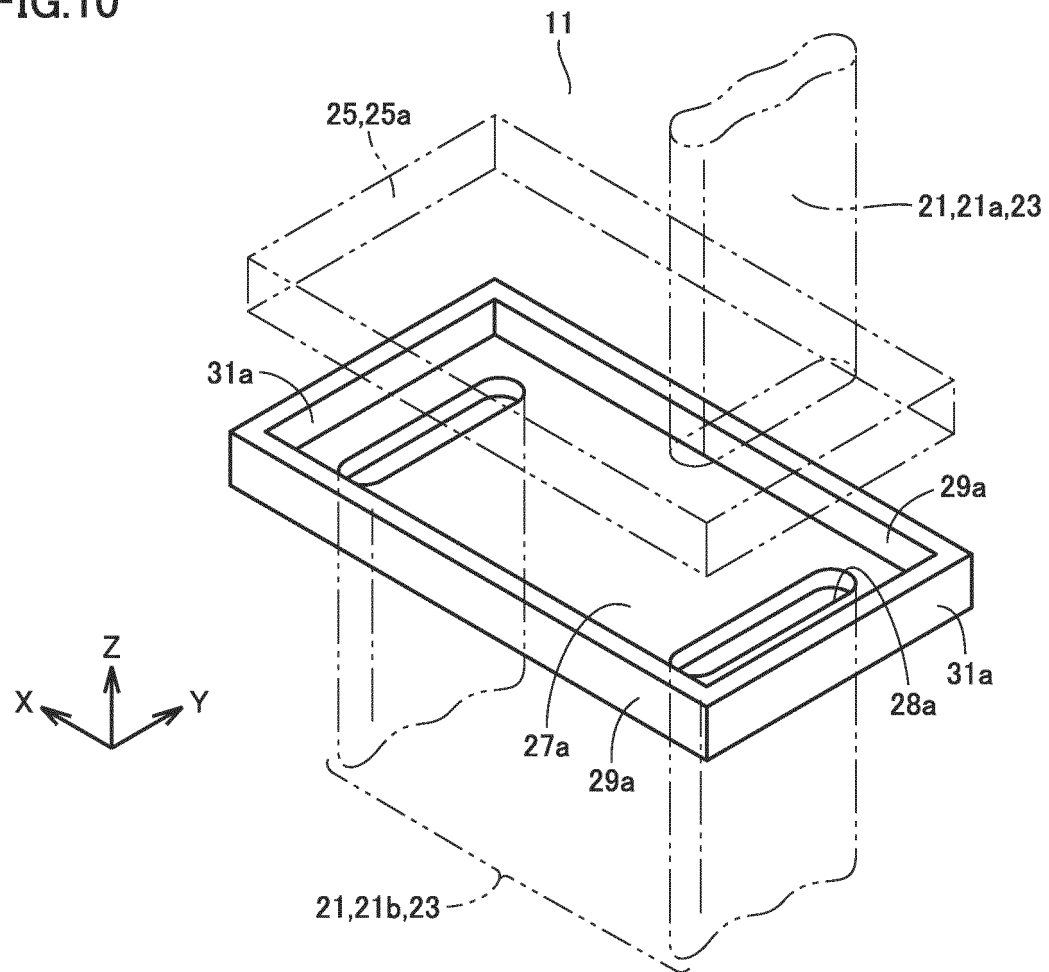


FIG.11

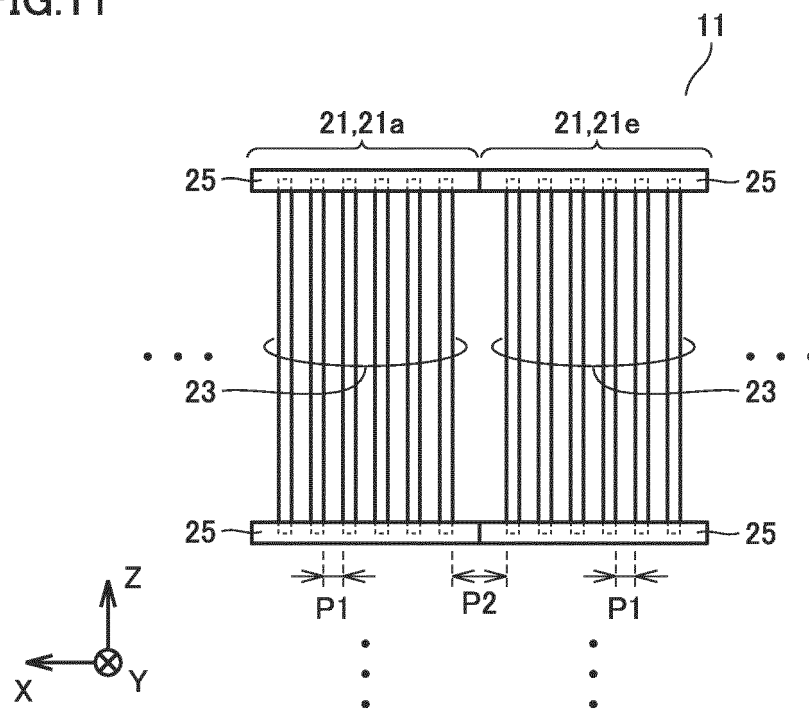


FIG.12

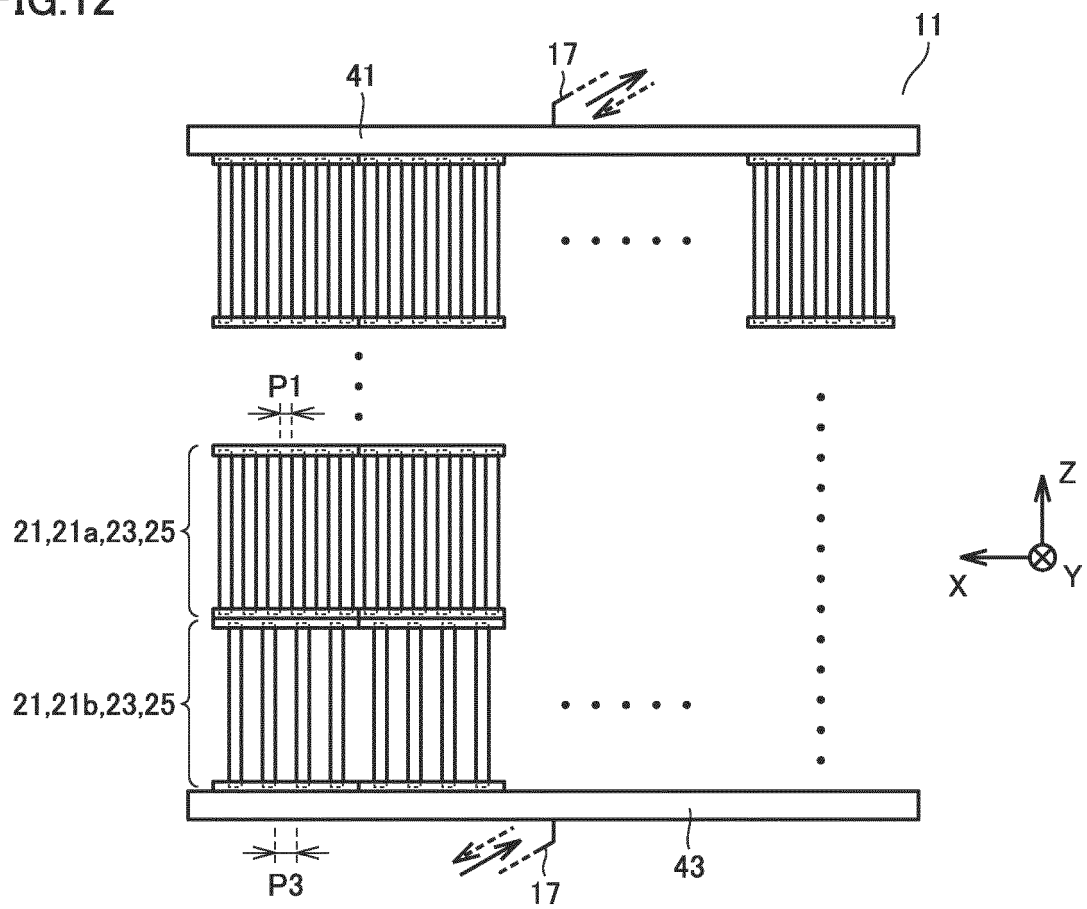
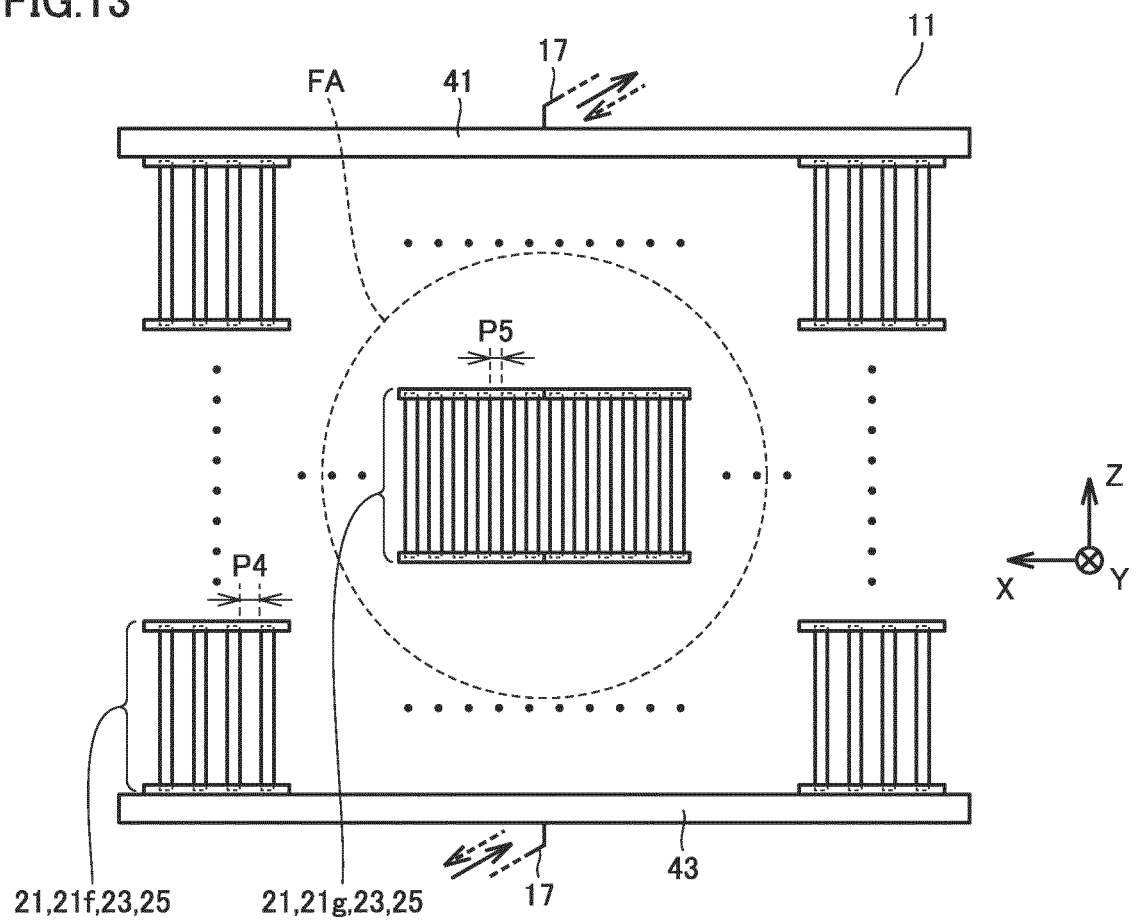


FIG.13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/041582

A. CLASSIFICATION OF SUBJECT MATTER

F28F 9/00 (2006.01) i

FI: F28F9/00 321

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)

F28F9/00

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 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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.
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Y	JP 2009-24956 A (CALSONIC KANSEI CORPORATION) 05 February 2009 (2009-02-05) paragraphs [0014]-[0043], fig. 1-3	1-11
Y	JP 2007-185709 A (DENSO CORP.) 26 July 2007 (2007-07-26) paragraphs [0012]-[0040], fig. 1-9	1-11
Y	DE 10112697 A1 (BEHR GMBH & CO.) 19 September 2002 (2002-09-19) paragraphs [0031]-[0038], fig. 1-10	2-11
Y	JP 2006-170600 A (SHOWA DENKO KABUSHIKI KAISHA) 29 June 2006 (2006-06-29) paragraphs [0046]-[0077], fig. 1-9	3-11
Y	JP 2018-179448 A (DENSO CORP.) 15 November 2018 (2018-11-15) paragraphs [0016]-[0123], fig. 1-12	4-11



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
24 November 2021 (24.11.2020)Date of mailing of the international search report
08 December 2020 (08.12.2020)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/041582

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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