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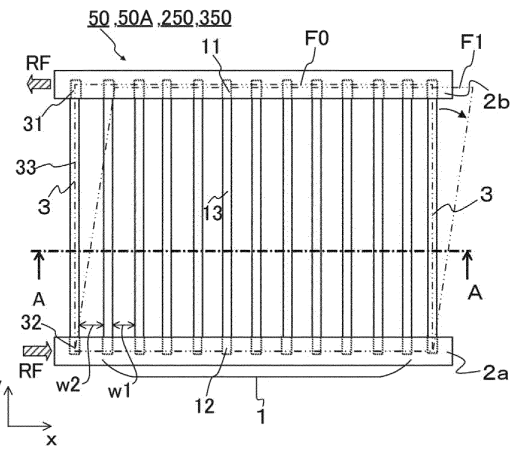
(54) HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE

(57) An object is to provide a heat exchanger that includes a plurality of heat transfer tubes connected to one another at both ends in a tube axis direction and can prevent deformation, and to provide a refrigeration cycle device. The heat exchanger includes: a plurality of heat transfer tubes configured to allow refrigerant to pass therethrough, arranged in a first direction and being spaced from each other; a first header connected to one end of each of the plurality of the heat transfer tubes; a second header connected to an other end of each of the plurality of the heat transfer tubes; and a plurality of reinforcing elements connected to each of the first header and the second header. Each of the plurality of heat transfer tubes and each of the plurality of reinforcing elements are disposed between the first header and the second header and are connected by the first header and the second header without being connected by a component connecting side surfaces of the plurality of heat transfer tubes and a side surface of each of the plurality of heat transfer tubes and a side surface of each of reinforcing elements.

FIG. 2



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Description

Technical Field

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle device including the heat exchanger, and particularly to a structure preventing deformation of heat transfer tubes.

Background Art

[0002] In recent years, a heat exchanger of a refrigerating and air-conditioning apparatus in which corrugated fins disposed in gaps among a plurality of heat transfer tubes are eliminated and each of the heat transfer tubes is reduced in diameter to narrow the gaps among the heat transfer tubes has been known. In such a heat exchanger, the plurality of heat transfer tubes are densely arranged, and air passes through the gaps among the heat transfer tubes, which makes it possible to improve heat exchange performance, and to achieve high performance and light weight of a refrigeration cycle device. Further, in recent years, reduction of a use amount of refrigerant having high global warming potential is an important issue. It is desirable to develop a heat exchanger that is small in capacity of each of the heat transfer tubes and is high in performance as compared with the existing heat exchanger.

[0003] For example, a heat exchanger disclosed in Patent Literature 1 includes flat tubes made of aluminum, in place of existing circular tubes made of copper. The heat exchanger includes the plurality of flat tubes arranged at intervals, and a pair of headers connected to both ends of each of the flat tubes in a tube axis direction.

[0004] A heat exchanger disclosed in Patent Literature 2 includes heat transfer tubes. Each of the heat transfer tubes is configured such that a plurality of circular tubes reduced in diameter are arranged in a ventilation direction, and fins are joined to the circular tubes to connect the circular tubes. The heat exchanger includes the plurality of heat transfer tubes arranged at intervals in a direction orthogonal to the ventilation direction, and a pair of headers connected to both ends of each of the circular tubes configuring the heat transfer tubes.

Citation List

Patent Literature

[0005]

Patent Literature 1: International Publication No. WO2015/005352

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2018-155479

Summary of Invention

Technical Problem

[0006] Each of the heat transfer tubes of the heat exchanger disclosed in each of Patent Literature 1 and Patent Literature 2 has a small area of a cross-section orthogonal to the tube axis direction as compared with the existing technique, and has low rigidity and low strength. Further, the heat exchanger does not include heat transfer promoting elements such as corrugated fins among the plurality of heat transfer tubes. Therefore, it is difficult to prevent buckling of each of the heat transfer tubes in the tube axis direction and warpage of each of the heat transfer tubes in an arrangement direction, which may deform the entire shape.

[0007] The present disclosure has been made to solve the above-described issues, and an object thereof is to provide a heat exchanger that includes the plurality of heat transfer tubes connected to one another at both ends in the tube axis direction and can prevent deformation, and to provide a refrigeration cycle device.

Solution to Problem

[0008] A heat exchanger according to one embodiment of the present disclosure includes: a plurality of heat transfer tubes configured to allow refrigerant to pass therethrough, arranged in a first direction and being spaced from each other; a first header connected to one end of each of the plurality of the heat transfer tubes; a second header connected to an other end of each of the plurality of the heat transfer tubes; and a plurality of reinforcing elements connected to each of the first header and the second header. Each of the plurality of heat transfer tubes and each of the plurality of reinforcing elements are disposed between the first header and the second header and are connected by the first header and the second header without being connected by a component connecting side surfaces of the plurality of heat transfer tubes and a side surface of each of the plurality of heat transfer tubes and a side surface of each of reinforcing elements.

[0009] A refrigeration cycle device according to another embodiment of the present disclosure includes the above-described heat exchanger.

Advantageous Effects of Invention

[0010] According to the embodiment of the present disclosure, it is possible to prevent deformation in the arrangement direction of the plurality of heat transfer tubes of the heat exchanger by the reinforcing elements connected to each of the first header and the second header.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram illustrating a configuration of a refrigeration cycle device including a heat exchanger 50 according to Embodiment 1.
[Fig. 2] Fig. 2 is a front view illustrating a configuration of a main part of the heat exchanger 50 according to Embodiment 1.
[Fig. 3] Fig. 3 is a plan view of the heat exchanger 50 in Fig. 2.
[Fig. 4] Fig. 4 is a side view of the heat exchanger 50 in Fig. 2.
[Fig. 5] Fig. 5 is a cross-sectional view of the heat exchanger 50 in Fig. 2.
[Fig. 6] Fig. 6 is a front view of a heat exchanger 150 as a comparative example of the heat exchanger 50 according to Embodiment 1.
[Fig. 7] Fig. 7 is a cross-sectional view of a heat exchanger 50A as a modification of the heat exchanger 50 according to Embodiment 1.
[Fig. 8] Fig. 8 is a cross-sectional view of a heat exchanger 50B as another modification of the heat exchanger 50 according to Embodiment 1.
[Fig. 9] Fig. 9 is a perspective view of a single reinforcing element 3B in Fig. 8.
[Fig. 10] Fig. 10 is a cross-sectional view of a heat exchanger 50C as still another modification of the heat exchanger 50 according to Embodiment 1.
[Fig. 11] Fig. 11 is a cross-sectional view of a heat exchanger 250 according to Embodiment 2.
[Fig. 12] Fig. 12 is a cross-sectional view of a heat exchanger 350 according to Embodiment 3.

Description of Embodiments

[0012] A heat exchanger and a refrigeration cycle device according to Embodiment 1 are described below with reference to drawings and the like. In the following drawings including Fig. 1, relative dimensional relationship, shapes, and the like of components may be different from those of actual components. Further, in the following drawings, the same or equivalent components are denoted by the same reference numerals, and this applies to the entire description of the specification. Further, terms representing directions (for example, "up", "down", "right", "left", "front", and "rear") are appropriately used to facilitate understanding; however, these terms are used for description and do not limit arrangement and directions of devices or components. In the specification, positional relationship of the components, extending directions of the components, and arrangement directions of the components are exhibited when the heat exchanger is installed in a usable state, in principle.

Embodiment 1

[Refrigeration Cycle Device 100]

[0013] Fig. 1 is a refrigerant circuit diagram illustrating a configuration of a refrigeration cycle device 100 including a heat exchanger 50 according to Embodiment 1. In Fig. 1, an arrow illustrated by a dashed line indicates a flowing direction of refrigerant in the refrigerant circuit 110 during cooling operation, and an arrow illustrated by a solid line indicates the flowing direction of the refrigerant during heating operation. First, the refrigeration cycle device 100 including the heat exchanger 50 is described with reference to Fig. 1. In the embodiment, an air-conditioning apparatus is illustrated as the refrigeration cycle device 100; however, the refrigeration cycle device 100 is used for refrigeration application or air-conditioning application, for example, a refrigerator, a freezer, an automatic vending machine, an air-conditioning apparatus, a refrigeration device, and a water heater. The illustrated refrigerant circuit 110 is only illustrative, and a configuration and the like of circuit elements are not limited to contents described in the embodiment, and can be appropriately modified within the technical scope according to the embodiment.

[0014] The refrigeration cycle device 100 includes the refrigerant circuit 110 in which a compressor 101, a flow switching device 102, an indoor heat exchanger 103, a decompression device 104, and an outdoor heat exchanger 105 are sequentially connected through refrigerant pipes. The heat exchanger 50 described below is used for at least one of the outdoor heat exchanger 105 and the indoor heat exchanger 103. The refrigeration cycle device 100 includes an outdoor unit 106 and an indoor unit 107. The outdoor unit 106 houses the compressor 101, the flow switching device 102, the outdoor heat exchanger 105, the decompression device 104, and an outdoor fan 108 supplying outdoor air to the outdoor heat exchanger 105. The indoor unit 107 houses the indoor heat exchanger 103 and an indoor fan 109 supplying air to the indoor heat exchanger 103. The outdoor unit 106 and the indoor unit 107 are connected through two extension pipes 111 and 112 that are a part of the refrigerant pipes.

[0015] The compressor 101 is a fluid machine that compresses suctioned refrigerant and discharges compressed refrigerant. The flow switching device 102 is, for example, a four-way valve, and switches a flow path of the refrigerant during the cooling operation and the heating operation under control of a controller (not illustrated).

[0016] The indoor heat exchanger 103 is a heat exchanger performing heat exchange between the refrigerant flowing through an inside of the indoor heat exchanger 103 and indoor air supplied by the indoor fan 109. The indoor heat exchanger 103 functions as a condenser during the heating operation, and functions as an evaporator during the cooling operation.

[0017] The decompression device 104 is, for example, an expansion valve, and decompresses the refrigerant. As the decompression device 104, an electronic expansion valve, an opening degree of which is controlled by the controller, is usable.

[0018] The outdoor heat exchanger 105 is a heat exchanger performing heat exchange between the refrigerant flowing through an inside of the outdoor heat exchanger 105 and air supplied by the outdoor fan 108. The outdoor heat exchanger 105 functions as an evaporator during the heating operation, and functions as a condenser during the cooling operation.

[Operation of Refrigeration Cycle Device]

[0019] Next, an example of operation of the refrigeration cycle device 100 is described with reference to Fig. 1. During the heating operation of the refrigeration cycle device 100, the refrigerant in a high-pressure and high-temperature gas state, that is discharged from the compressor 101, flows into the indoor heat exchanger 103 through the flow switching device 102, and exchanges heat with the air supplied by the indoor fan 109, thereby being condensed. The condensed refrigerant is in a high-pressure liquid state, flows out from the indoor heat exchanger 103, and is put into a low-pressure two-phase gas-liquid state by the decompression device 104. The refrigerant in the low-pressure two-phase gas-liquid state flows into the outdoor heat exchanger 105, and is evaporated by exchanging heat with the air supplied by the outdoor fan 108. The evaporated refrigerant is in a low-pressure gas state, and is suctioned into the compressor 101.

[0020] During the cooling operation of the refrigeration cycle device 100, the refrigerant flowing through the refrigerant circuit 110 flows in a direction opposite to the direction during the heating operation. More specifically, during the cooling operation of the refrigeration cycle device 100, the refrigerant in the high-pressure and high-temperature gas state, discharged from the compressor 101 flows into the outdoor heat exchanger 105 through the flow switching device 102, and exchanges heat with the air supplied by the outdoor fan 108, thereby being condensed. The condensed refrigerant is in the high-pressure liquid state, flows out from the outdoor heat exchanger 105, and is put into the low-pressure two-phase gas-liquid state by the decompression device 104. The refrigerant in the low-pressure two-phase gas-liquid state flows into the indoor heat exchanger 103, and is evaporated by exchanging heat with the air supplied by the indoor fan 109. The evaporated refrigerant is in the low-pressure gas state, and is suctioned into the compressor 101.

[Heat Exchanger 50]

[0021] Fig. 2 is a front view illustrating a configuration of a main part of the heat exchanger 50 according to Embodiment 1. Fig. 3 is a plan view of the heat exchanger 50 in Fig. 2. Fig. 4 is a side view of the heat exchanger 50 in Fig. 2. Fig. 5 is a cross-sectional view of the heat exchanger 50 in Fig. 2. Fig. 5 illustrates a cross-section taken along line A-A in Fig. 2, orthogonal to tube axes of flat tubes 1. The cross-section illustrated in Fig. 5 is referred to as a first cross-section in some cases. In Fig. 2, hatched arrows RF indicate a flow of the refrigerant flowing into the heat exchanger 50 and flowing out from the heat exchanger 50. The heat exchanger 50 according to Embodiment 1 is described with reference to Fig. 2 to Fig. 5.

[0022] The heat exchanger 50 according to Embodiment 1 includes the plurality of flat tubes 1, a first header 2b and a second header 2a connected to ends of each of the plurality of flat tubes 1, and a plurality of reinforcing elements 3 disposed in parallel with the plurality of flat tubes 1. The plurality of flat tubes 1 are arranged in an x direction. In addition, the plurality of flat tubes 1 are arranged such that the tube axes extend along a y direction. In Embodiment 1, the y direction is parallel to a gravity direction. However, arrangement of the heat exchanger 50 is not limited thereto, and the y direction may be inclined to the gravity direction. The plurality of flat tubes 1 are arranged at equal intervals in the x direction, and each of the intervals is a width w1.

[0023] The first header 2b is connected to one end 12 in the tube axis direction of each of the plurality of flat tubes 1. Further, the second header 2a is connected to the other end 11 in the tube axis direction of each of the plurality of flat tubes 1. The first header 2b and the second header 2a are disposed such that longitudinal directions extend in the arrangement direction of the plurality of flat tubes 1. The longitudinal directions of the first header 2b and the second header 2a are parallel to each other. In the following description, the first header 2b and the second header 2a are collectively referred to as headers 2 in some cases.

[0024] The reinforcing elements 3 are disposed outside of the flat tubes 1 positioned at both ends among the plurality of flat tubes 1 arranged in the x direction. In the heat exchanger 50 illustrated in Fig. 2 to Fig. 5, two reinforcing elements 3 are disposed. One of the reinforcing elements 3 is disposed at an end in the x direction of each of the first header 2b and the second header 2a. The other reinforcing element 3 is disposed at an end in a direction opposite to the x direction of each of the first header 2b and the second header 2a.

[0025] The ends 11 and 12 of each of the plurality of flat tubes 1 are inserted into the headers 2 and are joined to the headers 2 by a joining method such as brazing. Ends 31 and 32 of each of the plurality of reinforcing elements 3 are also inserted into the headers 2 and are joined to the headers 2 by a joining method such as brazing. Further, the plurality of flat tubes 1 and the plurality of reinforcing elements 3 are arranged side by side in the x direction. Each of the plurality of flat tubes 1 has a heat transfer portion 13 that is a portion other than the ends 11 and 12 and is positioned between a lower surface of the first header 2b and an upper surface of the second header 2a. Each of the reinforcing elements 3 has a center portion 33 that is a portion other than the ends 31 and 32 and is positioned between the lower surface of the first header 2b and the upper surface of the second header 2a.

(Flat Tube 1)

[0026] Each of the plurality of flat tubes 1 allows the refrigerant to pass therethrough. Each of the plurality of flat tubes 1 extends between the first header 2b and the second header 2a. The plurality of flat tubes 1 are arranged at intervals w1 in the x direction and are arranged side by side in the extending direction of the headers 2. The plurality of flat tubes 1 are disposed to face one another. A gap that is a flow path of air is formed between two adjacent flat tubes 1 among the plurality of flat tubes 1. In Embodiment 1, the arrangement direction of the plurality of flat tubes 1 and the extending direction of the headers 2, namely, the x direction is referred to as a first direction.

[0027] In the heat exchanger 50, the arrangement direction of the plurality of flat tubes 1 that is the first direction is coincident with a horizontal direction. The arrangement direction of the plurality of flat tubes 1 that is the first direction, however, is not limited to the horizontal direction, and may be coincident with a vertical direction or a direction inclined to the vertical direction. Likewise, in the heat exchanger 50, the extending direction of the plurality of flat tubes 1 is coincident with the vertical direction. The extending direction of the plurality of flat tubes 1, however, is not limited to the vertical direction, and may be coincident with the horizontal direction or the direction inclined to the vertical direction.

[0028] The adjacent flat tubes 1 among the plurality of flat tubes 1 are not connected by a heat transfer promoting element 130. The heat transfer promoting element 130 is, for example, a plate fin or a corrugated fin. In other words, the plurality of flat tubes are connected to one another only by the headers 2.

[0029] As illustrated in Fig. 5, each of the flat tubes 1 has a cross-sectional shape flat in one direction, such as an elliptical shape. Each of the flat tubes 1 has a first side end 60a, a second side end 60b, and a pair of flat surfaces 60c and 60d. In the cross-section illustrated in Fig. 5, the first side end 60a may be formed to protrude outward between one of ends of the flat surface 60c and one of ends of the flat surface 60d. In the same cross-section, the second side end 60b may be formed to protrude outward between the other end of the flat surface 60c and the other end of the flat surface 60d. In other words, each of the flat tubes 1 may include a fin extending in the z direction from the end 60a in a long axis direction of the cross-section and a fin extending in a direction opposite to the z direction from the end 60b. The fins extending from the first side end 60a and the second side end 60b of each of the plurality of flat tubes 1 are provided to improve heat exchange performance of each of the flat tubes 1 in the heat exchanger 50 including no heat transfer promoting element 130 (see Fig. 6) among the plurality of flat tubes 1.

[0030] In a case where the heat exchanger 50 functions as an evaporator of the refrigeration cycle device 100, the refrigerant flows from one end to the other end in the extending direction inside each of the plurality of flat tubes 1. In contrast, in a case where the heat exchanger 50 functions as a condenser of the refrigeration cycle device 100, the refrigerant flows from the other end to the one end in the extending direction inside each of the plurality of flat tubes 1.

(Header 2)

[0031] Each of the first header 2b and the second header 2a extends in the x direction, and allows the refrigerant to flow therethrough. As illustrated in Fig. 2, for example, the refrigerant flows into the second header 2a from one end thereof, and is distributed to the plurality of flat tubes 1. The refrigerant passing through the plurality of flat tubes 1 is merged in the first header 2b, and the refrigerant flows out from one end of the first header 2b.

[0032] In Fig. 2 to Fig. 5, each of the headers 2 has a cuboid outer shape; however, the outer shape is not limited thereto. Each of the headers 2 may have, for example, a columnar shape or an elliptic columnar shape, and the cross-sectional shape of each of the headers 2 is appropriately changeable. Further, as a structure of each of the headers 2, for example, a cylindrical body having closed ends, a stacked body in which plates each having a slit are stacked can be adopted. Each of the first header 2b and the second header 2a has a refrigerant inflow port from which the refrigerant can flow in/out.

(Reinforcing Element 3)

[0033] As illustrated in Fig. 5, in the heat exchanger 50, the reinforcing elements 3 are arranged side by side with the plurality of flat tubes 1. In other words, the reinforcing elements 3 are disposed such that longitudinal directions of the reinforcing elements 3 are parallel to the tube axes of the plurality of flat tubes 1. Further, in Embodiment 1, the reinforcing elements 3 are disposed at both ends of the arrangement of the plurality of flat tubes 1. In other words, the reinforcing elements 3 are provided at two positions of the heat exchanger 50. One of the reinforcing elements 3 is disposed adjacently to a flat tube 1a positioned at the end in the direction opposite to the x direction, and is positioned outside the arrangement of the plurality of flat tubes 1. The other reinforcing element 3 is disposed adjacently to a flat tube 1b positioned at the end in the x direction, and is positioned outside the arrangement of the plurality of flat tubes 1.

[0034] In Embodiment 1, each of the reinforcing elements 3 is a columnar body, and two columnar bodies are disposed as a pair at each of both ends of the arrangement of the plurality of flat tubes 1. When focusing on a reinforcing element 3a or 3b at one position, the two columnar bodies are arranged in the z direction. The two columnar bodies are disposed at an interval that is equivalent to a width in the z direction of each of the plurality of flat tubes 1.

[0035] Each of the reinforcing elements 3 is made of a material higher in strength than a material of each of the flat tubes 1. Each of the flat tubes 1 is made of aluminum. Therefore, each of the reinforcing elements 3 is preferably made of a material higher in rigidity and strength than aluminum, for example, stainless steel.

(Action of Reinforcing Element 3)

[0036] Fig. 6 is a front view of a heat exchanger 150 as a comparative example of the heat exchanger 50 according to Embodiment 1. The heat exchanger 150 according to the comparative example has a structure similar to that of Embodiment 1, but is different in that the heat exchanger 150 according to the comparative example includes corrugated fins as heat transfer promoting elements 130 among the plurality of flat tubes 1x and does not include the reinforcing elements 3. Each of the heat transfer promoting elements 130 connects side surfaces of adjacent flat tubes 1x among the plurality of flat tubes 1x. The heat transfer promoting elements 130 are joined to the side surfaces of the plurality of flat tubes 1x by a method such as brazing.

[0037] In the heat exchanger 50 according to Embodiment 1, the intervals w1 of the plurality of flat tubes 1 are narrowed to increase the number of arranged flat tubes 1. As a result, the heat exchanger 50 can improve heat exchange performance between the refrigerant and fluid passing through the heat exchanger while the capacity of the heat exchanger 50 is reduced, without being provided with the heat transfer promoting elements 130 disposed among the plurality of flat tubes 1 to connect the side surfaces of the flat tubes 1. Further, each of the plurality of flat tubes 1 according to Embodiment 1 has a width dimension in the x direction smaller than a width dimension of each of the flat tubes 1x of the heat exchanger 150 including the heat transfer promoting elements 130 according to the comparative example. Therefore, for example, in a case where a load in the x direction is applied to the heat transfer portion 13 of each of the flat tubes 1 of the heat exchanger 50 according to Embodiment 1 while the ends 11 and 12 are fixed, each of the flat tubes 1 is lower in strength and rigidity to bending than each of the flat tubes 1x of the comparative example. In contrast, in the heat exchanger 150 of the comparative example, the heat transfer promoting elements 130 are disposed among the plurality of flat tubes 1x. Therefore, even if a load is applied to a heat transfer portion 113 of each of the plurality of flat tubes 1x, deformation hardly occurs because the heat transfer promoting elements 130 and the adjacent flat tubes 1x are joined.

[0038] Here, as a comparative example in which the reinforcing elements 3 are not provided in the heat exchanger 50 according to Embodiment 1 and the flat tubes 1 are disposed at the positions of the reinforcing elements 3, a heat exchanger 50x is assumed. For example, when the second header 2a is fixed and a load in the x direction is applied to the first header 2b, the heat exchanger 50x is easily deformed from an initial shape F0 to a shape F1 as illustrated by alternate long and two short dashes lines in Fig. 2. Note that the shapes F0 and F1 are rectangles configured by connecting a center line along the x direction of each of the headers 2 and a center line along the y direction of each of the reinforcing elements 3 when the heat exchanger 50x is viewed from a front side, and each illustrates a rough shape of the heat exchanger 50x as viewed from the front side. As described above, in the case of the heat exchanger 50x that is configured by eliminating the heat transfer promoting elements 130 of the heat exchanger 150, there is a problem that strength to deformation in the arrangement direction of the plurality of flat tubes 1 is deteriorated.

[0039] In other words, in the case of the above-described heat exchanger 50x not including the reinforcing elements 3 of comparative example, there is a problem that strength to bending in the x direction of each of the plurality of flat tubes 1 is low, and in a case where a load in the x direction is applied to the first header 2b, each of the plurality of flat tubes 1 is easily deformed, and the entire shape of the heat exchanger 50x is accordingly easily deformed. In addition, there is a problem that, in a case where a load in the y direction is applied to the heat exchanger 50x, each of the plurality of flat tubes 1 is buckled and deformed, and the heat exchanger 50x is easily deformed in a direction in which a distance between the first header 2b and the second header 2a is reduced.

[0040] In contrast, the heat exchanger 50 according to Embodiment 1 includes the reinforcing elements 3 at both ends of the arrangement of the plurality of flat tubes 1. When the reinforcing elements 3 are added to the arrangement of the plurality of flat tubes 1, the load applied to the heat exchanger 50 can be shared by the reinforcing elements 3. This makes it possible to improve strength of the heat exchanger 50 and to prevent deformation of the heat exchanger 50. Further, when the reinforcing elements 3 are made higher in strength and rigidity to bending in the x direction than the flat tubes 1, it is possible to enhance an effect of preventing deformation of the entire body of the heat exchanger 50. In addition, since the reinforcing elements 3 are higher in strength and rigidity to buckling than the flat tubes 1, it is possible to prevent deformation in which the heat exchanger 50 is reduced in length in the y direction.

[0041] Further, since the reinforcing elements 3 are disposed such that the longitudinal directions of the reinforcing elements 3 extend along the tube axes of the plurality of flat tubes 1, it is possible to improve strength and rigidity of the heat exchanger 50 and to prevent deformation of the heat exchanger 50 without inhibiting flow-down of moisture generated by dew condensation or melting of frost of the plurality of flat tubes 1.

(Modifications of Reinforcing Element 3)

[0042] In the above description, each of the reinforcing elements 3 has a columnar shape; however, the shape of each of the reinforcing elements 3 is not limited thereto. In the following, modifications of each of the reinforcing elements 3 are described.

[0043] Fig. 7 is a cross-sectional view of a heat exchanger 50A as a modification of the heat exchanger 50 according to Embodiment 1. Fig. 7 illustrates a cross-section taken along line A-A in Fig. 2. The heat exchanger 50A is configured by replacing the reinforcing elements 3 of the heat exchanger 50 with reinforcing elements 3A each having the cross-sectional outer shape same as the cross-sectional outer shape of each of the plurality of flat tubes 1. Each of the reinforcing elements 3A has the cross-sectional outer shape same as the cross-sectional outer shape of each of the flat tubes 1 in the cross-section illustrated in Fig. 7, and an inside of each of the reinforcing elements 3A is solid. In contrast, each of the flat tubes 1 internally includes a refrigerant flow path. Therefore, when a neutral axis N along the z direction is assumed in the cross-section illustrated in Fig. 7, a section modulus of each of the reinforcing elements 3A around the neutral axis N is greater than a section modulus of each of the flat tubes 1 around the neutral axis N. Therefore, even if each of the reinforcing elements 3A is made of the material same as the material of each of the flat tubes 1, strength and rigidity of each of the reinforcing elements 3A are higher than strength and rigidity of each of the flat tubes 1. Further, in Embodiment 1, since each of the reinforcing elements 3A is made of a material higher in strength and rigidity than the material of each of the flat tubes 1, each of the reinforcing elements 3A is further higher in strength and rigidity than each of the flat tubes 1.

[0044] In addition, in the heat exchanger 50A according to the modification, the plurality of flat tubes 1 and the reinforcing elements 3A connected to the headers 2 each have the same cross-sectional outer shape. Therefore, when the headers 2 and the plurality of flat tubes 1 are joined by brazing in manufacturing, the reinforcing elements 3A are also joined by using a positioning tool common to the plurality of flat tubes 1. This makes it possible to simplify the positioning tool of the reinforcing elements 3A and the plurality of flat tubes 1 in manufacturing. In addition, in the headers 2, shapes of insertion portions into which the ends 11 and 12 of the plurality of flat tubes 1 and the ends 31 and 32 of the reinforcing elements 3A are inserted can also be made common. This makes it possible to reduce a manufacturing cost of the headers 2.

[0045] Each of the reinforcing elements 3A illustrated in Fig. 7 has flat side surfaces 35 in the cross-section illustrated in Fig. 7, and is disposed such that one of the side surfaces 35 faces one of flat surfaces 15 of the adjacent flat tube 1. Accordingly, as with the plurality of flat tubes 1, the reinforcing elements 3A allow the fluid to flow through spaces between the side surfaces 35 and the flat surfaces 15, and do not inhibit the flow of the fluid.

[0046] Fig. 8 is a cross-sectional view of a heat exchanger 50B as another modification of the heat exchanger 50 according to Embodiment 1. Fig. 8 illustrates a cross-section taken along line A-A in Fig. 2. The heat exchanger 50B includes reinforcing elements 3B each having an I-shaped cross-section in Fig. 8. Each of the reinforcing elements 3B has flange portions extending in the x direction and in the direction opposite to the x direction, at both ends in the z direction. Each of the reinforcing elements 3B can have a section modulus around the neutral axis N greater than the section modulus of each of the flat tubes 1 by appropriately setting a width in the x direction of each of the flange portions.

[0047] Fig. 9 is a perspective view of a single reinforcing element 3B in Fig. 8. A cross-sectional outer shape of each of the ends 31 and 32 of each of the reinforcing elements 3B is the same as the cross-sectional outer shape of each of the flat tubes 1. With this configuration, strength and rigidity of the center portion 33 of each of the reinforcing elements 3B are higher than strength and rigidity of the heat transfer portion 13 of each of the flat tubes 1. In addition, the ends 31 and 32 of each of the reinforcing elements 3B inserted into the insertion portions of the headers 2 have the shape same as the shape of each of the flat tubes 1. Therefore, the insertion portions of the headers 2 into which the reinforcing elements 3B are inserted can be made in the shape same as the insertion portions into which the flat tubes 1 are inserted. As a result, the reinforcing elements 3B can be inserted into the headers 2 as with the flat tubes 1 while each having the shape higher in strength and rigidity than each of the flat tubes 1, which facilitates manufacturing of the heat exchanger 50B.

[0048] Further, each of the reinforcing elements 3B has end surfaces 34 and 35 at both ends in the longitudinal direction. The end surfaces 34 and 35 of each of the reinforcing elements 3B respectively come into contact with the lower surface of the first header 2b and the upper surface of the second header 2a while the ends 31 and 32 are inserted into the headers 2. Therefore, when a load is applied in a direction in which the reinforcing elements 3B of the heat exchanger 50B are bent, the end surfaces 34 and 35 respectively come into contact with the lower surface of the first header 2b and the upper surface of the second header 2a to receive the load. This further improves strength and rigidity of the heat exchanger 50B. Furthermore, when the end surfaces 34 and 35 of each of the reinforcing elements 3B are joined to the headers 2, a joining area of the reinforcing elements 3B and the headers 2 is increased, which makes it possible to further improve strength and rigidity of the heat exchanger 50B.

[0049] Fig. 10 is a cross-sectional view of a heat exchanger 50C as a still another modification of the heat exchanger 50 according to Embodiment 1. Fig. 10 illustrates a cross-section taken along line A-A in Fig. 2. Each of reinforcing elements 3C of the heat exchanger 50C has a cross-sectional shape bent at a center portion. A width in the z direction of each of the reinforcing elements 3C is set to be equal to the width of each of the flat tubes 1. A width in the x direction of each of the reinforcing elements 3C is a width from both ends to the bent center portion in the z direction in each of the reinforcing elements 3C. In Embodiment 1, the width in the x direction of each of the reinforcing elements 3C is greater than the width in the x direction of each of the flat tubes 1. As a result, each of the reinforcing elements 3C can have the section modulus around the neutral axis N greater than the section modulus of each of the flat tubes 1.

[0050] Further, the reinforcing element 3C positioned at the end in the x direction of the heat exchanger 50C and the reinforcing element 3C positioned at the end in the direction opposite to the x direction of the heat exchanger 50C are disposed symmetrically about the center of the heat exchanger 50C in Fig. 10. With this configuration, strength and rigidity to deformation in the x direction and strength and rigidity to deformation in the direction opposite to the x direction are equal to each other in the heat exchanger 50C, which can exert stable strength.

[0051] Further, each of the reinforcing elements 3C is formed to open outward from the center toward both ends in the z direction, relative to the arrangement of the plurality of flat tubes 1 of the heat exchanger 50C. Therefore, the reinforcing elements 3C easily introduce the fluid to both ends of the arrangement of the plurality of flat tubes 1.

Embodiment 2

[0052] A heat exchanger 250 according to Embodiment 2 is described. The heat exchanger 250 is configured by changing positions of the reinforcing elements 3A of the heat exchanger 50A according to Embodiment 1. Note that components having the functions and the actions same as the components of Embodiment 1 are denoted by the same reference numerals, and descriptions of the components are omitted.

[0053] Fig. 11 is a cross-sectional view of the heat exchanger 250 according to Embodiment 2. Fig. 11 illustrates a cross-section taken along line A-A in Fig. 2. The heat exchanger 250 includes reinforcing elements 3Aa and 3Ab at both ends of the arrangement of the plurality of flat tubes 1 as with the heat exchanger 50A according to Embodiment 1, and further includes reinforcing elements 3Ac and 3Ad in the arrangement of the plurality of flat tubes 1. In other words, the reinforcing elements 3Ac and 3Ad are each disposed adjacently to two flat tubes 1 among the plurality of flat tubes 1. In Embodiment 2, the reinforcing elements 3Aa, 3Ab, 3Ac, and 3Ad are disposed at equal intervals. Further, the reinforcing elements 3Aa and 3Ab are disposed symmetrically about the center of the arrangement of the plurality of flat tubes 1, and the reinforcing elements 3Ac and 3Ad are disposed symmetrically about the center of the arrangement of the plurality of flat tubes 1. Note that the reinforcing elements 3Ac and 3Ad are referred to as first reinforcing elements, and the reinforcing elements 3Aa and 3Ab are referred to as second reinforcing elements in some cases.

[0054] Since the heat exchanger 250 according to Embodiment 2 further includes the reinforcing elements 3Ac and 3Ad, strength and rigidity are further improved as compared with the heat exchanger 50 according to Embodiment 1. In a case where the headers 2 are long in the x direction, strength at the center portion of the heat exchanger 250 in the x direction becomes weak. For example, in the case where the reinforcing elements 3A are disposed at both ends as with the heat exchanger 50A according to Embodiment 1, if a load in a direction opposite to the y direction is applied to the center portion of the first header 2b, the first header 2b is bent and the flat tubes 1 disposed at the center portion receive force in a buckling direction. However, since the heat exchanger 250 according to Embodiment 2 includes the reinforcing elements 3Ac and 3Ad in the arrangement in addition to the reinforcing elements at both ends of the plurality of flat tubes 1, it is possible to improve strength at the center portion of the heat exchanger 250. Therefore, the heat exchanger 250 is advantageous in a case where the structure is long in the x direction.

[0055] The arrangement of the reinforcing elements 3 is not limited to the form illustrated in Fig. 11. For example, the reinforcing elements 3 may be disposed only in the arrangement of the plurality of flat tubes 1. The arrangement of the reinforcing elements 3 can be appropriately set depending on the length in the x direction of the heat exchanger 250, and the reinforcing elements 3 are preferably disposed at positions symmetrical about the center of the arrangement of the plurality of flat tubes 1.

[0056] The arrangement of the reinforcing elements 3 may be set based on flow rate distribution of the fluid flowing into the heat exchanger 250. For example, in a case where air is sent to the heat exchanger 250 by a fan, the reinforcing elements 3 are preferably disposed at positions where the flow rate of the air is small by taking into consideration the flow rate of the air at positions of the heat exchanger 250 by the position of the fan.

[0057] Further, in the heat exchanger 250, the cross-sectional shape of each of the reinforcing elements 3 may be changed. For example, the cross-sectional shape of each of the reinforcing elements 3 may be changed depending on the position in the heat exchanger 250. In the heat exchanger 250 according to Embodiment 2, no heat transfer promoting element 130 is provided between each of the reinforcing elements 3Ac and 3Ad and the adjacent flat tubes 1. Therefore, the cross-sectional shape of each of the reinforcing elements 3Ac and 3Ad is appropriately changeable. The heat exchanger 250 can adopt reinforcing elements 3 high in section modulus and having non-flat side surface shape, such as the above-described reinforcing elements 3B each having the I-shaped cross-section and the above-described reinforcing elements 3C each having the bent shape.

Embodiment 3

[0058] A heat exchanger 350 according to Embodiment 3 is described. The heat exchanger 350 is configured by replacing the plurality of flat tubes 1 of the heat exchanger 50 according to Embodiment 1 with heat transfer tubes each having a structure different from the structure of each of the plurality of flat tubes 1. Note that components having the functions and the actions same as the components of Embodiment 1 are denoted by the same reference numerals, and descriptions of the components are omitted.

[0059] Fig. 12 is a cross-sectional view of the heat exchanger 350 according to Embodiment 3. Fig. 12 illustrates a cross-section taken along line A-A in Fig. 2. The heat exchanger 350 includes a plurality of heat transfer tubes 1A. Each of the plurality of heat transfer tubes 1A is configured such that two circular tubes 301 are disposed to cause tube axes of the two circular tubes 301 to be parallel to each other and are connected by a fin 4. Each of the heat transfer tubes 1A includes a fin 5 extending in the direction opposite to the z direction from an end of one of the circular tubes 301, and a fin 6 extending in the z direction from an end of the other circular tube 301. In Embodiment 3, each of the heat transfer tubes 1A includes the two circular tubes 301 connected to each other, but may include more circular tubes 301 connected to one another. Further, although the refrigerant flows through an inside of each of the circular tubes 301, a cross-sectional shape of each of the circular tubes 301 is not limited to a circular shape, and may be an elliptical shape or other shapes.

[0060] The heat exchanger 350 includes reinforcing elements 303 in the arrangement of the plurality of heat transfer tubes 1A. In the cross-section illustrated in Fig. 12, an outer shape of each of the reinforcing elements 303 is the same as the outer shape of each of the plurality of heat transfer tubes 1A. Each of the reinforcing elements 303 is configured such that two columnar bar materials 3D are disposed side by side and are connected by a plate material 304. Further, each of the reinforcing elements 303 includes a plate material 305 extending in the direction opposite to the z direction from one of ends and a plate material 306 extending in the z direction from the other end. Since each of the reinforcing elements 303 is configured by connecting the solid bar materials 3D by the plate material 304, a section modulus around the neutral axis N along the z direction of each of the reinforcing elements 303 is greater than the section modulus of each of the plurality of heat transfer tubes 1A.

[0061] In the heat exchanger 350, the arrangement of the reinforcing elements 303 may be changed. For example, as with the heat exchanger 50 according to Embodiment 1, the reinforcing elements 303 may be disposed at ends of the arrangement of the plurality of heat transfer tubes 1A. Further, in the heat exchanger 350, the number of reinforcing elements 303 may be further increased.

[0062] In the heat exchanger 350 according to Embodiment 3, strength and rigidity of each of the reinforcing elements 303 are higher than strength and rigidity of each of the heat transfer tubes 1A. Further, the ends 31 and 32 of each of the reinforcing elements 303 inserted into the insertion portions of the headers 2 have the shape same as the ends of each of the heat transfer tubes 1A. Therefore, the insertion portions of the headers 2 into which the reinforcing elements 303 are inserted can be made in the shapes same as the insertion portions into which the heat transfer tubes 1A are inserted. Accordingly, the reinforcing elements 303 can be inserted into the headers 2 in a manner similar to the heat transfer tubes 1A while each having the shape higher in strength and rigidity than each of the heat transfer tubes 1A. This facilitates manufacturing of the heat exchanger 350.

[0063] Further, not only the bar materials 3D but also the plate materials 304, 305, and 306 of each of the reinforcing elements 303 can be joined to the headers 2. As a result, the plate materials 304, 305, and 306 can contribute to strength and rigidity of the heat exchanger 350.

[0064] Although the embodiments have been described above, the configurations are not limited to the configurations described in the above-described embodiments. For example, the heat exchanger may be configured by combining the configurations described in the embodiments. In short, various modifications, applications, and utilization ranges made by a person skilled in the art as needed are also included in the technical scope. Note that the flat tubes 1, 1a, and 1b of Embodiments 1 and 2, and the heat transfer tubes 1A of Embodiment 3 are all referred to as heat transfer tubes in some cases.

Reference Signs List

[0065] 1: flat tube, 1A: heat transfer tube, 1a: flat tube, 1b: flat tube, 1x: flat tube, 2: header, 2a: second header, 2b: first header, 3: reinforcing element, 3A: reinforcing element, 3Aa: reinforcing element, 3Ab: reinforcing element, 3Ac: reinforcing element, 3B: reinforcing element, 3C: reinforcing element, 3D: bar material, 3a: reinforcing element, 3b: reinforcing element, 4: fin, 5: fin, 11: end, 12: end, 13: heat transfer portion, 31: end, 32: end, 33: center portion, 34: end surface, 50: heat exchanger, 50A: heat exchanger, 50B: heat exchanger, 50C: heat exchanger, 50x: heat exchanger, 60a: first side end, 60b: second side end, 60c: flat surface, 60d: flat surface, 100: refrigeration cycle device, 101: compressor, 102: flow switching device, 103: indoor heat exchanger, 104: decompression device, 105: outdoor heat exchanger, 106: outdoor unit, 107: indoor unit, 108: outdoor fan, 109: indoor fan, 110: refrigerant circuit, 111: extension pipe, 112: extension pipe, 113: center portion, 130: heat transfer promoting element, 150: heat exchanger, 250: heat exchanger, 301: circular tube, 303: reinforcing element, 304: plate material, 305: plate material, 350: heat exchanger, F0: shape, F1: shape, N: neutral axis, RF: arrow

Claims

1. A heat exchanger comprising:

   a plurality of heat transfer tubes configured to allow refrigerant to pass therethrough, arranged in a first direction and being spaced from each other;
   a first header connected to one end of each of the plurality of heat transfer tubes;
   a second header connected to an other end of each of the plurality of heat transfer tubes; and
   a plurality of reinforcing elements connected to each of the first header and the second header,
   each of the plurality of heat transfer tubes and each of the plurality of reinforcing elements being disposed between the first header and the second header and being connected by the first header and the second header without being connected by a component connecting side surfaces of the plurality of heat transfer tubes and a side surface of each of the plurality of heat transfer tubes and a side surface of each of reinforcing elements.

2. The heat exchanger of claim 1, wherein the plurality of reinforcing elements include first reinforcing elements each disposed adjacently to two heat transfer tubes in the first direction among the plurality of heat transfer tubes.

3. The heat exchanger of claim 1 or 2, wherein the plurality of reinforcing elements include second reinforcing elements disposed outside of the respective heat transfer tubes disposed on both ends in the first direction among the plurality of heat transfer tubes.

4. The heat exchanger of any one of claims 1 to 3, wherein the plurality of reinforcing elements are arranged in the first direction together with the plurality of heat transfer tubes, and are disposed at positions symmetrical about a center of arrangement of the plurality of heat transfer tubes.

5. The heat exchanger of any one of claims 1 to 4, wherein the plurality of reinforcing elements and the plurality of heat transfer tubes are disposed at equal intervals in the first direction.

6. The heat exchanger of any one of claims 1 to 5, wherein each of the plurality of reinforcing elements is higher in section modulus around a neutral axis than each of the plurality of heat transfer tubes in a first cross-section orthogonal to tube axes of the plurality of heat transfer tubes, the neutral axis intersecting the first direction.

7. The heat exchanger of any one of claims 1 to 6, wherein

   each of the plurality of reinforcing elements includes two insertion portions inserted into the first header and the second header, at both ends, and a heat transfer portion positioned between the two insertion portions,
   each of the two insertion portions has an outer shape same as an outer shape of each of the plurality of heat transfer tubes, in a first cross-section orthogonal to tube axes of the plurality of heat transfer tubes, and
   the heat transfer portion has an outer shape different from the outer shape of each of the two insertion portions in the first cross-section.

8. The heat exchanger of any one of claims 1 to 7, wherein each of the plurality of reinforcing elements has a cross-sectional shape same as a cross-sectional shape perpendicular to a tube axis of each of the plurality of heat transfer tubes.

9. The heat exchanger of any one of claims 1 to 8, wherein each of the plurality of reinforcing elements is made of a material higher in strength than a material of each of the plurality of heat transfer tubes.

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

    each of the plurality of heat transfer tubes is a flat tube, and
    each of the plurality of reinforcing elements has a flat side surface, and is disposed to cause the side surface to face a flat surface along a longitudinal direction of a cross-sectional shape of the adjacent flat tube in a cross-section perpendicular to the tube axes of the flat tubes.

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

FIG. 1

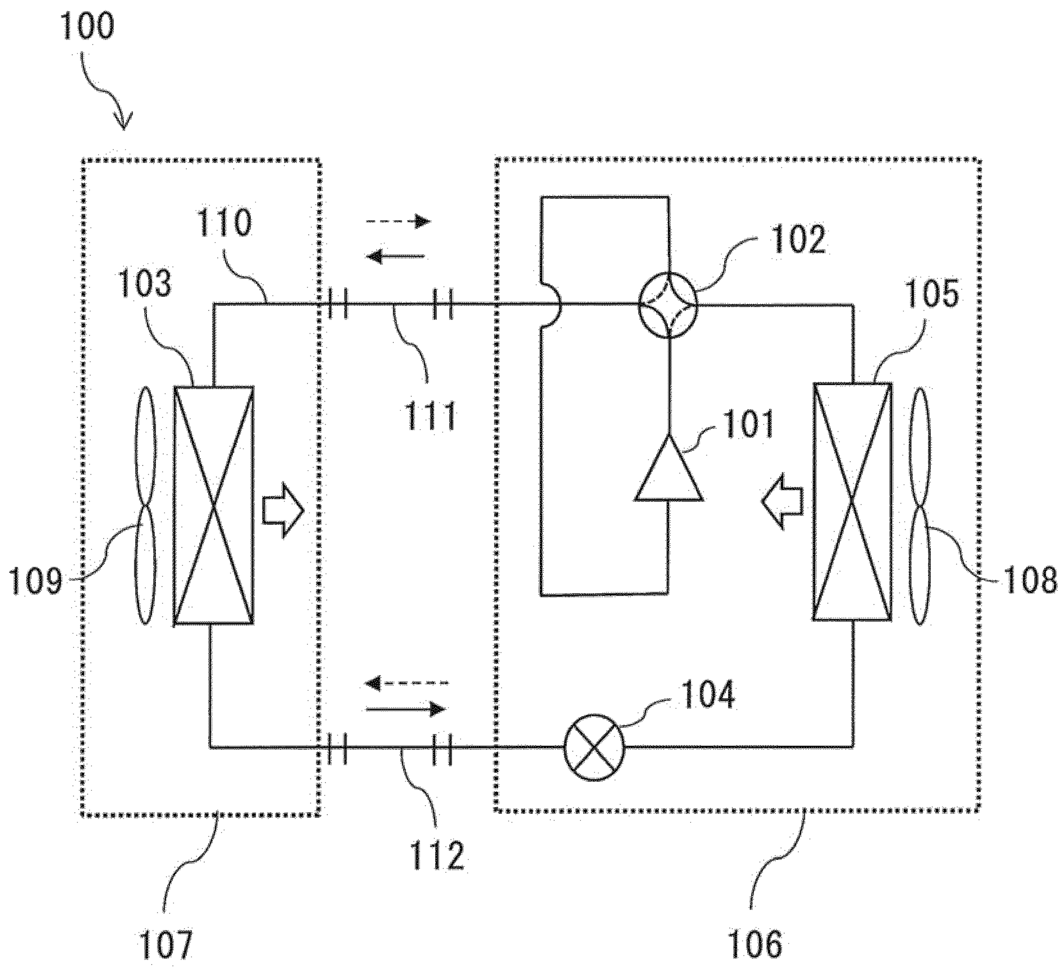
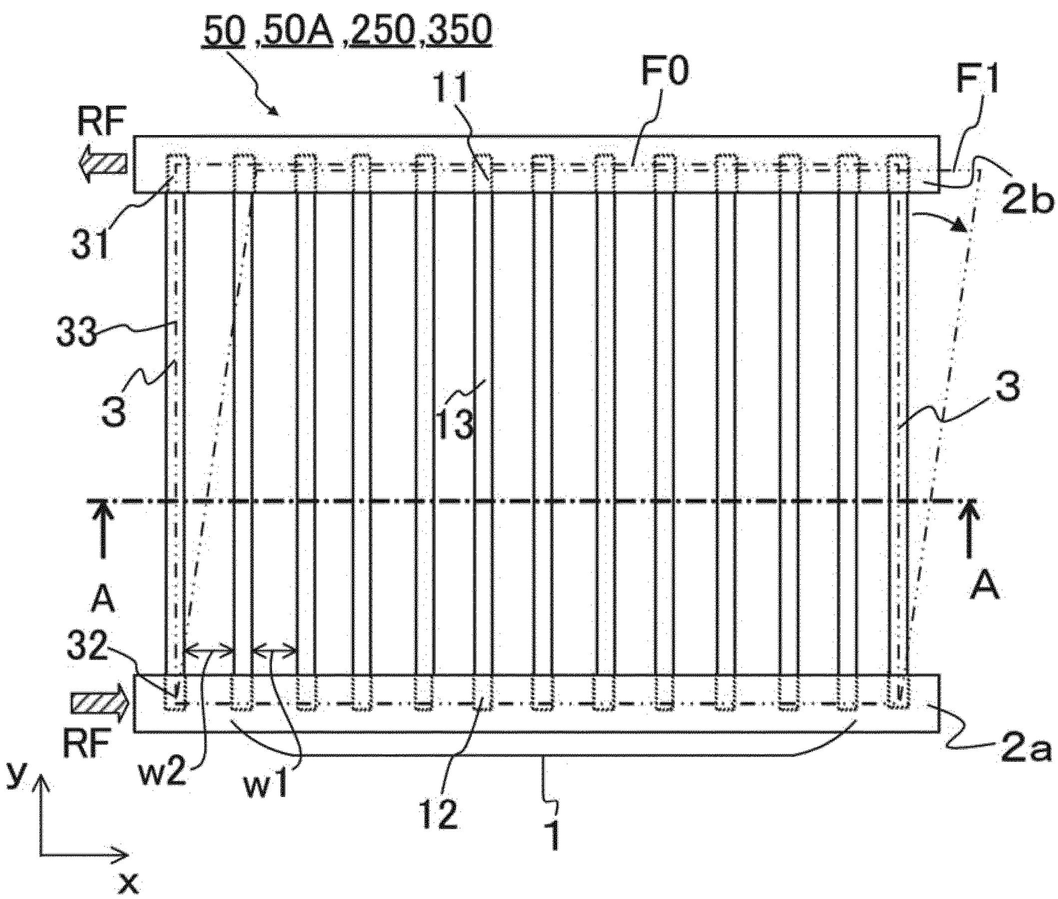


FIG. 2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11
F0
F1
2b
31
33
3
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3
A
A
32
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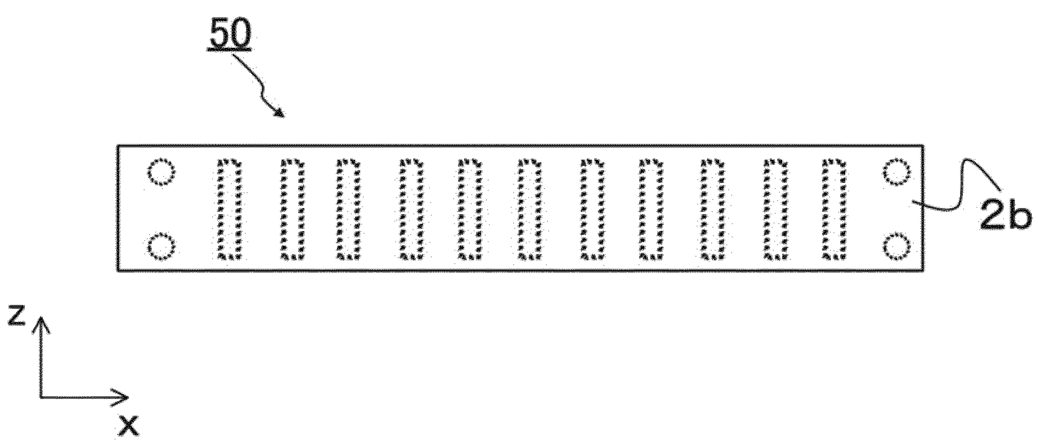
w2
w1
12
1
2a
y
x

FIG. 3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2b
z
x

FIG. 4

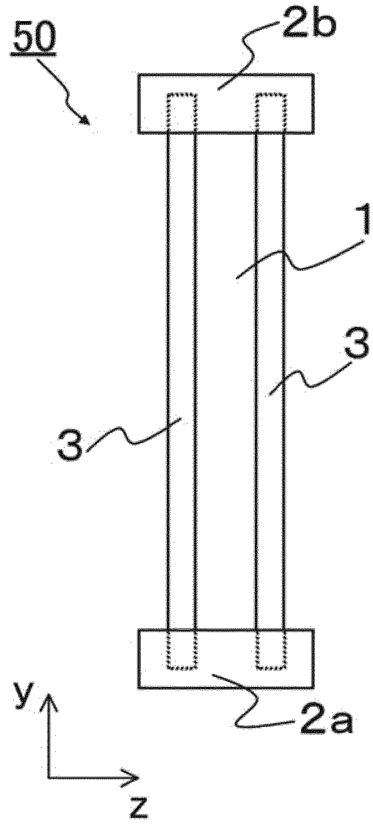


FIG. 5

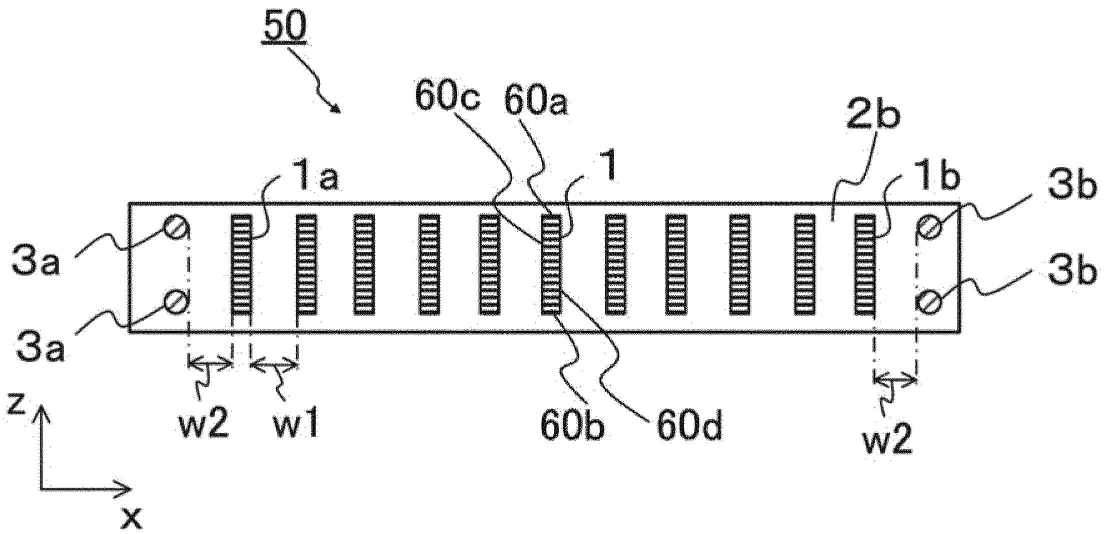
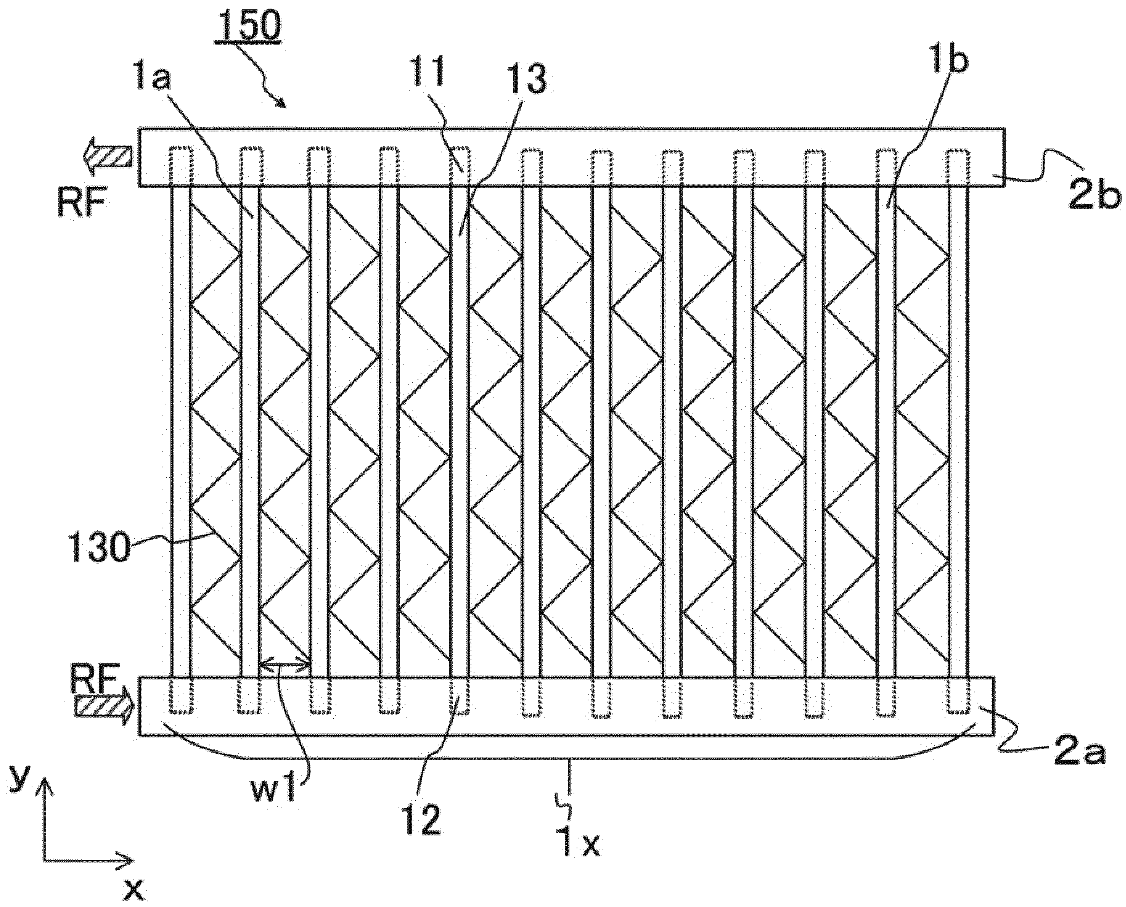


FIG. 6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RF
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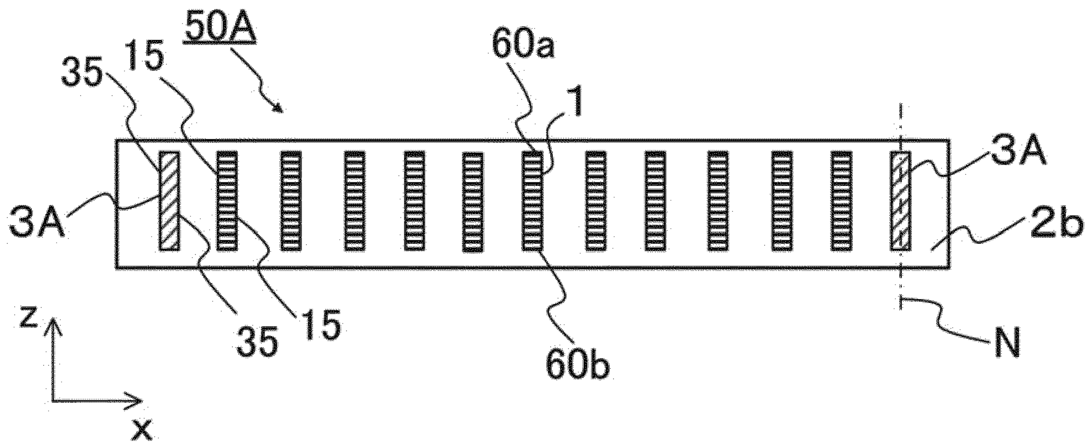
2a
y
x

FIG. 7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N
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x

FIG. 8

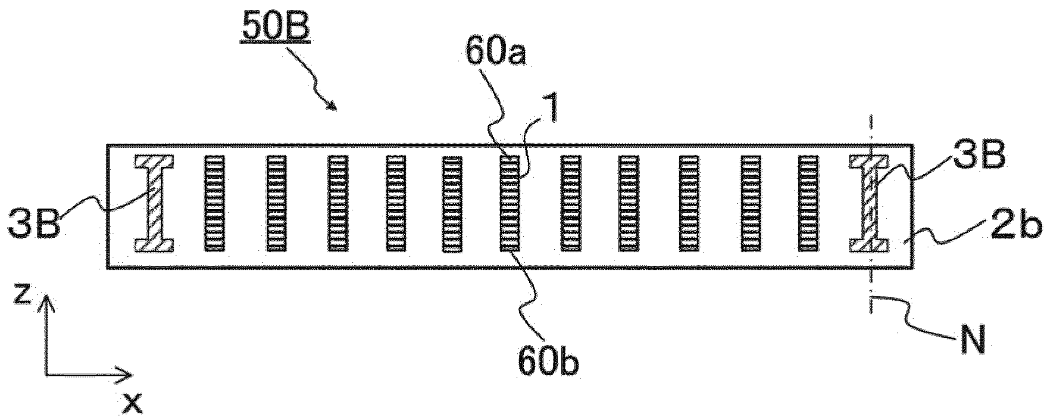


FIG. 9

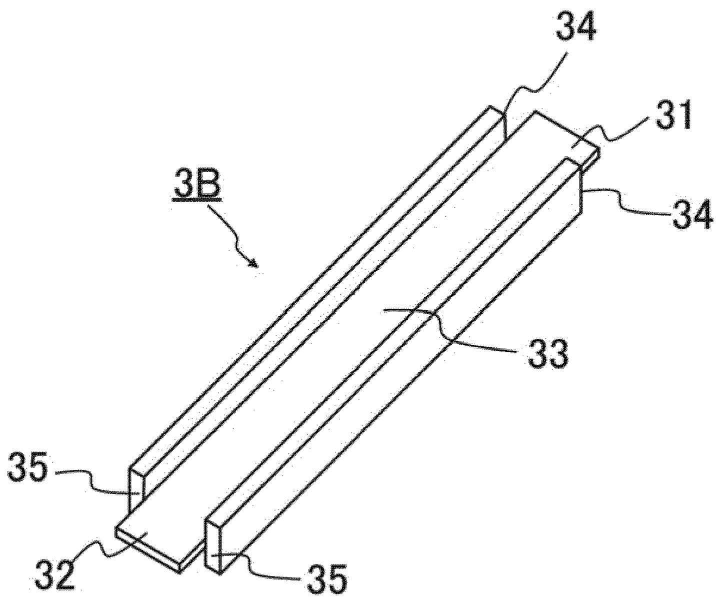


FIG. 10

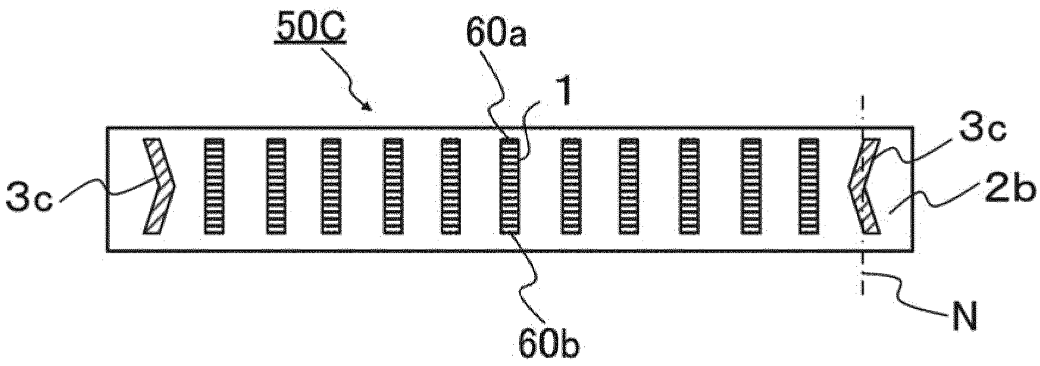
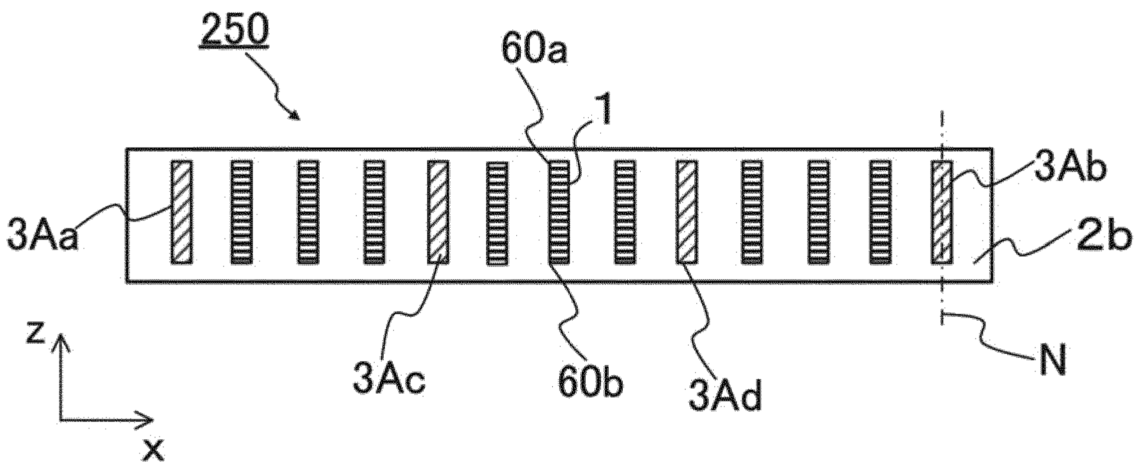


FIG. 11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3Ab
3Aa
2b
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3Ac
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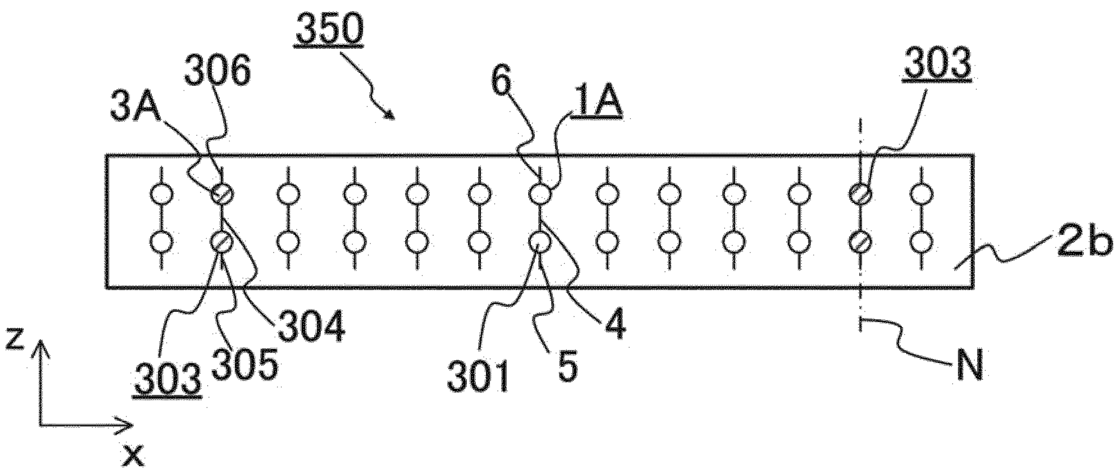
3Ad
N

FIG. 12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3A
6
1A
303
2b
304
4
z
303
305
301
5
N
x

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/019127

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F28D1/053(2006.01)i, F28F9/013(2006.01)i, F28F9/02(2006.01)i

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)
Int.Cl. F28D1/053, F28F9/013, F28F9/02

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2002-147986 A (SANDEN CORPORATION) 22 May 2002, paragraphs [0009], [0020], [0027], fig. 12, 15 (Family: none)	1-6, 10-11 7-11
X Y	JP 2002-228378 A (DENSO CORPORATION) 14 August 2002, paragraphs [0027], [0035], fig. 1, 4 (Family: none)	1, 3-7, 10-11 7-11
X Y	JP 3-279798 A (SHOWA ALUMINUM CORPORATION) 10 December 1991, page 4, lower right column, lines 7-17, fig. 4, 10 (Family: none)	1, 3-6, 8, 10-11 8-11

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

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"P" document published prior to the international filing date but later than the priority date claimed
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31.05.2019	16.07.2019

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	 Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2019/019127

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-50240 A (MITSUBISHI ELECTRIC CORPORATION) 14 March 2013, paragraph [0012] (Family: none)	9-11
Y	JP 2006-200775 A (FURUKAWA-SKY ALUMINUM CORP.) 03 August 2006, paragraph [0019] (Family: none)	9-11
Y	JP 10-206082 A (SANDEN CORPORATION) 07 August 1998, paragraph [0008] (Family: none)	9-11

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP 2018155479 A **[0005]**