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(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventors:
• **YATSUYANAGI, Akira**
Tokyo 1008310 (JP)

- **MAEDA, Tsuyoshi**
Tokyo 1008310 (JP)
- **MATSUMOTO, Takemi**
Tokyo 1008310 (JP)
- **NISHIMOTO, Keisuke**
Tokyo 1008310 (JP)
- **OKUMA, Yuriko**
Tokyo 1008310 (JP)

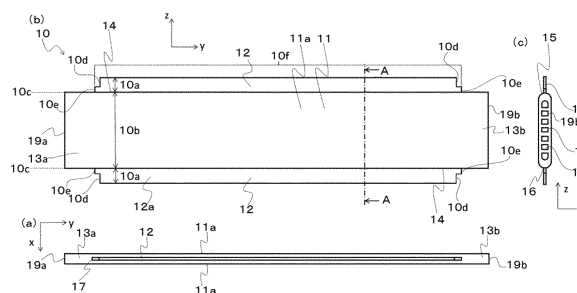
(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

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

(57) A heat exchanger in which an end portion of a heat exchange element is appropriately joined to an insertion hole of a header. The heat exchanger includes a heat exchange element extending in a first direction and a header to which the heat exchange element is connected. The heat exchange element includes at least one heat transfer tube extending in the first direction and a fin provided on part of an edge portion of the at least one

heat transfer tube in a second direction crossing orthogonally with the first direction. An end portion in the first direction of the heat exchange element includes an insertion part being inserted into an interior of the header, an abutment part abutting the header in a part other than the insertion part, and a spaced-apart part being spaced apart from the header in a part other than the insertion part.

FIG. 3



Description

Technical Field

[0001] The present disclosure relates to a heat exchanger, a heat exchanger unit including the heat exchanger, and a refrigeration cycle apparatus, and more particularly, relates to a structure of an insertion part of a heat exchange element that is inserted into a header.

Background Art

[0002] A known heat exchanger includes a heat exchange element including a fin and a heat transfer tube. The fin extends along the axis of the heat transfer tube. In such a heat exchanger, an end portion of the heat exchange element is inserted into a header. The whole of an end face of the fin abuts or is spaced apart from the header (refer to, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2018-155479

Summary of Invention

Technical Problem

[0004] For a heat exchange element disclosed in Patent Literature 1, a part of each fin that is in contact with or joined to a header has a long length. A brazing material enters a space between the fin and the header due to capillary action. In a case where the part, of each fin, to be in contact with or joined to the header has a long length, it is necessary to increase the amount of brazing material to be supplied to the space between the fin and the header. In a heat exchanger including such a heat exchange element, the heat exchange element may be damaged by, for example, erosion.

[0005] In view of the above issue, an object of the present disclosure is to provide a heat exchanger with little or no damage to a heat transfer tube caused by joining a heat exchange element to a header, a heat exchanger unit, and a refrigeration cycle apparatus.

Solution to Problem

[0006] A heat exchanger according to an embodiment of the present disclosure includes a heat exchange element extending in a first direction and a header to which the heat exchange element is connected. The heat exchange element includes at least one heat transfer tube extending in the first direction and a fin provided on part of an edge portion of the at least one heat transfer tube in a second direction crossing orthogonally with the first

direction. An end portion in the first direction of the heat exchange element includes an insertion part being inserted into an interior of the header, an abutment part abutting the header in a part other than the insertion part, and a spaced-apart part being spaced apart from the header in a part other than the insertion part.

[0007] A heat exchanger unit according to an embodiment of the present disclosure includes the above-described heat exchanger.

[0008] A refrigeration cycle apparatus according to an embodiment of the present disclosure includes the above-described heat exchanger unit.

Advantageous Effects of Invention

[0009] According to the embodiments of the present disclosure, the fin of the heat exchange element is joined to the header such that a joint between the fin and the header has an appropriate length. Thus, appropriate joining is achieved with less brazing material used to join the heat exchange element to the header, resulting in little or no damage to the heat exchange element in the heat exchanger.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram illustrating the configuration of a refrigeration cycle apparatus 50 including a heat exchanger 100 according to Embodiment 1.

[Fig. 2] Fig. 2 shows three views of the heat exchanger 100 according to Embodiment 1 illustrating essential components of the heat exchanger.

[Fig. 3] Fig. 3 shows three views of a heat exchange element 10 in Embodiment 1.

[Fig. 4] Fig. 4 shows three views of a first header 30 of the heat exchanger 100 according to Embodiment 1.

[Fig. 5] Fig. 5 is an enlarged view of a connection between the heat exchange element 10 and the first header 30 in the heat exchanger 100 according to Embodiment 1.

[Fig. 6] Fig. 6 is a top view of the heat exchange element 10 in Embodiment 1 illustrating modifications of fins 12.

[Fig. 7] Fig. 7 is a top view of the heat exchange element 10 in Embodiment 1 illustrating modifications of the fins 12.

[Fig. 8] Fig. 8 shows three views of a heat exchange element 10A, which is a modification of the heat exchange element 10 in Embodiment 1.

[Fig. 9] Fig. 9 is an enlarged view of a connection between the heat exchange element 10A of Fig. 8 and the first header 30.

[Fig. 10] Fig. 10 shows three views of a heat exchange element 10B, which is a modification of the

heat exchange element 10 in Embodiment 1.

[Fig. 11] Fig. 11 is an enlarged view of a connection between the heat exchange element 10B of Fig. 10 and the first header 30.

[Fig. 12] Fig. 12 shows three views of a heat exchange element 210A in Embodiment 2.

[Fig. 13] Fig. 13 is an enlarged view of a connection between the heat exchange element 210A and the first header 30 in a heat exchanger 200 according to Embodiment 2.

[Fig. 14] Fig. 14 shows three views of a heat exchange element 210B in Embodiment 2.

[Fig. 15] Fig. 15 is an enlarged view of a connection between the heat exchange element 210B and the first header 30 in the heat exchanger 200 according to Embodiment 2.

[Fig. 16] Fig. 16 shows three views of a header 302 of a heat exchanger 300 according to Embodiment 3.

[Fig. 17] Fig. 17 is an enlarged view of a connection between a heat exchange element 310 and a first header 330 in the heat exchanger 300 according to Embodiment 3.

[Fig. 18] Fig. 18 is an enlarged view of a connection between the heat exchange element 310 and a first header 330B, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 19] Fig. 19 is an enlarged view of a connection between the heat exchange element 310 and a first header 330C, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 20] Fig. 20 is an enlarged view of a connection between a heat exchange element 310A, which is a modification of the heat exchange element 310, and a first header 330A, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 21] Fig. 21 is an enlarged view of a connection between the heat exchange element 310A, which is a modification of the heat exchange element 310, and the first header 330B, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 22] Fig. 22 is an enlarged view of a connection between the heat exchange element 310A, which is a modification of the heat exchange element 310, and the first header 330C, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 23] Fig. 23 is an enlarged view of a connection between the heat exchange element 310B, which is a modification of the heat exchange element 310, and the first header 330A, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3.

[Fig. 24] Fig. 24 shows three views of a heat exchange element 410 in Embodiment 4.

[Fig. 25] Fig. 25 shows three views of a heat exchange element 510 of a heat exchanger 500 according to Embodiment 5.

5 Description of Embodiments

[0011] A heat exchanger according to Embodiment 1, a heat exchanger unit, and a refrigeration cycle apparatus will be described below with reference to the drawings, for example. Note that the relationship between the relative dimensions, the forms, and other conditions of components in the following figures including Fig. 1 may differ from those of actual ones. Furthermore, note that components designated by the same reference signs in the following figures are the same components or equivalents. This applies to the entire description herein. For the sake of easiness in understanding, terms representing directions, such as "upper", "lower", "right", "left", "front", and "rear", will be used as appropriate. These terms are used herein only for the purpose of convenience of description and are not intended to restrict the arrangement and orientations of devices or parts. The positional relationship between components, a direction in which each component extends, and a direction in which the components are arranged described herein are provided in principle in a state where the heat exchanger is placed in position ready for use.

Embodiment 1

(Refrigeration Cycle Apparatus 50)

[0012] Fig. 1 is a refrigerant circuit diagram illustrating the configuration of a refrigeration cycle apparatus 50 including a heat exchanger 100 according to Embodiment 1. In Fig. 1, broken-line arrows represent a direction in which refrigerant flows through a refrigerant circuit 110 in a cooling operation, and solid-line arrows represent a direction in which the refrigerant flows through the refrigerant circuit 110 in a heating operation. The refrigeration cycle apparatus 50 including the heat exchanger 100 will now be described with reference to Fig. 1. Although an air-conditioning apparatus is illustrated as an example of the refrigeration cycle apparatus 50 in Embodiment 1, the refrigeration cycle apparatus 50 is used for refrigeration or air conditioning and can be used as, for example, a refrigerator, a freezer, a vending machine, an air-conditioning apparatus, a refrigeration apparatus, or a water heater. The illustrated refrigerant circuit 110 is an example. For example, components of the circuit are not limited to those described in Embodiment 1, and can be appropriately changed within a technical scope of Embodiment 1.

[0013] The refrigeration cycle apparatus 50 includes the refrigerant circuit 110 in which a compressor 101, a flow switching device 102, an indoor heat exchanger 103, a pressure reducing device 104, and an outdoor heat exchanger 105 are connected sequentially by refrigerant

pipes. The heat exchanger 100, which will be described later, is used as at least one of the outdoor heat exchanger 105 and the indoor heat exchanger 103. The refrigeration cycle apparatus 50 includes an outdoor unit 106 and an indoor unit 107. Units having therein a heat exchanger, such as the outdoor unit 106 and the indoor unit 107, may be referred to as heat exchanger units. The outdoor unit 106 contains the compressor 101, the flow switching device 102, the outdoor heat exchanger 105, the pressure reducing device 104, and an outdoor fan 108, which provides outdoor air to the outdoor heat exchanger 105. The indoor unit 107 includes the indoor heat exchanger 103 and an indoor fan 109, which provides air to the indoor heat exchanger 103. The outdoor unit 106 and the indoor unit 107 are connected by two extension pipes 111 and 112, which are parts of the refrigerant pipes.

[0014] The compressor 101 is a piece of fluid machinery that sucks, compresses, and discharges the refrigerant. The flow switching device 102 is, for example, a four-way valve, and switches between a refrigerant passage for the cooling operation and a refrigerant passage for the heating operation under the control of a controller (not illustrated).

[0015] The indoor heat exchanger 103 is a heat exchanger that causes heat exchange to be performed between the refrigerant flowing through an interior of the heat exchanger and the indoor air provided by the indoor fan 109. The indoor heat exchanger 103 operates as a condenser in the heating operation and operates as an evaporator in the cooling operation.

[0016] The pressure reducing device 104 is, for example, an expansion valve, and reduces the pressure of the refrigerant. Examples of the pressure reducing device 104 include an electronic expansion valve whose opening degree is adjusted under the control of the controller.

[0017] The outdoor heat exchanger 105 is a heat exchanger that causes heat exchange to be performed between the refrigerant flowing through an interior of the heat exchanger and the air provided by the outdoor fan 108. The outdoor heat exchanger 105 operates as an evaporator in the heating operation and operates as a condenser in the cooling operation.

(Operation of Refrigeration Cycle Apparatus 50)

[0018] Exemplary operations of the refrigeration cycle apparatus 50 will now be described with reference to Fig. 1. In the heating operation of the refrigeration cycle apparatus 50, high-pressure and high-temperature gas refrigerant discharged from the compressor 101 flows through the flow switching device 102 and then enters the indoor heat exchanger 103, where the refrigerant exchanges heat with the air provided by the indoor fan 109 and thus condenses. The condensed refrigerant, which is in a high-pressure liquid state, flows out of the indoor heat exchanger 103 and is then turned into a low-pressure, two-phase gas-liquid state by the pressure reducing

device 104. The low-pressure, two-phase gas-liquid refrigerant enters the outdoor heat exchanger 105, where the refrigerant exchanges heat with the air provided by the outdoor fan 108 and thus evaporates. The evaporated refrigerant, which is in a low-pressure gas state, is sucked into the compressor 101.

[0019] In the cooling operation of the refrigeration cycle apparatus 50, the refrigerant flows through the refrigerant circuit 110 in a direction opposite to that in the heating operation. Specifically, in the cooling operation of the refrigeration cycle apparatus 50, high-pressure and high-temperature gas refrigerant discharged from the compressor 101 flows through the flow switching device 102 and then enters the outdoor heat exchanger 105, where the refrigerant exchanges heat with the air provided by the outdoor fan 108 and thus condenses. The condensed refrigerant, which is in a high-pressure liquid state, flows out of the outdoor heat exchanger 105 and is then turned into a low-pressure, two-phase gas-liquid state by the pressure reducing device 104. The low-pressure, two-phase gas-liquid refrigerant enters the indoor heat exchanger 103, where the refrigerant exchanges heat with the air provided by the indoor fan 109 and thus evaporates. The evaporated refrigerant, which is in a low-pressure gas state, is sucked into the compressor 101.

(Heat Exchanger 100)

[0020] Fig. 2 shows three views of the heat exchanger 100 according to Embodiment 1 illustrating essential components of the heat exchanger. Fig. 2(a) is a front view of the heat exchanger 100. Fig. 2(b) is a side view of the heat exchanger 100. Fig. 2(c) is a bottom view of the heat exchanger 100. In Fig. 2, each arrow RF represents the flow of the refrigerant flowing into or out of the heat exchanger 100. The heat exchanger 100 according to Embodiment 1 will now be described with reference to Fig. 2.

[0021] The heat exchanger 100 according to Embodiment 1 includes a plurality of heat exchange elements 10, a first header 30, and a second header 40, which are connected to opposite ends of the heat exchange elements 10 in a y direction. The heat exchange elements 10 are arranged side by side in an x direction. The heat exchange elements 10, which extend in the y direction, are arranged such that the axes thereof extend in the y direction. In Embodiment 1, the y direction is parallel to the direction of gravity. The placement of the heat exchanger 100 is not limited only to the above example. The heat exchanger 100 may be placed such that the y direction is inclined relative to the direction of gravity. The heat exchange elements 10 are evenly spaced or arranged at predetermined intervals in the x direction. The axial direction of the heat exchange elements 10, or the y direction may be referred to as a first direction. A width-wise direction of the heat exchange elements 10, or a z direction may be referred to as a second direction. The direction in which the heat exchange elements 10 are

arranged side by side, or the x direction may be referred to as a third direction.

[0022] The heat exchange elements 10 have first end portions 13a in the axial direction that are connected to the first header 30. The heat exchange elements 10 have second end portions 13b in the axial direction that are connected to the second header 40. The first header 30 and the second header 40 are arranged such that each header has a length in the direction in which the heat exchange elements 10 are arranged. The length of the first header 30 is parallel to that of the second header 40. In the following description, the first header 30 and the second header 40 may be collectively referred to as headers 2.

[0023] For the heat exchange elements 10, parts of the end portions 13a and 13b are inserted into interiors of the headers 2 and are joined to the headers 2 by a joining process, such as brazing, or with a joining material, such as adhesive. Parts of the heat exchange elements 10 other than the parts inserted into the headers 2 will be referred to as heat exchange parts 10f. The heat exchange parts 10f of the heat exchange elements 10 are located between an upper surface of the first header 30 and a lower surface of the second header 40.

[0024] The heat exchanger 100 is a finless heat exchanger, and does not have, for example, corrugated fins, which are to connect side faces 11a of heat transfer tubes 11 of the heat exchange elements 10, between the heat exchange elements 10. Specifically, the heat exchange elements 10 are connected only by the headers 2. The heat exchange elements 10 that are adjacent to each other have a space between the side faces thereof. The spacing between the side faces of the heat exchange elements 10 is set to be narrow to enhance the efficiency of heat exchange.

(Heat Exchange Element 10)

[0025] Fig. 3 shows three views of the heat exchange element 10 in Embodiment 1. Fig. 3(a) is a front view of the heat exchange element 10. Fig. 3(b) is a side view of the heat exchange element 10. Fig. 3(c) is a top view of the heat exchange element 10. In Embodiment 1, the heat exchange elements 10 each include the heat transfer tube 11, which is a flat tube extending in the y direction, and fins 12 each extending in the z direction from part of an edge portion 14 of the heat transfer tube 11. The heat transfer tube 11 has therein refrigerant passages 18, through which the refrigerant flows. The heat exchange elements 10 each extend between the first header 30 and the second header 40. The heat exchange elements 10 are arranged such that the side faces 11a face each other. Two adjacent heat exchange elements 10 of the heat exchange elements 10 have a space between these two adjacent heat exchange elements, and the space serves as an air passage.

[0026] In the heat exchanger 100, the direction in which the heat exchange elements 10 are arranged is a hori-

zontal direction. The direction in which the heat exchange elements 10 are arranged is not limited to the horizontal direction, and may be a vertical direction or a direction inclined relative to the vertical direction. Similarly, the axial direction of the heat exchange elements 10 in the heat exchanger 100 is the vertical direction. The direction in which the heat exchange elements 10 extend is not limited to the vertical direction, and may be the horizontal direction or a direction inclined relative to the vertical direction.

[0027] While the heat exchanger 100 is operating as an evaporator of the refrigeration cycle apparatus 50, the refrigerant flows through an interior of each of the heat exchange elements 10 from a first end face 19a of the heat exchange element 10 in the y direction to a second end face 19b thereof. While the heat exchanger 100 is operating as a condenser of the refrigeration cycle apparatus 50, the refrigerant flows through the interior of each of the heat exchange elements 10 from the second end face 19b of the heat exchange element 10 in the y direction to the first end face 19a.

[0028] As illustrated in Fig. 3, each heat exchange element 10 includes the heat transfer tube 11 and the fins 12. The heat transfer tube 11 of the heat exchange element 10 is a flat multi-hole tube whose cross-section has a shape that is flat in one direction, such as an oblong shape. In the heat exchange element 10, each of the fins 12 extends from part of the edge portion 14 in a direction along the major axis of a cross-section of the heat transfer tube 11 that is perpendicular to the y direction.

[0029] In the heat exchange element 10, the edge portions 14 of the heat transfer tube 11 include parts each having no fin 12. The parts, of the edge portions 14 of the heat transfer tube 11, having no fin 12 in the heat exchange element 10 are to be inserted into the interiors of the first header 30 and the second header 40. The parts of the end portions 13a and 13b are inserted into the first header 30 and the second header 40, so that the heat exchange element 10 communicates between the first header 30 and the second header 40.

[0030] Each of the end portions 13a and 13b of the heat exchange element 10 includes a plurality of parts defined by imaginary division in the z direction. The parts are non-insertion parts 10a and an insertion part 10b defined by division with imaginary lines along the axis of the tube of the heat exchange element 10. The boundary between each non-insertion part 10a and the insertion part 10b will be referred to as a transition 10c. In each of the end portions 13a and 13b of the heat exchange element 10 in Fig. 3, the heat transfer tube 11 corresponds to the insertion part 10b, and the fins 12 correspond to the non-insertion parts 10a. The insertion part 10b is a part of the end portion in the y direction of the heat exchange element 10 that is to be inserted into the interior of the header 2.

[0031] The non-insertion parts 10a are parts of each end portion in the y direction of the heat exchange element 10 that are other than the insertion part 10b. In

Embodiment 1, each of the fins 12, serving as the non-insertion parts 10a, includes a spaced-apart part 10d and an abutment part 10e at its end face in the y direction. The abutment part 10e is to abut the header 2 in a part other than the insertion part 10b. The spaced-apart part 10d is to be spaced apart from the header 2 in a part other than the insertion part 10b. The spaced-apart part 10d and the abutment part 10e form the end face in the y direction of the fin 12. The abutment part 10e is located closer to the end face 19a or 19b of the heat exchange element 10 than the spaced-apart part 10d. In other words, the abutment part 10e is located closer to the header 2 than the spaced-apart part 10d and is located between the spaced-apart part 10d and the insertion part 10b in the z direction.

(Header 2)

[0032] Fig. 4 shows three views of the first header 30 of the heat exchanger 100 according to Embodiment 1. Fig. 4(a) is a front view of the first header 30. Fig. 4(b) is a side view of the first header 30. Fig. 4(c) is a top view of the first header 30. The first header 30 and the second header 40, each of which extends in the x direction, are configured to cause the refrigerant to flow through the interior of the header, and can be connected to the heat exchange elements 10. As illustrated in Fig. 2, for example, the refrigerant enters one end of the first header 30 in a direction represented by the arrow RF. The refrigerant is distributed to the heat exchange elements 10, so that streams of the refrigerant pass through the heat exchange elements 10. Then, the streams of the refrigerant join together in the second header 40. The refrigerant flows out of one end of the second header 40.

[0033] In Figs. 2 and 4, each header 2 has a rectangular cuboid outer shape. The header 2 may have any other shape. For example, the outer shape of the header 2 may be a cylinder or an elliptic cylinder. The cross-sectional shape of the header 2 can be changed as appropriate. For the structure of the header 2, for example, a cylinder having opposite closed ends or a stack of plates having slits can be used. The first header 30 has a refrigerant port 33, through which the refrigerant can flow into or out of the header. The second header 40 has a refrigerant port 43, through which the refrigerant can flow into or out of the header.

[0034] As illustrated in Fig. 4, the first header 30 includes a first outer casing 31, which defines a header upper surface 34a, and a second outer casing 32, which defines a bottom portion. The first outer casing 31 and the second outer casing 32 are combined to form a rectangular cuboid shape of the first header 30. The refrigerant port 33 is located at an end of the second outer casing 32 in a direction opposite to the x direction. The header upper surface 34a of the first header 30 has a plurality of insertion holes 31a. The insertion holes 31a are arranged in the x direction in one-to-one correspondence with the heat exchange elements 10. The insertion

holes 31a are holes into which the insertion parts 10b of the heat exchange elements 10 can be inserted, and extend through the first outer casing 31 in a direction perpendicular to the upper surface. The second header 40 has the same structure as the first header 30.

(Structure of Connection between Heat Exchange Element 10 and Header 2)

[0035] Fig. 5 is an enlarged view of a connection between the heat exchange element 10 and the first header 30 in the heat exchanger 100 according to Embodiment 1. The heat transfer tube 11, serving as the insertion part 10b of each of the end portions 13a and 13b of the heat exchange element 10, is inserted into the insertion hole 31a of the first header 30. The insertion hole 31a has a shape that matches the shape of a peripheral surface of the insertion part 10b. The insertion part 10b is joined to the insertion hole 31a by, for example, brazing, to prevent leakage of the refrigerant flowing through the interior of the heat exchanger 100. The abutment part 10e of each fin 12, serving as the non-insertion part 10a, abuts the header upper surface 34a of the first header 30. The spaced-apart part 10d of the fin 12, serving as the non-insertion part 10a, is spaced apart from the header upper surface 34a of the first header 30. For the abutment part 10e, it is only required that at least one part of a face of the fin 12 facing the header upper surface 34a of the first header 30 be in contact with the header upper surface 34a of the first header 30. Furthermore, it is only required that the spaced-apart part 10d be a part of the face of the fin 12 facing the header upper surface 34a of the first header 30 in the y direction. In Fig. 5, side edges of the fins 12 are aligned with side faces 35 of the header 2. Even if the side edges of the fins 12 protrude farther than the side faces 35 of the header 2, the spaced-apart parts 10d can be arranged to face the first header 30 in the y direction.

[0036] Such a configuration of the heat exchanger 100 determines a unique positional relationship between the heat exchange elements 10 and the headers 2. This facilitates positioning of the heat exchange elements 10 relative to the headers 2. In manufacture of the heat exchanger 100, the heat exchange elements 10 can be readily positioned by merely combining the heat exchange elements 10 with the headers 2 without any step of positioning the heat exchange elements 10 relative to the headers 2 and any jig. This facilitates the manufacture of the heat exchanger 100. A reduction in dimension of the parts of the heat exchange elements 10 in contact with each header 2, or dimension of the fins 12 of the heat exchange elements 10 in contact with the header upper surface 34a of the header 2, reduces the amount of brazing material used to join the heat exchange elements 10 to the header 2. This leads to a lower manufacturing cost while the sealing performance and strength of joints between the heat exchange elements 10 and the headers 2 are enhanced. In addition, a reduction in

the amount of brazing material used to join the heat exchange elements 10 to the headers 2 in the heat exchanger 100 results in little or no damage to the heat transfer tubes caused by erosion.

[0037] In Embodiment 1, the non-insertion part 10a is a part of each fin 12. The abutment part 10e is included in the end face in the y direction of the fin 12 and is located closer to the header 2 than the spaced-apart part 10d. Such a configuration of the heat exchange element 10 facilitates shaping of the heat exchange element 10 because the spaced-apart part 10d is formed by forming a cut in the fin 12, which can be readily cut.

[0038] Figs. 6 and 7 are top views of the heat exchange element 10 in Embodiment 1 illustrating modifications of the fins 12. Fig. 6 is a diagram corresponding to Fig. 3(c). The fins 12 of the heat exchange element 10 are not limited to those integrated with the heat transfer tube 11. For example, each fin 12 may be formed by curving a plate and joining the curved plate to a flat multi-hole tube. The heat exchange element 10 of Fig. 6 is formed by interposing the heat transfer tube 11, which is a flat multi-hole tube, between plates such that the plates cover the opposite side faces 11a of the heat transfer tube 11. The plates are arranged along the peripheral surface of the heat transfer tube 11. Portions of the plates that protrude from the heat transfer tube 11 in the z direction are joined together, thus forming the fins 12.

[0039] The heat exchange element 10 of Fig. 7 is formed by joining a plate to one side face 11a of the heat transfer tube 11. The plate is curved to fit the one side face 11a of the heat transfer tube 11 and arc-shaped end portions in the z direction of the heat transfer tube 11, and is joined to the heat transfer tube 11 along the shape of the heat transfer tube 11. Portions of the plate that protrude from the heat transfer tube 11 in the z direction form the fins 12. The form of the plate is not limited to that curved along the shape of the heat transfer tube 11. The plate may remain flat and be joined to the side face 11a of the heat transfer tube 11.

(Modification of Heat Exchange Element 10)

[0040] Fig. 8 shows three views of a heat exchange element 10A, which is a modification of the heat exchange element 10 in Embodiment 1. The heat exchange element 10A, which is the modification, differs from the heat exchange element 10 in the shape of each fin 12, serving as the non-insertion part 10a. In the heat exchange element 10A, the abutment part 10e of the fin 12 is provided adjacent to the heat transfer tube 11 in the z direction as in the heat exchange element 10, and the spaced-apart part 10d is provided adjacent to the side edge of the fin 12. In other words, a commonality between the heat exchange element 10A and the heat exchange element 10 is that the abutment part is located between the insertion part 10b and the spaced-apart part 10d in the z direction. In the heat exchange element 10A, the spaced-apart part 10d is a sloping face that slopes toward

the side edge of the fin 12 away from the header 2.

[0041] Fig. 9 is an enlarged view of a connection between the heat exchange element 10A of Fig. 8 and the first header 30. As in the heat exchange element 10, the heat transfer tube 11, serving as the insertion part 10b of each of the end portions 13a and 13b of the heat exchange element 10A, is inserted into the insertion hole 31a of the first header 30. The abutment part 10e of each fin 12, serving as the non-insertion part 10a, abuts the header upper surface 34a of the first header 30. For the abutment part 10e, it is only required that at least one part of a face of the fin 12 facing the header upper surface 34a of the first header 30 be in contact with the header upper surface 34a of the first header 30. The spaced-apart part 10d of the fin 12, serving as the non-insertion part 10a, extends at an angle from an edge of the abutment part 10e that is remote from the heat transfer tube 11. The spaced-apart part 10d slopes away from the heat transfer tube 11 and away from the header upper surface 34a of the first header 30, and is located apart from the header upper surface 34a of the first header 30. Such a configuration of the heat exchange element 10A allows the heat exchanger 100 including the heat exchange element 10A to have the same advantages as those of the heat exchanger including the heat exchange element 10. Furthermore, an edge 12c of an end portion in the y direction of the fin 12 can have an obtuse angle. Thus, the fin 12 of the heat exchange element 10A can have a simpler shape and higher strength than the fin of the heat exchange element 10.

[0042] Fig. 10 shows three views of a heat exchange element 10B, which is a modification of the heat exchange element 10 in Embodiment 1. Fig. 11 is an enlarged view of a connection between the heat exchange element 10B of Fig. 10 and the first header 30. As in the heat exchange element 10, the heat transfer tube 11, serving as the insertion part 10b of each of the end portions 13a and 13b of the heat exchange element 10B, is inserted into the insertion hole 31a of the first header 30. In the heat exchange element 10B, the abutment part 10e of each fin 12, operating as the non-insertion part 10a, abuts the header upper surface 34a of the first header 30. The abutment part 10e is located remoter from the heat transfer tube 11 than the spaced-apart part 10d in the z direction. In other words, the spaced-apart part 10d is located between the insertion part 10b and the abutment part 10e in the z direction. The spaced-apart part 10d is provided next to the heat transfer tube 11 in the z direction. In other words, the non-insertion part 10a includes the spaced-apart part 10d to be spaced apart from the first header 30 in a part of the end face of the fin 12 that is adjacent to the heat transfer tube 11. The fins 12 extend from the two edge portions 14 of the heat transfer tube 11 in the z direction. The abutment parts 10e are located adjacent to the side edges of the two fins 12, or remote from the heat transfer tube 11. For each abutment part 10e, it is only required that at least one part of a face of the fin 12 facing the header upper surface 34a of the

first header 30 be in contact with the header upper surface 34a of the first header 30. Such a configuration of the heat exchange element 10B allows the heat exchanger 100 including the heat exchange element 10B to have the same advantages as those of the heat exchanger including the heat exchange element 10. The heat exchange element 10B includes the abutment part 10e located adjacent to the edge 12c of an end portion in the y direction of each fin 12. Therefore, the distance between the two abutment parts 10e, which are to be in contact with the header upper surface 34a of the first header 30, of the heat exchange element 10B in the z direction is longer than that in the heat exchange element 10. This improves the accuracy of positioning the heat exchange element 10B relative to the headers 2 in manufacture of the heat exchanger 100.

Embodiment 2

[0043] A heat exchanger 200 according to Embodiment 2 will be described. The heat exchanger 200 includes a heat exchange element 210A instead of the heat exchange element 10 of the heat exchanger 100 according to Embodiment 1. The heat exchange element 210A has a shape different from that of the heat exchange element 10. Components and elements having the same functions and effects as those in Embodiment 1 are designated by the same reference signs, and a description thereof is omitted.

(Heat Exchange Element 210A)

[0044] Fig. 12 shows three views of the heat exchange element 210A in Embodiment 2. Fig. 12(a) is a front view of the heat exchange element 210A. Fig. 12(b) is a side view of the heat exchange element 210A. Fig. 12(c) is a top view of the heat exchange element 210A. A plurality of heat exchange elements 210A in Embodiment 2 each include the heat transfer tube 11, which is a flat tube, and the fins 12 each extending from part of the edge portion 14 of the heat transfer tube 11 in the z direction. The heat transfer tube 11 has therein the refrigerant passages 18, through which the refrigerant flows. The heat exchange elements 210A each extend between the first header 30 and the second header 40. The heat exchange elements 210A are arranged such that the side faces 11a face each other. Two adjacent heat exchange elements 210A of the heat exchange elements 210A have a space, serving as an air passage, therebetween.

[0045] As illustrated in Fig. 12, the edge portions 14 of the heat transfer tube 11 in the heat exchange element 210A include parts each having no fin 12. Sections of the parts, of the edge portions 14 of the heat transfer tube 11, having no fin 12 in the heat exchange element 210A are to be inserted into the interiors of the first header 30 and the second header 40. The sections, or parts of the end portions 13a and 13b of the heat exchange element 210A are inserted into the first header 30 and the second

header 40, so that the heat exchange element 210A communicates between the first header 30 and the second header 40. In the heat exchange element 210A, a part of the end portion 13a that has no fins 12 on the edge portions 14 of the heat transfer tube 11 includes sloping parts 14a such that the width in the z direction of the heat transfer tube 11 decreases toward the end face 19a of the heat transfer tube 11. In other words, the insertion part 10b has a tapered shape and gradually diminishes toward the end face in the y direction of the heat transfer tube 11 of the heat exchange element 210A. The end portion 13b of the heat exchange element 210A has the same structure as the end portion 13a.

[0046] Fig. 13 is an enlarged view of a connection between the heat exchange element 210A and the first header 30 in the heat exchanger 200 according to Embodiment 2. Each of the end portions 13a and 13b of the heat exchange element 210A includes a plurality of parts defined by imaginary division in the z direction. The parts are the non-insertion parts 10a and the insertion part 10b defined by division with imaginary lines along the axis of the tube of the heat exchange element 210A. The boundary between each non-insertion part 10a and the insertion part 10b is referred to as the transition 10c. In each of the end portions 13a and 13b of the heat exchange element 210A in Fig. 12, a middle part of the heat transfer tube 11 in the z direction corresponds to the insertion part 10b, and the end portions in the z direction of the heat transfer tube 11 and the fins 12 correspond to the non-insertion parts 10a. The insertion part 10b is the middle part between the boundaries, each of which is located part of the way toward the end face 19a from the fin 12 on the sloping part 14a.

[0047] As illustrated in Fig. 13, the heat exchange element 210A includes the abutment parts 10e, each of which is included in the sloping part 14a. A section of the sloping part 14a that is adjacent to the fin 12 and the end face of the fin 12 forming the spaced-apart part 10d. In other words, the abutment part 10e is located between the insertion part 10b and the spaced-apart part 10d in the z direction. Unlike the heat exchange element 10 in Embodiment 1, the heat exchange element 210A in Embodiment 2 includes the abutment parts 10e included in the heat transfer tube 11. The heat exchanger 200 has a configuration in which the heat transfer tube 11 abuts the headers 2 and is thus positioned. The heat exchanger 200 according to Embodiment 2 with such a configuration has the same advantages as those of the heat exchanger 100 according to Embodiment 1. In the heat exchanger 200, the heat transfer tube 11, which is included in the heat exchange element 210A and is relatively highly rigid, is in contact with the headers 2, thus positioning the heat exchange element 210A. Thus, the heat exchange element 210A of the heat exchanger 200 can be firmly positioned, thus further improving the accuracy of positioning. Furthermore, the edge portions 14, which face in the z direction, of the insertion part 10b each include the sloping part 14a, so that the heat exchange element 210A

can be readily inserted into the insertion hole 31a of the header 2, thus improving the manufacturability of the heat exchanger 200.

(Modification of Heat Exchange Element 210B)

[0048] Fig. 14 shows three views of a heat exchange element 210B in Embodiment 2. Fig. 14(a) is a front view of the heat exchange element 210B. Fig. 14(b) is a side view of the heat exchange element 210B. Fig. 14(c) is a top view of the heat exchange element 210B. The heat exchange element 210B is a modification of the heat exchange element 210A in Embodiment 2. The heat exchange element 210B differs from the heat exchange element 210A in the shape of each of the non-insertion parts 10a and the insertion part 10b. In the heat exchange element 210B, the edge portions 14 of the heat transfer tube 11 include parts each having no fin 12. Sections of the parts, of the edge portions 14 of the heat transfer tube 11, having no fin 12 in the heat exchange element 210B are to be inserted into the interiors of the first header 30 and the second header 40. The sections, or parts of the end portions 13a and 13b of the heat exchange element 210B are inserted into the first header 30 and the second header 40, so that the heat exchange element 210B communicates between the first header 30 and the second header 40.

[0049] In the heat exchange element 210B, the part of the end portion 13a having no fins 12 on the edge portions 14 of the heat transfer tube 11 has steps, each of which is located part of the way toward the fin 12 from the end face 19a of the heat transfer tube 11. The abutment part 10e is a face of each of the steps that faces the header 2. A portion of the heat transfer tube 11 that is adjacent to the end face 19a is narrower than a portion of the heat transfer tube 11 that has the fins 12. In other words, the part, of the end portion 13a of the heat exchange element 210B, having no fins 12 has the following shape. A portion of the heat transfer tube 11 that is located between the steps, which extend from the spaced-apart parts 10d located at the end faces of the fins 12 toward the end face 19a of the heat transfer tube 11, has the same width in the z direction as that of the portion, of the heat transfer tube 11, having the fins 12. The portion, of the heat transfer tube 11, adjacent to the end face 19a has a smaller width in the z direction than the portion, of the heat transfer tube 11, having the fins 12. The end portion 13b of the heat exchange element 210B has the same structure as the end portion 13a.

[0050] Fig. 15 is an enlarged view of a connection between the heat exchange element 210B and the first header 30 in the heat exchanger 200 according to Embodiment 2. Each of the end portions 13a and 13b of the heat exchange element 210B includes a plurality of parts defined by imaginary division in the z direction. The parts are the non-insertion parts 10a and the insertion part 10b defined by division with imaginary lines along the axis of the tube of the heat exchange element 210B. The bound-

ary between each non-insertion part 10a and the insertion part 10b is referred to as the transition 10c. In each of the end portions 13a and 13b of the heat exchange element 210B in Fig. 14, a middle part of the heat transfer tube 11 corresponds to the insertion part 10b, and the end portions in the z direction of the heat transfer tube 11 and the fins 12 correspond to the non-insertion parts 10a. The insertion part 10b includes the narrow portion of the heat transfer tube 11. The edge portions 14, which face in the z direction, of the narrow portion of the heat transfer tube 11 serve as edge end faces 15 facing in the z direction. The edge end faces 15 are provided within a predetermined distance from the end face 19a and are to fit the insertion hole 31a of the header 2.

[0051] As illustrated in Fig. 15, the heat exchange element 210B includes the abutment parts 10e included in the end portions 13a and 13b. Unlike the heat exchange element 10 in Embodiment 1, the heat exchange element 210B in Embodiment 2 includes the abutment parts 10e included in the heat transfer tube 11. The heat exchanger 200 has a configuration in which the heat transfer tube 11 abuts the headers 2 and is thus positioned. The heat exchanger 200 according to Embodiment 2 with such a configuration has the same advantages as those of the heat exchanger 100 according to Embodiment 1. In the heat exchanger 200, the heat transfer tube 11, which is included in the heat exchange element 210B and is relatively highly rigid, is in contact with the headers 2, thus positioning the heat exchange element 210B. Thus, the heat exchange element 210 of the heat exchanger 200 can be firmly positioned, thus further improving the accuracy of positioning.

[0052] The heat exchange element 210B may have a configuration in which the edge end faces 15 are inclined to the end faces 19a and 19b such that the end portions of the heat exchange element gradually diminish toward the end faces. Such a configuration of the heat exchange element 210B facilitates insertion into the insertion holes 31a of the headers 2 because the edge end faces 15 of the insertion parts 10b are inclined to the end faces 19a and 19b such that the end portions gradually diminish toward the end faces, thus improving the manufacturability of the heat exchanger 200.

Embodiment 3

[0053] A heat exchanger 300 according to Embodiment 3 will be described. The heat exchanger 300 includes a header 302 instead of the header 2 of the heat exchanger 100 according to Embodiment 1. The header 302 has a shape different from that of the header 2. Components and elements having the same functions and effects as those in Embodiment 1 are designated by the same reference signs, and a description thereof is omitted.

(Header 302)

[0054] Fig. 16 shows three views of the header 302 of the heat exchanger 300 according to Embodiment 3. Fig. 16(a) is a front view of the header 302. Fig. 16(b) is a side view of the header 302. Fig. 16(c) is a top view of the header 302. The header 302 is used as a first header 330 or a second header 340 in the heat exchanger 300. The first header 330 and the second header 340 each extend in the x direction, and are configured to cause the refrigerant to flow through the interior of the header. The header 302 is used in place of the first header 30 or the second header 40 illustrated in Fig. 2. For example, the refrigerant enters one end of the first header 330 in the direction represented by the arrow RF. The refrigerant is distributed to heat exchange elements 310, so that streams of the refrigerant pass through the heat exchange elements 310. Then, the streams of the refrigerant join together in the second header 340. The refrigerant flows out of one end of the second header 340.

[0055] Although each header 2 in Embodiment 1 has a rectangular cuboid outer shape, the header may have any other shape. The header 302 in Fig. 16 has an outer shape having sloping faces 36 located at edges on opposite sides in the z direction of the header upper surface 34a having the insertion holes 31a to receive the heat exchange elements 310. As illustrated in Fig. 16(b), each of the sloping faces 36 is a face that slopes away from the heat exchange elements 310 in the z direction or a direction opposite to the z direction.

[0056] Fig. 17 is an enlarged view of a connection between the heat exchange element 310 and the first header 330 in the heat exchanger 300 according to Embodiment 3. As illustrated in Fig. 16, the first header 330 has the sloping faces 36 on the opposite sides of the header upper surface 34a in the z direction. This ensures that the fins 12 are spaced apart at a sufficient distance from the header 2 even though, unlike the fins 12 of the heat exchange element 10A illustrated in, for example, Fig. 8, each of the fins 12 includes no sloping part, which slopes away from the header 302, in the end portion adjacent to the header 2. This reduces the amount of cut in each fin 12 when viewed in the x direction, thus inhibiting a reduction in heat transfer area in the heat exchange element 310.

(Modification of Header 302)

[0057] Fig. 18 is an enlarged view of a connection between the heat exchange element 310 and a first header 330B, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3. The header upper surface 34a may have any shape other than that of the header upper surface 34a of the header 302 illustrated in Figs. 16 and 17. As illustrated in Fig. 18, the header upper surface 34a of the first header 330B has protrusions and depressions. The abutment parts 10e of the heat exchange element 310 abut protrusions

37a located closest to the heat transfer tube 11 in the z direction. Protrusions 37b located remoter from the heat transfer tube 11 than the protrusions 37a are spaced apart from the spaced-apart parts 10d, each of which is a part of the end face of each fin 12. In other words, the protrusions and the depressions of the header upper surface 34a of the header 302 define spaces with the spaced-apart parts 10d.

[0058] Fig. 19 is an enlarged view of a connection between the heat exchange element 310 and a first header 330C, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3. The header upper surface 34a of the first header 330C has fine protrusions and fine depressions. The abutment parts 10e of the heat exchange element 310 abut the tips of some of the protrusions of the header upper surface 34a. The spaced-apart parts 10d are spaced apart from the tips of the protrusions. The first headers 330B and 330C, which are the modifications, contribute to a reduction in the amount of cut in each fin 12 when viewed in the x direction to inhibit a reduction in heat transfer area, and allow a change in area of joints between the fins 12 and the header upper surface 34a as necessary, thus enhancing the strength of joints between the heat exchange element 310 and the header 302.

[0059] Fig. 20 is an enlarged view of a connection between a heat exchange element 310A, which is a modification of the heat exchange element 310, and a first header 330A, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3. In the heat exchange element 310A, which is the modification, unlike the fins 12 of the heat exchange element 310, the fins 12 have no cuts. Parts of the fins 12 of the heat exchange element 310A that face the header upper surface 34a serve as the abutment parts 10e. Parts of the fins 12 of the heat exchange element 310A that face the sloping faces 36 of the header 330A in the y direction serve as the spaced-apart parts 10d. In other words, the sloping faces 36 of the header 330A provide the spaced-apart parts 10d even though the fins 12 of the heat exchange element 310A have no cuts in the end portions adjacent to the header 2. Such a configuration of the heat exchanger 300 allows the fins 12 to have a maximum heat transfer area, allows the spaced-apart parts 10d of the fins 12 to be spaced apart from the header 330A, increases the area of joints between the fins 12 and the header upper surface 34a, and also enhances the accuracy of positioning the heat exchange element 310A. For the abutment parts 10e, the whole of each abutment part 10e does not have to abut the header upper surface 34a. A section of the abutment part 10e may abut the header upper surface 34a depending on the accuracy of dimensions of parts and the accuracy of positions of the parts.

[0060] Fig. 21 is an enlarged view of a connection between the heat exchange element 310A, which is a modification of the heat exchange element 310, and the first header 330B, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment

3. The header upper surface 34a of the first header 330B has the protrusions and the depressions. Parts of the fins 12 of the heat exchange element 310A that face the protrusions 37a and 37b of the header upper surface 34a in the y direction serve as the abutment parts 10e. Parts of the fins 12 of the heat exchange element 310A that face the depressions of the header upper surface 34a in the y direction serve as the spaced-apart parts 10d. Such a combination of the heat exchange element 310A and the first header 330B offers the same advantages as those of the combination illustrated in Fig. 20.

[0061] Fig. 22 is an enlarged view of a connection between the heat exchange element 310A, which is a modification of the heat exchange element 310, and the first header 330C, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3. Since the header upper surface 34a of the first header 330C has the fine protrusions and the fine depressions, parts of the fins 12 of the heat exchange element 310A that face the tips of the protrusions of the header upper surface 34a in the y direction serve as the abutment parts 10e, and parts of the fins 12 that face the depressions of the header upper surface 34a in the y direction serve as the spaced-apart parts 10d. Such a combination of the heat exchange element 310A and the first header 330B offers the same advantages as those of the combination illustrated in Fig. 20. For the heat exchanger 300 illustrated in each of Figs. 20 to 22, the area of joints between the fins 12 and the header upper surface 34a can be changed as necessary. This sufficiently enhances the strength of joints between the heat exchange elements 310 and the headers 320 in the heat exchanger 300.

[0062] Fig. 23 is an enlarged view of a connection between a heat exchange element 310B, which is a modification of the heat exchange element 310, and the first header 330A, which is a modification of the first header 330, in the heat exchanger 300 according to Embodiment 3. The heat exchange element 310B, which is the modification, has a shape different from that of the heat exchange element 310A in Fig. 20. The fins 12 and the heat transfer tube 11 of the heat exchange element 310B are partly removed by, for example, pressing. The heat exchange element 310B has the edge end faces 15 located on opposite sides of the insertion part 10b in the z direction. Each abutment part 10e of the heat exchange element 310B is formed by the end face of each fin 12 and a step face of the heat transfer tube 11. Such a configuration of the heat exchanger 300 allows the fins 12 to have a maximum heat transfer area, allows the spaced-apart parts 10d of the fins 12 to be spaced apart from the header 330A, and also increases the area of joints between the fins 12 and the header upper surface 34a. Each of the abutment parts 10e is formed by not only the fin 12 but also the step face of the heat transfer tube 11. This improves the rigidity of the abutment part 10e as well as the accuracy of positioning.

Embodiment 4

[0063] A heat exchanger 400 according to Embodiment 4 will be described. The heat exchanger 400 includes a heat exchange element 410 including a plurality of heat transfer tubes 411, which differ in number and shape from the heat transfer tube 11 of the heat exchange element 10 of the heat exchanger 100 according to Embodiment 1. The heat transfer tubes 411 are connected by fins 412. Components and elements having the same functions and effects as those in Embodiment 1 are designated by the same reference signs, and a description thereof is omitted.

[0064] Fig. 24 shows three views of the heat exchange element 410 in Embodiment 4. Fig. 24(a) is a front view of the heat exchange element 410. Fig. 24(b) is a side view of the heat exchange element 410. Fig. 24(c) is a top view of the heat exchange element 410. The heat exchange element 410 includes three heat transfer tubes 411, which are arranged in the z direction and are parallel to each other. The heat transfer tubes 411 have a circular cross-sectional shape at any position in the y direction. In the heat exchange element 410, each of the fins 412 is disposed between the adjacent heat transfer tubes 411.

[0065] In the heat exchange element 410, the heat transfer tubes 411 serve as the insertion parts 10b, and the fins 12 and 412 serve as the non-insertion parts 10a. Like the end faces of the fins 12 of the heat exchange element 10 in Embodiment 1, end faces of the fins 12 and 412 that are adjacent to the headers 2 include the spaced-apart parts 10d and the abutment parts 10e. As described above, the heat exchange element 410 can include the heat transfer tubes 411 having a circular cross-sectional shape instead of the heat transfer tube 11, which is a flat multi-hole tube. The insertion holes 31a of the headers 2 included in the heat exchanger 400 have a circular shape that fits the heat transfer tube 411. As in the heat exchanger 400 according to Embodiment 4, the heat transfer tubes 411 are not limited to flat multi-hole tubes. The heat exchanger 400 including the heat transfer tubes having any other shape offers the same advantages as those of the heat exchanger 100 according to Embodiment 1.

Embodiment 5

[0066] A heat exchanger 500 according to Embodiment 5 will be described. The heat exchanger 500 includes a heat exchange element 510 including a plurality of heat transfer tubes 511, which differ in number and shape from the heat transfer tube 11 of the heat exchange element 210 of the heat exchanger 200 according to Embodiment 2. The heat transfer tubes 511 are connected by fins 512. Components and elements having the same functions and effects as those in Embodiment 2 are designated by the same reference signs, and a description thereof is omitted.

[0067] Fig. 25 shows three views of the heat exchange element 510 of the heat exchange element 510 according to Embodiment 5. Fig. 25(a) is a front view of the heat exchange element 510. Fig. 25(b) is a side view of the heat exchange element 510. Fig. 25(c) is a top view of the heat exchange element 510. As in the heat exchange element 410 in Embodiment 4, the heat transfer tubes 511 of the heat exchange element 510 have a circular cross-sectional shape. Each of the heat transfer tubes 511 has steps in its end portions. In other words, as in the heat exchange element 210 in Embodiment 2, the non-insertion parts 10a of the heat exchange element 510 include the fins 12 and 512 and parts of the heat transfer tubes 511. Such a configuration of the heat exchanger 500 according to Embodiment 5 allows the heat transfer tubes 511, which are relatively highly rigid, to abut the header 2. Thus, as in the heat exchanger 200 according to Embodiment 2, the heat exchange element 510 of the heat exchanger 500 can be firmly positioned relative to the headers 2. This improves the accuracy of positioning and the manufacturability.

[0068] Although the embodiments have been described above, the present disclosure is not limited only to the above-described embodiments. For example, the embodiments may be combined. In other words, various modifications, applications, and uses made by those skilled in the art as needed may be within the technical scope.

Reference Signs List

[0069] 2: header, 10: heat exchange element, 10A: heat exchange element, 10B: heat exchange element, 10a: non-insertion part, 10b: insertion part, 10c: transition, 10d: spaced-apart part, 10e: abutment part, 10f: heat exchange part, 11: heat transfer tube, 11a: side face, 12: fin, 12c: edge, 13a: end portion, 13b: end portion, 14: edge portion, 14a: sloping part, 15: edge end face, 18: refrigerant passage, 19a: end face, 19b: end face, 30: first header, 31: first outer casing, 31a: insertion hole, 32: second outer casing, 33: refrigerant port, 34: upper surface, 34a: header upper surface, 36: sloping face, 37a: protrusion, 37b: protrusion, 40: second header, 50: refrigeration cycle apparatus, 100: heat exchanger, 101: compressor, 102: flow switching device, 103: indoor heat exchanger, 104: pressure reducing 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, 200: heat exchanger, 210: heat exchange element, 210A: heat exchange element, 210B: heat exchange element, 300: heat exchanger, 302: header, 310: heat exchange element, 310A: heat exchange element, 310B: heat exchange element, 330: first header, 330B: first header, 330C: first header, 340: second header, 400: heat exchanger, 410: heat exchange element, 411: heat transfer tube, 412: fin, 500: heat exchanger, 510: heat exchange element, 511: heat transfer tube, 512: fin, RF: arrow

Claims

1. A heat exchanger comprising:

- 5 a heat exchange element extending in a first direction; and
- a header to which the heat exchange element is connected,
- 10 the heat exchange element including
- at least one heat transfer tube extending in the first direction, and
- 15 a fin provided on part of an edge portion of the at least one heat transfer tube in a second direction crossing orthogonally with the first direction,

wherein an end portion in the first direction of the heat exchange element includes

- 20 an insertion part being inserted into an interior of the header,
- an abutment part abutting the header in a part other than the insertion part, and
- 25 a spaced-apart part being spaced apart from the header in a part other than the insertion part.

2. The heat exchanger of claim 1, wherein the abutment part is located between the insertion part and the spaced-apart part in the second direction.

3. The heat exchanger of claim 1, wherein the spaced-apart part is located between the insertion part and the abutment part in the second direction.

4. The heat exchanger of claim 1, wherein the abutment part is a part of an end face in the first direction of the fin.

5. The heat exchanger of claim 1 or 2, wherein the abutment part is a part of the at least one heat transfer tube and abuts the header in the first direction.

6. The heat exchanger of claim 5,

wherein the end portion of the heat exchange element has a tapered shape and gradually diminishes toward an end face of the one heat transfer tube in the first direction, and wherein the abutment part is a part of the tapered shape.

7. The heat exchanger of any one of claims 1 to 6, wherein the header has a surface to which the heat exchange element is connected, and the surface has protrusions and depressions.

8. The heat exchanger of any one of claims 1 to 7,
wherein the at least one heat transfer tube is a flat
multi-hole tube.
9. A heat exchanger unit comprising the heat exchang- 5
er of any one of claims 1 to 8.
10. A refrigeration cycle apparatus comprising the heat
exchanger unit of claim 9. 10

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FIG. 1

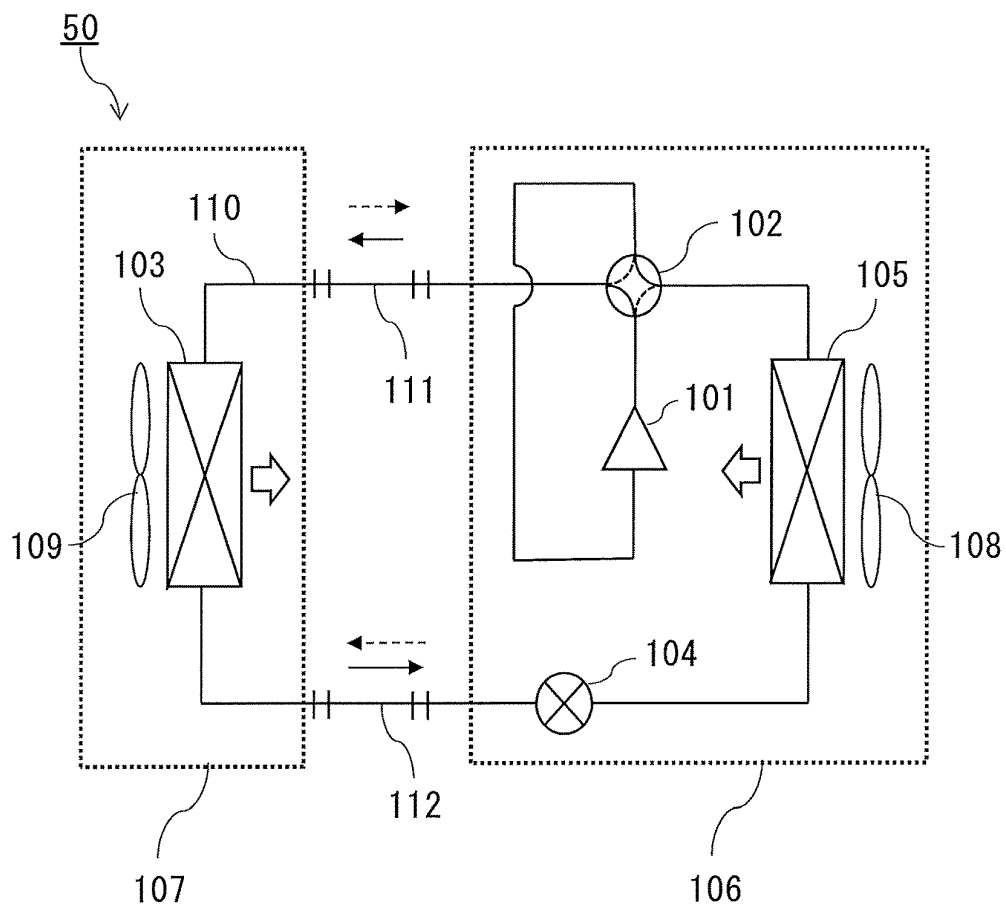


FIG. 2

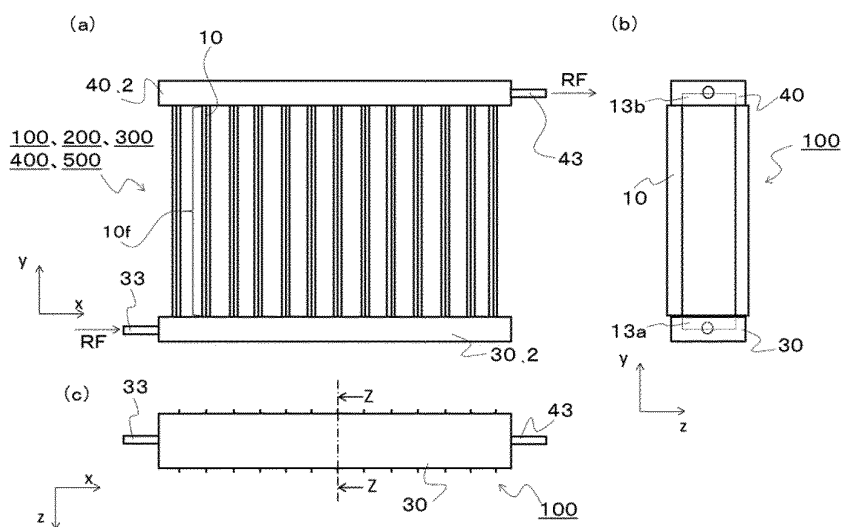


FIG. 3

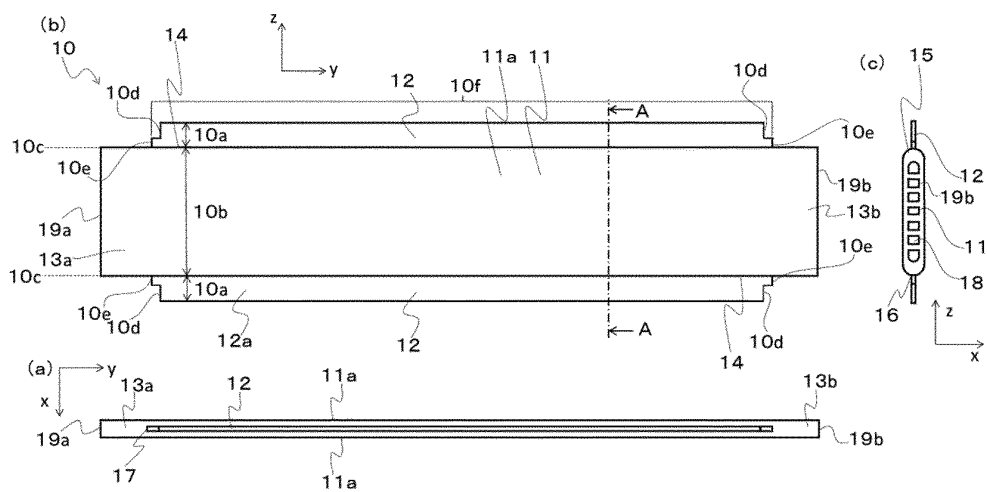


FIG. 4

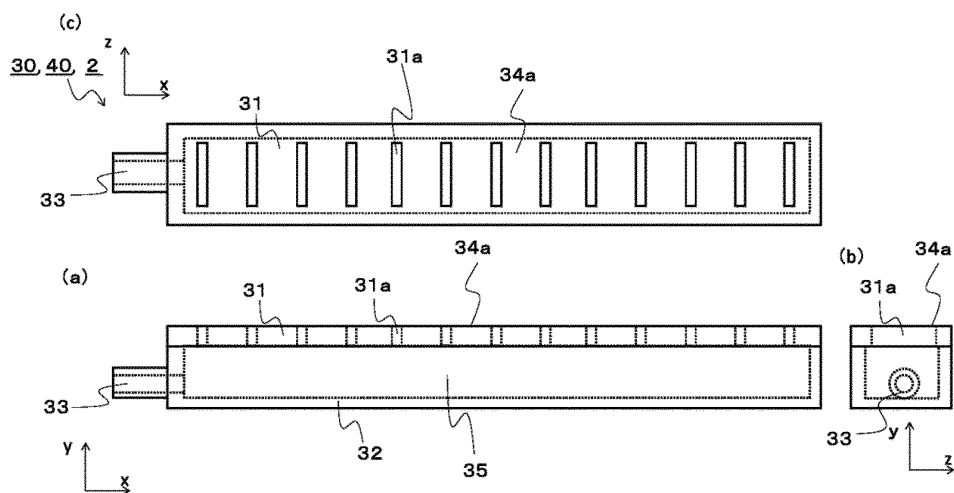


FIG. 5

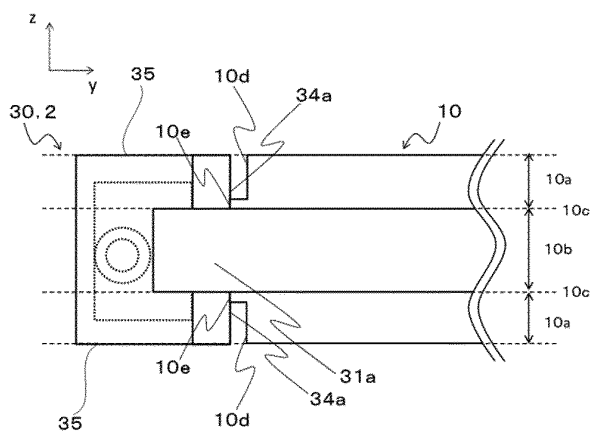


FIG. 6

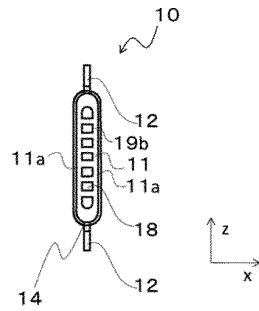


FIG. 7

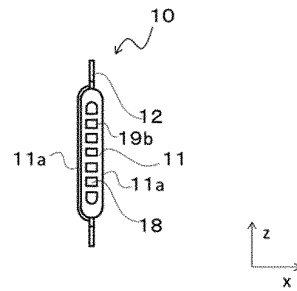


FIG. 8

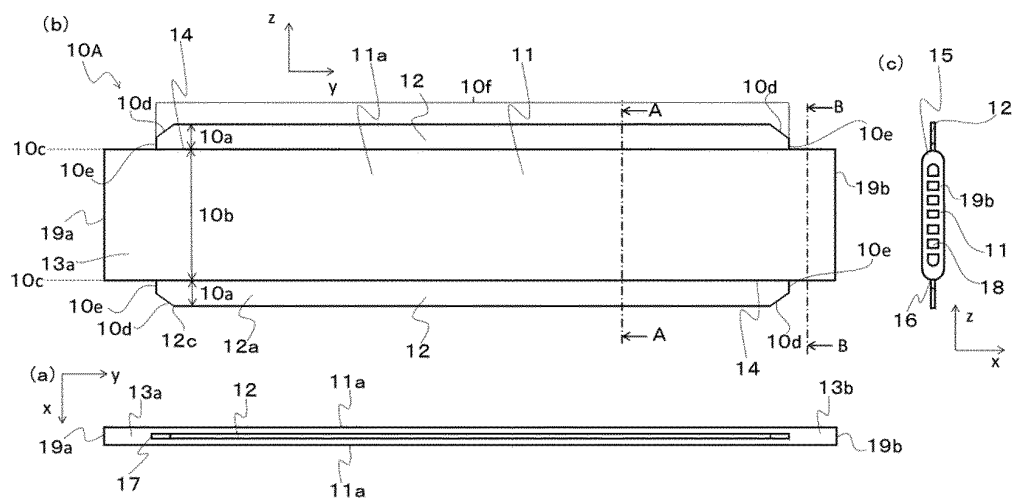


FIG. 9

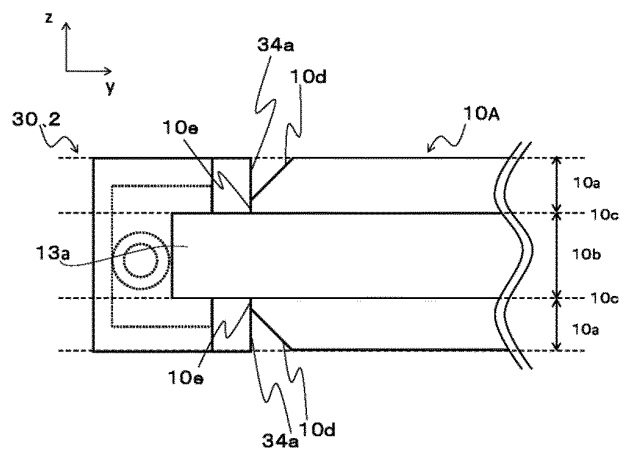


FIG. 10

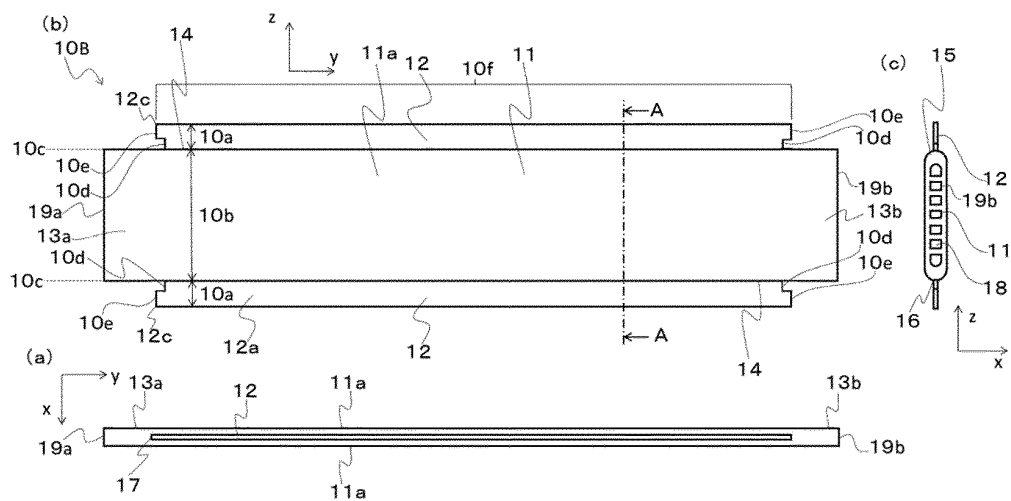


FIG. 11

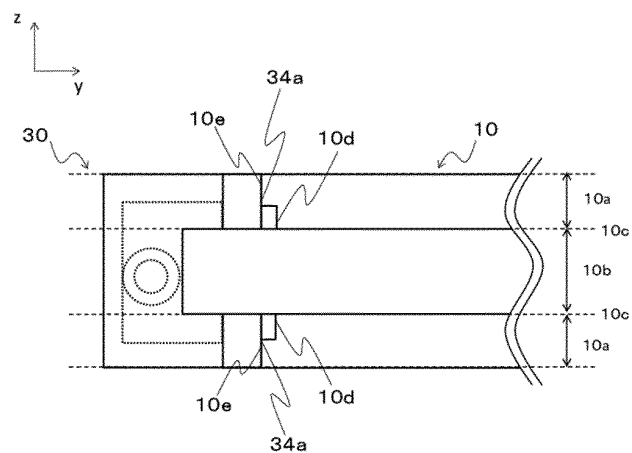


FIG. 12

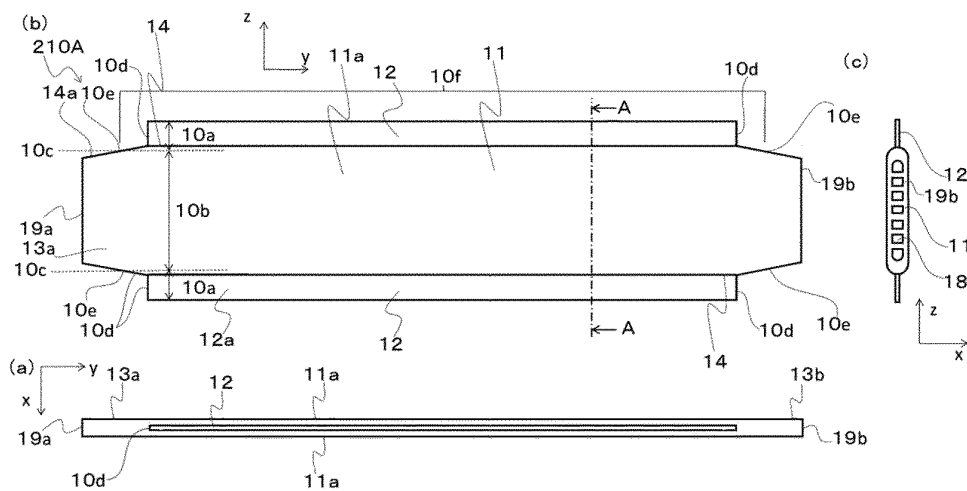


FIG. 13

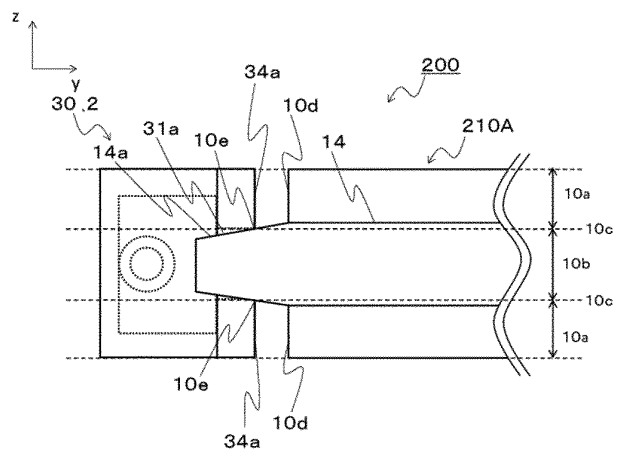


FIG. 14

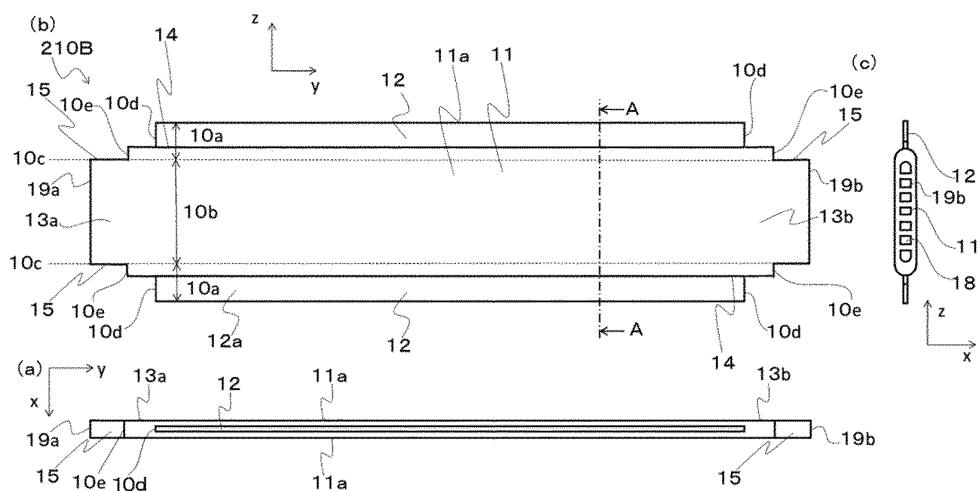


FIG. 15

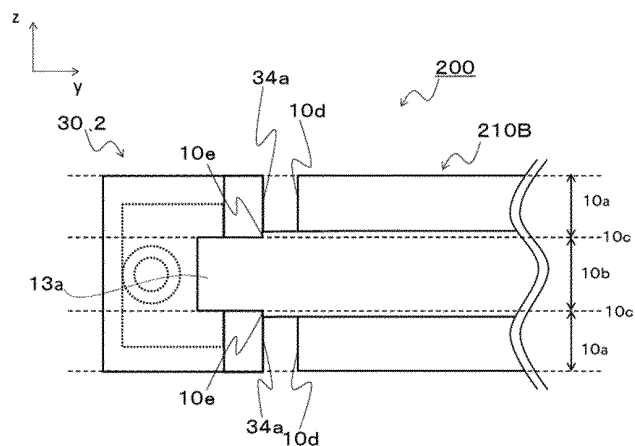


FIG. 16

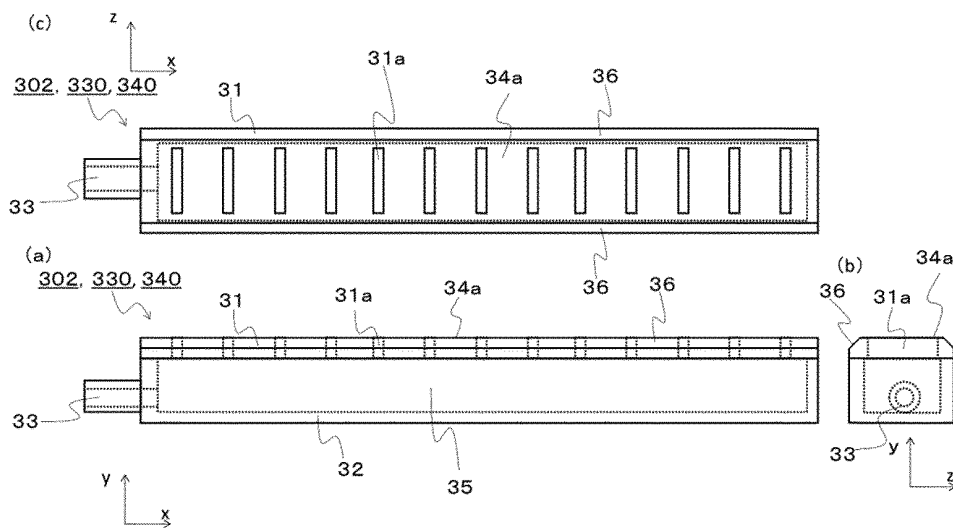


FIG. 17

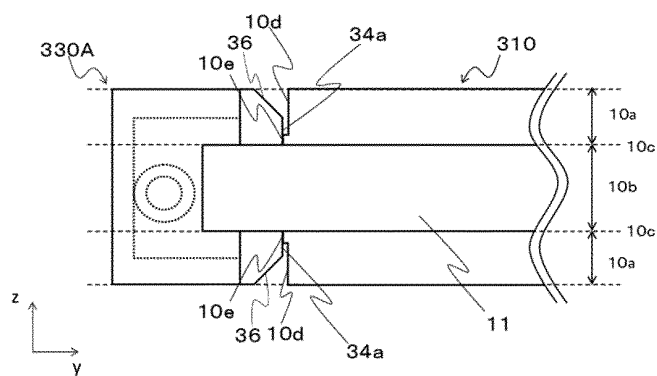


FIG. 18

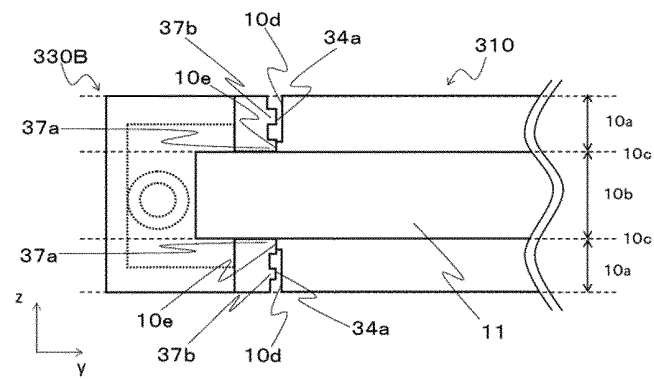


FIG. 19

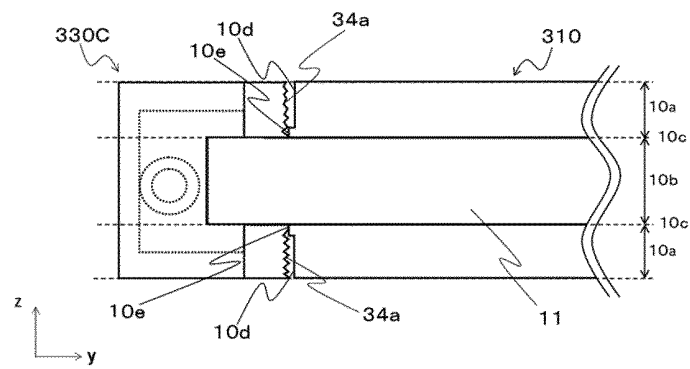


FIG. 20

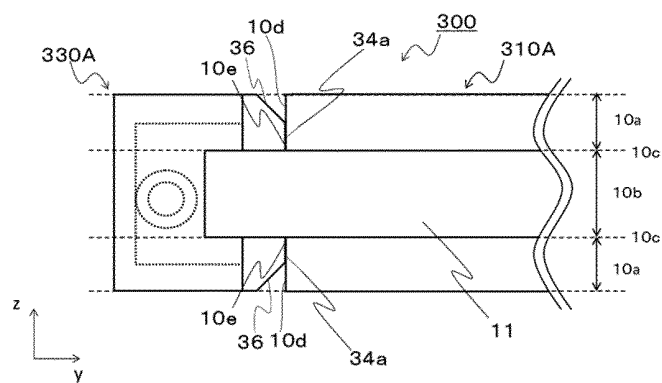


FIG. 21

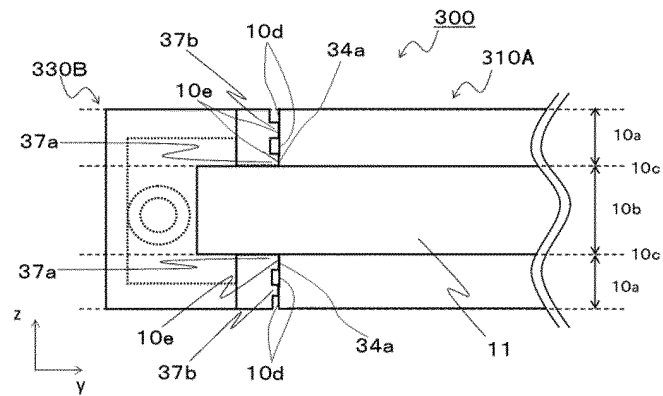


FIG. 22

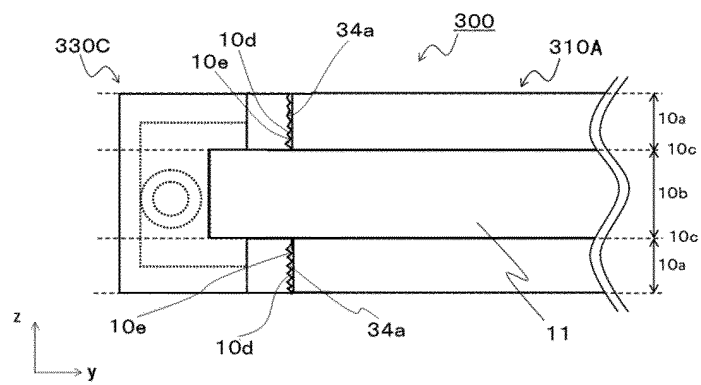


FIG. 23

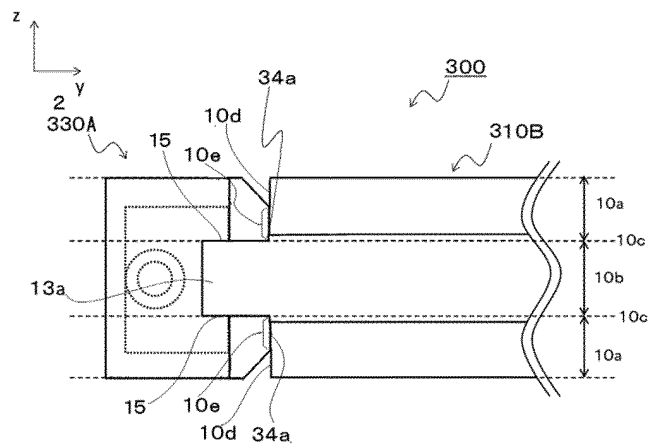


FIG. 24

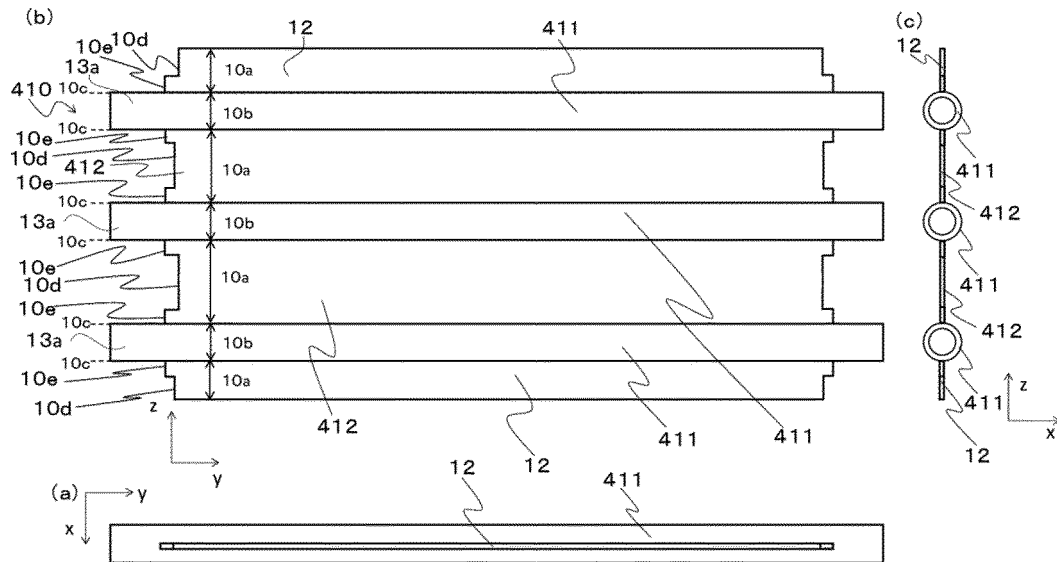
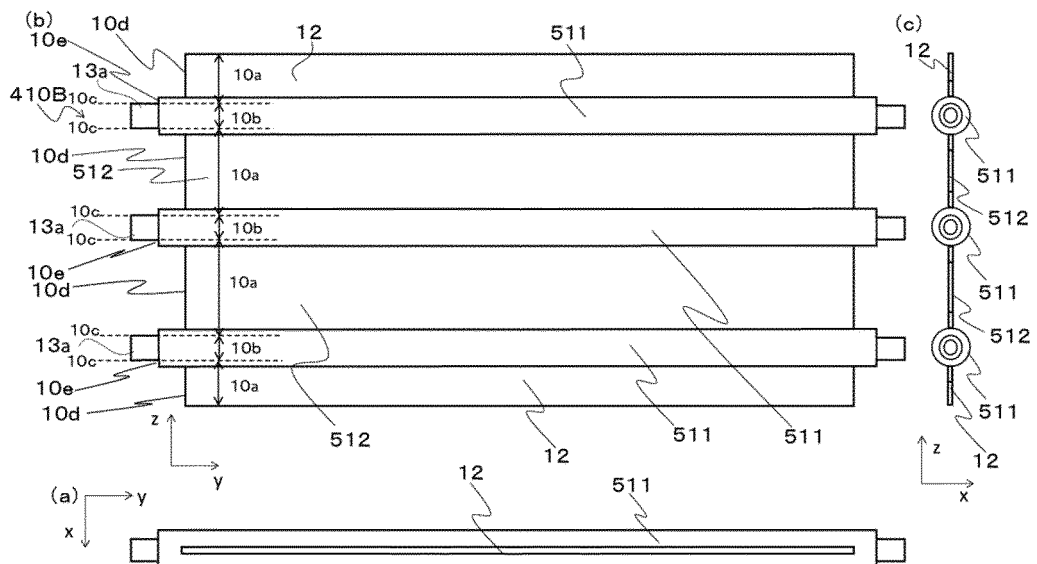


FIG. 25



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/049152

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F28D1/053(2006.01)i, F28F1/00(2006.01)i, F28F1/16(2006.01)i, F28F9/02(2006.01)i

FI: F28F1/00E, F28F9/02301G, F28D1/053A, F28F1/16Z

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, F28F1/00, F28F1/16, 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 1971-2020

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.
Y A	JP 2003-314987 A (DENSO CORPORATION) 06.11.2003 (2003-11-06), paragraphs [0032]-[0048], [0062]-[0066], fig. 1-3, 9-11	1-2, 4-10 3
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 152900/1989 (Laid-open No. 96574/1991) (SHOWA ALUMINUM CORPORATION) 02.10.1991 (1991-10-02), page 11, lines 6-9, fig. 4	1-2, 4-10
Y	US 2003/0094260 A1 (WHITLOW et al.) 22.05.2003 (2003-05-22), fig. 1-5	1-2, 4-10
Y	JP 10-113731 A (SHOWA ALUMINUM CORPORATION) 06.05.1998 (1998-05-06), paragraph [0013], fig. 4	6-10

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

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Date of the actual completion of the international search
28.01.2020Date of mailing of the international search report
10.02.2020Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/049152

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-81294 A (DENSO CORPORATION) 21.03.2000 (2000-03-21), fig. 2	1-10
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 148186/1989 (Laid-open No. 87085/1991) (SHOWA ALUMINUM CORPORATION) 04.09.1991 (1991-09-04), page 8, lines 4-11, fig. 1, 6	1-10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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paragraphs [0031]-[0047],
[0063]-[0067],
fig. 1-3, 9-11
DE 10306786 A1

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JP 3-96574 U1 02.10.1991 (Family: none)

US 2003/0094260 A1 22.05.2003 GB 2382133 A
DE 10218094 A1

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JP 10-113731 A 06.05.1998 (Family: none)

JP 2000-81294 A 21.03.2000 (Family: none)

JP 3-87085 U1 04.09.1991 (Family: none)

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018155479 A [0003]