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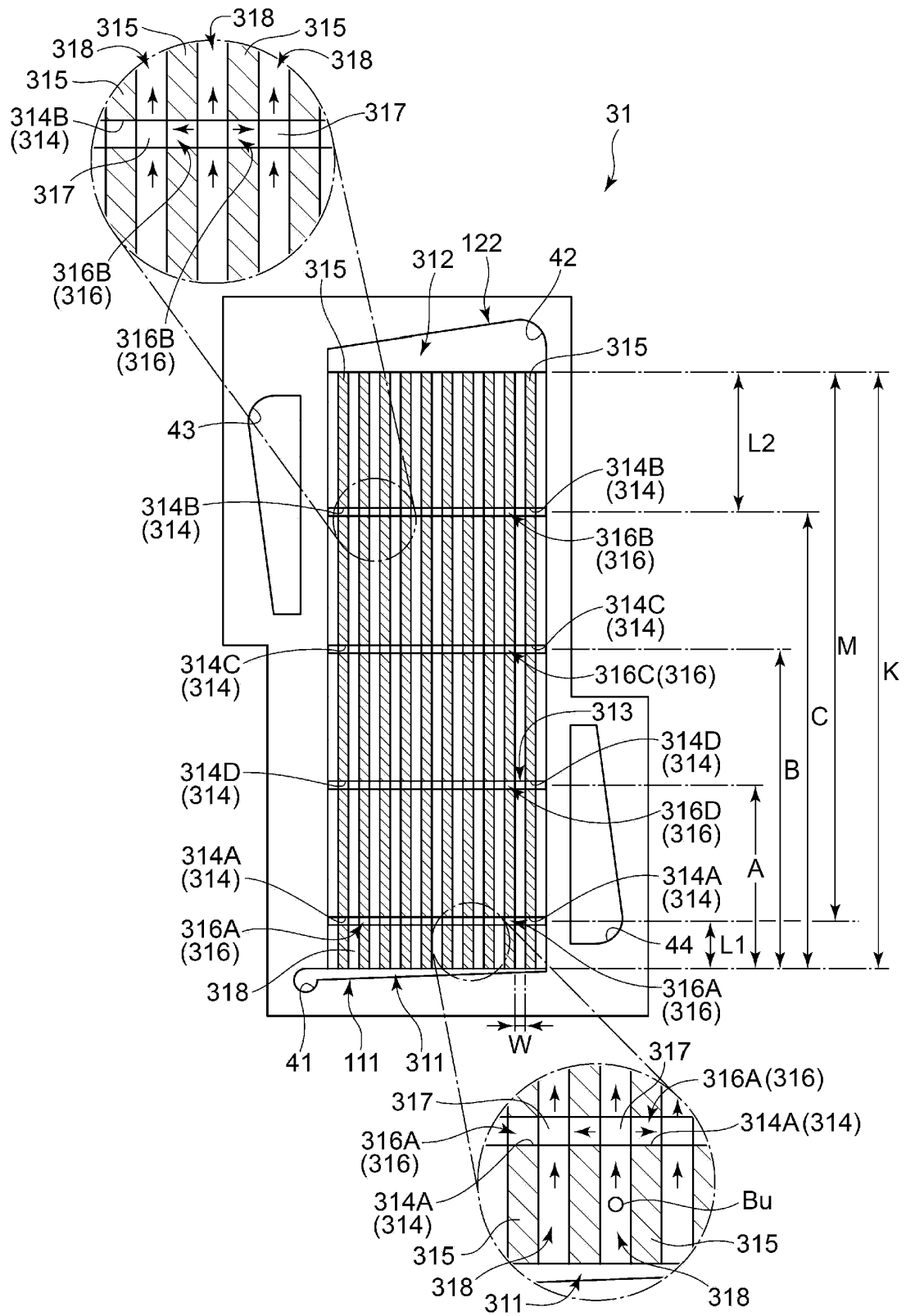
(54) **HEAT EXCHANGER PLATE, HEAT EXCHANGER PLATE LAMINATE, AND MICROCHANNEL HEAT EXCHANGER**

(57) A first heat exchanger plate includes: an inlet header formed by a first opening; an outlet header formed by a second opening; and a plurality of partition walls disposed between the inlet header and the outlet header so as to partition a flow path for a fluid from the inlet header toward the outlet header into a plurality of parallel flow paths. At least one partition wall among the plurality

of partition walls includes at least one notch. A pair of the parallel flow paths on both sides of the partition wall having the notch connect with each other via the notch. A first distance between the inlet header and the at least one notch in a flow direction of the fluid is less than a second distance between the outlet header and the at least one notch in the flow direction.

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FIG. 4



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger plate, a heat exchanger plate laminate, and a microchannel heat exchanger.

BACKGROUND

[0002] A known heat exchanger plate laminate includes a first plate forming a first flow path through which a first fluid flows, and a second plate forming a second flow path through which a second fluid for exchanging heat with the first fluid flows. Suppressing drift of the first fluid in the first flow path leads to an improvement in overall heat transfer coefficient of the heat exchanger plate laminate. In this regard, for example, in Patent Document 1 finds an event in which bubbles are generated by evaporation of a liquid phase of the first fluid flowing through the first flow path and as a result of a backflow of the first fluid, the first fluid drifts in the first flow path. Therefore, in Patent Document 1, an upstream portion of the first flow path is formed into a wave shape and a downstream portion of the first flow path is formed into a linear shape. Whereby, the bubbles easily flow downstream, suppressing the drift of the first fluid.

Citation List

Patent Literature

[0003] Patent Document 1: JP2019-020068A

SUMMARY

Technical Problem

[0004] According to the findings of the inventors of this application, although the above-described patent document exhibits a certain effect of suppressing the drift of the first fluid, there is room for further improvement.

[0005] The object of the present disclosure is to provide a heat exchanger plate, a heat exchanger plate laminate, and a microchannel heat exchanger that achieve a high overall heat transfer coefficient.

Solution to Problem

[0006] A heat exchanger plate according to at least one embodiment of the present disclosure, includes: an inlet header formed by a first opening; an outlet header formed by a second opening; and a plurality of partition walls disposed between the inlet header and the outlet header so as to partition a flow path for a fluid from the inlet header toward the outlet header into a plurality of parallel flow paths. At least one partition wall among the plurality of partition walls includes at least one notch. A

pair of the parallel flow paths on both sides of the partition wall having the notch connect with each other via the notch. A first distance between the inlet header and the at least one notch in a flow direction of the fluid is less than a second distance between the outlet header and the at least one notch in the flow direction.

[0007] A heat exchanger plate laminate according to at least one embodiment of the present disclosure, includes a plurality of the heat exchanger plates.

[0008] A microchannel heat exchanger according to at least one embodiment of the present disclosure, includes a plurality of the heat exchanger plate laminates.

Advantageous Effects

[0009] According to the present disclosure, it is possible to provide a heat exchanger plate, a heat exchanger plate laminate, and a microchannel heat exchanger that achieve a high overall heat transfer coefficient.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a conceptual explanatory view of a microchannel heat exchanger according to an embodiment.

FIG. 2 is another conceptual explanatory view of the microchannel heat exchanger according to an embodiment.

FIG. 3 is a conceptual cross-sectional view of a plate laminate as viewed from a direction of arrows A-A in FIG. 2.

FIG. 4 is a conceptual explanatory view of a first heat exchanger plate according to an embodiment.

FIG. 5 is a conceptual explanatory view of a second heat exchanger plate according to an embodiment.

FIG. 6 is a conceptual enlarged view of partition walls and notches according to an embodiment.

FIG. 7 is a conceptual cross-sectional view of the partition walls and the notches as viewed from a direction of arrows B-B in FIG. 6.

FIG. 8 is a conceptual explanatory view of the first heat exchanger plate according to another embodiment.

DETAILED DESCRIPTION

[0011] Some embodiments of the present disclosure will be described below with reference to the accompanying drawings. It is intended, however, that unless particularly identified, dimensions, materials, shapes, relative positions and the like of components described or shown in the drawings as the embodiments shall be interpreted as illustrative only and not intended to limit the scope of the present disclosure.

[0012] For instance, an expression of relative or absolute arrangement such as "in a direction", "along a direc-

tion", "parallel", "orthogonal", "centered", "concentric" and "coaxial" shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

[0013] For instance, an expression of an equal state such as "same", "equal", and "uniform" shall not be construed as indicating only the state in which the feature is strictly equal, but also includes a state in which there is a tolerance or a difference that can still achieve the same function.

[0014] Further, for instance, an expression of a shape such as a rectangular shape or a tubular shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

[0015] On the other hand, the expressions "comprising", "including" or "having" one constitutional element is not an exclusive expression that excludes the presence of other constitutional elements.

[0016] The same configurations are indicated by the same reference characters and may not be described again in detail.

<1. Overview of microchannel heat exchanger 1>

[0017] The overview of a microchannel heat exchanger 1 (hereinafter, may simply be referred to as the "heat exchanger 1") according to an embodiment of the present disclosure will be exemplified with reference to FIGs. 1 to 5. FIG. 1 is a conceptual explanatory view of the heat exchanger 1 according to an embodiment. FIG. 2 is another conceptual explanatory view of the heat exchanger 1 according to an embodiment. FIG. 3 is a conceptual cross-sectional view of a plate laminate 30 as viewed from a direction of arrows A-A in FIG. 2. FIG. 4 is a conceptual explanatory view of a first heat exchanger plate 31 according to an embodiment. FIG. 5 is a conceptual explanatory view of a second heat exchanger plate 32 according to an embodiment.

[0018] As shown in FIG. 1, the heat exchanger 1 according to an embodiment of the present disclosure is incorporated in a refrigeration cycle that includes a primary refrigerant circuit 11 for circulating a first fluid F1 and a secondary refrigerant circuit 12 for circulating a second fluid F2. In the present embodiment, the first fluid F1 flowing into the heat exchanger 1 in a gas-liquid two-phase state and the second fluid F2 flowing into the heat exchanger 1 in a gas phase state where the second fluid F2 has a higher saturation temperature than the first fluid F1 exchange heat with each other. The first fluid F1 is heated, boiled, and evaporated by heat exchange, flows out of the heat exchanger 1, and returns to the gas-liquid two-phase state in the course of circulating in the primary refrigerant circuit 11 as a primary refrigerant. Although not illustrated in detail, the primary refrigerant circuit 11

of the present example includes a compressor, a condenser, an expansion valve, and the like, and the first fluid F1 which is expanded by the expansion valve and is in the gas-liquid two-phase state flows into the heat exchanger 1. On the other hand, the second fluid F2 is cooled by heat exchange, flows out of the heat exchanger 1 in a relatively low-temperature liquid phase state, and cools another heat medium in the course of circulating in the secondary refrigerant circuit 12 as a secondary refrigerant. The secondary refrigerant circuit 12 of the present example includes a liquid receiver (receiver), a pump, a cooler, and the like. The cooler may be configured to exchange heat between the second fluid F2 and a heat medium such as air circulating inside a freezer. The second fluid F2 which has exchanged heat and evaporated in the cooler returns to the heat exchanger 1 in a gas phase state. As an example, the first fluid F1 is gas-phase or liquid-phase NH_3 and the second fluid F2 is gas-phase or liquid-phase CO_2 . However, the first fluid F1 and the second fluid F2 may be a refrigerant other than the above, and the second fluid F2 may be a liquid, such as brine, that does not undergo a phase change.

[0019] The heat exchanger 1 according to an embodiment of the present disclosure includes a plate laminate 30 including a plurality of laminated plates 35 and a pair of end plates 37, 38 sandwiching the plurality of plates 35 from both sides. These plates included in the plate laminate 30 are connected to each other by diffusion bonding as an example.

[0020] As shown in FIG. 1, 2, the end plate 37 is bonded to a first supply pipe 51 for supplying the first fluid F1 which has gone through the expansion valve and is in the gas-liquid two-phase state to the plate laminate 30, and a first discharge pipe 59 for discharging the first fluid F1. The first supply pipe 51 and the first discharge pipe 59 respectively connect with a first communication port 41 and a second communication port 42 disposed in each of the plurality of laminated plates 35.

[0021] Further, the end plate 37 is provided with a second supply pipe 52 for supplying the second fluid F2 which is supplied from the cooler and is in the relatively high-temperature gas phase state to the plate laminate 30, and a second discharge pipe 57 for discharging the second fluid F2 in the relatively low-temperature liquid phase state toward the receiver. The second supply pipe 52 and the second discharge pipe 57 respectively connect with a third communication port 43 and a fourth communication port 44 disposed in each of the plurality of laminated plates 35.

[0022] The configuration of the plurality of plates 35 according to the present embodiment will be described with reference to FIG. 2, 3. The plurality of plates 35 internally form a plurality of parallel flow paths 318 where the first fluid F1 supplied from the first communication port 41 flows, and a plurality of parallel flow paths 328 where the second fluid F2 supplied from the third communication port 43 flows. The plurality of parallel flow paths 318 and the plurality of parallel flow paths 328 are

partitioned from each other.

[0023] Specifically, the plurality of plates 35 sandwiched by the pair of end plates 37, 38 include the plurality of first heat exchanger plates 31 and a plurality of second heat exchanger plates 32 alternately arranged along a lamination direction, and a plurality of partition plates 33. The first heat exchanger plate 31 and the second heat exchanger plate 32 are each sandwiched by a pair of partition plates 33 from both sides in the lamination direction. That is, the plurality of plates 35 adopt a configuration in which the first heat exchanger plate 31, the partition plate 33, the second heat exchanger plate 32, and the partition plate 33 are arranged in order from one side in the lamination direction. Hereinafter, these three types of plates may simply be referred to as the "plate 35" when they are collectively referred to, and a thickness direction of the plate 35 may be referred to as a "plate thickness direction". The plate thickness direction coincides with the lamination direction of the plate laminate 30.

[0024] As shown in FIG. 4, the first heat exchanger plate 31 includes: an inlet header 311 which is formed by a first opening 111 including the first communication port 41, an outlet header 312 which is formed by a second opening 122 including the second communication port 42, and a plurality of partition walls 315 disposed between the inlet header 311 and the outlet header 312. The plurality of partition walls 315 are disposed so as to partition a flow path for the first fluid F1 from the inlet header 311 toward the outlet header 312 into the plurality of parallel flow paths 318, respectively. Each partition wall 315 of the present example linearly extends from the inlet header 311 to the outlet header 312. In the following description, an extension direction of the partition wall 315 may be referred to as a "flow direction of the first fluid F1", and a direction in which the plurality of partition walls 315 are arranged may be referred to as a "width direction of the parallel flow path 318". In the present embodiment, as already described, the first heat exchanger plate 31 is sandwiched by the pair of partition plates 33 (see FIG. 3). Therefore, the parallel flow path 318 is defined by the plurality of partition walls 315 and the pair of partition plates 33. Further, the inlet header 311 of the present embodiment is configured such that a flow-path width becomes narrower toward the downstream side. However, the inlet header 311 according to another embodiment may be configured such that a flow-path width on the upstream side and a flow-path width on the downstream side are the same.

[0025] As shown in FIG. 5, the second heat exchanger plate 32 includes: an inlet header 321 which is formed by a first opening 221 including the third communication port 43, an outlet header 322 which is formed by a second opening 222 including the fourth communication port 44, and a plurality of partition walls 325 disposed between the inlet header 321 and the outlet header 322. The plurality of partition walls 325 are disposed so as to partition a flow path for the second fluid F2 from the inlet header

321 toward the outlet header 322 into the plurality of parallel flow paths 328, respectively. Each partition wall 325 of the present example bends and linearly extends from the inlet header 321 to the outlet header 322. In the following description, the extension direction of the partition wall 325 may be referred to as a "flow direction of the second fluid F2", and a direction in which the plurality of partition walls 325 are arranged may be referred to as a "width direction of the parallel flow path 328". In the present embodiment, as already described, the second heat exchanger plate 32 is sandwiched by the pair of partition plates 33 (see FIG. 3). Therefore, the parallel flow path 328 is defined by the plurality of partition walls 315 and the pair of partition plates 33.

[0026] The heat exchange between the first fluid F1 and the second fluid F2 in the heat exchanger 1 having the structure described above with reference to FIGs. 1 to 5 is performed as follows. The first fluid F1 flowing into the plurality of parallel flow paths 318 from the inlet header 311 exchanges heat via the partition plate 33 with the second fluid F2 flowing into the plurality of parallel flow paths 328 from the inlet header 321. The first fluid F1 having flowed in in the gas-liquid two-phase state is heated as the first fluid F1 moves downstream in the flow direction of the first fluid F1, and is discharged in a vaporized state from the heat exchanger 1 from the outlet header 312 through the first discharge pipe 59. On the other hand, the second fluid F2 having flowed in in the relatively high-temperature gas phase state is cooled and condensed as the second fluid F2 moves downstream in the flow direction of the second fluid F2, and is discharged in the relatively low-temperature liquid phase state from the heat exchanger 1 from the outlet header 322 through the second discharge pipe 57.

<2. Details of configuration of first heat exchanger plate 31>

[0027] Details of the first heat exchanger plate 31 according to an embodiment of the present disclosure will be exemplified with reference to FIGs. 4, 6, and 7. FIG. 6 is a conceptual enlarged view of the partition walls 315 and notches 314 according to an embodiment. FIG. 7 is a conceptual cross-sectional view of the partition walls 315 and the notches 314 as viewed from a direction of arrows B-B in FIG. 6.

<2-1. Structure of connecting part 317 and notch 314>

[0028] As shown in FIG. 6, the first heat exchanger plate 31 of the present embodiment includes at least one connecting part 317 for connecting the plurality of partition walls 315. In the present embodiment, all the partition walls 315 are each connected to one of the connecting parts 317, but at least two partition walls 315 without intervention of the connecting part 317 may be provided.

[0029] In the present embodiment, at least one partition wall 315 among the plurality of partition walls 315

has a notch 314 at the position of the connecting part 317 in the flow direction of the first fluid F1. The notch 314 is aligned with the connecting part 317 in the width direction of the parallel flow path 318. In the present example, all the partition walls 315 are each provided with the notch 314. Further, in the present embodiment, a pair of parallel flow paths 318 located on both sides of the partition wall 315 having the notch 314 connect with each other via the notch 314. That is, the notch 314 defines a connecting part 316 connecting with the pair of parallel flow paths 318.

[0030] Therefore, as illustrated in the enlarged view of FIG. 4, the first fluid F1 can move between the plurality of parallel flow paths 318 via the connecting part 316 defined by the notch 314. The first fluid F1 flowing through each of the plurality of parallel flow paths 318 is mixed and branched, making it possible to equalize a flux configuration of the first fluid F1 in the plurality of parallel flow paths 318. Whereby, it is possible to suppress local occurrence of dryout in which the liquid-phase first fluid F1 disappears, for example, on the downstream side of the parallel flow path 318. Therefore, the first heat exchanger plate 31 can achieve a high overall heat transfer coefficient. Further, since the connecting part 317 is provided, it is possible to suppress deformation and displacement of the partition wall 315 before and during assembly of the first heat exchanger plate 31. In particular, when the plates constituting the plate laminate 30 such as the first heat exchanger plate 31 are diffusion-bonded, uniform heating cannot be performed immediately after heating is started, and a temperature gradient occurs in the plates. As a result, the partition wall 315 may be deformed due to a difference in expansion caused by the temperature gradient. In the present embodiment, however, the above-described deformation can be suppressed by providing the connecting part 317.

[0031] A machining method for producing the connecting part 317 according to an embodiment of the present disclosure is as follows, for example (see FIG. 6, 7). First, a plate-shaped base material for producing the first heat exchanger plate 31 is subjected to a double-sided etching process so that the parallel flow path 318 is formed. Then, instead of the double-sided etching process, a half-etching process is applied only to an installation location of the connecting part 317, thereby forming the connecting part 317. Therefore, the connecting part 317 is connected only to one end 315A on one side of both ends of each of the plurality of partition walls 315 in the plate thickness direction. Therefore, the connecting part 317 can function as a contraction of area for partially closing the parallel flow path 318. In the example of FIG. 7, a portion of the partition wall 315 from approximately the center to the one end 315A in the plate thickness direction is connected to the connecting part 317.

[0032] According to the surmise of the inventors, a pressure of the first fluid F1 flowing to the parallel flow path 318 may fluctuate greatly. For example, a pressure fluctuation due to boiling of the liquid-phase first fluid F1

(in the enlarged view at the bottom of FIG. 4, a bubble is indicated by reference sign Bu), a pressure difference due to a difference in degree of dryness of the first fluid F1 may occur. In this case, drift of the first fluid F1 is likely to occur.

[0033] In this regard, with the above configuration, the connecting part 317 is connected only to the one end 315A on the one side of the both ends of each partition wall 315 in the plate thickness direction. Therefore, the connecting part 317 also functions as the contraction of area for partially closing the parallel flow path 318. Consequently, a moderate pressure loss occurs in the connecting part 317, making it possible to reduce the difference in pressure between the plurality of parallel flow paths 318 caused by the above-described pressure fluctuation.

[0034] Therefore, the first fluid F1 can easily flow through the connecting part 316 defined by the notch 314, making it possible to suppress the drift of the first fluid F1 in the plurality of parallel flow paths 318. Whereby, the first heat exchanger plate 31 can achieve the high overall heat transfer coefficient.

[0035] As shown in FIG. 6, 7, the notch 314 of the present embodiment is formed at another end 315B which is an end of each of the plurality of partition walls 315 on another side in the plate thickness direction. The notch bottom 309 of the notch 314 and a surface 317F of the connecting part 317 on the another side are at the same position in the plate thickness direction. That is, the surface 317F of the connecting part 317 and the notch bottom 309 are directly connected. With the above configuration, the first fluid F1 that has passed through the connecting part 316 defined by the notch 314 can flow into the parallel flow path 318 through the surface 317F of the connecting part 317 on the another side. Since the passage of the first fluid F1 through the connecting part 317 causes mixing and branching of the first fluid F1 from the connecting part 316 toward the parallel flow path 318, it is possible to suppress the drift of the first fluid F1 in the plurality of parallel flow paths 318 and the first heat exchanger plate 31 can achieve the high overall heat transfer coefficient.

[0036] Further, as shown in FIG. 6, an upstream end 399 of the connecting part 317 in the flow direction of the first fluid F1 is recessed in an arc shape toward the downstream side. With the above configuration, it is possible to suppress an excessive pressure loss that occurs when the first fluid F1 passes through the connecting part 317 along the flow direction of the first fluid F1. Whereby, it is possible to suppress separation of the flow of the first fluid F1 along the extension direction of the partition wall 315. Therefore, it is possible to suppress the increase in pressure loss.

<2-2. Arrangement example of notches 314 (connecting parts 316)>

[0037] An arrangement example of the notches 314

will be described with reference to FIG. 4. In the following description, an embodiment will be exemplified in which the notch 314 and the connecting part 317 are arranged at the same position in the flow direction of the first fluid F1. However, the positions of the notch 314 and the connecting part 317 in the flow direction may be different.

[0038] In the present embodiment, the plurality of notches 314 arranged in the width direction of the parallel flow path 318 are arranged in four rows along the flow direction of the first fluid F1. Among the four rows of the notches 314, the notch 314 in a most upstream row is a first notch 314A and the notch 314 in a most downstream row is a second notch 314B. The notch 314 adjacent to the second notch 314B in the flow direction of the first fluid F1 is a third notch 314C and the notch 314 adjacent to each of the first notch 314A and the third notch 314C is a fourth notch 314D. That is, the plurality of notches 314 include the plurality of first notches 314A (first row), the plurality of fourth notches 314D (second row), the plurality of third notches 314C (three rows), and the plurality of second notches 314B (fourth row) in order from the upstream side. The connecting part 316 defined by the first notch 314A is a first connecting part 316A. Likewise, the connecting parts 316 defined by the second notch 314B, the third notch 314C, and the fourth notch 314D are a second connecting part 316B, a third connecting part 316C, and a fourth connecting part 316D, respectively. In the present embodiment, as an example, the numbers of first notches 314A, second notches 314B, third notches 314C, and fourth notches 314D are the same.

[0039] In the present embodiment, a first distance between the inlet header 311 and the at least one notch 314 in the flow direction of the first fluid F1 is less than a second distance between the outlet header 312 and the at least one notch 314 in the flow direction of the first fluid F1. As a more specific example, the first distance is a shortest distance (dimension L1) from the inlet header 311 to the center of the first notch 314A and the second distance is a shortest distance (dimension L2) from the outlet header 312 to the center of the second notch 314B. With the above configuration, since the first distance is shorter than the second distance, the first connecting part 316A (connecting part 316) defined by the first notch 314A approaches the inlet header 311. Consequently, even if bubbles are generated due to boiling of the liquid phase of the first fluid F1 or bubbles grow between the inlet header 311 and the first notch 314A, the bubbles can be introduced to the first connecting part 316A formed by the first notch 314A. Therefore, the drift of the first fluid F1 in the plurality of parallel flow paths 318 which is caused by backflow of the bubbles to the inlet header 311 is suppressed, making it possible to provide the first heat exchanger plate 31 that achieves the high overall heat transfer coefficient.

[0040] In another embodiment, the notch 314 may not include at least one of the first notch 314A, the second notch 314B, the third notch 314C, or the fourth notch

314D. For example, in an embodiment where the second notch 314B, the third notch 314C, and the fourth notch 314D are not provided, the second distance is a distance (dimension M) from the first notch 314A to the outlet header 312. Even in this case, the above-described advantages are obtained. Likewise, in an embodiment where only the third notch 314C and the fourth notch 314D are provided among the second notch 314B, the third notch 314C, and the fourth notch 314D, the second distance is a distance from the third notch 314C to the outlet header 312.

[0041] Further, in the present embodiment, the at least one notch 314 includes the plurality of first notches 314A included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1. Therefore, the first connecting parts 316A which are the connecting parts 316 defined by the first notches 314A are arranged in the width direction of the parallel flow paths 318. With the above configuration, even if bubbles are generated in any of the plurality of parallel flow paths 318, the bubbles can flow into any of the first connecting parts 316A, making it possible to suppress the drift of the first fluid F1 and to suppress the backflow of the bubbles to the inlet header 311.

[0042] Further, in the present embodiment, the first distance (the dimension L1 in the example of FIG. 4) is greater than 0% and less than 10%, more preferably greater than 0% and not greater than 5% with respect to an entire length (dimension K) of the parallel flow path 318. The technical effects brought about by this configuration are as follows. With the above configuration, since the first distance is greater than 0% and less than 10% with respect to the entire length of the parallel flow path 318, the first fluid F1 which has just flowed into each of the plurality of parallel flow paths 318 from the inlet header 311 interflows via the first connecting part 316A formed by the first notch 314A. That is, the first connecting part 316A performs a function similar to that of the inlet header 311, and the first fluid F1 having flowed into the parallel flow paths 318 from the inlet header 311 passes through a throttle of each parallel flow path 318 and is supplied toward the downstream side. Further, in the first connecting part 316A, there is no rightward (unidirectional) flow as in the inlet header 311 and a bidirectional flow is possible. Therefore, even if there is an imbalance of the gas-liquid ratio (degree of dryness) in the plurality of parallel flow paths 318, the first fluid F1 can be mixed and redistributed in the first connecting part 316A so as to eliminate the imbalance. Further, even if bubbles of the first fluid F1 are generated in the parallel flow paths 318 and cause the backflow, the bubbles are mixed with the flow from the inlet header 311 in the first connecting part 316A, redistributed, and supplied to the parallel flow paths 318. Therefore, the degree of dryness of the first fluid F1 on the upstream side of the plurality of parallel flow paths 318 can be equalized, making it possible to suppress the drift of the first fluid F1. Whereby, it is possible to provide the first heat exchanger plate 31 that achieves the high

overall heat transfer coefficient.

[0043] Further, the first heat exchanger plate 31 of the present embodiment includes at least one adjacent notch 313 located downstream of the first notch 314A and adjacent to the first notch 314A in the flow direction of the first fluid F1. In the present example, the fourth notch 314D corresponds to the adjacent notch 313. Then, an adjacent distance (dimension A) which is a shortest distance between the inlet header 311 and the adjacent notch 313 is not less than 25% and less than 90% with respect to the entire length of the parallel flow path 318. The adjacent distance is preferably not less than 25% and less than 35% with respect to the entire length of the parallel flow path 318.

[0044] If the first notch 314A and the adjacent notch 313 are too close to each other in the flow direction, the flux of the first fluid F1 in the connecting part 316 (the fourth connecting part 316D in the present example) formed by the adjacent notch 313 becomes excessively weak, making it difficult for the first fluid F1 to interflow between the plurality of parallel flow paths 318. In this regard, with the above configuration, since the first notch 314A and the adjacent notch 313 are moderately separated from each other, it is possible to optimize the flux of the first fluid F1 in the connecting part 316 and it is possible to promote the mixing of the first fluid F1 in the plurality of parallel flow paths 318. Therefore, it is possible to achieve the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0045] The present disclosure is not limited to the embodiment where the fourth notch 314D corresponds to the adjacent notch 313. In embodiment where the fourth notch 314D is not provided among the second notch 314B, the third notch 314C, or the fourth notch 314D, the third notch 314C corresponds to the adjacent notch 313 adjacent to the first notch 314A in the flow direction of the first fluid F1. The above-described adjacent distance in this case is preferably not less than 50% and less than 60% with respect to the entire length of the parallel flow path 318.

[0046] In the present embodiment, as described above, the at least one notch 314 includes the first notch 314A and the second notch 314B. With the above configuration, the first fluid F1 can flow between the plurality of parallel flow paths 318 via the second connecting part 316B which is the connecting part 316 formed by the second notch 314B located downstream of the first notch 314A. Therefore, the first fluid F1 can moderately interflow between the plurality of parallel flow paths 318. Whereby, it is possible to suppress the drift of the first fluid F1 in the plurality of parallel flow paths 318 and the heat exchanger plate can achieve the high overall heat transfer coefficient.

[0047] The second distance (the dimension L2 in the example of FIG. 4) of the present embodiment is not less than 10% and not greater than 35% with respect to the entire length of the parallel flow path 318. According to the findings of the inventors, if the first heat exchanger

plate 31 is used such that the first fluid F1 in the gas-liquid two-phase state is supplied to the inlet header 311, the difference in degree of dryness tends to appear depending on the plurality of parallel flow paths 318 on the upstream side of the parallel flow paths 318. In particular, the degree of dryness of the first fluid F1 tends to increase in the parallel flow path 318 connected to an upstream portion (a portion close to the first communication port 41) of the first opening 111 forming the inlet header 311, and dryout tends to occur easily on the downstream side of the parallel flow path 318 in the flow direction. Meanwhile, a thinner liquid film of the liquid-phase first fluid F1 flowing through the parallel flow path 318 exerts the higher overall heat transfer coefficient. Therefore, it is preferable that a position where the first fluid F1 flows into the parallel flow path 318 where dryout can occur from the another parallel flow path 318 is close to a position where dryout can occur. In this regard, with the above configuration, since the second connecting part 316B defined by the second notch 314B is moderately separated from the outlet header 312, the interflow of the first fluid F1 is promoted slightly upstream of a region where dryout is expected to occur. Therefore, the first heat exchanger plate 31 can effectively suppress dryout of the first fluid F1 while suppressing a decrease in overall heat transfer coefficient.

[0048] As already described, the notch 314 of the present embodiment further includes the at least one third notch 314C. The third notch 314C is located between the first notch 314A and the second notch 314B and is adjacent to the second notch 314B in the flow direction of the first fluid F1. The distance (dimension B) between the inlet header 311 and the third notch 314C is not less than 50% and less than 60% with respect to the entire length of the parallel flow path 318. With the above configuration, the first fluid F1 interflows between the plurality of parallel flow paths 318 via the third connecting part 316C which is the connecting part 316 formed by the third notch 314C. In addition to the increasing opportunity for the first fluid F1 to interflow, since the first notch 314A and the third notch 314C are moderately separated from each other, it is possible to secure the flux of the first fluid F1 in the third connecting part 316C and it is possible to more effectively promote the interflow of the first fluid F1 between the plurality of parallel flow paths 318.

[0049] As already described, the notch 314 of the present embodiment includes the at least one fourth notch 314D. The fourth notch 314D is located between the first notch 314A and the second notch 314B and is adjacent to the first notch 314A in the flow direction of the first fluid F1. The shortest distance (dimension A) between the inlet header 311 and the fourth notch 314D is not less than 25% and less than 35% with respect to the entire length of the parallel flow path 318. With the above configuration, the first fluid F1 interflows between the plurality of parallel flow paths 318 via the fourth connecting part 316D which is the connecting part 316

formed by the fourth notch 314D located between the first notch 314A and the second notch 314B. In addition to the increasing opportunity for the first fluid F1 to interflow, since the first notch 314A and the fourth notch 314D are moderately separated from each other, it is possible to secure the flux of the first fluid F1 in the fourth connecting part 316D and it is possible to more effectively promote the interflow of the first fluid F1 between the plurality of parallel flow paths 318.

<3. Details of configuration of second heat exchanger plate 32>

[0050] Details of the configuration of the second heat exchanger plate 32 will be exemplified with reference to FIG. 5. The second heat exchanger plate 32 has the same configuration as the first heat exchanger plate 31. Specifically, the second heat exchanger plate 32 includes the inlet header 321 formed in the first opening 221, the outlet header 322 formed by the second opening 222, and the plurality of partition walls 325 disposed between the inlet header 321 and the outlet header 322. The plurality of partition walls 325 are disposed so as to partition the flow path for the second fluid F2 from the inlet header 321 toward the outlet header 322.

<4. As to another arrangement example of notches 314 (connecting parts 316)>

[0051] Another arrangement example of the notches 314 will be described with reference to FIG. 8. FIG. 8 is a conceptual explanatory view of the first heat exchanger plate 31 according to another embodiment. In the following description, an embodiment will be exemplified in which the notch 314 and the connecting part 317 are arranged at the same position in the flow direction of the first fluid F1. However, the positions of the notch 314 and the connecting part 317 in the flow direction may be different.

[0052] The inlet header 311 of the embodiment shown in FIG. 8 is configured such that the flow-path width on the upstream side and the flow-path width on the downstream side are the same.

[0053] In the first heat exchanger plate 31 shown in FIG. 8, the same configurations as those of the first heat exchanger plate 31 shown in FIG. 4 are indicated by the same reference characters and may not be described in detail.

[0054] In the present embodiment, the plurality of notches 314 arranged in the width direction of the parallel flow path 318 are arranged in five rows along the flow direction of the first fluid F1. Among the five rows of the notches 314, the notches 314 in the most upstream row are the above-described first notches 314A. Among the five rows of the notches 314, the other four rows of the notches 314 excluding the first notches 314A are four fifth notches 314E having different positions in the flow direction.

[0055] Among the other four rows of the fifth notches 314E excluding the first notches 314A, the fifth notches 314E in the most upstream row is fifth A notches 314EA. The fifth notches 314E arranged downstream of the fifth A notches 314EA and adjacent to the fifth A notches 314EA in the flow direction of the first fluid F1 are fifth B notches 314EB. The fifth notches 314E arranged downstream of the fifth B notches 314EB and adjacent to the fifth B notches 314EB in the flow direction of the first fluid F1 are fifth C notches 314EC. The fifth notches 314E arranged downstream of the fifth C notches 314EC and adjacent to the fifth C notches 314EC in the flow direction of the first fluid F1 are fifth D notches 314ED.

[0056] That is, the plurality of notches 314 include the plurality of first notches 314A (first row), the plurality of fifth A notches 314EA (second row), the plurality of fifth B notches 314EB (three rows), the plurality of fifth C notches 314EC (fourth row), and the plurality of fifth D notches 314ED (fifth row) in order from the upstream side.

[0057] The connecting part 316 defined by the first notch 314A is the first connecting part 316A. Likewise, the connecting part 316 defined by the fifth notch 314E is a fifth connecting part 316E.

[0058] The connecting parts 316 defined by the fifth A notch 314EA, the fifth B notch 314EB, the fifth C notch 314EC, and the fifth D notch 314ED are a fifth A connecting part 316EA, a fifth B connecting part 316EB, a fifth C connecting part 316EC, and a fifth D connecting part 316ED, respectively. In the present embodiment, as an example, the numbers of fifth A connecting parts 316EA, fifth B connecting parts 316EB, fifth C connecting parts 316EC, and fifth D connecting parts 316ED are the same.

[0059] In the present embodiment, the fifth notches 314E having the different positions in the flow direction are located in a range where the distance from the inlet header 311 in the flow direction of the first fluid F1 is not less than 32.5% (dimension 0.325K) and not greater than 67.5% (dimension 0.675K) with respect to the entire length (dimension K) of the parallel flow path 318.

[0060] The technical effects brought about by the above-described fifth notches 314E are as follows.

[0061] According to the findings of the inventors, the drift may increase due to the pressure difference in the flow-path direction in the inlet header 311 (the extension direction of the inlet header 311), if the supply amount of the first fluid F1 is relatively large. In such a case, it is desirable to reduce the pressure loss of the inlet header 311 by increasing a flow path cross-sectional area of the inlet header 311. However, the first fluid F1 in the inlet header 311 has a flux configuration in which the gas-liquid is separated into two phases, by increasing the flow path cross-sectional area of the inlet header 311, and it is necessary to further improve the drift suppression effect by the notches 314.

[0062] According to the findings of the inventors, it was found that the mixing/branching of the first fluid F1 be-

tween the plurality of parallel flow paths 318 is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths 318 by arranging the plurality of fifth notches 314E having the different positions in the flow direction of the first fluid F1 in the range where the distance from the inlet header 311 in the flow direction is not less than 32.5% and not greater than 67.5% with respect to the entire length (dimension K) of the parallel flow paths 318.

[0063] With the above configuration, the first fluid F1 can move between the plurality of parallel flow paths 318 in the region between the upstream side and the downstream side of the parallel flow paths 318 via the plurality of fifth connecting parts 316E defined by the plurality of fifth notches 314E. Since the plurality of fifth notches 314E have the different positions in the flow direction, the mixing/branching of the first fluid F1 between the plurality of parallel flow paths 318 is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths 318. Whereby, even in the case of the flux configuration where the gas-liquid of the first fluid F1 separates into two phases in the inlet header 311, it is possible to effectively suppress dryout of the first fluid F1 in the region on the relatively downstream side of the parallel flow paths 318 which is a region where heat can be exchanged relatively efficiently, and it is possible to provide the first heat exchanger plate 31 that achieves the high overall heat transfer coefficient.

[0064] If the first notch 314A and the fifth notch 314E are too close to each other in the flow direction, the flux of the first fluid F1 in the fifth connecting part 316E formed by the fifth notch 314E becomes excessively weak, making it difficult for the first fluid F1 to interflow between the plurality of parallel flow paths 318. In this regard, with the above configuration, since the first notch 314A and the fifth notch 314E are moderately separated from each other, it is possible to optimize the flux of the first fluid F1 in the fifth connecting part 316E formed by the fifth notch 314E and it is possible to promote the mixing of the first fluid F1 in the plurality of parallel flow paths 318.

[0065] Further, according to the findings of the inventors, it was found that the heat exchange amount can be increased by completing the mixing/branching of the first fluid F1 between the plurality of parallel flow paths 318 with the fifth notch 314E and securing the size of the region on the relatively downstream side of the parallel flow paths 318, which is the region where heat can be exchanged relatively efficiently, before the first fluid F1 flows into said region. In this regard, with the above configuration, since the outlet header 312 and the fifth notch 314E are moderately separated from each other, it is possible to secure the size of said region and it is possible to increase the heat exchange amount.

[0066] In the present embodiment, as with the embodiment shown in FIG. 4, the first distance between the inlet header 311 and the at least one notch 314 in the flow direction of the first fluid F1 is less than the second distance between the outlet header 312 and the at least one

notch 314 in the flow direction of the first fluid F1. As a more specific example, the first distance is the shortest distance (dimension L1) from the inlet header 311 to the center of the first notch 314A and the second distance is a shortest distance (dimension L2d) from the outlet header 312 to the center of the fifth D notch 314ED. With the above configuration, since the first distance is shorter than the second distance, the first connecting part 316A (connecting part 316) defined by the first notch 314A approaches the inlet header 311. Consequently, even if bubbles are generated due to boiling of the liquid phase of the first fluid F1 or bubbles grow between the inlet header 311 and the first notch 314A, the bubbles can be introduced to the first connecting part 316A formed by the first notch 314A. Therefore, the drift of the first fluid F1 in the plurality of parallel flow paths 318 which is caused by backflow of the bubbles to the inlet header 311 is suppressed, making it possible to provide the first heat exchanger plate 31 that achieves the high overall heat transfer coefficient.

[0067] In the example shown in FIG. 8, the fifth notches 314E are provided in the four rows, but the fifth notches 314E can be provided in at least two rows, desirably at least three rows. The fifth notches 314E may be provided in at least five rows.

[0068] Whereby, the mixing/branching of the first fluid F1 between the plurality of parallel flow paths 318 is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths 318 by the plurality of fifth connecting parts 316E having the different positions in the flow direction.

[0069] For example, in an embodiment where the fifth D notch 314ED is not provided, the second distance is a distance (dimension L2c) from the fifth C notch 314EC to the outlet header 312. Even in this case, the above-described advantages are obtained. Likewise, in an embodiment where the fifth D notch 314ED and the fifth C notch 314EC are not provided, the second distance is a distance (dimension L2b) from the fifth B notch 314EB to the outlet header 312.

[0070] Further, in the present embodiment, as with the embodiment shown in FIG. 4, the at least one notch 314 includes the plurality of first notches 314A included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1. Therefore, it is possible to obtain the same technical effect as the embodiment shown in FIG. 4.

[0071] Further, in the present embodiment, as with the embodiment shown in FIG. 4, the first distance (the dimension L1 in the example of FIG. 8) is greater than 0% and less than 10%, more preferably greater than 0% and not greater than 5% with respect to the entire length (dimension K) of the parallel flow path 318. The technical effects brought about by this configuration are the same as the embodiment shown in FIG. 4.

[0072] In the present embodiment, the at least one notch 314 includes the plurality of fifth notches 314E included in the plurality of partition walls 315 respectively

and arranged at the same position in the flow direction of the first fluid F1. That is, in the present embodiment, the at least one notch 314 includes the plurality of fifth A notches 314EA included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1. In the present embodiment, the at least one notch 314 includes the plurality of fifth B notches 314EB included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1. In the present embodiment, the at least one notch 314 includes the plurality of fifth C notches 314EC included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1. In the present embodiment, the at least one notch 314 includes the plurality of fifth D notches 314ED included in the plurality of partition walls 315 respectively and arranged at the same position in the flow direction of the first fluid F1.

[0073] Whereby, the mixing/branching of the first fluid F1 between the plurality of parallel flow paths 318 is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths 318 in any of the plurality of parallel flow paths 318, making it possible to provide the first heat exchanger plate 31 that achieves the high overall heat transfer coefficient.

[0074] In the present embodiment, a separation distance ΔL in the flow direction between two of the fifth notches 314E adjacent in the flow direction among the plurality of fifth notches 314E is not less than 2% and not greater than 5% with respect to the entire length (dimension K) of the parallel flow path 318. A separation distance ΔL_{ab} between the fifth A notch 314EA and the fifth B notch 314EB, a separation distance ΔL_{bc} between the fifth B notch 314EB and the fifth C notch 314EC, and a separation distance ΔL_{cd} between the fifth C notch 314EC and the fifth D notch 314ED may be the same, or at least one of them may be different.

[0075] According to the findings of the inventors, it was confirmed that a good drift suppression effect can be obtained by conducting an experiment with the separation distance ΔL between the two fifth notches 314E adjacent in the flow direction being 5% with respect to the entire length (dimension K) of the parallel flow path 318.

[0076] The value of 5% is one-third of a value which is 15% of the entire length (dimension K) of the parallel flow path 318 given below.

[0077] The value of 15% with respect to the entire length (dimension K) of the parallel flow path 318 is, for example, a value corresponding to when a distance (dimension A-dimension L1) between the first notch 314A and the fourth notch 314D in FIG. 4 described above is the smallest or a value corresponding to when the distance (dimension B-dimension A) between the fourth notch 314D and the third notch 314C in FIG. 4 described above is the smallest.

[0078] It is considered that the drift suppression effect by the mixing/branching of the first fluid F1 between the

plurality of parallel flow paths 318 in the region between the upstream side and the downstream side of the parallel flow paths 318 is reduced if the separation distance ΔL is increased. Therefore, the separation distance ΔL is desirably not greater than 5% with respect to the entire length (dimension K) of the parallel flow path 318.

[0079] Further, it is considered that decreasing the separation distance ΔL has relatively little influence on the above-described drift suppression effect. However, due to the convenience of forming the partition wall 315, it is necessary to secure the dimension in the extension direction of the partition wall 315. Therefore, the separation distance ΔL is desirably not less than 2% with respect to the entire length (dimension K) of the parallel flow path 318.

[0080] Accordingly, the separation distance ΔL is desirably not less than 2% and not greater than 5% with respect to the entire length (dimension K) of the parallel flow path 318.

[0081] Therefore, by setting the separation distance ΔL between the two fifth notches 314E adjacent in the flow direction at not less than 2% and not greater than 5% with respect to the entire length (dimension K) of the parallel flow path 318, the separation distance ΔL becomes an appropriate distance and the mixing/branching of the first fluid F1 between the plurality of parallel flow paths 318 is efficiently performed in the region between the upstream side and the downstream side of the parallel flow paths 318.

[0082] For example, in the example shown in FIG. 8, the four fifth notches 314E are distributed and arranged two by two on the upstream side and the downstream side around a position (dimension 0.5K) where the distance from the inlet header 311 in the flow direction is 50% of the entire length (dimension K) of the parallel flow path 318.

[0083] Further, in the present embodiment, the four fifth notches 314E may be distributed and arranged two by two on the upstream side and the downstream side, for example, around a position where the distance from the inlet header 311 in the flow direction is 40% of the entire length (dimension K) of the parallel flow path 318. In this case, if the separation distance ΔL_{ab} and the separation distance ΔL_{bc} are 5% of the entire length (dimension K) of the parallel flow path 318, the distance from the inlet header 311 to the fifth A notch 314EA is 32.5% of the entire length (dimension K) of the parallel flow path 318.

[0084] Further, in the present embodiment, the four fifth notches 314E may be distributed and arranged two by two on the upstream side and the downstream side, for example, around a position where the distance from the inlet header 311 in the flow direction is 60% of the entire length (dimension K) of the parallel flow path 318. In this case, if the separation distance ΔL_{bc} and the separation distance ΔL_{cd} are 5% of the entire length (dimension K) of the parallel flow path 318, the distance from the inlet header 311 to the fifth D notch 314ED is 67.5%

of the entire length (dimension K) of the parallel flow path 318.

<5. Others>

[0085] The present disclosure is not limited to the above-described some embodiments. The parallel flow path 318 may partially include a flow path which is formed in a zigzag pattern instead of extending linearly over the entire length of parallel flow path 318. The zigzag pattern is a concept that includes a pattern with curved corners and a pattern with linearly bent corners. For example, in the example shown in FIG. 8, the flow path formed in the zigzag pattern may be formed in the region on the upstream side of the fifth A notch 314EA or the region on the upstream side of the position (dimension 0.5K) where the distance from the inlet header 311 in the flow direction is 50% of the entire length (dimension K) of the parallel flow path 318.

[0086] Further, in the above-described some embodiments, the flow-path widths (dimensions W) of the plurality of parallel flow paths 318 are all the same, but some of the parallel flow paths 318 may have different flow-path widths from those of the other parallel flow paths 318.

<6. Conclusion>

[0087] The present disclosure would be understood as follows, for instance.

1) A heat exchanger plate (first heat exchanger plate 31) according to at least one embodiment of the present disclosure, includes: an inlet header (311) formed by a first opening (111); an outlet header (312) formed by a second opening (122); and a plurality of partition walls (315) disposed between the inlet header and the outlet header so as to partition a flow path for a fluid (first fluid F1) from the inlet header toward the outlet header into a plurality of parallel flow paths (318). At least one partition wall among the plurality of partition walls includes at least one notch (314). A pair of the parallel flow paths on both sides of the partition wall having the notch connect with each other via the notch. A first distance (dimension L1) between the inlet header and the at least one notch in a flow direction of the fluid is less than a second distance (dimension L2) between the outlet header and the at least one notch in the flow direction.

[0088] With the above configuration 1), the fluid can move between the plurality of parallel flow paths via the connecting part (316) defined by the notch. Further, since the first distance is shorter than the second distance, the connecting part approaches the inlet header. Consequently, even if bubbles of the fluid are generated or grow on the upstream side of the parallel flow path and the

bubbles flow backward, the bubbles can flow into the connecting part. Therefore, it is possible to suppress an increase in gas phase of the fluid in the inlet header. Whereby, the drift of the fluid in the plurality of parallel flow paths is suppressed, making it possible to provide the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0089] 2) In some embodiments, the heat exchanger plate as defined in the above 1), wherein the at least one notch includes a plurality of first notches (314A) included in the plurality of partition walls respectively and arranged at the same position in the flow direction.

[0090] With the above configuration 2), even if bubbles are generated in any of the plurality of parallel flow paths, it is possible to suppress the backflow of the bubbles to the inlet header.

[0091] 3) In some embodiments, the heat exchanger plate as defined in the above 1) or 2), wherein the first distance is greater than 0% and less than 10% with respect to an entire length (dimension K) of the parallel flow paths.

[0092] According to the findings of the inventors, if the heat exchanger plate is used such that the fluid in the gas-liquid two-phase state is supplied to the inlet header, the difference in degree of dryness tends to appear depending on the plurality of parallel flow paths on the upstream side of the parallel flow paths. In particular, the degree of dryness of the fluid tends to increase in the parallel flow path connected to an upstream portion of the first opening forming the inlet header. In this regard, with the above configuration 3), since the first distance is greater than 0% and less than 10% with respect to the entire length of the parallel flow path, the fluid which has just flowed into each of the plurality of parallel flow paths from the inlet header is mixed and branched via the connecting part formed by the first notch, making it possible to equalize the degree of dryness of the fluid on the upstream side of the plurality of parallel flow paths and it is possible to suppress the drift of the fluid. Therefore, it is possible to provide the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0093] 4) In some embodiments, the heat exchanger plate as defined in any of the above 1) to 3), wherein the at least one notch includes: at least one first notch (314A) having a distance from the inlet header, which is the first distance; and at least one adjacent notch (313) located downstream of the first notch and adjacent to the first notch in the flow direction, and wherein an adjacent distance (dimension A, dimension B, dimension C) between the inlet header and the adjacent notch is not less than 25% and less than 90% with respect to an entire length (dimension K) of the parallel flow paths.

[0094] According to the findings of the inventors, if the first notch and the adjacent notch are too close to each other in the flow direction, the flux of the fluid in the connecting part formed by the adjacent notch becomes excessively weak, making it difficult for the fluid to mix/branch between the plurality of parallel flow paths.

In this regard, with the above configuration 4), since the first notch and the adjacent notch are moderately separated from each other, it is possible to promote the mixing of the fluid in the plurality of parallel flow paths and it is possible to achieve the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0095] 5) In some embodiments, the heat exchanger plate as defined in any of the above 1) to 4), wherein the at least one notch includes: at least one first notch (314A) having a distance from the inlet header, which is the first distance; and at least one second notch (314B) disposed downstream of the first notch in the flow direction and having a distance (dimension L2) from the outlet header, which is the second distance.

[0096] With the above configuration 5), the fluid can flow between the plurality of parallel flow paths via the second connecting part which is the connecting part formed by the second notch located downstream of the first notch. Therefore, the fluid can moderately interflow between the plurality of parallel flow paths. Whereby, it is possible to suppress the drift of the fluid in the plurality of parallel flow paths and the heat exchanger plate can achieve the high overall heat transfer coefficient.

[0097] 6) In some embodiments, the heat exchanger plate as defined in the above 5), wherein the second distance (dimension L2) is not less than 10% and not greater than 35% with respect to an entire length (dimension K) of the parallel flow paths in the flow direction.

[0098] According to the findings of the inventors, if the heat exchanger plate is used such that the fluid in the gas-liquid two-phase state is supplied to the inlet header, the difference in degree of dryness tends to appear depending on the plurality of parallel flow paths on the upstream side of the parallel flow paths. In particular, the degree of dryness of the fluid tends to increase in the parallel flow path connected to the upstream portion of the first opening forming the inlet header, and dryout tends to occur easily on the downstream side of the parallel flow path in the flow direction. Meanwhile, a thinner liquid film of the fluid flowing through the parallel flow path exerts the higher overall heat transfer coefficient. Therefore, it is preferable that a position where the fluid flows into the parallel flow path where dryout can occur from the another parallel flow path is close to a position where dryout can occur. In this regard, with the above configuration 7), since the second connecting part defined by the second notch is moderately separated from the outlet header, the interflow of the fluid is promoted slightly upstream of a region where dryout is expected to occur. Therefore, the first heat exchanger plate can effectively suppress dryout of the first fluid while suppressing a decrease in overall heat transfer coefficient.

[0099] 7) In some embodiments, the heat exchanger plate as defined in any of the above 1) to 6), wherein the at least one notch includes: at least one first notch (314A) having a distance from the inlet header, which is the first distance; at least one second notch (314B) disposed downstream of the first notch in the flow direction and

having a distance (dimension L2) from the outlet header, which is the second distance; and at least one third notch (314C) located between the first notch and the second notch and adjacent to the second notch in the flow direction, and wherein a distance (dimension B) between the first notch and the third notch is not less than 50% and less than 60% with respect to an entire length (dimension K) of the parallel flow paths.

[0100] With the above configuration 7), the fluid is mixed/branched between the plurality of parallel flow paths via the third connecting part which is the connecting part formed by the third notch located between the first notch and the second notch. In addition to the increasing opportunity for the fluid to mix/branch, since the first notch and the third notch are moderately separated from each other, it is possible to secure the flux of the fluid in the third connecting part and it is possible to more effectively promote the mixing/branching of the fluid between the plurality of parallel flow paths.

[0101] 8) In some embodiments, the heat exchanger plate as defined in any of the above 1) to 7), wherein the at least one notch includes: at least one first notch (314A) having a distance from the inlet header, which is the first distance; at least one second notch (314B) disposed downstream of the first notch in the flow direction and having a distance (dimension L2) from the outlet header, which is the second distance; and at least one fourth notch (314D) located between the first notch and the second notch and adjacent to the first notch in the flow direction, and wherein a distance (dimension A) between the first notch and the fourth notch is not less than 25% and less than 35% with respect to an entire length (dimension K) of the parallel flow paths.

[0102] With the above configuration 8), the fluid is mixed/branched between the plurality of parallel flow paths via the fourth connecting part which is the connecting part formed by the fourth notch located between the first notch and the second notch. In addition to the increasing opportunity for the fluid to mix/branch, since the first notch and the fourth notch are moderately separated from each other, it is possible to secure the flux of the fluid in the fourth connecting part and it is possible to more effectively promote the mixing/branching of the fluid between the plurality of parallel flow paths.

[0103] 9) In some embodiments, the heat exchanger plate as defined in the above 1), wherein at least one partition wall among the plurality of partition walls includes: at first notch having a distance from the inlet header, which is the first distance; and a plurality of fifth notches (314E) that are a plurality of notches located downstream of the first notch and in a range where a distance from the inlet header in the flow direction of the fluid is not less than 32.5% (dimension 0.325K) and not greater than 67.5% (dimension 0.675K) with respect to an entire length of the parallel flow paths, the plurality of fifth notches having different positions in the flow direction.

[0104] According to the findings of the inventors, the

drift may increase due to the pressure difference in the flow-path direction in the inlet header (the extension direction of the inlet header), if the supply amount of the fluid is relatively large. In such a case, it is desirable to reduce the pressure loss of the inlet header by increasing a flow path cross-sectional area of the inlet header. However, the fluid in the inlet header has a flux configuration in which the gas-liquid is separated into two phases, by increasing the flow path cross-sectional area of the inlet header, and it is necessary to further improve the drift suppression effect by the notches.

[0105] According to the findings of the inventors, it was found that the mixing/branching of the fluid between the plurality of parallel flow paths is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths by arranging the plurality of fifth notches having the different positions in the flow direction of the fluid in the range where the distance from the inlet header in the flow direction is not less than 32.5% and not greater than 67.5% with respect to the entire length of the parallel flow paths.

[0106] With the above configuration 9), the fluid can move between the plurality of parallel flow paths in the region between the upstream side and the downstream side of the parallel flow paths via the plurality of fifth connecting parts (316E) defined by the plurality of fifth notches. Since the plurality of fifth notches have the different positions in the flow direction, the mixing/branching of the fluid between the plurality of parallel flow paths is efficiently performed in the region between the upstream side and downstream side of the parallel flow paths. Whereby, even in the case of the flux configuration where the gas-liquid of the fluid separates into two phases in the inlet header, it is possible to effectively suppress dry-out of the fluid in the region on the relatively downstream side of the parallel flow paths which is a region where heat can be exchanged relatively efficiently, and it is possible to provide the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0107] If the first notch and the fifth notch are too close to each other in the flow direction, the flux of the fluid in the connecting part formed by the fifth notch becomes excessively weak, making it difficult for the fluid to inter-flow between the plurality of parallel flow paths. In this regard, with the above configuration 9), since the first notch and the fifth notch are moderately separated from each other, it is possible to optimize the flux of the fluid in the connecting part formed by the fifth notch and it is possible to promote the mixing of the fluid in the plurality of parallel flow paths.

[0108] Further, according to the findings of the inventors, it was found that the heat exchange amount can be increased by completing the mixing/branching of the fluid between the plurality of parallel flow paths with the fifth notch and securing the size of the region on the relatively downstream side of the parallel flow paths, which is the region where heat can be exchanged relatively efficiently, before the fluid flows into said region. In this regard, with

the above configuration 9), since the outlet header and the fifth notch are moderately separated from each other, it is possible to secure the size of said region and it is possible to increase the heat exchange amount.

[0109] 10) In some embodiments, the heat exchanger plate as defined in the above 9), wherein a separation distance (ΔL) in the flow direction between two of the fifth notches adjacent in the flow direction among the plurality of fifth notches is not less than 2% and not greater than 5% with respect to the entire length of the parallel flow paths.

[0110] According to the findings of the inventors, it was found that the separation distance between the two fifth notches adjacent in the flow direction is preferably not less than 2% and not greater than 5% with respect to the entire length of the parallel flow paths.

[0111] In this regard, with the above configuration 10), the separation distance between the two fifth notches adjacent in the flow direction becomes an appropriate distance and the mixing/branching of the fluid between the plurality of parallel flow paths is efficiently performed in the region between the upstream side and the downstream side of the parallel flow paths.

[0112] 11) In some embodiments, the heat exchanger plate as defined in the above 9) or 10), wherein the plurality of fifth notches are included in the plurality of partition walls respectively and arranged at the same position in the flow direction.

[0113] With the above configuration 11), since the mixing/branching of the fluid between the plurality of parallel flow paths is efficiently performed in the region between the upstream side and the downstream side of the parallel flow paths in any of the plurality of parallel flow paths, it is possible to provide the heat exchanger plate that achieves the high overall heat transfer coefficient.

[0114] 12) In some embodiments, the heat exchanger plate as defined in any of the above 9) to 11), wherein the plurality of fifth notches include: a fifth A notch (314EA); a fifth B notch (314EB) located downstream of the fifth A notch and adjacent to the fifth A notch in the flow direction; and a fifth C notch (314EC) located downstream of the fifth B notch and adjacent to the fifth B notch in the flow direction.

[0115] With the above configuration 12), the mixing/branching of the fluid between the plurality of parallel flow paths is efficiently performed in the region between the upstream side and the downstream side of the parallel flow paths by the three connecting parts having the different positions in the flow direction, that is, the connecting part (fifth A connecting part 316EA) formed by the fifth A notch, the connecting part (fifth B connecting part 316EB) formed by the fifth B notch, and the connecting part (fifth C connecting part 316EC) formed by the fifth C notch.

[0116] 13) In some embodiments, the heat exchanger plate as defined in the above 12), wherein the plurality of fifth notches include a fifth D notch (314ED) located downstream of the fifth C notch and adjacent to the fifth

C notch in the flow direction.

[0117] With the above configuration 13), the mixing/branching of the fluid between the plurality of parallel flow paths is more efficiently performed in the region between the upstream side and downstream side of the parallel flow paths by the above-described three connecting part having the different positions in the flow direction and the connecting part (fifth D connecting part 316ED) formed by the fifth D notch.

[0118] 14) A heat exchanger plate laminate (30) according to at least one embodiment of the present disclosure, includes a plurality of the heat exchanger plates (first heat exchanger plates 31) as defined in any of the above 1) to 13).

[0119] With the above configuration 14), for the same reason as the above 1), it is possible to provide the heat exchanger plate laminate that achieves the high overall heat transfer coefficient.

[0120] 15) A microchannel heat exchanger (1) according to at least one embodiment of the present disclosure, includes the heat exchanger plate laminate as defined in the above 14).

[0121] With the above configuration 15), for the same reason as the above 1), it is possible to provide the microchannel heat exchanger that achieves the high overall heat transfer coefficient.

Reference Signs List

[0122]

- 1: Heat exchanger (microchannel heat exchanger)
- 30: Plate laminate
- 31: First heat exchanger plate
- 35: Plate
- 111: First opening
- 122: Second opening
- 311: Inlet header
- 312: Outlet header
- 313: Adj acent notch
- 314: Notch
- 314A: First notch
- 314B: Second notch
- 314C: Third notch
- 314D: Fourth notch
- 314E: Fifth notch
- 315: Partition wall
- 316: Connecting part
- 318: Parallel flow path

Claims

1. A heat exchanger plate, comprising:

- an inlet header formed by a first opening;
- an outlet header formed by a second opening;
- and

a plurality of partition walls disposed between the inlet header and the outlet header so as to partition a flow path for a fluid from the inlet header toward the outlet header into a plurality of parallel flow paths,

wherein at least one partition wall among the plurality of partition walls includes at least one notch,

wherein a pair of the parallel flow paths on both sides of the partition wall having the notch connect with each other via the notch, and

wherein a first distance between the inlet header and the at least one notch in a flow direction of the fluid is less than a second distance between the outlet header and the at least one notch in the flow direction.

2. The heat exchanger plate according to claim 1, wherein the at least one notch includes a plurality of first notches included in the plurality of partition walls respectively and arranged at the same position in the flow direction.

3. The heat exchanger plate according to claim 1 or 2, wherein the first distance is greater than 0% and less than 10% with respect to an entire length of the parallel flow paths.

4. The heat exchanger plate according to claim 1 or 2, wherein the at least one notch includes:

at least one first notch having a distance from the inlet header, which is the first distance; and

at least one adjacent notch located downstream of the first notch and adjacent to the first notch in the flow direction, and

wherein an adjacent distance between the inlet header and the adjacent notch is not less than 25% and less than 90% with respect to an entire length of the parallel flow paths.

5. The heat exchanger plate according to claim 1 or 2, wherein the at least one notch includes:

at least one first notch whose distance from the inlet header is the first distance; and

at least one second notch disposed downstream of the first notch in the flow direction and having a distance from the outlet header, which is the second distance.

6. The heat exchanger plate according to claim 5, wherein the second distance is not less than 10% and not greater than 35% with respect to an entire length of the parallel flow paths in the flow direction.

7. The heat exchanger plate according to claim 1 or 2,

wherein the at least one notch includes:

at least one first notch having a distance
from the inlet header, which is the first distance;
at least one second notch disposed downstream of the first notch in the flow direction and having a distance from the outlet header, which is the second distance; and
at least one third notch located between the first notch and the second notch and adjacent to the second notch in the flow direction, and

wherein a distance between the inlet header and the third notch is not less than 50% and less than 60% with respect to an entire length of the parallel flow paths.

8. The heat exchanger plate according to claim 1 or 2,

wherein the at least one notch includes:

at least one first notch having a distance
from the inlet header, which is the first distance;
at least one second notch disposed downstream of the first notch in the flow direction and having a distance from the outlet header, which is the second distance; and
at least one fourth notch located between the first notch and the second notch and adjacent to the first notch in the flow direction, and

wherein a distance between the inlet header and the fourth notch is not less than 25% and less than 35% with respect to an entire length of the parallel flow paths.

9. The heat exchanger plate according to claim 1, wherein at least one partition wall among the plurality of partition walls includes:

at first notch having a distance from the inlet header, which is the first distance; and
a plurality of fifth notches that are a plurality of notches located downstream of the first notch and in a range where a distance from the inlet header in the flow direction of the fluid is not less than 32.5% and not greater than 67.5% with respect to an entire length of the parallel flow paths, the plurality of fifth notches having different positions in the flow direction.

10. The heat exchanger plate according to claim 9,

wherein a separation distance in the flow direction between two of the fifth notches adjacent in the flow direction among the plurality of fifth notches is not less than 2% and not greater than 5% with respect to the entire length of the parallel flow paths.

11. The heat exchanger plate according to claim 9 or 10, wherein the plurality of fifth notches are included in the plurality of partition walls respectively and arranged at the same position in the flow direction.

12. The heat exchanger plate according to claim 9 or 10, wherein the plurality of fifth notches include:

a fifth A notch;
a fifth B notch located downstream of the fifth A notch and adjacent to the fifth A notch in the flow direction; and
a fifth C notch located downstream of the fifth B notch and adjacent to the fifth B notch in the flow direction.

13. The heat exchanger plate according to claim 12, wherein the plurality of fifth notches include a fifth D notch located downstream of the fifth C notch and adjacent to the fifth C notch in the flow direction.

14. A heat exchanger plate laminate comprising a plurality of the heat exchanger plates according to claim 1 or 2.

15. A microchannel heat exchanger comprising the heat exchanger plate laminate according to claim 14.

FIG. 1

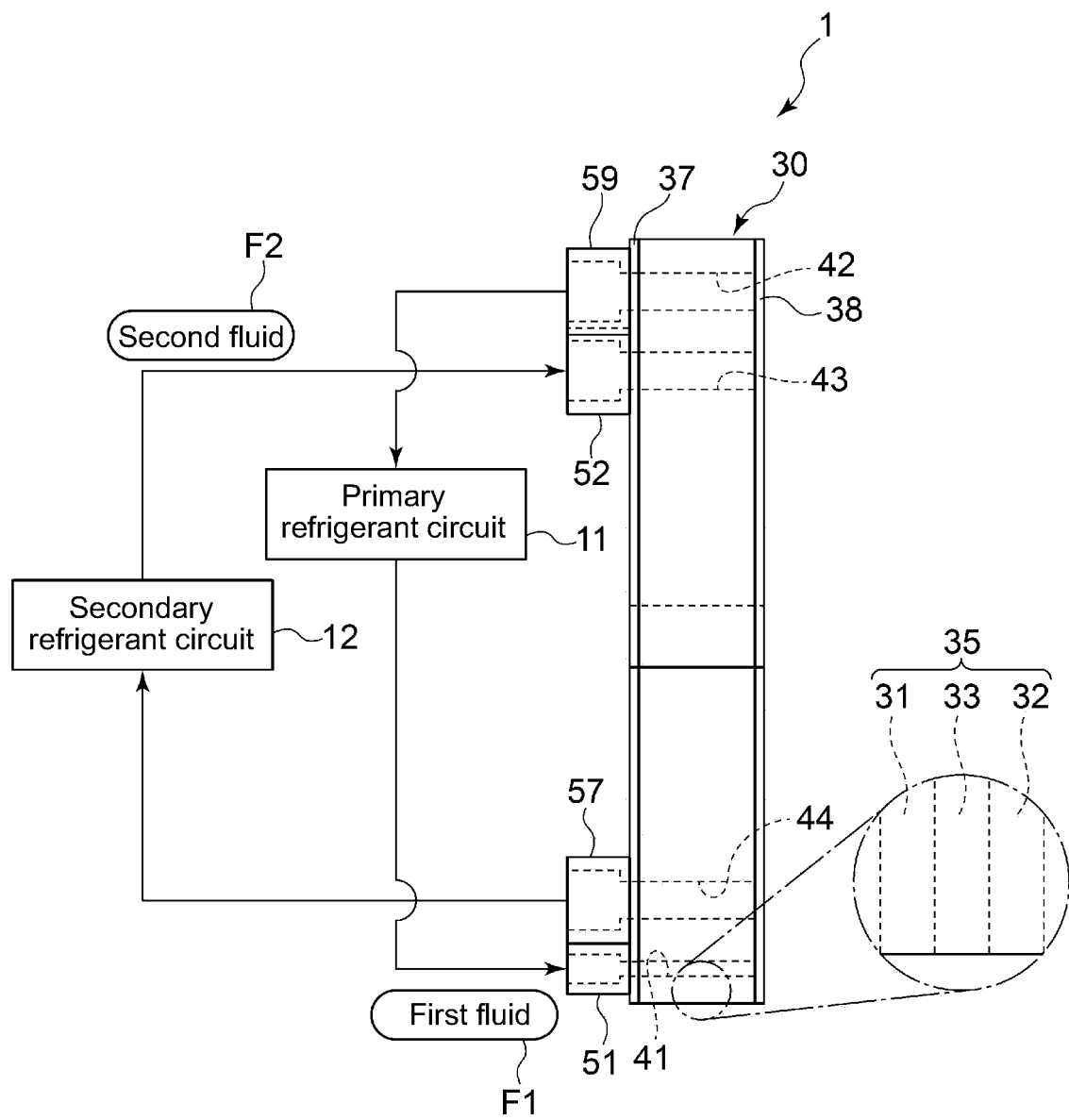


FIG. 2

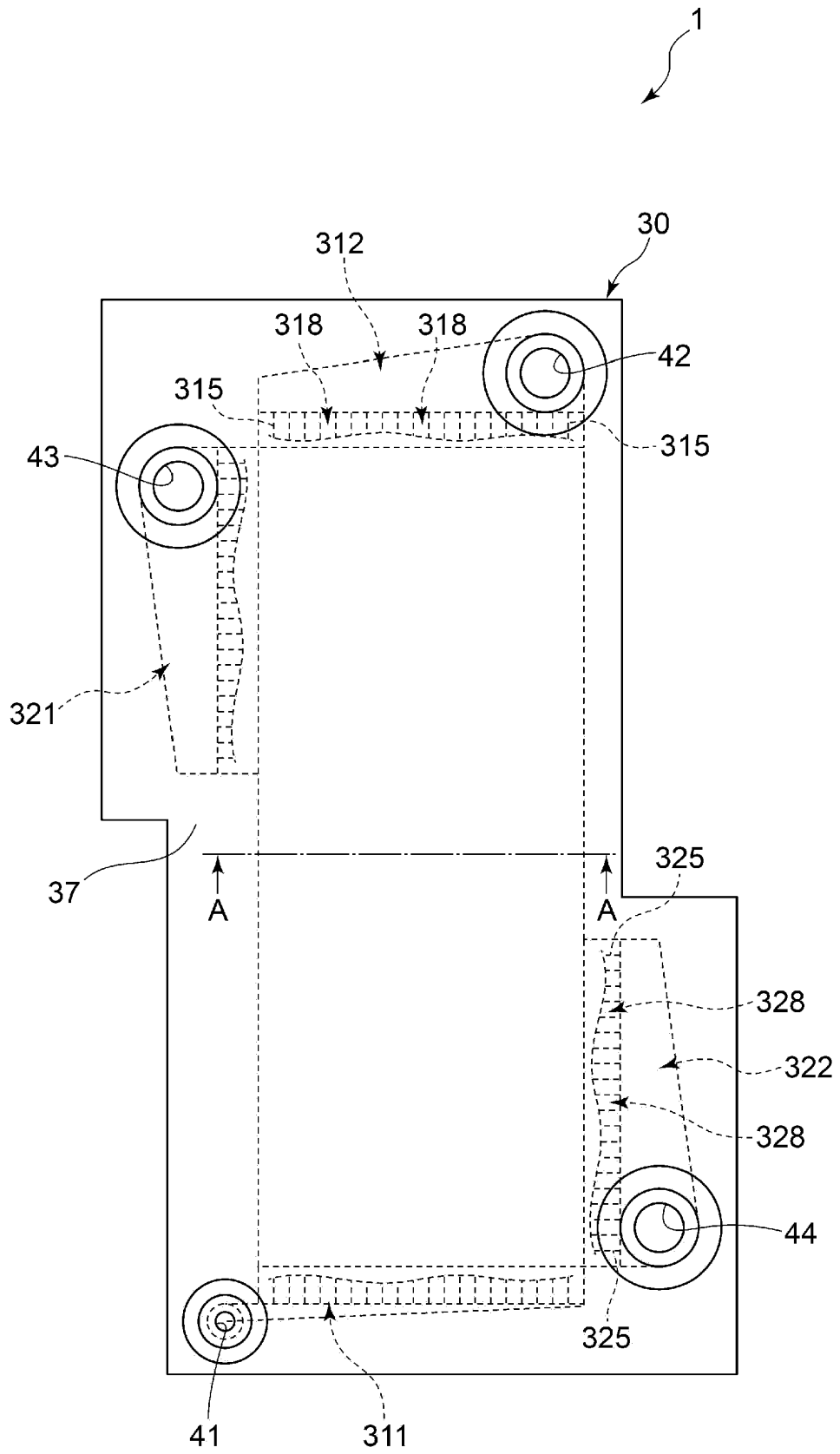
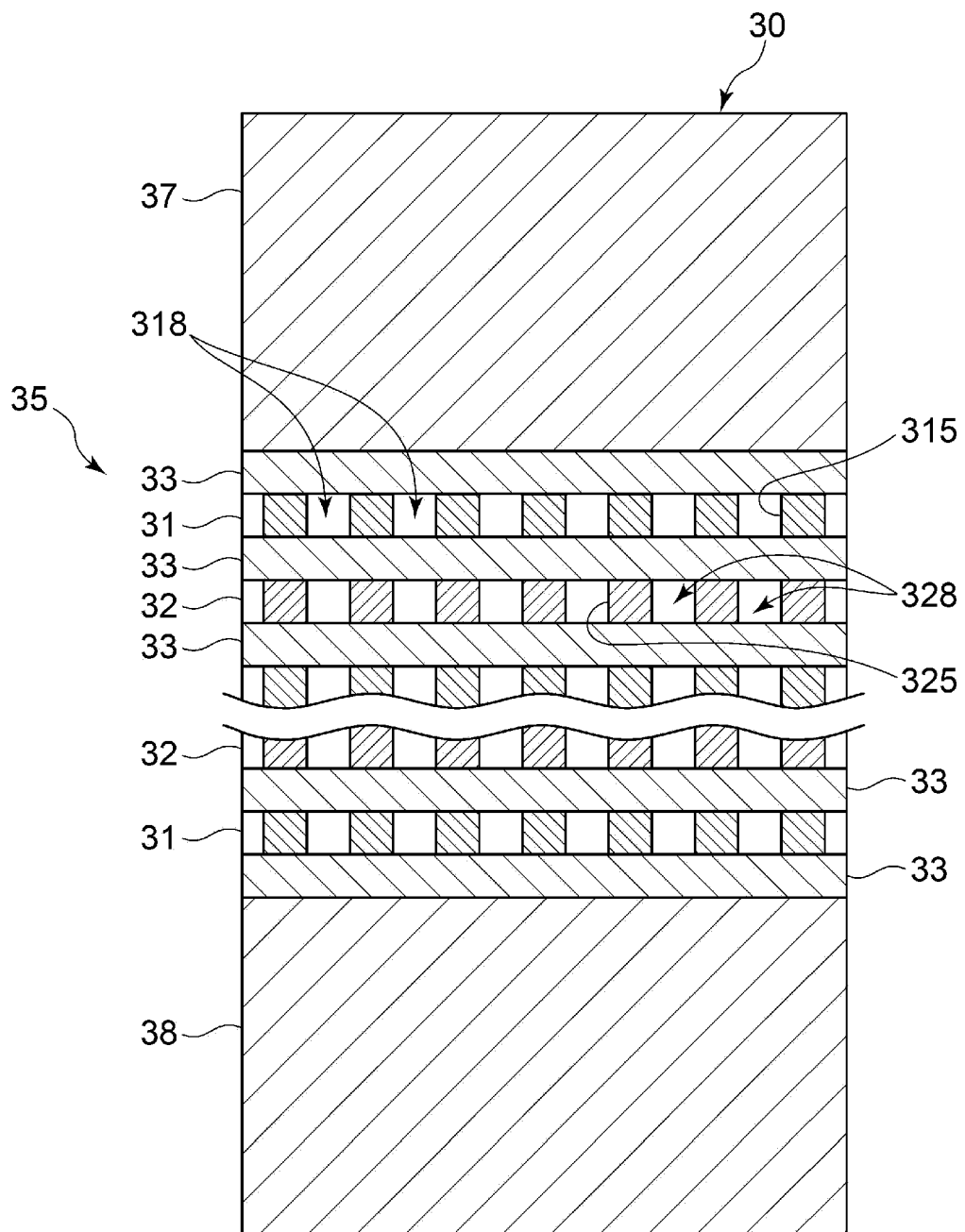


FIG. 3



A-A

FIG. 4

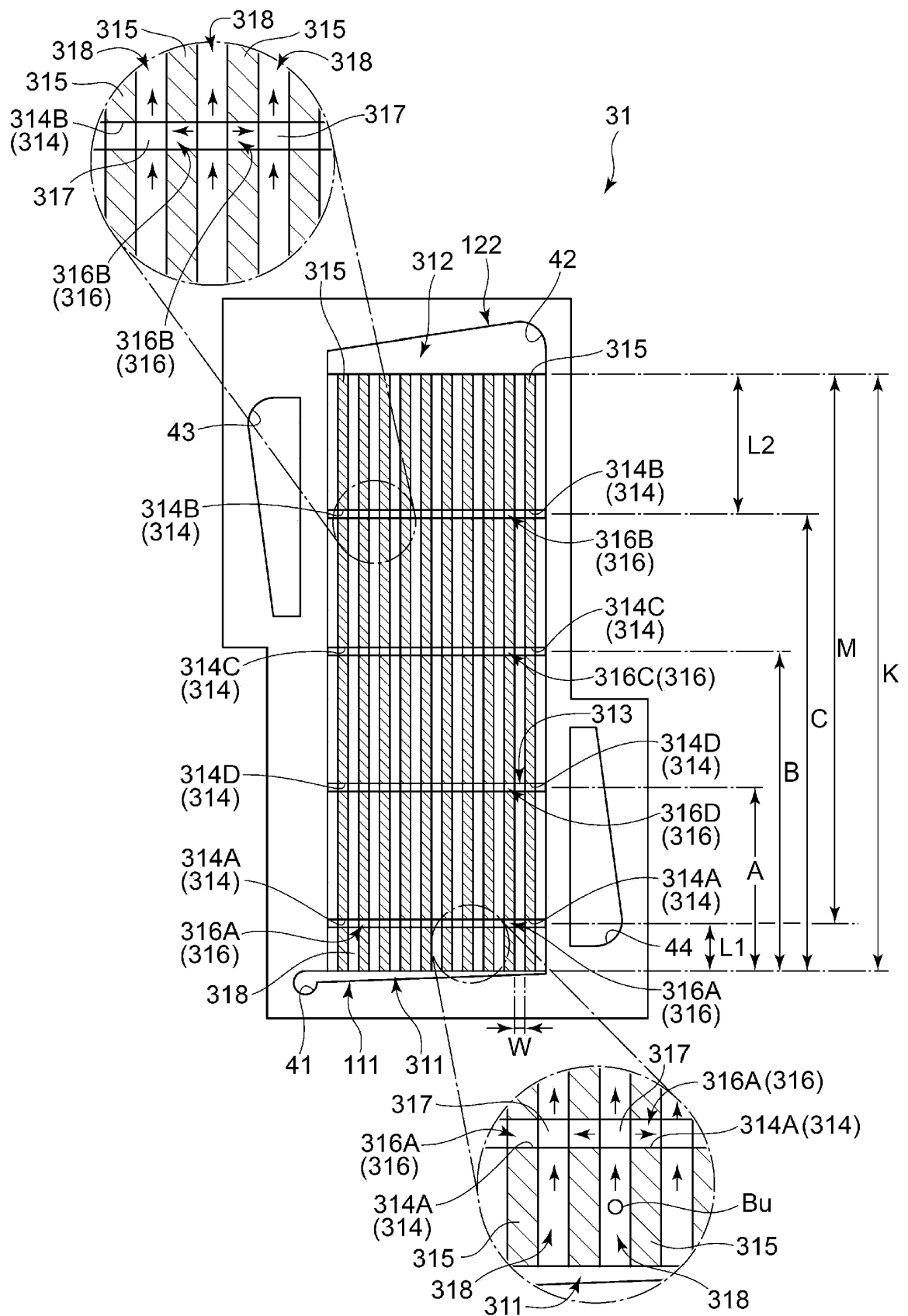


FIG. 5

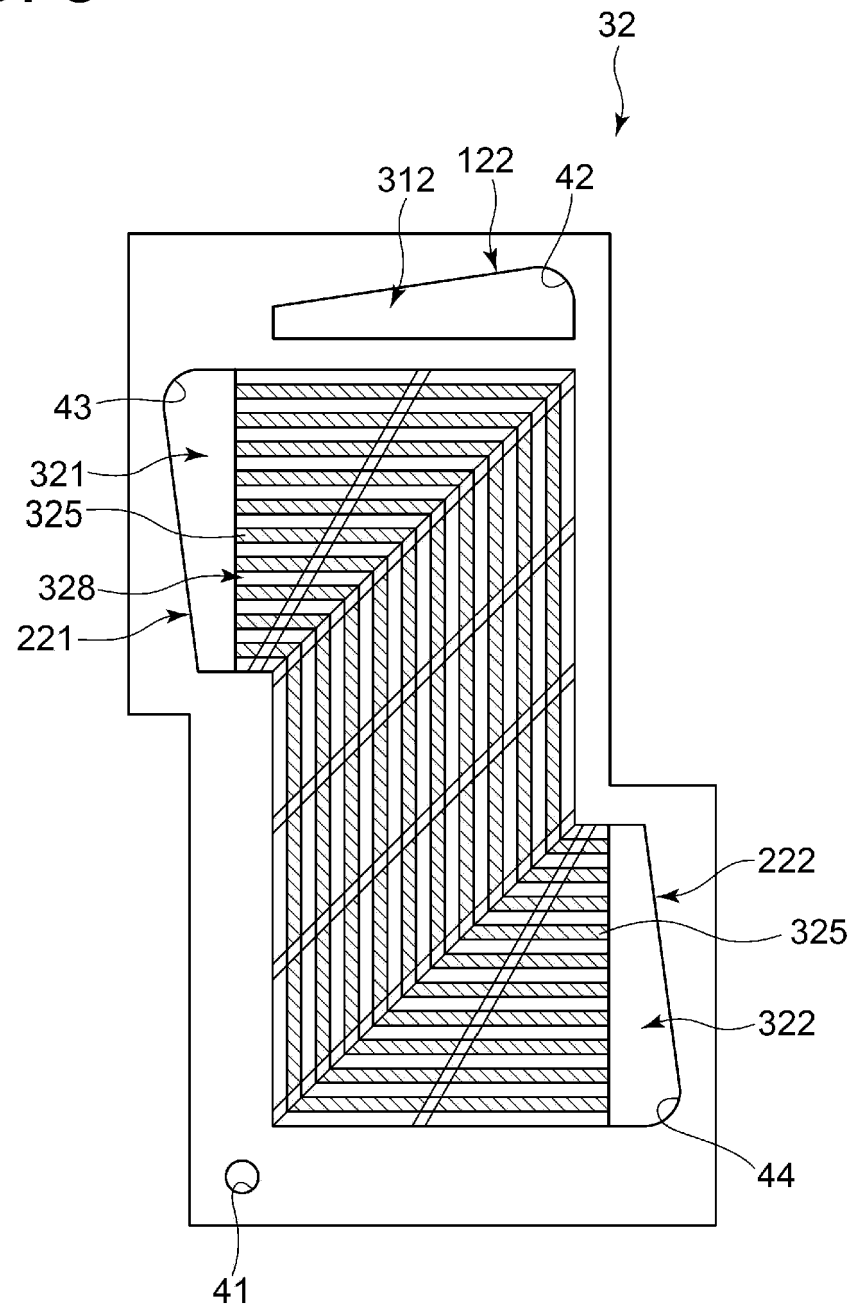


FIG. 6

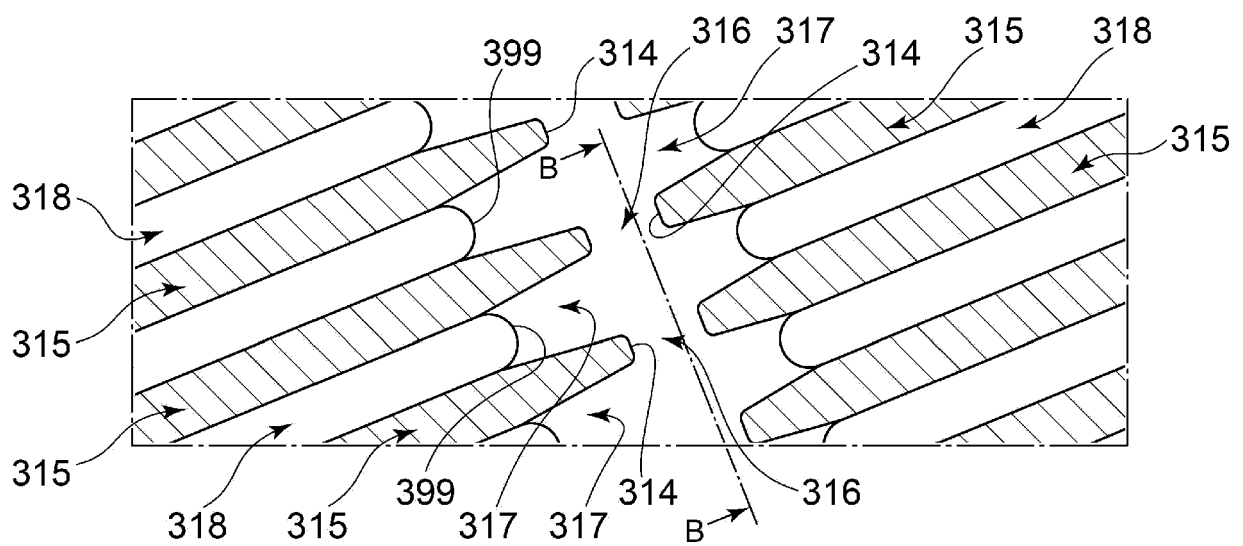
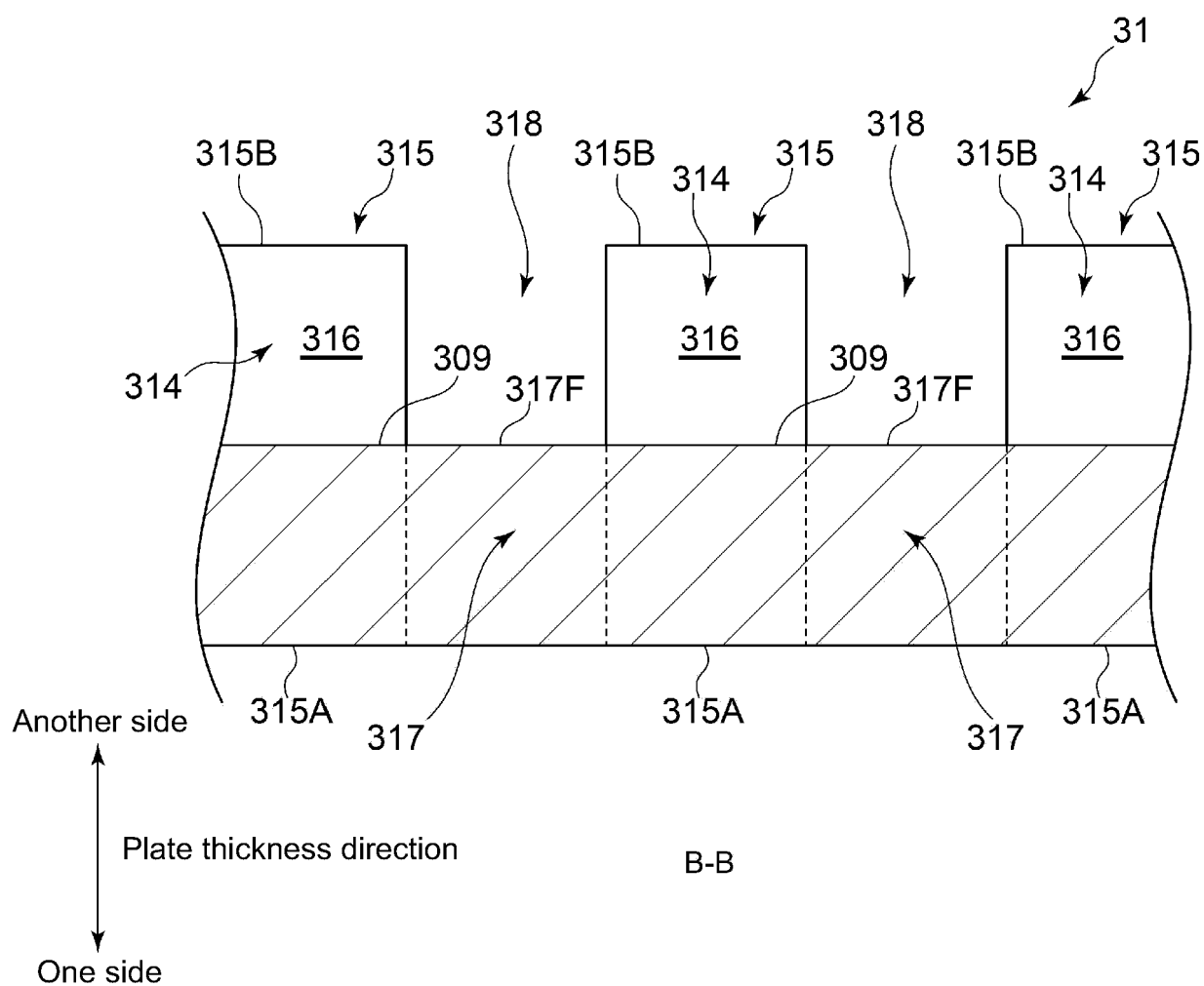
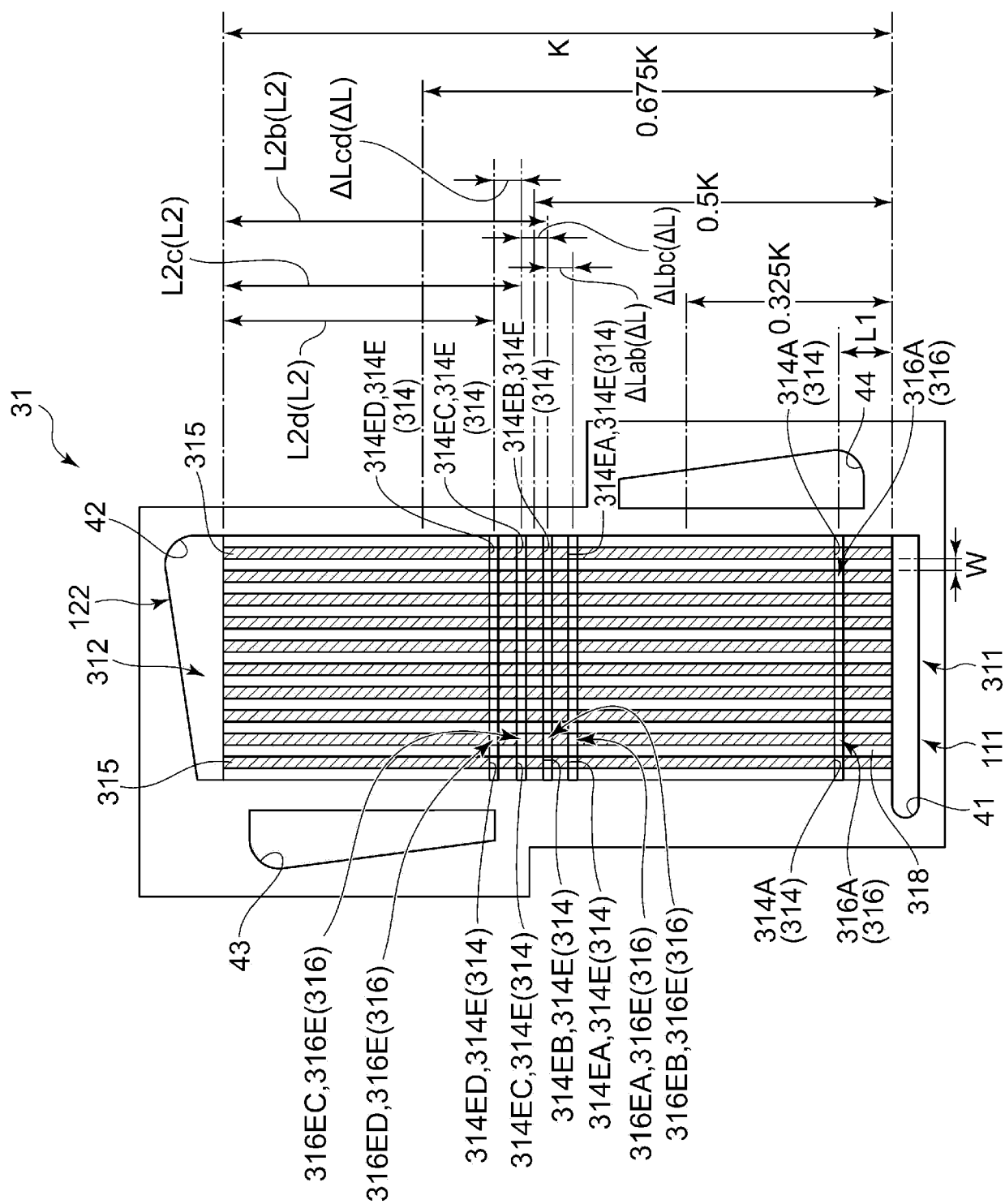


FIG. 7





INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/047036

A. CLASSIFICATION OF SUBJECT MATTER F28F 3/04 (2006.01)i; F28D 9/02 (2006.01)i; F28F 3/08 (2006.01)i; F28F 9/02 (2006.01)i FI: F28F3/04 Z; F28F3/08 301Z; F28D9/02; F28F9/02 301J 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) F28F3/00-3/14; F28D9/00-9/04; 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 1971-2023 Registered utility model specifications of Japan 1996-2023 Published registered utility model applications of Japan 1994-2023 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>CN 111059933 A (XIAN THERMAL POWER RES INST CO) 24 April 2020 (2020-04-24) in particular, paragraphs [0007]-[0025], fig. 1-2</td> <td>1-15</td> </tr> <tr> <td>Y</td> <td>JP 2019-20068 A (MAEKAWA SEISAKUSHO KK) 07 February 2019 (2019-02-07) in particular, paragraphs [0035]-[0063], fig. 6-7, 11-12</td> <td>1-15</td> </tr> <tr> <td>Y</td> <td>WO 2019/043802 A1 (WELCON INC) 07 March 2019 (2019-03-07) in particular, paragraphs [0026]-[0036], fig. 2-5</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>JP 2019-211166 A (KOBE STEEL LTD) 12 December 2019 (2019-12-12) in particular, paragraphs [0033]-[0042], fig. 4, 6</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>JP 2017-530330 A (MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION) 12 October 2017 (2017-10-12) in particular, paragraphs [0028]-[0059], fig. 3-8</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>CN 213455064 U (BEIJING FULLLINK AORI TECH CO LTD) 15 June 2021 (2021-06-15) in particular, paragraphs [0025]-[0028], fig. 1-6</td> <td>1-15</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	CN 111059933 A (XIAN THERMAL POWER RES INST CO) 24 April 2020 (2020-04-24) in particular, paragraphs [0007]-[0025], fig. 1-2	1-15	Y	JP 2019-20068 A (MAEKAWA SEISAKUSHO KK) 07 February 2019 (2019-02-07) in particular, paragraphs [0035]-[0063], fig. 6-7, 11-12	1-15	Y	WO 2019/043802 A1 (WELCON INC) 07 March 2019 (2019-03-07) in particular, paragraphs [0026]-[0036], fig. 2-5	1-15	A	JP 2019-211166 A (KOBE STEEL LTD) 12 December 2019 (2019-12-12) in particular, paragraphs [0033]-[0042], fig. 4, 6	1-15	A	JP 2017-530330 A (MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION) 12 October 2017 (2017-10-12) in particular, paragraphs [0028]-[0059], fig. 3-8	1-15	A	CN 213455064 U (BEIJING FULLLINK AORI TECH CO LTD) 15 June 2021 (2021-06-15) in particular, paragraphs [0025]-[0028], fig. 1-6	1-15
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Date of the actual completion of the international search 07 March 2023	Date of mailing of the international search report 20 March 2023																				
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INTERNATIONAL SEARCH REPORT

International application No.

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2015-223582 A (IHI CORP) 14 December 2015 (2015-12-14) paragraphs [0015]-[0047], fig. 1-3	1-15

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JP 2017-530330 A	12 October 2017	US 2017/0234622 A1 in particular, paragraphs [0058]-[0158], fig. 3-8 WO 2016/051608 A1 EP 3183526 A1 KR 10-2017-0063651 A CN 107208979 A	
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