



EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:

22.01.2020 Bulletin 2020/04

(51) Int Cl.:

F28F 3/08 ^(2006.01)

F28D 9/02 ^(2006.01)

F28F 3/04 ^(2006.01)

(21) Application number: **17908036.1**

(86) International application number:

PCT/JP2017/044707

(22) Date of filing: **13.12.2017**

(87) International publication number:

WO 2018/198420 (01.11.2018 Gazette 2018/44)

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

Designated Validation States:

MA MD TN

• **SHINOZAKI, Masaru**
Tokyo 100-8310 (JP)

• **ASAI, Yugo**
Tokyo 100-8310 (JP)

• **KIMOTO, Yusuke**
Tokyo 100-8310 (JP)

• **MIYAMA, Yoshihiro**
Tokyo 100-8310 (JP)

• **USUDA, Yuichi**
Tokyo 100-8310 (JP)

• **EIJIMA, Yoshitaka**
Tokyo 100-8310 (JP)

• **MARUYAMA, Seiji**
Tokyo 100-8310 (JP)

(30) Priority: **27.04.2017 JP 2017088287**

(71) Applicant: **Mitsubishi Electric Corporation**
Chiyoda-ku

Tokyo 100-8310 (JP)

(72) Inventors:

• **NAKAZONO, Junichi**
Tokyo 100-8310 (JP)

• **IPPOSHI, Shigetoshi**
Tokyo 100-8310 (JP)

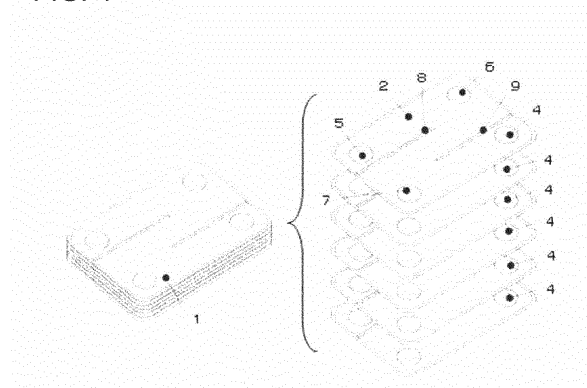
(74) Representative: **Trinks, Ole**

**Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Widenmayerstraße 47
80538 München (DE)**

(54) **PLATE HEAT EXCHANGER**

(57) A plate heat exchanger causes heat exchange to be performed using a plurality of heat transfer plates stacked. Each of the heat transfer plates includes a plate body, a first-medium inlet, a first-medium outlet, a second-medium inlet, a second-medium outlet, and a projection that provides a passage. At least one of the first-medium inlet and the first-medium outlet is located at one of two corners at one end of the plate body which the projection contacts. At least one of the second-medium inlet and the second-medium outlet is located at one of two corners at the other end of the plate body from which the projection is separated.

FIG. 1



DescriptionTECHNICAL FIELD

5 **[0001]** The present invention relates to a plate heat exchanger.

BACKGROUND ART

10 **[0002]** In a well-known plate heat exchanger, heat exchange is performed using media. For example, in such a plate heat exchanger, a plurality of metal plates subjected to presswork in the same manner are stacked, and a medium is made to flow through an interlayer space between a first metal plate and a second metal plate that are stacked and also through an interlayer space between the second metal plate and a third metal plate that are stacked, to thereby perform heat exchange (for example, Patent Literature 1 to 4).

15 **[0003]** A plate heat exchanger is configured to transfer heat between a medium made to flow in an interlayer space and a pair of metal plates defining the interlayer space. To be more specific, a first-layer metal plate and a second-layer metal plate exchange heat with a medium flowing in a first interlayer space between the first-layer metal plate and the second-layer metal plate; the second-layer metal plate and a third-layer metal plate exchange heat with a medium flowing in a second interlayer space between the second-layer metal plate and the third-layer metal plate; and the third-layer metal plate and a fourth-layer metal plate exchange heat with a medium flowing in a third interlayer space between the
20 third-layer metal plate and the fourth-layer metal plate.

[0004] In such a plate heat exchanger, a passage provided in the first interlayer space and a passage provided in the second interlayer space have the same length. Therefore, in the spaces between the plurality of metal plates, substantially uniform heat exchange can be performed.

25 CITATION LISTPATENT LITERATURE**[0005]**

30 PTL 1: Japanese Unexamined Patent Application Publication No. 5-280883
PTL 2: Japanese Unexamined Patent Application Publication No. 2011-149667
PTL 3: Japanese Unexamined Patent Application Publication No. 2000-241094
PTL 4: Japanese Unexamined Patent Application Publication No. 2009-186142

35 SUMMARY OF INVENTIONTECHNICAL PROBLEM

40 **[0006]** However, in view of the diversification of a heat exchange mechanism, it is conceivable that heat exchange is performed using a plurality of media having different heat capacities or a plurality of media having different thermal conductivities. In the above well-known plate heat exchanger, there is a possibility that in the case where the heat capacity of one of the medium is low, the heat exchange by the heat exchanger may depend only on the other medium, which has a greater heat capacity, and as a result the efficiency of heat exchange by the heat exchanger may be decreased; and on the other hand, in the case where the thermal conductivity of one of the media is high, the heat
45 exchange by the heat exchanger may depend on the other medium, which has a lower thermal conductivity, and the efficiency of heat exchange by the heat exchanger may also be decreased.

[0007] The present invention has been made to solve the above problem, and provides a plate heat exchanger in which even if a plurality of media for use in heat exchange have different heat capacities or different thermal conductivities, the decrease in the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon only one of the media, can be reduced.
50

SOLUTION TO PROBLEM

55 **[0008]** A plate heat exchanger according to an Embodiment of the present invention causes heat exchange to be performed using a plurality of heat transfer plates stacked. The plurality of heat transfer plates include a first heat transfer plate that performs heat exchange, and a second heat transfer plate that performs heat exchange, and is stacked on the first heat transfer plate, with a first interlayer space provided between the first and second heat transfer plates, the

first interlayer space being space through which a first medium flows. The first and second heat transfer plates each include: a rectangular plate body that performs heat exchange; a first-medium inlet and a first-medium outlet or a second-medium inlet and a second-medium outlet, the first-medium inlet allowing an inflow of the first medium, the first-medium outlet allowing an outflow of the first medium, the second-medium allowing an inflow of a second medium, the second-medium outlet allowing an outflow of the second medium; and a projection contacting one end of the plate body and separated from an other end of the plate body in a longitudinal direction of the plate body, the projection projecting in a stacking direction where the heat transfer plates are stacked and providing a passage allowing the first medium or the second medium to flow therethrough. At least one of the first-medium inlet and the first-medium outlet is located at one of two corners at the one end of the plate body which the projection contacts. At least one of the second-medium inlet and the second-medium outlet is located at one of two corners at the other end of the plate body from which the projection is separated. The first and second heat transfer plates are stacked such that the one end of the first heat transfer plate and the other end of the second heat transfer plate are in contact with each other.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the above Embodiment of the present invention, even if a plurality of media for use in heat exchange have different heat capacities or different thermal conductivities, the decrease in the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon one of the media, can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is an explanatory diagram illustrating a configuration of a plate heat exchanger according to Embodiment 1.
 FIG. 2 is a top view illustrating a shape of each of heat transfer plates according to Embodiment 1.
 FIG. 3 is a diagram illustrating a stacked state of a plurality of heat transfer plates in the plate heat exchanger according to Embodiment 1.
 FIG. 4 is a top view illustrating a shape of each of heat transfer plates according to Embodiment 2.
 FIG. 5 is a diagram illustrating a stacked state of a plurality of heat transfer plates in a plate heat exchanger according to Embodiment 3.
 FIG. 6 is a top view illustrating a shape of each of heat transfer plates according to Embodiment 4.
 FIG. 7 includes explanatory views indicating positions of a first-medium inlet 4, a first-medium outlet 5, a second-medium inlet 6, and a second-medium outlet 7 in a plate heat exchanger 1 according to Embodiment 5.
 FIG. 8 indicating relationships between passage lengths and temperatures for first refrigerant and second refrigerant in Embodiment 5.

DESCRIPTION OF EMBODIMENTS

[0011] A plate heat exchanger according to each of embodiments will be described in detail with reference to the accompanying drawings. It should be noted that the following embodiments are only exemplary, and the present invention is not limited to the embodiments.

Embodiment 1

[0012] Fig. 1 is a diagram illustrating a configuration of a plate heat exchanger 1 according to Embodiment 1. The plate heat exchanger 1 is a heat exchanger including a plurality of heat transfer plates 2 stacked in a thickness direction thereof. In the plate heat exchanger 1, a first medium or a second medium is made to flow through each of passages corresponding to interlayer spaces between adjoining ones of the stacked heat transfer plates 2, whereby heat exchange is performed between the first medium and the second medium. Arrows in Fig. 1 represent directions in which the medium flows in the interlayer spaces.

[0013] In the plate heat exchanger 1, a first interlayer space between a first heat transfer plate 2 and a second heat transfer plate 2 that are stacked and adjoin each other serves as a passage that allows the first medium to flow therethrough, a second interlayer space between the second heat transfer plate 2 and a third heat transfer plate 2 that are stacked and adjoin each other serves as a passage that allows the second medium to flow therethrough, a third interlayer space between the third heat transfer plate 2 and a fourth heat transfer plate 2 that are stacked and adjoin each other serves as a passage that allows the first medium to flow therethrough, and a fourth interlayer space between the fourth heat transfer plate 2 and a fifth heat transfer plate 2 that are stacked and adjoin each other serves as a passage that allows the second medium to flow therethrough. That is, in the plate heat exchanger 1, different media are made to flow through

different, alternating spaces provided in the above stacking direction such that the first medium flows through the first interlayer space, the second medium flows through the second interlayer space adjacent to the first interlayer space in the thickness direction, and the first medium flows through the third interlayer space adjacent to the second interlayer space in the thickness direction and so on. In the example illustrated in Fig. 1, different media are made to flow such that they alternate in the stacking direction. To be more specific, the first medium flows from the left side to the right side through the first interlayer space serving as the passage between the first heat transfer plate 2 at the top and the second heat transfer plate 2 located under and adjoining the first heat transfer plate 2, the second medium flows from the left side to the right side through the second interlayer space serving as the passage between the second heat transfer plate 2 and the third heat transfer plate 2 located under and adjoining the second heat transfer plate 2, and the first medium flows from the right side to the left side through the third interlayer space serving as the passage between the third heat transfer plate 2 and the fourth heat transfer plate 2 located under the third heat transfer plate 2.

[0014] The heat transfer plates 2 are plate-like elements each having a rectangular plate body and exchange heat with the first medium and the second medium. For example, each heat transfer plate 2 is an element formed by pressing a material such as stainless steel, iron, aluminum or copper.

[0015] The first medium and the second medium transmit heat between an external element and heat transfer plates 2, and are each a liquid medium, a gas medium or a gas-liquid medium, such as water, oil, CO₂ or HFC refrigerant. For example, the first medium is made of a different material from the material of the second medium, and has a higher thermal conductivity than the second medium.

[0016] Fig. 2 is a top view illustrating a shape of each of the heat transfer plates 2 according to Embodiment 1. Each heat transfer plate 2 includes, in the plate body thereof, two projections 8 and 9, a first-medium inlet 4, a first-medium outlet 5, a second-medium inlet/outlet 6, a second-medium outlet 7 and herringbone uneven portions 3.

[0017] A single heat transfer plate 2 is subjected to presswork such that two projections 8 and 9 are formed to project from a surface of the heat transfer plate 2 in a single direction in order to ensure an interlayer space between the heat transfer plate 2 and another heat transfer plate 2 stacked and adjoining each other. That is, the two projections 8 and 9 each project in the stacking direction in such a manner as to provide a passage for the first medium or the second medium, which will be described later

[0018] Reverse sides of the projections 8 and 9 form depressions that are depressed toward in the same direction as the projections 8 and 9 project. The projections 8 and 9 as illustrated in Fig. 2 each extend linearly in a longitudinal direction of the heat transfer plate 2, which is formed in the shape of a rectangular plate. The projection 8 is provided to contact one end of the heat transfer plate 2 but is separated from the other end of the heat transfer plate 2. The projection 9 is provided to contact the other end of the heat transfer plate 2 but is separated from the one end of the heat transfer plate 2.

[0019] The two projections 8 and 9 are located on lines with reference to which the heat transfer plate 2 is divided into three sections. To be more specific, the two projections 8 and 9 extending in the longitudinal direction are located to offset from respective positions where the heat transfer plate 2 is equally divided into three sections, toward one end of the heat transfer plate 2 in a width direction thereof. The height of each of the projections 8 and 9 in the stacking direction will be described later in detail.

[0020] The first-medium inlet 4 and the first-medium outlet 5 are each an opening portion that allows the first medium to flow into or flow out of an interlayer space between a heat transfer plate 2 and another heat transfer plate 2 which is located on one side relative to the heat transfer plate 2. The first medium flows into the above interlayer space through the first-medium inlet 4 and flows out of the interlayer space through the first-medium outlet 5. One of the first-medium inlet 4 and the first-medium outlet 5 is located at one corner on one of diagonal lines of the above heat transfer plate 2. It should be noted that the heat transfer plates 2 are rectangular. The other of the first-medium inlet 4 and the first-medium inlet 5 is located at the other corner on the above one diagonal line of the heat transfer plate 2.

[0021] The second-medium inlet 6 and the second-medium outlet 7 are each an opening portion that allows the second medium to flow into or flow out of another interlayer space between the heat transfer plate 2 including the above inlet 6 and outlet 7 and still another heat transfer plate 2 which is located on the other side relative to the heat transfer plate 2 including the above inlet 6 and outlet 7. The second medium flows into the above other interlayer space through the second-medium inlet 6 and flows out of the other interlayer space through the second-medium outlet 7. One of the second-medium inlet 6 and the second-medium outlet 7 is located at one corner on the other diagonal line of the above heat transfer plate 2. The other of the second-medium inlet 6 and the second-medium outlet 7 is located at the other corner on the other diagonal line of the heat transfer plate 2.

[0022] The herringbone uneven portions 3 are arranged in the pattern of a herringbone, with the projections 8 and 9 interposed between columns of parallel ones of the herringbone portions 3, and the surfaces of the herringbone uneven portion 3 are recessed or projected, in order to increase the efficiency of heat exchange between the first medium flowing in the above interlayer space and the second medium flowing in the above other interlayer space. In other words, the herringbone uneven portions 3 are arranged such that they are divided into three groups by the two projections 8 and 9.

[0023] The herringbone uneven portions 3 are projected or recessed in the thickness direction of the plate heat

exchanger 1, that is, in the stacking direction. Furthermore, the herringbone uneven portions 3 are arranged in the pattern of a V-shaped herringbone which tapers from one end side of the heat transfer plate 2 toward the other end side of the heat transfer plate 2.

[0024] In consideration of the flow rate of the first medium, in the thickness direction of the plate heat exchanger 1, space is provided between the herringbone uneven portions 3 and the above other heat transfer plate 2 located on the above one side. Similarly, in consideration of the flow rate of the second medium, in the thickness direction of the plate heat exchanger 1, space is provided between the herringbone uneven portions 3 and the above still other heat transfer plate 2 located on the above other side.

[0025] In the case where each heat transfer plate 2 includes the herringbone uneven portions 3 arranged in the above manner, the projections or recesses of one of heat transfer plates 2 defining a single interlayer space and the recesses or projections of the other of the heat transfer plates 2 defining the above single interlayer space narrow the interlayer space in the thickness direction. When the medium flowing in the above interlayer space flows through the above narrowed part thereof, the flow rate of the medium increases. It is therefore possible to further increase the efficiency of heat exchange between the medium flowing in the interlayer space and the heat transfer plate 2.

[0026] Fig. 3 is an explanatory diagram illustrating a stacked state of the heat transfer plates 2 included in the plate heat exchanger 1 according to Embodiment 1. With respect to the above stacked state, Fig. 3 schematically illustrates by way of example the stacked state of two of the heat transfer plates 2 in the plate heat exchanger 1. Fig. 3, the right part, illustrates the two heat transfer plates 2 that are located such that one of them is rotated by 180 degrees relative to the other in a planar direction of the plate, which is different from the thickness direction in which they are stacked; the middle part illustrates the stacked state of the two heat transfer plates 2; and the left part illustrates a section of the stacked heat transfer plates 2, which is taken along line A-A in the middle part.

[0027] As illustrated in Figs. 1 and 3, in the plate heat exchanger 1 according to Embodiment 1, a plurality of heat transfer plates 2 having the same plate-like shape are arranged such that they are alternately rotated by 180 degrees in the planar direction.

[0028] The first heat transfer plate 2 and the second heat transfer plate 2 are stacked such that the second heat transfer plate 2 is rotated by 180 degrees relative to the first heat transfer plate 1. As illustrated in Fig. 1, in the first and second heat transfer plates 2, the first-medium inlet 4 of the first heat transfer plate 2 and the first-medium inlet 4 of the second heat transfer plate 2 face each other, while spaced from each other in the thickness direction; and the first-medium outlet 5 of the first heat transfer plate 2 and the first-medium outlet 5 of the second heat transfer plate 2 face each other, while spaced from each other in the thickness direction. On the other hand, the second-medium inlet 6 of the first heat transfer plate 2 and the second-medium inlet 6 of the second heat transfer plate 2 are joined to each other, and the second-medium outlet 7 of the first heat transfer plate 2 and the second-medium outlet 7 of the second heat transfer plate 2 are joined to each other. Furthermore, the second heat transfer plate 2 and the third heat transfer plate 2 are stacked such that the second-medium inlet 6 of the second heat transfer plate 2 and the second-medium inlet 6 of the third heat transfer plate 2 face each other, while spaced from each other in the thickness direction, the second-medium outlet 7 of the second heat transfer plate 2 and the second-medium outlet 7 of the third heat transfer plate 2 face each other, while spaced from each other in the thickness direction, the first-medium inlet 4 of the second heat transfer plate 2 and the first-medium inlet 4 of the third heat transfer plate 2 are joined to each other, and the first-medium outlet 5 of the second heat transfer plate 2 and the first-medium outlet 5 of the third heat transfer plate 2 are joined to each other. The same is true of the subsequent heat transfer plates 2. That is, the fourth heat transfer plate, the fifth heat transfer plate 2 and subsequent heat transfer plates 2 to be stacked are alternately rotated by 180 degrees in the same manner as described above.

[0029] In the plate heat exchanger 1 including the heat transfer plates 2 rotated alternately by 180 degrees as described above, the first medium flows into the first interlayer space between the first heat transfer plate 2 and the second heat transfer plate 2 through the first-medium inlets 4 thereof that face each other, while spaced from each other in the thickness direction. On the other hand, the second medium neither flows into nor flows out of the first interlayer space, since the second-medium inlet 6 of the first heat transfer plate 2 and the second-medium inlet 6 of the second heat transfer plate 2 are joined to each other and the second-medium outlet 7 of the first heat transfer plate 2 and the second-medium outlet 7 of the second heat transfer plate 2 are joined to each other.

[0030] In the plate heat exchanger 1 including the heat transfer plates 2 rotated alternately by 180 degrees as described above, the second medium flows into and flows out of the second interlayer space between the second heat transfer plate 2 and the third heat transfer plate 2, through the second-medium inlet 6 and the second-medium outlet 7 which face each other, while spaced from each other in the thickness direction. On the other hand, the first medium neither flows into nor flows out of the second interlayer space because the first-medium inlet 4 of the second heat transfer plate 2 and the first-medium inlet 4 of the third heat transfer plate 2 are joined to each other and the first-medium outlet 5 of the second heat transfer plate 2 and the first-medium outlet 5 of the third heat transfer plate 2 are joined to each other.

[0031] In the plate heat exchanger 1, since the heat transfer plates 2 are alternately rotated by 180 degrees as described above, first-medium inflow/outflow interlayer spaces and second-medium inflow/outflow interlayer spaces are alternately

provided in the thickness direction of the plate heat exchanger 1. The first-medium inflow/outflow interlayer spaces are each space that allows the inflow and the outflow of the first medium, but does not allow the inflow or the outflow of the second medium, and the second-medium inflow/outflow interlayer spaces are each space that allows the inflow and the outflow of the second medium, but does not allow the inflow or the outflow of the first medium.

[0032] Each of the first-medium inflow/outflow interlayer spaces as described above includes facing part where the first-medium inlet 4 of the first heat transfer plate 2 and the first-medium inlet 4 of the second heat transfer plate 2 face each other, and another facing part where the first-medium outlet 5 of the first heat transfer plate 2 and the first-medium outlet 5 of the second heat transfer plate 2 face each other. One of those facing parts between the first-medium inlet and outlet 4 and 5 for the inflow and the outflow of the first medium is located at one corner of the heat transfer plate 2, which is located at one end of one of diagonal lines of the heat transfer plate 2. The other facing part between the first-medium inlet 4 and the first-medium outlet 5 is located at another corner of the heat transfer plate 2, which is located at the other end of the above one diagonal line on which the one corner is located. In the example illustrated in Fig. 1, the projection 8 that linearly extends to contact one end of the heat transfer plate 2 but is separated from the other end of the heat transfer plate 2, the projection 9 that linearly extends to contact the above other end of the heat transfer plate 2 but is separated from the above one end of the heat transfer plate 2, the outer periphery of the heat transfer plate 2 and the above two facing parts define an S-shaped passage. The two facing parts are located at two respective ends of the S-shaped passage. Therefore, in the plate heat exchanger 1, a folded flow passage that extends from one end of the heat transfer plate 2 to the other end thereof in the longitudinal direction, then turns from the other end toward the one end, and then further turns from the one end toward the other end is provided for the first medium having a higher thermal conductivity or a smaller heat capacity than the second medium.

[0033] The second-medium inflow/outflow interlayer space described above includes one facing part where the second-medium inlet/outlet 6 of the first heat transfer plate 2 and the second-medium inlet/outlet 7 of the second heat transfer plate 2 face each other, and another facing part where the second-medium inlet/outlet 7 of the first heat transfer plate 2 and the second-medium inlet/outlet 6 of the second heat transfer plate 2 face each other. One of these facing parts between the second-medium inlet and outlet 6 and 7 for the inflow and the outflow of the second medium is located at one corner of the heat transfer plate 2, which is located at one end of the above other diagonal line of the heat transfer plate 2. The other facing part between the second-medium inlet and outlet 6 and 7 is located at another corner of the heat transfer plate 2, which is located at the other end of the other diagonal line on which the one corner is positioned. In the example illustrated in Fig. 1, the projection 8 that linearly extends to contact one end of the heat transfer plate 2 but is separated from the other end of the heat transfer plate 2, the projection 9 that linearly extends to contact the other end of the heat transfer plate 2 but is separated from the one end of the heat transfer plate 2, the outer periphery of the heat transfer plate 2 and the above two second-medium facing parts define a Z-shaped passage corresponding to middle part of the S-shaped passage. The two facing parts are located at two respective ends of the Z-shaped passage. Therefore, in the plate heat exchanger 1, an unfolded passage that extends from one end of the heat transfer plate 2 to the other end thereof in the longitudinal direction, without turning from the above other end toward the above one end after reaching the other end from the one end, is provided for the second medium having a lower thermal conductivity or a greater heat capacity than the first medium.

[0034] As described above, the two projections 8 and 9 extending in the longitudinal direction offset toward one end of the heat transfer plate 2 in the thickness direction thereof from respective positions where the heat transfer plate 2 is equally divided into three sections. Therefore, as illustrated in the left part of Fig. 3, in the stacked heat transfer plates 2 alternately rotated by 180 degrees, the lower surface of one of any adjoining two of the heat transfer plates 2 is in contact with the two projections 8 and 9 of the other heat transfer plate 2. Because of this contact of the adjoining heat transfer plates 2, the S-shaped folded passage can be formed with a higher accuracy, and the Z-shaped unfolded passage can also be formed with a higher accuracy.

[0035] In interlayer spaces having the same capacity, the distance between the both ends of the Z-shaped unfolded passage which corresponds to part of the S-shaped folded passage and through which the second medium is to flow is shorter than the distance between the both ends of the S-shaped folded passage through which the first medium is to flow. Furthermore, the amount of change in a vector from the one end to the other end of the Z-shaped unfolded passage along the Z-shaped unfolded passage is smaller than the amount of change in a vector from one end to the other end of the S-shaped folded passage along the S-shaped folded passage, the Z-shaped unfolded passage being a passage which corresponds to part of the S-shaped folded passage and through which the second medium is to flow, the S-shaped folded passage being a passage through which the first medium is to flow. Thus, the flow rate of the second medium having a lower thermal conductivity or a greater heat capacity than the first medium can be made higher than the flow rate of the first medium. Therefore, in the plate heat exchanger 1 according to Embodiment 1, even if a plurality of media to be subjected to heat exchange have different heat capacities or even if a plurality of media having different thermal conductivities are applied to heat exchange, the decrease of the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon one of the media, can be reduced.

[0036] In the plate heat exchanger 1 according to Embodiment 1, as described above, a first-medium passage that

allows the first medium to flow therethrough and a second-medium passage that allows the second medium to flow therethrough are provided separately from each other. To be more specific, the first-medium passage is provided in the first interlayer space, and the second-medium passage is provided in the second interlayer space that is adjacent to the first interlayer space, with a heat transfer plate 2 interposed between them. Therefore, the first medium and the second medium do not mix with each other. Furthermore, in the plate heat exchanger 1 according to Embodiment 1, the distance from the inlet to the outlet in the first medium passage to the outlet therefor is longer than that from the inlet to the outlet in the second-medium passage, and the amount of change in the vector from the inlet to the outlet in the first-medium passage is larger than the amount of change in the vector from the inlet to the outlet in the second-medium passage. Therefore, the flow rate of the second medium having the lower thermal conductivity or the greater heat capacity can be made higher than the flow rate of the first medium having the higher thermal conductivity or the smaller heat capacity.

[0037] As described above, in the configuration of the plate heat exchanger 1 according to Embodiment 1, the flow rate, the amount of change in the vector, or the distance from the inlet to the outlet, which are associated with the first medium, are different from those associated with the second medium by stacking a plurality of heat transfer plates 2 having the same shape such that they are alternately rotated by 180 degrees, without employing a plurality of heat transfer plates having different shapes. Therefore, the plate heat exchanger 1 according to Embodiment 1 also contributes to the reduction of the manufacturing cost.

[0038] With respect to Embodiment 1, it is described above by way of example that each heat transfer plate 2 includes two projections 8 and 9. However, the present invention is not limited to such a case. Each heat transfer plate 2 may be formed to include three or more projections 8 and 9. In this case, the length of each of the passages can be further increased. It is therefore possible to further reduce the decrease of the efficiency of heat exchange.

[0039] With respect to Embodiment 1, it is also described above by way of example that the two projections 8 and 9 of each heat transfer plate 2 are integrally formed by subjecting the heat transfer plate 2 to presswork such that they project from the top surface thereof toward one side. However, the present invention is not limited to such a case. In order to ensure an interlayer space between any adjoining two of the stacked heat transfer plate 2, each heat transfer plate 2 may have two projections 8 and 9 that are formed as separate elements. For example, a frame-like plate having two projections 8 and 9 may be provided between any two adjoining heat transfer plates 2. Thereby, the flexibility in manufacturing the plate heat exchanger 1 is increased.

[0040] With respect to Embodiment 1, it is described above by way example that space in the thickness direction of a plate heat exchanger 1 is provided between the herringbone uneven portions 3 of a heat transfer plate 2 and another heat transfer plate 2 stacked on the above heat transfer plate 2 on one side and between the herringbone uneven portions 3 and still another heat transfer plate 2 stacked on the above heat transfer plate 2 on the other side. However, the present invention is not limited to such a case. In consideration of the improvement in the efficiency of heat exchange, the sizes of the projections or recesses corresponding to the herringbone uneven portions 3 in the thickness direction may be increased such that the above space is not provided. By contrast, in consideration of reduction of the efficiency of heat exchange, increasing of the flow rate of the medium, etc., the sizes of the projections or recesses of the herringbone uneven portion 3 in the thickness direction may be reduced. Furthermore, in consideration of further reduction of the efficiency of heat exchange or further increasing of the flow rate of the medium, the herringbone uneven portions 3 may be omitted.

[0041] With respect to Embodiment 1, it is described above by way of example that the projections 8 and 9 linearly extending in the longitudinal direction are provided at the heat transfer plate 2. However, the present invention is not limited to such a case. Curved projections 8 and 9 may be provided in the case where the amount of change in the vector from one end to the other end of the passage through which the first medium is to flow and the amount of change in the vector from one end to the other end of the passage through which the second medium is to flow are made different from each other.

[0042] With respect to Embodiment 1, it is described above by way of example that the heat transfer plate 2 includes two projections 8 and 9 extending in the longitudinal direction. However, the present invention is not limited to such a case. The heat transfer plate 2 may include three or more projections 8 and 9 in the case where the amount of change in the vector from one end to the other end of the passage through which the first medium is to flow and the amount of change in the vector from one end to the other end of the passage through which the second medium is to flow are made different from each other. For example, if three or more odd number of projections are provided, it suffices that a projection or projections extending to contact one end of the heat transfer plate 2 but separated from the other end of the heat exchanger 2 and a projection or projections extending to contact the above other end but separated from the above one end are alternately provided; and the first-medium inlet/outlet 4 is provided at one of corners located on an end of the heat exchanger 2, which the closest one of the projections contacts, and the first-medium inlet/outlet 5 is provided at the other corner of the corners which is opposite to the above one corner in the width direction of the heat transfer plate 2. Furthermore, for example, if a four or more even number of projections are provided, it suffices that projections contacting one end of the heat transfer plate 2 but separated from the other end thereof and projections contacting the above other end but separated from the above one end are alternately located, and the first-medium

inlet/outlet 4 is provided at one of corners located on an end of the heat exchanger 2, which the closest one of the projections contacts, and the first-medium inlet/outlet 5 is provided at the other corner that is opposite to the above one corner on the diagonal line of the heat transfer plate 2.

[0043] With respect to Embodiment 1, it is described above by way of example that each heat transfer plate 2 includes the herringbone uneven portions 3 arranged in the pattern of a V-shaped herringbone tapering from one end of the heat transfer plate 2 toward the other end thereof in the longitudinal direction of the heat transfer plate 2. However, the present invention is not limited to such a case. Each heat transfer plate 2 may include herringbone uneven portions 3 arranged in the pattern of a V-shaped herringbone tapering from the above one end toward the above other end in the longitudinal direction of the heat transfer plate 2.

Embodiment 2

[0044] Regarding the plate heat exchanger 1 according to Embodiment 1, it is described above by way of example that the first-medium inlet 4 and the first-medium outlet 5 have substantially the same opening areas as the second-medium inlet 6 and the second-medium outlet 7 as illustrated in Fig. 2. On the other hand, in a plate heat exchanger 1 according to Embodiment 2, the first-medium inlet 4 and the first-medium outlet 5 have different opening areas from the second-medium inlet 6 and the second-medium outlet 7. This configuration will be described with reference to Fig. 4. In the plate heat exchanger 1 according to Embodiment 2, descriptions concerning elements which are the same as or similar to those of the plate heat exchanger 1 according to Embodiment 1 will be omitted.

[0045] Fig. 4 is a top view illustrating a shape of each of heat transfer plates 2 in Embodiment 2. The heat transfer plate 2 includes two projections 8 and 9, a first-medium inlet 4, a first-medium outlet 5, a second-medium inlet 6, a second-medium outlet 7, and herringbone uneven portions 3.

[0046] In Embodiment 2, the first-medium inlet 4 and the first-medium outlet 5 have smaller opening areas than the second-medium inlet 6 and the second-medium outlet 7. The other configurations are the same as those of Embodiment 1, and their descriptions will thus be omitted.

[0047] One of the projections 8 which is the closest to the first-medium inlet 4 and the second-medium outlet 7 is separated from one end of the heat transfer plate 2 but extends to contact the other end of the heat transfer plate 2. Because of this configuration of the projection 8, part of the first-medium passage that is close to the first-medium inlet 4 is smaller than part of the second-medium passage that is close to the second-medium outlet 7. However, in Embodiment 2, since the opening area of the first-medium inlet 4 is smaller than the opening area of the second-medium inlet 6, it is possible to reduce the difference between the pressure loss in the first medium at the first-medium inlet 4 and the first-medium outlet 5 and the pressure loss in the second medium at the second-medium inlet 6 and the second-medium outlet 7.

[0048] One of the projections 9 that is the closest to the first-medium outlet 5 and the second-medium inlet/outlet 6 extends to contact the one end of the heat transfer plate 2, but is separated from the other end of the heat transfer plate 2. Because of this configuration of the projection 9, part of the first-medium passage that is close to the first-medium outlet 5 is smaller than part of the second-medium passage that is close to the second-medium inlet 6. However, in Embodiment 2, since the opening area of the first-medium inlet 5 is smaller than the opening area of the second-medium outlet 6, it is possible to reduce the difference between the pressure loss in the first medium at the first-medium inlet 5 and the pressure loss in the second medium at the second-medium outlet 6. Therefore, in the plate heat exchanger 1 according to Embodiment 2, even if a plurality of media having different heat capacities or different thermal conductivities are used, it is possible to reduce the decrease in the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon one of the media, while reducing the above difference in pressure loss.

Embodiment 3

[0049] With respect to the plate heat exchanger 1 according to Embodiment 1, it is described above by way of example that a plurality of heat transfer plates 2 are stacked such that they are alternately rotated by 180 degrees as illustrated in Figs. 1 and 3. By contrast, in a plate heat exchanger 1 according to Embodiment 3, a plurality of heat transfer plates 2 are stacked such that at least some of the heat transfer plates 2 are stacked in the same orientation without being rotated by 180 degrees. This configuration will be described with reference to Fig. 5. Regarding the plate heat exchanger 1 according to Embodiment 3, descriptions of elements that are the same as or similar to those of the plate heat exchanger 1 according to Embodiment 1 will be omitted.

[0050] Fig. 5 is an explanatory diagram illustrating a stacked state of a plurality of heat transfer plates 2 in the plate heat exchanger 1 according to Embodiment 3. Fig. 5 schematically illustrates as an example a stacked state of at least two of the plurality of heat transfer plates 2 included in the plate heat exchanger 1. Fig. 5, the right part, illustrates two heat transfer plates 2 that are in the same orientation without being rotated by 180 degrees in the planar direction of the plate, which is different from the thickness direction in which they are stacked; Fig. 5, the middle part, illustrates a stacked

state of the two heat transfer plates 2; and Fig. 5, the left part, illustrates a section of the stacked heat transfer plates 2, which is taken along line B-B.

[0051] In the plate heat exchanger 1 according to Embodiment 3, two heat transfer plates 2 having the same shape and oriented in the same direction are stacked. Therefore, the two projections 8 and 9 of the lower one of the two heat transfer plates 2 are not in contact with the upper one of the heat transfer plates 2. In other words, space is provided between the two projections 8 and 9 of the lower heat transfer plate 2 and the upper heat transfer plate 2. Therefore, the degree to which the two projections 8 and 9 divide the passage in the width direction of the heat transfer plate 2 is reduced, thereby promoting the flow from the medium outlet toward the medium inlet.

[0052] In the case where the configuration in which the heat transfer plates are stacked while oriented in the same direction is applied to an interlayer space serving as a passage that allows the second medium to flow, the flow rate of the second medium having a lower thermal conductivity or a greater heat capacity than the first medium can be further increased. Therefore, in the plate heat exchanger 1 according to Embodiment 3, even if a plurality of media having different thermal conductivities or different heat capacities are used, it is possible to reduce the decrease in the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon one of the media.

Embodiment 4

[0053] With respect to the plate heat exchanger 1 according to Embodiment 1, it is described above by way of example that as illustrated in Fig. 2, each of the heat transfer plates 2 includes two projections 8 and 9. By contrast, in a plate heat exchanger 1 according to Embodiment 4, each of the heat transfer plate 2 includes a single projection 8. This will be described with reference to Fig. 6. Regarding the plate heat exchanger 1 according to Embodiment 4, descriptions concerning elements which are the same as or similar to those of the plate heat exchanger 1 according to Embodiment 1 will be omitted.

[0054] Fig. 6 is a top view illustrating a shape of each of heat transfer plates 2 in Embodiment 4. Each heat transfer plate 2 includes a single projection 8, a first-medium inlet 4, a first-medium outlet 5, a second-medium inlet 6, a second-medium outlet 7, and herringbone uneven portions 3.

[0055] In Embodiment 4, the single projection 8 is separated from one end of the heat transfer plate 2, and extends to contact the other end thereof in the longitudinal direction. The second-medium inlet 6 is located at one of corners in the width direction at the one end of the heat transfer plate 2, which is separated from the projection 8, and the second-medium outlet 7 is located at the other corner. The first-medium inlet 4 is located one of corners in the width direction at the other end of the heat transfer plate 2, which the projection 8 contacts, and the first-medium outlet 5 is located at the other corner.

[0056] In Embodiment 4 as described above, as illustrated in Fig. 6, a U-shaped folded passage through which the first medium is to flow is provided, and an I-shaped unfolded passage which corresponds to part of the U-shaped folded passage and through which the second medium is to flow is provided. The distance between the two ends of the I-shaped unfolded passage is shorter than the distance between the two ends of the U-shaped folded passage. Furthermore, the amount of change in a vector from one end to the other end of the I-shaped unfolded passage which corresponds to part of the U-shaped folded passage and through which the second medium is to flow is smaller than the amount of change in a vector from one end to the other end of the U-shaped folded passage through which the first medium is to flow. Thus, the flow rate of the second medium having a lower thermal conductivity or a greater heat capacity than the first medium can be made higher than the flow rate of the first medium. Therefore, in the plate heat exchanger 1 according to Embodiment 4, even if a plurality of media to be subjected to heat exchange have different heat capacities or even if a plurality of media having different thermal conductivities are applied to heat exchange, the decrease in the efficiency of heat exchange, which is caused by the dependence of the heat exchange upon one of the media, can be reduced.

Embodiment 5

[0057] Fig. 7 is an explanatory diagram illustrating a configuration of first-refrigerant and second-medium inlets/outlets in a plate heat exchanger 1 according to Embodiment 5. Fig. 7 schematically illustrates positions of a first-medium inlet 4, a first-medium outlet 5, a second-medium inlet 6, and a second-medium outlet 7 that are provided in each of heat transfer plates 2 of the plate heat exchanger 1. Fig. 7 also illustrates a stacked state of the heat transfer plates 2, in which odd-numbered heat transfer plates 2 are rotated by 180 degrees, and even-numbered heat transfer plates 2 remain unchanged, such that a first heat transfer plate 2 is rotated by 180 degrees in the planar direction, a second heat transfer plate 2 remains unchanged and a third heat transfer plate is rotated by 180 degrees in the planar direction and so on. The left part of Fig. 7 illustrates the case where the first-medium inlet 4 and the second-refrigerant inlet 6 are provided at one of ends of the heat transfer plate 2 in the longitudinal direction, and the first-medium outlet 5 and the second-refrigerant outlet 7 are provided at the other end in the longitudinal direction. The right part of Fig. 7 illustrates the case where the first-medium inlet 4 and the second-refrigerant outlet 7 are provided at one of ends of the heat transfer

plate 2 in the longitudinal direction, and the first-medium outlet 5 and the second-refrigerant inlet 6 are provided at the other end in the longitudinal direction.

[0058] In the plate heat exchangers 1 according to Embodiment 5 as illustrated in the left part and the right part of Fig. 7, in each of odd-numbered interlayer spaces, a folded passage is provided in such a way as to extend from one end to the other end of the heat transfer plate 2 in the longitudinal direction, then turn from the other end to the one end, and further turn from the one end to the other end. In each of even-numbered interlayer spaces, an unfolded passage is provided in such a way as to extend from one end to the other end of the heat transfer plate 2 in the longitudinal direction. In the plate heat exchanger 1 as illustrated in the left part of Fig. 7, the first medium flows into the interlayer space through the first-medium inlet 4, and exchanges heat with the second medium flowing into the interlayer space through the second-medium inlet 6, while flowing along the linear projection 8. Then, the first medium turns along the linear projection 8, exchanges heat with the second medium flowing out of the interlayer space through the second-medium outlet 7, and flows out of the interlayer space through the first-medium outlet 5. On the other hand, in the plate heat exchanger 1 as illustrated in the right part of Fig. 7, the first medium flows into the interlayer space through the first-medium inlet 4, and exchanges heat with the second medium flowing out of the interlayer space through the second-medium outlet 7, while flowing along the linear projection 8. Then, the first medium turns along the linear projection 8, exchanges heat with the second medium flowing into the interlayer space through the second-medium inlet 6, and flows out of the interlayer space through the first-medium outlet 5.

[0059] Fig. 8 schematically indicates temperature distributions with respect to the lengths of the first-medium passage and the second-medium passage in the respective plate heat exchangers 1 according to Embodiment 5 as illustrated in Fig. 7. In the plate heat exchanger 1 as illustrated in the left part of Fig. 7, the difference between the temperature of the first medium and the temperature of the second medium is the greatest at the second-medium inlet 6, and an average temperature difference ΔT is expressed by an equation indicated below, where T_1 is the temperature of the first medium at the first-medium inlet 4, T_2 is the temperature of the first medium at the first-medium outlet 5, t_1 is the temperature of the second medium at the second-medium inlet 6, and t_2 is the temperature of the second medium at the second-medium outlet 7.

[Equation 1]

$$\Delta T = \frac{|T_1 - t_1| - |T_2 - t_2|}{\ln(|T_1 - t_1| / |T_2 - t_2|)} \quad (1)$$

[0060] In the plate heat exchanger 1 as illustrated in the right part of Fig. 7, the difference between the temperature of the first medium and the temperature of the second medium is the greatest at the second-medium inlet 6, and an average temperature difference ΔT is expressed by the following equation.

[Equation 2]

$$\Delta T = \frac{|T_1 - t_2| - |T_2 - t_1|}{\ln(|T_1 - t_2| / |T_2 - t_1|)} \quad (2)$$

[0061] As described above, the plate heat exchanger 1 as illustrated in the left part of Fig. 7 and the plate heat exchanger 1 as illustrated in the right part of Fig. 7 are different from each other regarding the temperature difference, the outlet temperature of the first medium, and the outlet temperature of the second medium. Therefore, the set temperature of the heat exchanger can be changed, and the heat exchanger can be designed with high flexibility in view of a target temperature.

[0062] The present invention is not limited to the specific configurations and typical embodiments explained and described above, and covers any modifications that are easily conceivable by a person with ordinary skill in the art and advantages of the modifications. Therefore, the present invention can be variously modified without departing from the spirit of the general concept or the scope of the invention defined by the claims and equivalents thereof.

REFERENCE SIGNS LIST

[0063]

- 1 plate heat exchanger
- 2 heat transfer plate

- 3 herringbone uneven portion
- 4 first-medium inlet
- 5 first-medium outlet
- 6 second-medium inlet
- 5 7 second-medium outlet
- 8 projection
- 9 projection

Claims

1. A plate heat exchanger that causes heat exchange to be performed using a plurality of heat transfer plates stacked,

- wherein the plurality of heat transfer plates include

a first heat transfer plate configured to perform the heat exchange, and
a second heat transfer plate configured to perform the heat exchange, stacked on the first heat transfer plate, with a first interlayer space provided between the first heat transfer plate and the second heat transfer plate, the first interlayer space being space through which a first medium flows,

- wherein the first heat transfer plate and the second heat transfer plate each include

a rectangular plate body configured to perform the heat exchange,
a first-medium inlet and a first-medium outlet or a second-medium inlet and a second-medium outlet, the first-medium inlet being configured to allow an inflow of the first medium, the first-medium outlet being configured to allow an outflow of the first medium, the second-medium inlet being configured to allow an inflow of a second medium, the second-medium outlet being configured to allow an outflow of the second medium, and
a projection contacting one end of the plate body and separated from an other end of the plate body in a longitudinal direction of the plate body, the projection projecting in a stacking direction where the heat transfer plates are stacked and providing a passage allowing the first medium or the second medium to flow therethrough,

- wherein at least one of the first-medium inlet and the first-medium outlet is located at one of two corners at the one end of the plate body which the projection contacts,

- wherein at least one of the second-medium inlet and the second-medium outlet is located at one of two corners at the other end of the plate body from which the projection is separated, and

- wherein the first and second heat transfer plates are stacked such that the one end of the first heat transfer plate and the other end of the second heat transfer plate are in contact with each other.

2. The plate heat exchanger of claim 1,
wherein the first-medium inlet of the first heat transfer plate and the first-medium inlet of the second heat transfer plate face each other, while spaced from each other, wherein the second-medium inlet of the first heat transfer plate and the second-medium inlet of the second heat transfer plate are joined to each other,
wherein the second-medium outlet of the second heat transfer plate and the second-medium outlet of the third heat transfer plate face each other, while spaced from each other, and
wherein the first-medium outlet of the second heat transfer plate and the first-medium outlet of the third heat transfer plate are joined to each other.

3. The plate heat exchanger of claim 1 or 2,
wherein a length of a passage in the first interlayer space that extends along the projection of the second heat transfer plate from the first-medium inlet to the first-medium outlet of the second heat transfer plate is greater than a length of a passage in the second interlayer space that extends along the projection of the third heat transfer plate from the second-medium inlet to the second-medium outlet of the third heat transfer plate.

4. The plate heat exchanger of any one of claims 1 to 3,
wherein an amount of change in a velocity vector from one of the first-medium inlet and the first-medium outlet of the second heat transfer plate to another along the projection of the second heat transfer plate in the first interlayer

space is larger than an amount of change in a velocity vector from one of the second-medium inlet and the second-medium outlet of the third heat transfer plate to another along the projection of the third heat transfer plate in the second interlayer space.

- 5 **5.** The plate heat exchanger of any one of claims 1 to 4,
wherein a flow rate of the first medium in the first interlayer space is lower than a flow rate of the second medium in the second interlayer space.
- 10 **6.** The plate heat exchanger of any one of claims 1 to 5,
wherein the first heat transfer plate, the second heat transfer plate, and the third heat transfer plate each include

another projection contacting the other end of the plate body and separated from the one end in the longitudinal direction, the other projection projecting in the stacking direction and providing a passage allowing the first medium or the second medium to flow therethrough,
15 wherein another of the first-medium inlet and the first-medium outlet is located at another of the two corners at the other end of the plate body which the other projection contacts, and
wherein another of the second-medium inlet and the second-medium outlet is located at another of the two corners at the one end of the plate body from which the other projection is separated.
- 20 **7.** The plate heat exchanger of any one of claims 1 to 6,
wherein the first heat transfer plate, the second heat transfer plate, and the third heat transfer plate each include herringbone uneven portions 3 arranged in a pattern of a V-shaped herringbone which tapers from the one end toward the other end of the plate body in the longitudinal direction, and
25 wherein the projection is located in such a manner as to divide the herringbone uneven portions 3.
- 30 **8.** The plate heat exchanger of any one of claims 1 to 7,
wherein the plurality of heat transfer plates further include a fourth heat transfer plate configured to perform the heat exchange and stacked on the third heat transfer plate, with a third interlayer space provided between the third heat transfer plate and the fourth heat transfer plate, and
35 wherein the fourth heat transfer plate is stacked on the third heat transfer plate such that the one end of the third heat transfer plate and the one end of the fourth heat transfer plate are in contact with each other.
- 40 **9.** The plate heat exchanger of any one of claims 1 to 8,
wherein an opening area of the first-medium inlet and an opening area of a first-medium outlet are smaller than an opening area of the second-medium inlet and an opening area of the second-medium outlet.

FIG. 1

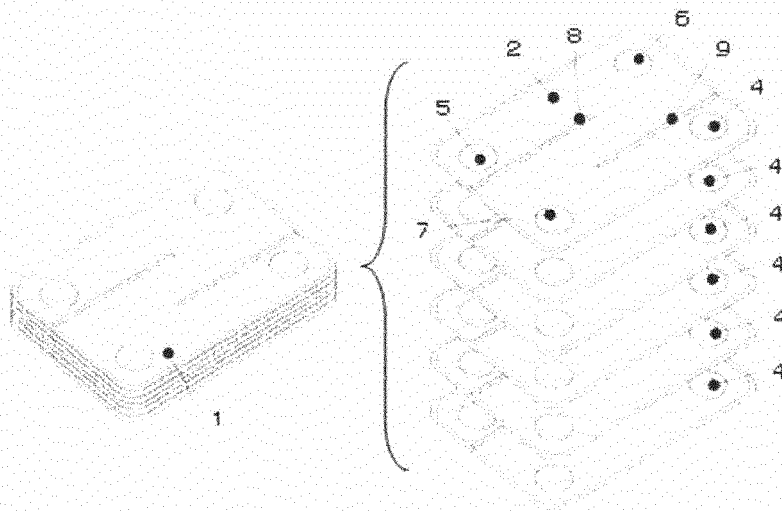


FIG. 2

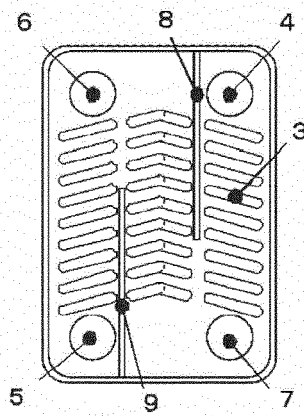


FIG. 3

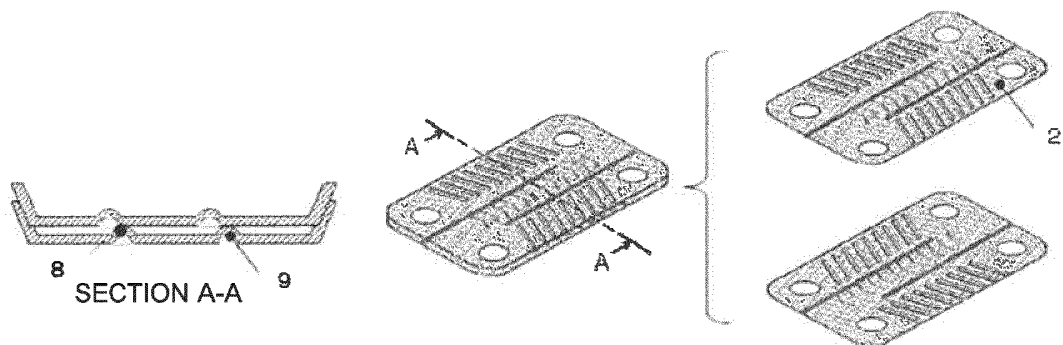


FIG. 4

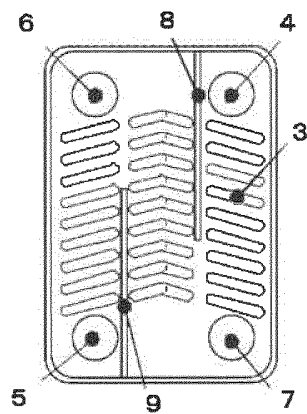


FIG. 5

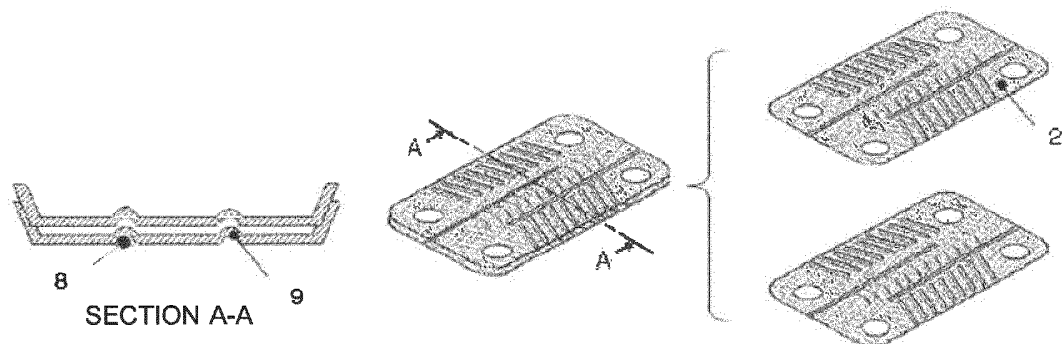


FIG. 6

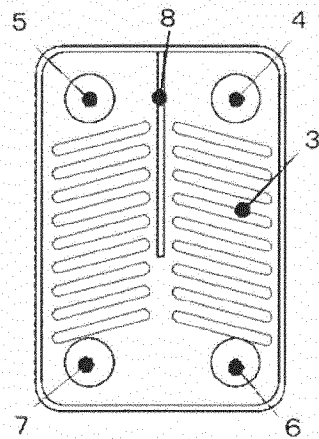


FIG. 7

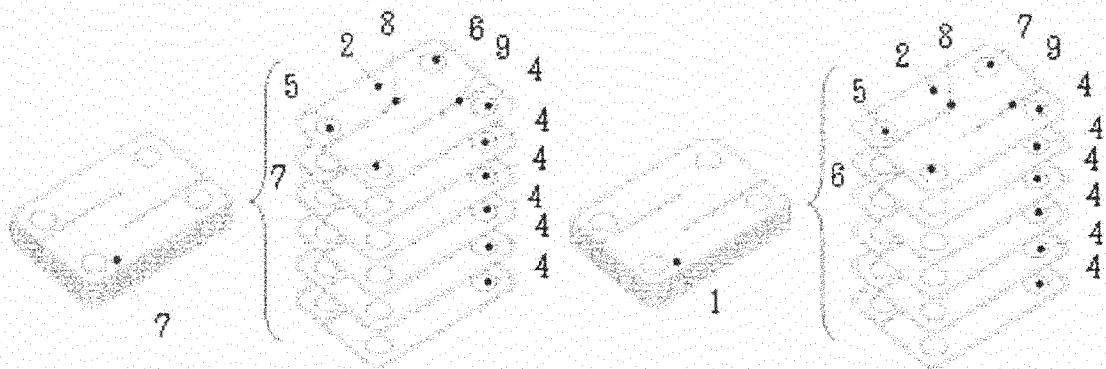
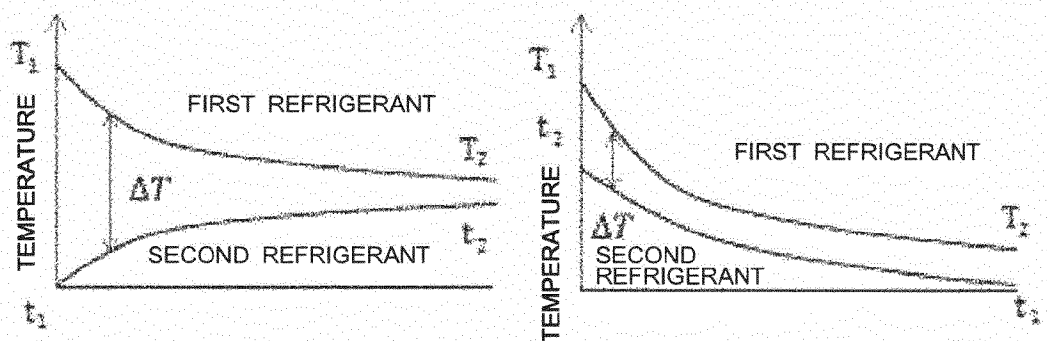


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/044707

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F28F3/08 (2006.01) i, F28D9/02 (2006.01) i, F28F3/04 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F28F3/08, F28D9/02, F28F3/04

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 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2006-183969 A (MAHLE FILTER SYSTEMS JAPAN CORP.)	1-2, 8-9
Y	13 July 2006, paragraphs [0009]-[0018], fig. 1-14	3-5, 7
A	(Family: none)	6
Y	JP 54-011552 A (HISAKA, LTD.) 27 January 1979, page	3-5
A	1, lower left column, line 16 to page 2, lower left	1-2, 6-9
	column, line 11, fig. 1, 3-4 (Family: none)	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
28 February 2018 (28.02.2018)Date of mailing of the international search report
13 March 2018 (13.03.2018)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/044707

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2006-064281 A (HISAKA, LTD.) 09 March 2006, paragraphs [0001], [0015]-[0035], fig. 1-3, 10 (Family: none)	7 1-6, 8-9
A	JP 2013-076523 A (T. RAD CO., LTD.) 25 April 2013, entire text, all drawings (Family: none)	6
A	CN 104792199 A (SHANDONG UNIVERSITY) 22 July 2015, entire text, all drawings (Family: none)	6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 026719/1975 (Laid-open No. 106960/1976) (HISAKA, LTD.) 26 August 1976, entire text, all drawings (Family: none)	1-9
A	JP 46-012688 Y1 (HISAKA, LTD.) 06 May 1971, entire text, all drawings (Family: none)	1-9
A	JP 2013-130300 A (T. RAD CO., LTD.) 04 July 2013, entire text, all drawings (Family: none)	1-9
A	JP 2011-220643 A (TOKYO ROKI CO., LTD.) 04 November 2011, entire text, all drawings (Family: none)	1-9
A	DE 19547185 A1 (BEHR GMBH & CO.) 19 June 1997, entire text, all drawings (Family: none)	1-9

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/044707

5 <Opinions about the international application>

1. "The third heat transfer plate" is mentioned in claims 2-4 and 6-8, but since "a third heat transfer plate" is not mentioned beforehand, it is impossible to know what kind of heat transfer plate the "third heat transfer plate" is and where the "third heat transfer plate" is disposed, and thus "the third heat transfer plate" is unclear.

10 2. "The second lamination space" is mentioned in claims 3-5, but since "a second lamination space" is not mentioned beforehand, it is impossible to know what kind of lamination space the "second lamination space" is, and thus "the second lamination space" is unclear.

15 3. "The protrusion of the third heat transfer plate" is mentioned in claims 3-4, but since "a protrusion of the third heat transfer plate" is not mentioned beforehand, it is impossible to know what kind of protrusion the "protrusion of the third heat transfer plate" is, and thus "the protrusion of the third heat transfer plate" is unclear.

20 4. Claim 8 includes the text "laminated so that the one end of the third heat transfer plate and the one end of the fourth heat transfer plate contact each other".

25 Meanwhile, paragraph [0027] of the description includes the text "in a plate-type heat exchanger 1, a plurality of heat transfer plates 2 having the same plate shape are alternately disposed inverted 180° in the planar direction". Also, paragraph [0028] includes the text "a first heat transfer plate 2 and a second heat transfer plate laminated inverted 180° ..."; and the text "for a fourth heat transfer plate 2, a fifth heat transfer plate 2, ..., which are laminated subsequently, the same 180° inverted arrangement is repeated".

30 Therefore, the text in claim 8, that is, "laminated so that the one end of the third heat transfer plate and the one end of the fourth heat transfer plate contact each other" is inconsistent with said text in the description.

Therefore, claim 8 is not sufficiently supported by the description.

35 Also, with regard to determining novelty and inventive step, this international search report was written in consideration of the text of the description by assuming that said text in claim 8 reads "laminated so that the one end of the third heat transfer plate and the other end of the fourth heat transfer plate contact each other".

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 5280883 A [0005]
- JP 2011149667 A [0005]
- JP 2000241094 A [0005]
- JP 2009186142 A [0005]