PLATE-TYPE HEAT EXCHANGER AND HEAT PUMP DEVICE

A plate heat exchanger with reduced pressure loss of a fluid and enhanced heat transfer efficiency is provided by a simple configuration. An upper heat transfer plate 2 and a lower heat transfer plate 3 adjacent to each other are corrugated in a wave pattern waving in a stacking direction. Between these plates, when seen in the stacking direction, intersection points are formed at intersections of a plurality of virtual bottom edge lines 21 and a plurality of virtual top edge lines 22, the bottom edge lines representing bottoms of the wave pattern of the upper heat transfer plate 2 and extending in a direction different from a direction of a long side, and the top edge lines representing tops of the wave pattern of the lower heat transfer plate 3 and extending in a direction different from the direction of the long side. Each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion. Between the upper heat transfer plate 2 and the lower heat transfer plate 3, a joint point 11 corresponding to an intersection point 23 at an end closest to an outer periphery 2-3 along the long side among the intersection points existing on one of the bottom edge lines 21 is formed at a position that substantially coincides with the outer periphery along the long side.
Description

Technical Field

[0001] This invention relates to a plate heat exchanger.

Background Art

[0002] Conventionally, there is a plate heat exchanger in which upper and lower plates are supported by providing a plurality of ridges on the plates in a longitudinal direction (for example, see Patent Document 1). There is also a plate heat exchanger in which upper and lower plates are joined at peaks of V-shaped wave portions of the respective plates (for example, see Patent Document 2).

Citation list

Patent Literature

[0003] Patent Document 1: JP 10-103888 A (page 4, Fig. 1)
Patent Document 2: JP 2002-107074 A (pages 6 to 8, Fig. 1)

Disclosure of Invention

Technical Problem

[0004] Conventionally, plate heat exchangers have the following problems. Firstly, when a flow rate is increased for enhancing heat transfer of a fluid, pressure loss is increased. Secondly, the increased pressure loss causes stagnation and clogging by dirt. Patent Document 1 provides a solution for solving these problems. However, the fluid is prompted to flow into flow paths formed by the ridges in a long axial direction, thereby being prevented from spreading in a short axial direction. There is also a general problem for plate heat exchangers. The problem is that when the peaks of V-shaped wave portions are joined between the upper and lower plates as discussed in Patent Document 2, ends of the wave portions are not aligned at an outer periphery, so that a brazing area at a joint portion between the upper and lower plates is enlarged, resulting in a narrower flow path and increased pressure loss.

[0005] It is an object of this invention to provide a plate heat exchanger that reduces pressure loss of a fluid and enhances heat exchange efficiency by a simple configuration.

Solution to Problem

[0006] A plate heat exchanger according to this invention is configured such that a plurality of rectangular plates having a long side, a short side, and an outer periphery are stacked such that corresponding long sides, short sides, and outer peripheries are aligned, the outer peripheries defining a space in which a fluid is sealed, each of the plates is corrugated in a wave pattern waving in a stacking direction, the plates adjacent to each other have intersection points therebetween when seen in the stacking direction, the intersection points being formed at intersections of a plurality of virtual bottom edge lines and a plurality of virtual top edge lines, the bottom edge lines representing bottoms of the wave pattern of one of the plates adjacent to each other and extending in a direction different from the direction of the long side, and each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion, and the plate heat exchanger is characterized in that the plates adjacent to each other are arranged such that the contact portion corresponding to one of the intersection points at an end closest to the outer periphery along the long side among the intersection points existing on one of the bottom edge lines is formed at a position that substantially coincides with the outer periphery along the long side.

Advantageous Effects of Invention

[0007] According to a plate heat exchanger of this invention, pressure loss of a fluid can be reduced and heat exchange efficiency can be enhanced. Due to the reduced pressure loss and the enhanced heat efficiency, the size (capacity) of the plate heat exchanger can be reduced. The enhanced heat efficiency also reduces power consumption, so that CO2 emission can be reduced.

Brief Description of Drawings

[0008] Fig. 1 is a diagram showing a plate heat exchanger 100 in a first embodiment;
Fig. 2 is a diagram showing adjacent plates in the first embodiment;
Fig. 3 is a diagram showing a distance b in a second embodiment;
Fig. 4 is a diagram illustrating an area c in a third embodiment;
Fig. 5 is a diagram illustrating an area d in a fourth embodiment;
Fig. 6 is a diagram illustrating that edge lines of alternate waves are shortened in a fifth embodiment;
Fig. 7 is a diagram illustrating a gap distance e in a sixth embodiment; and Fig. 8 is a diagram showing cross sections of plates in the plate heat exchanger 100.

### Description of Preferred Embodiments

#### First Embodiment

**[0009]** Fig. 1 is a diagram showing a plate heat exchanger 100 in a first embodiment.

1. In Fig. 1, (a) is a side view of the plate heat exchanger 100.
2. In Fig. 1, (b) is a front view (as seen along arrow X). A direction indicated by arrow X in (a) of Fig. 1 is a direction in which plates are stacked. A reinforcement side plate 1 in (b) of Fig. 1 is positioned at an outermost side, and is provided with fluid inlet and outlet pipes. The reinforcement side plate 1 is provided with a first fluid inlet pipe 5, a second fluid inlet pipe 6, a first fluid outlet pipe 7, and a second fluid outlet pipe 8.
3. In Fig. 1, (c) shows an upper heat transfer plate 2 that defines flow paths for a first fluid and a second fluid.
4. In Fig. 1, (d) shows a lower heat transfer plate 3 that is placed such that a wave pattern thereof is face to face with a wave pattern of the upper heat transfer plate 2, thereby defining the flow paths for the first fluid and the second fluid. By placing the upper heat transfer plate 2 and the lower heat transfer plate 3 alternately, the flow paths for the first fluid and the second fluid are formed alternately and repeatedly.
5. In Fig. 1, (e) shows a reinforcement side plate 4 that is positioned at an outermost side.
6. In Fig. 1, (f) is a view showing the upper heat transfer plate 2 and the lower heat transfer plate 3 stacked on top of each other. In (f) of Fig. 1, when the stacked plates are seen in the direction of arrow X in (a) of Fig. 1, the pattern of the upper heat transfer plate 2 that is actually visible is indicated by solid lines while the wave pattern of the lower heat transfer plate 3 that is not actually visible is indicated by dashed lines. Fig. 2 is an enlarged view of a range Y indicated by a dashed circle.

**[0010]** Fig. 8 shows a cross section AA’ ((c) of Fig. 1) and cross sections BB’ to DD’ (Fig. 2).

#### (Description of Configuration)

**[0011]** As shown in Fig. 1, the plate heat exchanger 100 is configured with a plurality of rectangular plates having short sides (a short side 2-1 of the upper heat transfer plate 2, a short side 3-1 of the lower heat transfer plate 3), long sides (a long side 2-2 of the upper heat transfer plate 2, a long side 3-2 of the lower heat transfer plate 3), and outer peripheries (an outer periphery 2-3 of the upper heat transfer plate 2, an outer periphery 3-3 of the lower heat transfer plate 3), the outer peripheries defining a space in which a fluid is sealed. The plates are stacked such that the corresponding long sides, short sides, and outer peripheries are aligned. Each plate is formed in a wave pattern waving in a stacking direction (direction X).

**[0012]** Fig. 2 is a front view of the heat transfer plates. Fig. 2 shows an enlarged view of the range Y in (f) of Fig. 1. In Fig. 2, a joint point 11 (contact portion) is formed between the upper and lower plates (the upper heat transfer plate 2 and the lower heat transfer plate 3) by an end portion 9 at a valley (bottom) of the wave pattern of the upper heat transfer plate 2 and by an end portion 10 at a peak of the wave pattern of the lower plate, the joint point 11 being at the shortest distance in a short axial direction (direction Z) from the outer periphery 2-3. This arrangement is characterized in that a distance a in Fig. 2 (a distance in the short axial direction (direction Z) from an outer periphery 12) can be shortened. The distance a is a distance in the short axial direction (direction Z) from the outer periphery 2-3.

The joint point at the shortest distance in the short axial direction (direction Z) means the first joint point that is encountered when proceeding in the short axial direction from the outer periphery 2-3.

**[0013]** A more specific explanation will be provided. In Fig. 2, solid lines on the surface of the upper heat transfer plate 2 represent the wave pattern, and dotted lines represent the wave pattern of the lower heat transfer plate 3 positioned under the upper heat transfer plate 2. A range 32 enclosed in a dashed box shows a cross-sectional shape of the wave pattern of the upper heat transfer plate 2. Dotted lines x1, y1, and z1 represent a peak, a valley, and a peak respectively A range 33 enclosed by a dashed box shows a cross-sectional shape of the wave pattern of the lower heat transfer plate 3. Dotted lines x2, y2, and z2 represent a peak, a valley, and a peak respectively In Fig. 2 (a view as seen in the stacking direction), between the upper heat transfer plate 2 and the lower heat transfer plate 3 adjacent to each other, intersection points 23 are formed at intersections of a plurality of virtual bottom edge lines 21, etc. and a plurality of virtual top edge lines 22, etc., the bottom edge lines representing bottoms of the wave pattern of the upper heat transfer plate 2 and extending in a direction different from a direction of the long side 2-2, and the top edge lines representing tops of the wave pattern of the lower heat transfer plate 3 and extending in a direction different from a direction of the long side 3-2. Then, each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines connect (come into contact) with each other at each of the intersection points 23, thereby forming a joint point (contact portion). In this configuration, between the upper heat transfer plate 2 and the lower heat transfer plate 3, the joint point 11 corresponding to
can be configured with a reduced number of stacked plates. As a result, manufacturing costs such as material costs and processing costs can be substantially reduced.

(4) Reduction of CO2 emission: With an air conditioner incorporating this plate heat exchanger, not only costs but also power consumption and CO2 emission can be reduced. In addition, due to the reduced pressure loss, the accumulation of refrigeration oil, sludge, dirt, and so on can be prevented in the heat exchanger, thereby enhancing the reliability of the heat exchanger.

Second Embodiment

[0017] In the first embodiment, the interval between the outer periphery 2-3 of the plate and the joint point 11 of the upper and lower plates at the shortest distance in the short axial direction (direction Z) is minimized by arranging the end point 9 at the valley of the wave pattern (an end of the bottom edge line) of the upper heat transfer plate 2 and the end point 10 at the peak (an end of the top edge line) of the lower heat transfer plate 3 to coincide with each other. That is, the joint point 11 is positioned to substantially coincide with the outer periphery along the short axial direction.

[0018] In the following explanation, reference will again be made to Fig. 3 used in the first embodiment. In the first embodiment, it has been described that it is effective in reducing the pressure loss when the distance b is as short as the distance a. In the second embodiment, it will be described that, even if the distance b is not as short as the distance a, the distance b is appropriately set to a predetermined range so as to secure a flow path.

[0019] When the distance b between the outer periphery of the plates and the joint point 11 of the upper and lower plates at the shortest distance in the short axial direction (direction Z) is too short, that is, when the distance b is not as short as the distance a but is insufficiently short so that the effect of the distance a cannot be ob-
tained, the following disadvantage is encountered. At the time of brazing, the brazing material at the outer periphery and the brazing material at the joint point converge and accumulate in the distance \( b \), thereby narrowing the flow path. On the other hand, when the distance \( b \) is too long, the interval between the joint point 11 of the upper and lower plates and a joint point 13 next to the joint point 11 is shortened (the joint point 13 being the second closest to the outer periphery after the joint point 11 on the top edge line 22). As a result, the brazing material of the joint point 11 and the brazing material of the joint point 13 converge and accumulate between these points, thereby narrowing the flow path. In the plates of the second embodiment, the distance \( b \) is set to a predetermined length that will not cause the accumulation of the brazing material. With this arrangement, an area corresponding to the distance \( b \) also serves as the flow path of a fluid. With the plate heat exchanger thus configured, the pressure loss can be reduced while the heat transfer area can be enlarged.

[0020] For example, when the size of the plate in the short axial direction is 70 mm, the distance \( b \) should be 3 to 4.5 mm. The distance \( b \) may be adjusted depending on the size of the plate in the short axial direction, a wave angle \( \theta \), a wave pitch, properties of a fluid, and usage conditions. In Fig. 3, for example, when the distance \( b \) is 3 to 4.5 mm, the wave angle \( \theta \) (a wave angle \( \theta 1 \) of the upper heat transfer plate 2, a wave angle \( \theta 2 \) of the lower heat transfer plate 3) is approximately between 60 degrees and 70 degrees, more preferably between 62.5 degrees to 67.5 degrees.

[0021] As described above, between the upper heat transfer plate 2 and the lower heat transfer plate 3, the joint point (contact portion) corresponding to the intersection point at the end closest to the outer periphery along the long side among the intersection points on one bottom edge line is formed at a position at a predetermined distance (3 to 4.5 mm) in a direction of the short side (direction Z) from the outer periphery, and the edge lines of the wave pattern are shortened in either of the upper and lower plates. In the first and second embodiments, the distance interval between the joint point of the upper and lower plates and the outer periphery has been discussed. In the third embodiment, it will be described that the edge lines of the wave pattern are shortened in either of the upper and lower plates.

[0025] Fig. 4 is a front view of the plates of the third embodiment, representing the upper heat transfer plate 2 and the lower heat transfer plate 3 as in Fig. 2. As shown in Fig. 4, for example, the edge lines of the wave pattern of the upper heat transfer plate 2 are shortened such that the end portion 9 of the wave pattern (the end of the bottom edge line) is formed at an inner position in the plate compared to the end portion 10 (the end of the top edge line) of the lower plate. With this arrangement, a flow path is formed in an area \( c \) enclosed by dashed lines.

[0026] By forming such a flow path \( c \) at the outer periphery, it is possible to avoid the narrowing of the flow path width due to the accumulation of the brazing material between the outer periphery and "the joint point of the upper and lower plates at the shortest distance in the short axial direction". Further, the wave pattern is not shortened in one of the plates, so that the pressure loss can be reduced while the effect of facilitating heat transfer is maintained by agitating action caused by flow movement. Furthermore, when two or more types of fluid flow through the plates, the heat exchanger may be configured by arranging the plates such that a fluid with high pressure loss flows through the plates having the wave pattern with short edge lines and a fluid with low pressure loss flows through the plates having the wave pattern with long edge lines. In Fig. 4, the area \( c \) is formed at the outer peripheries on both sides in the short axial direction. However, the area \( c \) may be provided at only one of the outer peripheries such that differential pressures are distributed evenly within each plate depending on the directions of the fluid inlets and outlets.

[0027] In the third embodiment, it has been described that in the plate heat exchanger configured by stacking a plurality of plates in which passage holes serving as fluid inlets and outlets are formed at four corners, the edge lines of the wave pattern are shortened in either of the upper and lower plates.

Fourth Embodiment

[0028] Referring to Fig. 5, a fourth embodiment will next be described. In the third embodiment, it has been described that the edge lines of the wave pattern are shortened in either of the upper and lower plates. In the
fourth embodiment, it will be described that the edge lines of the wave pattern are shortened in both of the upper and lower plates.

[0029] Fig. 5 is a front view of the heat transfer plates of the fourth embodiment. When the edge lines of the wave pattern are shortened in both of the upper and lower plates, a flow path is formed in an area d enclosed by dashed lines. By forming such a flow path at the outer periphery, the narrowing of the flow path width due to the converging of the brazing material is prevented. When a fluid contains scales and fibers, this is likely to cause the blocking of the flow path at the joint point of the upper and lower plates. The configuration of Fig. 5 allows scales and fibers to escape from the flow path in the area d, and is thus effective. When the pressure of a high-pressure fluid such as a refrigerant is raised by the blocking of the flow path, there is conventionally a risk of breakage of pipes. When the refrigerant oil accumulates in the heat exchanger and is thus prevented from returning to a compressor, there is conventionally a risk of breakage of the compressor. In such cases, the flow path in the area d of Fig. 5 serves as a bypass and these risks can be avoided.

[0030] As discussed in the third and fourth embodiments, in at least either of the upper heat transfer plate 2 and the lower heat transfer plate 3 adjacent to each other, the area c or the area d where no wave pattern is formed is provided only to an extent of a predetermined width W (Fig. 4, Fig. 5) from the outer periphery 2-3 along the long side in a direction to the other long side (direction Z) and only to an extent of a length L (Fig. 4, Fig. 5) in a direction from one of the short side to the other short side.

[0031] In the fourth embodiment, it has been described that in the plate heat exchanger configured by stacking a plurality of plates in which passage holes serving as fluid inlets and outlets are formed at four corners, the flow path is formed by shortening the edge lines of the wave pattern in both of the upper and lower plates.

Fifth Embodiment

[0032] Referring to Fig. 6, a fifth embodiment will next be described. In the fourth embodiment, it has been described that the edge lines of the wave pattern are shortened in both of the upper and lower plates. In the fifth embodiment, it will be described that the edge lines of alternate waves of the wave pattern are shortened at least either of the plates. Fig. 6 is a front view of the heat transfer plates of the fifth embodiment. In Fig. 6, the edge lines of alternate waves of the wave pattern are shortened in the upper heat transfer plate 2 and the lower heat transfer plate 3. With this arrangement, there is no joint point 11 of the upper and lower plates at the shortest distance in the short axial direction (direction Z) from the outer periphery 2-3. That is, no joint point is formed at an inconvenient position approximately at the distance b (the distance b of the first embodiment) that will cause the accumulation of the brazing material. Thus, the brazing material does not accumulate between the outer periphery 2-3 and the joint point of the upper and lower plates, and heat transfer is facilitated by the agitating action of flow movement in the short axial direction due to alternately varying lengths of the edge lines of the wave pattern. With the configuration of Fig. 6, the plate heat exchanger with the reduced pressure loss and the enhanced heat transfer capability can be provided. In Fig. 6, the lengths of the edge lines of alternate waves are shortened. The same effects can be obtained by varying the lengths of the edge lines depending on design conditions, such as heat transfer and pressure loss conditions, and flowing characteristics of a fluid.

[0033] Thus, in the fifth embodiment, in the upper heat transfer plate 2, for example, a plurality of the bottom edge lines are directed to the outer periphery 2-3 along the long side. Then, end portions of the plurality of the bottom edge lines corresponding to "the outer periphery 2-3 along the long side" are formed alternately at a position T and at a position S, the position T being immediately close to "the outer periphery 2-3 along the long side" and the position S being further away from the outer periphery 2-3 than the position T immediately close.

[0034] In the fifth embodiment, it has been described that in the plate heat exchanger configured by stacking a plurality of plates in which passage holes serving as fluid inlets and outlets are formed at four corners, the edge lines of alternate waves of the plates are shortened, the alternate waves being alternate in a direction in which the fluid flows.

Sixth Embodiment

[0035] Referring to Fig. 7, a sixth embodiment will be described. In the fifth embodiment, it has been described that the edge lines of alternate waves of the plates are shortened. In the sixth embodiment, it will be described that a gap of 0.2 mm or wider is provided between the valley (bottom) of the wave pattern of the upper heat transfer plate 2 and the peak (top) of the wave pattern of the lower heat transfer plate 3 at a point corresponding to the joint point of the upper and lower plates at the shortest distance in the short axial direction (direction Z) from the outer periphery of the upper and lower plates (there is a gap in place of the joint point).

[0036] Fig. 7 is a schematic depiction of a cross section of the heat transfer plates. Fig. 7 is provided for the convenience of explaining a gap distance e to be described later. The distance e is defined as a gap between the wave of the upper plate and the peak of the lower plate at a position at the distance b, that is, at a position of the joint point of the upper and lower plates at the shortest distance in the short axial direction (direction Z) from the outer periphery 2-3 of the plate (the same as Fig. 3) (to be precise, at a position of a point corresponding to the joint point because the gap exists as described above). The distance e is 0.2 mm or longer so that there is a gap between the upper and lower plates, thereby preventing
the accumulation of the brazing material originating from
the outer periphery 2-3 and the joint point of the upper
and lower plates. As a result, as with the first to fifth emb-
obodiments, the plate heat exchanger with the reduced
pressure loss and the enhanced heat transfer capability
can be provided.

[0037] As described above, in the sixth embodiment,
between the upper heat transfer plate 2 and the lower
heat transfer plate 3 adjacent to each other, at the inter-
section point at the end closest to “the outer periphery
along the long side” among the intersection points on
one bottom edge line of the upper heat transfer plate 2,
the gap is formed between the bottom of the wave pattern
represented by the bottom edge line and the top of the
wave pattern represented by the top edge line of the lower
heat transfer plate 3. Then, at the intersection points other
than the intersection point at the end, the bottoms of the
wave pattern represented by the bottom edge lines are
in contact with the tops of the wave pattern represented
by the top edge lines.

[0038] In the sixth embodiment, it has been described
that in the plate heat exchanger configured by stacking
a plurality of plates in which passage holes serving as
fluid inlets and outlets are formed at four corners, at the
position corresponding to the joint point of the upper and
lower plates at the shortest distance in the short axial
direction from the outer periphery of the upper and lower
plates, the gap of 0.2 mm or wider is provided between
the bottom and the top of the wave patterns of the plates.

[0039] The heat transfer plates described in the first to
sixth embodiments can be used in numerous industrial
machines and home appliances, such as air conditioners,
power generators, and heat sterilizers for foods. For ex-
ample, in a heat pump apparatus in which a compressor,
a radiator, an expansion mechanism, and an evaporator
are connected by pipes, the heat transfer plates can be
used in either or both of the radiator and the evaporator.

List of Reference Signs

[0040]

1: reinforcement side plate
2: upper heat transfer plate
2-1, 3-1: short sides
2-2, 3-2: long sides
2-3, 3-3: outer peripheries
3: lower heat transfer plate
4: reinforcement side plate
5: first fluid inlet pipe
6: second fluid inlet pipe
7: first fluid outlet pipe
8: second fluid outlet pipe
9: end point at the valley of the wave pattern of the
upper heat transfer plate
10: end point at the peak of the wave pattern of the
lower heat transfer plate
11: joint point of the upper and lower plates at the
shortest distance in the short axial direction from the
outer periphery
12: outer periphery of the plate
13: second joint point of the upper and lower plates
in the short axial direction from the outer periphery
100: plate heat exchanger

Claims

1. A plate heat exchanger configured such that
a plurality of rectangular plates having a long side,
a short side, and an outer periphery are stacked such
that corresponding long sides, short sides, and outer
peripheries are aligned, the outer peripheries defin-
ing a space in which a fluid is sealed;
each of the plates is corrugated in a wave pattern
waving in a stacking direction;
the plates adjacent to each other have intersection
points therebetween when seen in the stacking di-
rection, the intersection points being formed at inter-
sections of a plurality of virtual bottom edge lines and
a plurality of virtual top edge lines, the bottom edge
lines representing bottoms of the wave pattern of
one of the plates adjacent to each other and extend-
ing in a direction different from a direction of the long
side and the top edge lines representing tops of the
wave pattern of another one of the plates adjacent
to each other and extending in a direction different
from the direction of the long side; and
each of the bottoms of the wave pattern represented
by the bottom edge lines and each of the tops of the
wave pattern represented by the top edge lines come
into contact with each other at each of the intersec-
tion points, thereby forming a contact portion,
the plate heat exchanger, characterized in that
the plates adjacent to each other are arranged such
that the contact portion corresponding to one of the
intersection points at an end closest to the outer pe-
riphery along the long side among the intersection
points existing on one of the bottom edge lines is
formed at a position that substantially coincides with
the outer periphery along the long side.

2. A plate heat exchanger configured such that
a plurality of rectangular plates having a long side,
a short side, and an outer periphery are stacked such
that corresponding long sides, short sides, and outer
peripheries are aligned, the outer peripheries defin-
ing a space in which a fluid is sealed;
each of the plates is corrugated in a wave pattern
waving in a stacking direction;
the plates adjacent to each other have intersection
points therebetween when seen in the stacking di-
rection, the intersection points being formed at inter-
sections of a plurality of virtual bottom edge lines and
a plurality of virtual top edge lines, the bottom edge
lines representing bottoms of the wave pattern of
A plate heat exchanger configured such that the plates adjacent to each other are arranged such that the direction of the top edge lines and the direction of the bottom edge lines are different; and each of the plates is corrugated in a wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion, the plate heat exchanger, characterized in that the plates adjacent to each other are arranged such that the contact portion corresponding to one of the intersection points at an end closest to the outer periphery along the long side is formed at a position at a predetermined distance in a direction of the short side from the outer periphery and depending on the direction in which the bottom edge lines extend and the direction in which the top edge lines extend.

3. The plate heat exchanger of claim 2, wherein the plates adjacent to each other are arranged such that the closer the direction of the bottom edge lines and the direction of the top edge lines are to a direction perpendicular to the direction of the long side, the further away from the outer periphery along the long side the contact portion is formed.

4. The plate heat exchanger of claim 3, wherein the contact portion corresponding to the one of the intersection points at the end closest to the outer periphery along the long side among the intersection points existing on one of the bottom edge lines is formed at a distance of between 3mm and 4.5 mm in a direction of the short side from the outer periphery along the long side when the direction of the bottom edge lines relative to the direction of the long side is between 62.5 degrees and 67.5 degrees.

5. A plate heat exchanger configured such that a plurality of rectangular plates having a long side, a short side, and an outer periphery are stacked such that corresponding long sides, short sides, and outer peripheries are aligned, the outer peripheries defining a space in which a fluid is sealed; each of the plates is corrugated in a wave pattern having a stack direction; the plates adjacent to each other have intersection points therebetween when seen in the stacking direction, the intersection points being formed at intersections of a plurality of virtual bottom edge lines and a plurality of virtual top edge lines, the bottom edge lines representing bottoms of the wave pattern of one of the plates adjacent to each other and extending in a direction different from a direction of the long side and the top edge lines representing tops of the wave pattern of another one of the plates adjacent to each other and extending in a direction different from the direction of the long side; and each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion, the plate heat exchanger, characterized in that at least either of the plates adjacent to each other is configured such that the wave pattern is not formed in an area of a predetermined width from the outer periphery along the long side at another end, the area extending in a direction from the short side at one end toward the short side at another end.

6. A plate heat exchanger configured such that a plurality of rectangular plates having a long side, a short side, and an outer periphery are stacked such that corresponding long sides, short sides, and outer peripheries are aligned, the outer peripheries defining a space in which a fluid is sealed; each of the plates is corrugated in a wave pattern having a stack direction; the plates adjacent to each other have intersection points therebetween when seen in the stacking direction, the intersection points being formed at intersections of a plurality of virtual bottom edge lines and a plurality of virtual top edge lines, the bottom edge lines representing bottoms of the wave pattern of one of the plates adjacent to each other and extending in a direction different from a direction of the long side and the top edge lines representing tops of the wave pattern of another one of the plates adjacent to each other and extending in a direction different from the direction of the long side; and each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion, the plate heat exchanger, characterized in that at least either of the plates adjacent to each other is configured such that the wave pattern is not formed in an area of a predetermined width from the outer periphery along the long side at another end, the area extending in a direction from the short side at one end toward the short side at another end.

7. A plate heat exchanger configured such that a plurality of rectangular plates having a long side,
a short side, and an outer periphery are stacked such that corresponding long sides, short sides, and outer peripheries are aligned, the outer peripheries defining a space in which a fluid is sealed;

each of the plates is corrugated in a wave pattern waving in a stacking direction;

the plates adjacent to each other have intersection points therebetween when seen in the stacking direction, the intersection points being formed at intersections of a plurality of virtual bottom edge lines and a plurality of virtual top edge lines, the bottom edge lines representing bottoms of the wave pattern of one of the plates adjacent to each other and extending in a direction different from a direction of the long side and the top edge lines representing tops of the wave pattern of another one of the plates adjacent to each other and extending in a direction different from the direction of the long side; and

each of the bottoms of the wave pattern represented by the bottom edge lines and each of the tops of the wave pattern represented by the top edge lines come into contact with each other at each of the intersection points, thereby forming a contact portion,

the plate heat exchanger, characterized in that

the plates adjacent to each other are arranged such that the contact portion corresponding to one of the intersection points at an end closest to the outer periphery along the long side among the intersection points on the one of the bottom edge lines, a gap is formed between the bottom of the wave pattern represented by the bottom edge line and the top of the wave pattern represented by the top edge line, and at the intersection points other than the intersection point at the end, the bottoms of the wave pattern represented by the bottom edge lines are in contact with the tops of the wave pattern represented by the top edge lines.

8. The plate heat exchanger of claim 7, wherein the gap is 0.2 mm or wider in the stacking direction.

9. A heat pump apparatus wherein a compressor, a first heat exchanger, an expansion mechanism, and a second heat exchanger are connected by pipes, the heat pump apparatus, comprising:

   a plate heat exchanger as at least either of the first heat exchanger and the second heat exchanger,
   the plate heat exchanger being configured such that a plurality of rectangular plates having a long side, a short side, and an outer periphery are stacked such that corresponding long sides, short sides, and outer peripheries are aligned, the outer peripheries defining a space in which a fluid is sealed;
   each of the plates is corrugated in a wave pattern waving in a stacking direction;
Fig. 2
Fig. 3
Fig. 4
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
F28F3/04(2006.01)i, F28D9/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F3/04, F28D9/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevance to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>JP 2002-107074 A (Sanyo Electric Co., Ltd.), 10 April 2002 (10.04.2002), paragraphs [0002] to [0018], [0031] to [0043]; fig. 1, 5 to 8 (Family: none)</td>
<td>1, 9, 2-4</td>
</tr>
<tr>
<td>Y</td>
<td>JP 2008-39255 A (Toshiba Corp.), 21 February 2008 (21.02.2008), paragraph [0031]; fig. 2 (Family: none)</td>
<td>2-4</td>
</tr>
</tbody>
</table>

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 being obvious to a person skilled in the art
  "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
08 February, 2011 (08.02.11)

Date of mailing of the international search report
15 February, 2011 (15.02.11)

Name and mailing address of the ISA/

Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<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>Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 039294/1981 (Laid-open No. 154872/1982) (Hisaka Works, Ltd.), 29 September 1982 (29.09.1982), page 2, line 6 to page 3, line 6; fig. 1 (Family: none)</td>
<td>2-4</td>
</tr>
<tr>
<td>A</td>
<td>JP 61-83882 A (Hisaka Works, Ltd.), 28 April 1986 (28.04.1986), page 1, right column, line 17 to page 2, upper left column, line 3 (Family: none)</td>
<td>1-4</td>
</tr>
</tbody>
</table>
### INTERNATIONAL SEARCH REPORT

**Box No. II**  Observations where certain claims were found unsearchable (Continuation of Item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  □ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2.  □ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.  □ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III**  Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The international search has revealed that the matter common to the inventions of claims 1-9 is not novel since it is disclosed in document 1 (JP 2002-107074 A). Consequently, that common matter is not any technical feature within the meaning of PCT Rule 13.2, second sentence. The invention of claim 9 is not exceptionally required for the unity of invention. Since there is no other common feature which can be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence, no technical relationship within the meaning of PCT Rule 13 can be seen among those different inventions.

1.  □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.  □ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3.  □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
   Claims 1-4 and 9.

4.  □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

□ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

□ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

□ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)
In connection with the invention specifying matter that "said contact section corresponding to such one of said intersection points existing on one of said bottom ridge lines as corresponds to said intersection point at the end the closest to said outer peripheral edge section along said longer side is formed at a position of a predetermined distance in a shorter-side direction from said outer peripheral edge section along said longer side, in accordance with the extending direction of said bottom ridge lines and the extending direction of said top ridge lines" of claims 2(-4), what is disclosed within the meaning of PCT Article 5 is that "the size b (or the distance between the contact section and the outer peripheral edge section) is set to such a predetermined size that no soldering material resides", and the disclosure is not supported within the meaning of PCT Article 6.

Hence, the searches have been performed on the range which is supported by and disclosed in the description, that is, on the "plate type heat exchanger, wherein the distance between the contact section and the outer peripheral edge section is set to such a predetermined value as to allow no soldering material to reside".
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