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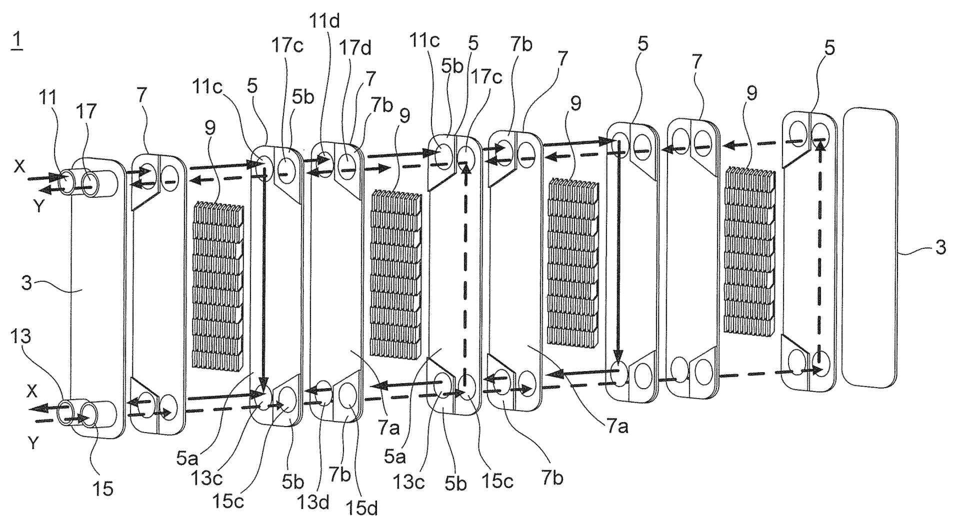
(54) **PLATE-TYPE HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE COMPRISING SAME**

(57) Provided is a heat exchanger (1) capable of enhancing long-term reliability of the device through prevention of leakage of a fluid while being excellent in heat exchange efficiency, simple in structure, and manufacturable at low cost. The heat exchanger (1) includes a plurality of heat transfer plates (5), a plurality of inner fins (9), and a plurality of leakage preventing plates (7). Each of the leakage preventing plates has formed therein passage holes through which the fluid is caused to flow. An inner fin of a first channel and an inner fin of a second channel are provided so that the thermal resistivities of two fluids are kept equal to each other.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a plate heat exchanger and a refrigeration cycle system including the plate heat exchanger.

Background Art

[0002] Plate heat exchangers include a plurality of stacked heat transfer plates each having corrugated projections and depressions formed in a plurality of arrays. As a related-art plate heat exchanger, there is proposed such a herringbone-type plate heat exchanger that a line connecting peak points (or valley points) of the corrugation of the heat transfer plate is formed so as to intersect with that of the adjacent heat transfer plate. There is also proposed an inner fin-type heat exchanger having a higher degree of freedom in designing the shape of the heat transfer plate than the herringbone-type plate heat exchanger (see, for example, Patent Literature 1).

[0003] The herringbone-type plate heat exchanger has the following problems. In the herringbone-type plate heat exchanger, each heat transfer plate has a corrugated shape, thereby being difficult to secure a leakage preventing function between a first fluid (for example, refrigerant) and a second fluid (for example, water). Hot water obtained by the plate heat exchanger that is mounted on a boiler is used as bathwater, which raises the need to prevent leakage of the refrigerant into the water. Therefore, without the leakage preventing function, high-pressure refrigerants such as CO_2 or combustible refrigerants such as hydrocarbons and low-GWP refrigerants cannot be used for the boiler. In addition, the channel sectional areas are substantially equal to each other, and hence, when different fluids are caused to flow, the thermal resistivities of both the fluids are not equal to each other, with the result that the heat exchange efficiency is poor. Further, a joining portion between the adjacent plates is formed through point contact of the corrugations, and hence the joining area is small, with the result that the joining portion is liable to be damaged.

[0004] In addition, the inner fin-type heat exchanger as disclosed in Patent Literature 1 has the following problems. First, the inner fin-type heat exchanger lacks the leakage preventing function, thereby being difficult for use in the boiler. Inner fins of a first channel and a second channel have the same shape, which is not an optimum shape for the fluid to be caused to flow through the inner fins. Therefore, the heat exchange efficiency is poor. Further, the inner fins are formed under specifications conforming to the strength necessary for one of the fluids, and hence the inner fins on the other fluid side have an excessively large joining area. Therefore, the cost is increased.

[0005] Note that, as another related-art heat exchanger, for example, Patent Literature 2 discloses a heat exchanger having a structure including a first channel plate and a second channel plate each having a channel formed inside a wall of the plate, and a partition plate for partitioning the channel plates. In the structure of Patent Literature 2, however, the partition plate is merely a plate-like member, and cannot therefore be employed in the type using the inner fins.

[0006] In addition, as a heat exchanger including corrosion preventing means, a heat exchanger disclosed in Patent Literature 3 is known. However, a sub-plate serving as the corrosion preventing means disclosed in Patent Literature 3 has a flat-plate shape, and is used only for partitioning between circular tubes and a flat surface. Therefore, the sub-plate cannot be employed in the type using the plurality of stacked plates. Further, the heat exchanger disclosed in Patent Literature 3 is configured to exchange heat between a fluid flowing in the circular tubes and a fluid flowing between the fins, and hence the heat is exchanged at only contact surfaces between the circular tubes and the core plates. As a result, the heat exchange efficiency is lower than that of the heat exchanger including the plurality of stacked inner fins.

Citation List

Patent Literature

[0007]

[PTL 1] JP 2003-185375 A (page 5, FIG. 1)
[PTL 2] JP 2008-157544 A (page 7, FIG. 2)
[PTL 3] JP 2009-133506 A (page 12, FIG. 4)

Summary of Invention

Technical Problems

[0008] The present invention has been made in view of the above, and it is therefore an object thereof to provide a plate heat exchanger capable of enhancing long-term reliability of the device through prevention of leakage of a fluid while being excellent in heat exchange efficiency, simple in structure, and manufacturable at low cost.

Solution to Problems

[0009] In order to attain the above-mentioned object, according to one embodiment of the present invention, there is provided a plate heat exchanger, including: a plurality of heat transfer plates each having a flat heat transfer surface; and a plurality of inner fins each being arranged in corresponding one of first channels or corresponding one of second channels, the first channels and the second channels being alternately formed between pairs of the plurality of heat transfer plates, respectively. One of the plurality of inner fins, which is arranged in the corresponding one of the first channels, and another of the plurality of inner fins, which is arranged in the corresponding one of the second channels, are provided so as to have different heat transfer areas. The plate heat exchanger further includes leakage preventing plates arranged between the pairs of the plurality of heat transfer plates, respectively, each of the leakage preventing plates at least having formed therein passage holes through which a first fluid or a second fluid is caused to flow.

Advantageous Effects of Invention

[0010] According to one embodiment of the present invention, it is possible to enhance the long-term reliability of the device through the prevention of the leakage of the fluid while the device is excellent in heat exchange efficiency, simple in structure, and manufacturable at low cost.

Brief Description of Drawings

[0011]

FIG. 1 is an exploded perspective view illustrating an offset fin-type plate heat exchanger according to a first embodiment of the present invention.
FIG. 2 is a perspective view illustrating an inner fin.
FIG. 3 is a perspective view illustrating an inner fin in a first channel and an inner fin in a second channel as seen from obliquely above.
FIG. 4 is a plan view illustrating the inner fin in the first channel and the inner fin in the second channel.
FIGS. 5A and 5B are explanatory views illustrating a feature of a second embodiment of the present invention.

Description of Embodiments

[0012] Now, an offset fin-type plate heat exchanger according to embodiments of the present invention is described with reference to the accompanying drawings. Note that, in the drawings, the same reference symbols represent the same or corresponding parts.

First Embodiment

[0013] FIG. 1 is an exploded perspective view illustrating an offset fin-type plate heat exchanger according to a first embodiment of the present invention. Further, FIG. 2 is a perspective view illustrating an inner fin. FIG. 3 is a perspective view illustrating an inner fin in a first channel and an inner fin in a second channel as seen from obliquely above, and FIG. 4 is a plan view illustrating the inner fin in the first channel and the inner fin in the second channel. A plate heat exchanger 1 includes at least a pair of side plates 3, a plurality of heat transfer plates 5 and a plurality of leakage preventing plates 7, which are arranged between the side plates 3, and at least a pair of inner fins 9.

[0014] The pair of side plates 3 serves for reinforcement, and has four passage holes formed at four corners thereof so as to serve as a first fluid inlet 11, a first fluid outlet 13, a second fluid inlet 15, and a second fluid outlet 17. Note that, in the illustrated example, as seen in FIG. 1, the first fluid inlet 11 is arranged at an upper corner on one of the right and left sides, and the first fluid outlet 13 is arranged at a lower corner on one of the right and left sides. The second fluid inlet 15 is arranged at a lower corner on the other of the right and left sides, and the second fluid outlet 17 is arranged at an upper corner on the other of the right and left sides. Note that, in FIG. 1, a flow direction of the first fluid is represented by the symbol X, and a flow direction of the second fluid is represented by the symbol Y.

[0015] At four corners of each of the heat transfer plates 5 and the leakage preventing plates 7, through-holes are formed as passage holes. Specifically, in each of the heat transfer plates 5, a first fluid advancing hole 11c, a first fluid returning hole 13c, a second fluid advancing hole 15c, and a second fluid returning hole 17c are formed as the passage holes. Similarly, in each of the leakage preventing plates 7, a first fluid advancing hole 11d, a first fluid returning hole 13d, a second fluid advancing hole 15d, and a second fluid returning hole 17d are formed as the passage holes.

[0016] The heat transfer plates 5 and the leakage preventing plates 7 are both processed by, for example, pressing a plate-like member having a substantially uniform thickness so as to form projections and depressions. Each heat transfer plate 5 is a member having a flat heat transfer surface forming a corresponding first or second channel. Each heat transfer plate 5 has a depressed portion 5a and projected portions 5b formed in a relative relationship therebetween.

[0017] As illustrated in FIG. 1, in a case of the heat transfer plate 5 forming the first channel through which the first fluid represented by the symbol X passes, the depressed portion 5a occupies the first fluid advancing hole 11c, the first fluid returning hole 13c, and a wide region facing the inner fin 9 therebetween, whereas the projected portions 5b occupy regions on the periphery of the second fluid advancing hole 15c and the second fluid returning hole 17c. In a case of the heat transfer plate 5 forming the second channel through which the second fluid represented by the symbol Y passes, on the other hand, the depressed portion 5a occupies the second fluid advancing hole 15c, the second fluid returning hole 17c, and a wide region facing the inner fin 9 therebetween, whereas the projected portions 5b occupy regions on the periphery of the first fluid advancing hole 11c and the first fluid returning hole 13c.

[0018] Each leakage preventing plate 7 is a member arranged on a back surface of the corresponding heat transfer plate 5, which is opposite to the channel forming surface. Further, each leakage preventing plate 7 has a flat portion in a region mated with the heat transfer surface of the heat transfer plate 5, and also has a depressed portion 7a and projected portions 7b formed in a relative relationship therebetween. As illustrated in FIG. 1, the surface of each leakage preventing plate 7, which has the same form of projections and depressions as that on the channel forming surface side being the front surface of the corresponding heat transfer plate 5, is stacked on the back surface of the corresponding heat transfer plate 5. Thus, the back surface of the heat transfer plate 5 and the front surface of the leakage preventing plate 7, which correspond to each other, are precisely mated with each other so that the projections and depressions of the heat transfer plate 5 are aligned with those of the leakage preventing plate 7. In this manner, the heat transfer plate 5 and the leakage preventing plate 7 are brought into surface contact with each other substantially in the entire region, and thus the heat transfer plate 5 and the leakage preventing plate 7 hold each other in a wide area.

[0019] The inner fin 9 is an offset fin arranged between the corresponding heat transfer plate 5 and leakage preventing plate 7, for promoting the heat transfer. Each inner fin 9 has a substantially plate-like shape that is dimensioned larger in a width direction and a height direction than in a thickness direction. As illustrated in FIG. 2, the inner fin 9 has such a structure that a thin element extends over the width direction so as to repeatedly form projections and depressions at substantially right angles. Further, the end portions (top portions and bottom portions) of the projections and depressions are formed into a flat shape, and hence the inner fin 9 is also brought into surface contact with the corresponding heat transfer plate 5 and leakage preventing plate 7 at the flat end portions.

[0020] In addition, the inner fin 9 arranged in the first channel and the inner fin 9 arranged in the second channel are different from each other in their heat transfer areas. Specifically, as illustrated in FIGS. 3 and 4, inner fins different from each other in their dimensions are used as the inner fin 9 (9a) arranged in the first channel and the inner fin 9 (9b) arranged in the second channel. In the illustrated example, the inner fin 9 (9b) arranged in the second channel is formed of smaller projections and depressions than the inner fin 9 (9a) arranged in the first channel. Note that, for the sake of clarity of illustration, FIG. 1 illustrates the same inner fins 9 as the inner fin arranged in the first channel and the inner fin arranged in the second channel.

[0021] Each heat transfer plate 5 is brazed to the corresponding leakage preventing plate 7. Further, the corresponding heat transfer plate 5 and leakage preventing plate 7, which are stacked so as to sandwich the corresponding inner fin 9, are brazed to each other.

[0022] As exemplified in FIG. 1, there is obtained such a stacking structure that the side plate 3, the leakage preventing plate 7, the inner fin 9 for the first channel, the heat transfer plate 5 for the first channel, the leakage preventing plate 7 precisely mated with the heat transfer plate 5 for the first channel, the inner fin 9 for the second channel, the heat transfer plate 5 for the second channel, the leakage preventing plate 7 precisely mated with the heat transfer plate 5 for the second channel, the inner fin 9 for the first channel, and other necessary stacking elements are arranged and stacked sequentially in a repeated manner and the side plate 3 is finally stacked.

[0023] With the above-mentioned plate heat exchanger according to the first embodiment, the following advantages are attained. First, in the plate heat exchanger according to this embodiment, the leakage preventing plate is provided on the back surface of the heat transfer plate, and hence, for example, even when the heat transfer plate forming the first channel through which the first fluid flows is damaged due to corrosion, leakage of the first fluid into the second channel can be prevented by the leakage preventing plate provided on the back of the heat transfer plate, and by the brazing material applied between the heat transfer plate and the leakage preventing plate. Further, suppression of further advance of the corrosion can be expected from the brazing material. Thus, the long-term reliability of the heat exchanger can be enhanced through the prevention of leakage of the fluid. In addition, no air layer is contained unlike a double-wall structure of the herringbone-type plate heat exchanger, and hence reduction in heat exchange amount is suppressed. As a result, the number of kinds of fluids to be used can be increased, and accordingly the heat exchange performance can be enhanced as well.

[0024] Besides, to attain the action of protecting the corroded heat transfer plate with the leakage preventing plate as described above, the substantially flat leakage preventing plate only needs to be interposed between the pair of substantially flat heat transfer plates, and hence the heat exchanger can be manufactured at low cost without any complication. Further, the heat transfer plate, the leakage preventing plate, and the inner fin are brought into surface contact with each other at their flat surface portions, and hence the heat transfer plate, the leakage preventing plate, and the inner fin hold each other, with the result that the surface contact state can easily be maintained as a whole.

[0025] In addition, no air layer is contained unlike the double-wall structure used in the herringbone-type plate heat exchanger, and hence the reduction in heat exchange amount due to reduction in heat transfer rate is suppressed. In the herringbone-type plate heat exchanger, the channel sectional areas for the first fluid and the second fluid are substantially equal to each other, and hence, when heat is exchanged between water and a refrigerant, the thermal resistance is increased on the refrigerant side than on the water side, with the result that the heat exchange efficiency is poor.

[0026] In the first embodiment, on the other hand, the inner fins different from each other in their dimensions are used. Therefore, the fin having smaller dimensions with high heat transfer efficiency is used for the refrigerant side, which is susceptible to influence of pressure loss, whereas the fin having poor heat transfer efficiency but smaller pressure loss is used for the water side. As a result, the thermal resistivities of the refrigerant and the water can be kept equal to each other. In this manner, the thermal resistivities of the first fluid and the second fluid can be adjusted in accordance with physical properties of the fluids to be caused to flow, and thus a heat exchanger having high heat exchange efficiency can be provided.

[0027] In the leakage preventing plate, the passage holes serving as the inlets and outlets of the fluids are formed in the direction perpendicular to the flat heat transfer surface, and hence the leakage preventing plate is applicable to the type using the plurality of stacked plates and the inner fins in both the channels on the water side and the refrigerant side. Further, in the leakage preventing plate, the passage holes serving as the inlets and outlets of the fluids are formed in the direction perpendicular to the flat heat transfer surface, and hence there is no need to form any distribution structure independently of the plate, thereby being capable of manufacturing a further compact heat exchanger in conjunction with the effect of forming thin channels by stacking the plates. In addition, in the leakage preventing plate, the passage holes serving as the inlets and outlets of the fluids are formed in the direction perpendicular to the flat heat transfer surface, and hence, when different kinds of fluids are used as the first fluid and the second fluid as described above, the leakage preventing plate can be manufactured by adjusting the diameters of the passage holes in accordance with the characteristics of the fluids.

[0028] When the hole diameter is set smaller, the flow rate can be increased in the passage hole. Therefore, when the heat exchanger is used as a condenser, the hole diameter is increased on a vapor side to reduce the increase in pressure loss, whereas the hole diameter is reduced on a liquid tube side to enhance drainage of the liquid from the heat exchanger. As a result, the heat exchanger can efficiently be used in the two-phase region of the vapor and the liquid, which is high in heat transfer efficiency.

[0029] In addition, when the heat exchanger is structured to have a large number of channels by stacking a plurality of plates, for example, 100 or 200 plates, the fluids can equally be distributed to the respective channels through the adjustment of the diameters of the passage holes. According to this embodiment, in which the passage holes are secured by the leakage preventing plates and the heat transfer plates, the plates can easily be manufactured by press working, and thus the hole diameters can be adjusted without increase in cost.

[0030] In addition, the following advantages are attained by the structure that the hole diameter can be adjusted easily. When the hole diameter is set smaller, the flow rate of the fluid is increased, and thus a large amount of fluid can easily be caused to flow to the channel on a deep side from an inlet pipe of the fluid. When the hole diameter is set larger, on the other hand, a large amount of fluid can easily be caused to flow to the channel close to the inlet pipe. Further, when the hole diameter is set larger, the flow rate can be reduced, and thus corrosion that may be caused by the flow rate in the passage hole (erosion) can be suppressed.

[0031] In addition, the first channel and the second channel are alternately stacked, and the inner fin is inserted between the channels. Therefore, the areas of the surfaces of the first channel and the second channel, which are adjacent to the inner fin, are increased as compared to the above-mentioned structure of Patent Literature 2. Thus, there is an advantage of high temperature efficiency.

[0032] The diameter of the passage hole is determined only by the diameter of a mold at the time of press working irrespective of the degree of elongation of a material, and therefore the diameter of the passage hole can be set larger. As a result, it is possible to suppress increase in pressure loss in the passage hole, and to suppress corrosion that may be caused along with the increase in flow rate of the fluid.

[0033] The inner fin and the flat heat transfer surface of the corresponding plate are joined to each other at the respective surfaces. Therefore, when the first fluid is a high-pressure fluid and the second fluid is a low-pressure fluid, the inner fin having a large area of contact with the plate is used in the first channel through which the first fluid flows, whereas the inner fin having a small area of contact with the plate is used in the second channel through which the second fluid flows. With this structure, a sufficient strength necessary for each section can be obtained, thereby being capable of attaining a heat exchanger that can ensure the strength with no waste as a whole.

[0034] As described above, according to the first embodiment, the thermal resistivities of the two fluids to be subjected to heat exchange are kept equal to each other, and thus the heat exchange efficiency can be kept excellent. Further, the long-term reliability of the device can be enhanced through the prevention of leakage of the fluid while the device is simple in structure and manufacturable at low cost. Thus, it is possible to use natural refrigerants such as CO_2 or combustible refrigerants such as hydrocarbons and low-GWP refrigerants, which cannot be used thus far due to the lack of the refrigerant leakage preventing function. Further, the range of selection of the fluid to be used is widened, and hence a refrigerant having a high latent heat can be selected. As a result, it is also possible to enhance the heat exchange performance.

Second Embodiment

[0035] Next, a plate heat exchanger according to a second embodiment of the present invention is described with reference to FIGS. 5A and 5B. In the above-mentioned first embodiment, as illustrated in FIG. 5A, there is used the leakage preventing plate 7 for covering the entire heat transfer plate 5. In the second embodiment, on the other hand, there is used a leakage preventing plate 107 for covering only a region in which the first fluid and the second fluid are adjacent to each other. That is, as the shape of the leakage preventing plate 107, for example, as illustrated in FIG. 5B, there is given a shape obtained by cutting out the region on the periphery of the first fluid advancing hole 11d (projected portion 7b) of the leakage preventing plate 7 according to the first embodiment. Thus, it is possible to reduce the usage amount of the material for the leakage preventing plate, and to therefore manufacture the heat exchanger at low cost.

Third Embodiment

[0036] As a third embodiment of the present invention, there is given such an embodiment that each of the leakage preventing plates 7 and 107 is formed of a cladding material. When the leakage preventing plate is formed of the cladding material as described above, the production efficiency can be enhanced. When the brazing material alone is sandwiched in the manufacturing process, the brazing material may be displaced from a proper position, which may cause joining failure. When the number of stacking members is increased at the time of assembling the heat exchanger, the production rate is reduced. However, those problems can be solved by the cladding of the leakage preventing plate. As a result, it is possible to suppress the brazing failure, and to reduce the cost required for processing the heat exchanger.

Fourth Embodiment

[0037] As a fourth embodiment of the present invention, there is given such an embodiment that the heat transfer plate, the inner fin, and the leakage preventing plate are integrated with each other by brazing. When the components are joined to each other by brazing, the close contact between the components is improved. Thus, it is possible to suppress the reduction in heat transfer rate even on the premise that the leakage preventing plate is provided. Particularly when a brazing material such as copper having high thermal conductivity is used, the effect of suppressing the reduction in heat transfer rate is greater. The brazing allows the components to be brought into close contact with each other, and hence the joining strength is increased, with the result that the heat exchanger can be manufactured stably.

Fifth Embodiment

[0038] As a fifth embodiment of the present invention, there is given such an embodiment that the heat transfer plate and the leakage preventing plate have different thickness dimensions. When the thickness of the leakage preventing plate is set larger than that of the heat transfer plate, such setting is effective in the advance of the corrosion of the heat exchanger and the improvement of the strength of the heat exchanger. When the thickness of the leakage preventing plate is set smaller than that of the heat transfer plate, on the other hand, the thermal resistance of the leakage preventing plate can be reduced. As a result, it is possible to suppress the reduction in heat exchange performance, and to reduce the cost of material as well. In this manner, the thickness of the leakage preventing plate only needs to be selected in accordance with desired conditions.

Sixth Embodiment

[0039] As a sixth embodiment of the present invention, there is given a refrigeration cycle system having mounted thereon the plate heat exchanger according to any one of the above-mentioned first to fifth embodiments. According to the sixth embodiment, in a refrigeration cycle system including a compressor, a condenser (including a gas cooler), an expansion valve, and an evaporator, which are sequentially coupled to each other through refrigerant piping, the plate heat exchanger according to any one of the first to fifth embodiments is used for both or one of the condenser and the evaporator. According to the sixth embodiment, it is possible to attain a refrigeration cycle system having high reliability.

[0040] The details of the present invention have been described above specifically with reference to the preferred embodiments, but it is apparent that a person skilled in the art may employ various modifications based on the basic technical thoughts and teachings of the present invention.

[0041] For example, there is exemplified a case where the single leakage preventing plate is provided, but a plurality of leakage preventing plates may be stacked, or the leakage preventing plate may be formed of a different material. The materials that may be used for the components of the heat exchanger also include metals such as stainless steel, copper, aluminum, and titanium, or synthetic resins.

[0042] Further, as examples of the application of the present invention, the present invention is applicable to an air conditioner, a power generator, a heat sterilizer for foods, or various other industrial devices and home appliances having the plate heat exchanger mounted thereon.

Reference Signs List

[0043] 1 plate heat exchanger, 5 heat transfer plate, 7 leakage preventing plate, 9 inner fin

Claims

1. A plate heat exchanger, comprising:

a plurality of heat transfer plates each having a flat heat transfer surface; and
a plurality of inner fins each being arranged in

corresponding one of first channels or corresponding one of second channels, the first channels and the second channels being alternately formed between pairs of the plurality of heat transfer plates, respectively,
one of the plurality of inner fins, which is arranged in the corresponding one of the first channels, and another of the plurality of inner fins, which is arranged in the corresponding one of the second channels, being provided so as to have different heat transfer areas,
leakage preventing plates being arranged between the pairs of the plurality of heat transfer plates, respectively, a passage hole through which at least a first fluid or a second fluid is flowed, is formed on each of the leakage preventing plates.

2. A plate heat exchanger according to claim 1, wherein the each of the leakage preventing plates has a flat portion in a region mated with the flat heat transfer surface of the corresponding one of the plurality of heat transfer plates, and
wherein each of the plurality of heat transfer plates and the each of the leakage preventing plates are brought into surface contact with each other so as to hold each other.

3. A plate heat exchanger according to claim 2, wherein the each of the plurality of inner fins is structured such that projections and depressions are formed repeatedly, the projections and the depressions have flat end portions, and each of the plurality of inner fins is brought into surface contact with corresponding one of the plurality of heat transfer plates and the plurality of leakage preventing plates at the flat end portions.

4. A plate heat exchanger according to any one of claims 1 to 3, wherein the each of the leakage preventing plates is configured to cover only a region in which the first fluid and the second fluid are adjacent to each other.

5. A plate heat exchanger according to any one of claims 1 to 4, wherein the each of the leakage preventing plates is formed of a cladding material.

6. A plate heat exchanger according to any one of claims 1 to 5, wherein a thickness of the each of the plurality of heat transfer plates and a thickness of the each of the leakage preventing plates are different from each other.

7. A refrigeration cycle system, comprising the plate heat exchanger according to any one of claims 1 to 6, which is provided in both or one of a condenser and an evaporator.

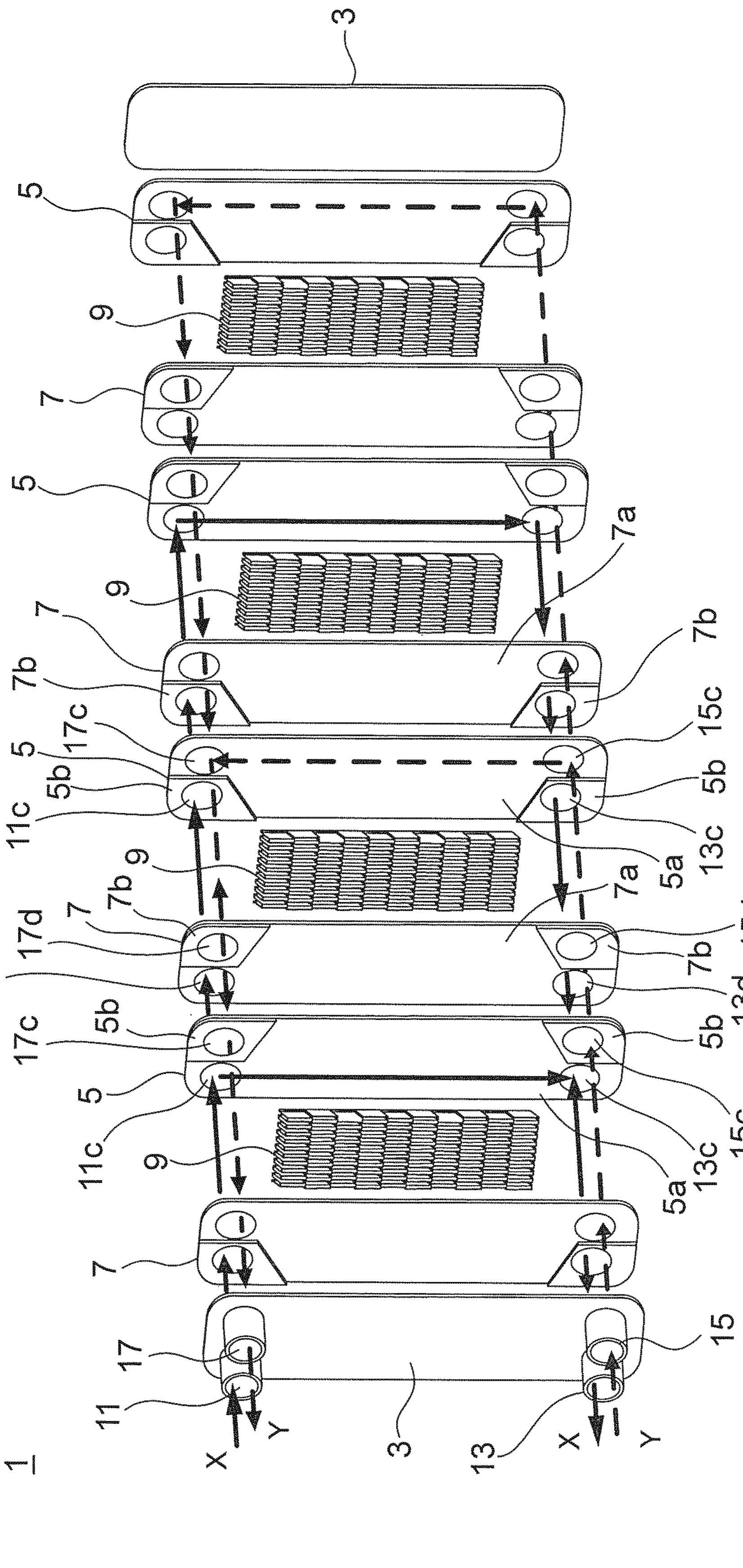


FIG. 1

FIG. 2

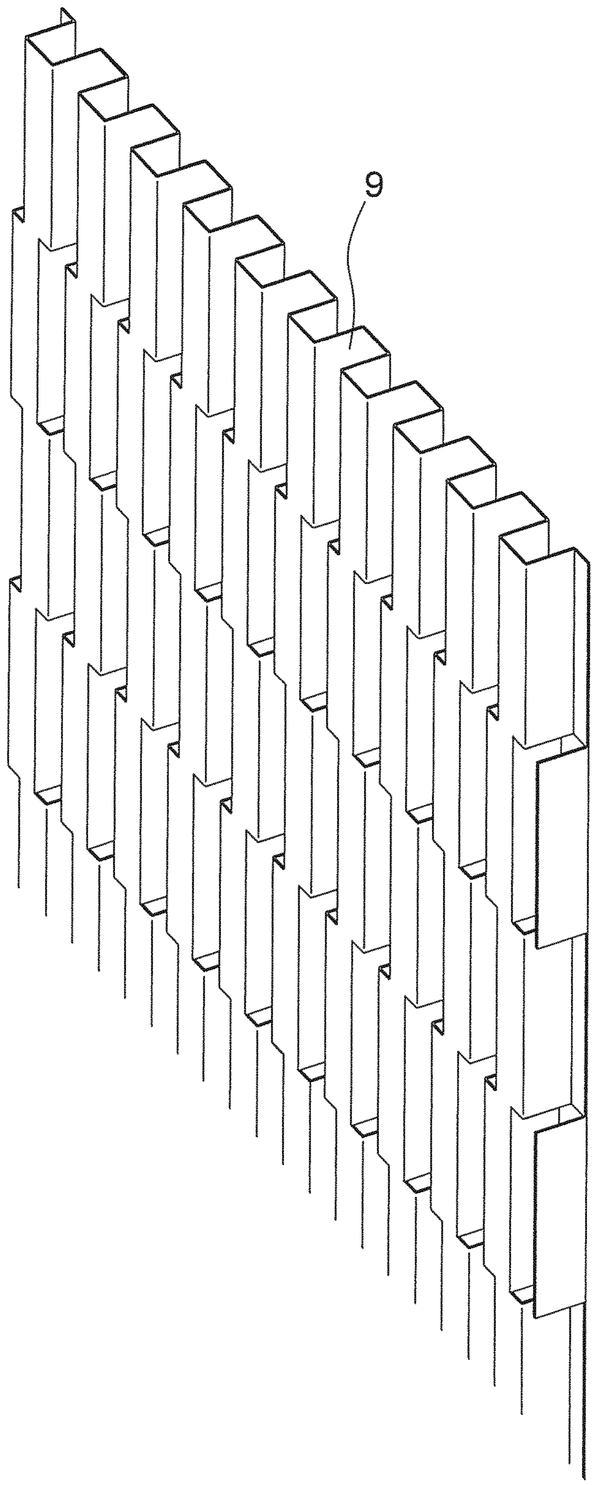


FIG. 3

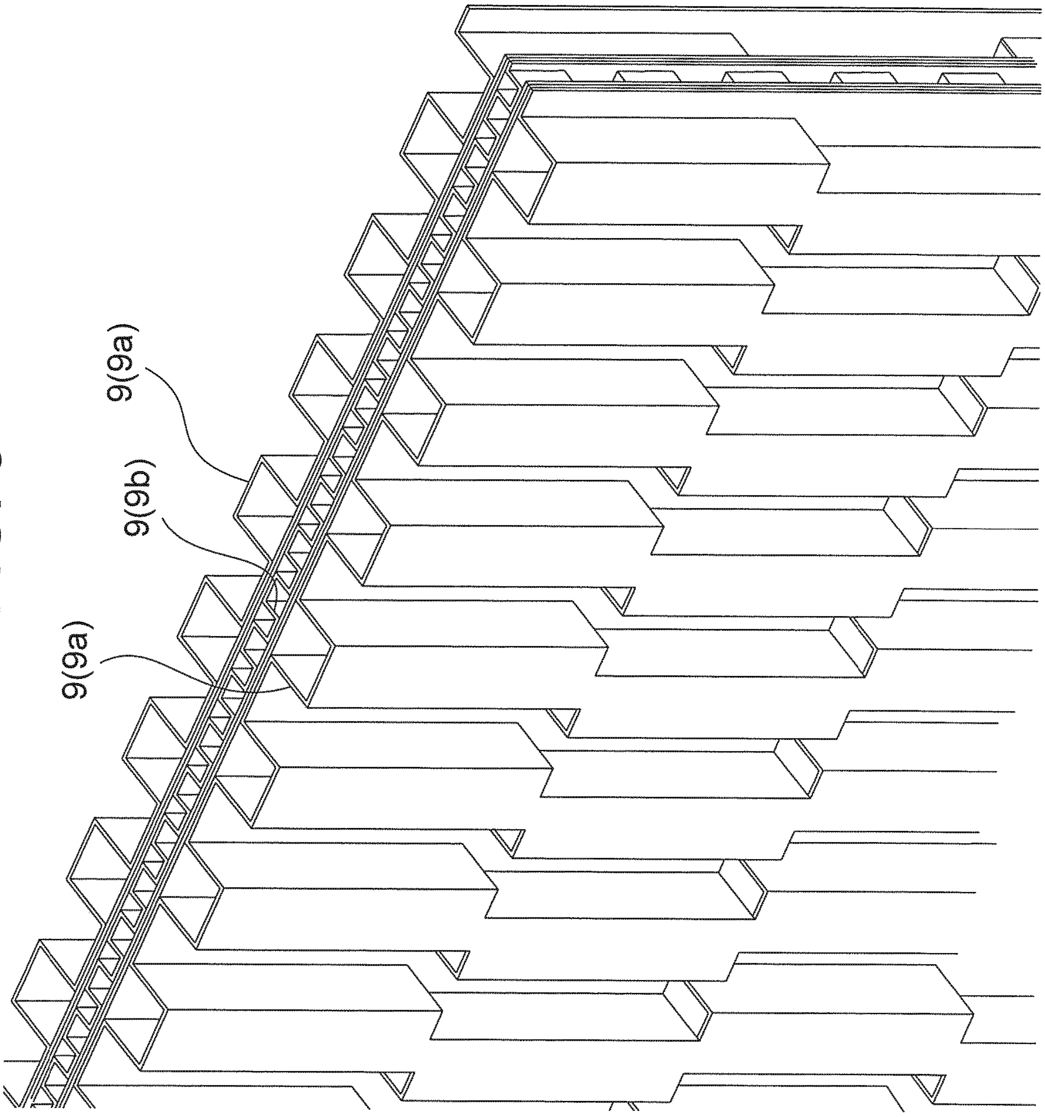


FIG. 4

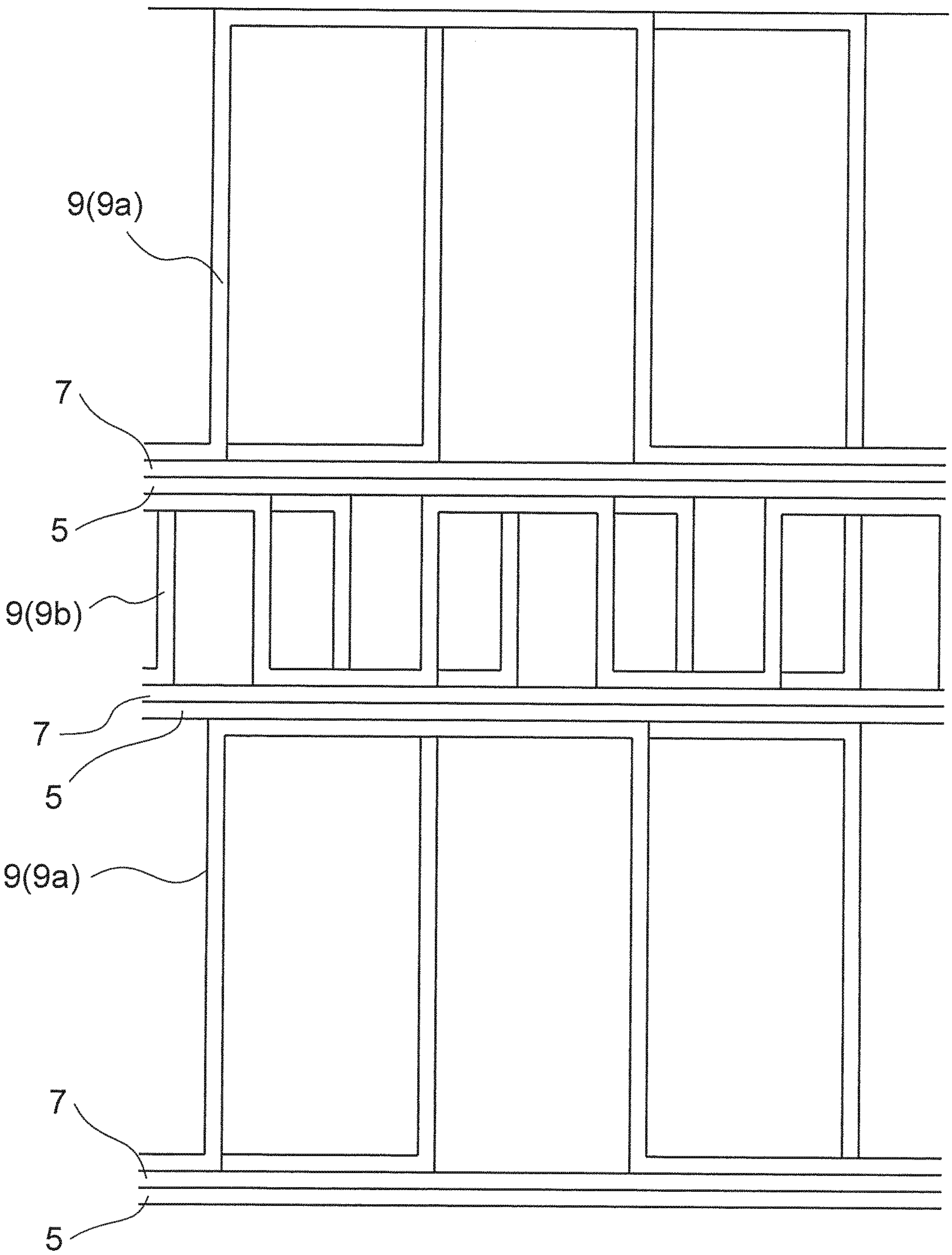


FIG. 5B

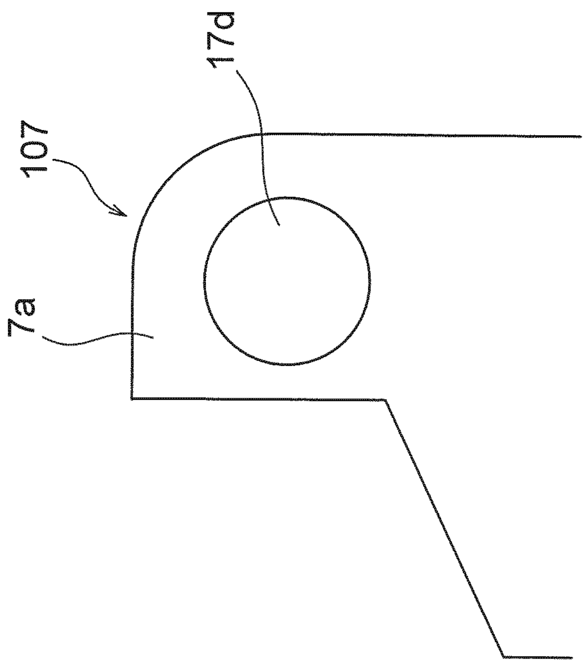
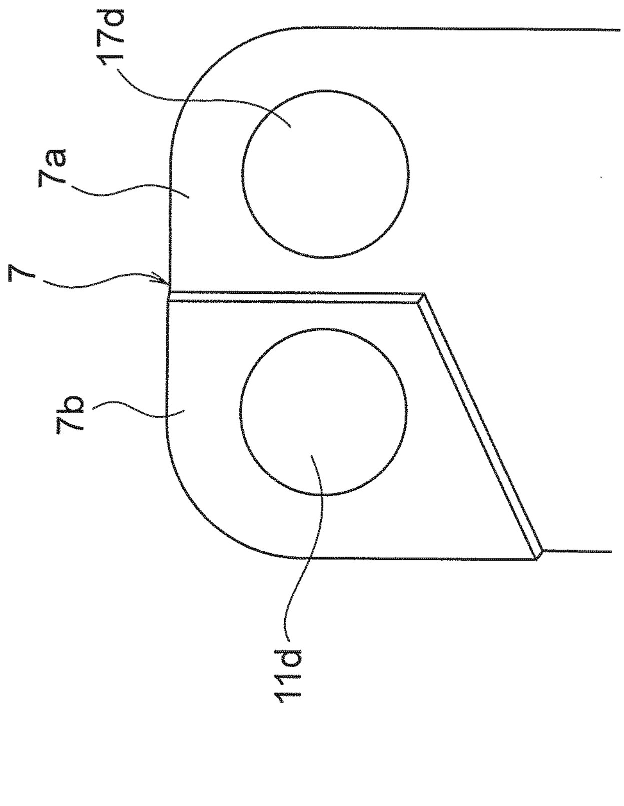


FIG. 5A



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/065456

A. CLASSIFICATION OF SUBJECT MATTER
F28D9/02(2006.01)i, *F28F3/00*(2006.01)i, *F28F3/08*(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)
F28D9/02, F28F3/00, F28F3/08

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2001-99585 A (Denso Corp.), 13 April 2001 (13.04.2001), entire text; all drawings (particularly, paragraphs [0001] to [0056]; fig. 1 to 6) & US 6298910 B1 & GB 2355683 A & GB 23572 D0 & DE 10048212 A	1-7
Y	JP 2002-203586 A (Calsonic Kansei Corp.), 19 July 2002 (19.07.2002), entire text; all drawings (particularly, paragraphs [0021], [0023]; fig. 1 to 4) (Family: none)	1-7

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

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12 August, 2013 (12.08.13)	20 August, 2013 (20.08.13)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/065456

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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REFERENCES CITED IN THE DESCRIPTION

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