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(54) **PLATE HEAT EXCHANGER**

(57) Disclosed is a plate heat exchanger. The plate heat exchanger comprises a plurality of heat transfer plates, the plurality of heat transfer plates comprising: a first heat transfer plate, comprising protrusions protruding upward, the protrusions having a top; and a second heat transfer plate stacked on the first heat transfer plate, the second heat transfer plate comprising recesses recessed downward, the recesses having a bottom. The tops of the protrusions have a concave portion which is sunken downward, and at least part of the bottoms of the recesses of the second heat transfer plate is disposed in the concave portion of the tops of the protrusions of the first heat transfer plate. It is thus possible to improve the weld quality of the heat exchanger.

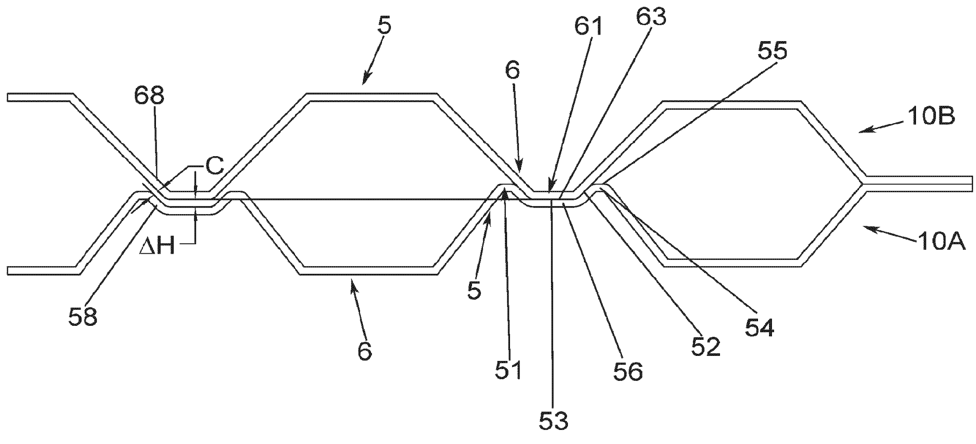

Fig. 4

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Description

Technical Field

[0001] The embodiments of the present invention relate to a plate heat exchanger.

Background

[0002] In a traditional plate heat exchanger, the top of a protrusion of one of two adjacent heat transfer plates is butt-welded to the bottom of a corresponding recess of the other heat transfer plate. Therefore, a flow path can be formed in a heat exchange zone of the plate heat exchanger.

Summary of the Invention

[0003] An objective of an embodiment of the present invention is to provide a plate heat exchanger, whereby the welding quality of a heat exchanger is improved.

[0004] According to an embodiment of the present invention, a plate heat exchanger is provided, including a plurality of heat transfer plates. The plurality of heat transfer plates include: a first heat transfer plate including a protrusion protruding upward, the protrusion having a top; and a second heat transfer plate stacked on the first heat transfer plate and including a recess sunken downward, the recess having a bottom, wherein the top of the protrusion has a concave portion sunken downward, and at least a part of the bottom of the recess of the second heat transfer plate is located in the concave portion at the top of the protrusion of the first heat transfer plate.

[0005] According to an embodiment of the present invention, the concave portion at the top of the protrusion is located in the middle of the top.

[0006] According to an embodiment of the present invention, the concave portion at the top of the protrusion is located on one side of the top, and the top of the protrusion is step-shaped.

[0007] According to an embodiment of the present invention, the concave portion at the top of the protrusion has an upward flat bottom surface.

[0008] According to an embodiment of the present invention, the bottom of the recess has a downward curved bottom surface or downward flat bottom surface.

[0009] According to an embodiment of the present invention, a portion at the top of the protrusion other than the concave portion has at least one of a curved top surface portion and a flat top surface portion.

[0010] According to an embodiment of the present invention, the bottom of the recess has a concave portion sunken upward.

[0011] According to an embodiment of the present invention, the concave portion at the bottom of the recess is located in the middle of the bottom.

[0012] According to an embodiment of the present invention, a bottom portion of the concave portion at the top of the protrusion has an upward convex portion, and at least a part of the convex portion of the bottom portion of the concave portion at the top of the protrusion is located in the concave portion at the bottom of the recess.

[0013] According to an embodiment of the present invention, the bottom of the recess has a convex portion protruding downward, and at least a part of the convex portion at the bottom of the recess is located in the concave portion at the top of the protrusion.

[0014] According to an embodiment of the present invention, the concave portion at the top of the protrusion is located on one side of the top, and the top of the protrusion is step-shaped; and the convex portion at the bottom of the recess is located on one side of the bottom of the recess, and the bottom of the recess is step-shaped.

[0015] According to an embodiment of the present invention, the top of the protrusion and the bottom of the recess have complementary shapes.

[0016] According to an embodiment of the present invention, the protrusion of the first heat transfer plate and the recess of the second heat transfer plate are located in at least a part of a heat exchange zone and/or at least a part of an opening zone of the plate heat exchanger.

[0017] According to an embodiment of the present invention, the first heat transfer plate further includes a recess sunken downward, and the second heat transfer plate further includes a protrusion protruding upward.

[0018] According to an embodiment of the present invention, the plurality of heat transfer plates include a plurality of first heat transfer plates and a plurality of second heat transfer plates, which are stacked on top of each other, the plurality of first heat transfer plates and the plurality of second heat transfer plates being alternately arranged, and the bottom of the recess of one of every two adjacent heat transfer plates being connected to the top of the protrusion of the other of the two adjacent heat transfer plates.

[0019] According to an embodiment of the present invention, the top of the protrusion of the second heat transfer plate has a concave portion sunken downward, and at least a part of the bottom of the recess of the first heat transfer plate is located in the concave portion at the top of the protrusion of the second heat transfer plate.

[0020] According to an embodiment of the present invention, the concave portion at the top of the protrusion of the first heat transfer plate and the bottom of the recess of the second heat transfer plate are circular when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate, or the concave portion at the top of the protrusion of the first heat transfer plate and the bottom of the recess of the second heat transfer plate are crescent-shaped when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate.

[0021] According to an embodiment of the present invention, the concave portion at the top of the protrusion of the first heat transfer plate is circular when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate, and the concave portion at the top of the protrusion of the second heat transfer plate is crescent-shaped when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate.

[0022] According to an embodiment of the present invention, the angle of inclination of at least a part of a side wall of the concave portion at the top of the protrusion of the first heat transfer plate with respect to a horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall of the recess of the second heat transfer plate with respect to the horizontal plane.

[0023] According to an embodiment of the present invention, the angle of inclination of at least a part of a side wall of the concave portion at the top of the protrusion of the first heat transfer plate with respect to a horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall of the convex portion at the bottom of the recess of the second heat transfer plate with respect to the horizontal plane.

[0024] In the plate heat exchanger according to the embodiments of the present invention, since at least a part of the bottom of the recess of the second heat transfer plate is located in the concave portion at the top of the protrusion of the first heat transfer plate, the welding quality is improved.

Brief Description of the Drawings

[0025]

FIG. 1 is a schematic perspective view of a plate heat exchanger according to an embodiment of the present invention;

FIG. 2 is a schematic perspective view of a heat transfer plate of the plate heat exchanger shown in FIG. 1;

FIG. 3 is a schematic enlarged view of a portion, located in a heat exchange zone, of the heat transfer plate of the plate heat exchanger shown in FIG. 1;

FIG. 4 is a schematic diagram of portions of two adjacent heat transfer plates of a plate heat exchanger according to an embodiment of the present invention;

FIG. 5 is a schematic diagram of portions of two adjacent heat transfer plates of a plate heat exchanger according to another embodiment of the present invention;

FIG. 6 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to a variant of an embodiment of the present invention;

FIG. 7 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to another variant of an embodiment of the present invention;

FIG. 8 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to yet another variant of an embodiment of the present invention;

FIG. 9 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to still yet another variant of an embodiment of the present invention;

FIG. 10 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to a further variant of an embodiment of the present invention;

FIG. 11 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to a further variant of an embodiment of the present invention;

FIG. 12 is a schematic diagram of protrusions and recesses of two adjacent heat transfer plates of a plate heat exchanger according to a further variant of an embodiment of the present invention;

FIG. 13 is a schematic front view of a portion of a heat transfer plate of a plate heat exchanger according to a variant of an embodiment of the present invention;

FIG. 14 is a schematic front view of a portion of a heat transfer plate of a plate heat exchanger according to another variant of an embodiment of the present invention;

FIGS. 15A and 15B are respectively views of portions of two adjacent heat transfer plates of a plate heat exchanger according to an embodiment of the present invention, showing patterns at tops of protrusions and at bottoms of recesses; and

FIGS. 16A and 16B are respectively views of portions of two adjacent heat transfer plates of a plate heat exchanger according to another embodiment of the present invention, showing patterns at tops of protrusions and at bottoms of recesses.

Detailed Description of the Invention

[0026] The present invention will be described below in further detail in conjunction with the drawings and specific embodiments.

[0027] As shown in FIGS. 1 to 16B, a plate heat exchanger 100 according to an embodiment of the present invention includes a plurality of heat transfer plates 10; heat exchange spaces formed between the adjacent heat transfer plates 10 of the plurality of heat transfer plates 10; and channels formed in the heat transfer plates 10. Openings 11 of the plurality of heat transfer plates 10 constitute the channels. The channels are configured for a heat exchange medium (for example, a refrigerant) to flow into or out of the heat exchanger 100. The heat transfer plate 10 or the heat exchanger 100 includes a heat exchange zone 21 for heat exchange of the heat exchange medium and an opening zone 22 surrounding the opening.

[0028] As shown in FIGS. 1 to 16B, the plurality of heat transfer plates 10 include: a first heat transfer plate 10A, the first heat transfer plate 10A including a protrusion 5 protruding upward, and the protrusion 5 having a top 51; and a second heat transfer plate 10B stacked on the first heat transfer plate 10A, the second heat transfer plate 10B including a recess 6 sunken downward, and the recess 6 having a bottom 61. The top 51 of the protrusion 5 has a concave portion 52 sunken downward, and at least a part of the bottom 61 of the recess 6 of the second heat transfer plate 10B is located in the concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A. The protrusion 5 of the first heat transfer plate 10A and the recess 6 of the second heat transfer plate 10B are located in at least a part of the heat exchange zone 21 of the plate heat exchanger 100. Of course, the protrusion 5 of the first heat transfer plate 10A and the recess 6 of the second heat transfer plate 10B may also be located in at least a part of the opening zone 22 of the plate heat exchanger 100. That is, the concept of the present invention may also be applied to the opening zone 22 of the plate heat exchanger 100.

[0029] As shown in FIGS. 3 to 16B, in an embodiment of the present invention, the first heat transfer plate 10A further includes the recess 6 sunken downward, and the second heat transfer plate 10B further includes the protrusion 5 protruding upward or a protrusion 5 protruding upward (free from the concave portion, see FIG. 14). The plurality of heat transfer plates 10 include a plurality of first heat transfer plates 10A and a plurality of second heat transfer plates 10B, which are stacked on top of each other, the plurality of first heat transfer plates 10A and the plurality of second heat transfer plates 10B being alternately arranged. That is, each heat transfer plate 10 has the protrusion 5 protruding upward and the recess 6 sunken downward, the top of the protrusion 5 of one of every two adjacent heat transfer plates 10 is connected to the bottom of the recess 6 of the other of the two adjacent heat transfer plates 10, and each heat transfer plate 10 other than the outermost heat transfer plate of the heat exchanger is stacked between two heat transfer plates 10. For example, the top 51 of the protrusion 5 of the second heat transfer plate 10B has the concave portion 52 sunken downward, and at least a part of the bottom 61 of the recess 6 of the first heat transfer plate 10A is located in the concave portion 52 at the top 51 of the protrusion 5 of the second heat transfer plate 10B.

[0030] As shown in FIGS. 4-6, 9 and 12-14, in an embodiment of the present invention, the concave portion 52 at the top 51 of the protrusion 5 is located in the middle of the top 51. For example, the top 51 is in a symmetrical shape with respect to one or more vertical planes passing through the center of the top 51 on a horizontal plane, or the top 51 is in a rotationally symmetrical shape with respect to a vertical straight line passing through the center of the top 51 on a horizontal plane. Accordingly, as an example, the bottom 61 is in a symmetrical shape with respect to one or more vertical planes passing through the center of the bottom 61 on a horizontal plane, or the bottom 61 is in a rotationally symmetrical shape with respect to a vertical straight line passing through the center of the bottom 61 on a horizontal plane.

[0031] As shown in FIGS. 8 and 11, in an embodiment of the present invention, the concave portion 52 at the top 51 of the protrusion 5 is located on one side of the top 51, and the top 51 of the protrusion 5 is step-shaped.

[0032] In an embodiment of the present invention, as shown in FIGS. 4-11, the concave portion 52 at the top 51 of the protrusion 5 has an upward flat bottom surface 53. As shown in FIGS. 4-12, the bottom 61 of the recess 6 has a downward curved bottom surface 63 or a downward flat bottom surface 63. As shown in FIGS. 4-12, a portion 54 at the top 51 of the protrusion 5 other than the concave portion 52 has at least one of a curved top surface portion 55 and a flat top surface portion 55. As shown in FIGS. 4, 5, 8, 9 and 11, the concave portion 52 at the top 51 of the protrusion 5 has an upward flat bottom surface 53, and the bottom 61 of the recess 6 has a downward flat bottom surface 63.

[0033] As shown in FIGS. 10 and 12, in an embodiment of the present invention, the bottom 61 of the recess 6 has a concave portion 62 sunken upward. The concave portion 62 at the bottom 61 of the recess 6 may be located in the middle of the bottom 61. For example, the bottom 61 is in a symmetrical shape with respect to one or more vertical planes passing through the center of the bottom 61 on a horizontal plane, or the bottom 61 is in a rotationally symmetrical shape with respect to a vertical straight line passing through the center of the bottom 61 on a horizontal plane. In an example of the present invention, as shown in FIG. 12, a bottom portion 56 of the concave portion 52 at the top 51 of the protrusion 5 has an upward convex portion 57, and at least a part of the convex portion 57 of the bottom portion 56 of the concave portion 52 at the top 51 of the protrusion 5 is located in the concave portion 62 at the bottom 61 of the recess 6.

[0034] As shown in FIGS. 9 and 11, in an embodiment of the present invention, the bottom 61 of the recess 6 has a convex portion 64 protruding downward, and at least a part of the convex portion 64 at the bottom 61 of the recess 6 is located in the concave portion 52 at the top 51 of the protrusion 5. In an embodiment as shown in FIG. 11, the concave portion 52 at the top 51 of the protrusion 5 is located on one side of the top 51, and the top 51 of the protrusion 5 is step-shaped; and the convex portion 64 at the bottom 61 of the recess 6 is located on one side of the bottom 61 of the recess 6, and the bottom 61 of the recess 6 is step-shaped.

[0035] As shown in FIGS. 9, 11 and 12, in an embodiment of the present invention, the top 51 of the protrusion 5 and the bottom 61 of the recess 6 have complementary shapes. In other words, a top surface of the top 51 of the protrusion 5 and a bottom surface of the bottom 61 of the recess 6 have complementary shapes.

[0036] As shown in FIGS. 4-8, 10 and 12, in an embodiment of the present invention, the angle of inclination of at least a part of a side wall 58 of the concave portion

52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A with respect to a horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall 68 of the recess 6 of the second heat transfer plate 10B with respect to the horizontal plane. The corresponding portion of the side wall 68 corresponds to the at least a part of the side wall 58.

[0037] As shown in FIGS. 9 and 11, in an embodiment of the present invention, the angle of inclination of at least a part of the side wall 58 of the concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A with respect to the horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall 69 of the convex portion 64 at the bottom 61 of the recess 6 of the second heat transfer plate 10B with respect to the horizontal plane. The corresponding portion of the side wall 69 corresponds to the at least a part of the side wall 58.

[0038] As shown in FIGS. 13 and 14, in an embodiment of the present invention, in the heat exchanger, the heat transfer plate separates two different channels. As shown in FIG. 13, all the heat transfer plates 10 may only have the protrusions 5 and the recesses 6 according to the embodiments of the present invention, or as shown in FIG. 14, some heat transfer plates 10 may have traditional protrusions 5 and recesses 6, and another heat transfer plate 10 may have the protrusion 5 and the recess 6 according to the embodiments of the present invention. Therefore, an appropriate symmetry ratio of the channels, and an appropriate design of the protrusion 5 and the recess 6 are selected according to the actually desired welding strength and performance requirements with reference to the complexity of design and process.

[0039] Referring to FIGS. 15A to 16B, in an embodiment of the present invention, the protrusions 5 and the recesses 6 of the first heat transfer plate 10A and the second heat transfer plate 10B are alternately arranged in a first direction and alternately arranged in a second direction intersecting the first direction. The concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A is circular or crescent-shaped when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B. The circular protrusion 5 of one of every two adjacent heat transfer plates 10 is connected to the circular recess 6 of the other of the two adjacent heat transfer plates 10, and the crescent-shaped recess 6 of one of every two adjacent heat transfer plates 10 is connected to the crescent-shaped protrusion 5 of the other of the two adjacent heat transfer plates 10. According to an example of the present invention, referring to FIGS. 15A and 15B, the protrusion 5 and the recess 6 of the first heat transfer plate 10A, and the protrusion 5 and the recess 6 of the second heat transfer plate 10B are circular when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B. The concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A and the concave portion 52 at the top 51 of the protrusion 5 of the second heat transfer plate 10B are circular when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B. According to another example of the present invention, referring to FIGS. 16A and 16B, the protrusion 5 of the first heat transfer plate 10A and the recess 6 of the second heat transfer plate 10B are circular when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B, and the recess 6 of the first heat transfer plate 10A and the protrusion 5 of the second heat transfer plate 10B are crescent-shaped when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B. The concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A and the bottom of the recess 6 of the second heat transfer plate 19B are circular when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B, and the bottom of the recess 6 of the first heat transfer plate 10A and the concave portion 52 at the top 51 of the protrusion 5 of the second heat transfer plate 10B are crescent-shaped when viewed in the stacking direction of the first heat transfer plate 10A and the second heat transfer plate 10B. The concave portion 52 at the top 51 of the protrusion 5 may also be in any other appropriate shapes. That is, the shape of the concave portion at the top 51 of the protrusion 5 may be consistent with that of the protrusion 5, and the shape of the bottom 61 of the recess 6 may be consistent with that of the recess 6, thus facilitating processing.

[0040] According to an embodiment of the present invention, at least a part of the bottom 61 of the recess 6 of the second heat transfer plate 10B is located in the concave portion 52 at the top 51 of the protrusion 5 of the first heat transfer plate 10A. That is, the concave portion 52 at least partially surrounds the bottom 61. Therefore, the butt welding of the top of the protrusion of one of two adjacent heat transfer plates to the bottom of the corresponding recess of the other heat transfer plate is changed into a combination of butt welding and overlap welding. Therefore, the bottom 61 of the recess 6 of the second heat transfer plate 10B is locked to the top 51 of the protrusion 5 of the first heat transfer plate 10A, so that the top 51 of the protrusion 5 of the first heat transfer plate 10A is kept facing the bottom 61 of the recess 6 of the second heat transfer plate 10B, thereby positioning the heat transfer plates in the technological process, increasing the welding area, and hence making the welding firmer. According to an embodiment of the present invention, referring to FIGS. 4 and 5, in case of a flatness defect and a molding problem, there is a gap ΔH between the bottoms 61 of some recesses 6 and bottom portions 56 of the concave portions 52 at the tops 51 of the corresponding protrusions 5. Since the angle of inclination of at least a part of the side wall 58 is greater than or equal to the angle of inclination of the corresponding portion of the side wall 68, a gap C between the side wall 58 and the side wall 68 is smaller than the gap ΔH between the bottoms 61 of the recesses 6 and the bottom portions 56 of the concave portions 52, which can offset the effects caused by the problems of flatness and molding of the heat transfer plates. Due to the concave portion 52 at the top 51 of the protrusion 5, more solder can be reserved for soldering, and solder paste can be used as the solder to reduce the cost.

[0041] According to an embodiment of the present invention, referring to FIGS. 6 to 11, the bottom 61 of the recess 6 and the bottom portion 56 of the concave portion 52 at the top 51 of the corresponding protrusion 5 may be curved surfaces or planes, and may be of symmetric structures or asymmetric structures. This reduces the requirements on the molding accuracy of the heat transfer plates while ensuring positioning and increasing the welding area, and may increase the possibility of adjusting the symmetry rate of the channels on two sides of the heat transfer plates. Therefore, the purpose of performance optimization is achieved.

[0042] According to an embodiment of the present invention, referring to FIG. 10, the bottom 61 of the recess 6 has the concave portion 62 sunken upward, and referring to FIG. 9, the bottom 61 of the recess 6 has the convex portion 64 protruding downward. Therefore, the welding area can be increased to a greater extent, the solder can be better preserved, and the possibility of adjusting the symmetry ratio of the channels on two sides of the heat transfer plates can be increased.

[0043] According to an embodiment of the present invention, referring to FIG. 11, the concave portion 52 at the top 51 of the protrusion 5 is located on one side of the top 51, and the top 51 of the protrusion 5 is step-shaped; and the convex portion 64 at the bottom 61 of the recess 6 is located on one side of the bottom 61 of the recess 6, and the bottom 61 of the recess 6 is step-shaped. Referring to FIG. 12, the bottom 61 of the recess 6 has the concave portion 62 sunken upward and the bottom portion 56 of the concave portion 52 at the top 51 of the protrusion 5 has the upward convex portion 57. That is, both of the bottom 61 of the recess 6 and the top 51 of the protrusion 5 have grooves or bulges. Thus, it is possible to increase the possibility of adjusting the symmetry ratio of the channels on two sides of the heat transfer plates.

[0044] Therefore, by using the technical solutions of the present invention, the welding quality and the heat exchange performance of the heat exchanger can be improved, and the process difficulty can be reduced.

[0045] Although the above embodiments have been described, certain features in the above embodiments can be combined to form new embodiments.

Claims

1. A plate heat exchanger, comprising a plurality of heat transfer plates, the plurality of heat transfer plates comprising:

    a first heat transfer plate comprising a protrusion protruding upward, the protrusion having a top; and

    a second heat transfer plate stacked on the first heat transfer plate and comprising a recess sunken downward, the recess having a bottom, **characterized in that** a top of the protrusion has a concave portion sunken downward, and at least a part of a bottom of the recess of the second heat transfer plate is located in the concave portion at the top of the protrusion of the first heat transfer plate.

2. The plate heat exchanger as claimed in claim 1, **characterized in that** the concave portion at the top of the protrusion is located in the middle of the top.

3. The plate heat exchanger as claimed in claim 1, **characterized in that** the concave portion at the top of the protrusion is located on one side of the top, and the top of the protrusion is step-shaped.

4. The plate heat exchanger as claimed in claim 1, **characterized in that** the concave portion at the top of the protrusion has an upward flat bottom surface.

5. The plate heat exchanger as claimed in claim 1, **characterized in that** the bottom of the recess has a downward curved bottom surface or a downward flat bottom surface.

6. The plate heat exchanger as claimed in claim 1, **characterized in that** a portion at the top of the protrusion other than the concave portion has at least one of a curved top surface portion and a flat top surface portion.

7. The plate heat exchanger as claimed in claim 1, **characterized in that** the bottom of the recess has a concave portion sunken upward.

8. The plate heat exchanger as claimed in claim 7, **characterized in that** the concave portion at the bottom of the recess is located in the middle of the bottom.

9. The plate heat exchanger as claimed in claim 8, **characterized in that** a bottom portion of the concave portion at the top of the protrusion has an upward convex portion, and at least a part of the convex portion of the bottom portion of the concave portion at the top of the protrusion

is located in the concave portion at the bottom of the recess.

10. The plate heat exchanger as claimed in claim 1, **characterized in that** the bottom of the recess has a convex portion protruding downward, and at least a part of the convex portion at the bottom of the recess is located in the concave portion at the top of the protrusion.

11. The plate heat exchanger as claimed in claim 10, **characterized in that**

    the concave portion at the top of the protrusion is located on one side of the top, and the top of the protrusion is step-shaped; and
    the convex portion at the bottom of the recess is located on one side of the bottom of the recess, and the bottom of the recess is step-shaped.

12. The plate heat exchanger as claimed in any one of claims 9 to 11, **characterized in that** the top of the protrusion and the bottom of the recess have complementary shapes.

13. The plate heat exchanger as claimed in claim 1, **characterized in that**

    the protrusion of the first heat transfer plate and the recess of the second heat transfer plate are located in at least a part of a heat exchange zone and/or
    at least a part of an opening zone of the plate heat exchanger.

14. The plate heat exchanger as claimed in claim 1, **characterized in that** the first heat transfer plate further comprises a recess sunken downward, and the second heat transfer plate further comprises a protrusion protruding upward.

15. The plate heat exchanger as claimed in claim 14, **characterized in that** the plurality of heat transfer plates comprise a plurality of first heat transfer plates and a plurality of second heat transfer plates, which are stacked on top of each other, the plurality of first heat transfer plates and the plurality of second heat transfer plates being alternately arranged, and the bottom of the recess of one of every two adjacent heat transfer plates being connected to the top of the protrusion of the other of the two adjacent heat transfer plates.

16. The plate heat exchanger as claimed in claim 15, **characterized in that** the top of the protrusion of the second heat transfer plate has a concave portion sunken downward, and at least a part of the bottom of the recess of the first heat transfer plate is located in the concave portion at the top of the protrusion of the second heat transfer plate.

17. The plate heat exchanger as claimed in claim 1, **characterized in that**

    the concave portion at the top of the protrusion of the first heat transfer plate and the bottom of the recess of the second heat transfer plate are circular when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate, or
    the concave portion at the top of the protrusion of the first heat transfer plate and the bottom of the recess of the second heat transfer plate are crescent-shaped when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate.

18. The plate heat exchanger as claimed in claim 16, **characterized in that** the concave portion at the top of the protrusion of the first heat transfer plate is circular when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate, and the concave portion at the top of the protrusion of the second heat transfer plate is crescent-shaped when viewed in the stacking direction of the first heat transfer plate and the second heat transfer plate.

19. The plate heat exchanger as claimed in claim 1, **characterized in that** the angle of inclination of at least a part of a side wall of the concave portion at the top of the protrusion of the first heat transfer plate with respect to a horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall of the recess of the second heat transfer plate with respect to the horizontal plane.

20. The plate heat exchanger as claimed in claim 10 or 11, **characterized in that** the angle of inclination of at least a part of a side wall of the concave portion at the top of the protrusion of the first heat transfer plate with respect to a horizontal plane is greater than or equal to the angle of inclination of a corresponding portion of a side wall of the convex portion at the bottom of the recess of the second heat transfer plate with respect to the horizontal plane.

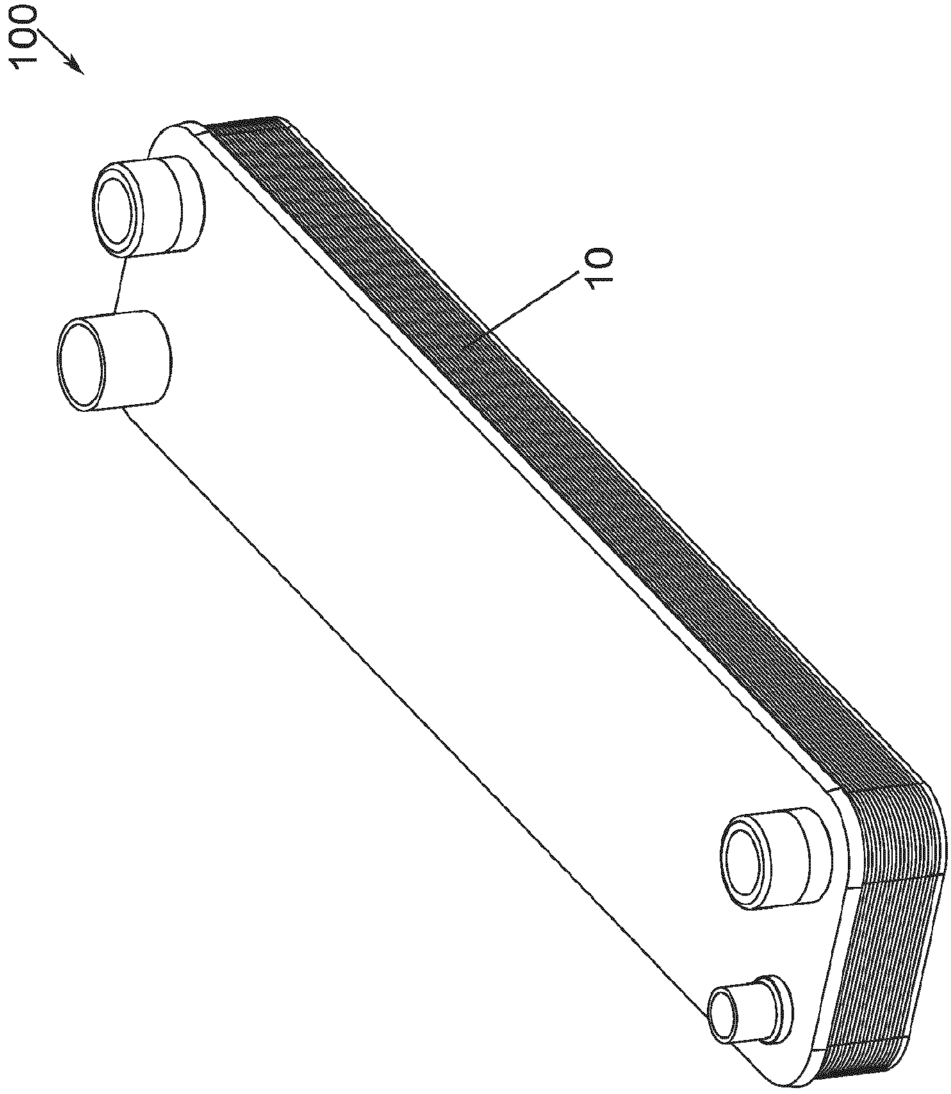


Fig. 1

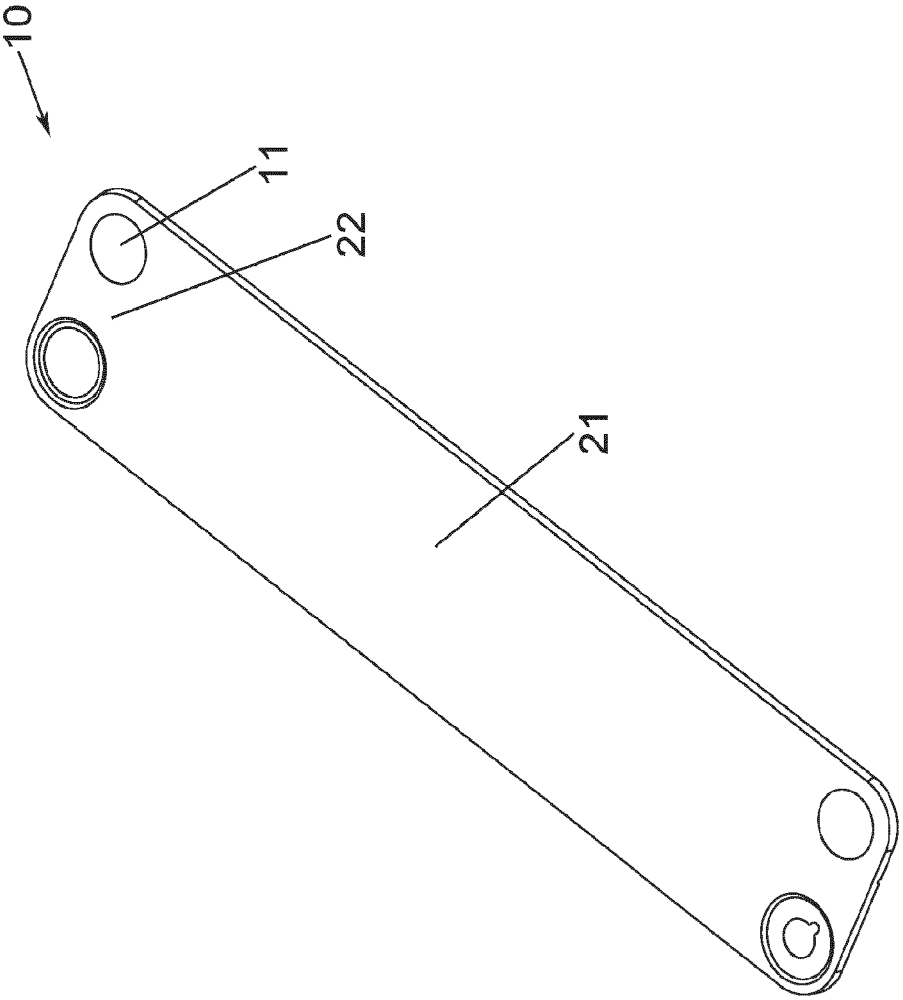


Fig. 2

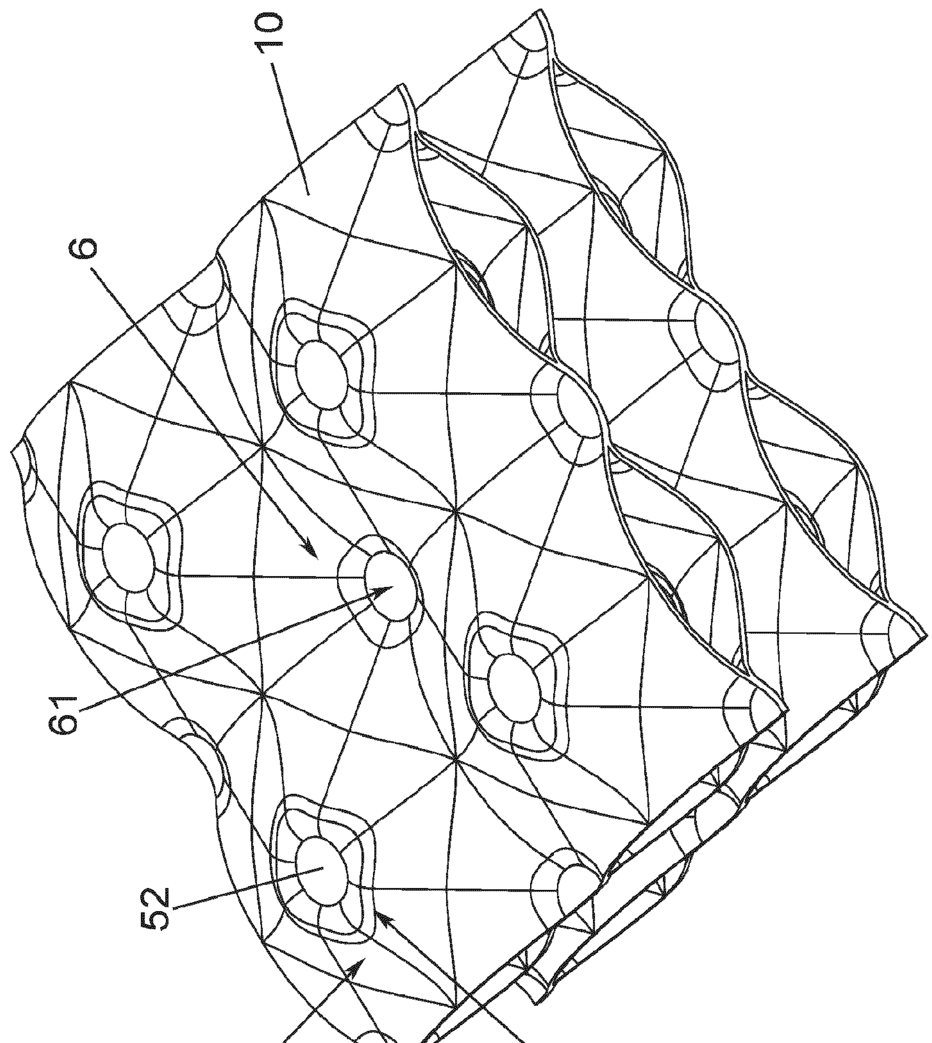


Fig. 3

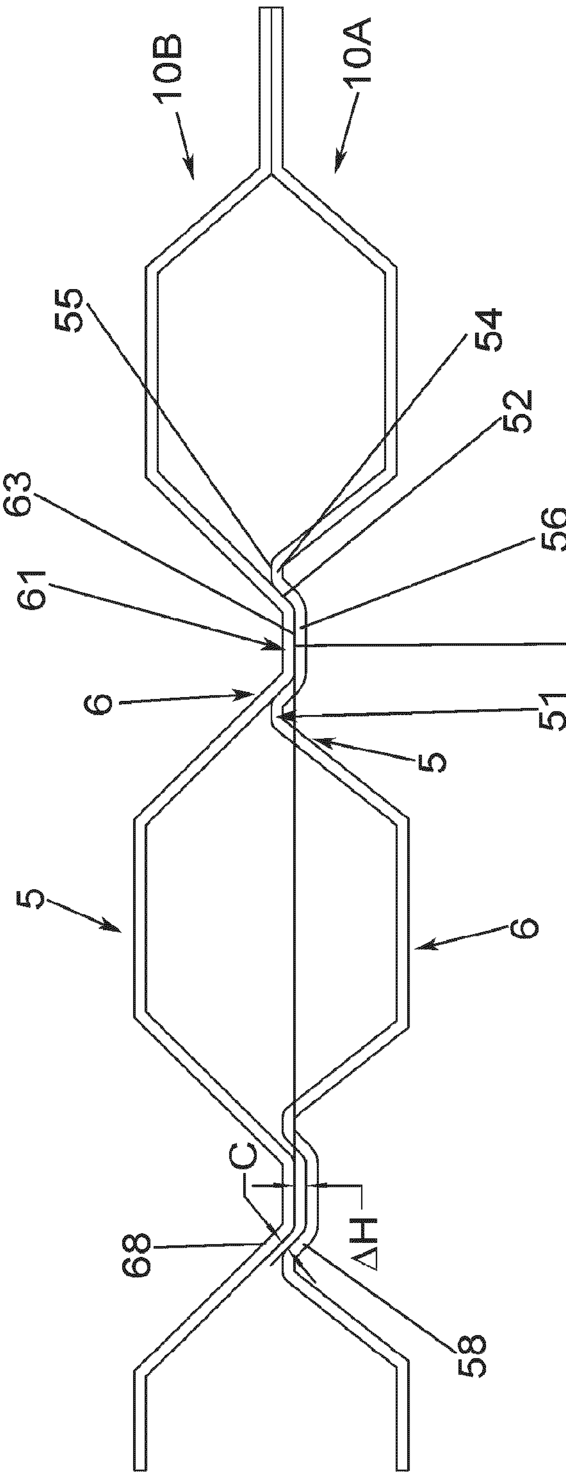


Fig. 4

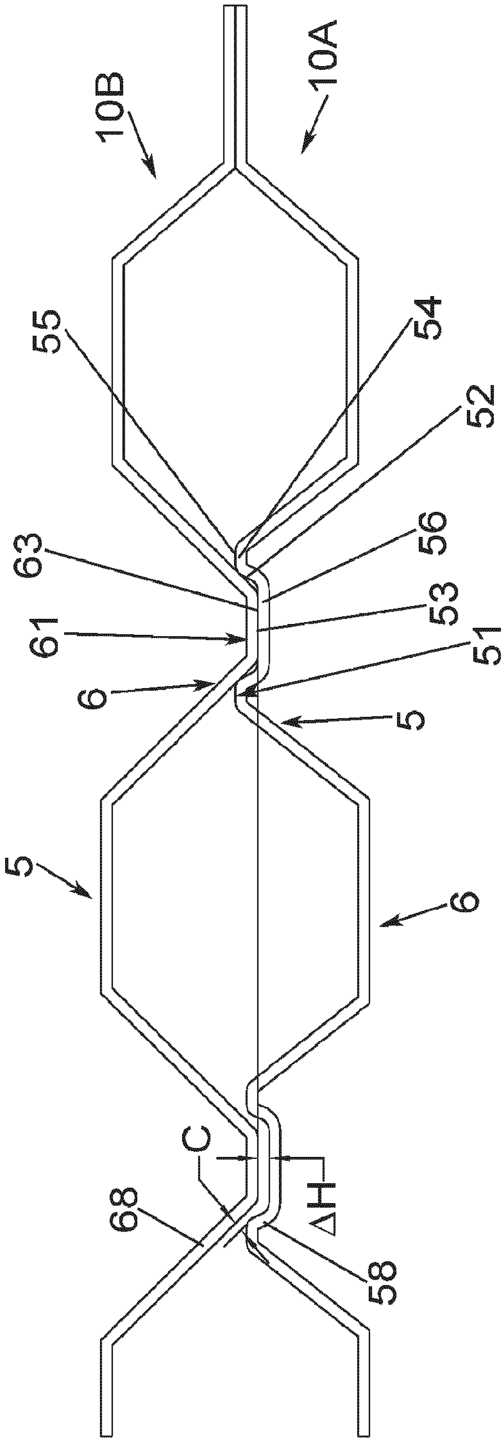


Fig. 5

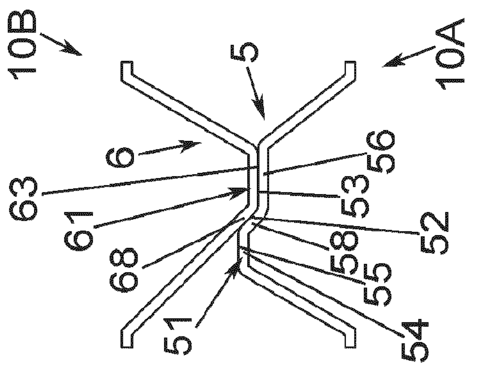


Fig. 8

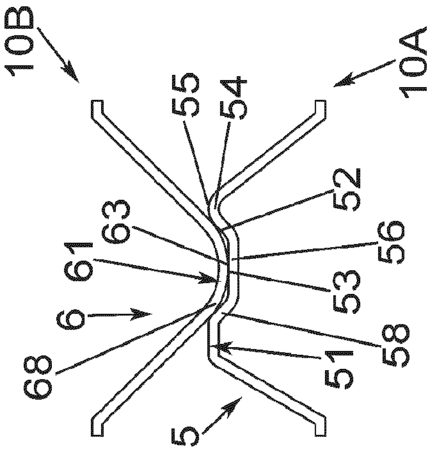
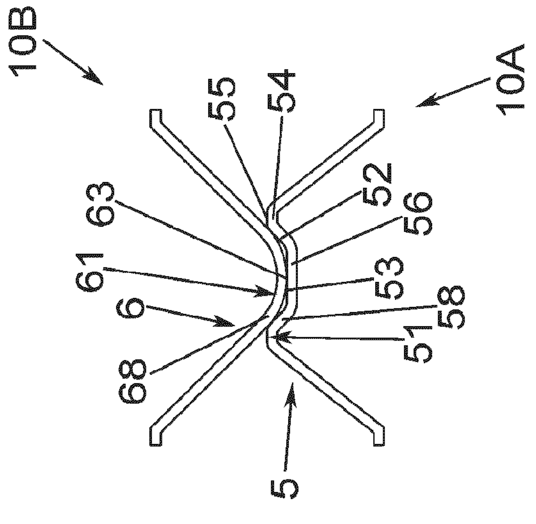


Fig. 7



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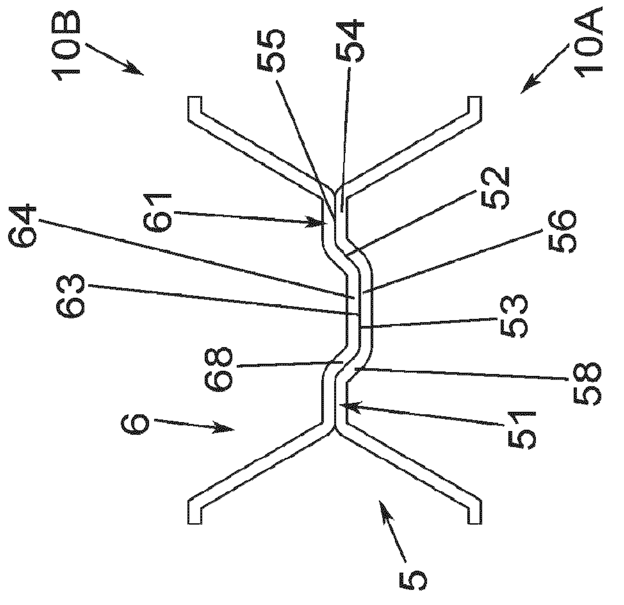
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Fig. 9

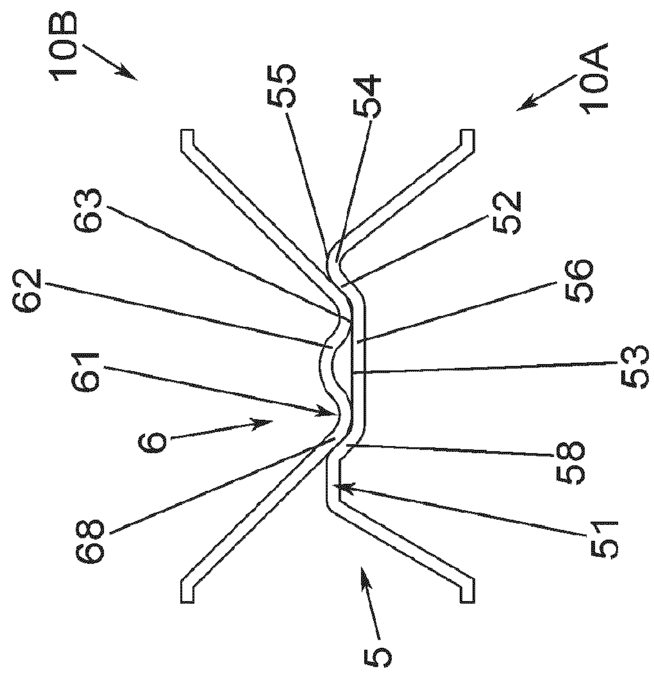
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Fig. 10

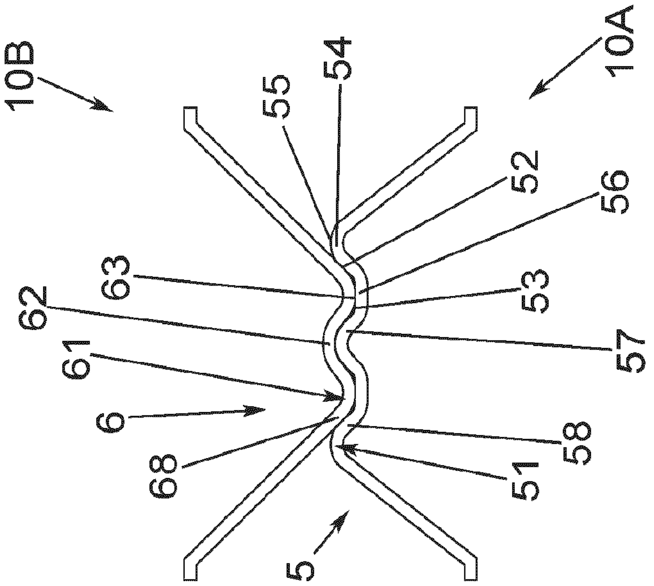
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Fig. 12

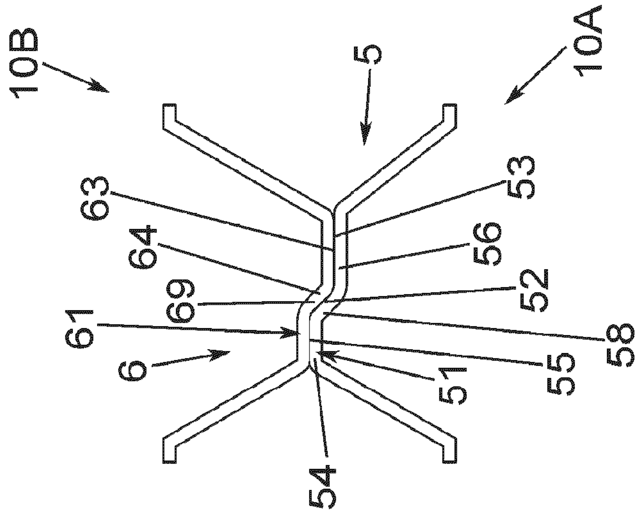
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Fig. 11

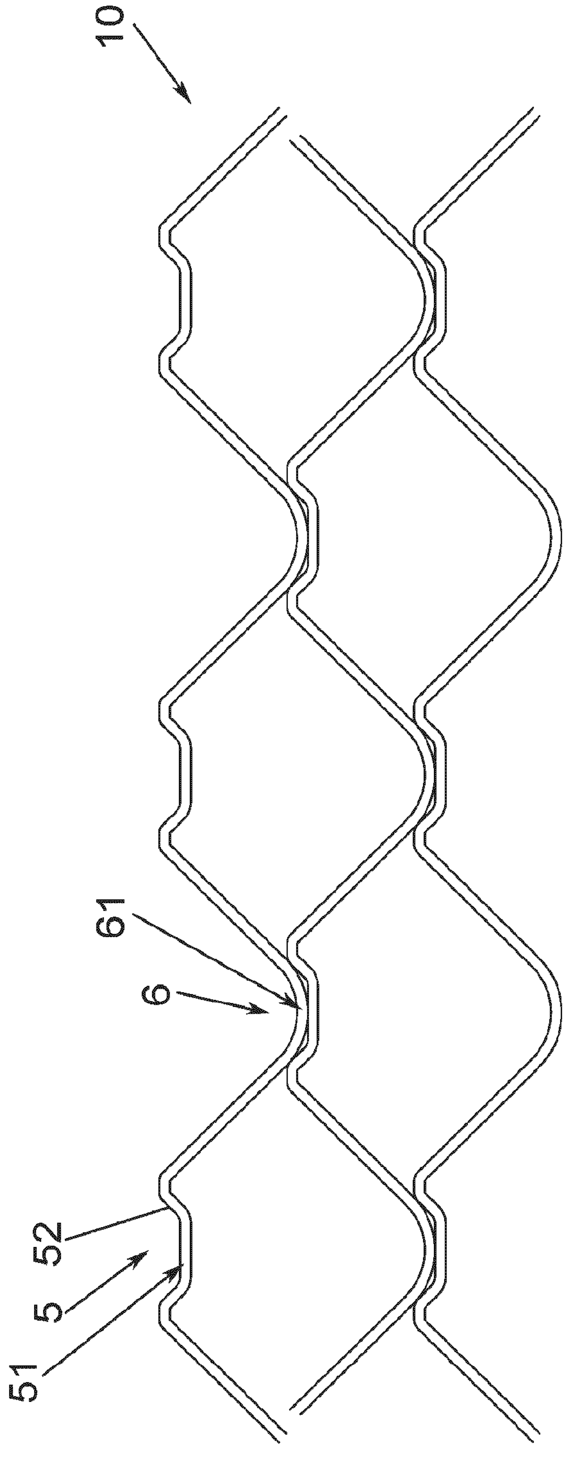

Fig. 13

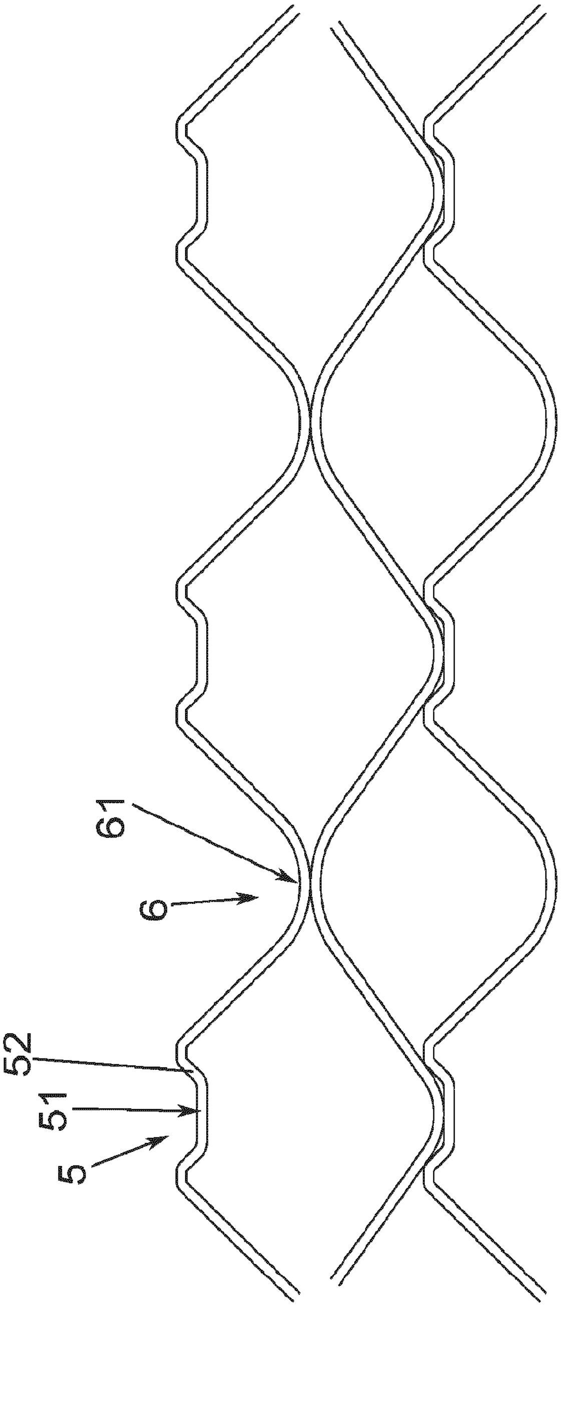

Fig. 14

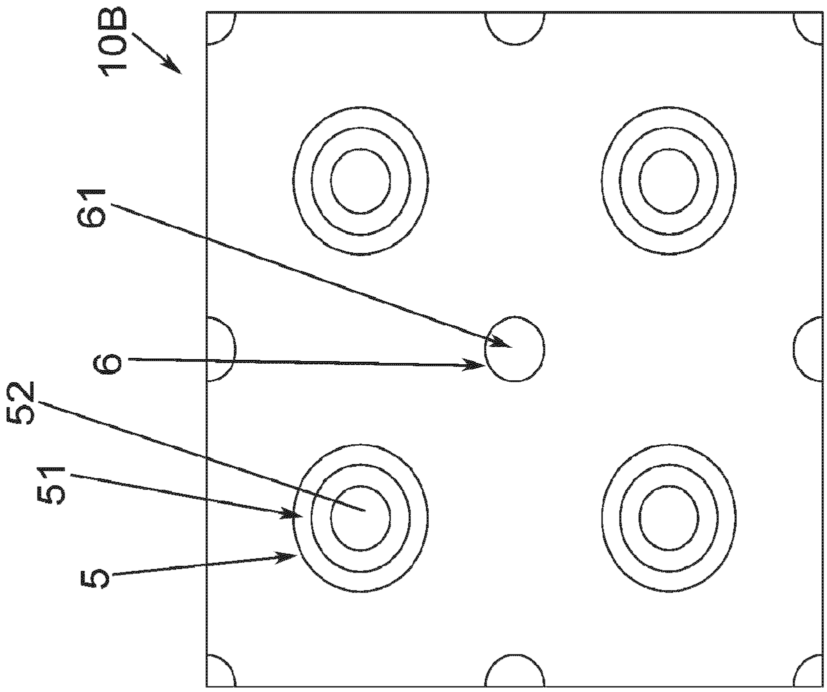

Fig. 15B

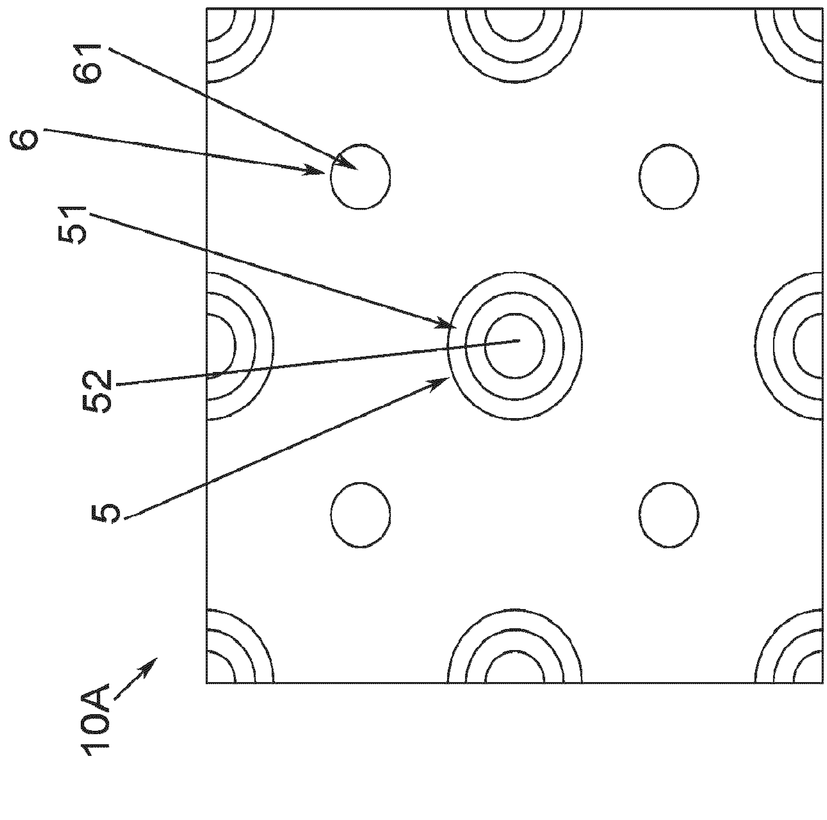

Fig. 15A

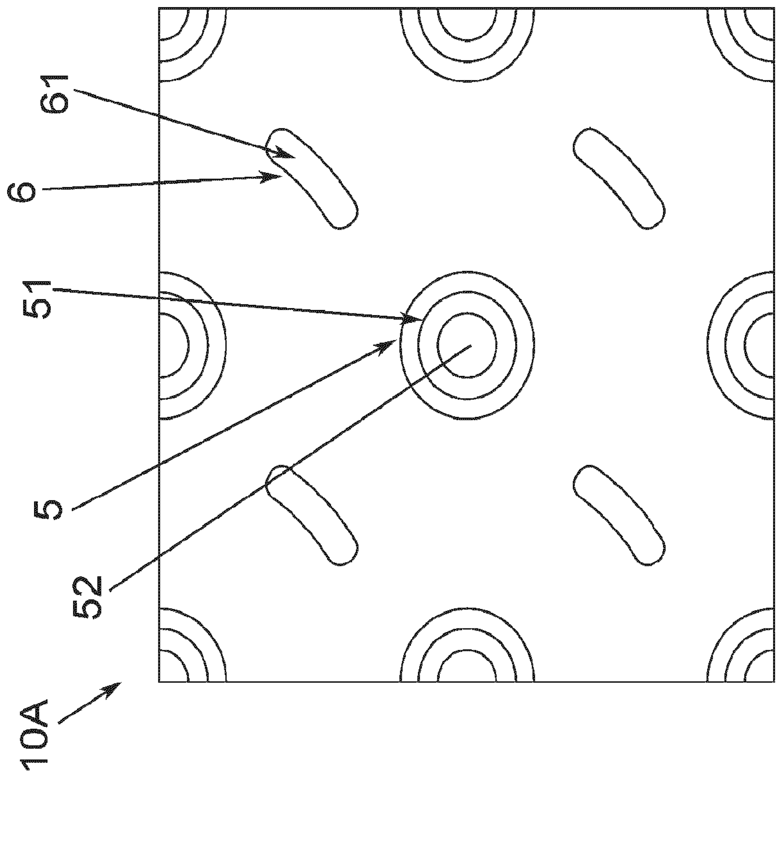

Fig. 16A

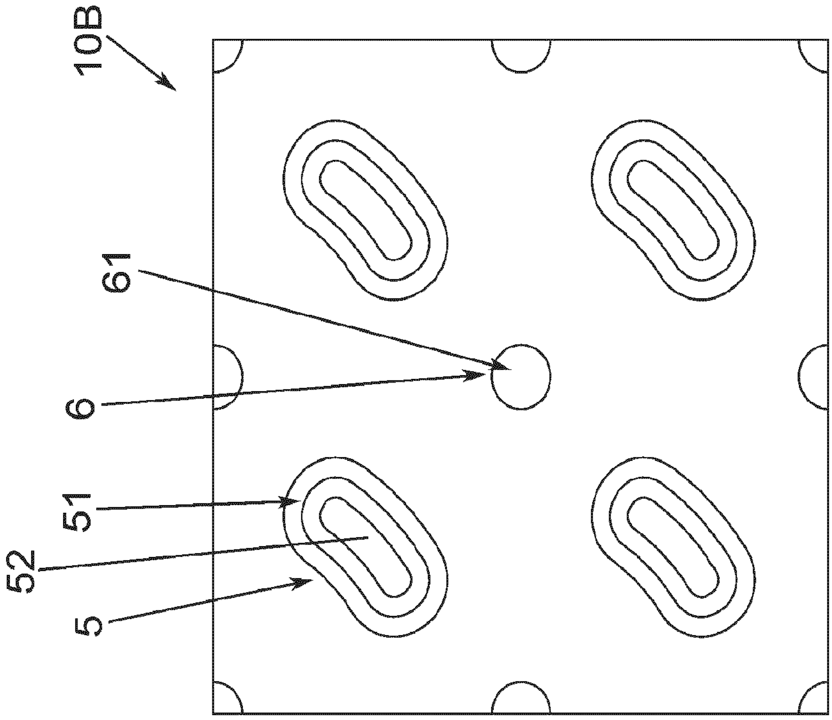

Fig. 16B

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2022/132842**

A. CLASSIFICATION OF SUBJECT MATTER

F28F 3/02(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)

F28F；F28D

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)

CNABS, VEN, CNKI: 换热, 热交换, 板, 凸部, 凹部, 顶部, 底部, 堆叠, 平坦, 台阶, heat exchang+, plate, project+, recess+, top, bottom, stack, flat+, step

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 101493293 A (LS CABLE LTD.) 29 July 2009 (2009-07-29) entire document	1-20
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A	CN 111220006 A (DANFOSS AS) 02 June 2020 (2020-06-02) entire document	1-20
A	CN 108020106 A (DANFOSS MICRO-CHANNEL HEAT EXCHANGER (JIAXING) CO., LTD.) 11 May 2018 (2018-05-11) entire document	1-20
A	US 2011073102 A1 (HANSON GORDON N. et al.) 31 March 2011 (2011-03-31) entire document	1-20
A	JP 2008116138 A (XENESYS INC.) 22 May 2008 (2008-05-22) entire document	1-20

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

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- "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	Date of mailing of the international search report
05 January 2023	**16 January 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	
Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/132842

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/132842

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Form PCT/ISA/210 (patent family annex) (January 2015)