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(54) **A PLATE FOR A PLATE KIND HEAT EXCHANGER WITH ASYMMETRICAL CORRUGATIONS**

(57) A plate (2) for a plate kind heat exchanger (1) is disclosed. The plate (2) is provided with a plurality of corrugations (8), a cross section of the plate (2) thereby defining a plurality of hills (9) and valleys (10) which define flow paths along surfaces of the plate (2). The hills (9) and/or the valleys (10) have a shape which is asymmetrical with respect to a centre line (11, 12) intersecting a top point of the hill (9) and/or valley (10). A plate kind heat exchanger (1) comprising a plurality of such plates (2) arranged in a stacked configuration, where the hills (9) and valleys (10) formed in the plates (2) define flow paths between the plates (2) is also disclosed.

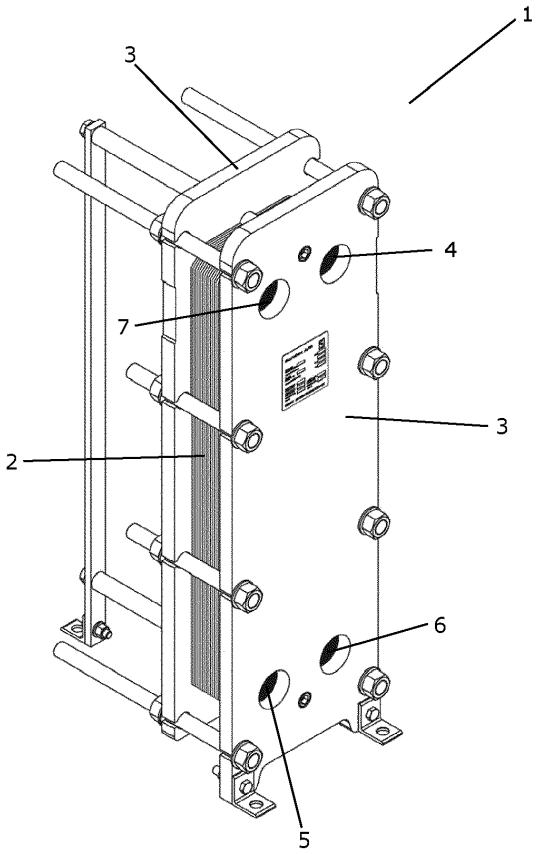

Fig. 1

EP 4 089 359 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a plate for a plate kind heat exchanger. The plate is provided with a plurality of corrugations which define flow paths along opposing sides of the plate. The invention further relates to a plate kind heat exchanger comprising a plurality of such plates.

BACKGROUND OF THE INVENTION

[0002] Plate kind heat exchangers comprise a plurality of stacked plates which are each provided with a corrugated pattern. Thereby flow paths are defined between the plates, and heat exchange can take place through the plate, between fluids passing along opposing sides of a plate, via the respective flow paths.

[0003] The size and shape of the flow paths are determined by the design of the corrugated pattern of the plates. In a cross sectional view of one of the plates, the corrugated pattern defines hills and valleys, which are often identical or similar to each other, and thereby define identical or very similar flow paths along opposing sides of the plate. Moreover, the hills and valleys defined by the corrugated patterns are normally symmetrical, in the sense that the parts of the plate extending from a top point of a hill or valley are substantially identical in terms of angle of inclination, radius of curvature, etc.

[0004] The plate kind heat exchanger may, e.g., be in the form of a gasket heat exchanger, where the plates are held together under tension in a non-permanent manner, i.e. the plates can be separated from each other. Alternatively the plate kind heat exchanger may be in the form of a brazed heat exchanger, where tops of the corrugated patterns are brazed or welded to each other, i.e. the plates are joined to each other in a permanent manner.

[0005] Identical flow paths along opposing sides of the plates has the consequence that pressure conditions in fluid flowing in the respective flow paths are also identical or very similar. For instance, the pressure drops as the respective heat exchanging fluids pass through the heat exchanger is substantially identical. However, it is sometimes desirable that the pressure drop of the hot fluid differs from the pressure drop of the cold fluid, in order to obtain a desired heat transfer in the heat exchanger. This could, e.g., be obtained by designing the corrugated pattern in such a manner that the hills are not identical to the valleys. This results in either the hills or the valleys being relatively large, and this may reduce the strength of the heat exchanger. In order to compensate for this, the thickness of the plates may be increased, at least in the weakened parts, leading to poorer heat transfer through the plates.

DESCRIPTION OF THE INVENTION

[0006] It is an object of embodiments of the invention to provide a plate for a plate kind heat exchanger in which improved heat transfer is obtained in the heat exchanger.

[0007] It is a further object of embodiments of the invention to provide a plate kind heat exchanger with improved heat transfer capability.

[0008] According to a first aspect the invention provides a plate for a plate kind heat exchanger, the plate being provided with a plurality of corrugations, a cross section of the plate thereby defining a plurality of hills and valleys which define flow paths along surfaces of the plate, wherein the hills and/or the valleys have a shape which is asymmetrical with respect to a centre line intersecting a top point of the hill and/or valley.

[0009] Thus, the first aspect of the invention provides a plate for a plate kind heat exchanger, i.e. a heat exchanger comprising a plurality of stacked plates, as described above. The plate is provided with a plurality of corrugations. Thereby, when plates a stacked to form the plate kind heat exchanger, flow paths are formed along opposing sides of the plate, and heat exchange can take place between fluids flowing in the flow paths formed along opposing sides of the plate. Due to the corrugations, a cross section of the plate defines a plurality of hills and valleys, and these hills and valleys define the flow paths on the opposing sides of the plate.

[0010] The hills and/or the valleys have a shape which is asymmetrical with respect to a centre line intersecting a top point of the hill and/or valley.

[0011] In the present context the term 'top point' should be interpreted to mean a position of a corrugation which constitutes an extremum, in the sense that a distance between the plate material and an average plane of the plate is at a maximum.

[0012] Since the hills and/or the valleys have a shape which is asymmetrical with respect to the centre line intersecting the respective top point, the shape of the part of the plate in a region approaching one of the top points from one direction differs from the shape of the part of the plate in a region approaching the top point from an opposite direction. This has the consequence that the flow paths defined by the hills and valleys of the corrugations are also asymmetrical. Furthermore, the asymmetry has the consequence that the flow paths formed on one side of the plate are not identical to the flow paths formed on the opposite side of the plate. Thereby the pressure conditions prevailing in the heat exchanging fluid flowing along opposing sides of the plate also differ from each other. For instance, the pressure drop of the hot fluid differs from the pressure drop of the cold fluid, when passing through the heat exchanger, and thereby desired heat transfer between the fluids can be obtained. Due to the asymmetric hills and/or valleys, this is obtained without significantly weakening the plates, since the hills and/or valleys are only enlarged on one side. Accordingly, it is not required to increase the thickness of the plate

in order to compensate for such a weakening.

[0013] Furthermore, when identical plates are stacked to form the plate kind heat exchanger, plates arranged adjacent to each other may be reversed with respect to each other in the sense that asymmetric hills of one plate becomes asymmetric valleys of a neighbouring plate. Thereby the asymmetric hills and the asymmetric valleys of the respective plates are arranged in abutment, thereby further improving the strength of the heat exchanger.

[0014] The hills as well as the valleys may have an asymmetrical shape. As an alternative, only the hills may have an asymmetrical shape, while the valleys have a symmetrical shape, or only the valleys may have an asymmetrical shape, while the hills have a symmetrical shape.

[0015] The cross section of the hills and/or valleys may define different curvatures at opposing sides of the centre line.

[0016] According to this embodiment, the asymmetry of the hills and/or valleys is in terms of the curvature of the plate in the region near the top point of the hills and/or valleys, i.e. the curvature of a path followed by the plate material in the region of the top point, within the cross section of the plate. For instance, a radius of curvature of the plate material may differ from one side of the centre line to an opposite side of the centre line.

[0017] Alternatively or additionally, a distance along a surface of the plate between a top point of a hill and a top point of a first neighbouring valley may differ from a distance along the surface of the plate between the top point of the hill and a top point of a second neighbouring valley.

[0018] In the corrugated pattern, the hills and valleys are arranged alternatingly, in the sense that a given hill is arranged between two valleys and a given valley is arranged between two hills, except for hills or valleys which are arranged at an outer boundary of the corrugated pattern. Such hills/valleys will only have one neighbouring valley/hill.

[0019] The plate material interconnects the top points of hills and valleys which are positioned adjacent to each other, i.e. neighbouring hills and valleys. According to this embodiment, the asymmetry of a given hill is in the form of differences in the distance, along the surface of the plate, to the neighbouring valleys arranged adjacent to the hill on opposing sides of the centre line intersecting the top point of the hill. The difference in distance may, e.g., be caused by a difference in slope of the respective parts of the plate.

[0020] It should be noted that, even though the embodiment described above refers to the distance between a top point of a hill and the respective top points of neighbouring or adjacent valleys, the above description also applies to a reversed situation, i.e. to distances between a top point of a valley and the respective top points of neighbouring or adjacent hills.

[0021] The hills and valleys may form a herring bone pattern on the plate. According to this embodiment, the top points of the hills and valleys extend along substantially linear lines along the surfaces of the plate, and lines formed on opposing halves of the surfaces form an angle with respect to each other. When stacking the plates in order to form the plate kind heat exchanger, the plates may be arranged in such a manner that adjacent plates are reversed with respect to each other. Thereby the lines defined by the hearing bone pattern on adjacent plates will not coincide, but will instead intersect each other at a number of intersection points. Fluid flowing through the flow paths defined between the plates by the corrugations is thereby forced to change direction, thereby causing turbulence in the fluid which provides improved heat transfer.

[0022] The asymmetry of a given hill and/or valley may vary along a direction in which the hill and/or valley extends.

[0023] According to this embodiment, the asymmetry of the hills and/or valleys, is not constant along the direction in which the respective hills and/or valleys extend. The variation in asymmetry may, e.g., be in terms of the magnitude of the asymmetry, i.e. how much the shape of the hill or valley at one side of the centre line intersecting the top point differs from the shape of the hill or valley at a second, opposite, side of the centre line.

[0024] Furthermore, the asymmetric shape may shift from one side of the centre line to the other. For instance, in the case that the asymmetry defines different curvatures at opposing sides of the centre line, a first radius of curvature, R1, may be defined at a first side of the centre line, and a second radius of curvature, R2, may be defined at a second, opposite, side of the centre line, at a given position along the direction in which the hill or valley extends. However, at another position along this direction, the second radius of curvature, R2, may be defined at the first side of the centre line, and the first radius of curvature, R1, may be defined at the second side of the centre line.

[0025] The variations in asymmetry may be smooth and continuous. Alternatively or additionally, abrupt changes in the asymmetry may occur at specific positions along the direction in which the hill or valley extends.

[0026] Due to the variations in asymmetry, the turbulence in the fluid flowing through the resulting flow paths is increased, thereby improving the heat transfer.

[0027] Furthermore, when stacking the plates in order to form the plate kind heat exchanger, the variations in asymmetry of adjacent plates can be arranged relative to each other in a manner which improves the strength of the plate kind heat exchanger. This allows the plates to be manufactured with a lower thickness, or at least without increasing the thickness, without compromising the strength of the heat exchanger. The lower thickness of the plates even further improves the heat transfer through the plate.

[0028] Finally, the variations in asymmetry provides a better locking or fixation of the plate during pressing when manufacturing the plate. Thereby the plate can be man-

ufactured in a more accurate manner. This, in turn, results in a more uniform thickness of the plate and improved contact between the plates when they are stacked under tension, in the case that the plate kind heat exchanger is in the form of a gasket heat exchanger. Similarly, in the case that the plate kind heat exchanger is in the form of a brazed heat exchanger, contact between the plates is also improved.

[0029] The variation in asymmetry may be periodic. According to this embodiment, the plates can suitably be stacked in a manner which ensures that specific sections of the hills or valleys of adjacent plates are in contact.

[0030] According to a second aspect the invention provides a plate kind heat exchanger comprising a plurality of plates according to the first aspect of the invention arranged in a stacked configuration, wherein the hills and valley formed in the plates define flow paths between the plates.

[0031] Since the plate kind heat exchanger comprises a plurality of plates according to the first aspect of the invention, the remarks set forth above with reference to the first aspect of the invention are equally applicable here.

[0032] In particular, in the case that the asymmetry of the hills and/or valleys varies along the direction in which the hills and/or valleys extend, the plates may be stacked in the manner described above, thereby improving the strength of the heat exchanger and improving the heat transfer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The invention will now be described in further detail with reference to the accompanying drawings in which

Fig. 1 is a perspective view of a plate kind heat exchanger according to an embodiment of the invention,

Fig. 2 illustrates four plates for a plate kind heat exchanger according to an embodiment of the invention,

Fig. 3 is a cross sectional view of part of a plate for a plate kind heat exchanger according to an embodiment of the invention,

Fig. 4 is a perspective view of part of a plate for a plate kind heat exchanger according to an embodiment of the invention,

Fig. 5 is a top view of the plate for a plate kind heat exchanger of Fig. 4, and

Fig. 6 is a schematic view of a plate for a plate kind heat exchanger according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0034] Fig. 1 is a perspective view of a plate kind heat exchanger 1 according to an embodiment of the invention. The plate kind heat exchanger 1 comprises a plurality of plates 2 arranged in a stack between two end plates 3. A first fluid inlet 4 is connectable to a fluid source of a first heat exchanging fluid, and a second fluid inlet 5 is connectable to a fluid source of a second heat exchanging fluid. Heat exchanging fluids thereby enter the plate kind heat exchanger 1 via the respective fluid inlets 4, 5, and pass along opposing sides of respective plates 2, while heat exchange takes place through the plates 2. The first heat exchanging fluid exits the plate kind heat exchanger 1 via a first fluid outlet 6, and the second heat exchanging fluid exits the plate kind heat exchanger 1 via a second fluid outlet 7.

[0035] Fig. 2 illustrates four plates 2 for a plate kind heat exchanger, e.g. the plate kind heat exchanger illustrated in Fig. 1. The plates 2 are shown in an exploded manner, i.e. with a distance between the plates 2. However, in order to form a plate kind heat exchanger by means of the plates 2, the plates 2 are stacked, i.e. arranged immediately adjacent to each other, with their surfaces completely overlapping. Thereby the fluid inlets 4, 5 and the fluid outlets 6, 7 are also arranged adjacent to each other, thereby forming inlet manifolds and outlet manifolds which distribute the heat exchanging fluids to flow paths formed between the plates 2.

[0036] Each of the plates 2 is provided with a plurality of corrugations 8 defining hills and valleys which are arranged in a herring bone pattern on the plate 2. The herring bone patterns are arranged in such a manner that their directions alternate from one plate 2 to the plates 2 arranged adjacent thereto. At positions where hills of adjacent plates 2 coincide, the plates 2 abut each other. Thereby flow paths are defined along the surfaces of the plates 2, and these flow paths ensure that turbulence is introduced in the fluid flowing therein, thereby ensuring a good heat exchange between heat exchanging fluids flowing along opposing sides of a given plate 2.

[0037] Fig. 3 is a cross sectional view of a part of a plate 2 for a plate kind heat exchanger according to an embodiment of the invention. The plate 2 is provided with a corrugated pattern 8 defining a plurality of hills 9 and valleys 10. In Fig. 3, two hills 9 and two valleys 10 are shown. A first heat exchanging fluid may pass along a first surface of the plate 2 in the cavities defined by the hills 9, and a second heat exchanging fluid may pass along a second, opposite, surface of the plate 2 in the cavities defined by the valleys 10. Accordingly, the hills 9 and valleys 10 of the corrugated pattern 8 define flow paths along the surfaces of the plate 2, and heat exchange can take place between the first heat exchanging fluid and the second heat exchanging fluid, through the plate 2.

[0038] The hills 9 have a shape which is asymmetric with respect to a centre line 11 intersecting a top point

of the hill 9, in the sense that a radius of curvature, R1, of the part of the hill 9 arranged to the left of the centre line 11, is smaller than a radius of curvature, R2, of the part of the hill 9 arranged to the right of the centre line 11. This further has the consequence that the distance along the surface of the plate 2 from the top point of the hill 9 to the top points of respective neighbouring valleys 10 differ from each other. Accordingly, the distance from the top point of the hill 9 to the top point of the valley 10 arranged to the left of the hill 9 is shorter than the distance from the top point of hill 9 to the top point of the valley 10 arranged to the right of the hill 9.

[0039] Furthermore, the valleys 10 also have a shape which is asymmetric with respect to a centre line 12 intersecting the top point of the valley 10, in the sense that distance to the top points of the neighbouring hills 9 differ from each other, similar to the situation described above. Furthermore, the valleys 10 define a radius of curvature, R3, which differs from the radii of curvature, R1 and R2, defined by the hills 9.

[0040] Due to the asymmetric shapes of the hills 9 and valleys 10, the flow paths defined by the hills 9 and the valleys 10 are also asymmetrical, and the flow paths defined along the respective opposing sides of the plate 2 are not identical to each other. Thereby the pressure conditions prevailing in the first and second heat exchanging fluids flowing along the opposing sides of the plate 2 also differ from each other, thereby allowing desired heat transfer between the fluids to be obtained.

[0041] Fig. 4 is a perspective view of part of a plate 2 for a plate kind heat exchanger according to an embodiment of the invention. The plate 2 of Fig. 4 could, e.g., be the plate 2 illustrated in Fig. 3.

[0042] In the plate 2 illustrated in Fig. 4, the asymmetry of the hills 9 and valleys 10 is not constant along a direction, illustrated by arrow 13, along which the hills 9 and valleys 10 extend. Instead, the asymmetry shifts from side to side, thereby defining shoulders 14. The shifts may, e.g., cause the radii of curvature, R1 and R2, to switch place in the sense that the first radius of curvature, R1, moves from the left side of the centre line to the right side of the centre line and back again, while the second radius of curvature, R2, moves from the right side of the centre line to the left side of the centre line, and back again. The change in the asymmetry along the direction 13 is substantially periodic.

[0043] These variations in the asymmetry along direction 13 forces the heat exchanging fluids flowing along the respective flow paths along the surface of the plate 2 to change direction, thereby causing the turbulence in the heat exchanging fluids to increase. Thereby the heat transfer between the fluids is improved.

[0044] Furthermore, when the plate 2 is stacked with other plates in order to form the plate kind heat exchanger, the variations in asymmetry of adjacent plates 2 can be arranged relative to each other in a manner which improves the strength of the plate kind heat exchanger. This allows the plates 2 to be manufactured with a lower thickness, without compromising the strength of the plate kind heat exchanger. The lower thickness of the plates 2 even further improves the heat transfer through the plates 2.

[0045] Finally, the variations in asymmetry provides a better locking or fixation of the plate 2 during pressing when manufacturing the plate 2. Thereby the plate 2 can be manufactured in a more accurate manner. This, in turn, results in a more uniform thickness of the plate 2 and improved contact between the plates 2 when they are stacked under tension.

[0046] Fig. 5 is a top view of the plate 2 of Fig. 4. Only part of the plate 2 is shown. It can clearly be seen how the shoulders 14 are shifting from side to side along the direction 13 in which the hills 9 extend. It can further be seen that the shoulders 14 causes the resulting flow paths along the plate 2 to have a curvy shape which forces the heat exchanging fluids flowing therein to change direction, thereby increasing the turbulence in the fluids.

[0047] Fig. 6 is a schematic view of a plate 2 for a plate kind heat exchanger according to an embodiment of the invention. The plate 2 is provided with a plurality of corrugations 8 defining a plurality of hills 9 and valleys 10 forming a herring bone pattern.

[0048] It can be seen that the hills 9 form shoulders 14 in the manner described above with reference to Fig. 4. Accordingly, the asymmetry of the hills 9 varies along the direction in which the hills 9 extend.

Claims

1. A plate (2) for a plate kind heat exchanger (1), the plate (2) being provided with a plurality of corrugations (8), a cross section of the plate (2) thereby defining a plurality of hills (9) and valleys (10) which define flow paths along surfaces of the plate (2), wherein the hills (9) and/or the valleys (10) have a shape which is asymmetrical with respect to a centre line (11, 12) intersecting a top point of the hill (9) and/or valley (10).

2. A plate (2) for a plate kind heat exchanger (1) according to claim 1, wherein the hills (9) as well as the valleys (10) have an asymmetrical shape.

3. A plate (2) for a plate kind heat exchanger (1) according to claim 1 or 2, wherein the cross section of the hills (9) and/or valleys (10) define different curvatures at opposing sides of the centre line (11, 12).

4. A plate (2) for a plate kind heat exchanger (1) according to any of the preceding claims, wherein a distance along a surface of the plate (2) between a top point of a hill (9) and a top point of a first neighbouring valley (10) differs from a distance along the surface of the plate (2) between the top point of the hill (9) and a top point of a second neighbouring val-

ley (10).

5. A plate (2) for a plate kind heat exchanger (1) according to any of the preceding claims, wherein the hills (9) and valleys (10) form a herring bone pattern on the plate (2).

6. A plate (2) for a plate kind heat exchanger (1) according to any of the preceding claims, wherein the asymmetry of a given hill (9) and/or valley (10) varies along a direction (13) in which the hill (9) and/or valley (10) extends.

7. A plate (2) for a plate kind heat exchanger (1) according to claim 6, wherein the variation in asymmetry is periodic.

8. A plate kind heat exchanger (1) comprising a plurality of plates (2) according to any of the preceding claims arranged in a stacked configuration, wherein the hills (9) and valleys (10) formed in the plates (2) define flow paths between the plates (2).

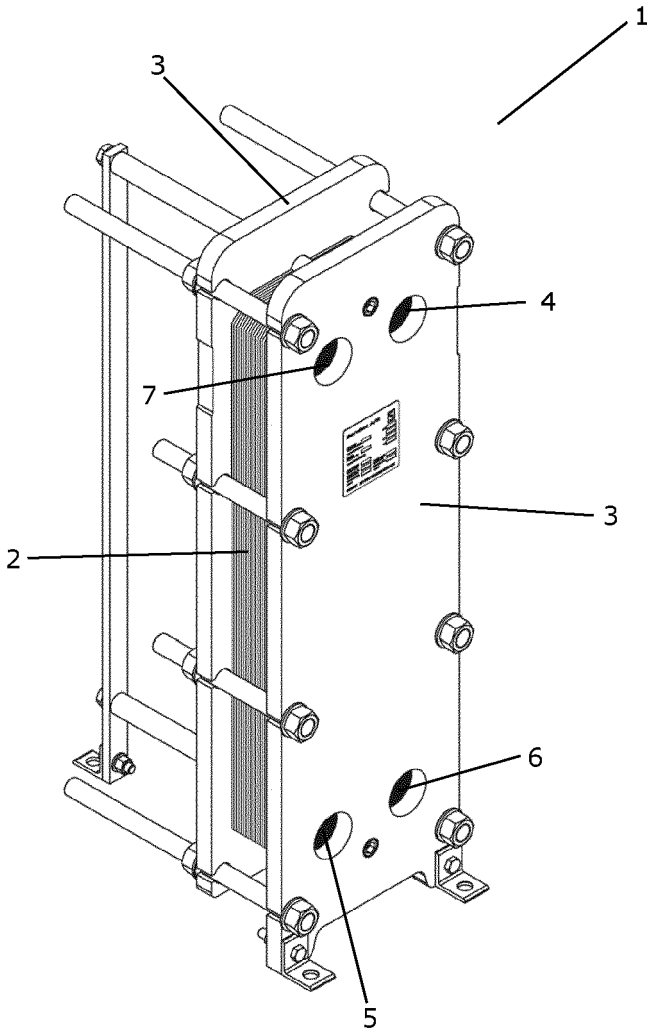

Fig. 1

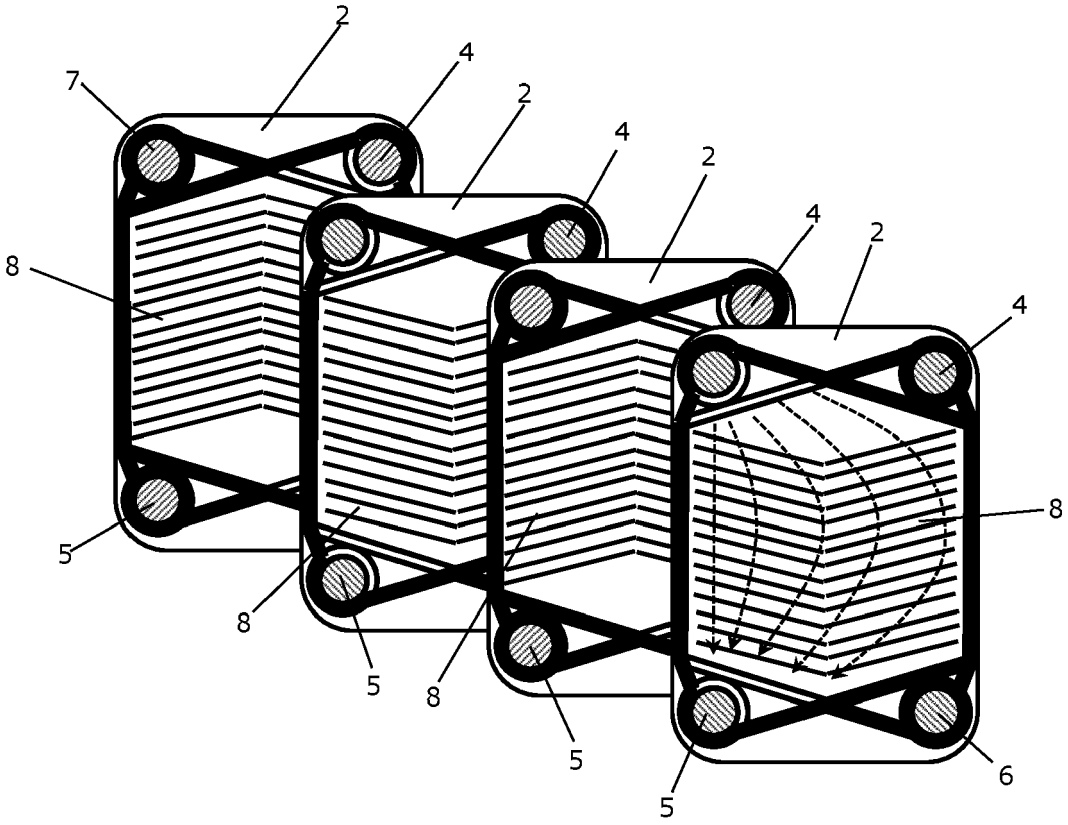

Fig. 2

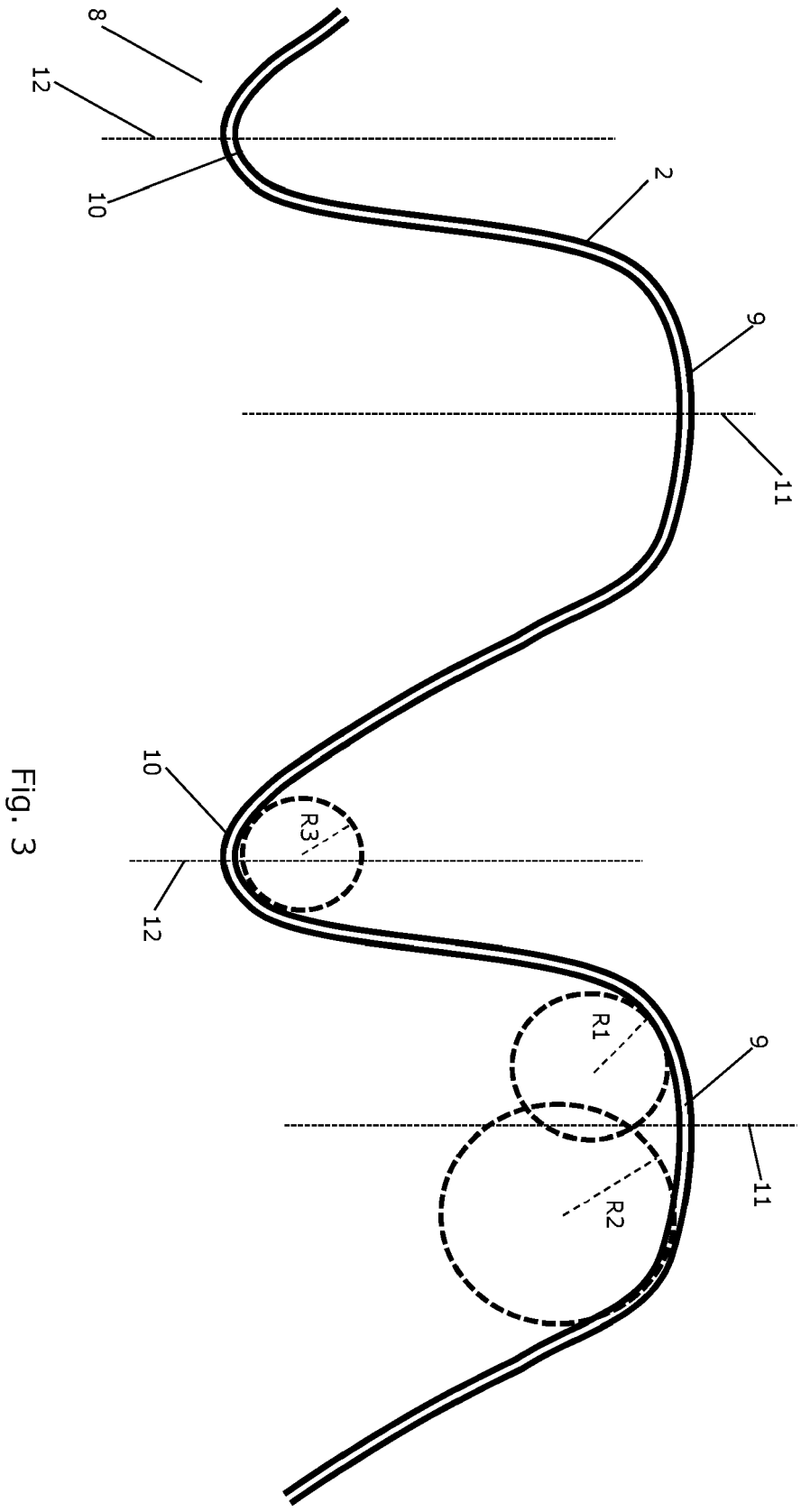

Fig. 3

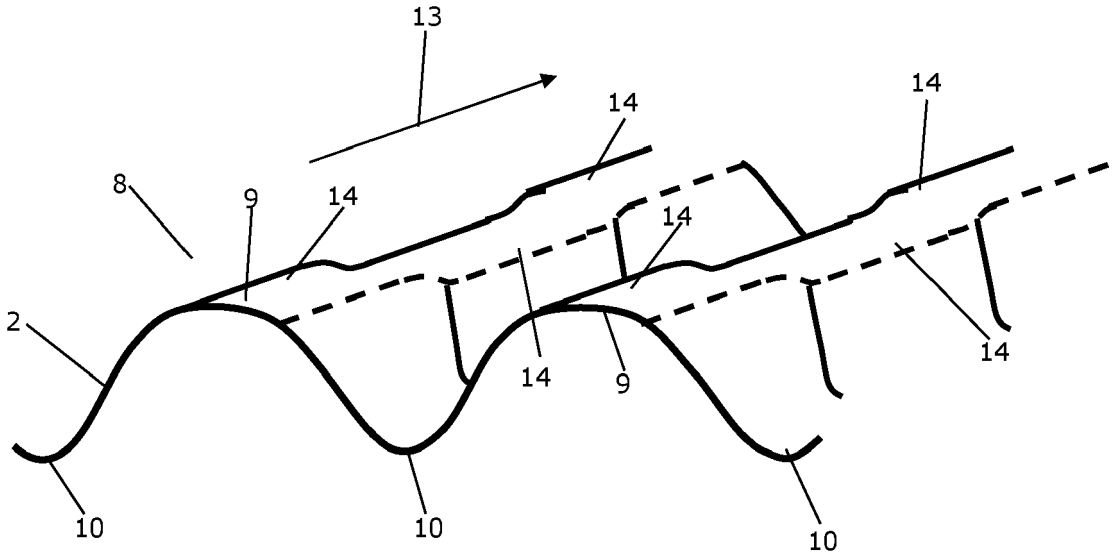

Fig. 4

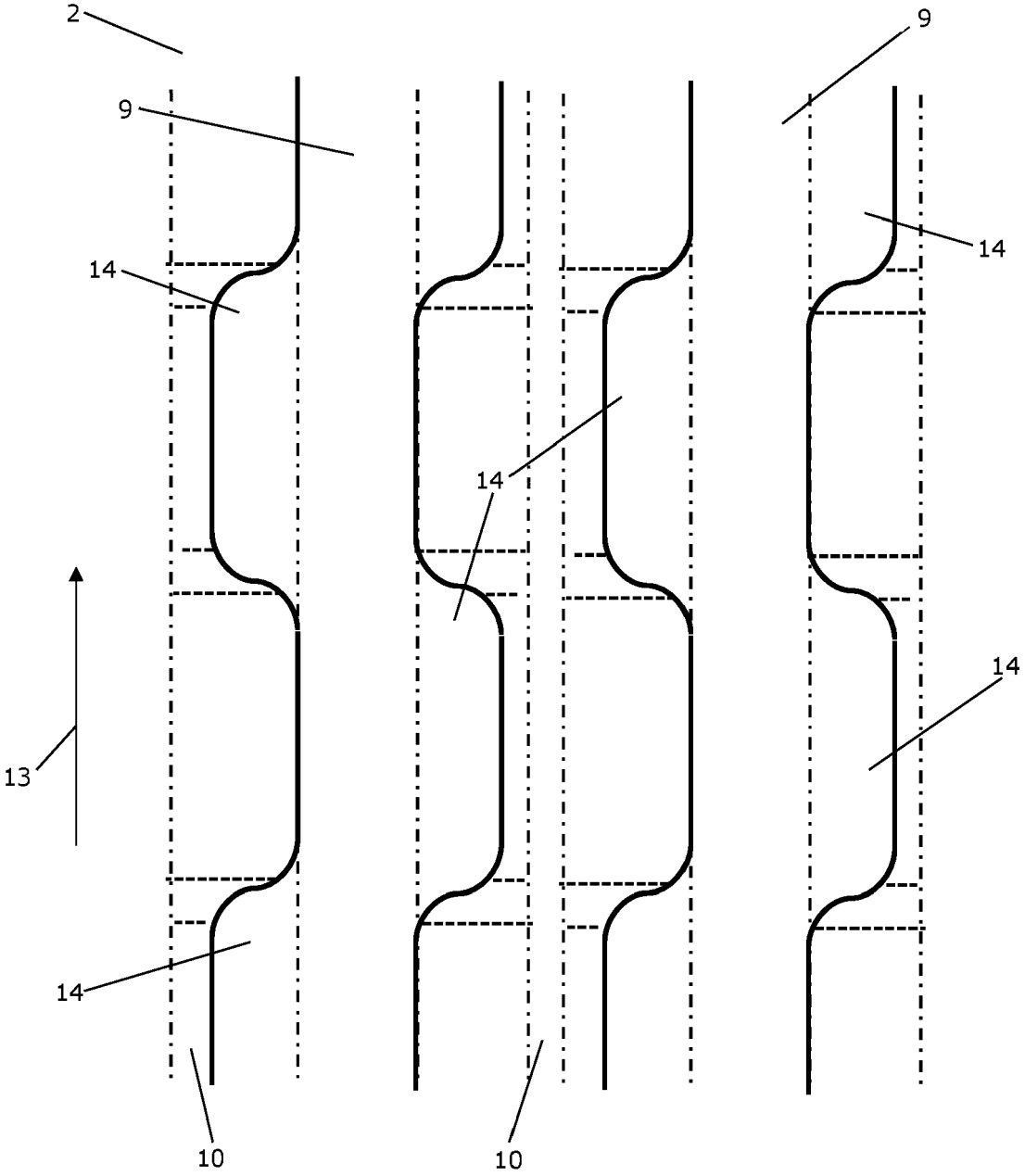

Fig. 5

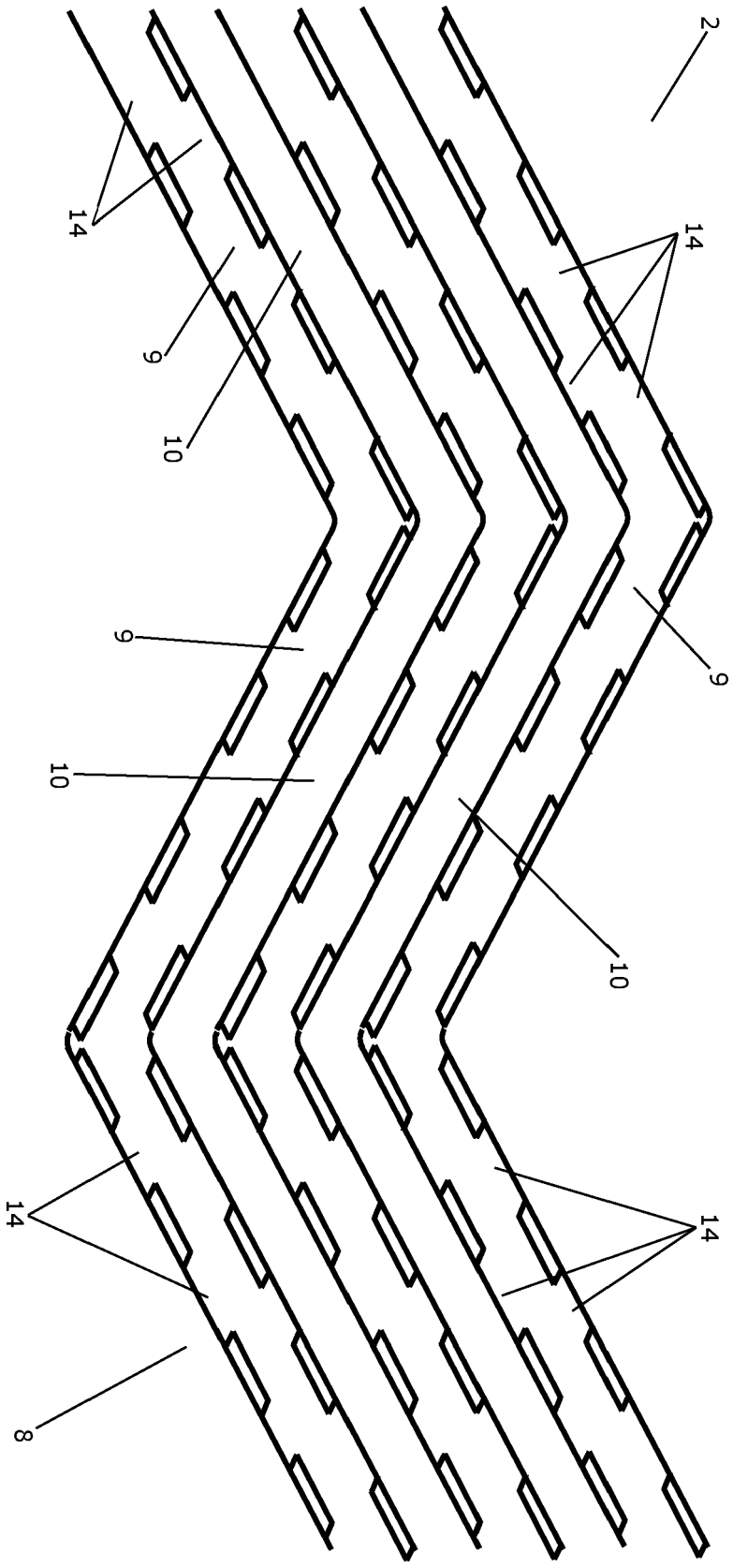

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 2117

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 September 2022	Bain, David

CATEGORY OF CITED DOCUMENTS

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