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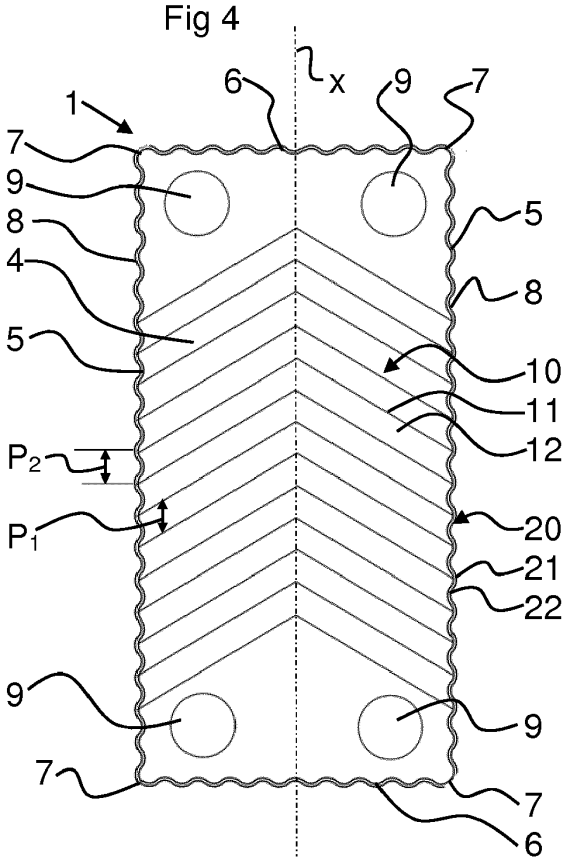
(54) **A HEAT EXCHANGER PLATE, AND A PLATE HEAT EXCHANGER**

(57) A heat exchanger plate (1) for a plate heat exchanger comprises a heat exchanger area (4) extending in parallel with an extension plane and comprising a primary corrugation (10). The heat exchanger area comprises at least three sides (5, 6). A longitudinal central axis (x) extends in parallel with the extension plane through at least one of the sides. A plurality of portholes (9) extends through the heat exchanger area. An edge flange (8) extends outside and around the heat exchanger area along the sides. The edge flange is inclined in relation to the extension plane. The edge flange comprises a secondary corrugation (20) of ridges (21) and valleys (22).

Fig 4



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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention refers to a heat exchanger plate for a plate heat exchanger, the heat exchanger plate comprising
a heat exchanger area extending in parallel with an extension plane and comprising a primary corrugation and at least three sides,
a longitudinal central axis extending in parallel with the extension plane through at least one of the sides,
a plurality of portholes extending through the heat exchanger area, and
an edge flange extending outside and around the heat exchanger area along the sides, wherein the edge flange is inclined in relation to the extension plane.

[0002] The invention also refers to a plate heat exchanger comprising a plurality of heat exchanger plates.

BACKGROUND OF THE INVENTION AND PRIOR ART

[0003] A heat exchanger plate of this kind is disclosed in US-8,061,416. One problem with such heat exchanger plates of the prior art is that the plates after the pressing operation will have a slightly curved, banana-like shape when seen from the side along the longitudinal central axis. This bending is due to the spring-back of the corrugated heat exchanger area after the pressing operation has been finished, and the fact that the inclined edge flange has a high stiffness. The stiff edge flange does not permit any spring-back corresponding to the one of the heat exchanger area. The curved, and relatively rigid, shape is disadvantageous when the plate heat exchanger is assembled.

[0004] EP-2370773 discloses another heat exchanger plate comprising a corrugated heat exchanger area and an inclined edge flange extending outside and around the heat exchanger area. A reinforcement portion having a pressed pattern, comprising upper and lower surfaces, is provided outside the edge flange. The reinforcement portion extends along a plane parallel to the extension plane of the heat exchanger plate.

SUMMARY OF THE INVENTION

[0005] The object of the present invention is to remedy the problems discussed above. In particular, it is aimed at a heat exchanger plate having a more flat extension after the pressing operation has been finished.

[0006] This object is achieved by the heat exchanger plate initially defined, which is characterized in that the inclined edge flange comprises a secondary corrugation of ridges and valleys.

[0007] The secondary corrugation will provide the inclined edge flange with an elasticity at least along the longitudinal central axis.

[0008] The heat exchanger plate will thus have a flat or plane extension in parallel with the extension plane after the pressing operation has been finished and before the heat exchanger plate is to be stacked onto other heat exchanger plates of a plate heat exchanger. The previous slightly curved shape will be avoided. The inclined edge flange will have a reduced stiffness so that spring-back of both the heat exchanger area and the inclined edge flange is permitted.

[0009] The primary corrugation may have various geometrical shapes, and may, for instance, comprise or consist of ridges and valleys, dimples or similar spot shaped depressions and/or protrusions.

[0010] The corrugated edge flange makes the heat exchanger plate less sensitive to bending of the plate. If the heat exchanger plate is bent greatly, no dents or other permanent deformation will remain, but the heat exchanger plate may return to the original shape.

[0011] The heat exchanger plate of the present invention will also provide an improved resistance against thermal fatigue along the longitudinal central axis of the extension plane, an improved burst pressure resistance due to larger brazing surface area in the direction perpendicular to the extension plane, and an improved pressure fatigue resistance.

[0012] The secondary corrugation of the edge flange also contributes to an improved locking of the heat exchanger plates when they are stacked on each other. The position of the heat exchanger plates relative to each other is determined. There is no, or a reduced, risk that the heat exchanger plates are locked against each other in an incorrect position, which means that the risk of missing or defect brazing points is reduced.

[0013] Since the secondary corrugation is elastic and flexible, the heat exchanger plates are more flexible and thus easily stacked onto each other when the plate heat exchanger is assembled.

[0014] The corrugated edge flanges of the heat exchanger plates may flex to a tight abutment against each other. With a small inclination angle of the edge flange, a close fit ensures tight abutment and material contact.

[0015] Thanks to the secondary corrugation of the edge flange, a turbulent flow, or more turbulent flow, is obtained along edge flange. Such turbulent flow impedes bypass along and in the proximity of the edge flange, and increases the alpha value of the plate heat exchanger.

[0016] In addition, the secondary corrugation of the edge flange may cause a turbulent flow around ports, which impedes freezing in these areas.

[0017] A further advantage of the secondary corrugation is that it is grip friendly, which means that a plate heat exchanger having heat exchanger plates with the secondary corrugation will be easier to grip and hold along the long sides.

[0018] Thanks to the secondary corrugation of the edge flange, the plate heat exchanger will present a larger surface towards the environment, which means that cooling and/or heating may be more rapid.

[0019] According to an embodiment of the invention,

the ridges and valleys of the secondary corrugation extend along a secondary direction away from extension plane of the heat exchanger area. The secondary direction crosses the extension plane.

[0020] According to a further embodiment of the invention, the edge flange has a root end at the heat exchanger area, and an outer end, wherein the edge flange is inclined from the root end to the outer end. Advantageously, the edge flange may be inclined with an inclination angle that is constant from the root end to the outer end.

[0021] According to a further embodiment of the invention, the primary corrugation extends to the root end of the edge flange. For instance, ridges and valleys of the primary corrugation may extend to the root end of the edge flange.

[0022] According to a further embodiment of the invention, the ridges and the valleys of the secondary corrugation extend from the root end to the outer end.

[0023] According to a further embodiment of the invention, the edge flange comprises a transition zone, which extends between the primary corrugation and the secondary corrugation, wherein the secondary corrugation extends from the transition zone to the outer end.

[0024] According to a further embodiment of the invention, the primary corrugation comprises ridges and valleys.

[0025] According to a further embodiment of the invention, the ridges of the primary corrugation extend into and continue in a respective one of the ridges of the secondary corrugation.

[0026] According to a further embodiment of the invention, the primary corrugation has a primary pitch and the secondary corrugation has a secondary pitch. The primary pitch may be equal to the secondary pitch.

[0027] According to a further embodiment of the invention, the ridges of the primary corrugation are disconnected from the ridges of the secondary corrugation. Thus, the transition zone may have no corrugation or provide an even surface between the heat exchanger area and the edge flange.

[0028] According to a further embodiment of the invention, primary pitch differs from the secondary pitch.

[0029] According to a further embodiment of the invention, the ridges of the primary corrugation are shifted in relation to the ridges of the secondary corrugation.

[0030] According to a further embodiment of the invention, the ridges and valleys of the primary corrugation extend along a primary direction crossing the longitudinal central axis. For instance, the ridges and valleys may extend along one direction from one of the long sides to the other long side, or the ridges and valleys may extend along two directions which meet at the longitudinal central axis, thus forming a fishbone pattern.

[0031] According to a further embodiment of the invention, the at least three sides comprise two opposite long sides and two opposite short sides.

[0032] According to a further embodiment of the invention, the secondary corrugation is provided on the edge flange at least along the long sides, or along the whole length of the long sides.

[0033] According to a further embodiment of the invention, the secondary corrugation provided on the edge flange along the short sides.

[0034] According to a further embodiment of the invention, the short sides and the long sides are connected to each other by four curved corners, wherein the secondary corrugation is provided on the edge flange along the curved corners. The secondary corrugation of the edge flange, especially at the corners, provides a better handling of excess material of the edge flange. The secondary corrugation forms a controlled folding of the edge flange. Thus, undesired folds and portions of thicker material as a result of the pressing operation can be avoided. The pressing operation may be performed without any plate holders holding the heat exchanger plate during the pressing operation.

[0035] The object is also achieved by the plate heat exchanger initially defined, comprising a plurality of heat exchanger plates as defined above.

[0036] The plate heat exchanger according to the invention will take advantage of the technical advantages and properties of the heat exchanger plates explained above. Although the individual heat exchanger plates according to the invention has a greater flexibility, the brazed plate heat exchanger will have a higher bending stiffness and higher rigidity.

[0037] According to a further embodiment of the invention, the heat exchanger plates are permanently joined to each other. Such permanent joining may be obtained through bonding, brazing, welding, gluing etc. Thanks to the secondary corrugation and the flexibility of the edge flange, less deadweight is needed to be put on the plate heat exchanger during the brazing process.

[0038] According to a further embodiment of the invention, the ridges of the secondary corrugation of one of the heat exchanger plates adjoin, or abut, the ridges of the secondary corrugation of the heat exchanger plates provided adjacent to said one heat exchanger plate. More precisely, the whole surface of the edge flange of one heat exchanger plate may thus adjoin the whole surface of the edge flange of the adjacent heat exchanger plate or plates. This contributes to the improved stiffness and improved strength of the plate heat exchanger according to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] The present invention is now to be explained more closely through a description of various embodiments and with reference to the drawings attached hereto.

Fig 1 discloses a plan view of a plate heat exchanger according to a first embodiment of the invention.

Fig 2 discloses a longitudinal section through the plate heat exchanger along the line II-II in Fig 1.

Fig 3 discloses a side view of the plate heat exchanger in Fig 1.

Fig 4 discloses a plan view of a heat exchanger plate of the plate heat exchanger in Fig 1.

Fig 5 discloses a side view of the heat exchanger plate in Fig 4.

Fig 6 discloses a perspective view of a part of an edge flange of the heat exchanger plate in Fig 4.

Fig 7 discloses a side view of a heat exchanger plate of a second embodiment of the invention.

Fig 8 discloses a plane view of a heat exchanger plate according to a third embodiment of the invention.

Fig 9 discloses a side view of a heat exchanger plate according to a fourth embodiment of the invention.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0040] Figs 1 to 3 disclose a plate heat exchanger comprising a plurality of heat exchanger plates 1 arranged beside each other in the plate heat exchanger. The heat exchanger plates 1 are permanently joined to each other. In the embodiments disclosed, the heat exchanger plates are permanently joined to each other through brazing. It should be noted that other joining techniques are also possible, such as bonding, welding, gluing etc.. The heat exchanger plates 1 may also be non-permanently joined to each other, for instance by means of tie bolts.

[0041] Each of the heat exchanger plates 1 extends in parallel with an extension plane p.

[0042] The heat exchanger plates 1 are arranged side by side in such in a way that first plate interspaces 2 for a first fluid and second plate interspaces 3 for a second fluid are formed.

[0043] The first plate interspaces 2 and the second plate interspaces 3 are provided side by side in an alternating order in the plate heat exchanger, as can be seen in Fig 2.

[0044] Each of the heat exchanger plates 1 comprises a heat exchanger area 4 extending in parallel with the extension plane p, see Fig 4.

[0045] The heat exchanger area 4 may comprise, or be limited by, at least three sides, and may have a triangular, rectangular, pentagonal or any other suitable shape.

[0046] In the embodiments disclosed, the heat exchanger plates 1 are rectangular, or substantially rectangular, with two opposite long sides 5 and two opposite short sides 6. The short sides 6 and the long sides 5 are connected to each other by four curved corners 7. A longitudinal central axis x extends in parallel with the extension plane p through the short sides 6. As can be seen in Fig 4, the longitudinal central axis x may be parallel with the long sides 5.

[0047] The heat exchanger plate 1 also comprises an edge flange 8, which extends outside and around the heat exchanger area 4 along the sides, i.e. in the embodiments disclosed along the long sides 5, the short sides 6 and the curved corners 7. The edge flange 8 is inclined in relation to the extension plane p, with an angle α of inclination, see Fig 5.

[0048] The heat exchanger plate 1 also comprises four portholes 9, which extend through the heat exchanger area 4.

[0049] The heat exchanger area 4 comprises a primary corrugation 10. In the embodiments disclosed, the primary corrugation comprises or consists of ridges 11 and valleys 12, see Fig 4.

[0050] The primary corrugation 10 may form various patterns, for instance a diagonal pattern, a fishbone pattern, etc. as is known in the art of plate heat exchangers. In the embodiments disclosed, the primary corrugation 10 forms a fishbone pattern of the ridges 11 and the valleys 12 extending along a primary direction crossing the longitudinal central axis x. The ridges 11 and valleys 12 form a positive angle of inclination on one side of the longitudinal central axis x and a corresponding negative angle of inclination on the other of the longitudinal central axis x.

[0051] Other geometrical shapes of the primary corrugation 10 are also possible, for instance a corrugation of dimples or other spot shaped depressions and/or protrusions.

[0052] As can be seen in Fig 4, the ridges 11 and valleys 12 of the primary corrugation 10 extend to the long sides 5.

[0053] The edge flange 8 of the heat exchanger plate 1 comprises a secondary corrugation 20 of ridges 21 and valleys 22.

[0054] The ridges 21 and valleys 22 of the secondary corrugation 20 extend along a secondary direction y away from extension plane p of the heat exchanger area 4, see Fig 5.

[0055] In the first embodiment, the secondary corrugation 20 is provided on the edge flange 8 along the long sides 5, the short sides 6 and the curved corners 7.

[0056] The edge flange 8 has a root end 25 at the heat exchanger area 4 and an outer end 26. The edge flange 8 is inclined from the root end 25 to the outer end 26, especially with the above mentioned angle α of inclination.

[0057] The ridges 21 and the valleys 22 of the secondary corrugation 20 extend from the root end 25 to the outer end 26 as can be seen in Fig 6, which discloses more closely the secondary corrugation 20 of the edge flange 8.

[0058] The primary corrugation 10 extends to the root end 25 of the edge flange 8, as can be seen in Fig 4.

[0059] In the first embodiment, the ridges 11 of the primary corrugation 10 extend into and continue in a respective one of the ridges 21 of the secondary corrugation 20, and the valleys 12 of the primary corrugation 10 extend into and continue in a respective one of the valleys 22 of the secondary corrugation 20, see Fig 4.

[0060] Furthermore, the primary corrugation 10 may have a primary pitch P_1 and the secondary corrugation 20 a secondary pitch P_2. The primary pitch P_1 is the distance between adjacent ridges 11, or adjacent valleys 12, along a line parallel with the longitudinal central axis x, see Fig 4. The secondary pitch P_2 is the distance between adjacent ridges 21, or adjacent valleys 22, perpendicular to the secondary direction y, see Figs 4 and 5. In the first embodiment, the primary pith P_1 is equal to the secondary pitch P_2.

[0061] As mentioned above, the plate heat exchanger is a brazed plate heat exchanger. The individual heat exchanger plates 1 are compression molded to obtain the shape disclosed and described herein. The heat exchanger plates 1 are the stacked onto each other with a sheet of braze material between each heat exchanger plate 1. Moreover, the heat exchanger plates 1 are stacked onto each other so that the ridges 21 of the secondary corrugation 20 of one of the heat exchanger plates 1 adjoin the ridges 21 of the secondary corrugation 20 of the heat exchanger plates 1 provided adjacent to said one heat exchanger plate 1. In the same way, the valleys 22 of the secondary corrugation 20 of one of the heat exchanger plates 1 adjoin the valleys 22 of the secondary corrugation 20 of the heat exchanger plates 1 provided adjacent to said one heat exchanger plate 1. The whole surface of the edge flange 8 of one heat exchanger plates 1 may thus adjoin the whole surface of the edge flange 8 of the adjacent heat exchanger plate 1 or plates 1.

[0062] In the plate heat exchanger with heat exchanger plates 1 according to the first embodiment, the portholes 9 of the heat exchanger plates 1 may form a first inlet port 31 for the first fluid to the first plate interspaces 2, a first outlet port 32 for the first fluid from the first plate interspaces 2, a second inlet port 33 for the second fluid to the second plate interspaces 3, and a second outlet port 34 for the second fluid from the second plate interspaces 3, see Fig 1. Each of the ports 31-34 may comprise a connection pipe, as can be seen in Figs 2 and 3.

[0063] The outermost heat exchanger plate 1, at which the ports 31-34 are provided, may form frame plate, and the opposite outermost heat exchanger plate 1 may form a pressure plate.

[0064] The stack of heat exchanger plates 1 are then brazed by being heated to a suitable temperature. The stack is held together during the heating and following cooling by a deadweight provided on top of the stack.

[0065] Fig 7 discloses a heat exchanger plate 1 according to a second embodiment, which differs from the first embodiment in that, the edge flange 8 comprises a transition zone 28, which extends around the heat exchanger area 4. The transition zone 28 is provided and extends between the primary corrugation 10 and the secondary corrugation 20. The transition zone 28 starts at the root end 25 and extends towards the outer end 26. The secondary corrugation 20 thus extends from the transition zone 28 to the outer end 26 of the edge flange 8.

[0066] In the second embodiment, the ridges 11 and the valleys 12 of the primary corrugation 10 are thus disconnected from the ridges 21 and valleys 22 of the secondary corrugation 20.

[0067] Fig 8 discloses a heat exchanger plate 1 according to a third embodiment, which differs from the first embodiment in that the secondary corrugation 20 is provided on the edge flange 8 along the long sides 5 only.

[0068] Fig 9 discloses a heat exchanger plate according to a fourth embodiment, which differs from the second embodiment in that the primary pitch P_1 is shorter than the secondary pitch P_2. The ridges 11 of the primary corrugation 10 are thus not aligned with the ridges 21 of the secondary corrugation 20, and the valleys 12 of the primary corrugation 10 are not aligned with the valleys 22 of the secondary corrugation 20.

[0069] The invention is not limited to the embodiments disclosed, but may be varied and modified within the scope of the following claims.

[0070] The invention is applicable to all permanently joined plate heat exchangers, especially brazed plate heat exchanger, not only those for two fluids, but also plate heat exchangers for more than two fluids, for instance three fluids.

[0071] Furthermore, the heat exchanger plate may then have more or less than four portholes, for instance two portholes, six portholes etc.

Claims

1. A heat exchanger plate (1) for a plate heat exchanger, the heat exchanger plate (1) comprising
   a heat exchanger area (4) extending in parallel with an extension plane (p) and comprising a primary corrugation (10) and at least three sides (5, 6),
   a longitudinal central axis (x) extending in parallel with the extension plane (p) through at least one of the sides (6),
   a plurality of portholes (9) extending through the heat exchanger area (4), and
   an edge flange (8) extending outside and around the heat exchanger area (4) along the sides (5, 6), wherein the edge flange (8) is inclined in relation to the extension plane (p), **characterized in that** the edge flange (8) comprises a secondary corrugation (20) of ridges (21) and valleys (22), and that the ridges (21) and valleys (22) of the secondary corrugation (20) extend along a secondary direction (y) away from extension plane (p) of the heat exchanger area (4).

2. A heat exchanger plate according to claim 1, wherein the edge flange (8) has a root end (25) at the heat exchanger area (4), and an outer end (26), wherein the edge flange (8) is inclined from the root end (25) to the outer end (26).

3. A heat exchanger plate according to claim 2, wherein

the primary corrugation (10) extends to the root end (25) of the edge flange (8).

4. A heat exchanger plate according to claim 3, wherein the ridges (21) and the valleys (22) of the secondary corrugation (20) extend from the root end (25) to the outer end (26).

5. A heat exchanger plate according to claim 3, wherein the edge flange (8) comprises a transition zone (28), which extends between the primary corrugation (10) and the secondary corrugation (20), and wherein the secondary corrugation (20) extends from the transition zone (28) to the outer end (26).

6. A heat exchanger plate according to any one of the preceding claims, wherein the primary corrugation (10) comprises ridges (11) and valleys (12).

7. A heat exchanger plate according to claim 6, wherein the ridges (11) of the primary corrugation (10) extend into and continue in a respective one of the ridges (21) of the secondary corrugation (20).

8. A heat exchanger plate according to claim 6, wherein the ridges (11) of the primary corrugation (10) are disconnected from the ridges (21) of the secondary corrugation (20).

9. A heat exchanger plate according to any one of claims 6 to 8, wherein the ridges (9) and valleys (10) of the primary corrugation (8) extend along a primary direction crossing the longitudinal central axis (x).

10. A heat exchanger plate according to any one of the preceding claims, wherein the at least three sides (5, 6) comprise two opposite long sides (5) and two opposite short sides (6),

11. A heat exchanger plate according to claim 10, wherein the secondary corrugation (20) is provided on the edge flange (8) along the long sides (5).

12. A heat exchanger plate according to any one of claims 10 and 11, wherein the secondary corrugation (20) is provided on the edge flange (8) along the short sides (6).

13. A heat exchanger plate according to any one of claims 10 to 12, wherein the short sides (6) and the long sides (5) are connected to each other by four curved corners (7), and wherein the secondary corrugation (20) is provided on the edge flange (8) along the curved corners (7).

14. A plate heat exchanger comprising a plurality of heat exchanger plates (1) according to any one of the preceding claims.

15. A plate heat exchanger according to claim 14, wherein the heat exchanger plates (1) are permanently joined to each other.

16. A plate heat exchanger according to any one of claims 14 and 15, wherein the ridges (21) of the secondary corrugation (20) of one of the heat exchanger plates (1) adjoin the ridges (21) of the secondary corrugation (20) of the heat exchanger plates (1) provided adjacent to said one heat exchanger plate (1).

Fig 1

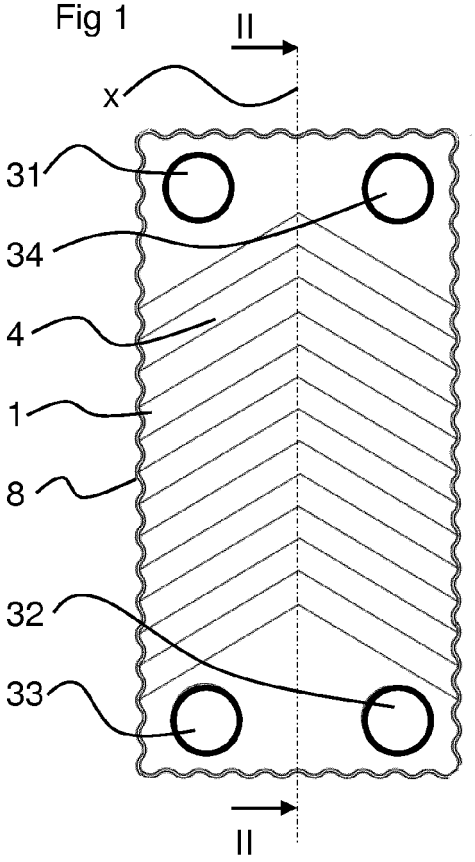


Fig 2

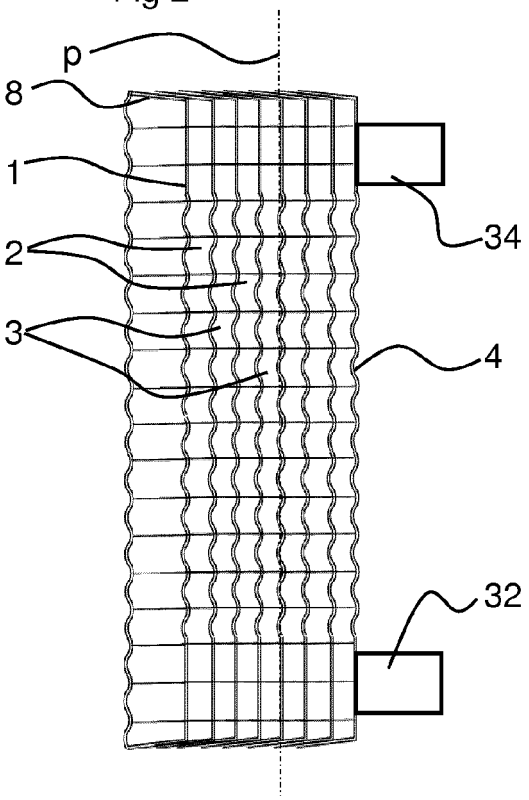


Fig 3

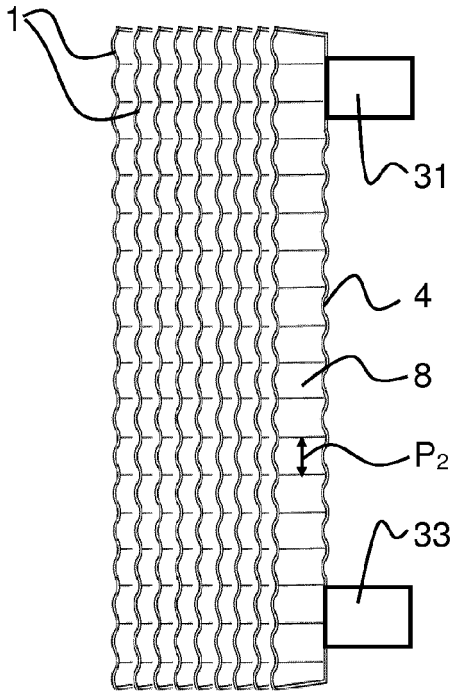


Fig 4

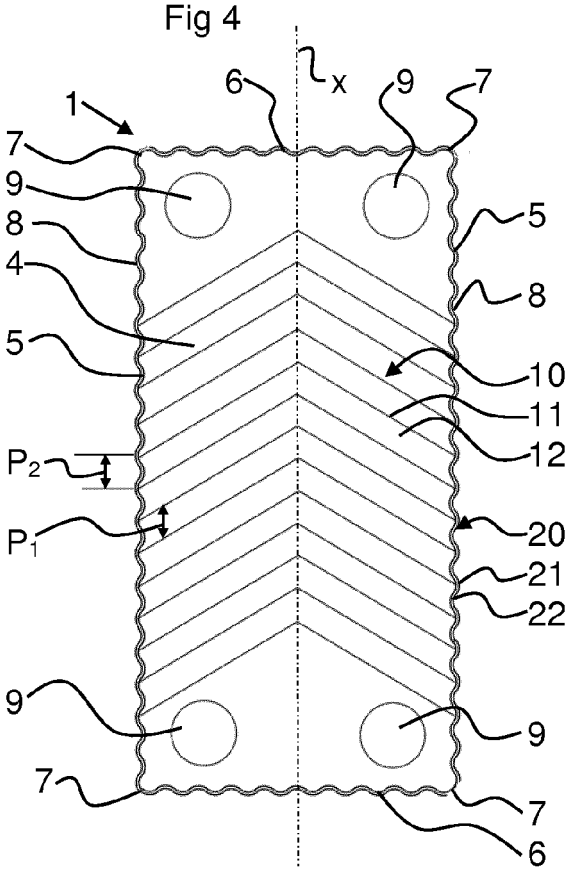


Fig 5

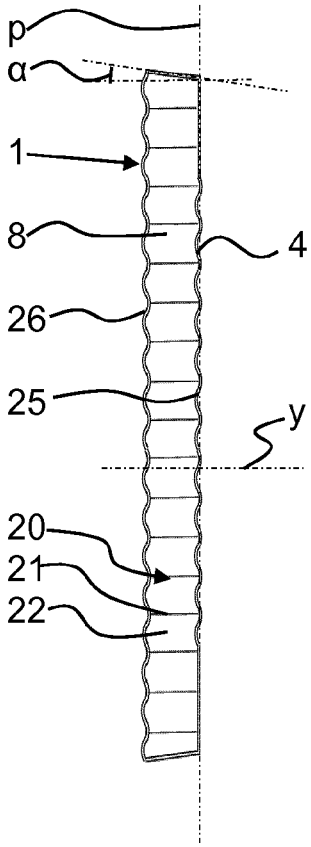


Fig 6

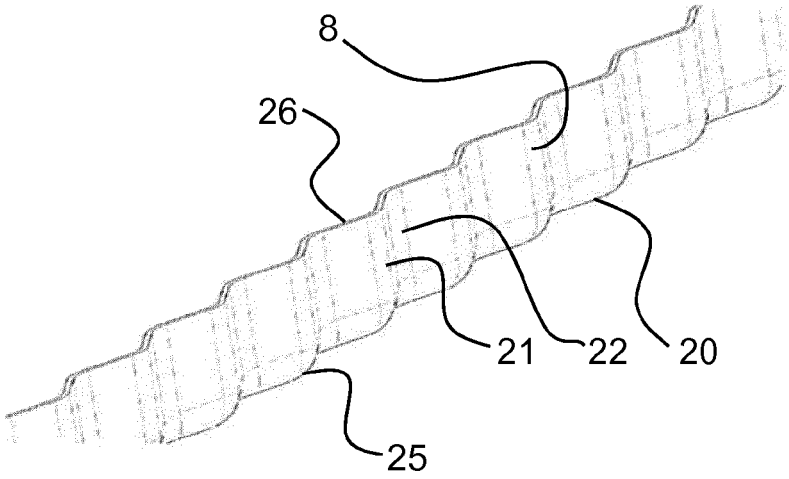


Fig 7

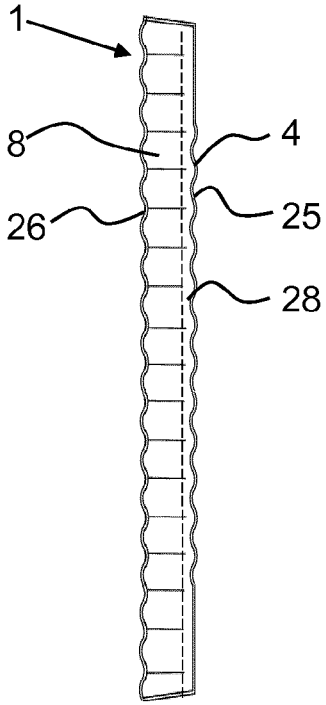


Fig 8

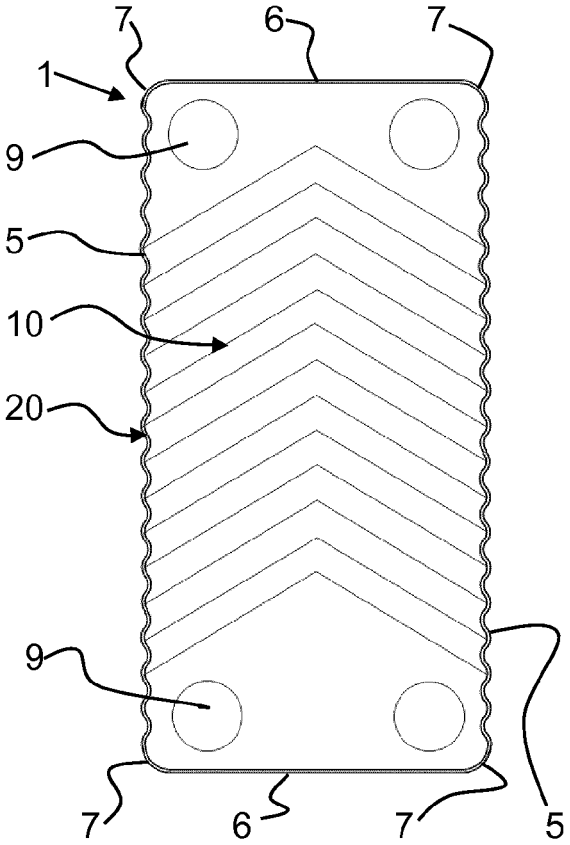
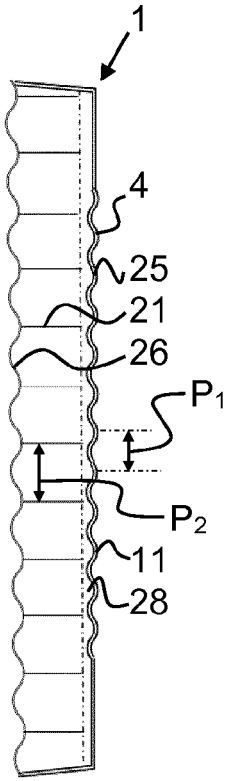


Fig 9



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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 6703

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 370 773 A1 (SWEP INT AB [SE]) 5 October 2011 (2011-10-05) * the whole document *	1-16	INV. F28D9/00 F28F3/02
A	WO 2015/062992 A1 (SWEP INT AB [SE]) 7 May 2015 (2015-05-07) * the whole document *	1-16	
A	WO 2009/080692 A1 (ALFA LAVAL CORP AB [SE]; KRANTZ JOAKIM [SE]; SVENSSON MAGNUS [SE]) 2 July 2009 (2009-07-02) * the whole document *	1-16	

TECHNICAL FIELDS SEARCHED (IPC)

F28D
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 January 2018	Axters, Michael

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 18 6703

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-01-2018

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