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(54) **HEAT TRANSFER PLATE**

(57) A heat transfer plate (2a) comprising an upper transition area (16) is provided. The upper transition area (16) is provided with a transition pattern (50) comprising alternately arranged support transition ridges (60) and support transition valleys (62). A respective top portion (60t) of at least a plurality of the support transition ridges (60) extends in a first plane (P1) and a respective bottom portion (62b) of at least a plurality of the support transition valleys (62) extends in a second plane (P2). An infinite imaginary straight transition line (68) extends through two opposing end points (70, 72) of each of the support transition ridges (60) and the support transition valleys (62). The heat transfer plate (2a) further comprises a front gasket groove (46) comprising a field front gasket groove portion (46a). Along at least more than half of a length of the field front gasket groove portion (46a), a bottom (55) of the front gasket groove (46) extends between the first and second planes (P1, P2). The heat transfer plate is characterized in that the imaginary straight transition line (68), for at least a plurality of the support transition ridges (60) and the support transition valleys (62), extends parallel to the longitudinal center axis (L) of the heat transfer plate (2a).

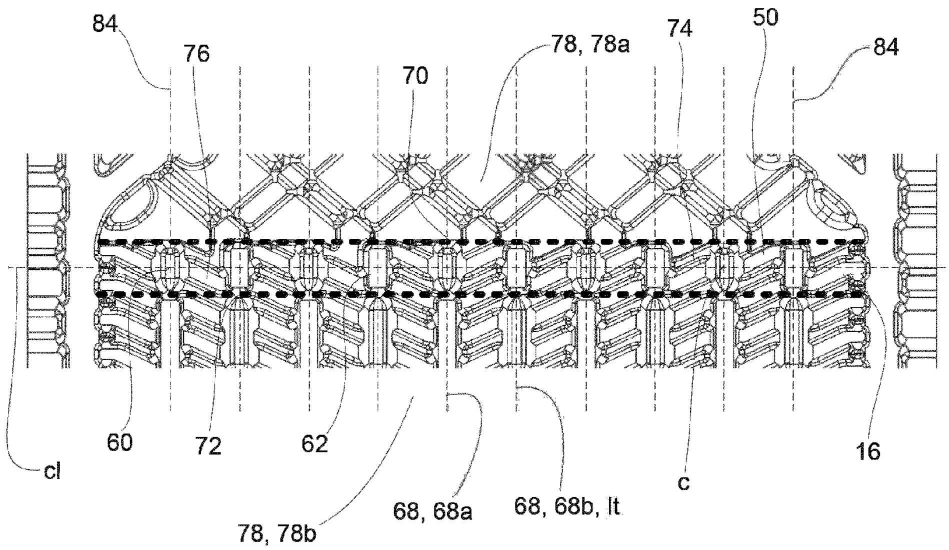


Fig. 4

EP 4 481 311 A1

Description

Technical Field

[0001] The invention relates to a heat transfer plate and its design.

Background Art

[0002] Plate heat exchangers, PHEs, typically consist of two end plates in between which a number of heat transfer plates are arranged aligned in a stack or pack. The heat transfer plates of a PHE may be of the same or different types and they may be stacked in different ways. In some PHEs, the heat transfer plates are stacked with the front side and the back side of one heat transfer plate facing the back side and the front side, respectively, of other heat transfer plates, and every other heat transfer plate turned upside down in relation to the rest of the heat transfer plates. Typically, this is referred to as the heat transfer plates being "rotated" in relation to each other. In other PHEs, the heat transfer plates are stacked with the front side and the back side of one heat transfer plate facing the front side and back side, respectively, of other heat transfer plates, and every other heat transfer plate turned upside down in relation to the rest of the heat transfer plates. Typically, this is referred to as the heat transfer plates being "flipped" in relation to each other.

[0003] In one type of well-known PHEs, the so called gasketed PHEs, gaskets are arranged between the heat transfer plates. The end plates, and therefore the heat transfer plates, are pressed towards each other by some kind of tightening means, whereby the gaskets seal between the heat transfer plates. Parallel flow channels are formed between the heat transfer plates, one channel between each pair of adjacent heat transfer plates. Two fluids of initially different temperatures, which are fed to/from the PHE through inlets/outlets, can flow alternately through every second channel for transferring heat from one fluid to the other, which fluids enter/exit the channels through inlet/outlet port holes in the heat transfer plates communicating with the inlets/outlets of the PHE.

[0004] Typically, a heat transfer plate comprises two end portions and an intermediate center portion. The end portions comprise the inlet and outlet port holes and a distribution area pressed with a corrugation distribution pattern of projections and depressions, such as ridges and valleys. Similarly, the center portion comprises a heat transfer area pressed with a corrugation heat transfer pattern of projections and depressions, such as ridges and valleys. The ridges and valleys of the distribution and heat transfer patterns of one heat transfer plate is arranged to contact, in contact areas, the ridges and valleys of the distribution and heat transfer patterns of other, adjacent, heat transfer plates in a plate heat exchanger. Typically, the contact areas provide for mechanical strength of the plate pack.

[0005] The main task of the distribution area of the heat transfer plates is to spread a fluid entering the channels across the width of the heat transfer plates before the fluid reaches the heat transfer area, and to collect the fluid and guide it out of the channels after it has passed the heat transfer area. On the contrary, the main task of the heat transfer area is heat transfer. Since the distribution area and the heat transfer area have different main tasks, the distribution pattern normally differs from the heat transfer pattern. At the transition between the distribution area and the heat transfer area, i.e. where the plate pattern changes, there may be relatively little contact between adjacent heat transfer plates of a plate pack. The result of this may be that the rigidity of the plate pack at the transition is somewhat reduced as compared to the rigidity of the rest of the plate pack.

[0006] A solution to the problem above is presented in applicant's patent EP 1899671. The solution involves the provision of a narrow band between the distribution and heat transfer areas of the heat transfer plates. The narrow band is provided with a herringbone pattern, more particularly densely arranged "steep" ridges and valleys which results in densely arranged point contact areas between the heat transfer plates when these are aligned in a plate pack. Thereby, the rigidity of the plate pack at the transition between the heat transfer area and the distribution area may be improved.

[0007] Even if the narrow band above solves the rigidity issue at the transition, it may cause a relatively large pressure drop inside the channels. This may be disadvantageous in that the efficiency of the heat transfer plate may be decreased, especially when the heat transfer plates comprise a heat transfer area provided with a heat transfer pattern which cause a relatively low pressure drop inside the channels.

Summary

[0008] An object of the present invention is to provide a heat transfer plate which at least partly solves the above discussed problem of prior art. The basic concept of the invention is to provide the heat transfer plate with a narrow band at the transition between the heat transfer area and distribution area which is designed so as to promote mechanical strength but a lower pressure drop as compared to prior art. The heat transfer plate, which is also referred to herein as just "plate", for achieving the object above is defined in the appended claims and discussed below.

[0009] A heat transfer plate according to the present invention comprises an upper end portion, a center portion and a lower end portion arranged in succession along a longitudinal center axis of the heat transfer plate. The longitudinal center axis divides the heat transfer plate into a first half and a second half and it extends perpendicular to a transverse center axis of the heat transfer plate. The center portion comprises a heat transfer area. The upper end portion comprises a first port hole, a second port hole, an upper distribution area and an upper transition area. The upper transition area adjoins the upper distribution area along a first borderline and the heat transfer area along a second borderline. The lower end portion comprises a third port hole, a fourth port hole, a lower distribution area and a lower transition area. The lower transition area adjoins the lower distribution area along a third borderline and the heat transfer area along a fourth borderline. The upper distribution area is provided with a distribution pattern. The upper transition area is provided with a transition pattern. The heat transfer area is provided with a heat transfer pattern. The transition pattern differs from the distribution pattern and the heat transfer pattern. The transition pattern comprises alternately arranged support transition ridges and support transition valleys as seen from a front side of the heat transfer plate. A respective top portion of at least a plurality, preferably at least a majority, of the support transition ridges extends in a first plane, and a respective bottom portion of at least a plurality, preferably at least a majority, of the support transition valleys extends in a second plane. An infinite imaginary straight transition line extends between two opposing end points of each of the support transition ridges and the support transition valleys. The heat transfer plate defines a plurality of separated imaginary straight transition lines The heat transfer plate further comprises, on the front side, a front gasket groove. In turn, the front gasket groove comprises a field front gasket groove portion enclosing the heat transfer area, the upper and lower transition areas, the upper and lower distribution areas and two of the first, second, third and fourth port holes. Along at least more than half of a length of the field front gasket groove portion, a bottom of the front gasket groove extends between the first and second planes. The heat transfer plate is characterized in that the imaginary straight transition line, for at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys, extends parallel to the longitudinal center axis of the heat transfer plate.

[0010] Herein, if not stated otherwise, ridges and valleys of the heat transfer plate are ridges and valleys when a front side of the heat transfer plate is viewed. Naturally, what is a ridge as seen from the front side of the plate is a valley as seen from an opposing back side of the plate, and what is a valley as seen from the front side of the plate is a ridge as seen from the back side of the plate, and vice versa.

[0011] The first, second, third and fourth borderlines are crossing the longitudinal center axis of the heat transfer plate. The first and/or the second borderline, just like the third and/or the fourth borderline, may be straight and possibly parallel to the transverse center axis, or curved, for example inwards bulging as seen from a center of the heat transfer plate.

[0012] The first and second planes may be parallel.

[0013] Herein, "majority" means more than half.

[0014] The imaginary straight transition lines may be equidistantly arranged across part of, or the complete, heat transfer plate. Further, the two port holes enclosed by the field front gasket groove portion of the front gasket groove may be arranged on the same side of the longitudinal center axis of the heat transfer plate. Both these configurations may enable a plate pack of heat transfer plates according to the invention which are either "flipped" or "rotated" in relation to each other.

[0015] The heat transfer plate may further comprise an outer edge portion extending all the way along an outer edge or periphery of the plate, which outer edge portion comprises corrugations extending between and in the first and second planes. The complete outer edge portion, or only one or more sub-portions thereof, may comprise corrugations. The corrugations may be evenly or unevenly distributed along the edge portion, and they may, or may not, all look the same. The corrugations define ridges and valleys which may give the edge portion a wave-like design. The corrugations may be arranged, at the front side of the heat transfer plate, to abut a first adjacent heat transfer plate, and at the opposing back side of the heat transfer plate, to abut a second adjacent heat transfer plate, when the heat transfer plate is arranged in a plate heat exchanger.

[0016] The heat transfer plate is arranged to be combined with other heat transfer plates in a plate pack. The heat transfer plates of the plate pack may all be of the same type. Alternatively, they may be of different types, but preferably, they are all configured according to claim 1.

[0017] In that the imaginary straight transition lines extend parallel to the longitudinal center axis of the heat transfer plate for at least a plurality of the support transition ridges and valleys, the upper distribution area may provide for relatively few but relatively large contact areas between the heat transfer plate and adjacent heat transfer plates in a plate pack. In turn, this may provide a good mechanical strength and a relatively low pressure drop at the upper distribution area.

[0018] The heat transfer plate may be so configured that the bottom of the front gasket groove, along at least more than half of the length of the field front gasket groove portion, extends in a center plane being parallel to, and extending halfway between, the first and second planes, in so-called half plane. Such a configuration may enable a plate pack of heat transfer plates according to the invention which are either "flipped" or "rotated" in relation to each other.

[0019] The support transition ridges may have the same or different, and any suitable, shape and/or size. Similarly, the support transition valleys may have the same or different, and any suitable, shape and/or size. As an example, at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys may be elongate, i.e. they may have a length that exceeds their width, which is beneficial as regards flow resistance and pressure drop across the heat transfer plate. Additionally/alternatively, at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys may be straight, i.e. they may have a straight longitudinal center axis, which may make the heat transfer plate suitable for use in a plate pack of "rotated" as well as "flipped" heat transfer plates.

[0020] Further, the heat transfer plate may be such that the imaginary straight transition line, for each of at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys, coincides with the respective longitudinal center axis of the support transition ridge or the support transition valley. Such a configuration enables support transition ridges and valleys having two symmetry axes which are parallel to the longitudinal and transverse center axes of the heat transfer plate. Further, such a configuration makes the heat transfer plate suitable for use in a plate pack of "rotated" as well as "flipped" heat transfer plates.

[0021] The total number of support transition ridges and support transition valleys may exceed the number of imaginary straight transition lines defined by the heat transfer plate such that one and the same of the imaginary straight transition lines extends through more than one of the support transition ridges and the support transition valleys. However, according to one embodiment of the invention, at least a plurality, preferably at least a majority, of the imaginary straight transition lines defined by the heat transfer plate extends through a single one of the support transition ridges and the support transition valleys. Such a design enables a heat transfer plate with an upper distribution area comprising one single row of alternately arranged support transition ridges and support transition valleys.

[0022] The heat transfer plate may be such that a respective center point of at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys is arranged along an imaginary center line which crosses the longitudinal center axis of the heat transfer plate. The imaginary center line may be straight and possibly parallel to the transverse center axis of the heat transfer plate. Alternatively, the imaginary center line may be curved.

[0023] The heat transfer plate may define an even number x of imaginary straight transition lines. This may result in an uneven number x-1 of interspaces between the imaginary straight transition lines. Further, especially if the imaginary straight lines are evenly distributed across the heat transfer plate, the longitudinal center axis may divide a center interspace of the interspaces lengthwise, in half, and (x-2)/2 complete interspaces, i.e. interspaces not divided by the longitudinal center axis, may be arranged on each of the first and the second half of the heat transfer plate. Such a design may make the heat transfer plate suitable for use in a plate pack comprising plates "rotated" in relation to each other and in a plate pack comprising plates "flipped" in relation to each other.

[0024] Besides for the support transition ridges and the support transition valleys, the transition pattern may further comprise turbulence transition ridges and turbulence transition valleys. A respective top portion of at least a plurality, preferably at least a majority, of the turbulence transition ridges may extend in a third plane arranged between, and parallel to, the first and second planes. A respective bottom portion of at least a plurality, preferably at least a majority, of the turbulence transition valleys may extend in a fourth plane arranged between, and parallel to, the second and third planes. At least a plurality, preferably at least a majority, of the turbulence transition ridges and the turbulence transition valleys may be alternately arranged in interspaces between the imaginary straight transition lines and connect the support transition ridges and the support transition valleys for adjacent ones of the imaginary straight transition lines.

[0025] The third and fourth planes may, or may not, be arranged at the same distance from the center plane.

[0026] The turbulence transition ridges and the turbulence transition valleys may have the advantageous effect of increasing the turbulence caused by the heat transfer plate and thus increase the heat transfer capacity of the heat transfer plate. The higher/deeper and more densely arranged the transition turbulence ridges and valleys are, the more they may increase the heat transfer capacity.

[0027] At least a plurality, preferably at least a majority, of the turbulence transition ridges and the turbulence transition valleys may, along at least a center portion of their longitudinal extension, extend inclined in relation to the transverse center axis of the heat transfer plate.

[0028] If a heat transfer plate has inclined turbulence transition ridges and valleys, alignment of the turbulence transition ridges and valleys of the heat transfer plate with the turbulence ridges and valleys of another similar "rotated" or "flipped" heat transfer plate, which is abutting the first heat transfer plate in a plate pack, may be avoided. This may be beneficial in that aligned turbulence transition ridges and valleys may result in channels, between the heat transfer plates, having a varying depth along a longitudinal center axis of the heat transfer plates which, in turn, may result in an intermittent restriction of a flow through the channels.

[0029] At least a plurality, preferably at least a majority, of the turbulence transition ridges and the turbulence transition valleys which are completely arranged, i.e. which are arranged in the complete interspaces, on the first half of the heat transfer plate, may, along their center portion, extend in a smallest angle α, $0<\alpha<90$, clockwise in relation to the transverse center axis of the heat transfer plate. At least a plurality, preferably at least a majority, of the rest of the turbulence transition ridges and the turbulence transition valleys may, along their center portion, extend in a smallest angle β, $0<\beta<90$, counter-clockwise in relation to the transverse center axis of the heat transfer plate. Thereby, it may be avoided that opposing turbulence transition ridges and valleys of two adjacent heat transfer plates, which are configured like this, in a plate pack, extend parallel to each other, when the plates are "rotated" as well as "flipped" in relation to each other. Such parallel extension could result in unnecessary restriction of a flow between the plates.

[0030] a may be different from β. Alternately, a may be equal to β. The latter option may result in that opposing turbulence transition ridges and valleys of two adjacent heat transfer plates, which are configured like this, in a plate pack, extend in the same way in relation to each other irrespective of whether the plates are "rotated" or "flipped" in relation to each other.

[0031] The heat transfer plate may be so configured that the upper transition area and the lower transition area, to at least 50 percent, are symmetrical with respect to the transverse center axis of the heat transfer plate. Such a design may make the heat transfer plate suitable for use in a plate pack comprising plates "rotated" in relation to each other and in a plate pack comprising plates "flipped" in relation to each other.

[0032] The heat transfer (HT) pattern of the heat transfer plate may comprise support HT ridges and support HT valleys. At least a plurality, preferably a majority, of the support HT ridges and the support HT valleys may longitudinally extend parallel to the longitudinal center axis of the heat transfer plate. A respective top portion of at least a plurality, preferably at least a majority, of the support HT ridges may extend in the first plane, and a respective bottom portion of at least a plurality, preferably at least a majority, of the support HT valleys may extend in the second plane. At least a plurality, preferably at least a majority, of the support HT ridges and the support HT valleys may be alternately arranged along a number of separated imaginary longitudinal straight HT lines extending parallel to the longitudinal center axis of the heat transfer plate, and along a number of separated imaginary transverse straight HT lines extending parallel to the transverse center axis of the heat transfer plate. At least a plurality, preferably a majority, of the support HT ridges and the support HT valleys may be centered with respect to the imaginary longitudinal straight HT lines and extend between adjacent ones of the imaginary transverse straight HT lines. The heat transfer pattern may further comprise turbulence HT ridges and turbulence HT valleys. A respective top portion of at least a plurality, preferably a majority, of the turbulence HT ridges may extend in a fifth plane arranged between, and parallel to, the first and second planes. A respective bottom portion of at least a plurality, preferably a majority, of the turbulence HT valleys may extend in a sixth plane arranged between, and parallel to, the second and fifth planes. At least a plurality, preferably at least a majority, of the turbulence HT ridges and the turbulence HT valleys may be alternately arranged in interspaces between the imaginary longitudinal straight HT lines and connect the support HT ridges and support HT valleys along adjacent ones of the imaginary longitudinal straight HT lines. Such a HT pattern may enable relatively few contact between adjacent heat transfer plates in a plate pack, which may be advantageous in some applications, for example when hygiene is an particularly important aspect.

[0033] The turbulence HT ridges and the turbulence HT valleys may increase the turbulence caused by the heat transfer plate and thus increase the heat transfer capacity of the heat transfer plate. The higher/deeper and more densely arranged the turbulence HT ridges and valleys are, the more they may increase the heat transfer capacity.

[0034] The fifth and sixth planes may, or may not, be arranged at the same distance from the center plane. The fifth plane may, or may not, coincide with the third plane referred to above. Similarly, the sixth plane may, or may not, coincide with the fourth plane referred to above.

[0035] The number of imaginary longitudinal straight HT lines may be an even or an odd number. The imaginary longitudinal straight HT lines may be equidistantly arranged across part of, or the complete, heat transfer area.

[0036] The number of imaginary transverse straight HT lines may be an even or an odd number. The imaginary transverse straight HT lines may be equidistantly arranged across part of, or the complete, heat transfer area.

[0037] At least a plurality, preferably at least a majority, of the imaginary longitudinal straight HT lines may coincide with a respective one of the imaginary straight transition lines. This enables alignment of the support transition ridges and valleys and the support HT ridges and valleys. This may be beneficial as regards flow resistance across the heat transfer plate.

[0038] The HT pattern of the heat transfer plate may further be such that at least a plurality, preferably at least a majority, of the turbulence HT ridges and the turbulence HT valleys along at least a center portion of their longitudinal extension extend inclined in relation to the imaginary transverse straight HT lines.

[0039] In that the turbulence HT ridges and turbulence HT valleys, along at least part of their length, extend obliquely between the imaginary longitudinal straight HT lines, they may connect support HT ridges and support HT valleys which are not arranged between the same two imaginary transverse straight HT lines. "Rotation" and "flipping", in relation to each other, of two heat transfer plates, which have non-oblique turbulence ridges and valleys, may result in channels where the turbulence HT ridges or valleys of one plate end up directly aligned with the turbulence HT ridges or valleys of the other plate. Such channels may have a varying depth along a longitudinal center axis of the heat transfer plates which may result in an intermittent restriction of a flow through the channels. If the two heat transfer plates instead have oblique turbulence HT ridges and valleys, directly aligned turbulence HT ridges and valleys, and thus channels of varying depth, may be avoided, when the plates are "flipped" and "rotated" in relation to each other.

[0040] The heat transfer plate may be so designed that a longitudinal extension of at least a plurality, preferably at least a majority, of the support transition ridges and the support transition valleys is smaller than a longitudinal extension of the support HT ridges and the support HT valleys. This may be beneficial as regards the mechanical strength of a plate pack comprising the heat transfer plate.

[0041] It should be stressed that the advantages of most, if not all, of the above discussed features of the inventive heat transfer plate appear when the heat transfer plate is combined with other suitably constructed heat transfer plates in a plate pack.

[0042] Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief Description of the Drawings

[0043] The invention will now be described in more detail with reference to the appended schematic drawings, in which

Fig. 1a is a schematic plan view of a heat transfer plate,
Fig. 1b is a schematic cross section along line A-A in Fig. 1a,
Fig. 2a is a schematic plan view of the heat transfer plate in Fig. 1a cooperating with a gasket,
Fig. 2b is a schematic cross section along line B-B in Fig. 2a,
Fig. 3 schematically illustrates abutting outer edges of adjacent heat transfer plates in a plate pack, as seen from the outside of the plate pack,
Fig. 4 is an enlargement of a portion of the heat transfer plate in Fig. 1a,
Fig. 5a schematically illustrates a cross section of a support transition ridge of the heat transfer plate in Fig. 1a,
Fig. 5b schematically illustrates a cross section of a support transition valley of the heat transfer plate in Fig. 1 a,
Fig. 6 schematically illustrates a cross section of a turbulence transition ridge and a turbulence transition valley, as well as a cross section of a turbulence HT ridge and a turbulence HT valley, of the heat transfer plate in Fig. 1a,
Fig. 7 is an enlargement of a portion of the heat transfer plate in Fig. 1 a,
Fig. 8 is an enlargement of a portion of the heat transfer plate in Fig. 1a,
Fig. 9 schematically illustrates a cross section of a support HT ridge and a support HT valley of the heat transfer plate in Fig. 1a, and
Fig. 10 is an enlargement of a portion of the heat transfer plate in Fig. 1a,

Detailed description

[0044] Figs. 1a and 2a shows a heat transfer plate 2a of a gasketed plate heat exchanger as described by way of introduction. The gasketed PHE, which is not illustrated in full, comprises a pack of heat transfer plates 2 like the heat transfer plate 2a, i.e. a pack of similar heat transfer plates, separated by gaskets 1, which also are similar and one of which is illustrated in Fig. 2a. With reference to Fig. 3, in the plate pack, a front side 4 (illustrated in Figs. 1a and 2a) of the plate 2a faces an adjacent plate 2b while a back side 6 (not visible in Figs. 1a and 2a but indicated in Fig. 3) of the plate 2a faces another adjacent plate 2c.

[0045] With reference to Fig. 1a, the heat transfer plate 2a is an essentially rectangular sheet of stainless steel. It comprises an upper end portion 8, which in turn comprises a first port hole 10, a second port hole 12, an upper distribution area 14 and an upper transition area 16. The upper transition area 16 adjoins the upper distribution area 14 along a first borderline bl1 (illustrated with a dashed line) which is parallel to a transverse center axis T of the heat transfer plate 2a. The plate 2a further comprises a lower end portion 18, which in turn comprises a third port hole 20, a fourth port hole 22, a lower distribution area 24 and a lower transition area 26. The lower transition area 26 adjoins the lower distribution area 24 along a third borderline bl3 (illustrated with a dashed line) which is parallel to the transverse center axis T of the heat transfer plate 2a. The plate 2a further comprises a center portion 28, which in turn comprises a heat transfer area 30, and an outer edge portion 32 extending around the upper and lower distribution areas 14 and 24, the upper and lower transition areas 16 and 26, the heat transfer area 30 and the port holes 10, 12, 20 and 22. The heat transfer area 30 adjoins the upper transition area 16 along a second borderline bl2 (illustrated with a dashed line) and the lower transition area 26 along a fourth borderline bl4 (illustrated with a dashed line), the second and fourth borderlines bl2 and bl4, respectively, being parallel to the transverse center axis T.

[0046] As is clear from Fig. 1a, the upper end portion 8, the center portion 28 and the lower end portion 18 are arranged in succession along a longitudinal center axis L of the plate 2a, which extends half way between, and parallel to, first and second opposing long sides 34, 36 of the plate 2a. The longitudinal center axis L divides the plate 2a into first and second halves 38, 40. Further, the longitudinal center axis L extends perpendicular to the transverse center axis T of the plate 2a, which extends half way between, and parallel to, first and second opposing short sides 42, 44 of the plate 2a. Also, the heat transfer plate 2a comprises, on the front side 4, a front gasket groove 46 and, on the back side 6, a back gasket groove 47 (indicated in Figs. 1b and 2b). The front and back front gasket grooves are enclosed by the outer edge portion 32, partly aligned with each other and arranged to receive a respective gasket 1, as is illustrated, for the front gasket groove 46, in Fig. 2a. The front gasket groove 46 comprises a field front gasket groove portion 46a enclosing the heat transfer area 30, the upper and lower distribution areas 14, 24, the upper and lower transition areas 16, 26 and the first and third portholes 10, 20. The front gasket groove 46 further comprises two ring front gasket groove portions 46b, each enclosing a respective one of the second and fourth portholes 12, 22. The field and ring front gasket groove portions 46a, 46b are integrally formed. With reference also to Fig. 2a, the field front gasket groove portion 46a is arranged to accommodate a field gasket portion 1a of the gasket 1 (as is also illustrated in Fig. 2b), while each of the ring front gasket groove portions 46b is arranged to accommodate a ring gasket portion 1b of the gasket 1.

[0047] The heat transfer plate 2a is pressed, in a conventional manner, in a pressing tool, to be given a desired structure, more particularly the front and back gasket grooves above, as well as different corrugation patterns within different portions of the heat transfer plate. As was discussed by way of introduction, the corrugation patterns are optimized for the specific functions of the respective plate portions. Accordingly, the upper and lower distribution areas 14, 24 are provided with a distribution pattern 48, the upper and lower transition areas 16, 26 are provided with a transition pattern 50, and the heat transfer area 30 is provided with a heat transfer pattern 52. The distribution pattern 48, the transition pattern 50 and the heat transfer pattern 52 are all different from each other. Further, the outer edge portion 32 comprises corrugations 54 which make the outer edge portion 32 stiffer and, thus, the heat transfer plate 2a more resistant to deformation. Further, the corrugations 54 form a support structure in that they are arranged to abut corrugations of the adjacent heat transfer plates in the plate pack of the PHE. With reference again to Fig. 3, illustrating peripheral contact between the heat transfer plate 2a and the two adjacent heat transfer plates 2b and 2c of the plate pack, along a major part of the long sides 34, 36 (Fig. 1a) thereof, the corrugations 54 extend between and in a first plane P1 and a second plane P2, which are parallel to the figure plane of Fig. 1a. A center plane CP extends half way between the first and second planes P1, P2. As is clear from Fig. 1b, a bottom 55 of the front gasket groove 46, and a bottom 57 of the back gasket groove 47, extend in this center plane CP, i.e. in so called half plane.

[0048] With reference to Fig. 1a, the distribution pattern 48 is of so-called chocolate type and comprises elongate distribution ridges 56 and distribution valleys 58 arranged so as to form a respective grid within each of the upper and lower distribution areas 14, 24. A respective top portion of the distribution ridges 56 extends in the first plane P1 and a respective bottom portion of the distribution valleys 58 extends in the second plane P2. The distribution ridges 56 and distribution valleys 58 are arranged to abut distribution ridges and distribution valleys of the adjacent heat transfer plates in the plate pack of the PHE. The chocolate-type distribution pattern is well-known and will not be described in further detail herein.

[0049] With reference to Fig. 4, which contains an enlargement of the upper transition area 16, the transition pattern 50 comprises elongate, straight support transition ridges 60 and support transition valleys 62 longitudinally extending parallel to the longitudinal center axis L (Fig. 1a) of the plate 2a. With reference to Fig. 5a, which illustrates a center cross section of the support transition ridges 60, and Fig. 5b, which illustrates a center cross section of the support transition valleys 62, taken parallel to their longitudinal extension, i.e. parallel to the longitudinal center axis L of the plate 2a, a respective top portion 60t of the support transition ridges 60 extends in the first plane P1, while a respective bottom portion 62b of the support transition valleys 62 extends in the second plane P2.

[0050] With reference to Figs. 1a and 4, within the upper transition area 16, there are five support transition ridges 60 and five support transition valleys 62. These are alternately arranged in a row extending parallel to the transverse center axis T of the heat transfer plate 2a, wherein a respective center point c of them is arranged on an imaginary straight center line cl which is perpendicular to the longitudinal center axis L of the heat transfer plate 2a. An infinite imaginary straight transition line 68, which is parallel to the longitudinal center axis L of the heat transfer plate 2a, extends through two opposing end points 70 and 72 of each of the support transition ridges 60 and the support transition valleys 62, and coincides with a longitudinal center axis lt of the respective one of the support transition ridges 60 and the support transition valleys 62. This means that the heat transfer plate 2a defines x = 10 infinite imaginary straight transition lines 68.

[0051] With reference to Figs. 4 and 7, the transition pattern 50 further comprises elongate turbulence transition ridges 74 and elongate turbulence transition valleys 76. Some of the turbulence transition ridges 74 and the turbulence transition valleys 76 are alternately arranged in interspaces 78 (78a, 78b) between adjacent ones of the imaginary straight transition lines 68, and arranged like that, some of these turbulence transition ridges 74 and turbulence transition valleys 76 connect the support transition ridges 60 and the support transition valleys 62 along adjacent ones of the imaginary straight transition lines 68. The rest of the turbulence transition ridges 74 and turbulence transition valleys 76 are alternately arranged on an outside of the outermost ones of the imaginary straight transition lines 68 where they extend from the outermost ones of the support transition ridges 60 and the support transition valleys 62.

[0052] Since the number x of imaginary straight transition lines 68 is 10, there are 9 interspaces 78. The longitudinal center axis L (Fig. 1a) of the plate 2a lengthwise divides a center interspace 78a in half which leaves 4 complete interspaces 78b on each side of the longitudinal center axis L of the plate 2a. The imaginary straight transition lines 68 defining the center interspace 78a form center imaginary longitudinal straight transition lines 68a, 68b.

[0053] As is clear from the figures, the turbulence transition ridges 74 and the turbulence transition valleys 76, or more particularly a center portion 74a and 76a (Fig. 7), respectively, thereof, extend obliquely in relation to the transverse center axis T (Fig. 1a) of the heat transfer plate 2a. At the center imaginary longitudinal straight transition line 68a, the transition pattern 50 changes. More particularly, with reference to Figs. 4 and 7, to the left (as seen in Fig. 4) of the line 68a, the center portions 74a and 76a (Fig. 7) of the turbulence transition ridges 74 and the turbulence transition valleys 76 extend in a smallest angle α (largest angle = α + 180) degrees clockwise in relation to the transverse center axis T (Fig. 1a) of the heat transfer plate 2a. Further, to the right (as seen in Fig. 4) of the line 68a, the center portions 74a and 76a of the turbulence transition ridges 74 and the turbulence transition valleys 76 extend in a smallest angle β (largest angle = β + 180) degrees counter-clockwise in relation to the transverse center axis T. Here, α=β=25 but this may not be the case in alternative embodiments in which α may differ from β and α and β may have other values within the range 15-75.

[0054] Further, with reference to Fig. 6, which illustrates a center portion cross section of the turbulence transition ridges 74 and the turbulence transition valleys 76 taken perpendicular to their longitudinal extension, a respective top portion 74t of the turbulence transition ridges 74 extends in a third plane P3, while a respective bottom portion 76b of the turbulence transition valleys 76 extends in a fourth plane P4.

[0055] The third plane P3 is parallel to, and arranged between, the first plane P1 and the center plane CP, while the fourth plane P4 is parallel to, and lies just slightly below, the center plane CP, i.e. between the second plane P2 and the center plane CP. As the turbulence transition ridges and valleys 74, 76 are positioned and designed, within the upper transition area 16, a first volume V1 enclosed by the plate 2a and the first plane P1 will be smaller than a second volume V2 enclosed by the plate 2a and the second plane P2.

[0056] The upper end portion 8 and the lower end portion 18, and thus the upper transition area 16 and the lower transition area 26, of the heat transfer plate 2a are symmetrical with respect to the transverse center axis T of the heat transfer plate 2a.

[0057] With reference to Fig. 1a and Fig. 8, which contains an enlargement of a portion of the heat transfer area 30, the heat transfer (HT) pattern 52 comprises straight, elongate support HT ridges 80 and support HT valleys 82 longitudinally extending parallel to the longitudinal center axis L (Fig. 1a) of the plate 2a. With reference to Fig. 9, which illustrates a center cross section of the support HT ridges 80 and the support HT valleys 82 taken parallel to their longitudinal extension, i.e. parallel to the longitudinal center axis L of the plate 2a, a respective top portion 80t of the support HT ridges 80 extends in the first plane P1, while a respective bottom portion 82b of the support HT valleys 82 extends in the second plane P2. As is clear from, for example, Figs. 4 and 7, the longitudinal extension of the support HT ridges and valleys 80 and 82 is larger than the longitudinal extension of the support transition ridges and valleys 60 and 62.

[0058] With reference to Figs. 1a and 8, the support HT ridges 80 and the support HT valleys 82 are alternately arranged along y=10 equidistantly arranged imaginary longitudinal straight HT lines 84 extending parallel to the longitudinal center axis L of the plate 2a. The imaginary longitudinal straight HT lines 84 extend through a respective center of the support HT ridges 80 and support HT valleys 82 and coincide with a respective one of the imaginary straight transition lines 68. Further, the support HT ridges 80 and the support HT valleys 82 are alternately arranged along a number of equidistantly arranged imaginary transverse straight HT lines 86 extending parallel to the transverse center axis T of the plate 2a. Only half of these imaginary transverse straight HT lines 86 are illustrated in Fig. 1a. The support HT ridges 80 and support HT valleys 82 are arranged between the imaginary transverse straight HT lines 86. Two outermost ones of the imaginary transverse straight HT lines 86 coincide with a respective one of the second and fourth borderlines bl2 and bl4.

[0059] With reference to Figs. 1a and 8, the heat transfer pattern 52 further comprises elongate turbulence HT ridges 88 and elongate turbulence HT valleys 90. Some of the turbulence HT ridges 88 and the turbulence HT valleys 90 are alternately arranged in interspaces 92 (92a, 92b) between adjacent ones of the imaginary longitudinal straight HT lines 84, and arranged like that, some of these turbulence HT ridges 88 and turbulence HT valleys 90 connect the support HT ridges 80 and the support HT valleys 82 along adjacent ones of the imaginary longitudinal straight HT lines 84. The rest of the turbulence HT ridges 88 and turbulence HT valleys 90 are alternately arranged on an outside of the outermost ones of the imaginary longitudinal straight HT lines 84 where they extend from the outermost ones of the support HT ridges 80 and the support HT valleys 82.

[0060] Since the number y of imaginary longitudinal straight HT lines 84 is 10, there are 9 interspaces 92. The longitudinal center axis L (Fig. 1a) of the plate 2a lengthwise divides a center interspace 92a in half which leaves 4 complete interspaces 92b on each side of the longitudinal center axis L of the plate 2a. The imaginary longitudinal straight HT lines 84 defining the center interspace 92a form center imaginary longitudinal straight HT lines 84a, 84b.

[0061] As is clear from the figures, and especially Fig. 10, the turbulence HT ridges 88 and the turbulence HT valleys 90, or more particularly a center portion 88a and 90a, respectively, thereof, extend obliquely in relation to the transverse center axis T (Fig. 1a) of the heat transfer plate 2a. At the center imaginary longitudinal straight HT line 84a the heat transfer pattern 52 changes. More particularly, with reference to Figs. 1a and 10, to the left (as seen in the figures) of the line 84a, the center portions 88a and 90a of the turbulence HT ridges 88 and the turbulence HT valleys 90 extend in a smallest angle α (largest angle = α + 180) degrees clockwise in relation to the transverse center axis T (Fig. 1a) of the heat transfer plate 2a. Further, to the right (as seen in the figures) of the line 84a, the center portions 88a and 90a of the turbulence HT ridges 88 and the turbulence HT valleys 90 extend in a smallest angle β (largest angle = β + 180) degrees counter-clockwise in relation to the transverse center axis T. Here, $\alpha=\beta=25$ but this may not be the case in alternative embodiments in which α may differ from β and α and β may have other values within the range 15-75.

[0062] Further, with reference to Fig. 6, which illustrates a center portion cross section of the turbulence HT ridges 88 and the turbulence HT valleys 90 taken perpendicular to their longitudinal extension, a respective top portion 88t of the turbulence HT ridges 88 extends in a fifth plane P5 while a respective bottom portion 90b of the turbulence HT valleys 90 extends in a sixth plane P6. The fifth plane P5 coincides with the third plane P3 while the sixth plane P6 coincides with the fourth plane P4. As the turbulence HT ridges and valleys 88, 90 are positioned and designed, within the heat transfer area 30, a first volume V1 enclosed by the plate 2a and the first plane P1 will be smaller than a second volume V2 enclosed by the plate 2a and the second plane P2.

[0063] Thus, the heat transfer plate 2a comprises turbulence transition ridges 74 and turbulence transition valleys 76 connecting the support transition ridges 60 and the support transition valleys 62 along adjacent ones of the imaginary straight transition lines 68. Further, the heat transfer plate 2a comprises turbulence HT ridges 88 and turbulence HT valleys 90 connecting the support HT ridges 80 and the support HT valleys 82 along adjacent ones of the imaginary longitudinal straight HT lines 84. As is clear from the figures, and particularly Figs. 4 and 7, some of the turbulence transition ridges and valleys 74 and 76 connect one of the support transition ridges and valleys 60 and 62 and one of the support HT ridges and valleys 80 and 82. Similarly, some of the turbulence HT ridges and valleys 88 and 90 connect one of the support HT ridges and valleys 80 and 82 and one of the support transition ridges and valleys 60 and 62.

[0064] As previously said, and as illustrated in Fig. 3, in the plate pack, the plate 2a is arranged between the plates 2b and 2c. With the above specified design of the heat transfer pattern, the plates 2b and 2c may be arranged either "flipped" or "rotated" in relation to the plate 2a.

[0065] If the plates 2b and 2c are arranged "flipped" in relation to the plate 2a, the front side 4 and back side 6 of the plate 2a face the front side 4 of the plate 2b and the back side 6 of plate 2c, respectively. This means that the support transition ridges 60 and the support HT ridges 80 of the plate 2a will abut the support transition ridges and the support HT ridges of the plate 2b while the support transition valleys 62 and the support HT valleys 82 of the plate 2a will abut the support transition valleys and the support HT valleys of the plate 2c. Further, the turbulence transition ridges 74 and the turbulence HT ridges 88 of the plate 2a will face but not abut, and extend with an angle $2\alpha=2\beta$ in relation to, the turbulence transition ridges and the turbulence ridges of the plate 2b, while the turbulence transition valleys 76 and the turbulence HT valleys 90 of the plate 2a will face but not abut, and extend with an angle $2\alpha=2\beta$ in relation to, the turbulence transition valleys and the turbulence HT valleys of the plate 2c. Within the heat transfer area 30 and the upper and lower transition areas 16 and 26 the plates 2a and 2b will form a channel of volume 2xV1, while the plates 2a and 2c will form a channel of volume 2xV2, i.e. two asymmetric channels since V1 <V2.

[0066] If the plates 2b and 2c are arranged "rotated" in relation to the plate 2a, the front side 4 and back side 6 of the plate 2a face the back side 6 of the plate 2b and the front side 4 of the plate 2c, respectively. This means that the support transition ridges 60 and the support HT ridges 80 of the plate 2a will abut the support transition valleys and the support HT valleys of the plate 2b while the support transition valleys 62 and the support HT valleys 82 of plate 2a will abut the support transition ridges and the support HT ridges of the plate 2c. Further, the turbulence transition ridges 74 and the turbulence HT ridges 88 of the plate 2a will face but not abut the turbulence transition valleys and the turbulence HT valleys of the plate 2b, while the turbulence transition valleys 76 and the turbulence HT valleys 90 of the plate 2a will face but not abut the turbulence transition ridges and the turbulence HT ridges of the plate 2c. Within all interspaces 78, 92 except for the center interspaces 78a, 92a, the turbulence transition ridges and valleys 74, 76 and the turbulence HT ridges and valleys 88, 90 of the plate 2a will extend with an angle $2\alpha=2\beta$ in relation to the turbulence transition and HT valleys of the plate 2b and the turbulence transition and HT ridges of the plate 2c, respectively. Within the center interspaces 78a, 92a the turbulence transition ridges and valleys 74, 76 and the turbulence HT ridges and valleys 88, 90 of the plate 2a will extend parallel to the turbulence transition and HT valleys of the plate 2b and the turbulence transition and HT ridges of the plate 2c, respectively. Within the heat transfer area 30 and the upper and lower transition areas 16 and 26 the plates 2a and 2b will form a channel of volume V1+V2, while the plates 2a and 2c will form a channel of volume V1+V2, i.e. two symmetric channels.

[0067] The above described embodiment of the present invention should only be seen as an example. A person skilled in the art realizes that the embodiment discussed can be varied in a number of ways without deviating from the inventive conception.

[0068] As an example, the number x of imaginary straight transition lines, just like the number y of imaginary longitudinal straight HT lines, need not be 10 but could be more or less. Plates so designed could be "flipped" but possibly not "rotated" in relation to each other. Further, in alternative embodiments, x may differ from y.

[0069] Further, the transition and heat transfer patterns need not change at a center imaginary straight transition line and a center imaginary longitudinal straight HT line, respectively, like above. For example, the turbulence ridges and turbulence valleys could instead have the same orientation within the complete transition and heat transfer patterns. Plates provided with such a pattern could be "flipped" but possibly not "rotated" in relation to each other.

[0070] The turbulence transition and/or HT ridges and the turbulence transition and/or HT valleys need not be designed as in the drawings but they may have any suitable design, or even be omitted and non-existent.

[0071] The support transition and/or HT ridges and the support transition and/or HT valleys need not be elongate parallel to the longitudinal center axis of the plate, but they could have any suitable design. For example, they could be quadratic or elongate parallel to the transverse center axis of the plate.

[0072] α and β need not be the same within the transition and heat transfer patterns.

[0073] Naturally, the distribution pattern need not be of chocolate-type but may be of other types.

[0074] The heat transfer plate need not be asymmetric but could be symmetric. Accordingly, with reference to Figs. 6 and 9, the plate could be designed such that V1=V2.

[0075] The bottom of the front gasket groove need not extend in half plane. Further, the bottom of the front gasket groove need not extend in one and the same plane along its complete extension.

[0076] The plate pack described above contains only plates of one type. The plate pack could instead comprise plates of two or more different types, such as plates having differently configurated heat transfer patterns and/or distribution patterns.

[0077] The heat transfer plate need not be rectangular but may have other shapes, such as essentially rectangular with rounded corners instead of right corners, circular or oval. The heat transfer plate need not be made of stainless steel but could be of other materials, such as titanium or aluminium.

[0078] It should be stressed that the attributes front, back, upper, lower, first, second, third, etc. is used herein just to distinguish between details and not to express any kind of orientation or mutual order between the details.

[0079] Further, it should be stressed that a description of details not relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale. It should also be said that some of the figures have been more simplified than others. Therefore, some components may be illustrated in one figure but left out on another figure.

Reference numerals list:

[0080]

1	Gasket
1a	Field gasket portion
1b	Ring gasket portion
2, 2a, 2b, 2c	Heat transfer plate
4	Front side
6	Back side
8	End portion
10	First port hole
12	Second port hole
14	Upper distribution area
16	Upper transition area
18	Lower end portion
20	Third port hole
22	Fourth port hole
24	Lower distribution area
26	Lower transition area
28	Center portion
30	Heat transfer area
32	Outer edge portion
34	First long side
36	Second long side
38	First half
40	Second half
42	First short side
44	Second short side
46	Front gasket groove
46a	Field front gasket groove portion
46b	Ring front gasket groove portion
47	Back gasket groove
48	Distribution pattern
50	Transition pattern
52	Heat transfer pattern
54	Corrugations
55	Bottom
56	Distribution ridge
57	Bottom
58	Distribution valley
60	Support transition ridge
60t	Top portion
62	Support transition valley
62b	Bottom portion
68, 68a, 68b	Imaginary straight transition line
70	End point
72	End point
74	Turbulence transition ridge
74a	Center portion
74t	Top portion
76	Turbulence transition valley
76a	Center portion
76b	Bottom portion
78, 78a, 78b	Interspace
80	Support HT ridges

80t	Top portion
82	Support HT valleys
82b	Bottom portion
84, 84a, 84b	Imaginary longitudinal straight HT line
86	imaginary transverse straight HT line
88	Turbulence HT ridge
88a	Center portion
88t	Top portion
90	Turbulence HT valley
90a	Center portion
90b	Bottom portion
92, 92a, 92b	Interspace
bl1	First borderline
bl2	Second borderline
bl3	Third borderline
bl4	Fourth borderline
c	Center point
cl	center line
CP	Center plane
lt	Longitudinal center axis
L	Longitudinal center axis
P1	First plane
P2	Second plane
P3	Third plane
P4	Fourth plane
P5	Fifth plane
P6	Sixth plane
T	Transverse center axis
V1	First volume
V2	Second volume
x	Number of imaginary straight transition lines
y	Number of imaginary longitudinal straight HT lines
α	Angle
β	Angle

Claims

1. A heat transfer plate (2a) comprising an upper end portion (8), a center portion (28) and a lower end portion (18) arranged in succession along a longitudinal center axis (L) of the heat transfer plate (2a) which divides the heat transfer plate (2a) into a first and a second half (38, 40) and extends perpendicular to a transverse center axis (T) of the heat transfer plate (2a), the center portion (28) comprising a heat transfer area (30), the upper end portion (8) comprising first and second port holes (10, 12), an upper distribution area (14) and an upper transition area (16) adjoining the upper distribution area (14) along a first borderline (bl1) and the heat transfer area (30) along a second borderline (bl2), and the lower end portion (18) comprising third and fourth port holes (20, 22), a lower distribution area (24) and a lower transition area (26) adjoining the lower distribution area (24) along a third borderline (bl3) and the heat transfer area (30) along a fourth borderline (bl4), the upper distribution area (14) being provided with a distribution pattern (48), the upper transition area (16) being provided with a transition pattern (50), and the heat transfer area (30) being provided with a heat transfer pattern (52), the transition pattern (50) differing from the distribution pattern (48) and the heat transfer pattern (52), the transition pattern (50) comprising alternately arranged support transition ridges (60) and support transition valleys (62) as seen from a front side (4) of the heat transfer plate (2a), a respective top portion (60t) of at least a plurality of the support transition ridges (60) extending in a first plane (P1) and a respective bottom portion (62b) of at least a plurality of the support transition valleys (62) extending in a second plane (P2), an infinite imaginary straight transition line (68) extending through two opposing end points (70, 72) of each of the support transition ridges (60) and the support transition valleys (62), wherein the heat transfer plate (2a) defines a plurality of separated imaginary straight transition lines (68), the heat transfer plate (2a) further comprising, on the front side (4), a front gasket groove (46) comprising a field front gasket groove portion (46a) enclosing the heat transfer area (30), the upper and lower transition areas (16, 26), the upper and lower distribution areas (14, 24) and two of the first, second, third and fourth port holes (10, 12, 20, 22), wherein a bottom (55) of the front gasket groove (46), along at least more than half of a length of the field front gasket groove portion (46a), extends between the first and second planes (P1, P2), **characterized in that** the imaginary straight transition line (68), for at least a plurality of the support transition ridges (60) and the support transition valleys (62), extends parallel to the longitudinal center axis (L) of the heat transfer plate (2a).

2. A heat transfer plate (2a) according to claim 1, wherein the bottom (55) of the front gasket groove (46), along at least more than half of the length of the field front gasket groove portion (46a), extends in a center plane (CP) being parallel to, and extending halfway between, the first and second planes (P1, P2).

3. A heat transfer plate (2a) according to any of the preceding claims, wherein at least a plurality of the support transition ridges (60) and the support transition valleys (62) are elongate and/or straight.

4. A heat transfer plate (2a) according to any of the preceding claims, wherein the imaginary straight transition line (68), for each of at least a plurality of the support transition ridges (60) and the support transition valleys (62), coincides with a respective longitudinal center axis (lt) of the support transition ridge (60) or the support transition valley (62).

5. A heat transfer plate (2a) according to any of the preceding claims, wherein at least a plurality of the imaginary straight transition lines (68) defined by the heat transfer plate (2a) extends through a single one of the support transition ridges (60) and the support transition valleys (62).

6. A heat transfer plate (2a) according to any of the preceding claims, wherein a respective center point (c) of at least a plurality of the support transition ridges (60) and the support transition valleys (62) is arranged on an imaginary center line (cl) which crosses the longitudinal center axis (L) of the heat transfer plate (2a).

7. A heat transfer plate (2a) according to any of the preceding claims, wherein the number of imaginary straight transition lines (68) is an even number x.

8. A heat transfer plate (2a) according to any of the preceding claims, wherein the transition pattern (50) further comprises turbulence transition ridges (74) and turbulence transition valleys (76), a respective top portion (74t) of at least a plurality of the turbulence transition ridges (74) extending in a third plane (P3) arranged between, and parallel to, the first and second planes (P1, P2), and a respective bottom portion (76b) of at least a plurality of the turbulence transition valleys (76) extending in a fourth plane (P4) arranged between, and parallel to, the second and third planes (52, 72), at least a plurality of the turbulence transition ridges and turbulence transition valleys (74, 76) being alternately arranged in interspaces (78) between the imaginary straight transition lines (68) and connecting the support transition ridges (60) and support transition valleys (62) for adjacent ones of the imaginary straight transition lines (68).

9. A heat transfer plate (2a) according to claim 8, wherein at least a plurality of the turbulence transition ridges (74) and turbulence transition valleys (76) along at least a center portion (74a, 76a) of their longitudinal extension extend inclined in relation to the transverse center axis (T) of the heat transfer plate (2a).

10. A heat transfer plate (2a) according to any of claims 8-9, wherein at least a plurality of the turbulence transition ridges (74) and turbulence transition valleys (76) completely arranged on the first half (38) of the heat transfer plate (2a) along their center portion (74a, 76a) extend in a smallest angle α, $0<\alpha<90$, clockwise in relation to the transverse center axis (T) of the heat transfer plate (2a), and wherein at least a plurality of the rest of the turbulence transition ridges (74) and turbulence transition valleys (76) along their center portion (74a, 76a) extend in a smallest angle β, $0<\beta<90$, counter-clockwise in relation to the transverse center axis (T) of the heat transfer plate (2a).

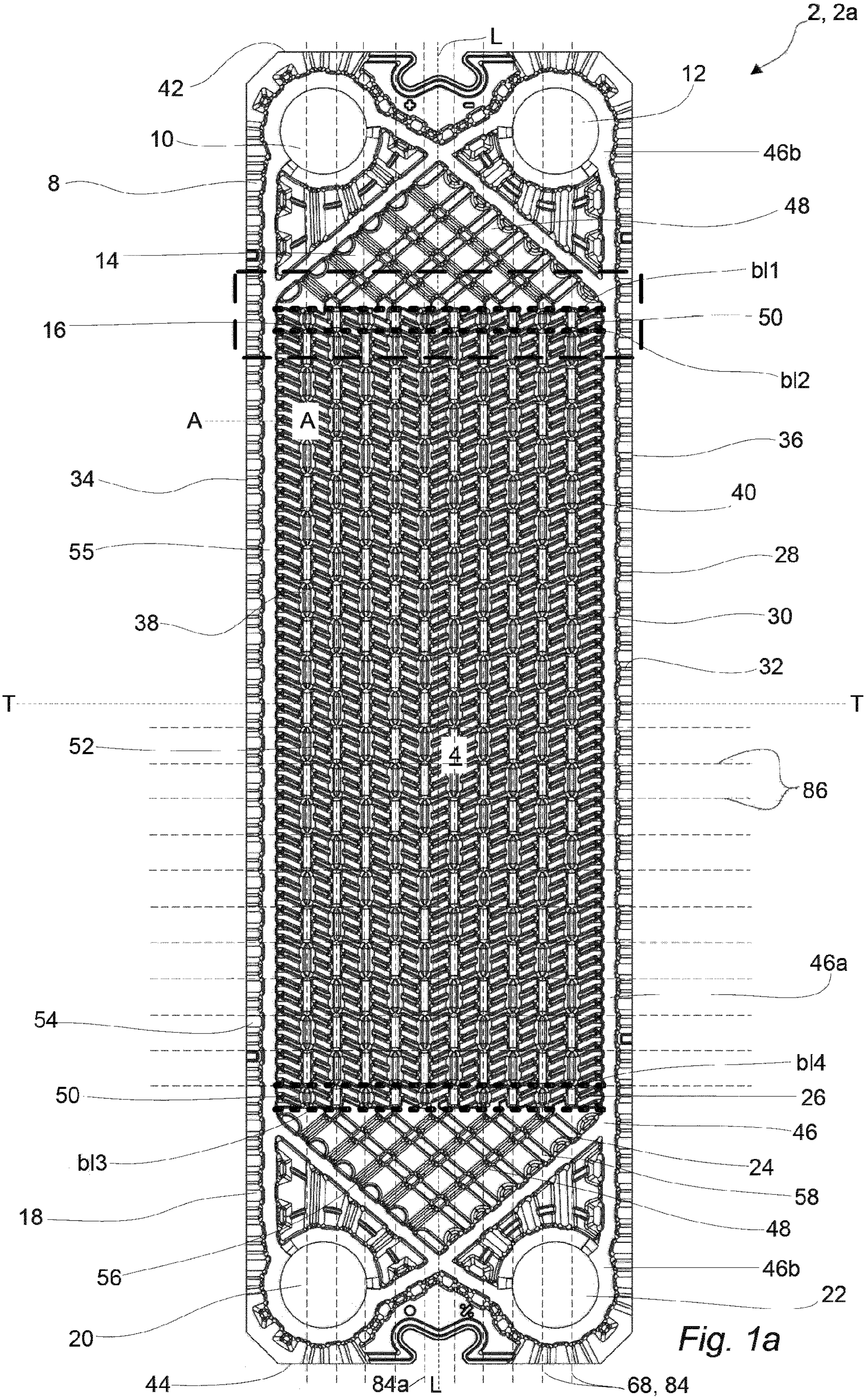
11. A heat transfer plate (2a) according to claim 10, wherein α equals β.

12. A heat transfer plate (2a) according to any of the preceding claims, wherein the upper transition area (16) and the lower transition area (26), to at least 50 percent, are symmetrical with respect to the transverse center axis (T) of the heat transfer plate (2a).

13. A heat transfer plate (2a) according to any of the preceding claims, wherein the heat transfer pattern (52) comprises support HT ridges (80) and support HT valleys (82), at least a plurality of the support HT ridges (80) and support HT valleys (82) longitudinally extending parallel to the longitudinal center axis (L) of the heat transfer plate (2a), a respective top portion (80t) of at least a plurality of the support HT ridges (80) extending in the first plane (P1) and a respective bottom portion (82b) of at least a plurality of the support HT valleys (82) extending in the second plane (P2), at least a plurality of the support HT ridges (80) and support HT valleys (82) being alternately arranged along a number of separated imaginary longitudinal straight HT lines (84) extending parallel to the longitudinal center axis (L) of the heat transfer plate (2a), and along a number of separated imaginary transverse straight HT lines (86) extending parallel to the transverse center axis (T) of the heat transfer plate (2a), at least a plurality of the support HT ridges (80) and support HT valleys (82) being centered with respect to the imaginary longitudinal straight HT lines (84) and extending between adjacent ones of the imaginary transverse straight HT lines (86), the heat transfer pattern (52) further comprising turbulence HT ridges (88) and turbulence HT valleys (90), a respective top portion (88t) of at least a plurality of the turbulence HT ridges (88) extending in a fifth plane (P5) arranged between, and parallel to, the first and second planes (P1, P2), and a respective bottom portion (90b) of at least a plurality of the turbulence HT valleys (90) extending in a sixth plane (P6) arranged between, and parallel to, the second and fifth planes (P2, P5), a least a plurality of the turbulence HT ridges and turbulence HT valleys (88, 90) being alternately arranged in interspaces (92) between the imaginary longitudinal straight HT lines (84) and connecting the support HT ridges (80) and support HT valleys (82) along adjacent ones of the imaginary longitudinal straight HT lines (84).

14. A heat transfer plate (2a) according to claim 13, wherein at least a plurality of the imaginary longitudinal straight HT lines (84) coincide with a respective one of the imaginary straight transition lines (68).

15. A heat transfer plate (2a) according to any of claims 13-14, wherein a longitudinal extension of at least a plurality of the support transition ridges (60) and the support transition valleys (62) is smaller than a longitudinal extension of the support HT ridges (80) and the support HT valleys (82).


2, 2a
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38
30
32
T
T
52
4
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46a
54
bl4
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20
44
84a
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68, 84

Fig. 1a

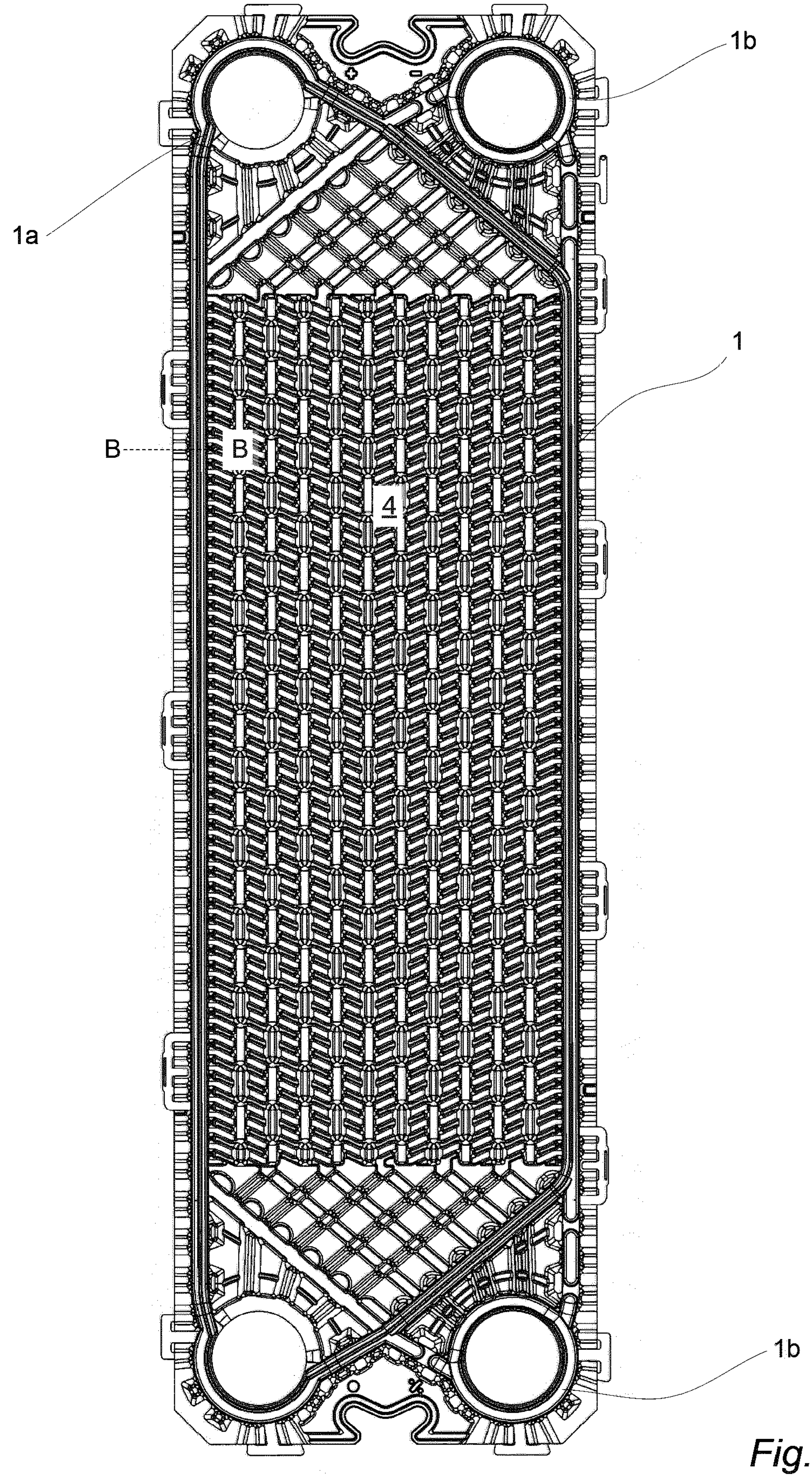

Fig. 2a

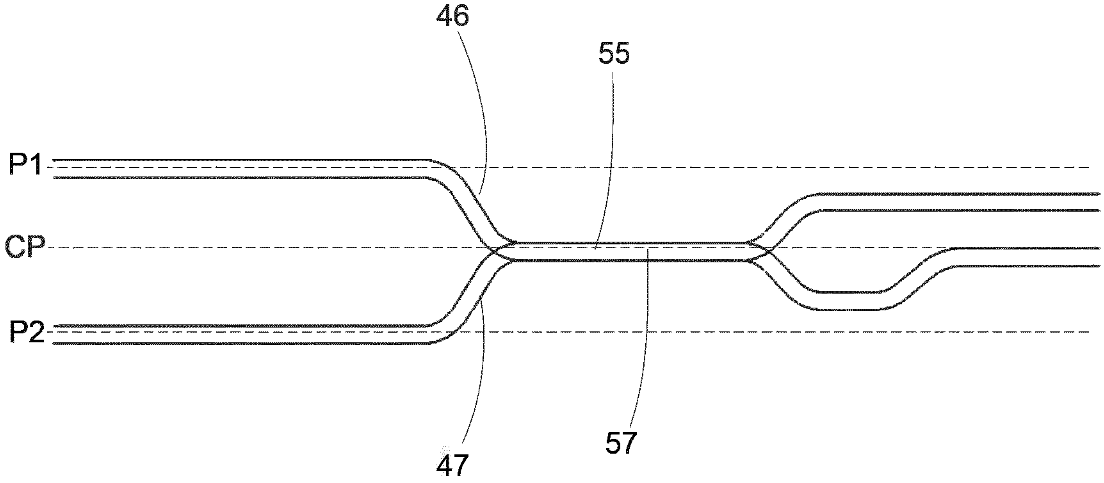

Fig. 1b

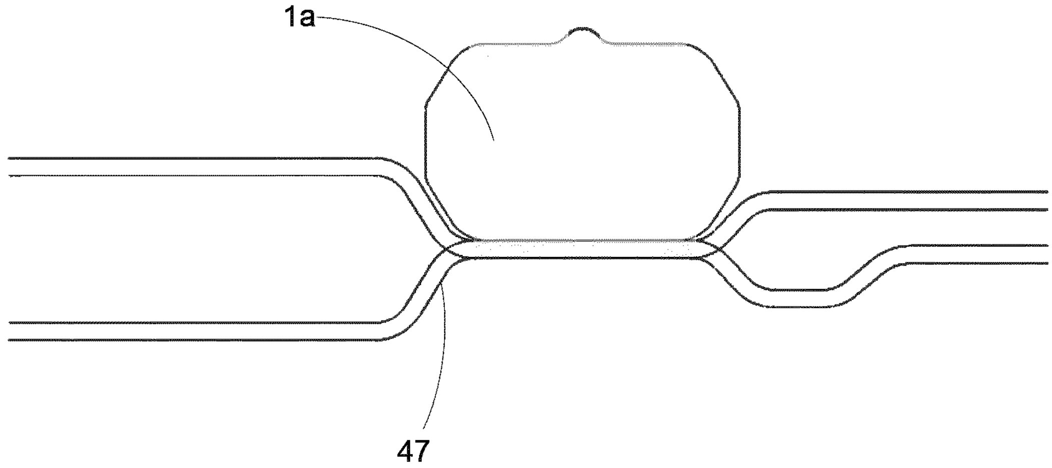

Fig. 2b

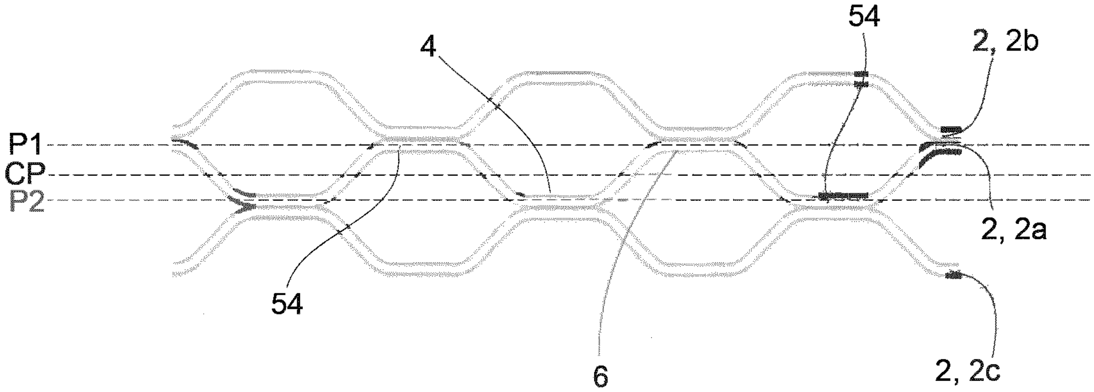

Fig. 3

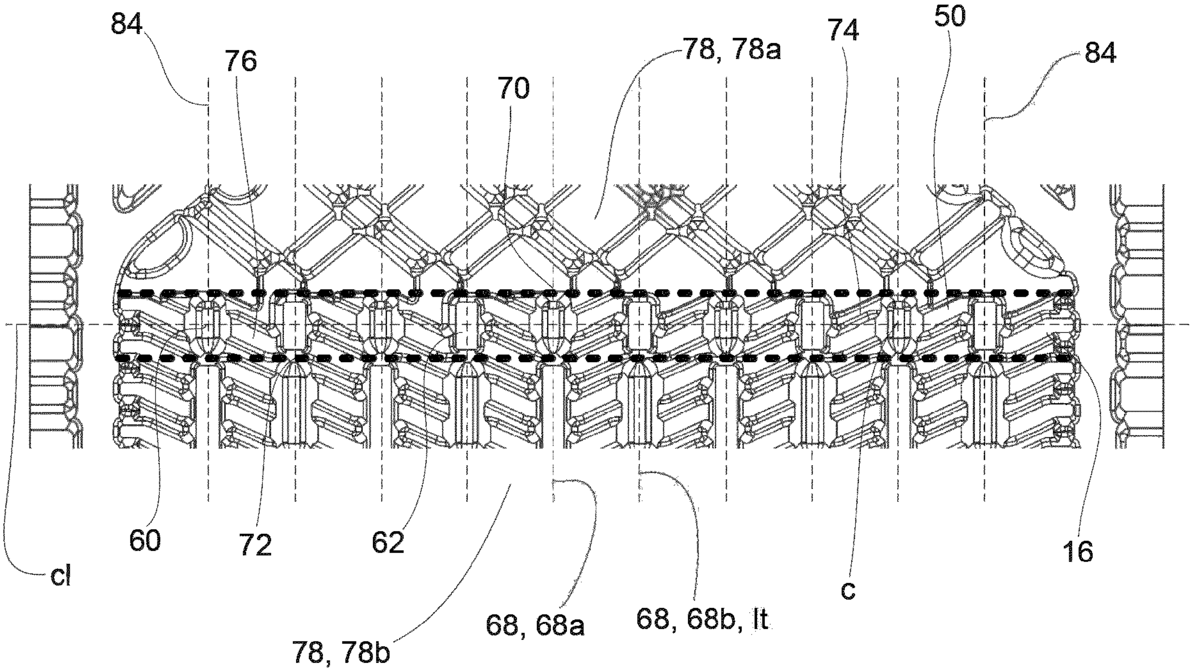

Fig. 4

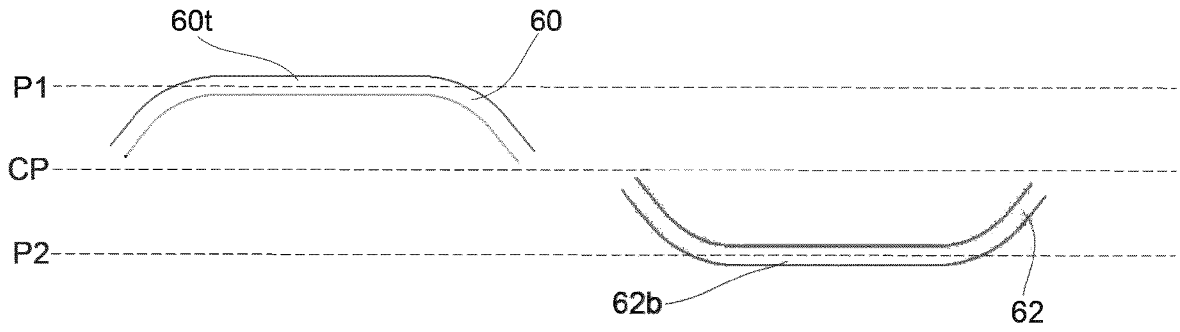

Fig. 5a *Fig. 5b*

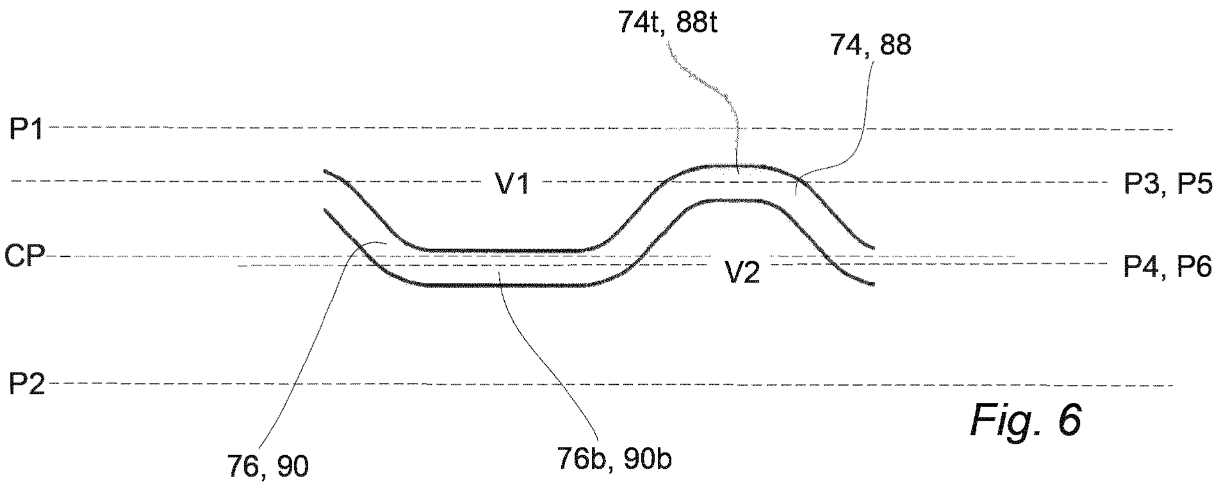

Fig. 6

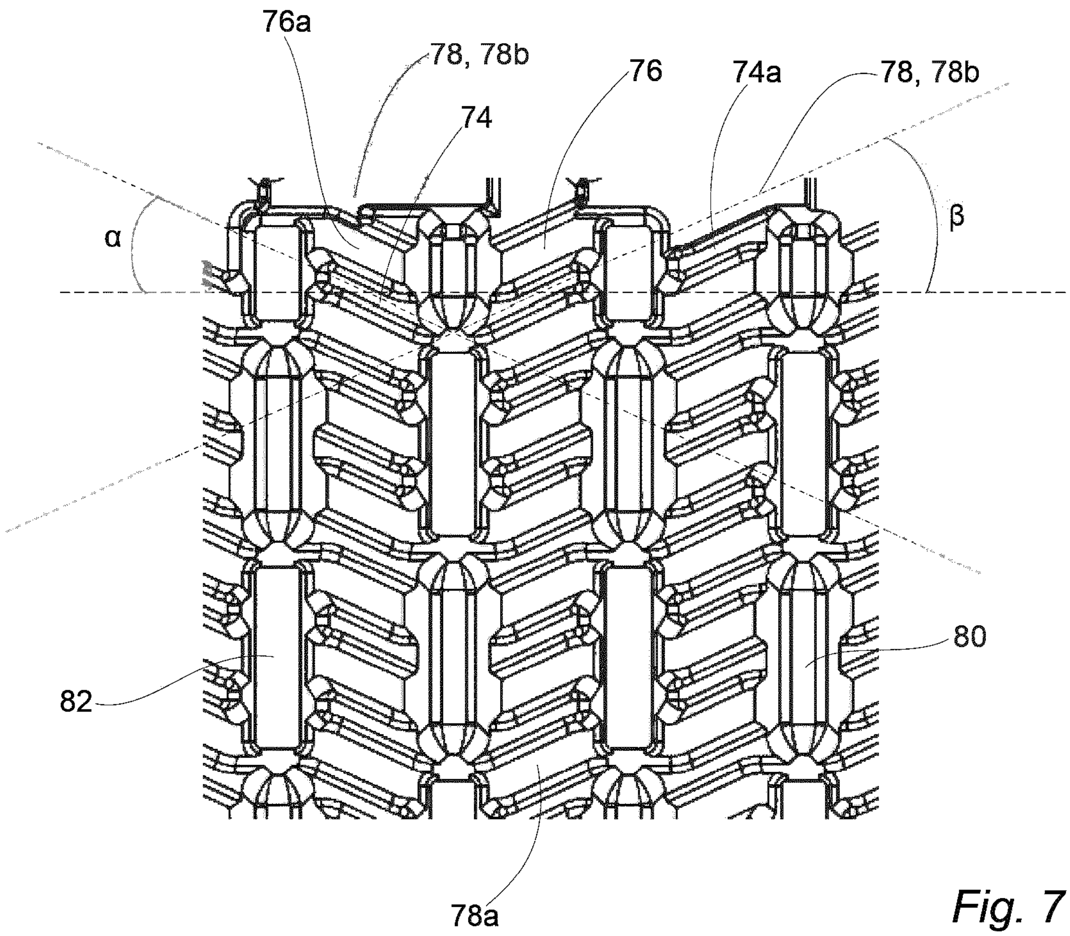

Fig. 7

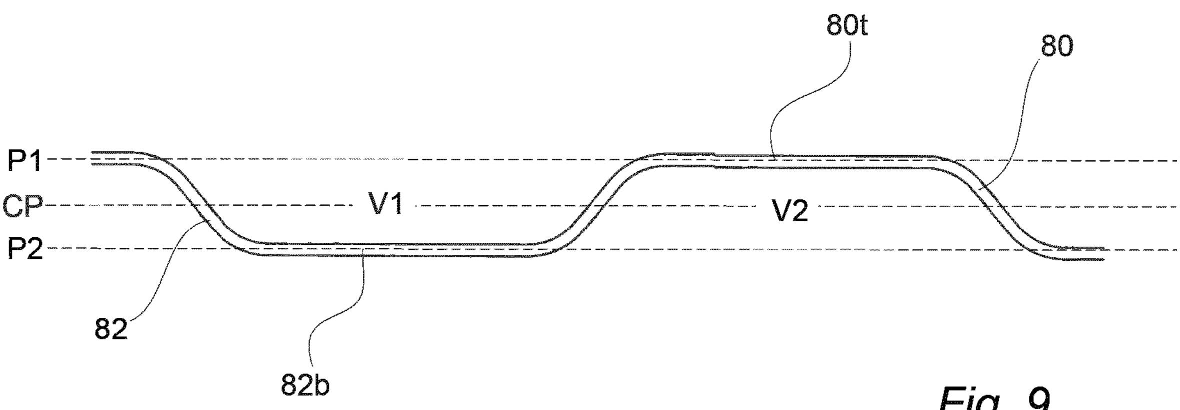

Fig. 9

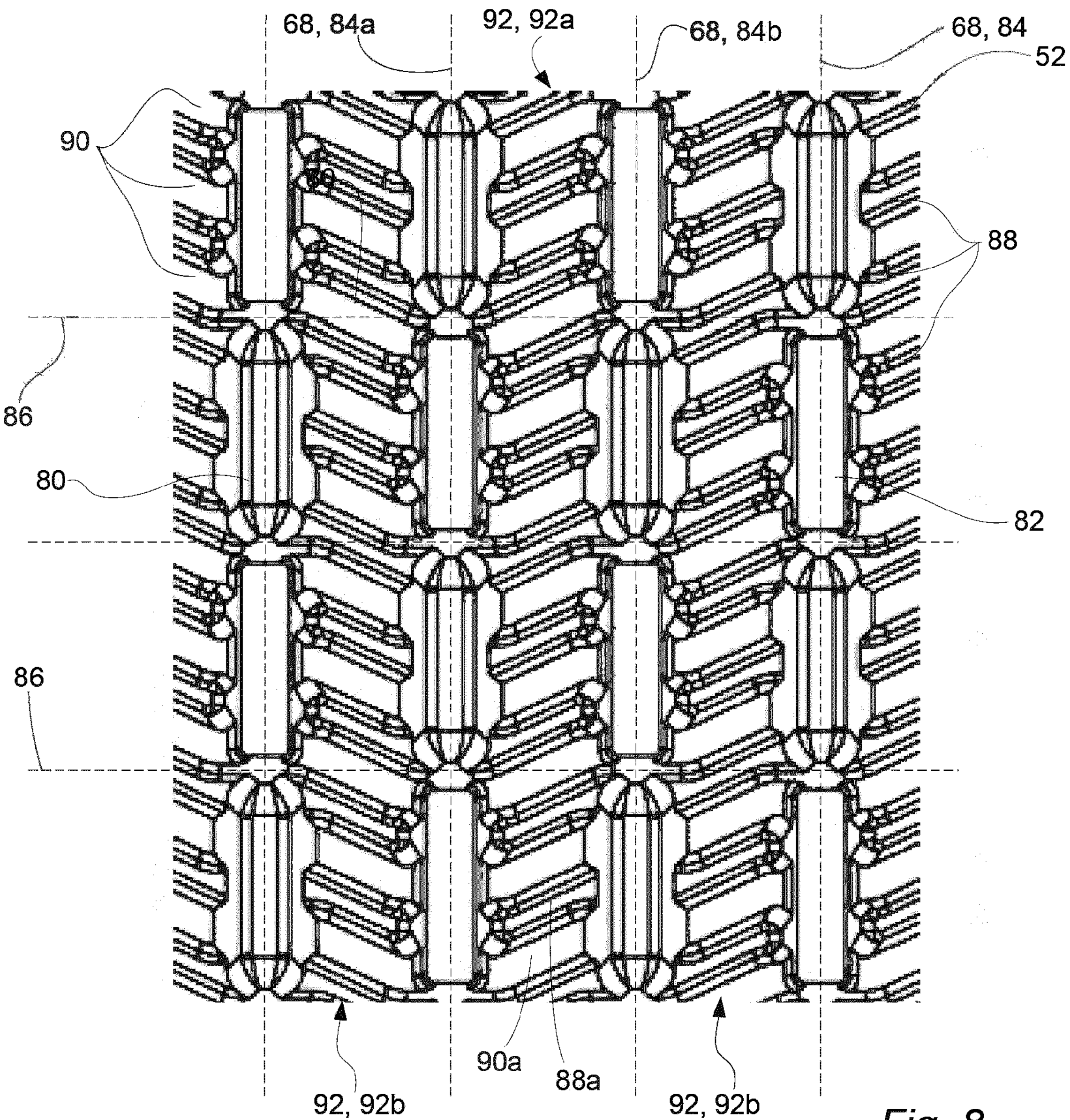
68, 84a
92, 92a
68, 84b
68, 84
52
90
88
86
80
82
86
92, 92b
90a
88a
92, 92b

Fig. 8

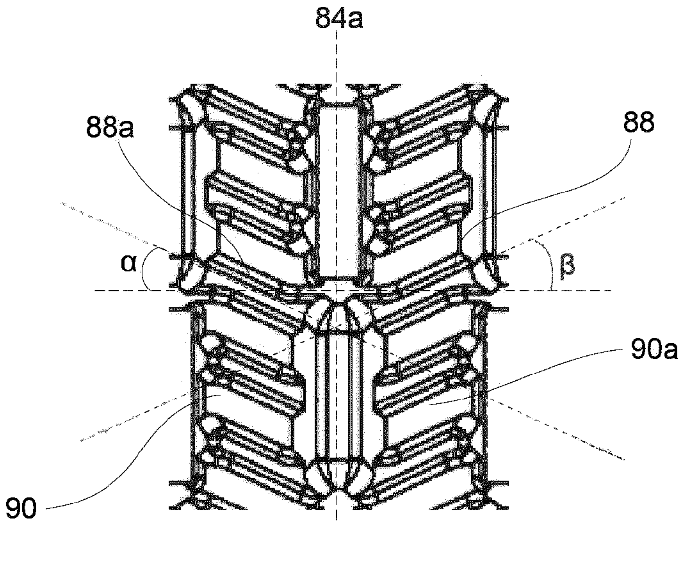
84a
88a
88
α
β
90a
90

Fig. 10

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Application Number
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Place of search	Date of completion of the search	Examiner
Munich	9 November 2023	Axters, Michael

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