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(54) Heat transfer plate

(57) A heat transfer plate comprising a number of rows (23, 24) of alternating ridges (26) and grooves (27), where a transition between each ridge (26) and the adjacent groove (27) in the same row (23) is formed by a portion (28) of the heat transfer plate that is inclined relative the central plane (P1), and a central opening (22) that is configured to receive a fluid separation device (10), such that a first part (32) of the central opening (22) may act as a fluid inlet and a second part (33) of the central opening (22) may act as a fluid outlet, wherein the plate comprises plate portions (30, 31) that extend between the rows (23, 24) of ridges (26) and grooves (27) such that the rows (23, 24) are separated from each other.

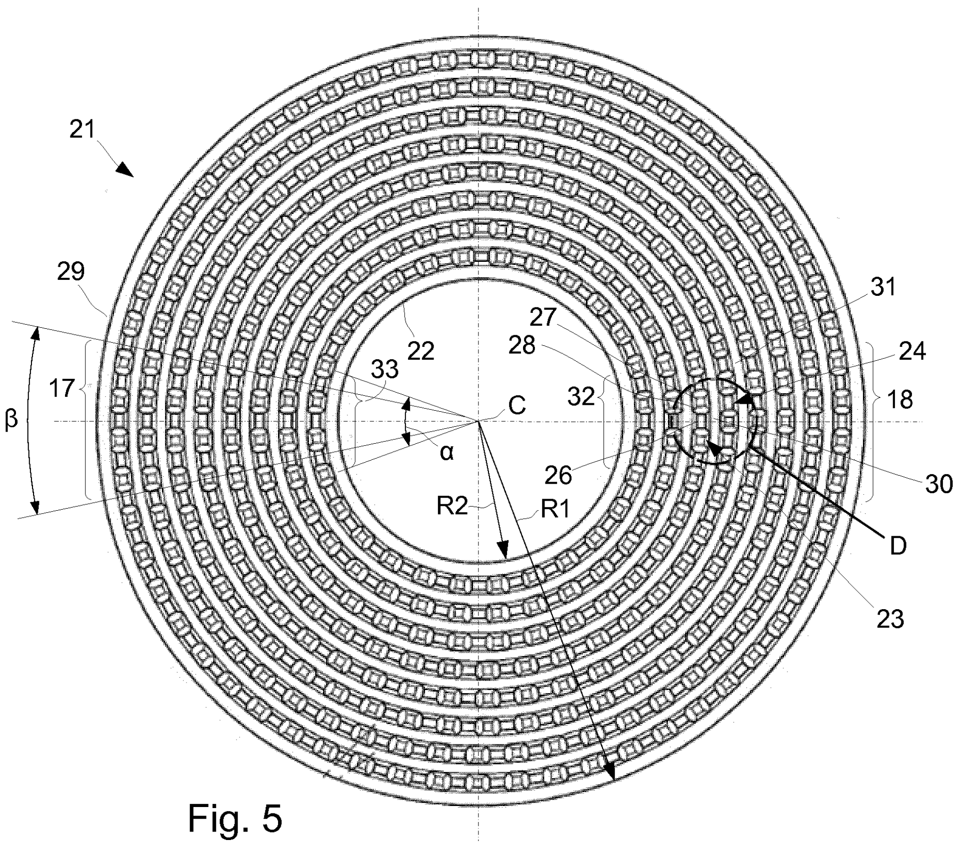

Fig. 5

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Description

Technical Field

[0001] The invention relates to a heat transfer plate of a type that has a central opening for receiving a fluid separation device that allows a first part of the central opening to act as a fluid inlet and a second part of the central opening to act as a fluid outlet.

Background Art

[0002] Today many different types of plate heat exchangers exist and are employed in various applications depending on their type. Some types of plate heat exchangers are assembled from a casing that forms a sealed enclosure in which heat transfer plates that are joined are arranged. The heat transfer plates form a stack of heat transfer plates where alternating first and second flow paths for a first and a second fluid are formed in between the heat transfer plates.

[0003] For one type of plate heat exchangers, the so called central-port plate heat exchanger, each heat transfer plate has a central opening (central port) for the first fluid path. Fluid in the first fluid path enters a heat transfer plate at an inlet section of the central opening in the heat transfer plate, flows across the plate and leaves the plate at an outlet section of the same central opening. The outlet section is opposite the inlet section and a fluid separation device is inserted in the central opening for separating the fluid flow to the inlet section from the fluid flow from the outlet section. Thus, the same port is, by virtue of the separation device, used both as a fluid inlet and a fluid outlet for a fluid that flows over the heat transfer plate. Basically, the first fluid makes a 180° turn over the heat transfer plate, such that the first fluid leaves the plate at a location that is, as seen across the central opening, opposite the location where the first fluid entered the plate.

[0004] The second fluid enters the heat transfer plate at an inlet section of a periphery of the plate, flows across the plate and leaves the plate at an outlet section of a periphery of the plate, which outlet section is opposite the inlet section.

[0005] Obviously, the inlet and outlet for the first fluid are located between every second pair of plates while the inlet and outlet for the second fluid are located between every other, second pair of plates. Thus, the first and second fluid flows over a respective side of a heat transfer plate, in between every second pair of heat transfer plates. The plates of a plate pair that have an inlet and an outlet for the first fluid are sealed to each other along their entire peripheries while the plates of a plate pair that have an inlet and outlet for the second fluid are sealed to each other at their central openings.

[0006] Since the heat transfer plates are surrounded by the casing, the central-port plate heat exchanger may withstand high pressure levels in comparison with many other types of plate heat exchangers. Still, the central-port plate heat exchanger is compact, it has good heat transfer properties and may withstand hard operation conditions without breaking.

[0007] The joined heat transfer plates are sometimes referred to as a plate pack or a stack of heat transfer plates. The stack of heat transfer plates has a substantially cylindrical shape with an internal, central through hole that is characteristic for the central-port plate heat exchanger. The stack of heat transfer plates may be all-welded such that rubber gaskets may be omitted between heat transfer plates. This makes the central-port plate heat exchanger suitable for operation with a wide range of aggressive fluids, at high temperatures and at high pressures.

[0008] During maintenance of the central-port plate heat exchanger, the stack of heat transfer plates may be accessed and cleaned by removing e.g. a top or bottom cover of the shell and by flushing the stack of heat transfer plates with a detergent. It is also possible to replace the stack of heat transfer plates with a new stack that may be identical to or different from the previous stack as long as it is capable of being properly arranged within the shell.

[0009] Generally, the central-port plate heat exchanger is suitable not only for use as a conventional heat exchanger but also as a condenser or reboiler. In the two latter cases the shell may comprise additional inlets/outlets for a condensate, which may eliminate the need for a special separator unit.

[0010] The design of the central-port plate heat exchanger with its stack of heat transfer plates provides, as indicated, a combination of advantages and properties that are quite specific for the type. A number of embodiments of central-port plate heat exchangers have been disclosed, such as those found in patent document EP2002193A1. In comparison to several other types of plate heat exchangers, the central-port plate heat exchanger has a compact design and may withstand high pressure levels. However, it is estimated that the central-port plate heat exchanger may be improved in respect of its capability to efficiently transfer heat from one of the fluids to the other fluid, while still assuring that relatively high pressures levels may be handled.

Summary

[0011] It is an object of the invention to provide improved performance for a central-port plate heat exchanger. In particular, it is an object to improve the heat transfer capability of heat transfer plates that have a respective central opening that allows the plates to be used in a central-port plate heat exchanger.

[0012] To solve these objects a heat transfer plate is provided. The heat transfer plate is configured to be arranged in a plate heat exchanger and comprises a number of rows where each row has alternating ridges and grooves that extend along a central plane of the heat transfer plate, between a top plane and a bottom plane of the heat transfer plate, the top plane and bottom plane being substantially parallel to the central plane and located on a respective side of the central plane. A transition between each ridge and adjacent groove in the same row is formed by a portion of the heat transfer plate that is inclined relative the central plane. The heat transfer plates also has a central opening that is configured to receive a fluid separation device, such that a first part of the central opening may act as a fluid inlet and a second part of the central opening may act as a fluid outlet, and plate portions that extend along the central plane of the heat transfer plate, between the rows of ridges and grooves such that the rows are separated from each other.

[0013] The heat transfer plate is advantageous in that it is very rigid and robust while at the same time is suitable for a central-port plate heat exchanger and provides efficient transfer of heat.

[0014] The plate portions that extend along the central plane of the heat transfer plate, between the rows of ridges and grooves, may be referred to as reinforcement sections or reinforcement portions. The reinforcement sections have, in a direction parallel to the central plane, typically a higher stiffness than the rows of ridges and grooves. One or more of the reinforcement sections may, in any combination, be any of flat, stepped and wave shaped. The reinforcement sections may be elongated. The reinforcement sections typically extend along the central plane of the heat transfer plate. The reinforcement sections may extend between a first plane and a second plane of the heat transfer plate, where the first plane and second plane are substantially parallel to the central plane and located on a respective side of the central plane. The first plane is located between the top plane and the central plane. The second plane is located between the central plane and the bottom plane. This makes the heat transfer plate robust in its planar extension.

[0015] A contact area of a top surface of a number of the ridges, on a top side of the heat transfer plate, may be larger than a contact area of a bottom surface of a number of the grooves, on a bottom side of the heat transfer plate. This is advantageous in that the heat transfer plate may better handle situations where the pressure on one side of the heat transfer plate is higher than on the other side of the heat transfer plate.

[0016] A number of the rows of alternating ridges and grooves may extend in a tangential direction of the heat transfer plate.

[0017] A number of the rows of alternating ridges and grooves may extend in a radial direction of the heat transfer plate.

[0018] The radial direction may be any direction that starts from a center of the plate and is directed to a periphery of the plate. The tangential direction may be a direction that is perpendicular to the radial direction.

[0019] The heat transfer plate may comprise a number of sections of rows of alternating ridges and grooves, wherein an inner section of the sections provides a higher flow resistance than an outer section of the sections, the inner section being arranged closer to the central opening than the outer section. The inner section with the higher flow resistance may be a section over which water is intended to flow during operation of a heat exchanger in which the heat transfer plate is arranged.

[0020] In the context herein, when a section of the heat transfer plate has the higher flow resistance this means that the section provides the higher flow resistance for a fluid that flows across the section or in a channel that is at least partially formed or enclosed by the section.

[0021] The inner section may have a higher tangential flow resistance than the outer section.

[0022] The heat transfer plate may comprise a first, geometrical center axis that extends across the first part of the central opening, through a center of the heat transfer plate and across the second part of the central opening, and a second, geometrical center axis that is perpendicular to the first center axis and extends through the center, wherein the inner section is, as seen along a direction parallel to the second center axis, arranged closer to the central opening than the outer section. The heat transfer plate may be symmetrical about the first center axis. The heat transfer plate may also be symmetrical about the second center axis.

[0023] The rows of alternating ridges and grooves of the inner section may have a different pitch than the rows of alternating ridges and grooves of the outer section. For example, the pitch may be different between the ridges and grooves in the same row, the pitch may be different between the ridges and grooves in different rows, and the pitch (distance) between different rows may be different.

[0024] Any of the inner section and the outer section may have the shape of a bent rectangle.

[0025] The heat transfer plate may comprise a first baffle and a second baffle that are arranged on a respective side of the first part of the central opening, and a third baffle and a fourth baffle that are arranged on a respective side of the second part of the central opening, wherein each of the baffles has an extension in a radial direction of the heat transfer plate.

[0026] The heat transfer plate may comprise a peripheral edge with a first part that may act as a fluid inlet and a second part that may act as a fluid outlet, wherein sections of the peripheral edge that are located intermediate the first part and the second part of the peripheral edge are configured to be sealed with corresponding sections of a similar heat transfer plate that is located at a top side of the heat transfer plate, and sections of the central opening that are located intermediate the first part and the second part of the central opening are configured to be sealed with corresponding sections of a similar heat transfer plate that is located at a bottom side of the heat transfer plate.

[0027] According to another aspect a heat exchanger is provided, which comprises a number of heat transfer plates of which each incorporate of the previously described features, a casing that forms a sealed enclosure, and a separation device that is arranged in central openings of the heat transfer plates, such that the central openings may act both as a fluid inlet and a fluid outlet. The heat transfer plates are permanently joined and are arranged in the sealed enclosure such that alternating first and second flow paths for a first and a second fluid are formed in between the heat transfer plates. The provided heat exchanger is typically a central-port plate heat exchanger.

[0028] The distance between the central planes of at least two adjacent heat transfer plates may be smaller at inner sections of the heat transfer plates than at outer sections of the heat transfer plates, the inner sections being arranged closer to the central opening than the outer sections.

[0029] The heat transfer plate may comprise a central edge that is folded towards and joined with a corresponding folded, central edge of an adjacent heat transfer plate, and a peripheral edge that is folded towards and joined with a corresponding folded, peripheral edge of another, adjacent heat transfer plate.

[0030] According to another aspect a method of operating the heat exchanger described above is provided, wherein water is passed over sides of the heat transfer plates where baffles are arranged. Additionally or alternatively, liquid media is passed through the central opening and into the first fluid path while gaseous media is passed into the second fluid path. The liquid media may be water.

[0031] 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

[0032] Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 is a cross-sectional top view of a central-port plate heat exchanger, as seen along line B-B in Fig. 2,
Fig. 2 is a cross-sectional side view of the heat exchanger of Fig. 1, as seen along line A-A in Fig. 1,
Fig. 3 is a cross-sectional side view of a flow divider that is installed in the heat exchanger of Fig. 1,
Fig. 4 is a side view of the flow divider of Fig. 3,
Fig. 5 is a principal top view of a heat transfer plate that may be installed in a heat exchanger like the one in Fig. 1,
Fig. 6 is an enlarged view of section D in Fig. 5,
Fig. 7 is a cross-sectional side view as seen along line C-C in Fig. 6, when the heat transfer plate is arranged on top of a similar heat transfer plate,
Fig. 8 is a principal cross-sectional side view of four heat transfer plate of the kind shown in Fig. 5,
Fig. 9 is a top view of a section of another heat transfer plate that may be installed in the heat transfer plate of Fig. 1,
Fig. 10 is top a view of the heat transfer plate shown in Fig. 9, showing all of the plate,
Fig. 11 is an enlarged sectional view that corresponds to Fig. 6, but showing another embodiment of a heat transfer plate,
Fig. 12 is a cross-sectional side view as seen along line E-E in Fig. 11, when the heat transfer plate is arranged on top of a similar heat transfer plate,
Fig. 13 is a principal section of another embodiment of a heat transfer plate,
Figs 14 and 15 are cross-sectional side views as seen along lines F-F and G-G in Fig. 13
Fig. 16 is a principal section of another embodiment of a heat transfer plate, and
Figs 17 and 18 are cross-sectional side views as seen along lines H-H and I-I in Fig. 16.

Detailed description

[0033] With reference to Figs 1 and 2 a central-port plate heat exchanger 2 is illustrated. The heat exchanger 2 has a casing 19 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover 5. The top cover 4 has the shape of a circular disc and a periphery of the top cover 4 is attached to an upper edge of the cylindrical shell 3. The bottom cover 5 has the shape a circular disc and a periphery of the bottom cover 5 is attached to a lower edge of the cylindrical shell 3. The covers 4, 5 are in the illustrated embodiment welded to the cylindrical shell 3. In another embodiment the covers 4, 5 are attached to the cylindrical shell 3 via bolts that engage flanges (not shown) of the cylindrical shell 3 and the covers 4, 5.

[0034] The top cover 4 has a fluid inlet 8 for a first fluid that passes through the heat exchanger 2 via a first flow path F1. This fluid inlet 8 is referred to as a first fluid inlet 8. The bottom cover 5 has a fluid outlet 9 for the first fluid that passes through the heat exchanger 2 via the first flow path F1. This fluid outlet 9 is referred to as a first fluid outlet 9. The first fluid inlet 8 is located at a center of the top cover 4 and the first fluid outlet 9 is located at a center of the bottom cover 5. Thus, the first fluid inlet 8 and the first fluid outlet 9 are located opposite each other in the casing 19.

[0035] The cylindrical shell 3 has a fluid inlet 6 for a second fluid that passes through the heat exchanger 2 via a second flow path F2. This fluid inlet 6 is referred to as a second fluid inlet 6. The cylindrical shell 3 also has a fluid outlet 7 for the second fluid that passes through the heat exchanger 2 via the second flow path F2. The outlet 7 is referred to as a second fluid outlet 7. The second fluid inlet 6 is located on a side of the cylindrical shell 3, midway between the upper edge of the cylindrical shell 3 and the lower edge of the cylindrical shell 3. The second fluid outlet 7 is located on a side of the cylindrical shell 3 that is opposite the second fluid inlet 6, midway between the upper edge of the cylindrical shell 3 and the lower edge of the cylindrical shell 3.

[0036] The casing 19, i.e. in the illustrated embodiment the cylindrical shell 3, the top cover 4 and the bottom cover 5, forms a sealed enclosure or an interior space in which a stack of heat transfer plates 20 is arranged. The heat transfer plates in the stack 20, such as heat transfer plates 21', 21 and 21 ", are permanently joined and arranged in the sealed enclosure such that the first and second flow paths F1, F2 flow in respective, alternating flow paths in between the heat transfer plates. Each of the heat transfer plates in the stack 20 has a central opening 22. The central openings of several heat transfer plates in the stack 20 together form a central space in the stack 20.

[0037] With further reference to Figs 3 and 4, a fluid separation device 10 is inserted into the central space in the stack 20. The separation device 10 has the form of a cylinder 12 that fits close to central openings 22 of the heat transfer plates 21', 21, 21" in the stack 20. The height of the separation device 10 is the same as the height of the central space in the stack 20. A flow divider 11 extends diagonally from an upper part of the cylinder 12 to a lower part of the cylinder 12 and separates the interior of the cylinder 12 into a first cylinder section 15 and a second cylinder section 16. The flow divider 11 completely separates the first cylinder section 15 from second cylinder section 16, such that no fluid may flow directly between the sections 15, 16. Instead, fluid may flow from the first cylinder section 15 to the second cylinder section 16 only via the heat transfer plates in the stack 20.

[0038] The separation device 10 has a first opening 13 in the first cylinder section 15 and a second opening 14 in the second cylinder section 16. The first opening 13 is arranged opposite the second opening 14 with the flow divider 11 symmetrically arranged between the openings 13, 14.

[0039] With reference to Figs 5 - 7 a heat transfer plate 21 that may be used for the heat exchanger 2 of Fig. 1 is shown. The heat transfer plate 21 has a number of rows 23, 24 where each row 23, 24 comprises alternating ridges and grooves, such as ridge 26 and groove 27 of row 23 and ridge 26' and groove 27' of row 24. The rows 23, 24 extend along a central plane P1 of heat transfer plate 21, between a top plane P2 and a bottom plane P3 of the heat transfer plate 21. The central plane P1 is typically a plane that extends in the center of the heat transfer plate 21, in the illustrated embodiment at equal distances from a top side of the heat transfer plate and a bottom side of the heat transfer plate 21. The top plane P2 and bottom plane P3 are substantially parallel to the central plane P1 and are located on a respective side of the central plane P1. A transition between each ridge 26 and adjacent groove 27 in the same row 23 is formed by a portion 28 of the heat transfer plate 21 that is inclined relative the central plane P1. The row 24 has a corresponding inclined portion 28' between ridge 26' and groove 27'. Flat elongated plate portions 30, 31 extend along the central plane P1 of the heat transfer plate, between the rows 23, 24 of ridges and grooves. The rows 23, 24 are thereby separated from each other. The flat elongated plate portions 30, 31 may be referred to as reinforcement sections. Generally, the central plane P1 is located in, or extends along, the center of the flat elongated plate portions 30, 31. The planes P1, P2 and P3 are seen from the side in Fig. 7.

[0040] The ridges 26 have respective top surface 35 on the top side 38 of the heat transfer plate 21 and the grooves 27 have a respective bottom surface 36 on the bottom side 39 of the heat transfer plate 21. The top side 38 may be referred to as a first side 38 of the heat transfer plate 21 and the bottom side 39 may be referred to as a second side 39 of the heat transfer plate 21. The top surface 35 has a contact area that abuts a heat transfer plate that is arranged above (on the top side 38 of) the heat transfer plate 21. The bottom surface 36 has a contact area that abuts a heat transfer plate that is arranged below (on the bottom side 39 of) the heat transfer plate 21. For several, most or even all of the ridges and grooves the contact area of the top surface 35 is larger than the contact area of the bottom surface 36.

[0041] With further reference to Fig. 8 a principal view of the heat transfer plates 21', 21, 22" are shown together with a further heat transfer plate 22"', along a cross section that extends from a center C of the heat transfer plate 21 to a peripheral edge (periphery) 29 of the heat transfer plate 21. The periphery 29 of the heat transfer plate 21 is along its full length joined with a corresponding periphery of the upper heat transfer plate 21'. The plates 21', 22" have central planes P1', P1" that correspond to the central plane P1 of plate 21.

[0042] The heat transfer plate 21 is partly joined with the upper heat transfer plate 21' at the central opening 22 of the heat transfer plate 21, i.e. the central opening 22 of the heat transfer plate 21 is partly joined with a similar central opening of the upper heat transfer plate 21'. The central opening 22 of the heat transfer plate 21 is joined with the upper heat transfer plate 21' except for a first part (section) 32 and a second part (section) 33. The parts 32, 33 of the central openings that are not joined are defined by a respective angle α (the angle α is shown only for the second part 33). The parts 32, 33 are arranged symmetrically opposite each other.

[0043] The exemplified heat transfer plate 21 has a central opening 22 with a radius R2 and since the first part 32 subtends an angle of $\alpha°$, the length L of the first part 32 is $L = \alpha \cdot \pi \cdot R2/180$. Since the second part 33 also subtend an angle of $\alpha°$ the length L of the second part 33 is $L = \alpha \cdot \pi \cdot R2/180$. This means that the heat transfer plate 21 is joined with the upper heat transfer plate 21' at its central opening 22 at two sections between the first part 32 and the second part 33. The total length L1 of the joined sections is then the circumference of the heat transfer plate 21 subtracted by the lengths of the parts 32 and 33, i.e. $L1 = 2 \cdot \pi \cdot R2 - 2 \cdot (\alpha \cdot \pi \cdot R2/180)$.

[0044] The first part 32 of the central opening 22 is referred to as a first plate inlet 32, since it acts as an inlet for a fluid that shall flow over the heat transfer plate 21, between heat transfer plate 21 and the upper heat transfer plate 21'. The second part of the 33 central opening 22 is referred to as a first plate outlet 33, since it acts as an outlet for fluid that has flown over the heat transfer plate 21. The space between the heat transfer plates 21 and 21' is a part of the first flow path F1.

[0045] In one embodiment it is not required to join heat transfer plates 21 and 21' at all along their central openings. Instead the separation device 10 prevents a flow of liquid over other sections than the first plate inlet 32 and the first plate outlet 33. The first opening 13 of the separation device 10 then subtends the angle of $\alpha°$ and the second opening 14 subtend a corresponding angle $\alpha°$.

[0046] The central opening 22 of the heat transfer plate 21 is along its full length joined with a corresponding central opening of the lower heat transfer plate 21 ".

[0047] The heat transfer plate 21 is also partly joined with the lower heat transfer plate 21" at the periphery 29 of the heat transfer plate 21, i.e. the periphery 29 of the heat transfer plate 21 is partly joined with a similar central periphery of the lower heat transfer plate 21 ". A first part (section) 17 and a second part (section) 18 of the periphery 29 are not joined with the lower heat transfer plate 21 ". The parts 17, 18 that are not joined are defined by a respective angle of β degrees (the angle β is shown only for the first part 17). The parts 17, 18 are symmetrical and are arranged opposite each other.

[0048] Since the exemplified heat transfer plate 21 has a circular shape with a radius R1 and since the first part 17 subtends an angle of $\beta°$, the length L of the first part 17 is $L = \beta \cdot \pi \cdot R1/180$. Since the second part 18 also subtend an angle of $\beta°$ the length L of the second part 18 is $L = \beta \cdot \pi \cdot R1/180$. This means that the heat transfer plate 21 is joined with the lower heat transfer plate 21" at its periphery 29 at two sections between the first part 17 and the second part 18. The total length L2 of the joined sections is then the circumference of the heat transfer plate 21 subtracted by the lengths of the parts 17 and 18, i.e. $L2 = 2 \cdot \pi \cdot R1 - 2 \cdot (\beta \cdot \pi \cdot R1/180)$.

[0049] The first part 17 of the periphery 29 is referred to a second plate inlet 17, since it acts as an inlet for a fluid that shall flow under the heat transfer plate 21, between heat transfer plate 21 and the lower heat transfer plate 21 ". The second part 18 of the central opening 22 is referred to a second plate outlet 18, since it acts as an outlet for fluid that has flown under the heat transfer plate 21. The space between the heat transfer plates 21 and 21" is a part of the second flow path F2.

[0050] In one embodiment it is not required to join heat transfer plates 21, 21" at all along their peripheries. Instead the cylindrical shell 3 seals the plates at their peripheries to prevent a flow of liquid over all sections but for the second plate inlet 17 and the second plate outlet 18. Thus, the cylindrical shell 3 then seals the peripheral edges apart from at the sections 17, 18 subtended by a respective angle $\beta°$.

[0051] The joining of the heat transfer plates 21"', 21', 21, 21" is typically accomplished by welding. The heat transfer plate 21 may have a central edge 92 that is folded towards and joined with a corresponding folded, central edge 92" of adjacent heat transfer plate 21 ". The heat transfer plate 21 may also have a peripheral edge 91 that is folded towards and joined with a corresponding folded, peripheral edge 91' of the other adjacent heat transfer plate 21'.

[0052] The heat transfer plates may then be joined at to each other at their folded edges. A seal may be arranged between the separation device 10 and the heat transfer plates for sealing plates like plates 21 and 21' along their central openings 22 at all sections but at the first plate inlet 32 and the first plate outlet 33. A seal may also be arranged between the cylindrical shell 3 and the heat transfer plates for sealing plates like plates 21 and 21" along their peripheries 29 at all sections but at the second plate inlet 17 and second plate outlet 18.

[0053] Turning back to Figs 1-4 the flow over the heat transfer plates may be seen. The flow of the first fluid follows the first flow path F1. By virtue of the separation device 10 and its flow divider 11, the flow of the first fluid passes the first fluid inlet 8, enters the first cylinder section 15 and flows out through the first opening 13 in the separation device 10, into first plate inlets 32 of the heat transfer plates 21 in the stack 20. The first fluid then "turns around" when it flow across the heat transfer plates, see the first flow path F1 in Fig. 1, leaves the heat transfer plates via first plate outlets 33 of the heat transfer plates 21 in the stack 20 and enters the second cylinder section 16 via the second opening 14. From the second cylinder section 16 the first fluid flows to the first fluid outlet 9 where it leaves the heat exchanger 2.

[0054] The flow of the second fluid follows the second flow path F2. The flow of the second fluid passes the second fluid inlet 6 and into second plate inlets 17 of the heat transfer plates 21 in the stack 20. For facilitating distribution of the fluid into all second plate inlets 17 of the heat transfer plates, the heat exchanger 2 may at the second fluid inlet 6 comprise a distributor (not shown). A collector (not shown) that has a similar shape as the distributor may be arranged at the second fluid outlet 7. Alternatively, the heat transfer plates 21 may comprise a first cut-out 46 at the second plate inlet 17 and a second cut-out 47 at the second plate outlet 18 (see Fig. 1). Even though such cut-outs 46, 47 give the periphery 29 of the heat transfer plate 21 a different shape, the second plate inlet 17 and the second plate outlet 18 may still subtend a respective angle of $\beta°$.

[0055] When the second fluid has entered the second plate inlets 17 it flows across the plates in the stack 20, see the second flow path F2 in Fig. 1, leaves the heat transfer plates in the stack 20 via the second plate outlets 18 and thereafter leaves the heat exchanger 2 via the second fluid outlet 7.

[0056] With reference to Figs 9 and 10 another embodiment of a heat transfer plate 121 is illustrated. The heat transfer plate 121 is symmetrical about first geometrical axis A1 and second geometrical axis A2. The heat transfer plate 121 of Figs 9 and 10 have several features that are same as for the heat transfer plate 21 of Fig. 5. For example, the heat transfer plate 121 has a central opening 22 with a first plate inlet 32 and a first plate outlet 33, and a periphery 29 with a second plate inlet 48 and a second plate outlet 49. The second plate inlet 48 and the second plate outlet 49 comprise a respective first and second cut-out like the cut-outs 46, 47 shown in Fig. 1. The heat transfer plate 121 is joined and sealed to adjacent, similar plates in a manner that corresponds to how the heat transfer plate 21 of Fig. 5 is joined and sealed to other heat transfer plates.

[0057] The heat transfer plate 121 also has flat, elongated plate portions 130, 131 that extend along the central plane of the heat transfer plate 121, between the rows of ridges and grooves such that the rows are separated from each other. The rows are arranged different in different sections of the heat transfer plate 121.

[0058] For example, a first section 41 of the rows 42 of alternating ridges 43 and grooves 44 extend in a tangential direction D1. As is known, a tangential direction is a direction that is orthogonal to the radius of rotation of the plate, as seen from the center C of the heat transfer plate 121, which has a radius R1. A radial direction is a direction that is parallel to the radius of rotation of the plate, as seen from the center C of the heat transfer plate 121.

[0059] A second section 51 of the rows 52 of alternating ridges 53 and grooves 54 also extend in a tangential direction D1 while a third section 61 of the rows 62 of alternating ridges 63 and grooves 64 extend in a radial direction D2. A fourth section 81 of the rows of alternating ridges and grooves extend in a radial direction D2.

[0060] The second section 51 has the shape of a bent rectangle. By bent reactance is meant a geometrical shape where two sides of the shape have the form of a respective arc where the arcs have different radiuses but shares the same radial center and subtends the same angle, and where the two sides are joined by to additional sides that extends in a radial direction. A bent rectangle may be said having the form of a truncated circular sector or annular sector.

[0061] The second section 51 is arranged closer to the center C than the third section 61 and may be referred to as an "inner section". The third section 61 is arranged further from the center C and may be referred to as an outer section or a peripheral section. From a geometrical point of view, the first geometrical axis A1 extends across the first part 32 of the central opening 22, through the center C of the heat transfer plate 121 and across the second part 33 of the central opening 22. The second geometrical axis A2 is perpendicular to the first center axis A1 and extends through the center C. Then the inner section 51 is, as seen along a direction parallel to the second center axis A2, arranged closer to the central opening 22 than the outer section 61.

[0062] The inner section 51 has a higher flow resistance than the outer section 61. Specifically, the inner section 51 has a higher tangential flow resistance than the outer section 61. To accomplish different flow resistances, the rows 52 of alternating ridges and grooves 53, 54 of the inner section 51 may, for example, have a different pitch than the rows 62 of alternating ridges and grooves 63, 64 of the outer section 61. Another way to accomplish the different flow resistance is to arrange the rows of ridges and grooves in different directions. For example, a tangential direction of the rows may give a higher tangential flow resistance than a radial direction of the rows.

[0063] Moreover, the flow resistance may be increased by decreasing the pitch (distance) between the rows. Increasing flow resistance in this way is particularly efficient when the rows extend in a flow direction, which may be the tangential direction.

[0064] The flow resistance may e.g. in the outer section 61 be decreased by arranging the rows in a non-staggered manner, i.e. by arranging the ridges in the different rows after each other in the flow direction. When this is done the grooves of different rows are arranged after each other in the flow direction or tangential direction. Decreasing flow resistance in this way is particularly efficient when the rows extend in a radial direction, or transverse the flow direction.

[0065] The flow resistance of a section may also be increased by giving the heat transfer plate 21 a shape that locates flat elongated plate portions 30, 31 relatively closer to an adjacent plate, which effectively decreases the flow path and thus increases the flow resistance at the location of the section.

[0066] The heat transfer plate 121 has a first baffle 71 and a second baffle 72 that are arranged on a respective side of the first plate inlet 32 (first part 32) of the central opening 22, and a third baffle 73 and a fourth baffle 74 that are arranged on a respective side of the first plate outlet 33 (second part 33) of the central opening 22. Each of the baffles 71, 72, 73, 74 has an extension in a radial direction D2 of the heat transfer plate. They may in one embodiment extend in parallel with a respective radial direction of the heat transfer plate 121. The baffles typically have the shape of an elongated ridge.

[0067] The baffles ensures that fluid that enters the first plate inlet 32 and leaves the first plate outlet 33 is distributed more evenly over the heat transfer plate 121, such that the fluid does not take shortcuts by flowing very close to the central opening 22 when flowing from the first plate inlet 32 to the first plate outlet 33.

[0068] In one application of the heat transfer plate 121 the heat exchanger in which the heat transfer plate 121 is arranged is operated by passing water over a side of the heat transfer plate where the baffles 71, 72, 73, 74 are arranged, i.e. on the side where the baffles form a respective protrusion or elongated ridge.

[0069] With reference to Figs 11 and 12 another embodiment of a heat transfer plate 221 is illustrated. The heat transfer plate 221 has a number of rows 223, 224 where each row 223, 224 comprises alternating ridges and grooves. Reinforcement sections 230, 231 extend along the central plane P1 of the heat transfer plate, between the rows 223, 224 of ridges and grooves. Each of the reinforcement sections 230, 231 is wave shaped and extends along the central plane P1 of the heat transfer plate, between a first plane P4 and a second plane P5 of the heat transfer plate. The first plane P4 and second plane P5 are substantially parallel to the central plane P1 and located on a respective side of the central plane P1. The first plane P4 is located between the top plane P2 and the central plane P1. The second plane P5 is located between the central plane P1 and the bottom plane P3. In this context, when ridges and grooves extend between two planes P2, P3 this means that all of the ridges and grooves are located between these planes P2, P3. In a similar manner, all of the reinforcement sections 230, 231 extend between the first and second planes P4, P5, i.e. the extension of the reinforcement sections 230, 231 is limited by the first and second planes P4, P5.

[0070] With reference to Figs 13-15 another embodiment of a heat transfer plate 321 is illustrated. This embodiment shows rows 323, 324 of alternating ridges and grooves that are separated by a reinforcement section 330. The rows 323, 324 are non-staggered and the reinforcement section 330 is stepped.

[0071] With reference to Figs 16-18 another embodiment of a heat transfer plate 421 is illustrated. This embodiment shows rows 423, 424 of alternating ridges and grooves that are separated by a reinforcement section 430. The rows 423, 424 are staggered and the reinforcement section 430 is both stepped and tilted.

[0072] From the description above follows that, although various embodiments of the invention have been described and shown, the invention is not restricted thereto, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims.

Claims

1. A heat transfer plate configured to be arranged in a plate heat exchanger (2), the heat transfer plate comprising

a number of rows (23, 24) where each row (23, 24) has alternating ridges (26) and grooves (27) that extend along a central plane (P1) of the heat transfer plate, between a top plane (P2) and a bottom plane (P3) of the heat transfer plate, the top plane (P2) and bottom plane (P3) being substantially parallel to the central plane (P1) and located on a respective side of the central plane (P1), where a transition between each ridge (26) and adjacent groove (27) in the same row (23) is formed by a portion (28) of the heat transfer plate that is inclined relative the central plane (P1), and

a central opening (22) that is configured to receive a fluid separation device (10), such that a first part (32) of the central opening (22) may act as a fluid inlet and a second part (33) of the central opening (22) may act as a fluid outlet, **characterized by** plate portions (30, 31) that extend along the central plane (P1) of the heat transfer plate, between the rows (23, 24) of ridges (26) and grooves (27) such that the rows (23, 24) are separated from each other.

2. A heat transfer plate according to claim 1, wherein a contact area of a top surface (35) of a number of the ridges (26), on a top side (38) of the heat transfer plate, is larger than a contact area of a bottom surface (36) of a number of the grooves (27), on a bottom side (39) of the heat transfer plate.

3. A heat transfer plate according to claim 1 or 2, wherein a number of the rows (42) of alternating ridges (43) and grooves (44) extend in a tangential direction (D1) of the heat transfer plate.

4. A heat transfer plate according to any one of claims 1 - 3, wherein a number of the rows (62) of alternating ridges (63) and grooves (64) extend in a radial direction (D2) of the heat transfer plate.

5. A heat transfer plate according to any one of claims 1 - 4, comprising a number of sections (51, 61) of rows (52, 62) of alternating ridges (53, 63) and grooves (54, 64), wherein an inner section (51) of the sections (51, 62) provides a higher flow resistance than an outer section (61) of the sections (51, 61), the inner section (51) being arranged closer to the central opening (22) than the outer section (61).

6. A heat transfer plate according to claim 5, wherein the inner section (51) has a higher tangential flow resistance than the outer section (61).

7. A heat transfer plate according to claim 5 or 6, comprising a first, geometrical center axis (A1) that extends across the first part (32) of the central opening (22), through a center (C) of the heat transfer plate and across the second part (33) of the central opening (22), and a second, geometrical center axis (A2) that is perpendicular to the first center axis (A1) and extends through the center (C), wherein the inner section (51) is, as seen along a direction parallel to the second center axis (A2), arranged closer to the central opening (22) than the outer section (61).

8. A heat transfer plate according to claim 5 - 7, wherein the rows (52) of alternating ridges and grooves (53, 54) of the inner section (51) have a different pitch than the rows (62) of alternating ridges and grooves

(63, 64) of the outer section (61).

9. A heat transfer plate according to any one of claims 5 - 8, wherein any of the inner section (51) and the outer section (61) has the shape of a bent rectangle.

10. A heat transfer plate according to any one of claims 1 - 9, comprising
a first baffle (71) and a second baffle (72) that are arranged on a respective side of the first part (32) of the central opening (22), and
a third baffle (73) and a fourth baffle (74) that are arranged on a respective side of the second part (33) of the central opening (22), wherein
each of the baffles (71, 72, 73, 74) has an extension in a radial direction (D2) of the heat transfer plate.

11. A heat transfer plate according to any one of claims 1 - 10, comprising
a peripheral edge (29) with a first part (17, 48) that may act as a fluid inlet and a second part (18, 49) that may act as a fluid outlet, wherein
sections of the peripheral edge (29) that are located intermediate the first part (17, 48) and the second part (18, 49) of the peripheral edge (29) are configured to be sealed with corresponding sections of a similar heat transfer plate (21') that is located at a top side (38) of the heat transfer plate, and
sections of the central opening (22) that are located intermediate the first part (32) and the second part (33) of the central opening (22) are configured to be sealed with corresponding sections of a similar heat transfer plate (21 ") that is located at a bottom side (39) of the heat transfer plate.

12. A heat exchanger comprising a number of heat transfer plates (21', 21, 21 ") according to any one of claims 1 - 11, a casing (3, 4, 5) that forms a sealed enclosure, and a separation device (10) arranged in central openings (22) of the heat transfer plates (21', 21, 21 "), such that the central openings (22) may act both as a fluid inlet (32) and a fluid outlet (33), wherein the heat transfer plates (21', 21, 21") are permanently joined and arranged in the sealed enclosure such that alternating first and second flow paths (F1, F2) for a first and a second fluid are formed in between the heat transfer plates (21', 21, 21").

13. A heat exchanger according to claim 12, wherein the distance between the central planes (P1, P1') of at least two adjacent heat transfer plates is smaller at inner sections (51) of the heat transfer plates (21', 21, 21") than at outer sections (61) of the heat transfer plates (21', 21, 21 "), the inner sections (51) being arranged closer to the central opening (22) than the outer sections (61).

14. A heat exchanger according to claim 12 or 13, wherein the heat transfer plate (21) comprises
a central edge (92) that is folded towards and joined with a corresponding folded, central edge (92") of an adjacent heat transfer plate (21 "), and a peripheral edge (91) that is folded towards and joined with a corresponding folded, peripheral edge (91') of another, adjacent heat transfer plate (21').

15. A method of operating a heat exchanger according to any one of claims 12 - 14, wherein fluid is passed through the central opening (22) and into the first fluid path (F1) at a pressure that is lower than a pressure of a fluid that is passed into the second fluid path (F2).

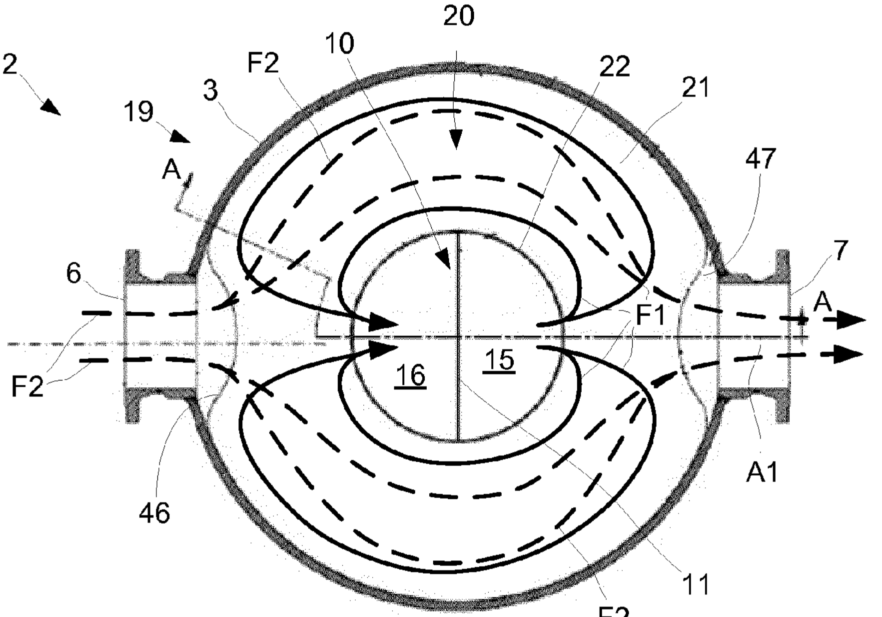


Fig. 1 (B-B)

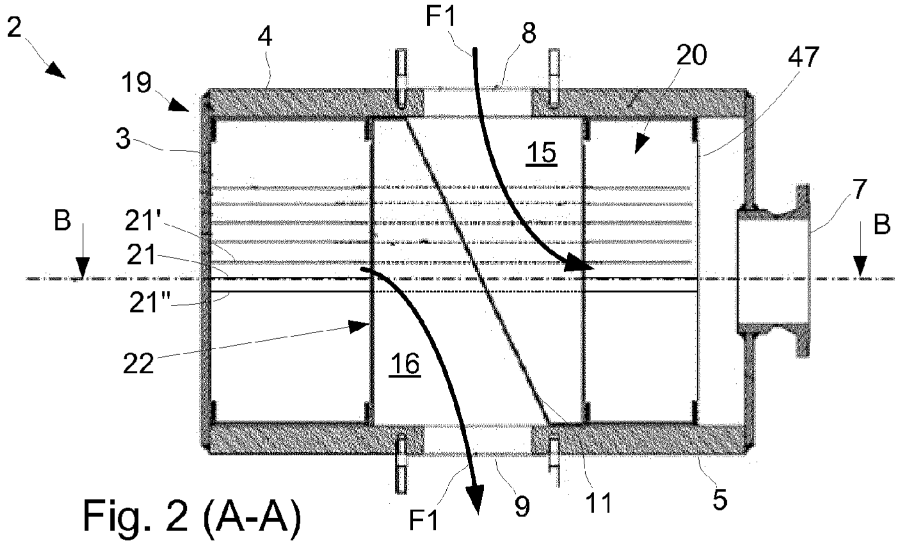


Fig. 2 (A-A)

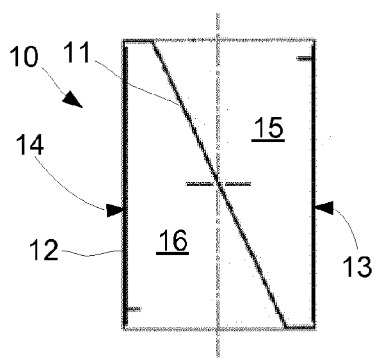


Fig. 3

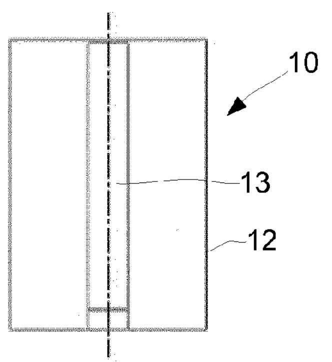


Fig. 4

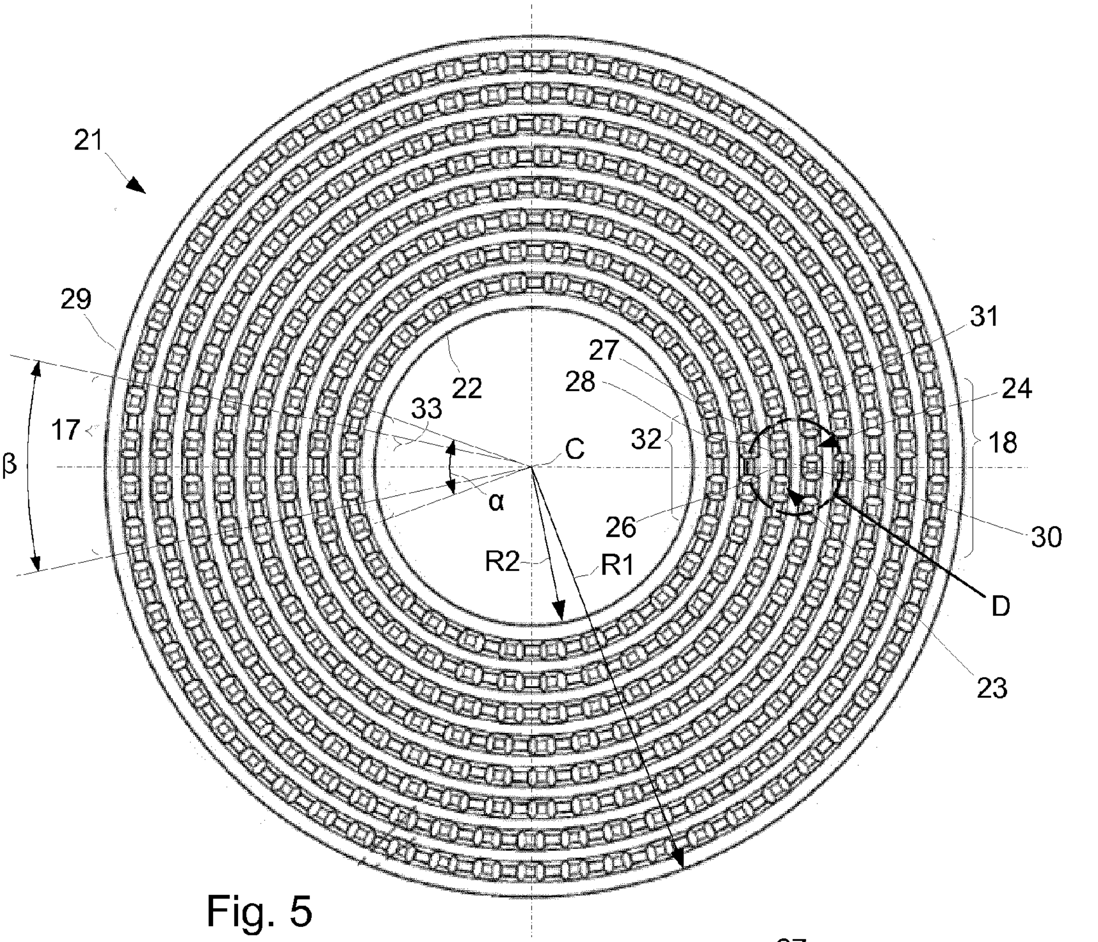


Fig. 5

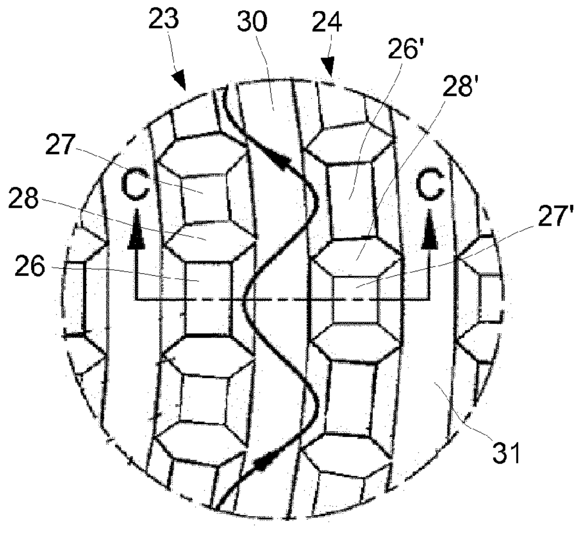


Fig. 6 (D)

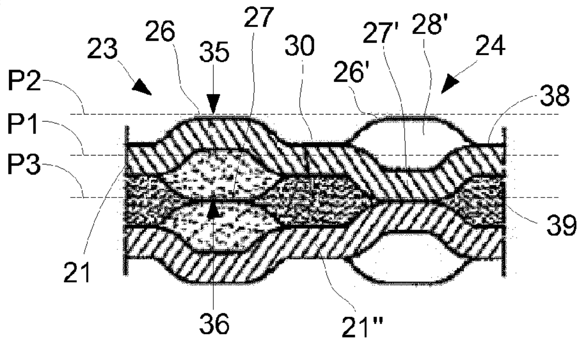


Fig. 7 (C-C)

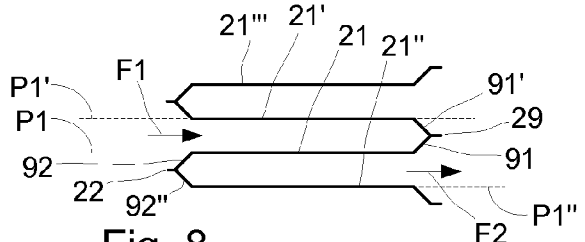
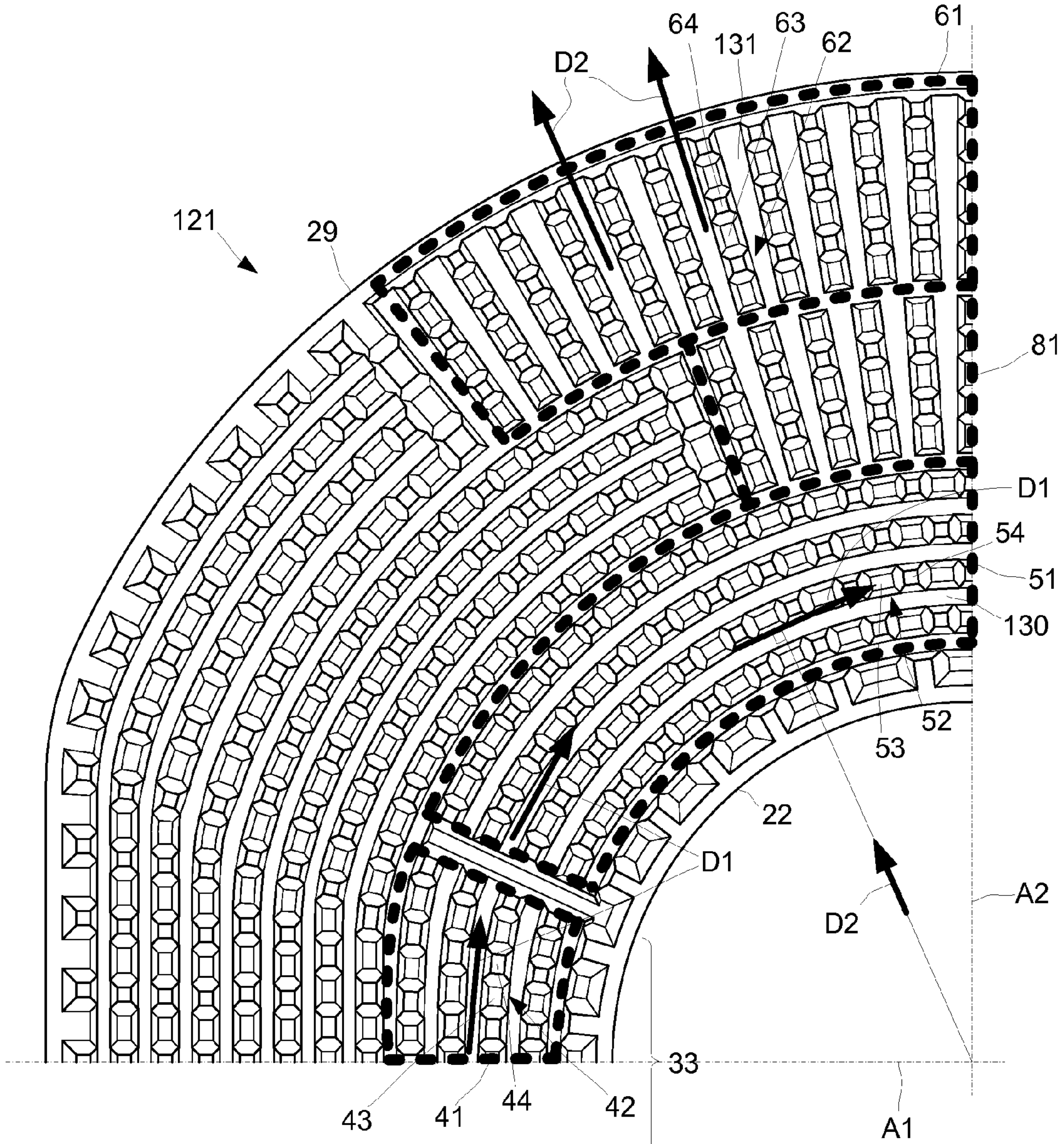


Fig. 8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131
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62
61
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D1
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53
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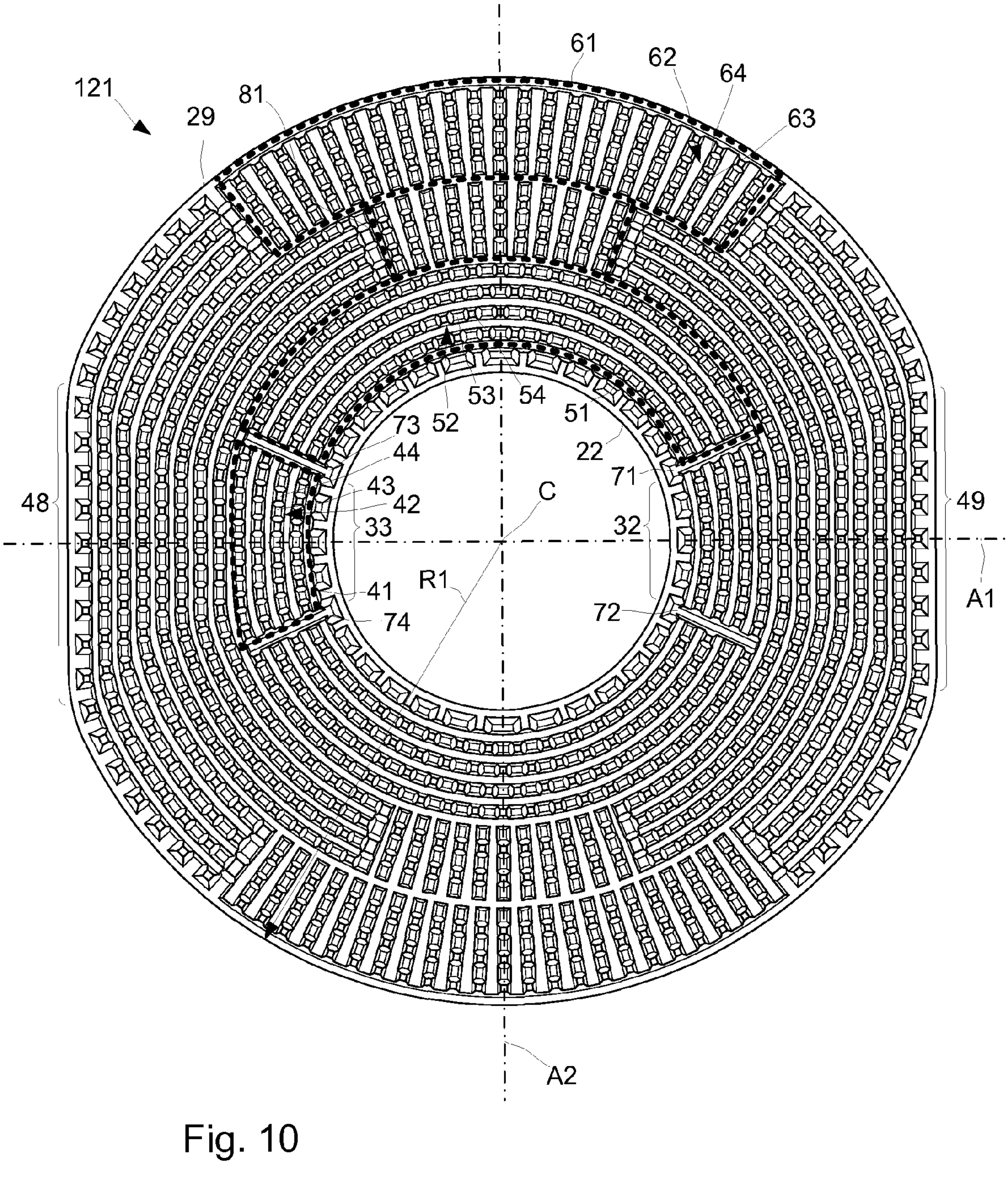
D1
D2
A2
33
43
41
44
42
A1

Fig. 9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71
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R1
41
72
74
A1
A2

Fig. 10

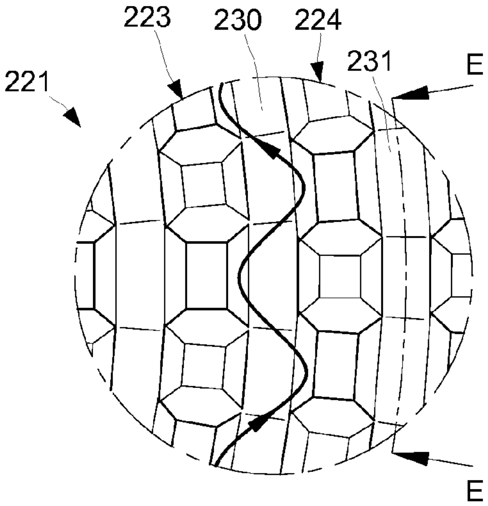

Fig. 11

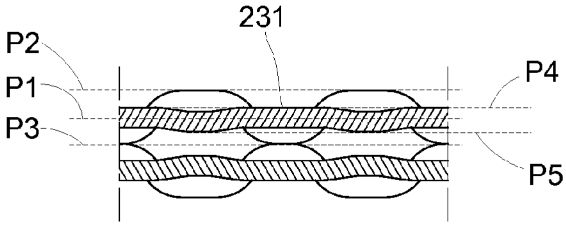

Fig. 12 (E-E)

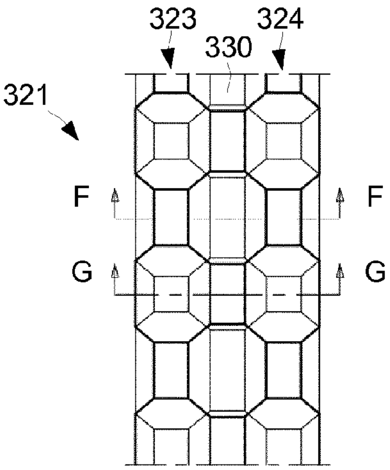

Fig. 13

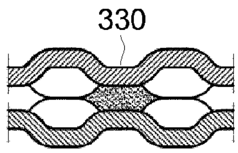

Fig. 14 (F-F)

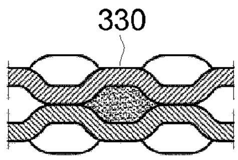

Fig. 15 (G-G)

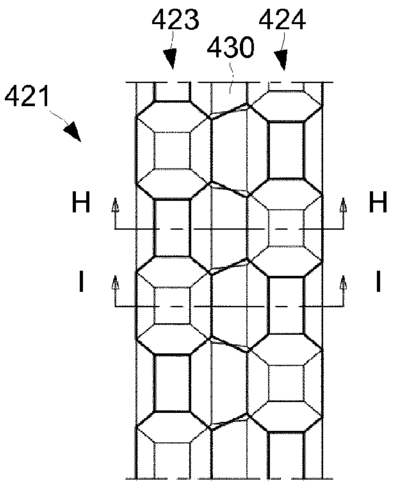

Fig. 16

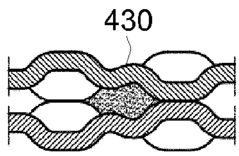

Fig. 17 (H-H)

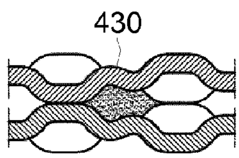

Fig. 18 (I-I)

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 0151

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	27 January 2014	Vesselinov, Vladimir

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X : particularly relevant if taken alone
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