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(54) HEAT EXCHANGER

WÄRMETAUSCHER

ÉCHANGEUR DE CHALEUR

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Description

[0001] The invention relates to a heat exchanger according to the preamble of claim 1.

[0002] Such a heat exchanger is known, for example, from WO2015/162936 A1 or WO 2016/038830 A1.

[0003] In a plate heat exchanger heat is usually transferred between a first fluid flowing through primary heat channels and a second fluid flowing through secondary fluid channels. The structured plates are stacked on top of each other and fixed between the top and bottom plates by e.g. bolts. Usually each structured plate cooperates to form primary fluid channels on one of its sides and secondary fluid channels on the opposite side of the structured plate.

[0004] Plate heat exchangers of the above kind are produced with a plurality of different structured plates and corresponding primary and secondary fluid channels. The type and number of structured plates that is used for the heat exchanger and the resulting shape of the fluid channels then defines the characteristics of the heat exchanger like the heat transfer efficiency, flow speed, pressure drop etc.

[0005] However, only a limited number of standard types of structured plates are mass produced and can be used to assemble heat exchangers costs efficiently. If a heat exchanger is however desired with specifications that cannot be achieved using one of the types of mass produced standard structured plates, then this will require to use a non-standard design of structured plates resulting in an increased cost and production time for the heat exchanger.

[0006] Task of the invention is therefore to provide a heat exchanger that can be produced with a wide range of specifications without increasing the costs or production time.

[0007] According to the present invention the above task is solved by the features of claim 1.

[0008] This solution allows to produce heat exchangers with a wider range of specifications by using stacks of different types of structured plates in the same heat exchanger. The individual structured plates can however still be chosen from standard, mass produced types and consequently the production costs and time is not significantly increased compared to a standard heat exchanger.

[0009] The types of structured plates that are used may be chosen such that a cooperation of the adjacent structured plates where different stacks meet is possible or by separating adjacent stacks.

[0010] Between each pair of adjacent stacks of structured plates a structureless separator plate is arranged. The structureless separator plate may still comprise openings to allow the inlet and outlet flows for the primary and secondary fluid to flow towards or away from the primary and secondary fluid channels. Using a structureless separator plate allows to use different kinds of structured plates that would otherwise not be able to be

stacked directly on top of each other. The latter may otherwise result in the failure of the heat exchanger by deformation during assembly or operation.

[0011] At least one transition plate is arranged on each side of the structureless separator plate. The transition plates may serve to keep the primary fluid channels and the secondary fluid channels separated despite the presence of the structureless separator plate. The transition plates may to this end comprise inlet and outlet structures to allow to direct the flow from the primary and secondary inlet as well as from the primary and secondary outlet from and to the correct fluid channels.

[0012] In an embodiment one of the transition plates is arranged fitting closely to the adjacent structureless plate for the majority of the area of the structureless plate. The majority of the area of the structureless plate may here mean the area of the structureless plate excluding the area surrounding one of the inlets and one of the outlets such that the first fluid and the second fluid may still be kept separate.

[0013] In an embodiment one of the transition plates is arranged fitting closely to an adjacent structured plate of one of the adjacent stacks of structured plates for the majority of the area of the adjacent structured plate. As in the previous embodiment this solution allows to keep the primary fluid and the secondary fluid separate in the region adjacent to the separator plate.

[0014] In an embodiment each structured plate comprises at least one primary inlet to and at least one primary outlet from adjacent primary fluid channels, and wherein each structured plate comprises at least one secondary inlet to and at least one secondary outlet from adjacent secondary fluid channels. The same may be true for each structureless separator plate as well as each transition plate. However, the structured plates may comprise inlet and outlet structures that are absent in the structureless separator plates.

[0015] In an embodiment adjacent to at least one primary inlet and/or at least one primary outlet and/or at least one secondary inlet and/or at least one secondary outlet a fluid separator structure is arranged in at least one of the structured plates. The fluid separation structure may serve to separate the fluid flowing into the primary fluid channel or secondary fluid channel such that the fluid is distributed more effectively over the whole plane of the structured plate.

[0016] In an embodiment at least one fluid separation structure is formed by cooperating ridges of two adjacent structured plates. This embodiment furthermore stabilizes the heat exchanger.

[0017] In an embodiment the structured plates in at least one of the stacks of structured plates form alternating hills and valleys to improve the heat transfer between the fluids and said structured plates. Depending on the number of stacks of structured plates used more than one of the stacks of structured plates may comprise structured plates with such alternating hills and valleys. Moreover, the heat exchanger may comprise for example two

or more stacks of structured plates with alternating hills and valleys wherein the design of the hill and valley structure of the individual stacks is different.

[0018] In an embodiment the structured plates in at least one of the stacks of structured plates form wedge-like structures to improve the heat transfer between the fluids and said structured plates. Again depending on the number of stacks of structured plates several of the stacks may comprise structured plates with wedge-like structures and/or the wedge-like structures of different stacks may differ in design.

[0019] Embodiments of the invention will now be described with reference to the figures, wherein:

- Fig. 1 shows an external view of a heat exchanger according to the invention,
- Fig. 2 shows a simplified top view of a structured plate according to the invention,
- Fig. 3 shows a simplified side view of several structured plates arranged on top of each other,
- Fig. 4 shows an isometric view of a structured plate according to the invention,
- Fig. 5a+b show cooperating adjacent structured plates according to the invention,
- Fig. 6 shows an embodiment of a heat exchanger in a partial exploded view,
- Fig. 7 shows the same embodiment as Fig. 6 in a cut view through an inlet and an outlet,
- Fig. 8 shows a detailed view of an inlet or an outlet with cooperating structured plates in the embodiment according to Fig. 6 and 7,
- Fig. 9 shows a cut side view of adjacent stacks of structured plates and a separator plate,
- Fig. 10 shows a detailed view of the embodiment according to Fig. 6 to 9 of an outlet of a heat exchanger according to the invention.

[0020] Fig. 1 shows a simplified depiction of a heat exchanger 1 according to the invention. The heat exchanger 1 comprises a top plate 2 as well as a bottom plate 3. Between the top plate 2 and the bottom plate 3 a plurality of structured plates 4, 5 are arranged.

[0021] Fig. 2 shows a simplified top view of a structured plate 4, 5. The structured plate comprises a primary inlet 6 as well as primary outlet 7. A primary fluid entering through the primary inlet 6 flows over the top side of the structured plate 4, 5 towards the primary outlet 7. Similarly, the structured plate 4, 5 comprises a secondary

inlet 8 as well as a secondary outlet 9. A secondary fluid flowing along the bottom side of the structured plate 4, 5 enters through the secondary inlet 8 and flows towards the secondary outlet 9. Heat can then be transferred from the primary fluid to the secondary fluid through the structured plate 4, 5. The respective inlets and outlets may alternatively be arranged diagonally from each other across the structured plate 4, 5.

[0022] Along the top side of the structured plate 4, 5 primary fluid channels 10 are thus formed to guide the primary fluid from the primary inlet 6 to the primary outlet 7. Similarly, secondary fluid channels 11 are formed on the bottom side of the structured plate 4, 5 to guide the secondary fluid from the secondary inlet 8 to the secondary outlet 9. The primary fluid channels 10 and the secondary fluid channels 11 may be formed by microstructures such as a pattern of alternating hills 12 and valleys 13 as shown in Fig. 2. Alternatively, the structured plates 4, 5 can also comprise different structures, for example, wedge-like structures.

[0023] Fig. 3 shows a side view of four structured plates 4, 5 arranged on top of each other. The topmost structured plate 4, 5 cooperates at its valleys 13 with hills 12 of the structured plate arranged directly below. Thereby, primary fluid channels 10 as well as secondary fluid channels 11 are formed.

[0024] Fig. 4 shows an isometric view of a structured plate comprising hills 12 and valleys 13 as in Fig. 2 and 3.

[0025] Fig. 5a shows a detail of a structured plate 4 cooperating with an adjacent structured plate 5. A valley 13 of the structured plate 4 cooperates with a hill 12 of the structured plate 5. In this example, the structured plates 4, 5 comprise the same microstructure of hills 12 and valleys 13. The contact surface of the hills 12 has the same extent as the contact surface of the valleys 13 thereby allowing a good stability of the cooperating adjacent structured plates 4, 5.

[0026] Fig. 5b shows a slightly different situation in which the microstructure of the structured plates 4, 5 is different. Here, the extent of the contact surface of the valleys 13 of the structure plate 4 is smaller than the contact surface of the hills 12 of the structured plate 5. In principle, it is possible that structured plates 4, 5 with different microstructures can cooperate to form primary fluid channels and secondary fluid channels as long as the structured plates can be stacked in such a way that the cooperating structured plates are sufficiently stable. In the example according to Fig. 5b the distance between neighboring hills and valleys would need to be the same for both structured plates 4, 5 to allow them to cooperate to form primary fluid channels and secondary fluid channels despite the difference in shape of the hills 12 and valleys 13.

[0027] Fig. 6 shows a further embodiment of a heat exchanger according to the invention. The heat exchanger 1 comprises two stacks of structured plates 14, 15. Between the stacks of structured plates 14, 15 a structureless separator plate 16 is arranged. The structureless

separator plate 16 allows to combine a broad range of different structured plates 4, 5 in the same heat exchanger 1. In particular, the microstructures of the structured plates 4, 5 arranged in the stack of structured plates 14 may be different to the microstructures of the structured plates 4, 5 arranged in the stack of structured plates 15. The structureless separator plate 16, however, comprises openings to allow the primary and secondary fluid to flow through the structureless separator plate 16 from one stack of structure plates 14, 15 to the next stack of structure plates 14, 15.

[0028] Fig. 7 shows an exploded cut view of an embodiment of a heat exchanger 1 according to the invention. In this case, the heat exchanger 1 again comprises two stacks of structured plates 14, 15. The heat exchanger 1 may however comprise a larger number of stacks of structured plates 14, 15. Between the stack of structured plates 14 and the adjacent stack of structured plates 15 a structureless separator plate 16 is arranged. On each side of the structureless separator plate 16 one transition plate 17, 18 is arranged. One of the transition plates 17 is arranged fitting closely to the adjacent structureless plate 16 for the majority of the area of the structureless plate 16. On the other hand, the transition plate 18 is arranged fitting closely to an adjacent structured plate 4 for the majority of the area of the adjacent structured plate 4. Thereby, the transition plates 17, 18 ensure that the primary fluid and the secondary fluid can be kept separate despite the use of the structureless separator plate 16 to separate the stacks of structured plates 14, 15. The transition plates 17, 18 may be structureless apart from inlet structures 19 and/or outlet structures formed to block the entry of a primary or a secondary fluid. In Fig. 7 two arrows show the fluid flow direction through an inlet manifold 20 and an outlet manifold 21. The inlet manifold 20 is formed by a plurality of subsequent inlets 22 in adjacent structured plates 4, 5. Similarly, the outlet manifold 21 is formed by a plurality of outlets 23 arranged in adjacent structured plates 4, 5. The inlet manifold 20 as well as the outlet manifold 21 may furthermore be formed by inlets 22 and outlets 23 formed in the structureless separator plate 16 and/or in the separator plates 18, 19.

[0029] Fig. 8 shows a further detail of a heat exchanger 1 according to Fig. 6 and 7. Fig. 8 shows a detail of the inlet manifold 20 as shown in Fig. 7. Furthermore, Fig. 8 shows detailed top views of the transition plates 17, 18 as well as the inlet structures 19 arranged in the transition plates 17, 18. The transition plates 17, 18 comprise similar outlet structures that may, for example, be arranged on the diagonally opposite side of the transition plates 17, 18. Furthermore, Fig. 8 shows a detailed top view of the structure of an inlet 22 of the structured plates 4, 5. The inlet 22 here comprises a fluid separation structure 24. The fluid separation structure 24 comprises cooperating ridges 25. The fluid separation structure 24 serves to separate the fluid flow coming out of the outlet 22 into the corresponding primary fluid channel or secondary fluid channel. The use of such a fluid separation structure

24 improves the heat transfer efficiency of the heat exchanger 1. Irrespective of the structures of the structured plates 4, 5, each of the structured plates 4, 5 may comprise the same fluid separation structure 24 but different primary and secondary fluid channels for each stack structured plates 14, 15.

[0030] Fig. 9 shows a cut side view of the cooperation of the structureless separator plate 16 with the adjacent transition plates 17, 18. In particular, Fig. 9 shows how the inlet structure 19 fits to the structureless separator plate 16. Moreover, between the transition plate 18 and the structureless separator plate 16 a primary fluid channel 10 or a secondary fluid channel 11 may be arranged. The transition plate 18 may to this end comprise microstructures (hills and valleys and/or wedge-like structures) to improve the heat transfer but these are omitted for simplicity.

[0031] Fig. 10 shows a detailed view of an outlet manifold 21 as shown in Fig. 7. Moreover, Fig. 10 shows a detailed isometric view of a fluid separation structure 24. Adjacent structured plates 4 may here cooperate by comprising matching ridges 25 to both form the fluid separation structure 24 as well as block the entry of e.g. the secondary fluid flowing into a primary fluid channel 10.

Claims

1. A heat exchanger (1) comprising a top plate (2) and a bottom plate (3) as well as a plurality of structured plates (4, 5) arranged between the top plate (2) and the bottom plate (3), wherein adjacent structured plates (4, 5) cooperate to form primary fluid channels (10) and secondary fluid channels (11) between neighboring structured plates (4, 5), wherein the heat exchanger (1) comprises at least two stacks of structured plates (14, 15), wherein the structured plates (4, 5) in at least one of the stacks of structured plates (14, 15) form different primary fluid channels (10) and secondary fluid channels (11) than the primary fluid channels (10) and secondary fluid channels (11) in at least one other stack of structured plates (14, 15), wherein between each pair of adjacent stacks of structured plates (14, 15) a structureless separator plate (16) is arranged, **characterized in that** at least one transition plate (17, 18) is arranged on each side of the structureless separator plate (16).
2. The heat exchanger (1) according to claim 1, **characterized in that** one of the transition plates (17, 18) is arranged fitting closely to the adjacent structureless plate (16) for the majority of the area of the structureless plate (16).
3. The heat exchanger (1) according to claim 1 or 2, **characterized in that** one of the transition plates (17, 18) is arranged fitting closely to an adjacent structure plate (4, 5) of one of the adjacent stacks of

structured plates (14, 15) for the majority of the area of the adjacent structure plate (4, 5).

4. The heat exchanger (1) according to any of claims 1 to 3, **characterized in that** each structure plate (4, 5) comprises at least one primary inlet (6) and at least one primary outlet (7) from adjacent primary fluid channels (10), and wherein each structure plate (4, 5) comprises at least one secondary inlet to and at least one secondary outlet from adjacent secondary fluid channels (11).
5. The heat exchanger (1) according to claim 4, **characterized in that** at least one primary inlet (6) and/or at least one primary outlet (7) and/or at least one secondary inlet and/or at least one secondary outlet a fluid separation structure (24) is arranged in at least one of the structured plates (4, 5).
6. The heat exchanger (1) according to any of claims 1 to 5, **characterized in that** at least one fluid separation structure (24) is formed by cooperating ridges (25) of two adjacent structured plates (4, 5).
7. The heat exchanger (1) according to any of claims 1 to 6, **characterized in that** the structured plates (4, 5) in at least one of the stacks of structured plates (14, 15) form alternating hills 12 and valleys 13 to improve the heat transfer between the fluids and said structure plates (4, 5).
8. The heat exchanger (1) according to any of claims 1 to 7, **characterized in that** the structured plates (4, 5) in at least one of the stacks of structured plates (14, 15) form wedge-like structures to improve the heat transfer between the fluids and said structured plates (4, 5).

Patentansprüche

1. Wärmetauscher (1), der eine obere Platte (2) und eine untere Platte (3) sowie eine Mehrzahl von strukturierten Platten (4, 5) aufweist, die zwischen der oberen Platte (2) und der unteren Platte (3) angeordnet sind, wobei benachbarte strukturierte Platten (4, 5) zusammenwirken, um primäre Fluidkanäle (10) und sekundäre Fluidkanäle (11) zwischen benachbarten strukturierten Platten (4, 5) zu bilden, wobei der Wärmetauscher (1) mindestens zwei Stapel von strukturierten Platten (14, 15) aufweist, wobei die strukturierten Platten (4, 5) in mindestens einem der Stapel von strukturierten Platten (14, 15) unterschiedliche primäre Fluidkanäle (10) und sekundäre Fluidkanäle (11) als die primären Fluidkanäle (10) und die sekundären Fluidkanäle (11) in mindestens einem anderen Stapel von strukturierten Platten (14, 15) bilden, wobei zwischen jedem Paar

von benachbarten strukturierten Platten (14, 15) eine strukturlose Trennplatte (16) angeordnet ist, **dadurch gekennzeichnet, dass** mindestens eine Übergangsplatte (17, 18) auf jeder Seite der strukturlosen Trennplatte (16) angeordnet ist.

2. Wärmetauscher (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** eine der Übergangsplatten (17, 18) eng an die benachbarte strukturlose Platte (16) für den größten Teil der Fläche der strukturlosen Platte (16) angepasst angeordnet ist.
3. Wärmetauscher (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** eine der Übergangsplatten (17, 18) eng an einer benachbarten strukturierten Platte (4, 5) eines der benachbarten Stapel von strukturierten Platten (14, 15) für den größten Teil der Fläche der benachbarten strukturierten Platte (4, 5) angeordnet ist.
4. Wärmetauscher (1) nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** jede strukturierte Platte (4, 5) mindestens einen primären Einlass (6) und mindestens einen primären Auslass (7) aus benachbarten primären Fluidkanälen (10) aufweist, und wobei jede strukturierte Platte (4, 5) mindestens einen sekundären Einlass zu und mindestens einen sekundären Auslass aus benachbarten sekundären Fluidkanälen (11) aufweist.
5. Wärmetauscher (1) nach Anspruch 4, **dadurch gekennzeichnet, dass** in mindestens einer der strukturierten Platten (4, 5) mindestens ein primärer Einlass (6) und/oder mindestens ein primärer Auslass (7) und/oder mindestens ein sekundärer Einlass und/oder mindestens ein sekundärer Auslass einer Fluidstruktur (24) angeordnet ist.
6. Wärmetauscher (1) nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** mindestens eine Fluidtrennstruktur (24) durch zusammenwirkende Rippen (25) von zwei benachbarten strukturierten Platten (4, 5) gebildet ist.
7. Wärmetauscher (1) nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die strukturierten Platten (4, 5) in mindestens einem der Stapel von strukturierten Platten (14, 15) abwechselnd Hügel (12) und Täler (13) bilden, um den Wärmeübergang zwischen den Fluiden und den strukturierten Platten (4, 5) zu verbessern.
8. Wärmetauscher (1) nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die strukturierten Platten (4, 5) in mindestens einem der Stapel von strukturierten Platten (14, 15) keilförmige Strukturen bilden, um den Wärmeübergang zwischen den Fluiden und den strukturierten Platten (4, 5) zu ver-

bessern.

sortie secondaire d'une structure de séparation de fluide (24) est disposée dans au moins l'une des plaques structurées (4, 5).

Revendications

1. Échangeur de chaleur (1) comprenant une plaque supérieure (2) et une plaque inférieure (3) ainsi qu'une pluralité de plaques structurées (4, 5) disposées entre la plaque supérieure (2) et la plaque inférieure (3), dans lequel des plaques structurées adjacentes (4, 5) coopèrent pour former des canaux de fluide principaux (10) et des canaux de fluide secondaires (11) entre des plaques structurées voisines (4, 5), dans lequel l'échangeur de chaleur (1) comprend au moins deux piles de plaques structurées (14, 15), dans lequel les plaques structurées (4, 5) dans au moins l'une des piles de plaques structurées (14, 15) forment des canaux de fluide principaux (10) et canaux de fluide secondaires (11) différents des canaux de fluide principaux (10) et des canaux de fluide secondaires (11) dans au moins une autre pile de plaques structurées (14, 15), dans lequel, entre chaque paire de piles adjacentes de plaques structurées (14, 15), une plaque de séparation sans structure (16) est disposée, **caractérisé en ce qu'**au moins une plaque de transition (17, 18) est disposée de chaque côté de la plaque de séparation sans structure (16).
2. Échangeur de chaleur (1) selon la revendication 1, **caractérisé en ce que** l'une des plaques de transition (17, 18) est disposée de manière à épouser la plaque sans structure (16) adjacente pour la majorité de la superficie de la plaque sans structure (16).
3. Échangeur de chaleur (1) selon la revendication 1 ou 2, **caractérisé en ce que** l'une des plaques de transition (17, 18) est disposée de manière à épouser une plaque structurée (4, 5) adjacente de l'une des piles adjacentes de plaques structurées (14, 15) pour la majorité de la superficie de la plaque structurée adjacente (4, 5).
4. Échangeur de chaleur (1) selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** chaque plaque structurée (4, 5) comprend au moins une entrée principale (6) et au moins une sortie principale (7) de canaux de fluide principaux (10) adjacents, et dans lequel chaque plaque structurée (4, 5) comprend au moins une entrée secondaire vers des canaux de fluide secondaires (11) adjacents et au moins une sortie secondaire hors de ceux-ci.
5. Échangeur de chaleur (1) selon la revendication 4, **caractérisé en ce qu'**au moins une entrée principale (6) et/ou au moins une sortie principale (7) et/ou au moins une entrée secondaire et/ou au moins une
6. Échangeur de chaleur (1) selon l'une quelconque des revendications 1 à 5, **caractérisé en ce qu'**au moins une structure de séparation de fluide (24) est formée par des nervures (25) qui coopèrent de deux plaques structurées (4, 5) adjacentes.
7. Échangeur de chaleur (1) selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** les plaques structurées (4, 5) dans au moins l'une des piles de plaques structurées (14, 15) forment des bosses (12) et creux (13) qui alternent pour améliorer le transfert de chaleur entre les fluides et lesdites plaques structurées (4, 5).
8. Échangeur de chaleur (1) selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** les plaques structurées (4, 5) dans au moins l'une des piles de plaques structurées (14, 15) forment des structures semblables à un coin pour améliorer le transfert de chaleur entre les fluides et lesdites plaques structurées (4, 5).

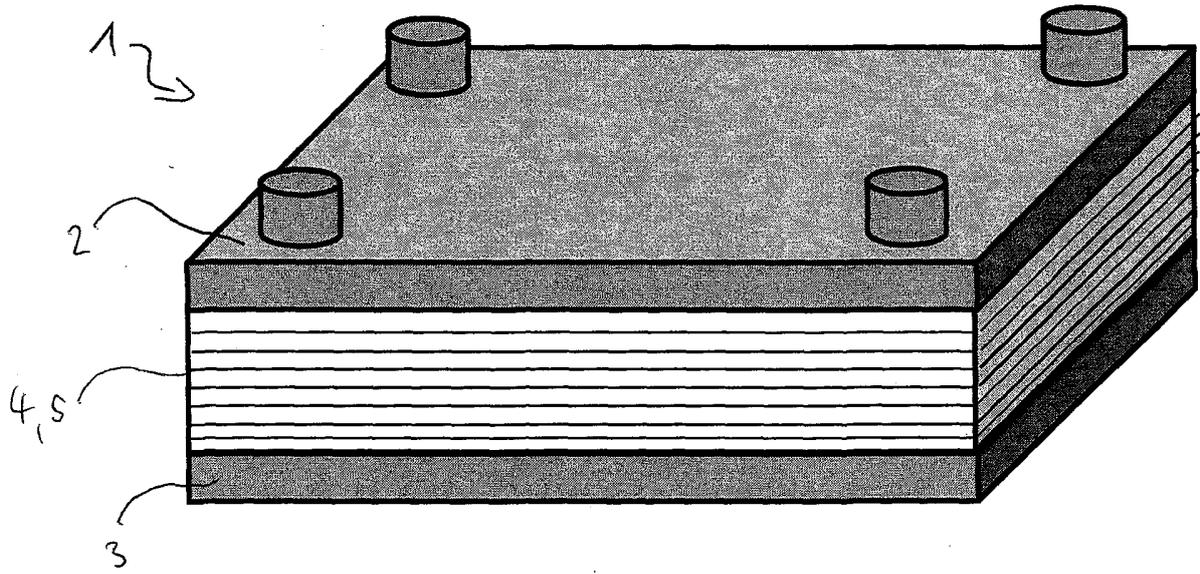


Fig. 1

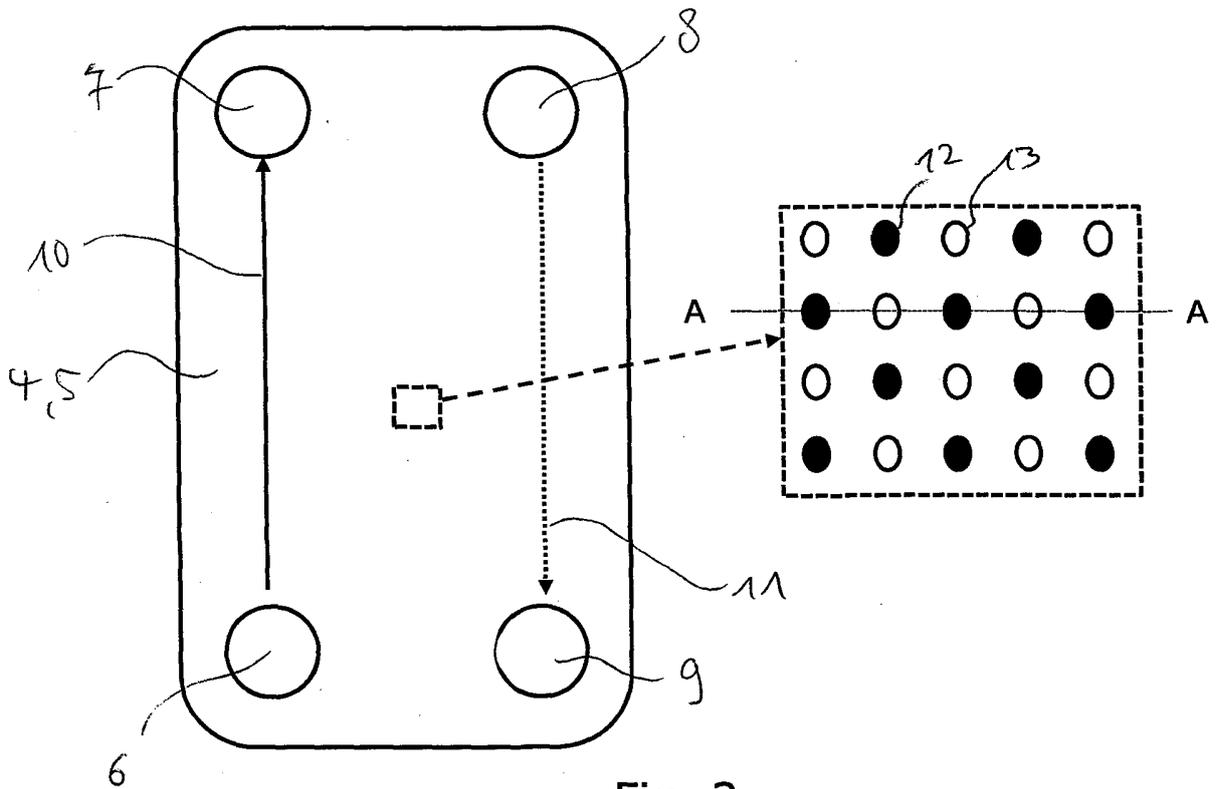
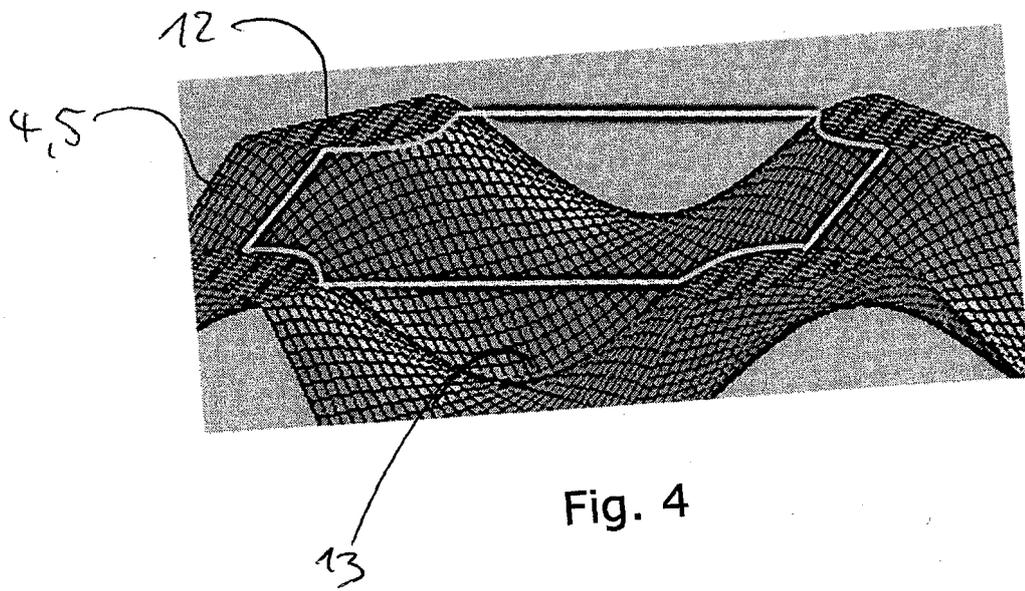
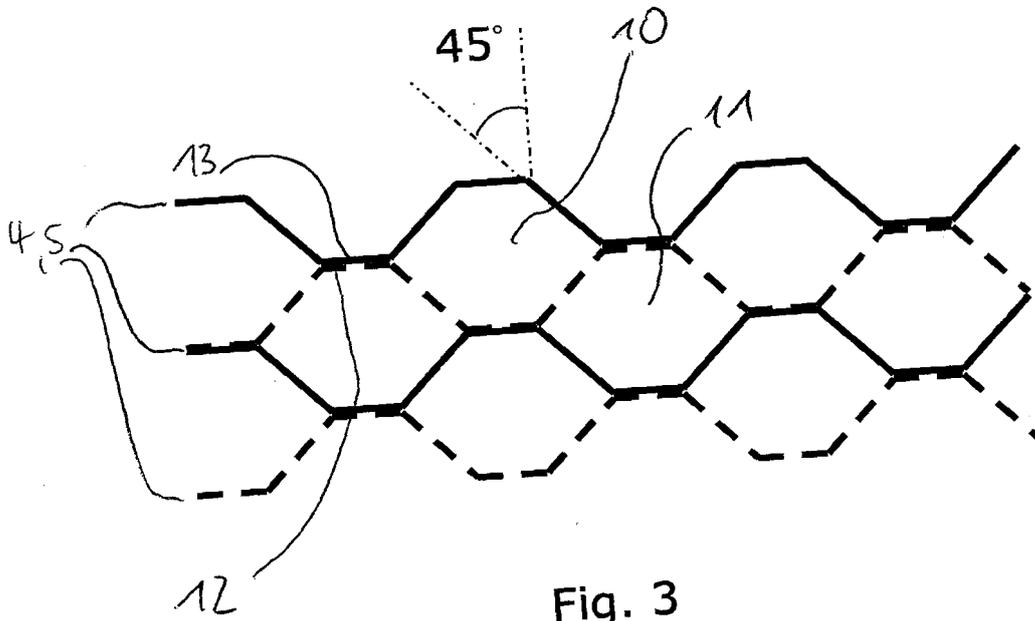


Fig. 2



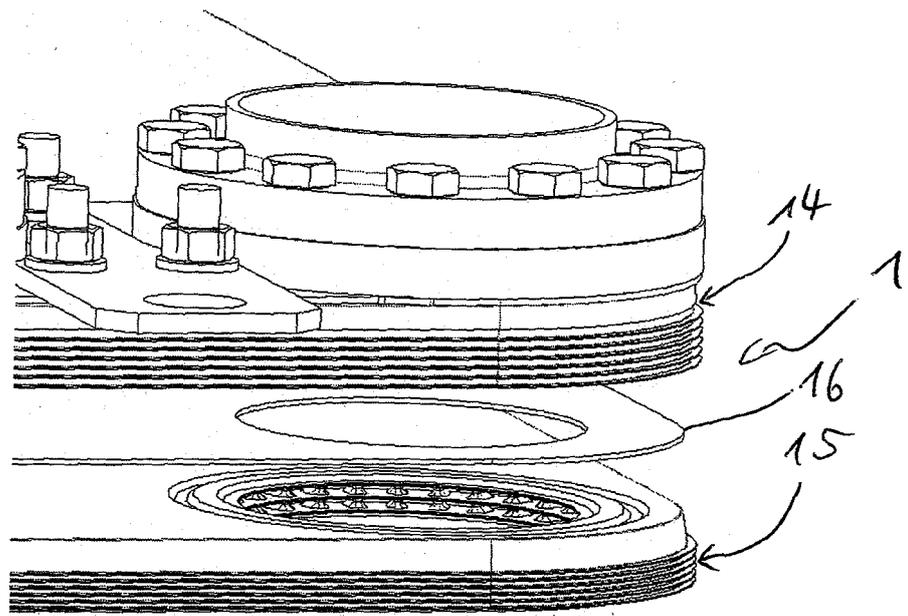
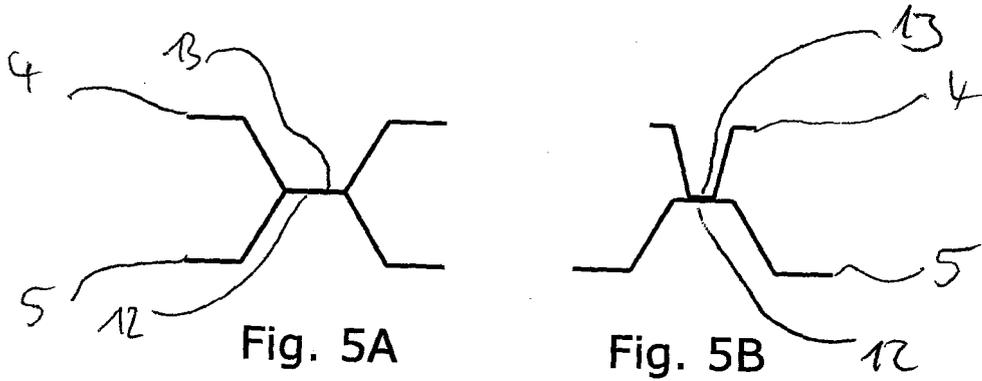
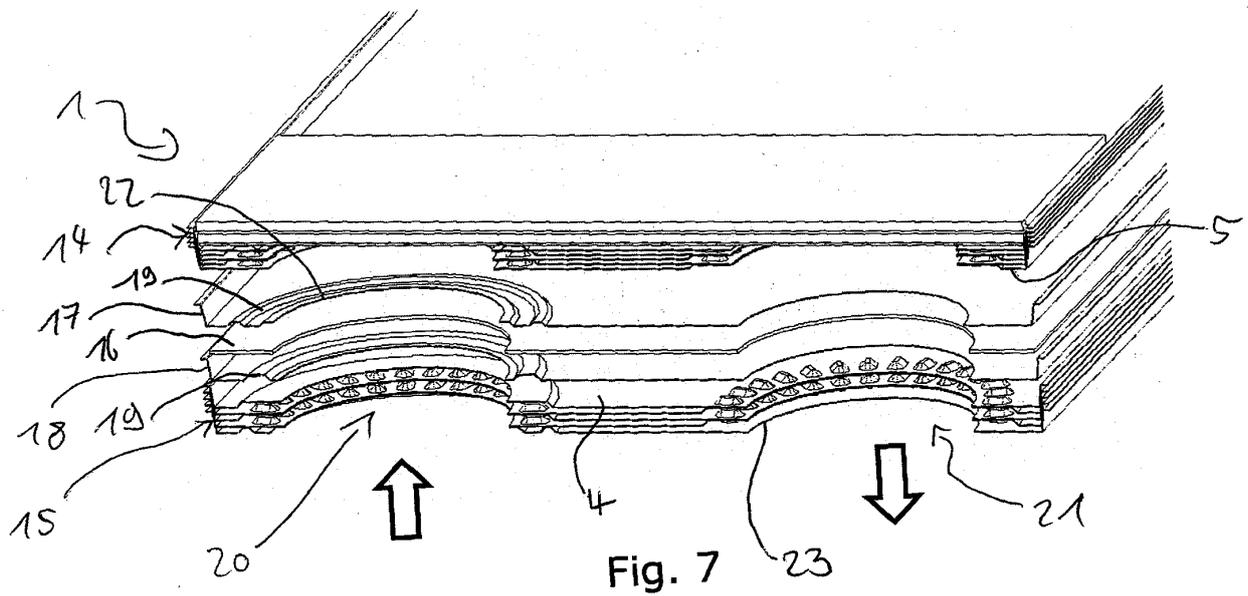


Fig. 6



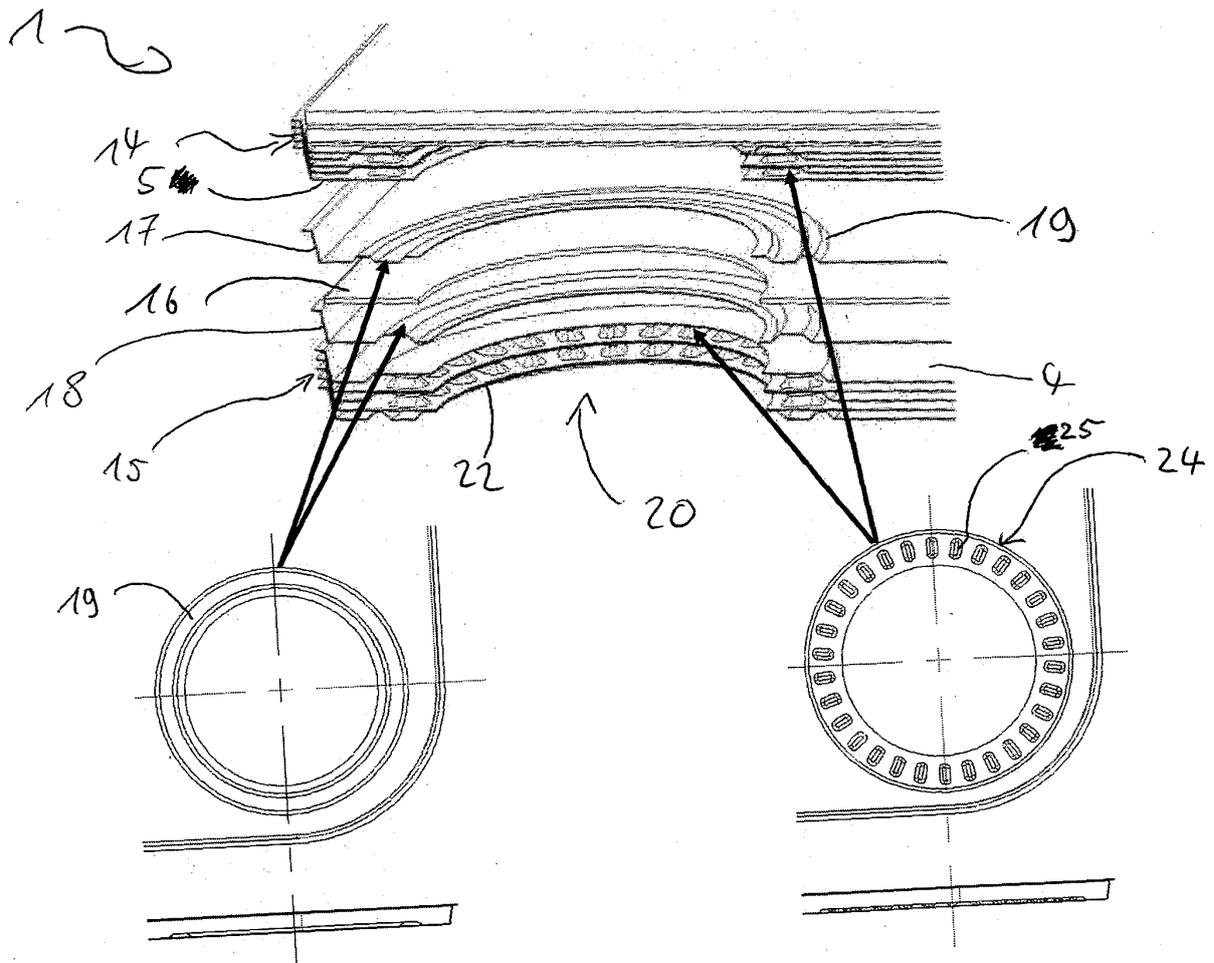


Fig. 8

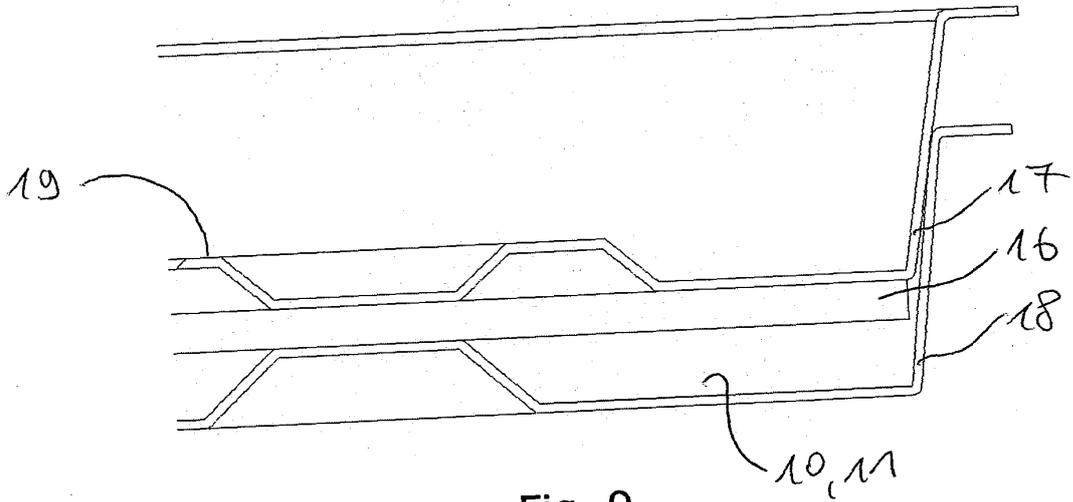


Fig. 9

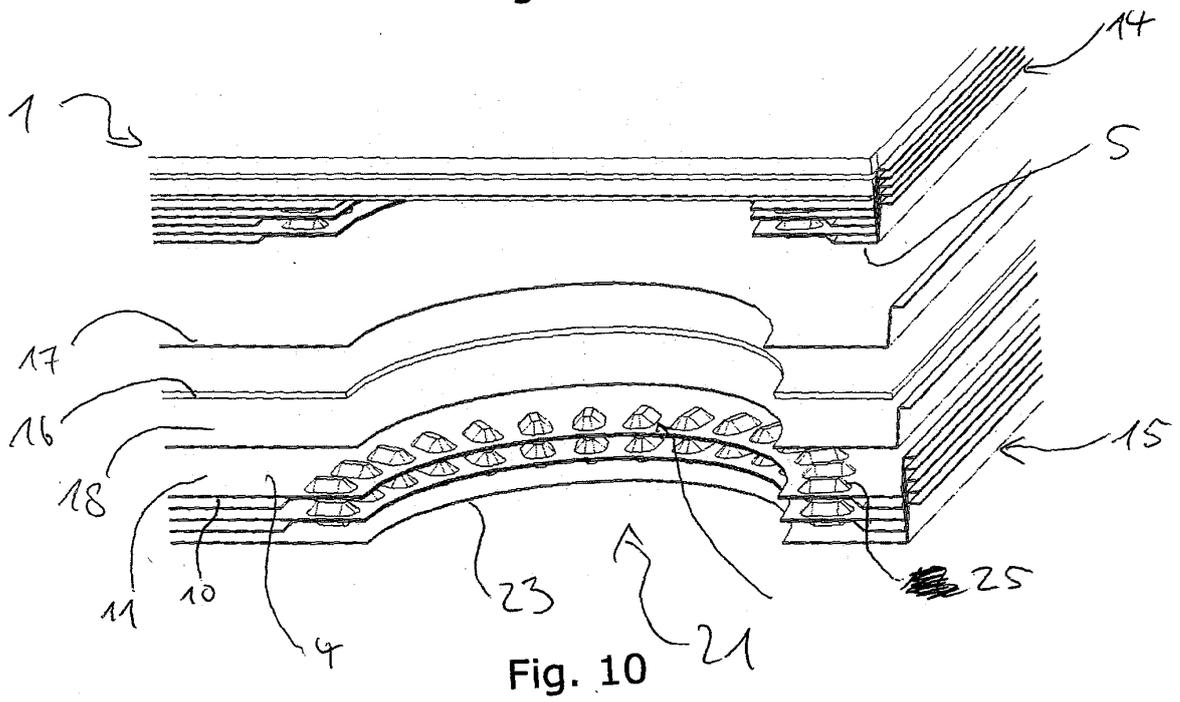


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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