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(54) Plate for heat exchanger, heat exchanger and air cooler comprising a heat exchanger.

(57) The present invention relates to a plate (1) for a heat exchanger for heat exchange between a first and a second medium, wherein the plate has a first side (A) and an opposing second side (B), wherein said first side (A) is configured with at least one heat transferring elevation (2) and with at least one heat transfer surface (4) surrounding said elevation, wherein dimples (5; 7) are provided at either or both of the heat transferring elevation (2) and the heat transfer surface (4) to permit provision of a through-flow duct (X) for the first medium, and wherein said second side (B) is configured with at least one heat transferring depression (3) corresponding to said elevation, said depression being configured to define a part of a through-flow duct (Y) for the second medium, and with at least one bonding surface (6) corresponding to said heat transfer surface and surrounding said depression. The present invention also relates to a heat exchanger comprising a stack of the above-mentioned plates and to an air cooler comprising such a heat exchanger.

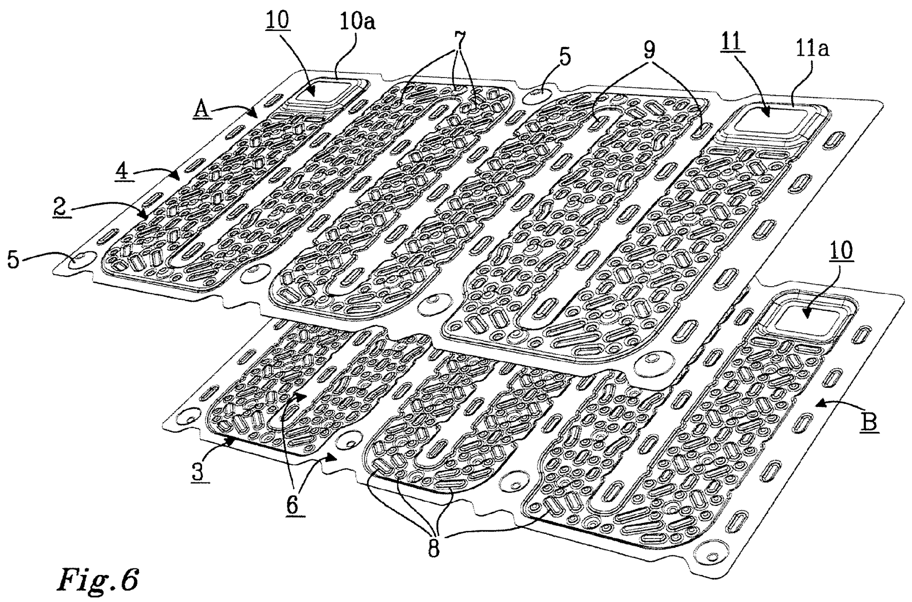

Fig.6

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Description

TECHNICAL FIELD

[0001] The present invention relates to a plate for a heat exchanger for heat exchange between a first and a second medium. The plate has a first side and an opposing second side. The first side of said plate is configured with at least one heat transferring elevation and is also configured to permit provision of a through-flow duct for the first medium. The second side of said plate is configured with at least one heat transferring depression corresponding with the elevation on said first side to define a part of a through-flow duct for the second medium.

[0002] The present invention further relates to a heat exchanger, wherein the heat exchanger comprises a stack of the above-mentioned plates. The plates are arranged such that the first side of each plate is abutting and assembled with the first side of an adjacent plate in the stack, thereby defining the through-flow duct for the first medium between said first sides of said plates. Consequently, the plates are also arranged such that the second side of each plate is abutting and assembled with the second side of an adjacent plate in the stack, thereby defining at least one through-flow duct for the second medium between said second sides of said plates.

[0003] The present invention also relates to an air cooler comprising the above-mentioned heat exchanger.

BACKGROUND OF THE INVENTION

[0004] Heat exchangers are used in many different areas, e.g. in the food processing industry, in buildings for use in heating and cooling systems, in gas turbines, boilers and many more. Attempts to improve the heat exchanging capacity of a heat exchanger is always interesting and even small improvements are highly appreciated.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide a plate for a heat exchanger and a heat exchanger for improved primary as well as secondary heat exchange.

[0006] The above and further objects are achieved by means of a plate wherein the first side of said plate is configured not only with at least one heat transferring elevation, but also with at least one heat transfer surface which surrounds said elevation and where dimples are provided at either or both of the heat transfer surface and the heat transferring elevation to permit provision of the through-flow duct for the first medium, and wherein the second side of the plate is configured not only with at least one heat transferring depression, but also with at least one bonding surface which corresponds to said heat transfer surface and which surrounds said depression.

[0007] Thus, the heat transferring elevation on the first side of the plate defines a primary heat transfer area for the first medium and the heat transfer surface surrounding said elevation a secondary heat transfer area for the first medium and the heat transferring depression on the second side of the plate defines a primary heat transfer area for the second medium. Thereby, a plate for a heat exchanger is provided, by means of which a larger heat transfer area for said first medium, which is the medium having the smallest coefficient of heat transmission, e.g. air in relation to water, which shall flow at a smaller speed/pressure, is defined.

[0008] By configuring the heat transferring elevation and the corresponding heat transferring depression such that the width thereof is many times larger than their height/depth and such that they have an extension with two or more straight, parallel or substantially parallel portions, the primary heat transfer areas for the first and the second medium respectively, are enlarged.

[0009] The above and other objects are achieved also by means of a heat exchanger wherein said plates are not only arranged such that the first side of each plate is abutting the first side of an adjacent plate in the stack, but also such that said plates thereby provide, by means of the dimples on either or both of the heat transfer surfaces and the heat transferring elevations on the first sides of two adjacent plates in the stack, the through-flow duct for the first medium between said first sides of said plates, and said plates are not only arranged such that the second side of each plate is abutting the second side of an adjacent plate in the stack, but also such that said plates thereby define, by means of the heat transferring depressions on the second sides of two adjacent plates in the stack, at least one through-flow duct for the second medium between said second sides of said plates.

[0010] Thus, since the through-flow duct for the first medium is provided by means of opposing dimples on the heat transfer surfaces on the first sides of two adjacent plates in the stack, and since the through-flow duct for the second medium is defined by opposing heat transferring depressions on the second sides of two adjacent plates in the stack, a heat exchanger is provided, by means of which a larger volume of the through-flow duct for said first medium is defined.

[0011] Since the through-flow duct for the second medium is defined by opposing heat transferring depressions having a width which is many times larger than their depth, i.e. the heat transferring surface of the through-flow duct is large in relation to its volume, and having an extension with two or more straight, parallel or substantially parallel portions, the primary heat transferring capacity of the heat exchanger is improved.

[0012] As defined, a heat exchanger is provided, the total heat-exchanging capacity of which is improved and the costs for its manufacture are reduced.

[0013] As defined, the heat exchanger may be used to provide e.g. an improved air cooler, i.e. one medium is air and the other a liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention will be further described below with reference to the accompanying drawings, in which

fig. 1 is a schematic perspective view of an embodiment of a plate according to the invention;

fig. 2 is another perspective view of the plate of fig. 1;

fig. 3 is a schematic plan view of one side of the embodiment of a plate according to figs 1 and 2;

fig. 4 is schematic plan view of the opposite side of the plate of fig. 3;

fig. 5 is a schematic side view of a part of the plate of figs. 1-4;

fig. 6 is a schematic perspective view of two plates according to figs. 1-4 ready for assembly;

fig. 7 is a schematic side view of the two plates of fig. 6 after assembly;

fig. 8 is a schematic view of four plates according to figs. 1-4 after assembly;

fig. 9a is a schematic perspective view of a heat exchanger according to the invention, comprising a stack of plates as illustrated in figs. 1-8;

fig. 9b illustrates schematically how the heat exchanger of fig. 9a is located in a refrigerated display case and how the first and second media thereby flow through the heat exchanger; and

fig. 10 is a schematic perspective view of a second embodiment of a plate according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0015] As already stated, the present invention relates to a plate for a heat exchanger for heat exchange between a first and a second medium.

[0016] The first and second medium referred to for heat exchange may be the same, e.g. gas/ /gas (such as air) or liquid/liquid (such as water). The first and second medium referred to may also be two different media, e.g. gas/liquid or two different gases or liquids.

[0017] As illustrated in particularly figs. 1-6, the plate 1 has a first side A and a second side B. The first side A of the plate 1 is configured with at least one heat transferring elevation 2. The first side A of the plate 1 is also configured to permit provision of a through-flow duct X (see fig. 8) for the first medium. The second side B of the plate 1 is configured with at least one heat transferring depression 3 substantially corresponding to the elevation 2 on the first side A, i.e. the depression defines the elevation 2 on said first side of the plate, with substantially the same length and width and with a depth corresponding to the height of said elevation. The heat transferring depression 3 is configured to define a part of a through-flow duct Y (see figs. 7 and 8) for the second medium. The heat transferring elevation 2 and the heat transferring depression 3 are brought to correspond to each other by subjecting the plate 1 to e.g. a stamping or punching process. If desired, more than one elevation 2 and corresponding depression 3 may be provided on the first side A and the second side B respectively, of the plate 1.

[0018] As is apparent from particularly figs. 1, 3 and 6, the first side A of the plate 1 is further configured with at least one heat transfer surface 4 which surrounds the heat transferring elevation 2. The heat transfer surface 4 is provided with dimples 5 which permit provision of the through-flow duct X for the first medium. The elevation 2 on the first side A of the plate 1 defines a primary heat transfer area for the first medium and the heat transfer surface 4 surrounding said elevation a secondary heat transfer area for the first medium. These primary and secondary heat transfer areas, i.e. the area of said elevation 2 and the area of said heat transfer surface 4 are together substantially equal to the entire area of the first side A of the plate 1. Correspondingly, as is apparent from figs. 2, 4 and 6, the second side B of the plate 1 is further configured with at least one bonding surface 6 which corresponds to, i.e. has the same extension as the heat transfer surface 4 on the first side A, and which accordingly surrounds the heat transferring depression 3. The depression 3 defines a primary heat transfer area for the second medium. This primary heat transfer area, i.e. the area of the depression 3, is substantially equal to the entire area of said second side of the plate minus the area of the bonding surface 6. From the above, it is apparent that the combined heat transfer areas for the first medium are larger than the heat transfer area for the second medium. This feature is advantageous when the first medium has a smaller coefficient of heat transmission, such as air in relation to water, and shall flow at a smaller speed/pressure then the second medium in order to provide for optimum heat transfer. A heat exchanger comprising plates constructed as described above, will have an improved heat-exchanging capacity.

[0019] Thus, a primary heat transfer area as defined above is provided by a surface on a member of the plate which is in direct contact with one medium and where the opposite surface on said member is in direct contact with the other medium, and a secondary heat transfer area is provided by a surface on a member of the plate which is in direct contact with one medium and where the opposite surface on said member is not in direct contact with the other medium.

[0020] To permit provision of the through-flow duct X for the first medium, the heat transferring elevation 2 on the first side A of the plate 1 is configured with a first height h1 and the dimples 5 on the heat transfer surface 4 on said first side has a second height h2 which is larger than said first height (see particularly fig. 5). Thereby, the dimples 5 protrude up above the elevation 2. The heat transferring depression 3 on the second side B of the plate 1, corresponding to the elevation 2, is consequently configured with a depth corresponding substantially to said first height h1. The heat transferring elevation 2 on the first side A of the plate 1 is in the illustrated embodiment of the plate provided with additional dimples 7 to permit provision of the through-flow duct X for the first medium. For this purpose, these additional dimples 7 have a height which together with the (first) height h1 of the elevation 2 is larger than said first height. In the illustrated embodiments, the height of the dimples 7 and the height h1 of the elevation 2 corresponds substantially to said second height h2, i.e. to the height of the dimples 5 on the heat transfer surface 4. Thus, the height of the dimples 7 is h2 minus h1. In the illustrated embodiment of a plate according to figs. 1-8, the heat transferring elevation 2 on the first side A of the plate has a first height h1 from the heat transfer surface 4 of about 0,5-1 millimeter and the corresponding heat transferring depression 3 on the second side B of the plate a depth from the bonding surface 6 corresponding substantially to said first height, and the dimples 5 on the heat transfer surface of side A has a second height h2 from said heat transfer surface of about 2-2,5 millimeters. These heights however, may vary in view of the intended application and size of the heat exchanger in which the plate shall be used. The dimples 5 and 7 on the first side A of the plate 1 can be made in any suitable manner, e.g. by a similar stamping or punching process as the heat transferring elevation 2/depression 3 such that corresponding depressions are formed in the bonding surface 6 and in the depression respectively, on the second side B of the plate, and simultaneously with said elevation/depression. The size, shape and number of the dimples 5, 7 may also vary in view of the intended application and size of the heat exchanger and so may the patterns in which they are arranged. The larger the plate 1, the more dimples 5, 7 providing distances and supporting points to permit provision of the through-flow duct X for the first medium will be required. It should be emphasized however, that according to the invention, it is possible to permit provision of the through-flow duct X for the first medium also by means of the dimples 5 on the heat transfer surface 4 only or by means of the dimples 7 on the heat transferring elevation 2 only. In the illustrated embodiment, the dimples 5, 7 are substantially round.

[0021] The dimples 5, 7 on the first side A of the plate 1 are suitable for abutment against and assembly in any suitable manner with corresponding dimples on the first side of another plate such that said dimples thereby permit provision of the through-flow duct X for the first medium (fig. 8). The bonding surface 6 on the second side B of the plate 1 is in the same way suitable for abutment against and leak-free assembly in any suitable manner with a corresponding bonding surface on the second side of another plate such that the heat transferring depressions 3 on said plates thereby define the through-flow duct Y for the second medium (figs. 7 and 8). However, the dimples 5, 7 on the first side A of the plate 1 may also be located such that abutment against and assembly with corresponding dimples on the first side of another plate is avoided, i.e. the dimples on the two plates are in some way located offset relative to each other. Similarly, it is also possible to locate the heat transferring depression 3 on the second side B of the plate 1 such that it is offset relative to a heat transferring depression on the second side of another plate.

[0022] The heat transferring depression 3 defining a part of the through-flow duct Y for the second medium on the second side B of the plate and the corresponding heat transferring elevation 2 on the first side A of the plate, may vary in shape, size, number and location. Accordingly, the depression 3 and the corresponding elevation 2 may e.g. be U-shaped, comprising two straight, parallel or substantially parallel portions. However, in order to prolong the time for heat exchange between the first and second media, the depression 3 and the corresponding elevation 2 may alternatively have a substantially sinusoidal shape with three or more straight, parallel or substantially parallel portions, i.e. an uneven (see fig. 10) or (as in figs. 1-8) an even number of straight, parallel or substantially parallel portions. In order to maximize the heat exchange between the first and second media, it is advantageous if the heat transfer area of the depression 3 and of the corresponding elevation 2 is as large as possible relative to the volume of the through-flow duct Y for the second medium. Therefore, the width w of the depression 3 and of the corresponding elevation 2 is in the illustrated embodiments substantially larger than the depth of said depression and the corresponding height of the elevation, e.g. at least about 5 times larger and preferably, as in the illustrated embodiments, about 50-70 times larger. Accordingly, in the illustrated embodiments with a heat transferring elevation 2 with a first height h1 of about 0,5-1 mm and a corresponding heat transferring depression 3 with a depth corresponding to said first height, the width w of the elevation and the corresponding depression will be at least about 2,5 mm and preferably about 25-70 mm. The width w of the depression 3 and the corresponding elevation 2 may be constant or may also vary along its length, as illustrated in particularly figs. 1-4, 6 and 10. In figs. 1-4, 6 and 10 it is shown how the width w of the straight parallel portions first decrease and then increase back to the original width. Thus, if the first height h1 and the corresponding depth is about 0,5 mm, the width w of the heat transferring elevation 2 and the corresponding heat transferring depression 3 may decrease from about 35 mm to about 25 mm and then again increase to about 35 mm. At the portions of the depression 3 and the corresponding elevation 2 connecting the straight parallel portions thereof, the width w is much smaller than at said straight portions, in the illustrated embodiments about 20 times larger than the first height h1 and the depth corresponding thereto. Also, the depression 3 and the corresponding elevation 2 may, as in the illustrated embodiments with a rectangular plate 1, be provided with the straight parallel portions thereof running in a direction transverse to the longitudinal direction of the plate or substantially transverse thereto. If desired, said straight parallel portions may alternatively run in the longitudinal direction of the plate 1 or in any other desired direction.

[0023] To prevent compression of the through-flow duct Y for the second medium, the heat transferring depression 3 on the second side B of the plate 1 is configured with pressure resisting dimples 8. These pressure resisting dimples 8 have in the illustrated embodiment a height corresponding substantially to said first height h1, i.e. the height of the heat transferring elevation 2 and consequently, the depth of the corresponding heat transferring depression, such that these dimples 8 end substantially at the same level from which the depression protrude. By ending at the same level as the bonding surface 6 on the second side B of the plate 1, said dimples 8 may engage the corresponding dimples on the second side of another plate to prevent compression of the through-flow duct Y for the second medium, and may also contribute to safe and effective assembly of said second side with the second side of said other plate. The dimples 8 also promote the flow of the second medium through the through-flow duct Y therefore, by creating turbulence in said flow such that the heat exchanging effect is improved. However, if desired, the height of the dimples 8 may be less than said first height h1. In the illustrated embodiment, the dimples 8 have a round as well as an elongated shape. Some of the elongated dimples are also curved. The dimples 8 may also be arranged in any suitable pattern for optimizing the heat exchanging effect.

[0024] To promote the flow of the first medium through the through-flow duct X therefor by reinforcing the through-flow duct and prevent it from collapsing, the heat transfer surface 4 on the first side A of the plate 1 is in a similar way provided with reinforcing dimples 9. These reinforcing dimples 9 have in the illustrated embodiments a height corresponding substantially to said first height h1, i.e. the height of the heat transferring elevation 2, such that the dimples end substantially at the same level as the elevation 2. However, it is desired that the height of the dimples 9 is less than said first height h1 and preferably as small as possible in order to minimize the pressure drop in the flow of the first medium in the through-flow duct X and yet maintain the reinforcing capacity of the dimples. The height of the dimples 9 can also be larger than said first height as long as it does not exceed the (second) height h2 of the dimples 5. In the illustrated embodiments, the dimples 9 have an elongated shape. The dimples 9 may also be arranged in any suitable pattern for optimizing the heat exchanging effect.

[0025] As with the heat transferring elevation 2/depression 3 and the above-mentioned dimples 5, 7 permitting provision of the through-flow duct X for the first medium, the dimples 8 and 9 can be made e.g. by a stamping or punching process or in any other suitable manner, and simultaneously with said elevation/depression and said above-mentioned dimples 5, 7. Corresponding depressions are thereby formed on the respective opposite side A, B of the plate 1, i.e. in the elevation 2 on side A and in the bonding surface 6 on side B respectively.

[0026] As stated above, the plate 1 may be rectangular in shape, with two opposing long sides 1 a and 1 b and two opposing short sides 1 c and 1 d, and with first and second portholes 10 and 11 for the second medium close to one of or both long sides and/or close to one of or both short sides. The location of the portholes 10, 11 is depending on the shape of the plate 1 as well as on the shape and location of the heat transferring elevation 2 and the corresponding heat transferring depression 3 on the plate. In the illustrated embodiment of a rectangular plate 1 with an elevation 2 and a corresponding depression 3 which comprises an even number of straight parallel portions, each of the portholes 10, 11 is located close to the same long side 1 a and one of the short sides 1 c, 1 d, in the corner defined by said long side and the respective short side (see figs. 1-4). With an elevation 2 and a corresponding depression 3 which comprises an uneven number of straight parallel portions, each of the portholes 10, 11 is e.g. located close to one of the long sides 1 a, 1 b and one of the short sides 1 c, 1 d, in the corner defined by the respective long side and the respective short side, i.e. diagonally opposite each other on the plate 1 (see fig. 10). Each of said portholes 10, 11 is on said first side A of the plate configured with an edge 10a and 11a respectively, which surrounds said porthole. Each edge 10a, 11a forms a part of the elevation 2 and has in the illustrated embodiment a height corresponding to the second height h2, i.e. to the height of the dimples 5 and to the combined height of the elevation 2 (h1) and the dimples 7 (h2-h1) respectively, and may have the same function as said dimples, i.e. to permit provision of the through-flow duct X for the first medium, as well as to pre-vent leakage of the second medium into the through-flow duct X for the first medium. The plate 1 may alternatively have a square shape, with four equally long sides, or any other suitable four-sided, triangular, multi-sided, round, rhombic, elliptic or other shape for the intended application or use.

[0027] In the illustrated embodiment according to at least figs. 1-8, where the intended use for the plate 1 is in a heat exchanger for a refrigerated display case, the plate 1 may have a length of about 270 millimeters and a width of about 150 millimeters. However, the plate 1 may have any other size optimized for its intended application. Accordingly, the length of the plate 1 may e.g. exceed 1 meter and the width thereof may exceed 0,5 meter. The size of the plate 1 may also be smaller than the plate in the illustrated embodiment and what is regarded as the width of the plate may be larger than what is regarded as the length thereof, based e.g. on how the plate is located in the heat exchanger and/or how the through-flow ducts X, Y for the first and second media are oriented.

[0028] As mentioned above, the present invention also relates to a heat exchanger for heat exchange between a first and a second medium, wherein said heat exchanger comprises a stack of plates 1 of the above-mentioned configuration. The stack of plates 1 may thereby be located in a more or less open frame work 12 as illustrated in fig. 9a with opposing plate elements 13 and 14, wherein at least one of the opposing plate elements (in fig. 9a plate element 13) is provided with pipe connections 15 and 16 for the second medium, and with a top panel 17 and a partially open bottom panel 18. The stack of plates 1 which may be located in the illustrated framework 12 may comprise 360 plates, having a total height of about 900 millimeters if each plate has a total height of about 2,5 millimeters. However, the number of plates 1 in the stack thereof may vary and so may the size of the heat exchanger, depending on its intended application or use.

[0029] If the heat exchanger is located in a refrigerated display case as illustrated in fig. 9b with the bottom panel 18 of the frame work 12 facing downwards, the top panel 17 of the frame work facing upwards and the opposing plate elements 13, 14 of the frame work facing to the sides, the plates 1 in the stack thereof will then in turn extend in substantially parallel vertical planes and the first medium (e.g. air to be chilled) will flow substantially horizontally into and through the heat exchanger. Thus, the first medium may flow into the heat exchanger e.g. from the left side thereof and then substantially horizontally to the right through the heat exchanger and leave the heat exchanger at its right side or, as is illustrated in fig. 9b, from the right side of the heat exchanger and then substantially horizontally, in a direction (illustrated by an arrow D2 in fig. 9b) to the left through the heat exchanger and leave the heat exchanger at its left side. The second medium (e.g. water for chilling the air) will flow into the heat exchanger through one of the pipe connections 15, 16 of the plate element 13 provided therewith, pass horizontally through the heat exchanger along a substantially sinusoidal path, the straight parallel or substantially parallel portions of which run in a substantially vertical direction (illustrated by an arrow D1 in fig. 9b), and leave the heat exchanger through the other of said pipe connections 16, 15 of said plate element. In the illustrated embodiment according to fig. 9b, the second medium flows into the heat exchanger through the left pipe connection 15 of the plate element 13 and leaves the heat exchanger through the right pipe connection 16. Thus, according to fig. 9b, the first medium flows in a substantially horizontal direction through the heat exchanger and the second medium in an opposite horizontal direction along a substantially vertical and substantially sinusoidal path through the heat exchanger, such that the first medium to be chilled meets the second medium for chilling in a heat transferring or heat exchanging manner when both media have the highest temperature and such that said first medium is gradually chilled by the gradually colder second medium. A multi-step counter flow is achieved, in which the first medium to be chilled repeatedly is brought in contact with the second medium for chilling which flows in the opposite horizontal direction along a substantially vertical and substantially sinusoidal path through the heat exchanger. Condensate from the chilled first medium will leave the heat exchanger at the bottom thereof, through the partially open bottom panel 18. A drain (not shown) may be provided at the bottom of the heat exchanger for collecting the condensate. Thus, the frame work 12 of the heat exchanger facilitates drainage of condensate from the heat exchanger. Also, inspection, cleaning and maintenance of the heat exchanger as shown, is facilitated by the illustrated frame work 12 thereof.

[0030] As already indicated above, the plates 1 in the stack thereof in the heat exchanger are arranged such that the first side A of each plate is abutting the first side A of an adjacent plate in the stack, thereby providing, by means of the dimples 5 on the heat transfer surfaces 4 and/or by means of the dimples 7 on the heat transferring elevations 2 on the first sides of two adjacent plates in the stack, the through-flow duct X for the first medium between said first sides of said plates. Furthermore, the plates 1 are arranged such that the second side B of each plate is abutting the second side B of an adjacent plate in the stack, thereby defining, by means of the heat transferring depressions 3 on the second sides of two adjacent plates in the stack, at least one through-flow duct Y for the second medium between said second sides of said plates.

[0031] By e.g. configuring each plate 1 such that the dimples 5 on the first side A of the plate have a second height h2 which is larger than the depth (corresponding to the first height h1 of the heat transferring elevation) of the heat transferring depression 3 on the second side B of the plate and such that the area of the heat transferring elevation 2 and of the heat transfer surface 4 on said first side of the plate is larger than the area of the heat transferring depression on the second side of the plate, as indicated above, the volume of the through-flow duct X for the first medium can be made larger than the volume of the through-flow duct Y for the second medium when the first sides A of two adjacent plates 1 and the second sides B of two adjacent plates respectively, are brought to abut each other. This may be true also if the dimples and the elevations/depressions are offset. As illustrated in figs. 7 and 8, the volume of the through-flow duct X for said first medium relative to the volume of the through-flow duct Y for said second medium is further increased when the through-flow duct for the first medium is provided by means of opposing dimples 5 on the heat transfer surfaces 4 and/or by means of opposing dimples 7 on the elevations 2 on the first sides A of two adjacent plates in the stack, and when the through-flow duct for the second medium is defined by opposing depressions 3 on the second sides B of two adjacent plates in the stack.

[0032] To provide for a safe and durable stack of plates 1, the first sides A of two adjacent plates in the stack are assembled at the dimples 5, offset or not, on the heat transfer surfaces 4 on said first sides and the second sides B of two adjacent plates in the stack are assembled at the bonding surfaces 6 on said second sides. The first sides A of two adjacent plates 1 in the stack may also or alternatively be assembled at the dimples 7 on the heat transferring elevations 2 if such dimples are present. Thus, in consequence of that the combined heat transfer areas on the first side A of the plate 1 are larger than the heat transfer area on the second side B of the plate, the total bonding area on said first side of the plate is smaller than the bonding area on said second side of the plate. Adjacent plates 1 may be assembled by means of e.g. a brazing process or by means of another suitable assembling method. Leak-free assembly is required at least of the opposing bonding surfaces 6 on the second sides B of respectively two adjacent plates 1 in the stack, and of the opposing edges 10a, 11 a of the portholes 10, 11 on the first sides A of respectively two adjacent plates in the stack.

[0033] It is obvious from the above that the different heights of the dimples 5 and of the heat transferring elevation 2/depression 3 will provide for a through-flow duct X for the first medium which is configured with an alternating height, i.e. when said first medium flows from left to right or from right to left in fig. 8 and from right to left as in fig. 9b. This alternating height will alter the speed/ /pressure of the first medium during the flow thereof through said through-flow duct X. Thus, in the illustrated embodiment according to at least figs. 1-8, the through-flow duct X for the first medium is configured with a third height h3 between the heat transferring elevations 2 on the first sides A of two adjacent plates 1 and a fourth height h4, which is larger than said third height, between the heat transfer surfaces 4, surrounding said elevations, on said first sides of said two adjacent plates. The fourth height h4 is thereby substantially equal to twice the (second) height h2 of the dimples 5 on the heat transfer surface 4 on the first side A of each plate 1 and the third height h3 is substantially equal to said fourth height minus twice the (first) height h1 of the elevation 2 on the first side of each plate (see particularly fig. 8).

[0034] In the illustrated embodiment according to at least figs. 1-8, the through-flow duct Y for the second medium is configured with a fifth height h5 which is substantially equal to twice the depth (corresponding to the (first) height h1 of the heat transferring elevation 2) of the heat transferring depression 3 on the second side B of each plate 1 (see particularly fig. 7).

[0035] The stack of plates 1 in the heat exchanger may comprise plates of one type. This may be the case when e.g. the heat transferring elevation 2 on the first side A of each plate and the corresponding heat transferring depression 3 on the second side B of each plate have a substantially sinusoidal shape with an even number of straight, parallel or substantially parallel portions (as in the embodiment of a plate according to figs. 1-8). Alternatively, the stack of plates 1 may comprise plates of two types. This may be the case when e.g. the elevation 2 on the first side A of each plate and the corresponding depression 3 on the second side B of each plate have a substantially sinusoidal shape with an uneven number of straight, parallel or substantially parallel portions (as in the embodiment of a plate according to fig. 10). Two types of plates 1 will also be required if e.g. the dimples 5 and/or the heat transferring elevations 2/depressions 3 on two adjacent plates are offset relative to each other and if the height of said elevation and/or said dimples on the first side A of one plate differs from the height of said elevation and/or said dimples on the first side A of another plate. The heights of the dimples 5 and/ /or of the elevations 2/depressions 3 may vary widely, but it is of course important in said latter embodiment with two types of plates that at least the total height of opposing dimples always is larger than the total height of opposing elevations for providing the through-duct X for the first medium between the first sides A of two adjacent plates.

[0036] The heat exchanger according to the present invention may be of the cross-flow type, wherein the straight, substantially parallel portions of the heat transferring depressions 3 on the second sides B of two adjacent plates 1 defining the through-flow duct Y for the second medium extend in a first direction D1 of the plate, and wherein the through-flow duct X for the first medium provided between the first sides A of two adjacent plates extends in a second direction D2 of the plate which is substantially perpendicular to said first direction. The heat exchanger outlined above is, as indicated, primarily a heat exchanger of this type. The heat exchanger according to the present invention may alternatively be of another type than said cross-flow type.

[0037] By utilizing a heat exchanger as defined above, comprising, inter alia, a stack of plates as defined above, it is in fact possible to reduce the energy consumption for chilling by about 20 % when e.g. water is used to chill air from a refrigerated display case. The primary reason for this positive result is that the temperature of the chilling water must not be reduced as much as in prior art constructions to provide for efficient chilling of the air. This is in turn the result of the prolonged, more extensive direct and indirect contact of the air with the water.

[0038] It will be evident to a skilled person that the plate and the heat exchanger according to the present invention can be modified and altered within the scope of the subsequent claims without departing from the idea and purpose of the invention. Thus, although the plate 1 is made preferably of aluminum, it can also be made of any other suitable material. The stack of plates in the heat exchanger can be located in a frame work which is more open as in the illustrated embodiment according to fig. 9a and the frame work can also be made of any suitable material. Furthermore, it is obvious that the heat exchanger in its intended application can be located in any suitable position, i.e. horizontally as in the illustrated embodiment or vertically or obliquely if that is required or desired. A heat exchanger as defined is suitable for use as an air cooler, since the first medium, the medium to be chilled, may be air.

Claims

1. Plate for a heat exchanger for heat exchange between a first and a second medium, wherein the plate (1) has a first side (A) and an opposing second side (B),
wherein the first side (A) of said plate (1) is configured with at least one heat transferring elevation (2) and with at least one heat transfer surface (4) surrounding said elevation, wherein dimples (5; 7) are provided at either or both of the heat transferring elevation (2) and the heat transfer surface (4) to permit provision of a through-flow duct (X) for the first medium, and
wherein the second side (B) of said plate (1) is configured with at least one heat transferring depression (3) corresponding to said elevation (2), said depression being configured to define a part of a through-flow duct (Y) for the second medium, and with at least one bonding surface (6) corresponding to said heat transfer surface (4) and surrounding said depression.

2. Plate according to claim 1,
wherein the heat transferring elevation (2) on the first side (A) of the plate (1) has a first height (h1) corresponding to a depth of the heat transferring depression (3) on the second side (B) of the plate, and
wherein the heat transferring elevation (2) has a width (w) corresponding to a width of the heat transferring depression (3).

3. Plate according to claim 2,
wherein the dimples (5) provided on the heat transfer surface (4) on the first side (A) of the plate (1) has a second height (h2) which is larger than said first height (h1), and/or wherein the dimples (7) provided on the heat transferring elevation (2) on said first side (A) of the plate (1) has a height (h2-h1) which together with the height (h1) of the elevation is larger than said first height (h1).

4. Plate according to claim 2 or 3, wherein the width (w) of the heat transferring elevation (2) and of the corresponding heat transferring depression (3) is at least 5 times larger than said first height (h1) of said heat transferring elevation and the depth of said corresponding heat transferring depression.

5. Plate according to any one of claims 1-4, wherein the heat transferring elevation (2) on the first side (A) of the plate (1) and the corresponding heat transferring depression (3) on the second side (B) of the plate are configured with two or more straight, parallel or substantially parallel portions.

6. Plate according to any one of claims 2-5, wherein the heat transferring depression (3) on the second side (B) of the plate (1) is provided with pressure resisting dimples (8) with a height corresponding to said first height (h1) of the heat transferring elevation (2) and the depth of said corresponding heat transferring depression.

7. Plate according to any one of claims 2-6, wherein the heat transfer surface (4) on the first side (A) of the plate (1) is provided with reinforcing dimples (9).

8. Plate according to any one of claims 3-7, wherein the plate (1) is configured with first and second portholes (10 and 11) for the second medium, each of said portholes (10, 11) being on said first side (A) of the plate (1) configured with an edge (10a, 11a) which surrounds said porthole, said edge forming part of said heat transferring elevation (2) and having a height corresponding to said second height (h2) of the dimples (5) and/or corresponding to the height (h2-h1) of the dimples (7) provided on the heat transferring elevation (2) together with the height (h1) of said heat transferring elevation.

9. Heat exchanger for heat exchange between a first and a second medium,
wherein said heat exchanger comprises a stack of plates (1) according to any one of claims 1-8, and
wherein said plates (1) are arranged such that the first side (A) of each plate is abutting the first side (A) of an adjacent plate (1) in the stack, thereby providing, by means of the dimples (5; 7) on either or both of the heat transfer surfaces (4) or the heat transferring elevations (2) on the first sides (A) of two adjacent plates in the stack, the through-flow duct (X) for the first medium between said first sides of said plates, and such that the second side (B) of each plate (1) is abutting the second side (B) of an adjacent plate (1) in the stack, thereby defining, by means of the heat transferring depressions (3) on the second sides (B) of two adjacent plates in the stack, at least one through-flow duct (Y) for the second medium between said second sides of said plates.

10. Heat exchanger according to claim 9,
wherein the first sides (A) of two adjacent plates (1) in the stack are assembled at opposing dimples (5; 7) on either or both of the heat transfer surfaces (4) and the heat transferring elevations (2) on said first

sides, and assembled at opposing edges (10a, 11a) on said first sides surrounding portholes (10, 11) for the second medium in the plates by leak-free bonding of said edges to each other.

11. Heat exchanger according to claim 9 or 10, wherein the second sides (B) of two adjacent plates (1) in the stack are assembled by leak-free bonding of opposing bonding surfaces (6) on said second sides to each other.

12. Heat exchanger according to any one of claims 9-11, wherein straight, parallel or substantially parallel portions of the heat transferring depressions (3) on the second sides (B) of two adjacent plates (1) defining the through-flow duct (Y) for the second medium extend in a first direction (D1) of the plate, and wherein the through-flow duct (X) for the first medium provided between the first sides (A) of two adjacent plates (1) extends in a second direction (D2) of the plate which is substantially perpendicular to said first direction (D1).

13. Heat exchanger according to any one of claims 9-12, wherein the stack of plates (1) of the heat exchanger is located in a frame work (12) with opposing plate elements (13 and 14).

14. Heat exchanger according to claim 13, wherein at least one of the opposing plate elements (13, 14) is provided with pipe connections (15 and 16) for the second medium.

15. Air cooler comprising a heat exchanger according to any one of claims 9-14, wherein the first medium is air and the second medium is a liquid.

Amended claims in accordance with Rule 137(2) EPC.

1. Plate for a heat exchanger for heat exchange between a first and a second medium, wherein the plate (1) has a first side (A) and an opposing second side (B),
wherein the first side (A) of said plate (1) is configured with at least one heat transferring elevation (2) and with at least one heat transfer surface (4) surrounding said elevation, wherein dimples (5; 7) are provided at either or both of the heat transferring elevation (2) and the heat transfer surface (4) to permit provision of a through-flow duct (X) for the first medium, wherein the second side (B) of said plate (1) is configured with at least one heat transferring depression (3) corresponding to said elevation (2), said depression being configured to define a part of a through-flow duct (Y) for the second medium, and with at least one bonding surface (6) corresponding to said heat transfer surface (4) and surrounding said depression,
wherein the heat transferring elevation (2) on the first side (A) of the plate (1) has a first height (h1) corresponding to a depth of the heat transferring depression (3) on the second side (B) of the plate and a width (w) corresponding to a width of the heat transferring de-pression (3), and
wherein the heat transferring depression (3) on the second side (B) of the plate (1) is provided with pressure resisting dimples (8) with a height corresponding to said first height (h1) of the heat transferring elevation (2) and to the depth of said corresponding heat transferring depression.

2. Plate according to claim 1,
wherein the dimples (5) provided on the heat transfer surface (4) on the first side (A) of the plate (1) has a second height (h2) which is larger than said first height (h1), and/or wherein the dimples (7) provided on the heat transferring elevation (2) on said first side (A) of the plate (1) has a height (h2-h1) which together with the height (h1) of the elevation is larger than said first height (h1).

3. Plate according to claim 1 or 2, wherein the width (w) of the heat transferring elevation (2) and of the corresponding heat transferring depression (3) is at least 5 times larger than said first height (h1) of said heat transferring elevation and the depth of said corresponding heat transferring depression.

4. Plate according to any one of claims 1-3, wherein the heat transferring elevation (2) on the first side (A) of the plate (1) and the corresponding heat transferring depression (3) on the second side (B) of the plate are configured with two or more straight, parallel or substantially parallel portions.

5. Plate according to any one of claims 1-4, wherein the heat transfer surface (4) on the first side (A) of the plate (1) is provided with reinforcing dimples (9).

6. Plate according to any one of claims 2-5, wherein the plate (1) is configured with first and second portholes (10 and 11) for the second medium, each of said portholes (10, 11) being on said first side (A) of the plate (1) configured with an edge (10a, 11a) which surrounds said porthole, said edge forming part of said heat transferring elevation (2) and having a height corresponding to said second height (h2) of the dimples (5) and/or corresponding to the height (h2-h1) of the dimples (7) provided on the heat transferring elevation (2) together with the height (h1) of said heat transferring elevation.

7. Heat exchanger for heat exchange between a first and a second medium,

wherein said heat exchanger comprises a stack of plates (1) according to any one of claims 1-6, and wherein said plates (1) are arranged
such that the first side (A) of each plate is abutting the first side (A) of an adjacent plate (1) in the stack, thereby providing, by means of the dimples (5; 7) on either or both of the heat transfer surfaces (4) or the heat transferring elevations (2) on the first sides (A) of two adjacent plates in the stack, the through-flow duct (X) for the first medium between said first sides of said plates, and
such that the second side (B) of each plate (1) is abutting the second side (B) of an adjacent plate (1) in the stack, thereby defining, by means of the heat transferring depressions (3) on the second sides (B) of two adjacent plates in the stack, at least one through-flow duct (Y) for the second medium between said second sides of said plates.

8. Heat exchanger according to claim 7,
wherein the first sides (A) of two adjacent plates (1) in the stack are assembled at opposing dimples (5; 7) on either or both of the heat transfer surfaces (4) and the heat transferring elevations (2) on said first sides, and assembled at opposing edges (10a, 11a) on said first sides surrounding portholes (10, 11) for the second medium in the plates by leak-free bonding of said edges to each other.

9. Heat exchanger according to claim 7 or 8,
wherein the pressure resisting dimples (8) in the heat transferring depressions (3) on the second sides (B) of two adjacent plates (1) in the stack are configured for engagement with each other when said second sides (B) of said two adjacent plates (1) in the stack abut each other.

10. Heat exchanger according to claim 9,
wherein the second sides (B) of two adjacent plates (1) in the stack are assembled by leak-free bonding of opposing bonding surfaces (6) on said second sides to each other and assembled at opposing dimples (8) in the heat transferring depressions (3) on said second sides.

11. Heat exchanger according to any one of claims 7-10,
wherein straight, parallel or substantially parallel portions of the heat transferring depressions (3) on the second sides (B) of two adjacent plates (1) defining the through-flow duct (Y) for the second medium extend in a first direction (D1) of the plate, and
wherein the through-flow duct (X) for the first medium provided between the first sides (A) of two adjacent plates (1) extends in a second direction (D2) of the plate which is substantially perpendicular to said first direction (D1).

12. Heat exchanger according to any one of claims 7-11, wherein the stack of plates (1) of the heat exchanger is located in a frame work (12) with opposing plate elements (13 and 14).

13. Heat exchanger according to claim 12, wherein at least one of the opposing plate elements (13, 14) is provided with pipe connections (15 and 16) for the second medium.

14. Air cooler comprising a heat exchanger according to any one of claims 7-13, wherein the first medium is air and the second medium is a liquid.

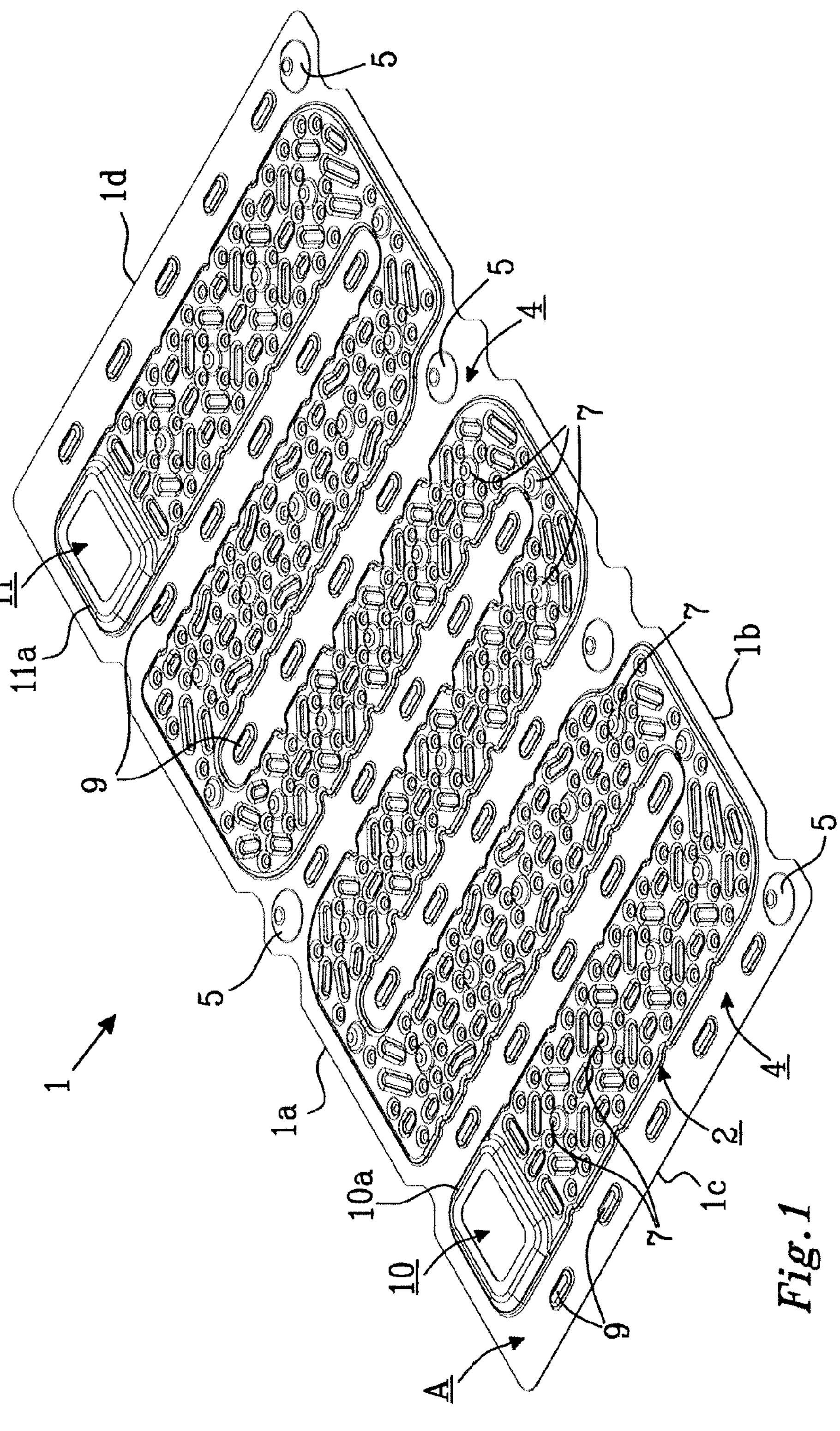

Fig. 1

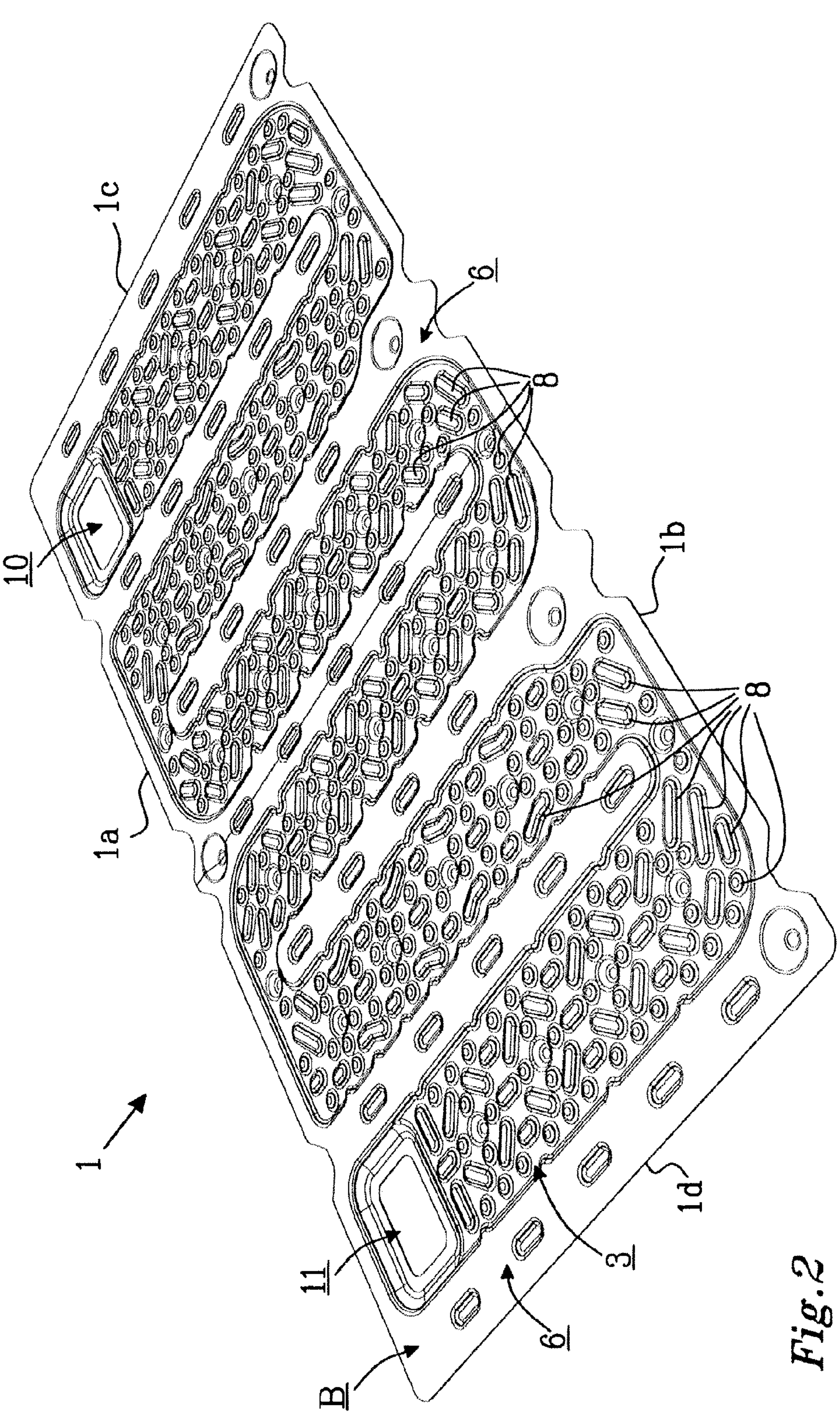

Fig.2

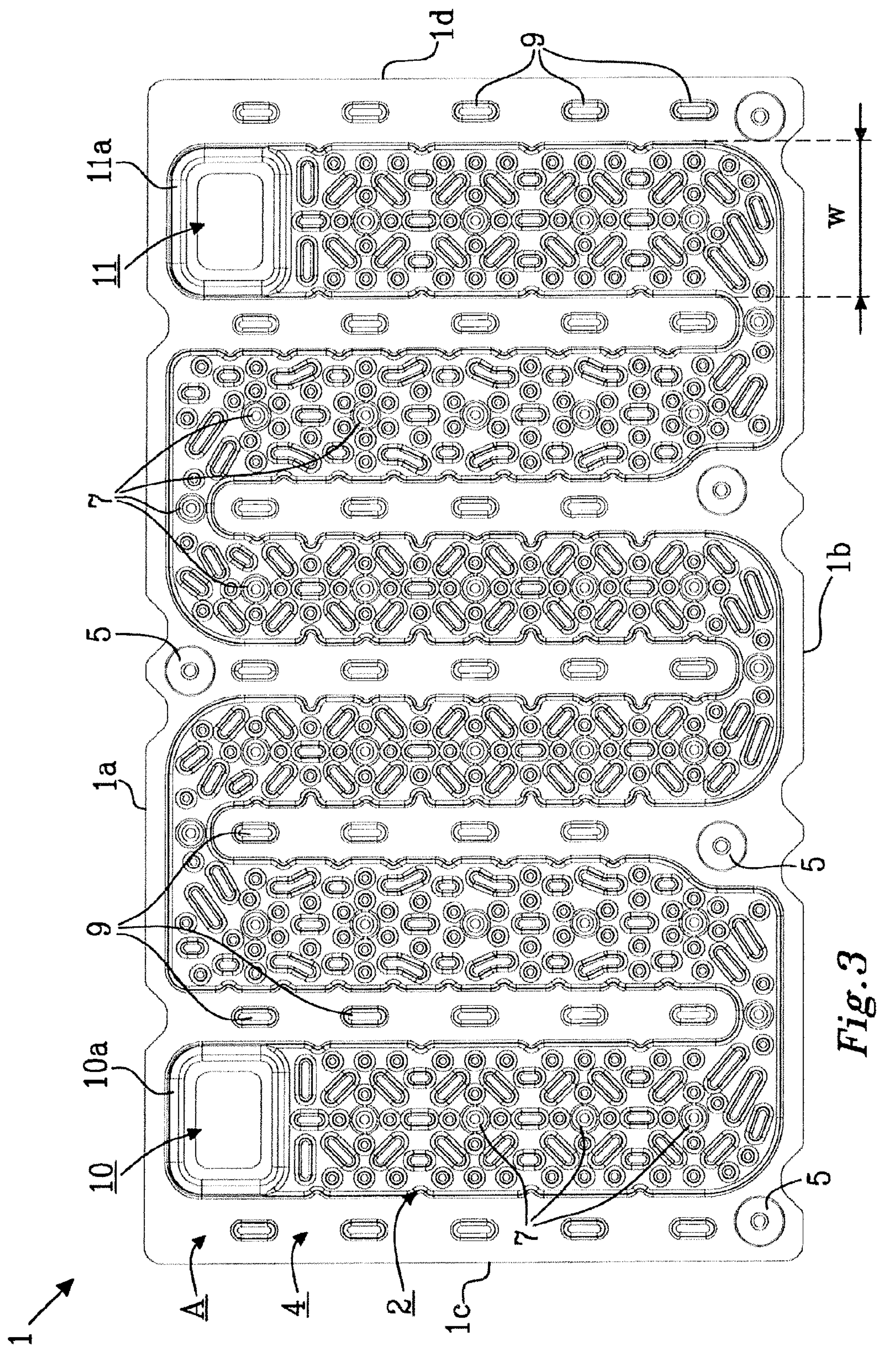

Fig.3

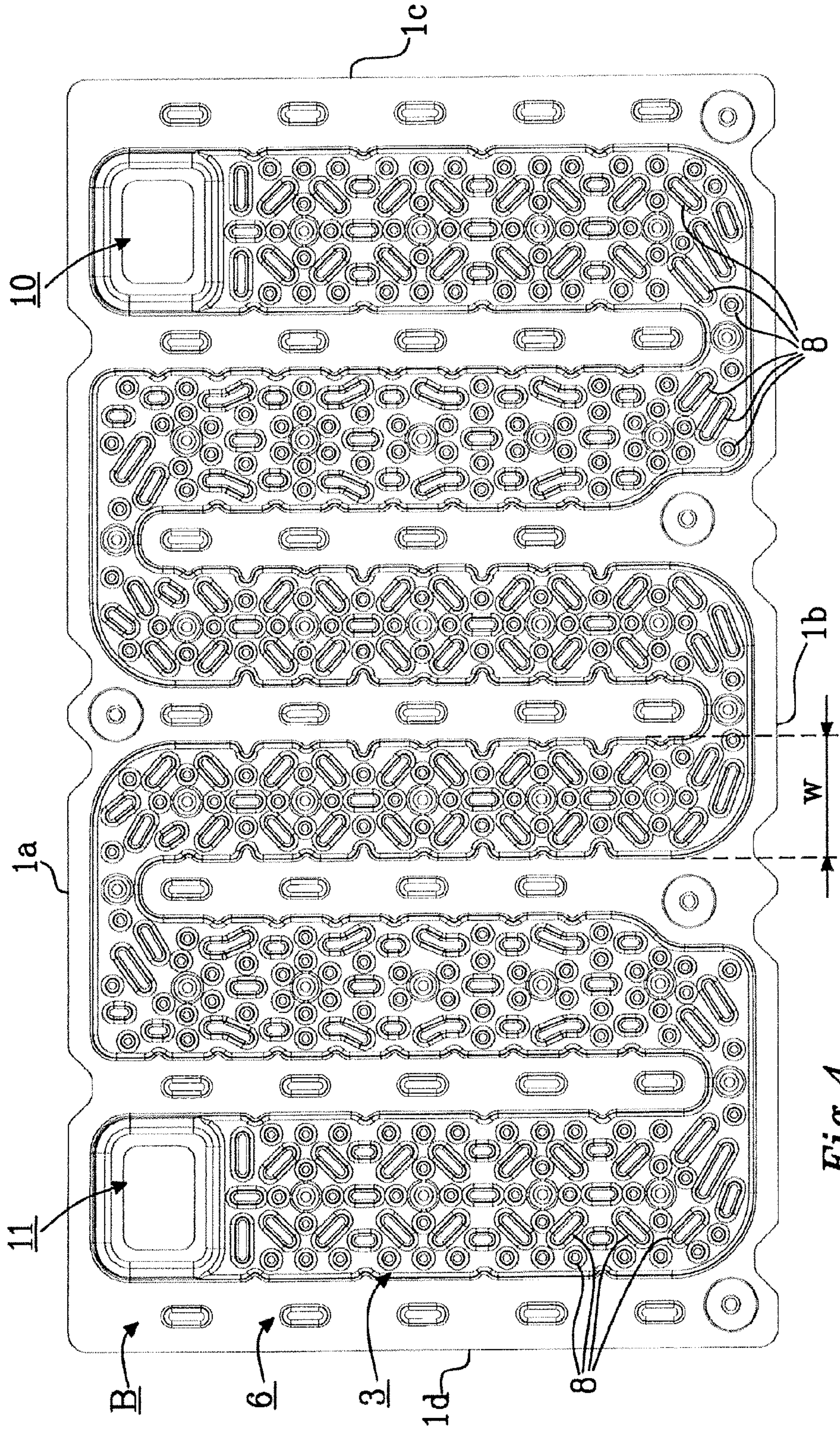

Fig.4

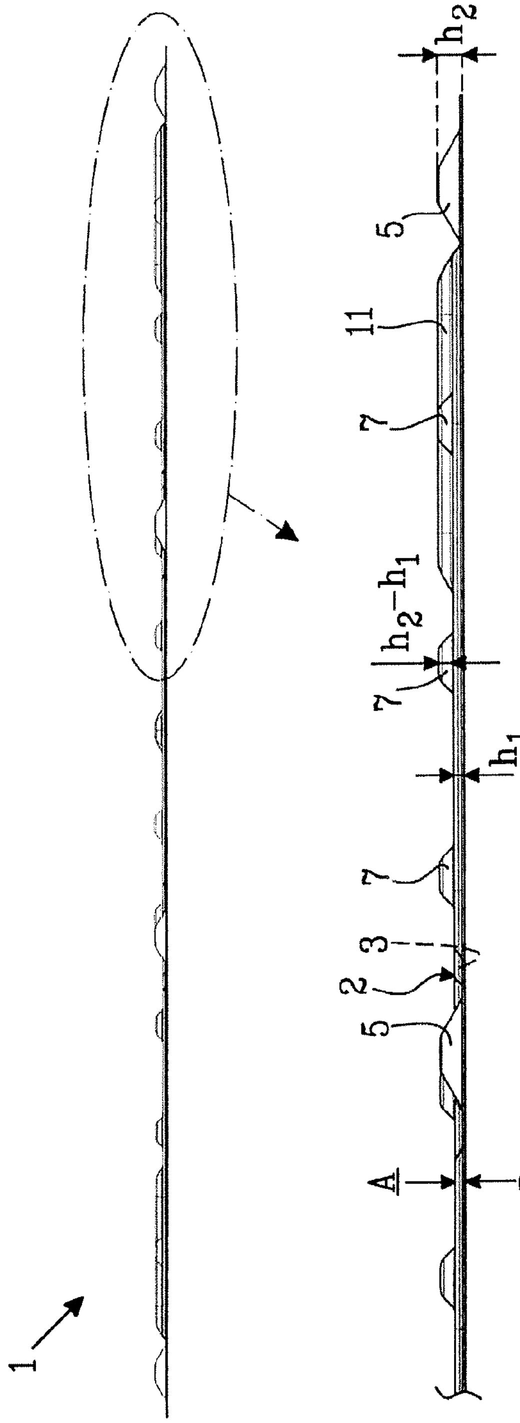

Fig.5

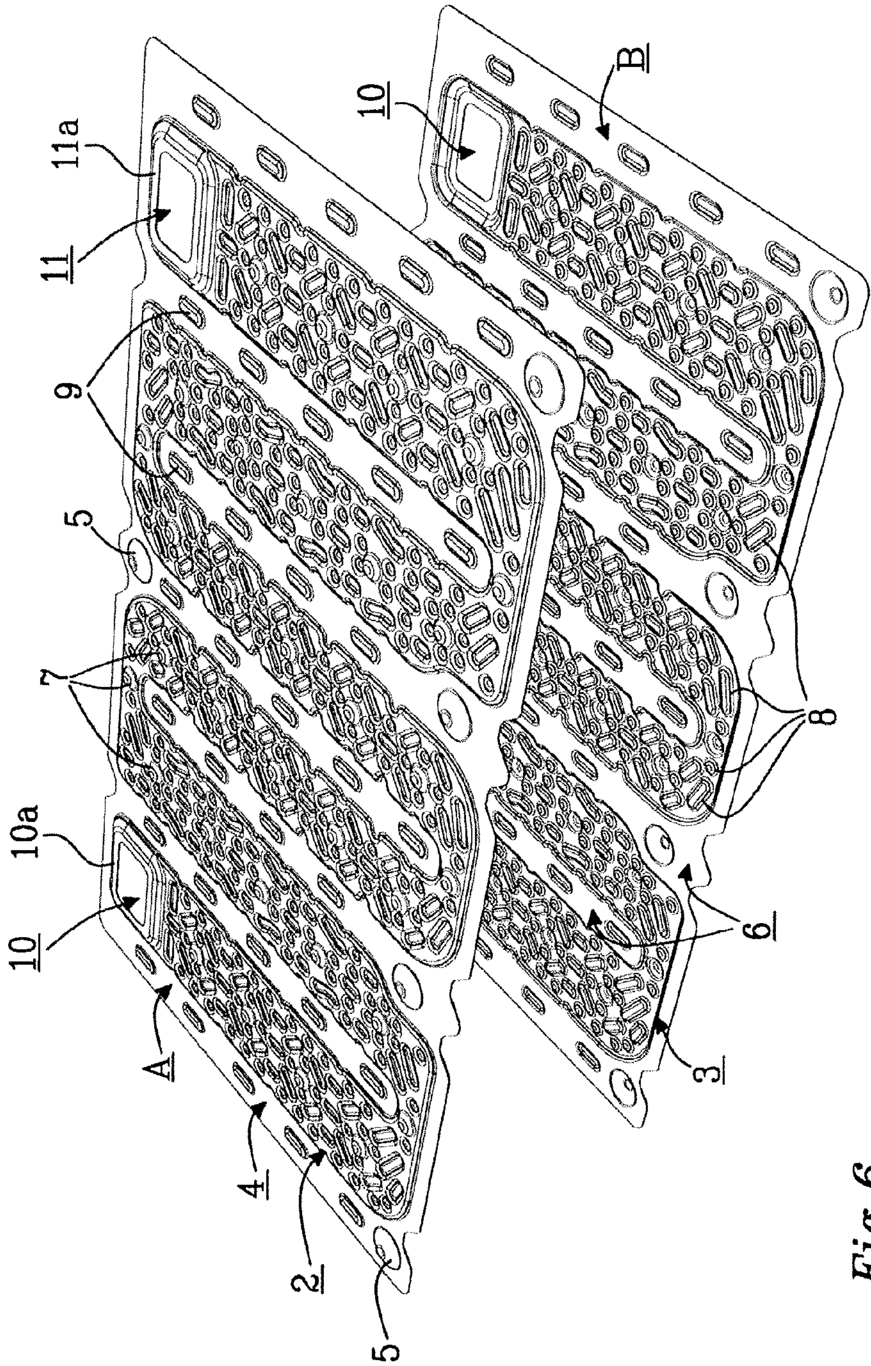

Fig.6

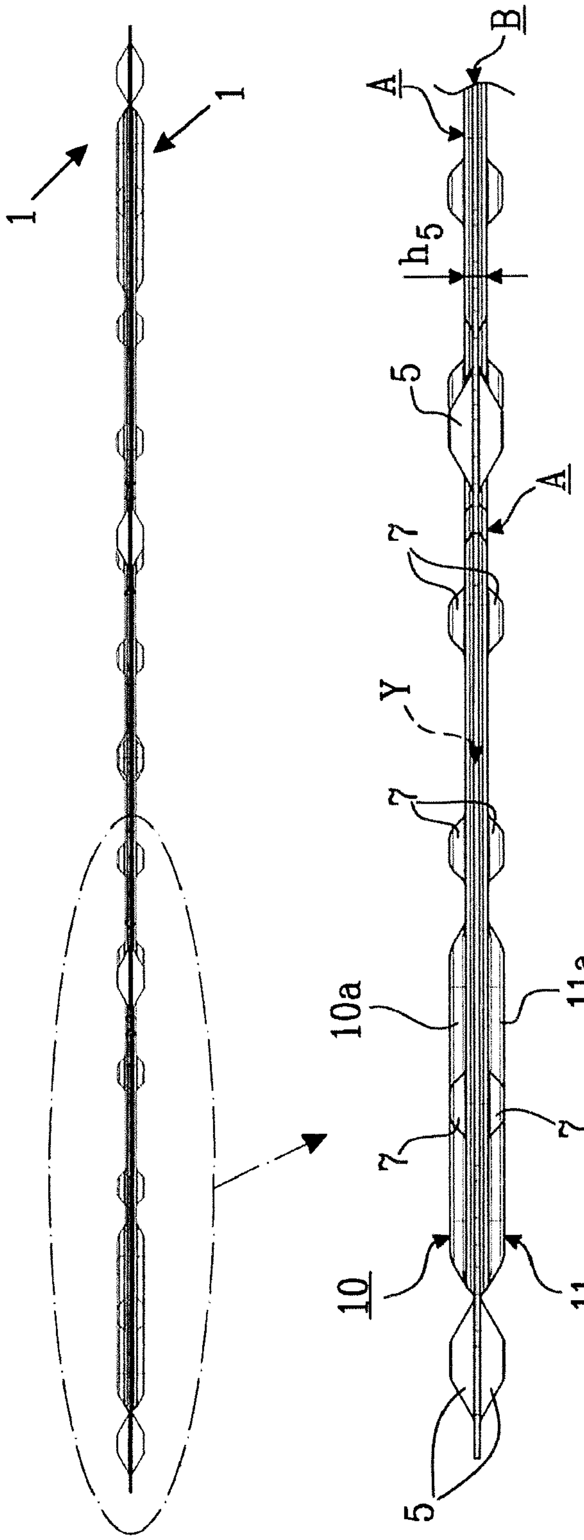

Fig. 7

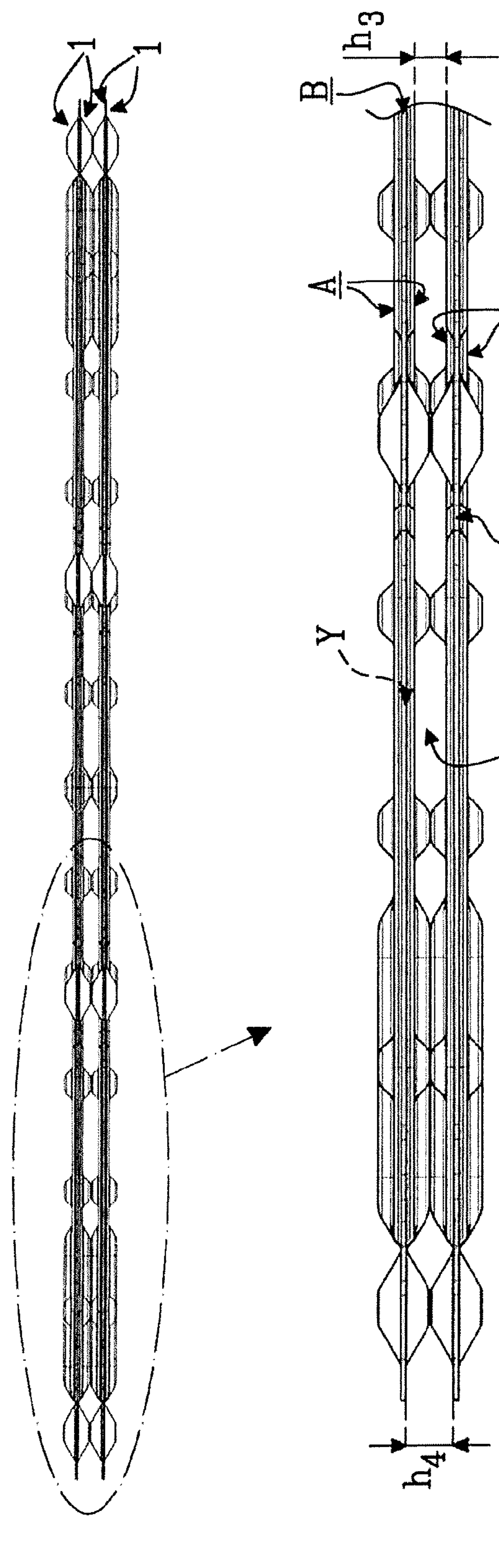

Fig.8

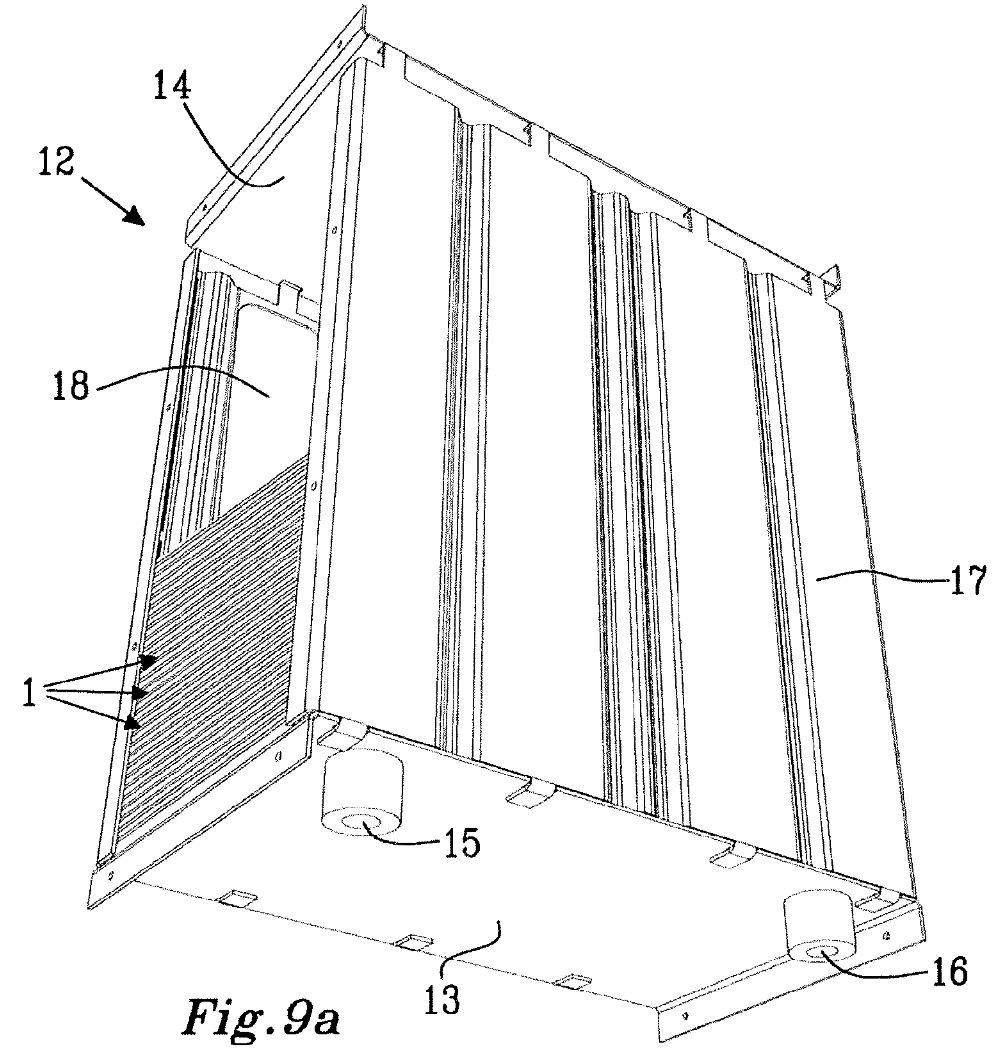

Fig.9a

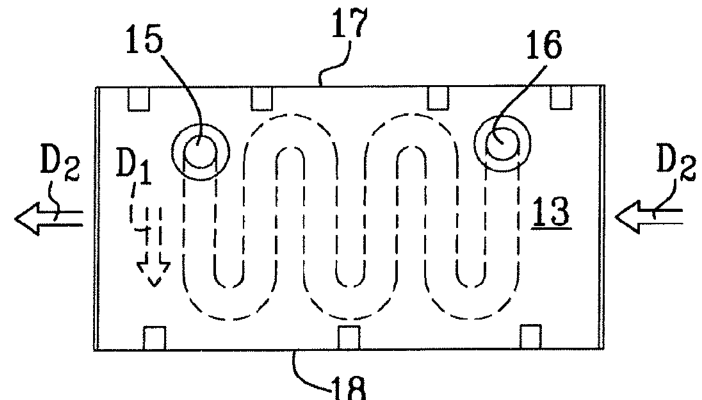

Fig.9b

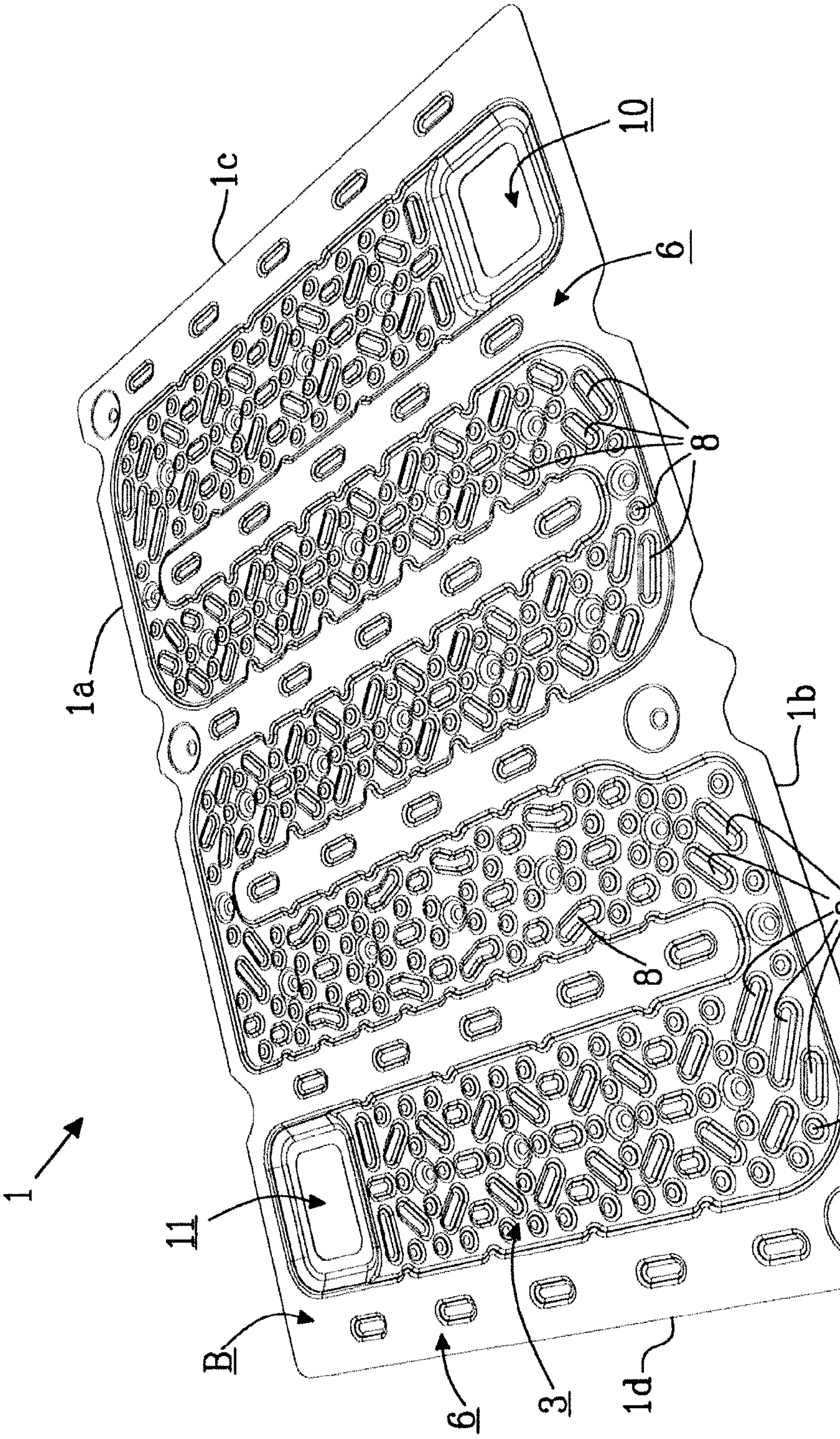

Fig.10

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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 5135

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F28D
F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	31 January 2013	Bain, David

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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