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(54) **A FLAT TUBE**

(57) The object of the invention is, among others, a flat tube (1) for the flow therein of a fluid in a heat exchanger, the tube (1) being formed by bending a sheet metal strip (2) along the length of the strip, the tube comprising: a first main wall (4); a second main wall (5) parallel to the first main wall (4), said main walls (4, 5) being substantially flat; and two complementary side wall portions (6) joining said main walls together so as to define a closed profile of the tube (1), said strip (2) defining over its width a middle region and two intermediate regions on either side of said middle region, the first main wall (4) of the tube (1) being formed from said middle region, said second main wall (5) of the tube (1) comprising two wall portions (5A, 5B) each formed from a respective one

of said intermediate regions, with said wall portions (5A, 5B) of the second main wall (5) being juxtaposed in substantially a common plane, a median wall (7) defined by a double thickness of the sheet metal strip (2) with one part attached to a first wall portion (5A) and the other part attached to a second wall portion (5B), and inner walls (8A, 8B) each formed from a respective one of said parts of the median wall (7), wherein a first piece of said inner wall is at least partially fixed and parallel to the first main wall (4), and a second piece of said inner wall is joining the main walls (4,5) within the middle region of the tube (1), wherein the strip 2 further comprises at least one deformation (9) configured to locally deviate the surface of any of the walls (4,5,6 5A, 5B).

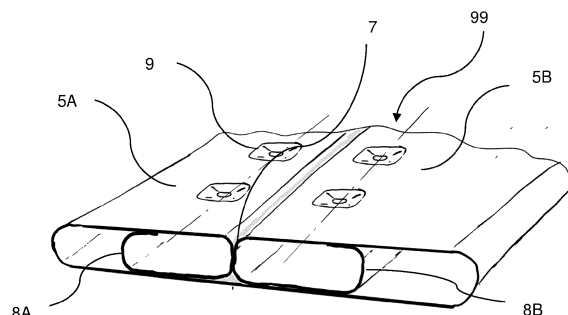


Fig. 4

## Description

### FIELD OF THE INVENTION

[0001] The invention relates to a flat tube. In particular, the invention relates to a flat tube for a heat exchanger.

### BACKGROUND OF THE INVENTION

[0002] Heat exchangers having folded flat tubes are well known in the art. Such heat exchangers typically include a plurality of the folded flat tubes spaced apart and arranged in parallel and extending between an inlet header tank and an outlet header tank. The inlet header tank receives a first fluid and distributes the first fluid between a plurality of flow pathways formed within the flat tubes. The first fluid exchanges heat energy with a second fluid flowing through the spaces between adjacent ones of the flat tubes. After exchanging the heat energy within the flat tubes, the first fluid is recombined within the outlet header tank before exiting the heat exchanger.

[0003] One common construction of a flat tube includes folding a sheet of aluminum into a tubular structure wherein two opposing edges of the sheet are brought together and then brazed or welded at the resulting seam to form a substantially B-shaped flat tube. The central seam of the B-shaped flat tube is typically further reinforced by adding at least one fold to the opposing edges of the sheet. The folded over portions of the sheet of aluminum are positioned to abut an inner surface of the flat tube along a length thereof to form a longitudinally extending partition, wherein the partition divides a hollow interior of each of the flat tubes into two flow separate paths while also structurally reinforcing the flat tube along the central seam of the tube.

[0004] One potential issue faced by the traditional B-shaped flat tube construction occurs as a result of the effects of thermal cycling. The repeated presence of varying characteristics within different portions of each of the tubes, such as varying temperatures experienced in different regions of each of the tubes, may lead to the formation of a bending moment within each of the tubes, such as between two adjacent flow channels formed within each of the tubes. The formation of such bending moments may affect the durability of such tubes when exposed to extended periods of thermal cycling including varying temperatures experienced between the two flow channels of each of the tubes.

[0005] The B-shaped folded flat tube construction has been found to be particularly susceptible to thermal cycling failure at an intersection of each of the tubes and each of the header tanks. Each of the tubes is inserted into an opening formed in each of the header tanks, the opening having a cross-sectional shape substantially similar to that of an outer surface of each of the tubes, thereby restricting outward deformation of the outer surface of each of the tubes. Concurrently, the central partition adds rigidity to the interior of each of the tubes fur-

ther restricting relative movement between the opposing surfaces of each of the tubes adjacent the central partition. The added rigidity adjacent the intersection of each of the tube ends and each of the header tanks exacerbates the incidence of failure due to thermal cycling because the different portions of the tubes experiencing different degrees of thermal expansion are restricted from moving and deforming relative to each other during use of the heat exchanger. The restricted motion may in some circumstances lead to elevated stresses within portions of each of the tubes that can lead to permanent deformation or eventual failure adjacent each of the header tanks.

[0006] It would therefore be desirable to produce a tube for use in a heat exchanger having multiple flow channels while also preventing the incidence of failure at an intersection of the tube and an opening in a header tank configured to receive an end of the tube.

### SUMMARY OF THE INVENTION

[0007] The object of the invention is, among others, a flat tube for the flow therein of a fluid in a heat exchanger, the tube being formed by bending a sheet metal strip along the length of the strip, the tube comprising: a first main wall; a second main wall parallel to the first main wall, said main walls being substantially flat; and two complementary side wall portions joining said main walls together so as to define a closed profile of the tube, said strip defining over its width a middle region and two intermediate regions on either side of said middle region, the first main wall of the tube being formed from said middle region, said second main wall of the tube comprising two wall portions each formed from a respective one of said intermediate regions, with said wall portions of the second main wall being juxtaposed in substantially a common plane, a median wall defined by a double thickness of the sheet metal strip with one part attached to a first wall portion and the other part attached to a second wall portion, and inner walls each formed from a respective one of said parts of the median wall, wherein a first piece of said inner wall is at least partially fixed and parallel to the first main wall, and a second piece of said inner wall is joining the main walls within the middle region of the tube, wherein the strip further comprises at least one deformation configured to locally deviate the surface of any of the walls.

[0008] Advantageously, at least one deformation is disposed on at least one main wall.

[0009] Advantageously, at least one deformation is disposed on at least one of side wall portions.

[0010] Advantageously, at least one deformation is disposed on at least one of the wall portions.

[0011] Advantageously, the deformation is in form of protrusion projecting inwardly towards the center of the intermediate region.

[0012] Advantageously, the deformation is in form of protrusion projecting outwardly from the center of the in-

intermediate region.

**[0013]** Advantageously, the strip comprises at least one set of deformations, wherein the set is limited by the walls.

**[0014]** Advantageously, the deformations are equidistant within the set, with respect to axis of elongation of the tube.

**[0015]** Advantageously, the distance between consecutive deformations forming the set are different.

**[0016]** Advantageously, the deformation has an oblong shape.

**[0017]** Advantageously, the deformation has a pyramidal shape.

**[0018]** Advantageously, wherein the deformation has a substantially rectangular shape.

**[0019]** Advantageously, the sheet metal strip comprises an outside surface and a layer of braze metal on said outside surface, said layer having been pre-applied on the corresponding surface of said strip.

**[0020]** Another object of the invention is a heat exchanger comprising at least one flat tube .

**[0021]** The deformations allow to increase the rigidity of the tube in desired regions, without using additional elements and without increasing the thickness of the metal sheet strip. Consequently, the tube is able to withstand thermal shock caused by the rapid temperature and/or pressure change of the fluid. Furthermore, the deformations may increase the overall performance of the heat exchanger by deflecting the path of the fluid flowing through the tube, so that the heat exchange may be increased.

## BRIEF DESCRIPTION OF DRAWINGS

**[0022]** Examples of the invention will be apparent from and described in detail with reference to the accompanying drawings, in which:

Fig. 1 shows a perspective view of the tube section.

Fig. 2 shows a detailed view of a main wall of the tube of Fig.1.

Fig. 3 shows a cross-section view with locations suitable for receiving deformations.

Fig. 4 shows a perspective view of the tube with deformations on one of the main walls.

Fig. 5a shows a perspective view of the tube with deformations on one of the wall portions.

Fig 5b shows a top view of the tube of Fig. 5a.

## DETAILED DESCRIPTION OF EMBODIMENTS

**[0023]** The subject-matter of the invention is a flat tube 1 for the flow therein of a fluid in a heat exchanger. The

heat exchanger may be of any type as long as it is provided with so-called folded tubes. Such tube 1 may be formed by bending a sheet metal strip 2 along the length of the strip 2. The sheet of metal may be for example, aluminum.

**[0024]** The tube 1 may comprise an outside surface and a layer of braze metal 3 thereon. The braze material 3 may be, for example, a flux. The flux is a chemical compound applied to the joint surfaces before brazing. Its use, with a few exceptions, is crucial in the atmospheric brazing process. The braze material 3 may thus be pre-applied on the corresponding surface of said strip 2 to enhance the quality of the brazing joint.

**[0025]** As shown in Fig. 1, the tube 1 may further comprise a first main wall 4, a second main wall 5 which is substantially parallel with respect to the first main wall 4. The main walls 4, 5 may be substantially flat. The terms "substantially parallel" and "substantially flat" should be understood as allowing some deviances from ideal. It is desired that the walls are perfectly parallel or perfectly flat, yet one must take into account that during the production process or during the operational mode of the heat exchanger some deviations may occur.

**[0026]** The tube 1 may further comprise two complementary side wall portions 6 joining said main walls 4, 5 together so as to define a closed profile of the tube 1. Side wall portions 6 may be substantially arcuate in shape having a desired radius of curvature, but other shapes may be used without departing from the scope of the present invention.

**[0027]** Fig. 2 shows a detailed view of a main wall of the tube of Fig.1. It is notable that the braze material 3 is located on one side of the metal strip 2. This allows brazing all portions together.

**[0028]** As shown in Fig. 3 said strip 2 may define over its width a middle region and two intermediate regions on either side of said middle region. The middle region may comprise two channels for the fluid being separated by a median wall 7. The median wall 7 may divide the tube 1 into two substantially mirror-imaged portions. However, an embodiment in which the median wall is shifted towards either of the wall portions 6, or inclined so that it does not divide the tube 1 into two mirror-image portions, is also envisaged.

**[0029]** The median wall 7 may be twice the thickness of any of the main walls 4, 5 or any of the side wall portions 6.

**[0030]** The first main wall 4 of the tube 1 may be formed from said middle region. The second main wall 5 of the tube 1 may comprise two wall portions 5A, 5B each formed from a respective one of said intermediate regions.

**[0031]** The median wall 7 extends in the longitudinal direction of the tube 1, i.e. in the axis of elongation of the tube 1, and contacts the first and second main walls 4, 5. The portions forming the median wall 7 are preferably substantially perpendicular to the main walls 4,5. The median wall 7 is defined by a double thickness of the

metal sheet strip 2 with one part attached to the second main wall 5 and is located intermediate the side wall portions 6 and the wall portions 5A, 5B. Further, the wall portions 5A, 5B of the second main wall 5 may be juxtaposed in substantially a common plane.

**[0032]** The double thickness of the metal sheet strip 2 may extend in parallel to the first main wall 4 and within the respective middle region to form a first inner wall 8A and a second inner wall 8B. The wall portions inner walls 8A, 8B may protrude directly from the median wall 7 formed by the double thickness of the metal sheet strip 2 towards respective side wall portions 6. At least part of each inner wall 8A, 8B, namely a first piece, may be substantially parallel to the first main wall 4 and fixed thereto, for example, by brazing. The braze material 3 on corresponding side of the sheet metal strip 2 enhances the process of fixation. A respective second pieces of the inner walls 8A, 8B may protrude directly form the first pieces, yet they are no longer fixed to the first main wall 4. The second pieces may project towards the second main wall 5 and they may be fixed thereto. Further, the second pieces, similarly to side wall portions, be substantially arcuate in shape having a desired radius of curvature, but other shapes may be used without departing from the scope of the present invention. Substantially, the second pieces of the inner walls 8A, 8B may be fixed to the first main wall 4 so that the terminal end of second pieces face each other and at least portion of each of second pieces is substantially parallel to the second main wall 5. Said inner walls 8A, 8B along with the respective part of the median wall 7 and respective portions of the main walls 4, 5 may be regarded as the perimeter of the middle region of the tube 1.

**[0033]** The strip 2 may further comprise at least one deformation 9. Referring to Fig.3, the desired locations of the deformations 9 are marked with an oval shapes. The deformations allow to locally deviate the surface of any of the walls 4,5,6, 5A, 5B 8A, 8B. The deformations 9 allow to increase the rigidity of the tube 1 in desired regions, without using additional elements and without increasing the thickness of the metal sheet strip. Consequently, the tube 1 is able to withstand thermal shock caused by the rapid temperature and/or pressure change of the fluid. Furthermore, the deformations 9 may increase the overall performance of the heat exchanger by deflecting the path of the fluid flowing through the tube 1, so that the heat exchange may be increased.

**[0034]** The location and the number of the deformations 9 is not a limiting factor, thus they may be allocated according to the desired effects.

**[0035]** For example, at least one deformation 9 may be disposed on at least one of the main walls 4,5. The deformations 9 may also be located on both main walls 4,5.

**[0036]** Further, at least one deformation 9 may be disposed on at least one of side wall portions 6. The deformations 9 may also be located on both side wall portions 6.

**[0037]** For example, at least one deformation 9 may be disposed on at least one of the inner walls 8A, 8B. The deformations 9 may also be located on both inner walls 8A, 8B. Further, at least one deformation 9 may be disposed on at least first piece of inner wall 8A, 8B or second piece of inner wall 8A, 8B.

**[0038]** Further, at least one deformation 9 may be disposed on at least one of the wall portions 5A, 5B. The deformations 9 may also be located on both wall portions 5A, 5B.

**[0039]** As shown in Fig. 4, one or more deformations located on the same wall 4, 5, 5A, 5B may form a set 99. Each set 99 may comprise a random pattern, i.e. one cannot distinguish any rule or conception according to which the deformations are allocated. However, it is more likely that one can distinguish pattern in which the set 99 of deformations 9 is allocated on particular wall 4, 5, 5A, 5B.

**[0040]** For example, the deformations 9 may be arranged in series. The distance between each deformation 9 of the set 99 may be equal or different or increasing. The deformations 9 may thus be equidistant within the set 99, with respect to axis of elongation of the tube 1.

**[0041]** For example, the deformations 9 may be arranged in zig-zag pattern. The distance between each deformation 9 of the set 99 may be equal or different or increasing.

**[0042]** As shown in Figs 5a and 5b, the deformation 9 may be in form of protrusion projecting inwardly towards the center of the middle region. In other words, the deformation 9 may deviate from the surface of the inner wall 8A, 8B towards the axis of the channel for the fluid formed in the middle portion. In particular, the deformations 9 project from a second piece of the inner wall 8A.

**[0043]** Alternatively, the deformation 9 may be in form of protrusion projecting outwardly from the center of the middle region. In other words, the deformation 9 may deviate from the surface of the wall 4, 5, 8A, 8B away from the axis of the channel for the fluid formed in the middle portion.

**[0044]** The deformations 9 may comprise different shapes and sizes. Thus, the shape or size of the deformation 9 does not limit the invention to any particular example.

**[0045]** For example, the deformation 9 may have an oblong shape, or a pyramidal shape, or a trapezoidal shape, or substantially rectangular shape.

**[0046]** Another object of the invention may be a heat exchanger 100 comprising aforementioned flat tube 1. The flat tube 1 may provide a fluid communication between the manifolds, thus increasing overall performance thereof.

**[0047]** Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of drawings, the disclosure, and the appended claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a com-

ination of these measures cannot be used to the advantage.

## Claims

1. A flat tube (1) for the flow therein of a fluid in a heat exchanger, the tube (1) being formed by bending a sheet metal strip (2) along the length of the strip, the tube comprising: a first main wall (4); a second main wall (5) parallel to the first main wall (4), said main walls (4, 5) being substantially flat; two complementary side wall portions (6) joining said main walls together so as to define a closed profile of the tube (1), said strip (2) defining over its width a middle region and two intermediate regions on either side of said middle region, the first main wall (4) of the tube (1) being formed from said middle region, said second main wall (5) of the tube (1) comprising two wall portions (5A, 5B) each formed from a respective one of said intermediate regions, with said wall portions (5A, 5B) of the second main wall (5) being juxtaposed in substantially a common plane, a median wall (7) defined by a double thickness of the sheet metal strip (2) with one part attached to a first wall portion (5A) and the other part attached to a second wall portion (5B), and inner walls (8A, 8B) each formed from a respective one of said parts of the median wall (7), wherein a first piece of said inner wall is at least partially fixed and parallel to the first main wall (4), and a second piece of said inner wall is joining the main walls (4,5) within the middle region of the tube (1), wherein the sheet metal strip (2) further comprises at least one deformation (9) configured to locally deviate the surface of any of the walls (4,5,6, 5A, 5B).
 

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2. The flat tube (1) according to claim 1, wherein at least one deformation (9) is disposed on at least one main wall (4,5).
 

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3. The flat tube (1) according to any of the preceding claims, wherein at least one deformation (9) is disposed on at least one of side wall portions (6).
 

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4. The flat tube (1) according to any of the preceding claims, wherein at least one deformation (9) is disposed on at least one of the inner walls (8A, 8B).
 

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5. The flat tube (1) according to any of the preceding claims, wherein the deformation (9) is in form of protrusion projecting inwardly towards the center of the intermediate region.
 

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6. The flat tube (1) according to any of the preceding claims, wherein the deformation (9) is in form of protrusion projecting outwardly from the center of the intermediate region.
 

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7. The flat tube (1) according to any of the preceding claims wherein the strip (2) comprises at least one set (99) of deformations (9), wherein the set (99) is limited by the walls (4,5,6 8A, 8B).
 

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8. The flat tube (1) according to claim 7, wherein the deformations (9) are equidistant within the set (99), with respect to axis of elongation of the tube (1).
 

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9. The flat tube (1) according to claim 7, wherein the distance between consecutive deformations (9) forming the set (99) are different.
 

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10. The flat tube (1) according to any of the preceding claims, wherein the deformation (9) has an oblong shape.
 

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11. The flat tube (1) according to any of the preceding claims, wherein the deformation (9) has a pyramidal shape.
 

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12. The flat tube (1) according to any of the preceding claims, wherein the deformation (9) has a substantially rectangular shape.
 

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13. The tube (1) according to any of the preceding claims, wherein the sheet metal strip (2) comprises an outside surface and a layer of braze metal (3) on said outside surface, said layer having been pre-applied on the corresponding surface of said strip (2).
 

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14. A heat exchanger (100) comprising at least one flat tube (1) according to claims 1-12.
 

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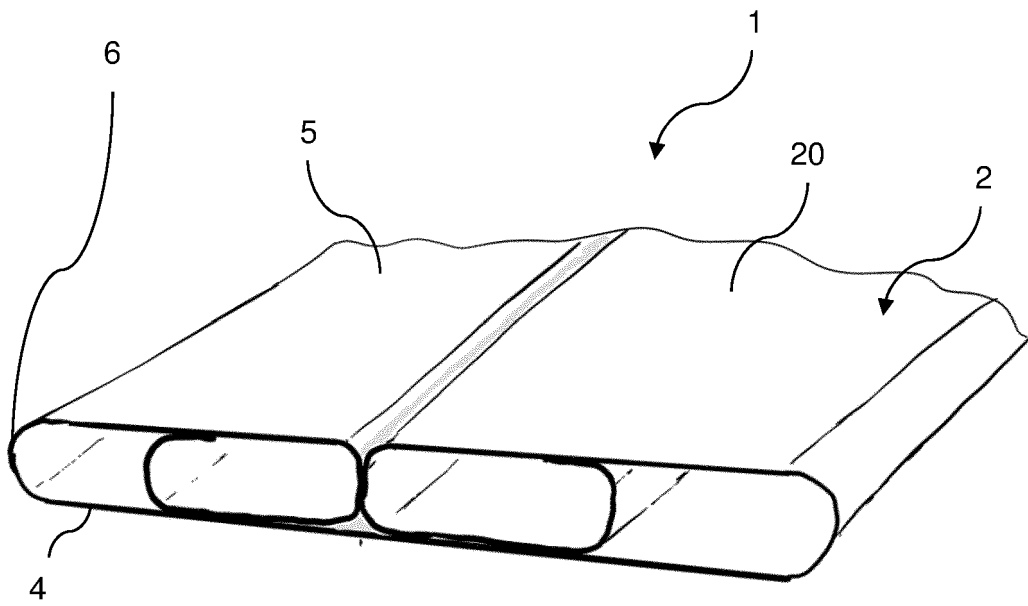


Fig. 1

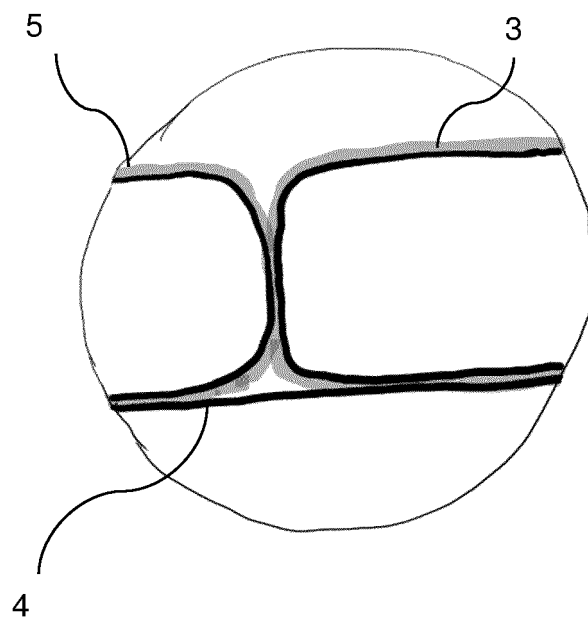


Fig. 2

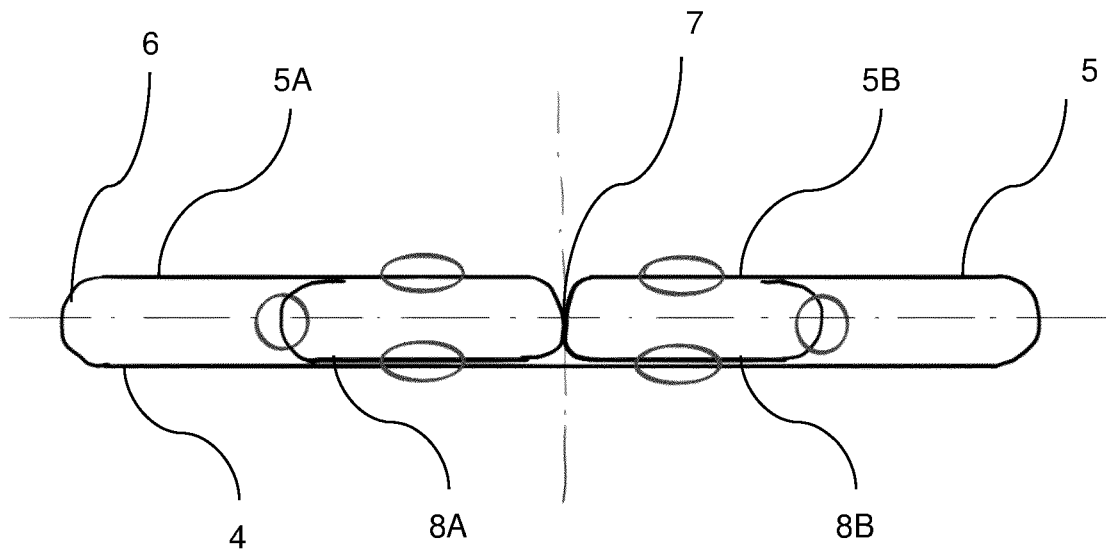


Fig. 3

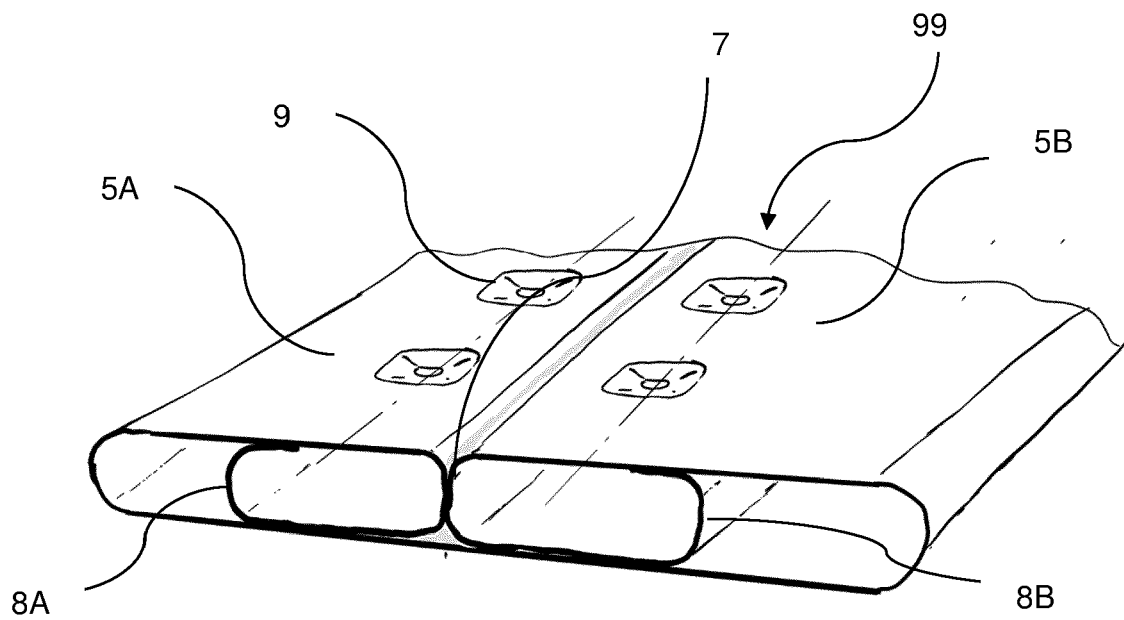


Fig. 4

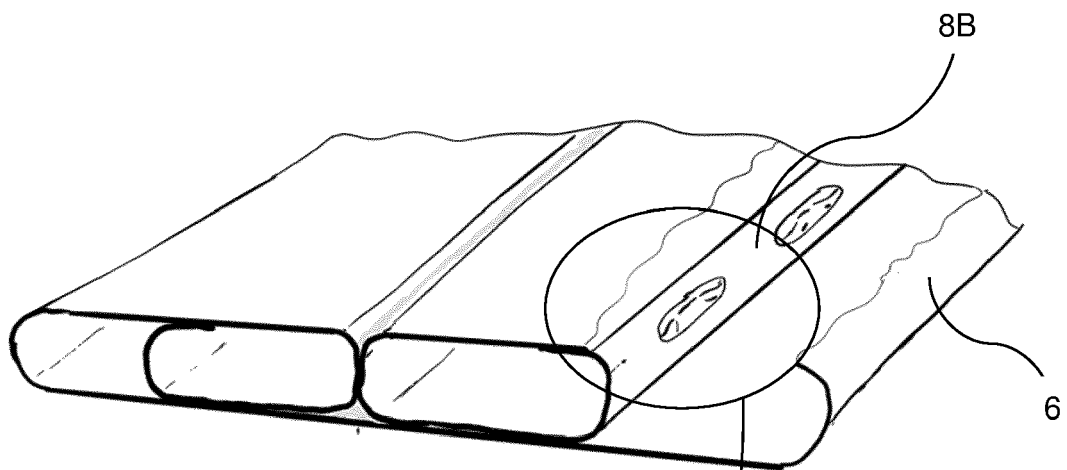


Fig. 5a

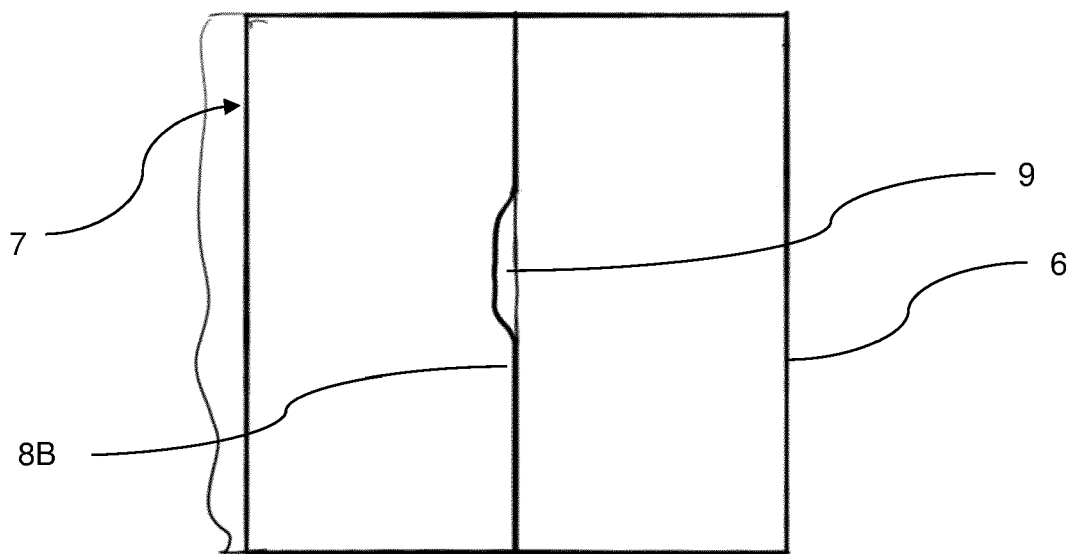


Fig. 5b



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Application Number

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                          |                                                                                                                                                                                                                                                                                       |                                          |
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| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                            | Relevant to claim                                                                                                                                                                                                                                                                     | CLASSIFICATION OF THE APPLICATION (IPC)  |
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| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                          |                                                                                                                                                                                                                                                                                       |                                          |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                       |                                                                                                          | Date of completion of the search<br><b>7 June 2022</b>                                                                                                                                                                                                                                | Examiner<br><b>Mellado Ramirez, J</b>    |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                          | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                          |

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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