(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 382 408 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**12.06.2024 Bulletin 2024/24**

(21) Application number: **22306836.2**

(22) Date of filing: **09.12.2022**

(51) International Patent Classification (IPC):
***B63B 73/43*** *(2020.01)*

(52) Cooperative Patent Classification (CPC):
**B63B 73/43**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA**
Designated Validation States:
**KH MA MD TN**

(71) Applicant: **TOTALENERGIES ONETECH**
**92400 Courbevoie (FR)**

(72) Inventor: **RABOIN, Jean-Christophe**
**92078 PARIS LA DEFENSE (FR)**

(74) Representative: **Lavoix**
**2, place d'Estienne d'Orves**
**75441 Paris Cedex 09 (FR)**

# (54) METHOD OF MANUFACTURING A WALL MADE OF METAL PLATES WELDED TOGETHER AND CORRESPONDING WALL

(57) The method of manufacturing a wall comprises the steps of obtaining the plates (4), the plates (4) including at least one stiffened plate (4) provided with a rim (12) extending along a first edge (6) of the stiffened plate (4) opposite a second edge (8) of the stiffened plate (4), the rim (12) being made integrally in a single piece of metal with the stiffened plate (4), and welding the plates (4) together along edges of the plates (4) such as to form the wall (2), including welding the first edge (6) of each stiffened plate (4) to an edge of another one of the plates (4) such that the rim (12) of the stiffened plate (4) protrudes on one of the two opposed sides of the wall (2) at the junction between the stiffened plate (4) and said other plate (4).

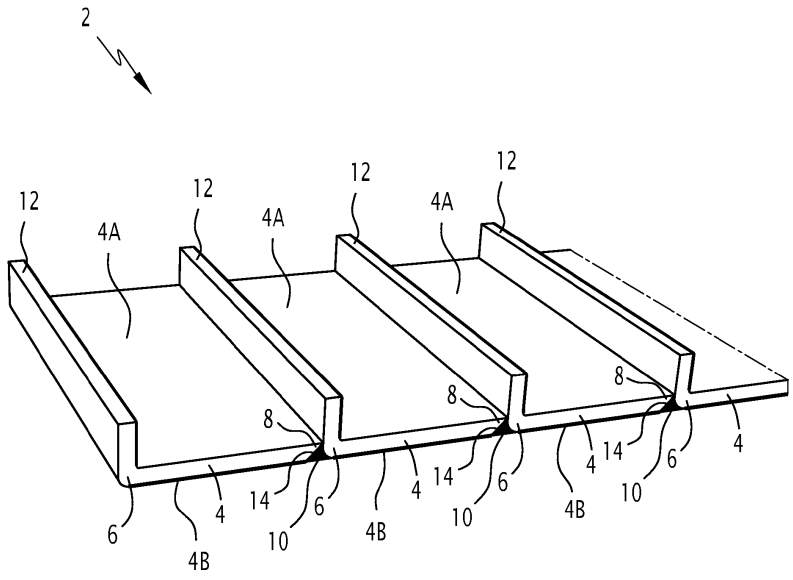


FIG.1

EP 4 382 408 A1

## Description

**[0001]** The present invention relates to the field of metallic constructions, and in particular to the construction of a wall made of a metal plates welded together.

**[0002]** Metallic floating marine structures such as vessels, platforms, buoys, and floaters may comprise hulls having walls made of metal plates welded together and provided with stiffeners welded to the plates.

**[0003]** The stiffeners are for example provided as metallic stiffening profiles, which are welded onto the plates to be stiffened. Each stiffening profile has for example a cross-section having a L shape, a T shape, a U shape or H shape.

**[0004]** The stiffeners allow limiting the thickness of the plates, while preserving the floatability of the structure. Thinner plates result in faster welding and easier shaping, albeit it increases welding works since stiffeners have to be welded onto the plates.

**[0005]** Welding is traditionally on the critical path for metal constructions since it is usually a lengthy procedure, which requires highly skilled artisans, while risks of defects are significant and may result in final work rebuttal.

**[0006]** One of the aims of the invention is to propose a method of manufacturing a wall made of metal plates welded together which allows a reduction of the weight whilst being easy and cost-effective.

**[0007]** To this end, the invention proposes method of manufacturing a wall made of metal plates welded together along edges of the plates, the method comprising the steps of:

- obtaining the plates, the plates including at least one stiffened plate, each stiffened plate being provided with a rim extending along a first edge of the stiffened plate opposite a second edge of the stiffened plate, the rim being made integrally in a single piece of metal with the stiffened plate; and
- welding the plates together along edges of the plates such as to form the wall, including welding the first edge of each stiffened plate to an edge of another one of the plates such that the rim of the stiffened plate protrudes on one of the two opposed sides of the wall at the junction between the stiffened plate and said other plate.

**[0008]** The wall is manufactured by welding plates including stiffened plates, each stiffened plate being provided with a stiffener formed by a rim provided along an edge of the stiffened plate. Each stiffened plate forms a fraction of the wall and the rim provided on each stiffened plate forms a stiffener.

**[0009]** A stiffened wall can thus be obtained while limiting the welding operations, as the rim of each stiffened plate is formed integrally in a single piece of material with the stiffened plate and does not need to be welded to the stiffened plate.

**[0010]** Each stiffened plate provided with a rim integrally formed in a single piece of material with the stiffened plate is obtained easily, for example by forming a blank, in particular by folding a blank to define the stiffened plate and the rim provided along a first edge of the stiffened plate.

**[0011]** In specific embodiments, the manufacturing method comprising one or several of the following optional features, taken individually or in any technically feasible combination:

- the first edge of at least one or each stiffened plate is welded to the second edge of another stiffened plate;
- the plates are welded together such that the rims of the stiffened plates protrude on only one of the two sides of the wall or protrude on both sides of the wall;
- the wall extends along a closed contour, for example a circular contour or a polygonal contour;
- the plates are assembled together such that the rim of each stiffened plate protrudes on an inner side of the wall;
- at least one or each stiffened plate is flat;
- at least one or each stiffened plate comprises a first flat portion adjacent the first edge and a second flat portion adjacent the second edge, the first flat portion and the second flat portion extending at a non-zero angle one relative to the other.
- at least one or each stiffened plate is arched between the first edge and the second edge, preferably along a portion of circle.
- the rim of at least one stiffened plate has a straight profile and/or the rim of at least one stiffened plate has an arched profile and/or the rim of at least one stiffened plate has a profile with two opposed curvatures;
- at least one or each stiffened plate is provided with at least one additional stiffener, each additional stiffener being welded on a side of the stiffened plate with extending transversely between the first edge and the second edge of the stiffened plate, preferably from the rim to the second edge of the stiffened plate;
- at least one or each stiffened plate is obtained by forming a blank such as to obtain the stiffened plate with the rim protruding form a first edge of the stiffened plate defined by the fold formed into the blank;
- the second edge of at least one or each stiffened plate is chamfered.

**[0012]** The invention also relates to a method of manufacturing a marine structure comprising a wall, in particular a vessel, a platform, a buoy or a floater, wherein the wall is manufactured according to the manufacturing method as defined above.

**[0013]** The invention further relates to a wall of a metal construction, in particular a marine structure, the wall being made of metal plates welded together along edges of the plates, the plates including at least one stiffened

plate, each stiffened plate being provided with a rim along a first edge of the stiffened plate opposite a second edge of the stiffened plate, the rim being made in a single piece of metal with the stiffened plate, the first edge of the stiffened plate being welded to an edge of another plate such that the rim of the stiffened plate protrudes on one of the two opposed sides of the wall at the junction between the stiffened plate and said other plate.

**[0014]** In specific embodiments, the wall comprises one or several of the following optional features, taken individually or according to any technically feasible combination:

- the first edge of at least one or each stiffened plate is welded to the second edge of another stiffened plate and/or the second edge of at least one or each stiffened plate is welded to the first edge of another stiffened plate;
- the plates are welded together such that the rims of the stiffened plates protrude only on one of the two sides of the wall or protrude on both sides of the wall;
- the wall extends along a closed contour, for example a circular contour or a polygonal contour;
- at least one or each stiffened plate is flat;
- at least one or each stiffened plate comprises a first flat portion adjacent the first edge and a second flat portion adjacent the second edge, the first flat portion and the second flat portion extending at a non-zero angle one relative to the other;
- at least one or each stiffened plate is arched between the first edg and the second edge, preferably along a portion of circle;
- the rim of at least one stiffened plate has a straight profile and/or the rim of at least one stiffened plate has an arched profile and/or the rim of at least one stiffened plate has a profile with two opposed curvatures separated by a point of inflexion or a straight section;
- at least one or each stiffened plate is provided with at least one additional stiffener, each additional stiffener being welded on a side of the stiffened plate with extending transversely between the first edge and the second edge of the stiffened plate, preferably from the rim to the second edge of the stiffened plate.

**[0015]** The invention further relates to a marine structure, e.g. a vessel, a platform, a buoy or a floater, in particular a floater of a floating structure of an off-shore wind turbine, the marine structure including at least one wall as defined above.

**[0016]** The invention and its advantages will be better understood upon reading the following description, which is given solely by way of non-limiting example, and which is made with reference to the appended drawings, in which:

- Figures 1 - 6 are schematic perspective views and side views of walls manufactured by welding metal plates together;
- Figures 7 and 8 are schematic assembled and exploded perspective views of a floater comprising walls manufactured by welding metal plates together;
- Figure 9 is a cross-sectional view of a wall of the floater;
- Figure 10 is a cross-sectional view similar to that of Figure 9, illustrating a wall of the floater according to another example;
- Figure 11 and 12 illustrate steps of manufacturing stiffened plates to be used for manufacturing a wall.

**[0017]** The wall 2 illustrated on Figure 1 is formed of a plurality of metal plates 4 arranged edge-to-edge and welded together along their adjacent edges welded.

**[0018]** Each plate 4 forms a fraction of the wall 2.

**[0019]** Each plate 4 comprises a first edge 6 and second edge 8 opposite to the first edge 6. The first edge 6 and the second edge 8 are preferably parallel.

**[0020]** Each plate 4 has a first side 4A and a second side 4B opposite the first side 4A.

**[0021]** Each plate 4 has its first edge 6 welded to the second edge 8 of an adjacent plate 4 and/or its second edge 8 welded to the first edge 6 of another adjacent plate 4.

**[0022]** Welding beads 10 extend along the edges of the plates 4 welded together.

**[0023]** The plates 4 include at least one stiffened plate 4. The plates 4 may all be stiffened plates 4 or may optionally comprise at least one non-stiffened plate 4. In the following, unless otherwise indicated, a plate 4 designates any plate 4 of the wall 2, i.e. a stiffened plate 4 or a non-stiffened plate 4.

**[0024]** Each stiffened plate 4 is provided with a rim 12 formed integrally in one single piece of metal with the stiffened plate 4. The rim 12 extending along the first edge of the plate 4 acts as a stiffener for the stiffened plate 4.

**[0025]** The rim 12 of each stiffened plate 4 protrudes for example from the first side 4A of the stiffened plate 4.

**[0026]** Each stiffened plate 4 has its first edge 6 welded to the second edge of another plate 4, such that the rim 12 of this stiffened plate 4 protrudes from the wall 6 along the junction between the stiffened plate 4 and the other plate 4.

**[0027]** The rim 12 of each stiffened plate 4 protruding from the wall 2 acts a stiffener for the wall 2 as a whole.

**[0028]** As illustrated on Figure 1, the wall 2 is formed of a series of stiffened plates 4, the first edge 6 of each stiffened plate 4 being welded to the second edge 8 of the next stiffened plate 4 of the series of stiffened plates 4.

**[0029]** In one embodiment, as illustrated on Figure 1, the rims 12 of all the stiffened plates 4 protrude on a same side of the wall 2.

**[0030]** In the embodiment illustrated on Figure 1, this first edge 6 of the last stiffened plate of the series of stiffened plates 4 is free.

**[0031]** Advantageously, the second edge 8 of each plate 4 welded to the first edge 6 of a stiffened plate 4 is provided with a chamfer 14.

**[0032]** The chamfer 14 is configured to create a groove between the second edge 8 of the plate 4 and the first edge 6 of the stiffened plate 4 for welding the second edge 8 to the first edge 6 with filler material.

**[0033]** The chamfer 14 is preferably inclined such as to be orientated opposite the first side 4A of the stiffened plate 4 to which the second edge is welded.

**[0034]** In one embodiment, the second edge 8 of each stiffened plat 4 is provided with a chamfer 14 orientated opposite the first side 4A of the stiffened plate 4.

**[0035]** This allows forming a wall 2 with fastening a series of stiffened plates 4 with the rim 12 protruding on one side of the wall 2 and the welding beads 10 being located on the other side of the wall 2, as in the embodiment illustrated on Figure 6.

**[0036]** A plurality of flat plates 4 are for example welded to each other such as to be coplanar and to form a flat wall 2, the rim 12 of each stiffened plate 4 protruding from the flat wall 2.

**[0037]** In one embodiment, as illustrated on Figure 2, two flat plates 4 including at least one stiffened plate 4 provided with a rim 12 are welded together with a non-zero angle between the plates 4.

**[0038]** This allows forming a non-planar wall 2 with at least one rim 12 protruding from the wall 2. In particular, this allows forming a wall 2 having facets separated by corners, each plate 4 defining a respective facet. Even more in particular, this allows forming a wall 2 extending along a polygonal contour, each plate 4 defining a respective facet of the wall 2.

**[0039]** In a particular embodiment, as illustrated on Figure 2, two or more flat stiffened plates 4 are welded together with a non-zero angle between the plates 4 of each pair of adjacent plates 4.

**[0040]** As illustrated on Figure 3, advantageously, at least one plate 4, in particular at least one stiffened plate 4, comprises a first flat portion 16 adjacent the first edge 6 and a second flat portion 18 adjacent the second edge 8, the first flat portion 16 and the second flat portion 18 defining a non-zero angle between them.

**[0041]** The plate 4 comprises for example an intermediate fold 20 located between the first flat portion 16 and the second flat portion 18.

**[0042]** The intermediate fold 20 is preferably parallel to the first edge 6 and the second edge 8 and located at a distance from the first edge 6 and at a distance from the second edge 8.

**[0043]** In one example, the first flat portion 16 extends from the intermediate fold 20 to the first edge 6 and/or the second flat portion 18 extends from the intermediate fold 20 to the second edge 8.

**[0044]** A wall 2 is for example obtained with welding a plurality of plates 4, including at least one stiffened plate 4, each having a first flat portion 16 and a second flat portion 18, with welding the first edge 6 of a plate 4 to the second edge 6 of another plate 4 such that the first portion 6 of the plate 4 is coplanar with the second potion 18 of the other plate 4.

**[0045]** This allows forming a wall 2 comprising facets separated by corners in which the welding beads 10 and the corners are offset along the wall 2. Each facet is defined by a first potion 16 of one of the plates 4 and the second portion 18 of an adjacent plate 4.

**[0046]** In one embodiment, as illustrated on Figure 4, at least one or each plate 4, in particular at least one or each stiffened plate 4, is arched between the first edge 6 and the the second edge 8 along a curve, in particular a portion of a circle.

**[0047]** This allows manufacturing a wall 2 extending along a curve, in particular a wall 2 extending along a portion of a circle, in particular a circular wall 2.

**[0048]** As illustrated on Figure 5, at least one or each stiffened plate 4 is optionally provided with at least one additional stiffener 22 welded to the stiffened plate 4 and extending transversely between the first edge 6 and the second edge 8 of the stiffened plate 4.

**[0049]** Each additional stiffener 22 extends for example on the first side 4A of the stiffened plate 4, from the rim 12 to the second edge 8.

**[0050]** Each additional stiffener 22 is for example a metal profile. Each additional stiffener 22 has for example a cross-section exhibiting a L shape, a T shape, a U shape or a H shape.

**[0051]** As illustrated on Figure 1 - 5, the rim 12 of each stiffened plate 4 is for example profiled along the first edge 6 of the plate 4.

**[0052]** As illustrated on Figures 1 - 3, the rim 12 of each stiffened plate 4 has for example a cross-section that is straight.

**[0053]** The rim 12 extends for example at an angle comprised between 60 and 120° with respect to the stiffened plate 4 or a flat portion of the stiffened plate 4 adjacent the first edge 6, e.g. a first flat portion 16 of the stiffened plate 4.

**[0054]** As illustrated on Figures 1 - 3, the rim 12 of each stiffened plate 4 has a cross-section that is straight and extends at an angle of 90° with respect to the stiffened plate 4 or the first flat portion 16 of the stiffened plate 4.

**[0055]** The rim 12 of at least one or each stiffened plate 4 has for example a cross-section that is curved.

**[0056]** In one example, at least one or each stiffened plate 4 is curved with a first radius of curvature between the first edge 6 and the second edge 8 and the rim 12 is curved with a second radius of curvature strictly greater than the first radius of curvature.

**[0057]** In the example of Figure 4, the rim 12 of each stiffened plate 4 has a curvature strictly greater than that of the stiffened plate 4.

**[0058]** In one example, the rim 12 of at least one or each stiffened plate 4 has for example a cross-section that has two opposite curvatures separated by a point of inflexion or a straight section.

**[0059]** As illustrated on Figure 5, the rim 12 of at least

one or each stiffened plate 4 has for example a cross-section that has two opposite curvatures separated by a point of inflexion.

**[0060]** The shape of the cross-section of the rim 12 of each stiffened plate 4 allows tuning the stiffness imparted by the rim 12.

**[0061]** Other combinations of the shape of a stiffened plate 4 and the shape of the rim 12 may be contemplated.

**[0062]** For example, a stiffened plate 4 that is curved may be provided with a rim 12 having a straight cross-section.

**[0063]** In the examples of Figures 1 - 5, the rims 12 of all the stiffened plates 4 of the wall 2 protrude on a same side of the wall 2.

**[0064]** In a variant, as illustrated on Figure 6, the rims 12 of the stiffened plates 4 protrude on either sides of the wall 2. The rim 12 of at least one stiffened plate 4 protrudes on one side of the wall 2 and the rim 12 of at least one stiffened plate 4 protrudes on the other side of the wall 2.

**[0065]** In the specific embodiment illustrated on Figure 6, the stiffened plates 4 are arranged alternately such that the rim 12 of the preceding stiffened plate 4 protrudes on one side of the wall 2 and the rim of the following stiffened plate 4 protrudes on the other side of the wall 2.

**[0066]** Other arrangements may be contemplated depending on specific needs for a particular application.

**[0067]** In each one of the stiffened walls of Figures 1 - 6 is made of identical stiffened plates 4.

**[0068]** In one example, a wall 2 incorporates at least two stiffened plates 4 which are of different shape and/or are provided with rims 12 of different shapes. This can be contemplated for tuning the overall weight and/or overall stiffness of the wall 2.

**[0069]** A wall 2 incorporates for example at least one stiffened plate 4 which is flat between the first edge 6 and the second edge 8 (see e.g. Figure 1) and/or at least one stiffened plate 4 which is arched between the first edge 6 and the second edge 8 (see e.g. Figure 4), preferably along a portion of circle, and/or at least one stiffened plate 4 which has a first flat portion 16 adjacent the first edge 6 of the stiffened plate 4 and a second flat portion 18 adjacent the second edge 8, the first flat portion 16 and the second flat portion 18 extending at a non-zero angle one relative to the other (see e.g. Figure 3).

**[0070]** Similarly, a wall 2 incorporates for example at least one stiffened plate 4 provided with a rim 12 of straight profile and/or at least one stiffened plate 4 with a rim 12 of curved profile with a curvature on only one side and/or at least one stiffened plate 4 with a rim 12 of curved profile with two opposed curvatures.

**[0071]** A wall 2 made of plate 4 welded together including at least one stiffened plate 4 may be incorporated in a metal construction, in particular in a marine structure, such as a vessel, a platform, a buoy or a floater.

**[0072]** The structure 30 illustrated Figure 7 and 8 comprises a tubular body 32 extending along a central axis A and two end plates 34 closing the axial ends of the body 32, the body 32 comprising at least one section 36 each section 36 being formed of a stiffened wall 2 of circular or polygonal cross-section.

**[0073]** Such a structure 30 is for example a floater, in particular a floater of a floating structure of an off-shore wind turbine.

**[0074]** The body 32 comprises for example a plurality of sections 36 along the central axis A.

**[0075]** Optionally, two adjacent sections 36 of the body 32 are separated by an annular stiffener 38.

**[0076]** As illustrated on Figure 7 and 8, the body 32 comprises two sections 36 separated by an annular stiffener 38.

**[0077]** The wall 2 of each section 36 extends along a closed contour.

**[0078]** Each wall 2 is manufactured by welding a series of plates 4 with welding the first edge 6 of each preceding plate 4 to the second edge of following edge 4 and welding the first edge 6 of the last plate 4 to the second edge of the first plate 4. Each plate 4 defines a fraction of the circumference of the wall 2.

**[0079]** Each wall 2 is formed for example of a series of stiffened plates 4. The first edge 6 of each preceding stiffened plate 4 is welded to the second edge 8 of the next stiffened plate 4 and the first edge 6 of the last stiffened plate 4 is welded to the second edge 8 of the first stiffened plate 4. Each stiffened plate 4 defines a fraction of the circumference of the wall 2.

**[0080]** The rim 12 of each stiffened plate 4 protrudes inside the wall 2, i.e. on an inner side of the wall 2.

**[0081]** In one example illustrated on Figure 9, the wall 2 of at least one or each section 36 is circular. Each stiffened plate 4 of the wall is curved along a portion of circle such that the stiffened plate 4 welded together define a circular wall 2. Each stiffened plate 4 defines a fraction of the circumference of the wall 2.

**[0082]** In a variant illustrated on Figure 10, the wall 2 of at least one or each section 36 is polygonal.

**[0083]** The stiffened plates 4 are shaped such that the weld beads 10 coincide with the corners of the polygon.

**[0084]** In a variant, the stiffened plates 4 are shaped such that the weld beads 10 and the corners of the polygon are circumferentially offset.

**[0085]** In such a variant, the wall 2 includes for examples stiffened plate 4 and/or non-stiffened plates 4 comprising a first flat potion 16 adjacent the first edge 6 and as second flat portion 18 adjacent the second edge 8, the first flat portion 16 and the second flat portion 18 forming a non-zero angle between them.

**[0086]** The wall 2 of polygonal shape illustrated on Figure 10 is formed using stiffened plates 4 as illustrated on Figure 5. In other examples, stiffened plates 4 with other shapes are used, such as stiffened plates as illustrated on Figure 1 - 3.

**[0087]** The walls 2 illustrated on Figures 9 and 10 consist of stiffened plates 4. In other examples, a wall 2 of closed contour, in particular a wall 2 of circular contour or polygonal contour, comprises stiffened plates 4 mixed

with non-stiffened plates 4.

**[0088]** Different patterns of stiffened plates 4 and non-stiffened plates 4 along the circumference of the wall 2 of closed contour can be contemplated as a function of the stiffness that is sought.

**[0089]** A method of manufacturing a wall 2 made of metal plates 4 welded together along edges of the plates 4 comprises the steps of:

- obtaining the plates 4, the plates 4 including at least one stiffened plate 4;
- welding the plates 4 together along edges thereof such as to form the wall 2, including welding the first edge 6 of each stiffened plate 4 to an edge of another plate 4 such that the rim 12 of the stiffened plate 14 protrudes on one of two opposed sides of the wall 2 at the junction between the stiffened plate 4 and the other plate 4.

**[0090]** The manufacturing method is in particular operable to manufacture a wall 2 according to the examples described above and illustrated on Figures 1 - 10.

**[0091]** In one example, the manufacturing method comprises welding the first edge 6 of at least one or each stiffened plate 4 to the second edge 8 of another stiffened plate 4.

**[0092]** In one example, the manufacturing method comprises welding the plates 4 together such that the rims 12 of the stiffened plates 4 protrude on only one of the two sides of the wall 2 (see e.g. Figures 1 - 5, 9 and 10) or protrude on either sides of the wall 2 (see e.g. Figure 6).

**[0093]** In one example, the manufacturing method comprises manufacturing a wall extending along a closed contour, for example a circular contour or a polygonal contour (see e.g. Figures 9 and 10).

**[0094]** The method comprises for example welding a series of plates 4 including at least one stiffened plate 4 or consisting of stiffened plates 4, the first edge 6 of each plate 4 being welded to the second edge 8 of the next plate 4, and the first edge 6 of the last plate 4 being welded to the second edge 8 of the first plate 4.

**[0095]** In one example, the plates 4 are welded together such that the rim 12 of each stiffened plate 4 protrudes on the inner side 2A of the wall 2, i.e. the side of the wall 2 oriented towards the inside of the contour.

**[0096]** The manufacturing method is for example implemented using at least one stiffened plate 4 which is flat between the first edge 6 and the second edge 8 (see e.g. Figure 1) and/or at least one stiffened plate 4 which is arched between the first edge 6 and the second edge 8 (see e.g. Figure 4), preferably along a portion of circle, and/or at least one stiffened plate 4 which has a first flat portion 16 adjacent the first edge 6 of the stiffened plate 4 and a second flat portion 18 adjacent the second edge 8, the first flat portion 16 and the second flat portion 18 extending at a non-zero angle one relative to the other (see e.g. Figure 3).

**[0097]** In one example, at least one each stiffened plate 4 or each stiffened plate 4 comprises a first flat portion 16 adjacent the first edge 6 of the stiffened plate 4 and a second flat portion 18 adjacent the second edge 8, the first flat portion 16 and the second flat portion 18 extending at a non-zero angle one relative to the other.

**[0098]** Advantageously, the manufacturing method comprises welding the first edge 6 of at least one or each stiffened plate 4 having a first flat portion 16 and a second flat portion 18 to the second edge 8 of another stiffened plate 4 having a first flat portion 16 and a second flat portion 18 such that the first flat portion 16 of the stiffened plate 4 is coplanar with the second flat portion 18 of the other stiffened plate 4 (see e.g. Figure 3).

**[0099]** In particular, the manufacturing method comprises forming a wall 2 by welding a series of stiffened plates 4 each provided with a first flat portion 16 and a second flat portion 18, with welding the first edge 6 of each preceding stiffened plate 4 to the second edge 8 of the next stiffened plate 4 such that the first flat portion 16 of the preceding stiffened plate 4 is coplanar with the second flat portion 18 of the next stiffened plate 4 (see e.g. Figure 3).

**[0100]** Optionally, the manufacturing method comprises welding the first edge 6 of the last stiffened plate 4 to the second edge 8 of the first stiffened plate 4 such that the first flat portion 16 of the last stiffened plate 4 is coplanar with the second flat portion 18 of the first stiffened plate 4

**[0101]** In one example, at least one or each stiffened plate 4 is provided with at least one additional stiffener 22, each additional stiffener 22 being welded on a side of the stiffened plate 4 with extending transversely between the first edge 6 and the second edge 8 of the stiffened plate 4, preferably from the rim 12 to the second edge 8 of the stiffened plate 4 (see e.g. Figure 5).

**[0102]** The manufacturing method comprises for example obtaining each stiffened plate 4 provided with a rim 12 by forging metal, by molding metal and/or by forming a metal blank, in particular by shaping, stamping and/or folding the metal blank.

**[0103]** In one example, at least one or each stiffened plate 4 is obtained by forming a blank, in particular a rectangular blank, such as to obtain the stiffened plate 4 provided with the rim 12 extending along a first edge 6 of the stiffened plate 4.

**[0104]** The forming of the blank comprises for example folding the blank between two parallel opposed edges of the blank such as to form the stiffened plate 4 extending between the fold of the blank and one of the two opposed edges of the blank, and the rim 12 extending between the fold and the other one of the two opposed edges of the blank.

**[0105]** The step of obtaining each plate 4, in particular each stiffened plate 4, comprises optionally obtaining the blank from a roll, in particular by unrolling the roll.

**[0106]** Optionally, the step of obtaining the plates 4 comprises providing a chamfer 14 on the second edge

8 of at least one or each plate 4, in particular at least one or each stiffened plate 4, for example by grinding the second edge 8.

**[0107]** As illustrated on Figure 11, a stiffened plate 4 is obtained from a roll 40 by unrolling the roll 40 into a blank 42, then forming the blank 42 to define the plate 4 with a rim 12 extending along a first edge 6 of the plate 4, and, optionally, providing a chamfer 14 on a second edge 8 of the plate 4 opposite the first edge 6 of the plate 4.

**[0108]** The blank 42 is here folded parallel to two opposed edges of the blank 42 such as to form the plate 4 extending between the fold of the blank 42 and one of the edges of the blank, and the rim 12 extending between the fold and the other edge of the blank 42. The fold of the blank thus forms the first edge 6 of the plate 4.

**[0109]** As illustrated on Figure 12, a stiffened plate 4 is obtained from a roll 40 by unrolling the roll 40 into a blank 42, then forming the blank 42 to define the plate 4 with a rim 12 extending along a first edge 6 of the plate 4, here a rim 12 with a double curvature, optionally welding at least one additional stiffener 22 on the plate 4, each additional stiffener 22 extending from the rim 12 to the second edge 8 of the stiffened plate 4, and, optionally, providing a chamfer 14 on a second edge 8 of the plate 4 opposite the first edge 6 of the plate 4.

**[0110]** As illustrated on Figure 12, the end of each additional fastener 22 adjacent the second edge 8 of the stiffened plate 4 is machined to match the first edge 8 of the stiffened plate 4 to ensure a good positioning when welding the second edge 8 of the stiffened plate 4 to the first edge 6 of another identical stiffened plate 4.

**[0111]** The metal of the plates 4 is preferably steel. Steel grades used in automotive industry are preferred to the extent they allow lower curvature radius deformations without excessively impairing mechanical properties.

**[0112]** Examples of appropriate steel grades include ultra-low carbon interstitial free steels (aka. "IF" steels), which are normally alloyed with manganese, silicon and phosphorous. Suitable IF steels include commercial IF180, IF210, IF220, IF240, IF260, IF280 and IF300 grades.

**[0113]** The blank 42 or rolls 40 used to obtain the plates 4 have preferably a thickness from 15 to 25 mm, preferably a thickness from 18 to 22 mm, in particular a thickness of 20 mm.

**[0114]** The blank 42 or rolls has for example a length comprises between 5 and 30 m, typically 10 m and/or a width comprised between 0.5 m and 3.5 m.

**[0115]** Rolls may be obtained through cold forming or hot forming. Rolling method results in different crystalline forms and therefore different mechanical properties.

**[0116]** The manufacturing method is suitable for use in any kind of metallic construction and is particularly useful when weight reduction and ease of construction is expected.

**[0117]** The manufacturing method is suitable for manufacturing of walls of marine structures, in particular floating marine structures, e.g. vessels, platforms, buoys and floaters.

**[0118]** Owing to the invention, a wall made of plates welded together including stiffened plates, with stiffeners located on one side of the wall or one either sides of the wall, can be obtained with limiting the number of welding operations, as each rim stiffening a stiffened plates are formed integrally in a single piece of metal with the stiffened plate.

**[0119]** The use of stiffened plates allows using thin plates, which reduces the time that is necessary for welding the plates 4 together edge-to-edge, and reduces the weight of the wall 2.

**[0120]** When the stiffened plate 4 is formed by folding a blank to obtain the stiffened plate 4 with the rim 12 extending along a first edge of the stiffened plate 4, the welding of the first edge of the stiffened plate 4 induces relaxation of internal stress within the crystalline lattice of the metal of the stiffened plate 4 that may have appeared upon folding the blank, hence improving mechanical properties of the stiffened plate 4.

## Claims

1. Method of manufacturing a wall (2) made of metal plates (4) welded together along edges of the plates (4), the method comprising the steps of :

   - obtaining the plates (4), the plates (4) including at least one stiffened plate (4), each stiffened plate (4) being provided with a rim (12) extending along a first edge (6) of the stiffened plate (4) opposite a second edge (8) of the stiffened plate (4), the rim (12) being made integrally in a single piece of metal with the stiffened plate (4); and
   - welding the plates (4) together along edges of the plates (4) such as to form the wall (2), including welding the first edge (6) of each stiffened plate (4) to an edge of another one of the plates (4) such that the rim (12) of the stiffened plate (4) protrudes on one of the two opposed sides of the wall (2) at the junction between the stiffened plate (4) and said other plate (4).

2. Method according to claim 1, wherein the first edge (6) of at least one or each stiffened plate (4) is welded to the second edge (8) of another stiffened plate (4).

3. Method according to claim 1 or 2, wherein the wall (2) extends along a closed contour, for example a circular contour or a polygonal contour.

4. Method according to any one of the preceding claims, wherein the plates are assembled together such that the rim (12) of each stiffened plate (4) protrudes on an inner side of the wall (2).

5. Method according to any one of the preceding claims, wherein at least one or each stiffened plate (4) comprises a first flat portion (16) adjacent the first edge (6) and a second flat portion (18) adjacent the second edge (8), the first flat portion (16) and the second flat portion (18) extending at a non-zero angle one relative to the other.

6. Method according to any one of the preceding claims, wherein at least one or each stiffened plate (4) is arched between the first edge (6) and the second edge (8), preferably along a portion of circle.

7. Method according to any one of the preceding claims, wherein the rim (12) of at least one stiffened plate (4) has a straight profile and/or the rim (12) of at least one stiffened plate (4) has an arched profile and/or the rim (12) of at least one stiffened plate (4) has a profile with two opposed curvatures.

8. Method according to any one of the preceding claims, wherein at least one or each stiffened plate (4) is provided with at least one additional stiffener (22), each additional stiffener (22) being welded on a side of the stiffened plate (4) with extending transversely between the first edge (6) and the second edge (8) of the stiffened plate (4), preferably from the rim (12) to the second edge (8) of the stiffened plate (4).

9. Method according to any one of the preceding claims, wherein at least one or each stiffened plate (4) is obtained by forming a blank such as to obtain the stiffened plate (4) with the rim (12) protruding form a first edge (6) of the stiffened plate (4) defined by the fold formed into the blank.

10. Method according to any one of the preceding claims, wherein the second edge (8) of at least one or each stiffened plate (4) is chamfered.

11. Method of manufacturing a marine structure comprising a wall, in particular a vessel, a platform, a buoy or a floater, wherein the wall is manufactured according to the manufacturing method of any one of the preceding claims.

12. Wall (2) of a metal construction, in particular a marine structure, the wall (2) being made of metal plates (4) welded together along edges of the plates (4), the plates (4) including at least one stiffened plate (4), each stiffened plate (4) being provided with a rim (12) along a first edge (6) of the stiffened plate (4) opposite a second edge (8) of the stiffened plate (4), the rim (12) being made in a single piece of metal with the stiffened plate (4), the first edge (6) of the stiffened plate (4) being welded to an edge of another plate (4) such that the rim (12) of the stiffened plate (4) protrudes on one of the two opposed sides of the wall at the junction between the stiffened plate (4) and said other plate (4).

13. Wall (2) according to claim 12, wherein the first edge (6) of at least one or each stiffened plate (4) is welded to the second edge (8) of another stiffened plate (4) and/or the second edge (8) of at least one or each stiffened plate (4) is welded to the first edge (6) of another stiffened plate (4).

14. Wall (2) according to claim 12 or 13, wherein the wall (2) extends along a closed contour, for example a circular contour or a polygonal contour.

15. Wall (2) according to any one of claims 12 - 13, wherein at least one or each stiffened plate (4) comprises a first flat portion (16) adjacent the first edge (6) and a second flat portion (18) adjacent the second edge (8), the first flat portion (16) and the second flat portion (18) extending at a non-zero angle one relative to the other.

16. Wall (2) according to any one of claims 12 - 16, wherein at least one or each stiffened plate (4) is arched between the first edge (6) and the second edge (8), preferably along a portion of circle.

17. Wall (2) according to any one of claims 12-16, wherein the rim (12) of at least one stiffened plate (4) has a straight profile and/or the rim (12) of at least one stiffened plate (4) has an arched profile and/or the rim (12) of at least one stiffened plate (4) has a profile with two opposed curvatures separated by a point of inflexion or a straight section.

18. Wall (2) according to any one of claims 12 - 17, wherein at least one or each stiffened plate (4) is provided with at least one additional stiffener (22), each additional stiffener (22) being welded on a side of the stiffened plate (4) with extending transversely between the first edge (6) and the second edge (8) of the stiffened plate (4), preferably from the rim (12) to the second edge (8) of the stiffened plate (4).

19. Marine structure, e.g. a vessel, a platform, a buoy or a floater, in particular a floater of a floating structure of an off-shore wind turbine, the marine structure including at least one wall (2) according to any one of claims 12 - 18.

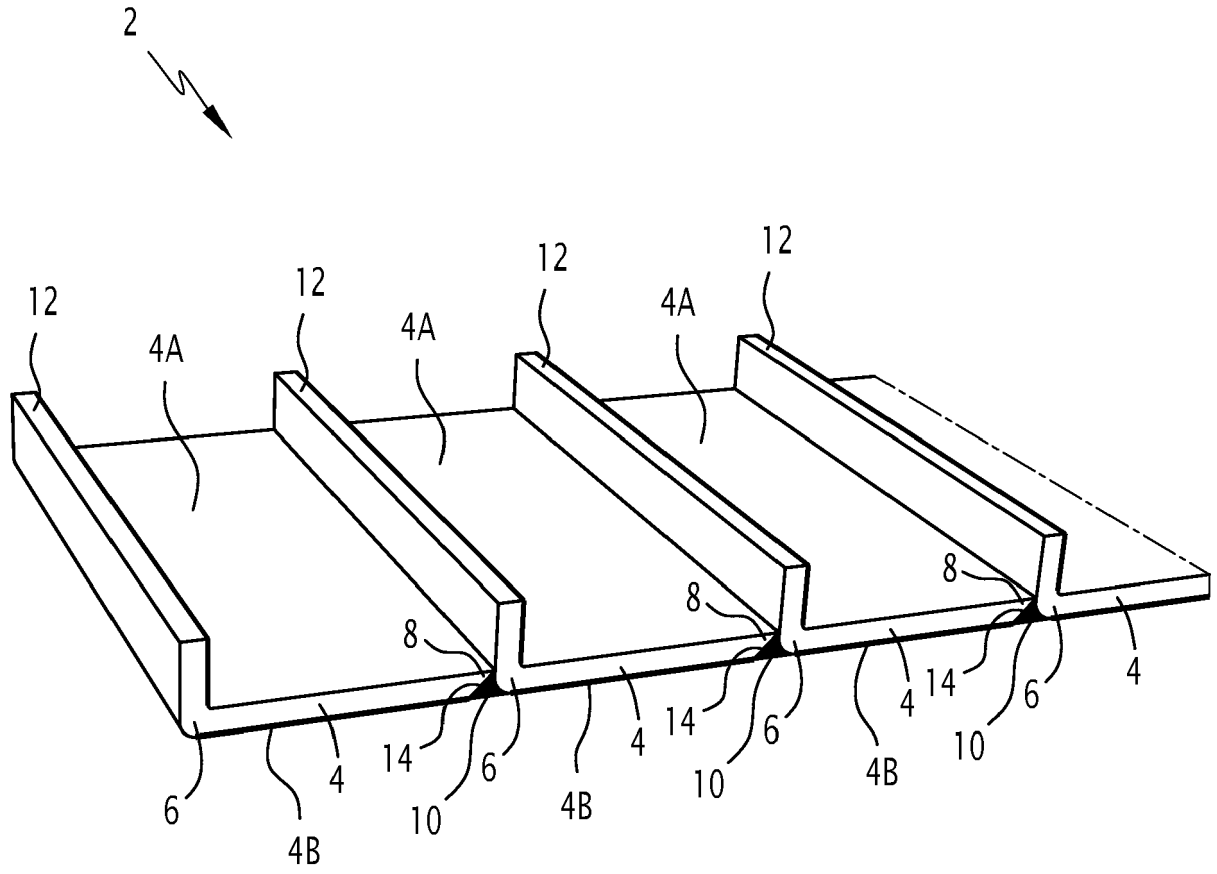


FIG.1

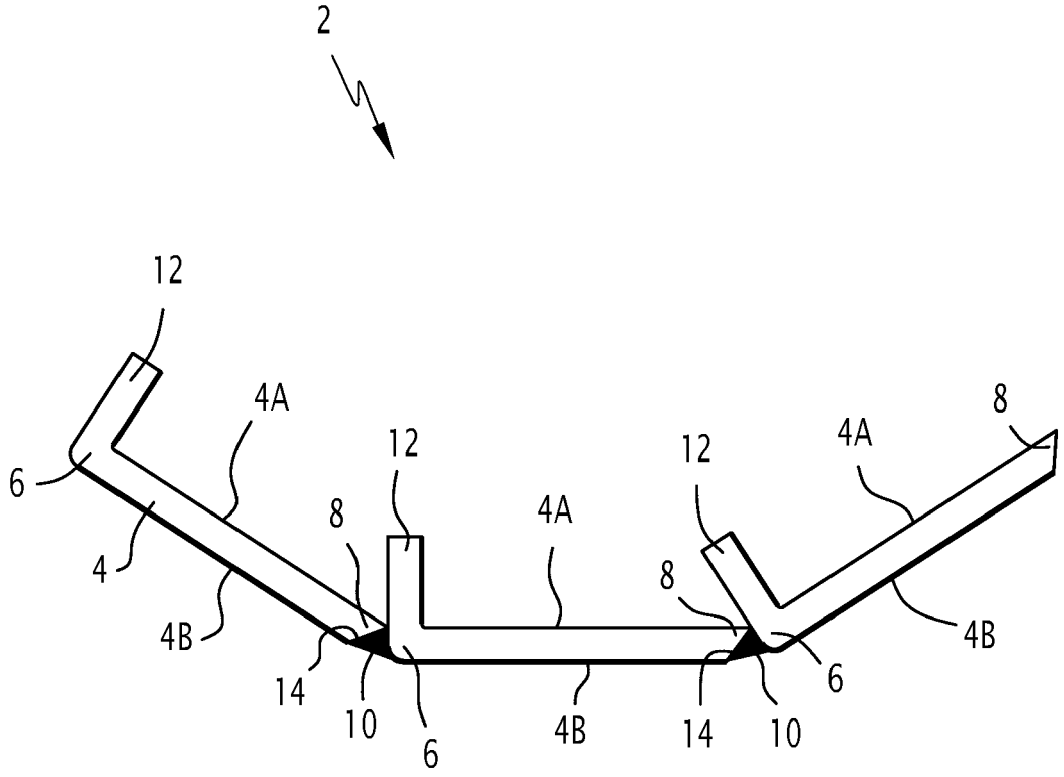


FIG.2

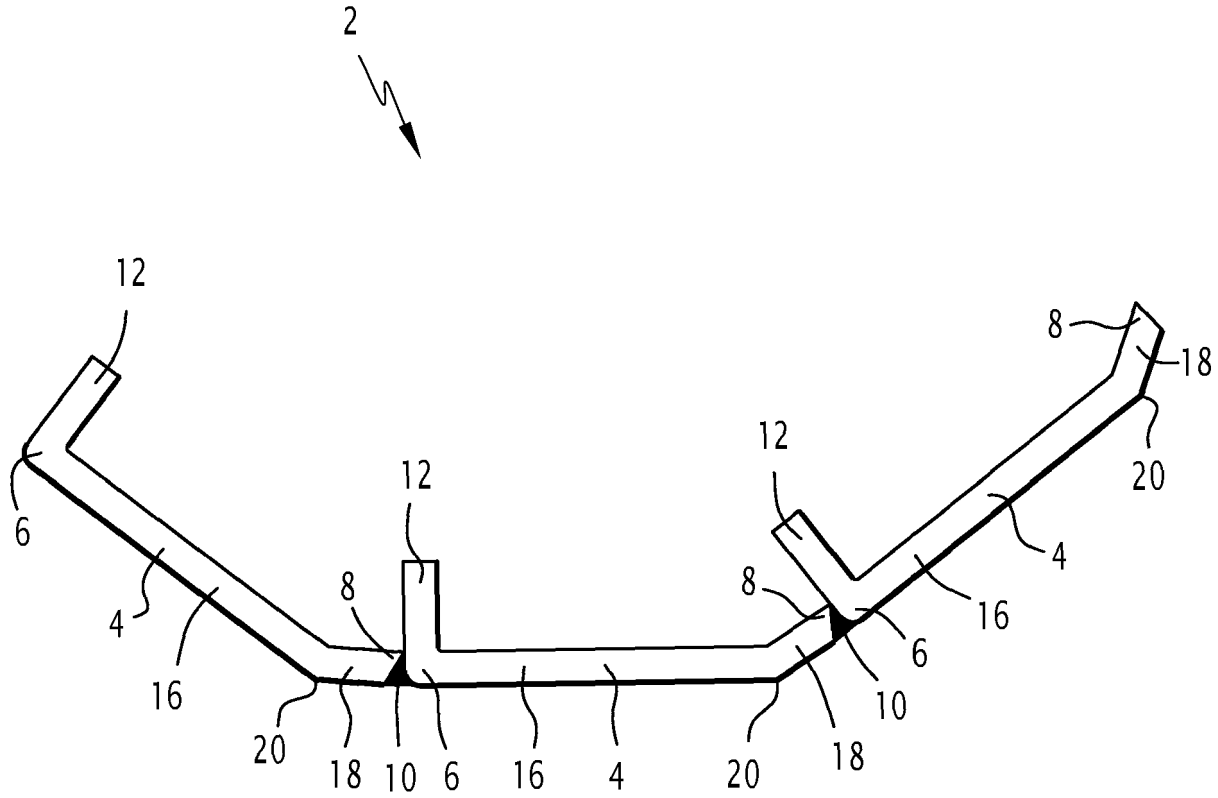


FIG.3

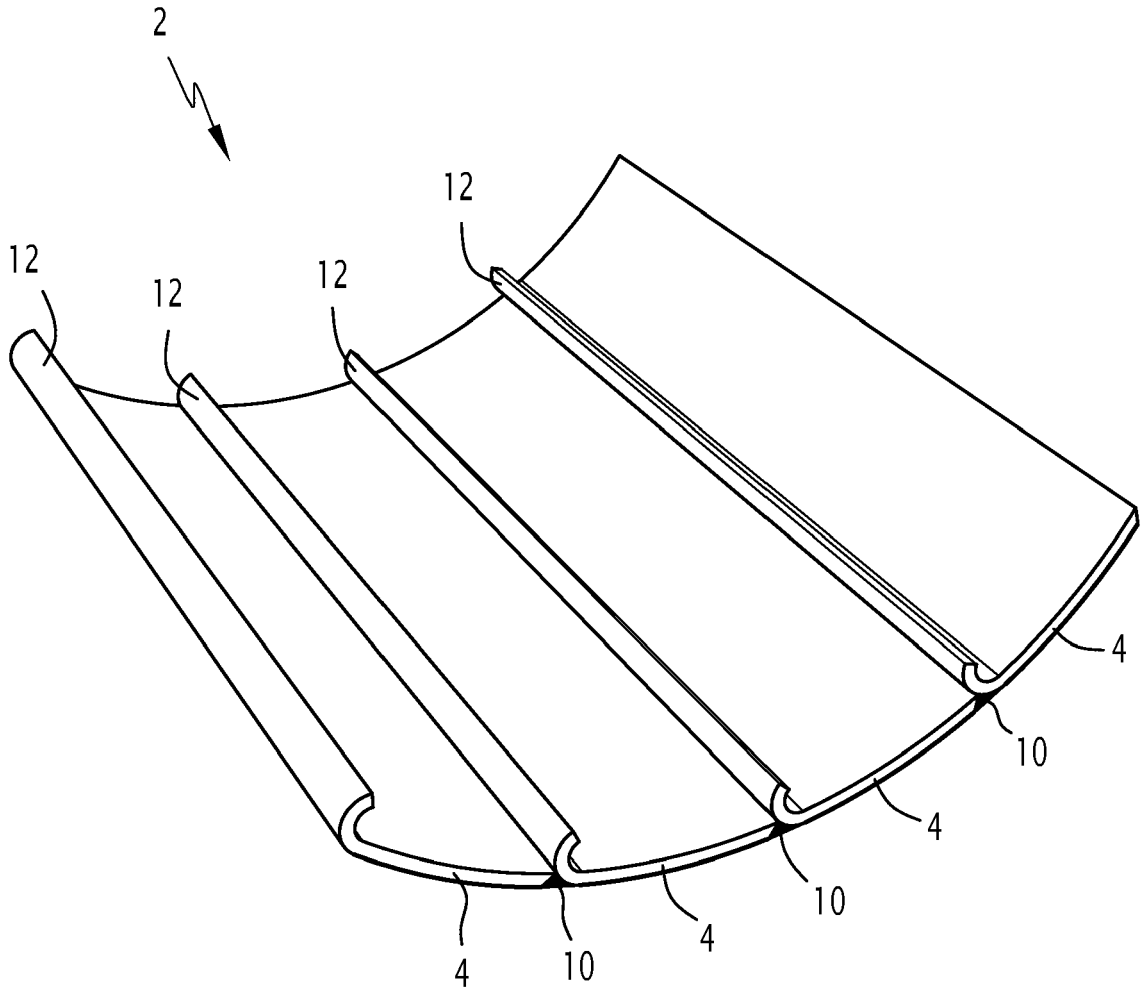


FIG.4

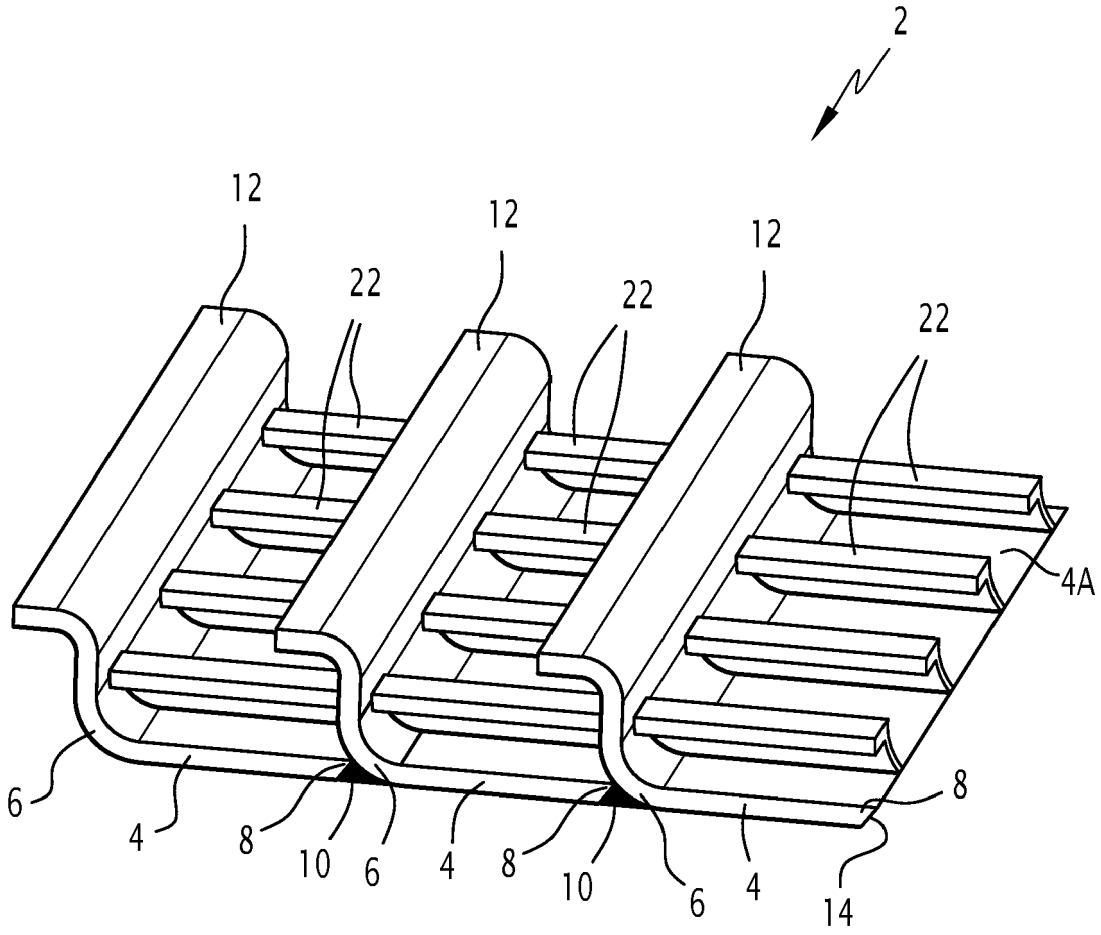


FIG.5

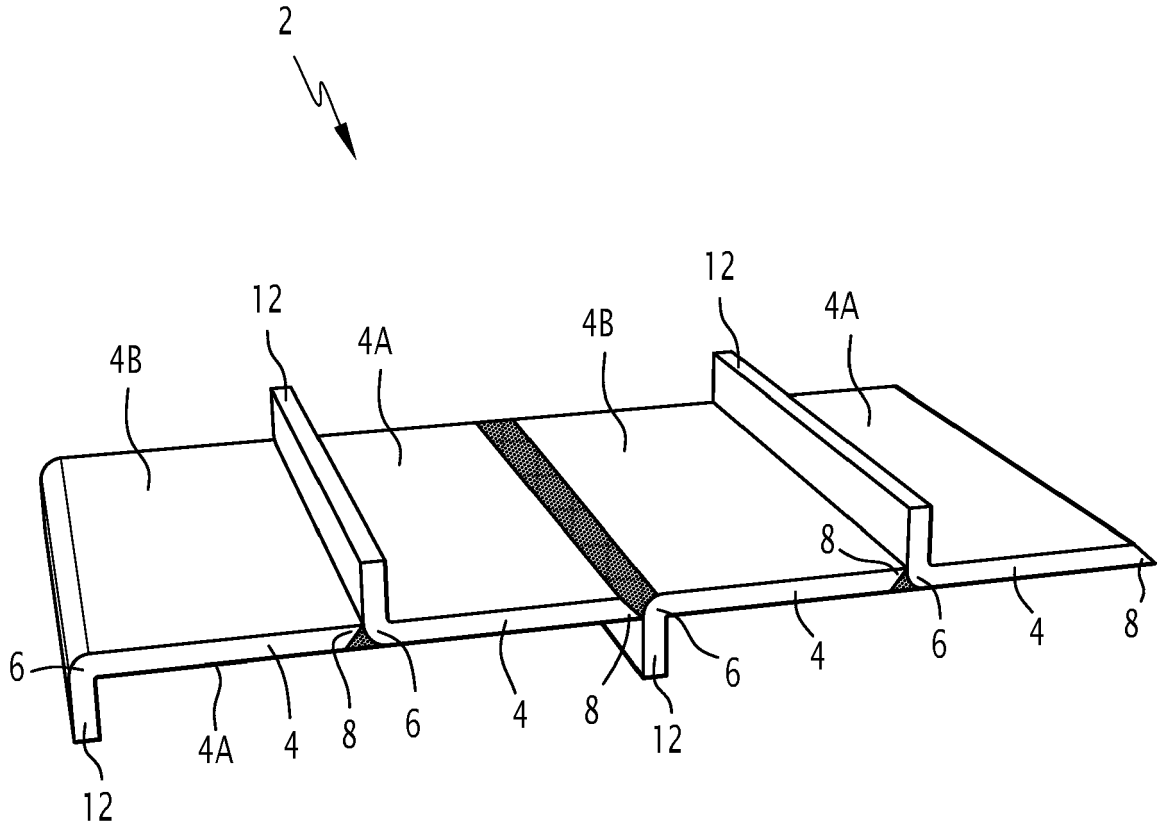


FIG.6

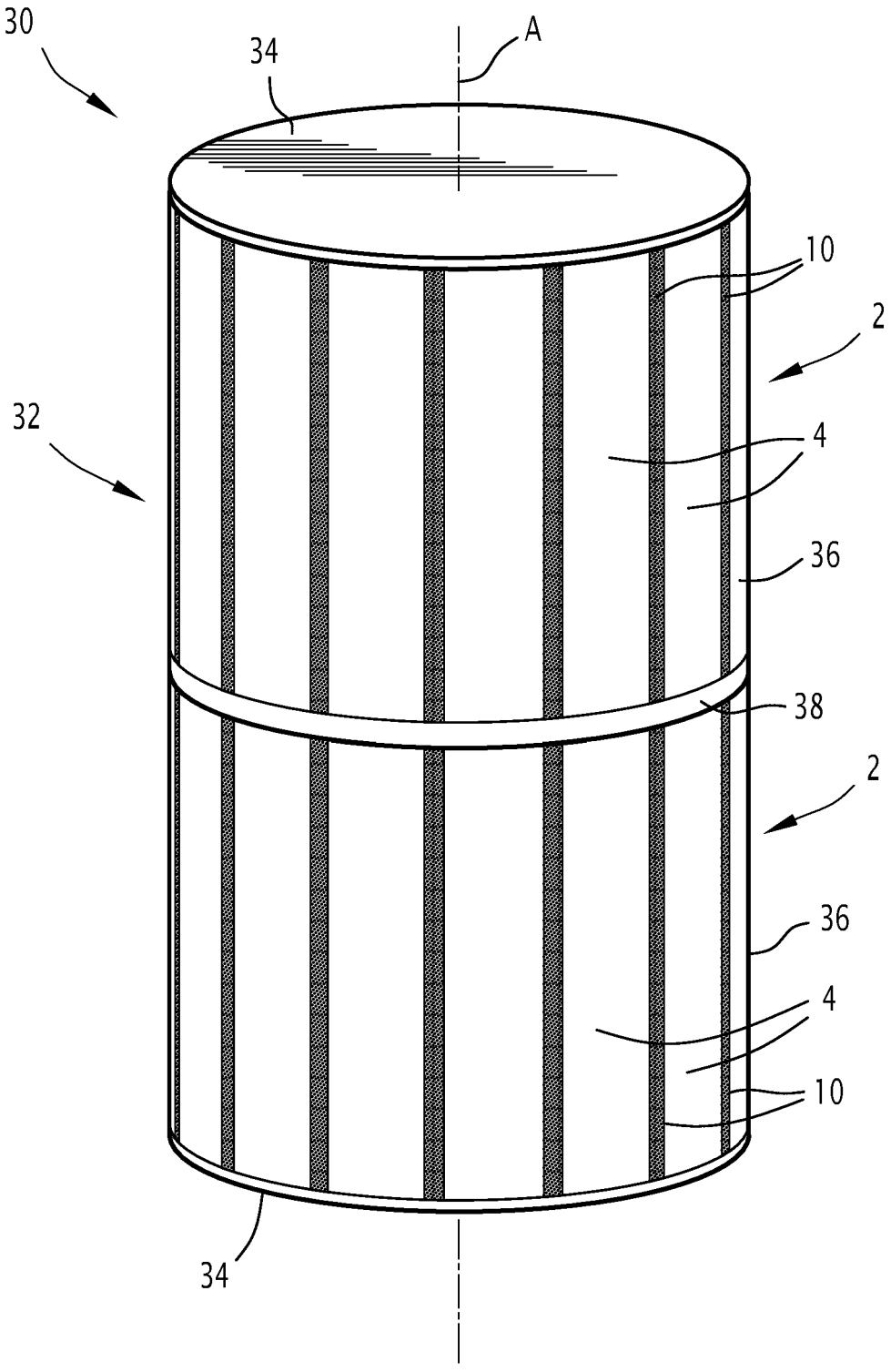


FIG.7

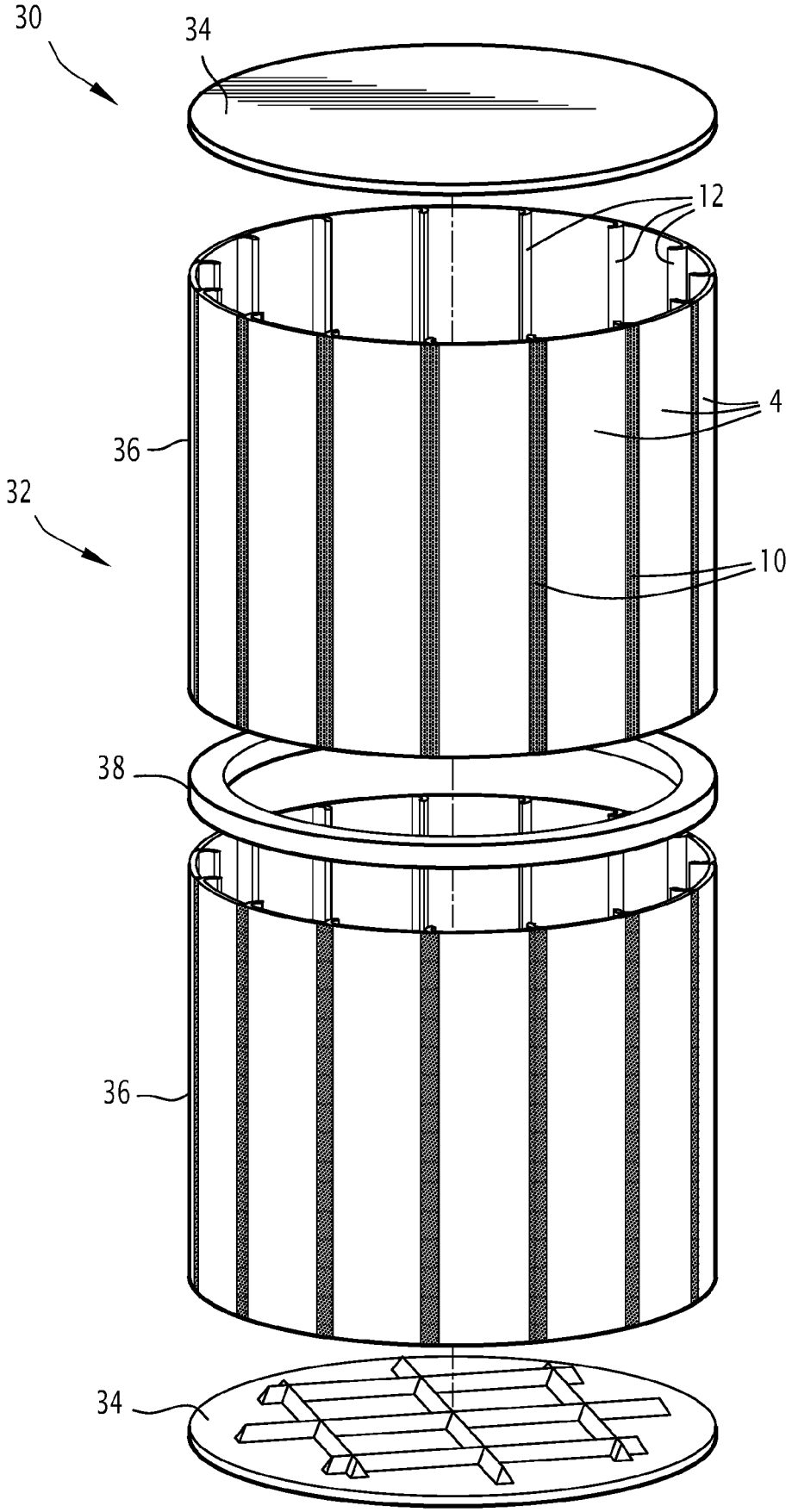


FIG.8

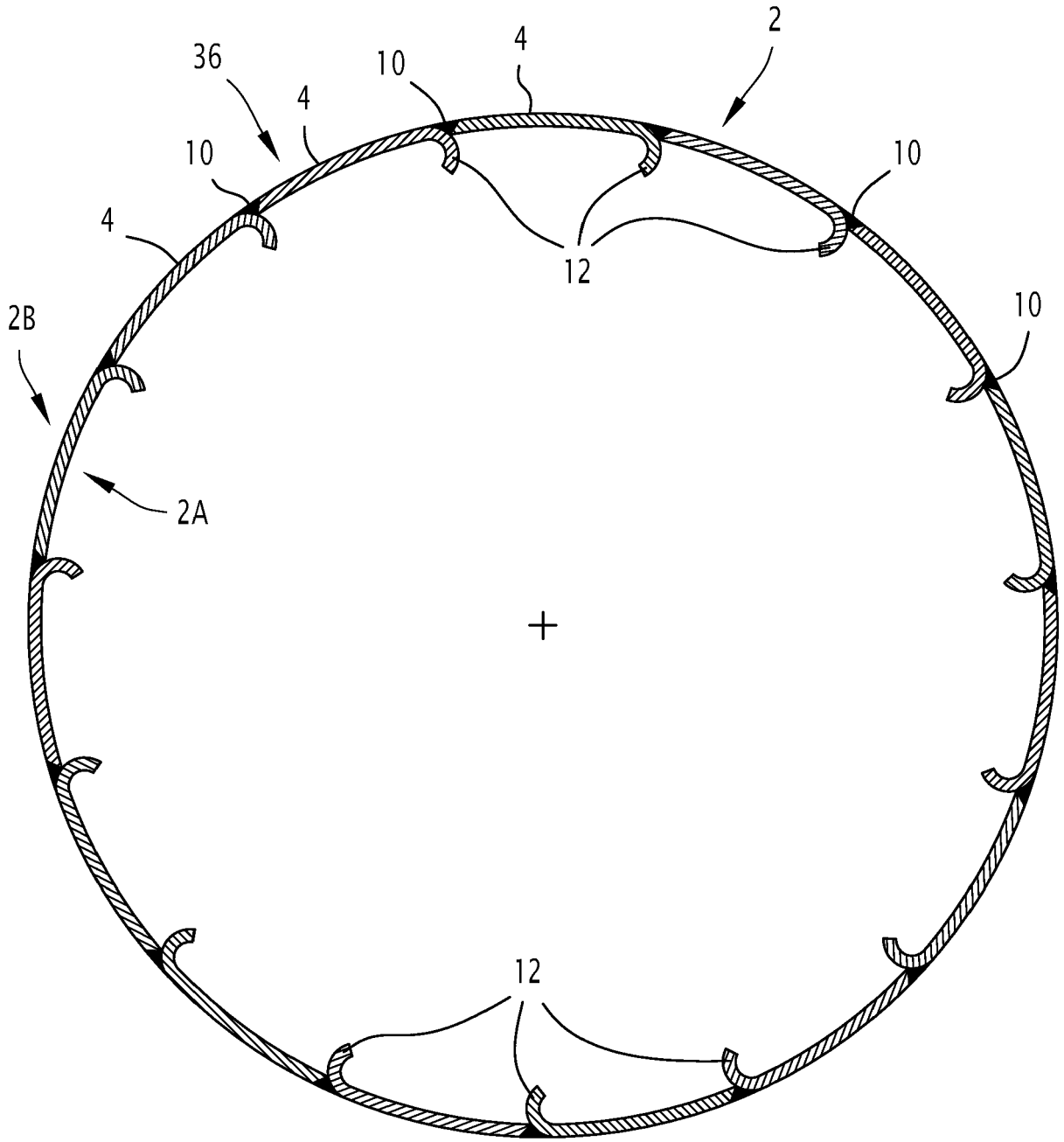


FIG.9

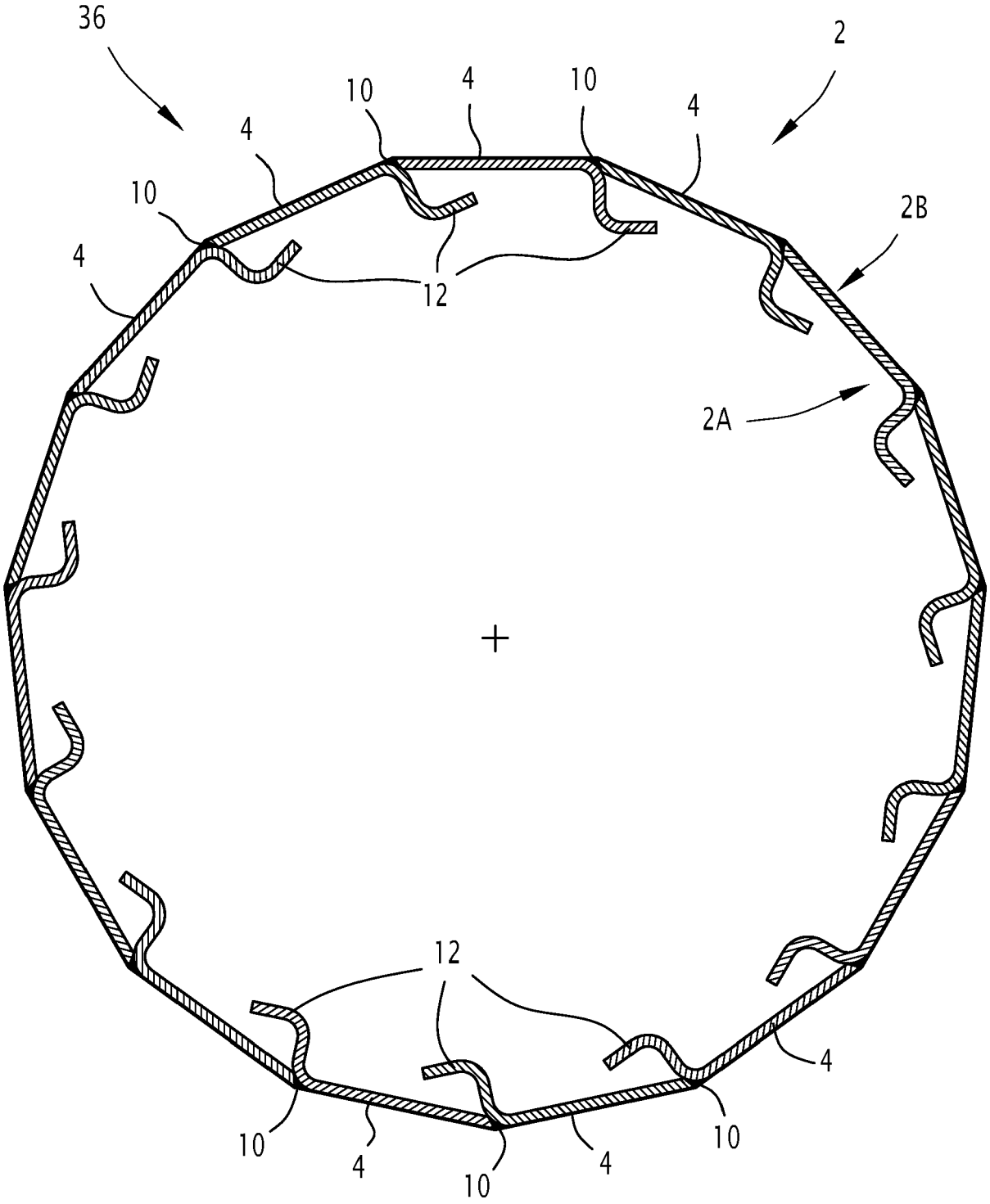


FIG.10

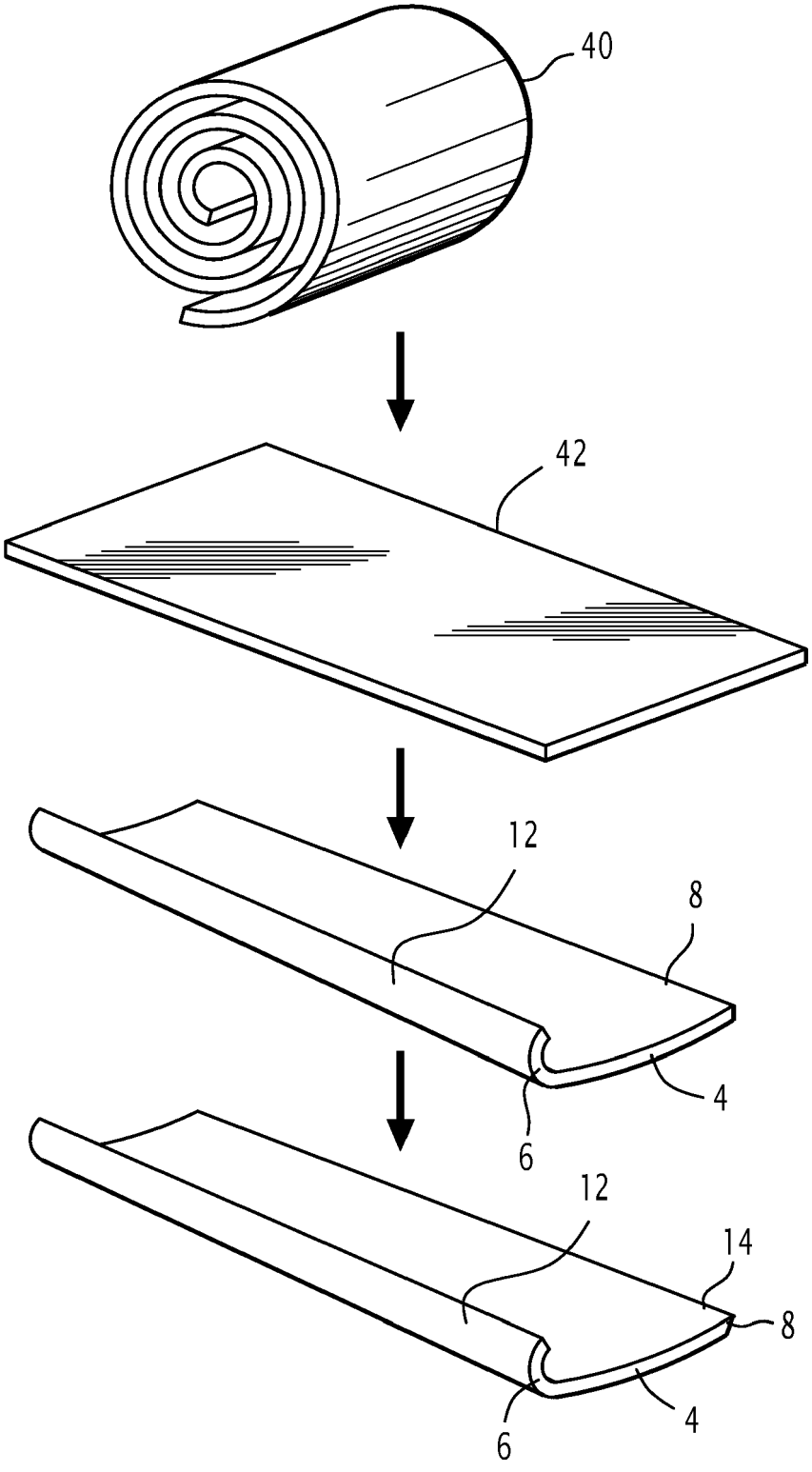


FIG.11

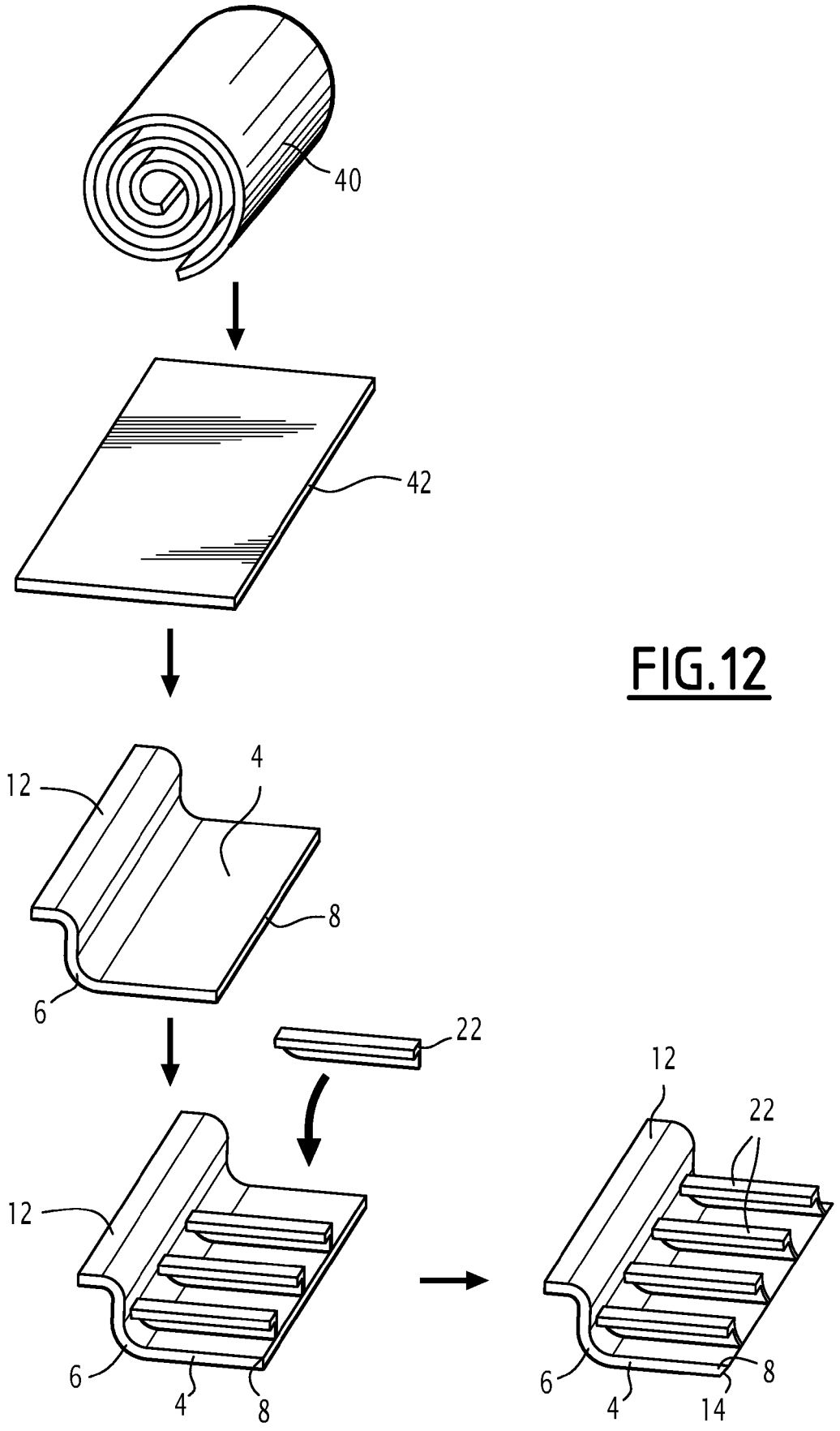


FIG.12

Europäisches Patentamt
European Patent Office
Office européen des brevets

# EUROPEAN SEARCH REPORT

Application Number
EP 22 30 6836

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | US 2010/101478 A1 (BIANCHI TAMO P [CA] ET AL) 29 April 2010 (2010-04-29)<br>* paragraph [0001] - paragraph [0066]; figures 1-26 * | 1-19 | INV.<br>B63B73/43 |
| X | US 8 136 464 B1 (BARBIER BRIAN K [US] ET AL) 20 March 2012 (2012-03-20) | 1-4,7-9, 11-14, 17-19 | |
| A | * column 2, line 4 - column 7, line 5; figures 1-11 * | 5,6,10, 15,16 | |
| X | JP 2006 160229 A (HAMANAKA MASAYOSHI) 22 June 2006 (2006-06-22) | 1-4,7,9, 11-14, 17,19 | |
| A | * paragraph [0001] - paragraph [0009]; figures 1-9 * | 5,6,8, 10,15, 16,18 | |
| A | GB 1 473 666 A (MARCH R) 18 May 1977 (1977-05-18)<br>* page 8, line 96 - page 11, line 44; figures 1-33 * | 1-19 | TECHNICAL FIELDS SEARCHED (IPC)<br>B63B |
| A | US 6 058 865 A (THIBEAULT SYLVIO [CA]) 9 May 2000 (2000-05-09)<br>* column 2, line 6 - column 4, line 21; figures 1-4 * | 1-19 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 30 May 2023 | Martínez, Felipe |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 30 6836

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-05-2023

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 2010101478 A1 | 29-04-2010 | CA 2684066 A1 | 29-04-2010 |
| | | US 2010101478 A1 | 29-04-2010 |
| US 8136464 B1 | 20-03-2012 | NONE | |
| JP 2006160229 A | 22-06-2006 | NONE | |
| GB 1473666 A | 18-05-1977 | NONE | |
| US 6058865 A | 09-05-2000 | NONE | |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82