

(22) Date of filing: **21.12.2018**

(72) Inventors:

- **Puillandre, Youen**
54400 Longwy (FR)
- **Obsadny, Krzysztof**
PL-63-440 Raszkwow (PL)

(74) Representative: **BRP Renaud & Partner mbB**
Rechtsanwälte Patentanwälte
Steuerberater
Königstraße 28
70173 Stuttgart (DE)

by a first longitudinal section (908) and a second longitudinal section (909), the front section (906), the back section (907), the first longitudinal section (908) and the second longitudinal (909) section define the at least one fluid channel (905), the back section (907) being formed by the first end section (903) and the second end section (904) contacting each other at least partially, the front section (906) having at least one reinforcement folding (910).



Description

[0001] The present invention relates to a heat exchanger comprising at least one folded tube formed of a single plate.

[0002] Such heat exchangers comprise a first manifold and a second manifold being spaced apart from each other and fluidically connected by at least one folded tube. By bending a first end section and a second end section of the single plate in such way that the first end section and the second end section contacting each other at least partially, a back section of the folded tube is formed. In most cases, the heat exchanger comprises a plurality of folded tubes which are spaced apart from each other. Adjacent folded tubes may be interconnected by fins in order to increase the available surface area for heat transfer.

[0003] In vehicles with internal combustion engines, such heat exchangers are used as radiators in which a coolant that was heated by the engine may transfer its heat energy to the environment of the vehicle. In the field of tension between mechanical strength and weight as well as material costs, the thickness of the single plate is minimized. Since radiators are usually installed in a front area of the vehicle and/or near the ground, one side of the radiator is exposed to the impact of external bodies like insects and stones. In particular, sections of the folded tubes directed towards the front of the vehicle are vulnerable due to the limited thickness of the single plate. In order to protect the folded tubes of the heat exchanger, a protection grid formed from plastic may be used. However, such protection grids lead to increased assembly and material costs.

[0004] In FR 2 690 228, EP 1 158 260 B1 and US 2004/0206481 A1 the impact strength of the folded tubes is increased by forming a reinforcement folding in the back section of the folded tubes. Thus, in the heat exchanger the back sections of the folded tubes are directed towards the front of the vehicle. The reinforcement folding provides a back section with a thickness higher than the thickness of the single plate. However, the reinforcement folding in the back section is difficult to manufacture due to the small distances to the end edges of the single plate. Thus, the production of such folded tubes is expensive and cost-intensive.

[0005] The present invention is based on the task of specifying a heat exchanger with improved impact strength without an additional protection grid.

[0006] This problem is solved according to the invention by the subject matter of the independent claims. Advantageous embodiments are the subject matter of the dependent claims.

[0007] The present invention is based on the general concept that at least one folded tube comprises a front section that is arranged opposite the back section, said front section having at least one reinforcement folding.

[0008] The innovative heat exchanger comprises at least one folded tube formed of a single plate. The single

plate may be formed from a heat conductive material, for example aluminum and/or aluminum alloy. The single plate may comprise a single material layer or several material layers. If the single plate comprises several material layers, at least one material layer may be a brazing clad layer. In the circumferential direction along the cross-section of the folded tube the single plate has a first end section and a second end section. The folded tube may be manufactured by bending and/or by roll forming the single plate.

[0009] The folded tube has at least one fluid channel through which a fluid may flow. The first manifold and the second manifold may be fluidically connected by the fluid channel of the tube.

[0010] The folded tube has a cross-section shape comprising a front section and a back section, the front section and the back section being arranged opposite each other. The front section and the back section are connected by a first longitudinal section and a second longitudinal section. The first longitudinal section and the second longitudinal section may be spaced apart from each other at least in some parts. The first longitudinal section and the second longitudinal section each may form a substantially straight section. In a cross-section view, the first longitudinal section and the second longitudinal section may extend substantially parallel to a longitudinal axis. The front section, the back section, the first longitudinal section and the second longitudinal section define the at least one fluid channel. The cross-section of the respective folded tube may have an oblong shape having a long diameter and a short diameter perpendicular to the long diameter. Said long diameter defines the longitudinal axis of the folded tube.

[0011] The back section is formed by the first end section and the second end section of the plate contacting each other at least partially. The front section has at least one reinforcement folding. The reinforcement folding provides a thickness which is greater than the thickness of the single plate. The front section and/or the reinforcement folding may be formed from a continuous section of the single plate. In the heat exchanger, the front section of the folded tube may be aligned towards the front of a vehicle. If the heat exchanger comprises a plurality of folded tubes, the front sections of all folded tubes may be aligned towards the same aligned, preferably towards the front of a vehicle.

[0012] The reinforcement folding increases the impact strength of the tube as well as of the heat exchanger. Since the reinforcement folding is located in the front section, the manufacturing is simpler resulting in lower production costs.

[0013] In an advantageous embodiment of the solution according to the invention, the first end section and the second end section being at least partially bent in a bending direction. The first end section and the second end section may be at least partially bent in an opposite direction. The first end section may have a larger bending radius than the second end section.

[0014] Between a start point and an end point of the bending of the first end section, the first end section may be bent by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°. Between a start point and an end point of the bending of the second end section, the second end section may be bent by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°. The start point of the bending of first end section may coincide with a part of the first longitudinal section. The start point of the bending of second end section may coincide with a part of the second longitudinal section.

[0015] The first end section may form a U-shaped socket in which a part of the second end section is inserted. The second end section may form a U-shaped socket in which a part of the first end section is inserted.

[0016] In an advantageous embodiment of the solution according to the invention, the reinforcement folding is mirror symmetric with respect to an axis parallel to a longitudinal axis. As a result, the impact strength of the folded tube is symmetric and the manufacturing is simpler.

[0017] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in a second bending direction with a second bending radius, a third section being bent in the first bending direction with a third bending radius.

[0018] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0019] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0020] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the bending of the second section may coincide with the end point of the bending of the first section while an end point of the bending of the second section may coincide with a start point of the bending of the third section. The second section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0021] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the bending of the third section may coincide with the end point of the bending of the second section while an

end point of the bending of the third section may coincide with a part of the second longitudinal section. The third section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0022] The first bending radius, the second bending radius and the third bending radius may have the same length.

[0023] This embodiment increases the impact strength of the folded tube.

[0024] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in the first bending direction with a second bending radius, the second bending radius being smaller than the first bending radius, a third section being bent in a second bending direction with a third bending radius, the third bending radius being greater than the second bending radius, a fourth section being bent in the second bending direction with a fourth bending radius, the fourth bending radius being smaller than the third bending radius, a fifth section being bent in the first bending direction with a fifth bending radius, the fifth bending radius being greater than the fourth bending radius.

[0025] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0026] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0027] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the bending of the second section may coincide with the end point of the bending of the first section while an end point of the bending of the second section may coincide with a start point of the bending of the third section. The second section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0028] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the bending of the third section may coincide with the end point of the bending of the second section while an end point of the bending of the third section may coincide with a start point of the bending of the fourth section. The third section may be bent between its start point and end

point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0029] The third section may be followed by the fourth section of the reinforcement folding. Thus, the start point of the bending of the fourth section may coincide with the end point of the bending of the third section while an end point of the bending of the fourth section may coincide with a start point of the bending of the fifth section. The fourth section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0030] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, the start point of the bending of the fifth section may coincide with the end point of the bending of the fourth section while an end point of the bending of the fifth section may coincide with a start point of a sixth section. The fifth section may be bent between its start point and end point by a bending angle between 80° to 180°, preferably by 100°.

[0031] This embodiment increases the impact strength of the folded tube.

[0032] In a further embodiment of the solution according to the invention, the reinforcement folding comprises: a sixth section being bent in the second bending direction with a sixth bending radius, a seventh section being bent in the first bending direction with a seventh bending radius.

[0033] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, the start point of the bending of the sixth section may coincide with the end point of the bending of the fifth section while an end point of the bending of the sixth section may coincide with a start point of the bending of the seventh section. The sixth section may be bent between its start point and end point by a bending angle between 20° to 90°, preferably by 45°.

[0034] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, the start point of the bending of the seventh section may coincide with the end point of the bending of the sixth section while an end point of the bending of the seventh section may coincide with a part of the second longitudinal section. The seventh section may be bent between its start point and end point by a bending angle between 20° to 90°, preferably by 45°.

[0035] This embodiment increases the impact strength of the folded tube.

[0036] In a further embodiment of the solution according to the invention, the reinforcement folding comprises: a sixth section forming a straight section, a seventh section being bent in the first bending direction with a seventh bending radius.

[0037] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, the start point of the sixth section may coincide with the end point of the bending of the fifth section while an end point of the sixth section may coincide with a start point of the bending of the seventh section.

[0038] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, the start point of the bending of the seventh section may coincide with the end point of the sixth section while an end point of the bending of the seventh section may coincide with a part of the second longitudinal section. The seventh section may be bent between its start point and end point by a bending angle between 20° to 90°, preferably by 45°.

[0039] This embodiment increases the impact strength of the folded tube.

[0040] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in the first bending direction with a second bending radius, the second bending radius being smaller than the first bending radius, a third section being bent in a second bending direction with a third bending radius, the third bending radius being smaller than the first bending radius, a fourth section forming a straight section, a fifth section being bent in the second bending direction with a fifth bending radius, the fifth bending radius being smaller than the first bending radius, a sixth section being bent in the first bending direction with a sixth bending radius, the sixth bending radius being smaller than the first bending radius, a seventh section being bent in the first bending direction with a seventh bending radius, the seventh bending radius being greater than the sixth bending radius.

[0041] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0042] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 20° to 110°, preferably by 70°.

[0043] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the bending of the second section may coincide with the end point of the bending of the first section while an end point of the bending of the second section may coincide with a start point of the bending of the third section. The second section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0044] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the bending of the third section may coincide with the

end point of the bending of the second section while an end point of the bending of the third section may coincide with a start point of the fourth section. The third section may be bent between its start point and end point by a bending angle between 150° to 190° , preferably by 170° .

[0045] The third section may be followed by the fourth section of the reinforcement folding. Thus, the start point of the fourth section may coincide with the end point of the bending of the third section while an end point of the fourth section may coincide with a start point of the bending of the fifth section.

[0046] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, the start point of the bending of the fifth section may coincide with the end point of the fourth section while an end point of the bending of the fifth section may coincide with a start point of the bending of a sixth section. The fifth section may be bent between its start point and end point by a bending angle between 150° to 190° , preferably by 170° .

[0047] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, the start point of the bending of the sixth section may coincide with the end point of the bending of the fifth section while an end point of the bending of the sixth section may coincide with a start point of the bending of the seventh section. The sixth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0048] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, the start point of the bending of the seventh section may coincide with the end point of the bending of the sixth section while an end point of the bending of the seventh section may coincide with a part of the second longitudinal section. The seventh section may be bent between its start point and end point by a bending angle between 20° to 110° , preferably by 70° .

[0049] This embodiment increases the impact strength of the folded tube.

[0050] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in the first bending direction with a second bending radius, the second bending radius being smaller than the first bending radius, a third section being bent in a second bending direction with a third bending radius, the third bending radius being greater than the second bending radius, a fourth section being bent in the second bending direction with a fourth bending radius, the fourth bending radius being smaller than the third bending radius, a fifth section being bent in the first bending direction with a fifth bending radius, the fifth bending radius being smaller than the first bending radius, a sixth section being bent in the second bending direction with a sixth bending radius, the sixth bending radius being smaller than the first bending radius, a seventh section being bent in the second bending direction with a seventh bending radius,

the seventh bending radius being greater than the sixth bending radius, an eighth section being bent in the first bending direction with an eighth bending radius, the eighth bending radius being smaller than the seventh bending radius, a ninth section being bent in the first bending direction with a ninth bending radius, the ninth bending radius being greater than the eighth bending radius.

[0051] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0052] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 5° to 60° , preferably by 40° .

[0053] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the bending of the second section may coincide with the end point of the bending of the first section while an end point of the bending of the second section may coincide with a start point of the bending of the third section. The second section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0054] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the bending of the third section may coincide with the end point of the bending of the second section while an end point of the bending of the third section may coincide with a start point of the bending of the fourth section. The third section may be bent between its start point and end point by a bending angle between 5° to 80° , preferably by 15° .

[0055] The third section may be followed by the fourth section of the reinforcement folding. Thus, the start point of the bending of the fourth section may coincide with the end point of the bending of the third section while an end point of the bending of the fourth section may coincide with a start point of the bending of the fifth section. The fourth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0056] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, the start point of the bending of the fifth section may coincide with the end point of the bending of the fourth section while an end point of the bending of the fifth section may coincide with a start point of the bending of a sixth section. The

fifth section may be bent between its start point and end point by a bending angle between 120° to 200° , preferably by 160° .

[0057] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, the start point of the bending of the sixth section may coincide with the end point of the bending of the fifth section while an end point of the bending of the sixth section may coincide with a start point of the bending of the seventh section. The sixth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0058] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, the start point of the bending of the seventh section may coincide with the end point of the bending of the sixth section while an end point of the bending of the seventh section may coincide with a start point of the bending of the eighth section. The seventh section may be bent between its start point and end point by a bending angle between 5° to 80° , preferably by 15° .

[0059] The seventh section may be followed by the eighth section of the reinforcement folding. Thus, the start point of the bending of the eighth section may coincide with the end point of the bending of the seventh section while an end point of the bending of the eighth section may coincide with a start point of the bending of the ninth section. The eighth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0060] The eighth section may be followed by the ninth section of the reinforcement folding. Thus, the start point of the bending of the ninth section may coincide with the end point of the bending of the eighth section while an end point of the bending of the ninth section may coincide with a part of the second longitudinal section. The ninth section may be bent between its start point and end point by a bending angle between 5° to 60° , preferably by 40° .

[0061] This embodiment increases the impact strength of the folded tube.

[0062] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section forming a straight section, a third section being bent in a second bending direction with a third bending radius, a fourth section forming a straight section, a fifth section being bent in the first bending direction with a fifth bending radius, a sixth section forming a straight section, a seventh section being bent in the second bending direction with a seventh bending radius, an eighth section forming a straight section, a ninth section being bent in the first bending direction with a ninth bending radius.

[0063] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the

respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0064] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the second section. The first section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0065] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the second section may coincide with the end point of the bending of the first section while an end point of the second section may coincide with a start point of the bending of the third section.

[0066] The second section may be followed by the third section of the reinforcement folding. Thus, a start point of the bending of the third section may coincide with the endpoint of the second section while an end point of the bending of the third section may coincide with a start point of the fourth section. The third section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0067] The third section may be followed by the fourth section of the reinforcement folding. Thus, the start point of the fourth section may coincide with the end point of the bending of the third section while an end point of the fourth section may coincide with a start point of the bending of the fifth section.

[0068] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, a start point of the bending of the fifth section may coincide with the endpoint of the fourth section while an end point of the bending of the fifth section may coincide with a start point of the sixth section. The fifth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0069] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, the start point of the sixth section may coincide with the end point of the bending of the fifth section while an end point of the sixth section may coincide with a start point of the bending of the seventh section.

[0070] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, a start point of the bending of the seventh section may coincide with the endpoint of the sixth section while an end point of the bending of the seventh section may coincide with a start point of the eighth section. The seventh section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0071] The seventh section may be followed by the

eighth section of the reinforcement folding. Thus, the start point of the eighth section may coincide with the end point of the bending of the seventh section while an end point of the eighth section may coincide with a start point of the bending of the ninth section.

[0072] The eighth section may be followed by the ninth section of the reinforcement folding. Thus, the start point of the bending of the ninth section may coincide with the end point of the eighth section while an end point of the bending of the ninth section may coincide with a part of the second longitudinal section. The ninth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0073] This embodiment increases the impact strength of the folded tube.

[0074] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in a second bending direction with a second bending radius, a third section forming a straight section, a fourth section being bent in the second bending direction with a fourth bending radius, a fifth section forming a straight section, a sixth section being bent in the first bending direction with a sixth bending radius, a seventh section being bent in the first bending direction with a seventh bending radius, an eighth section being bent in the first bending direction with an eighth bending radius, the seventh bending radius being greater than the sixth bending radius, the seventh bending radius being greater than the eighth bending radius, a ninth section forming a straight section, a tenth section being bent in the second bending direction with a tenth bending radius, an eleventh section forming a straight section, a twelfth section being bent in the second bending direction with a twelfth bending radius, a thirteenth section being bent in the first bending direction with a thirteenth bending radius.

[0075] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0076] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0077] The first section may be followed by the second section of the reinforcement folding. Thus, a start point of the bending of the second section may coincide with the end point of the bending of the first section while an

end point of the bending of the second section may coincide with a start point of the third section. The second section may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0078] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the third section may coincide with the end point of the bending of the second section while an end point of the third section may coincide with a start point of the bending of the fourth section.

[0079] The third section may be followed by the fourth section of the reinforcement folding. Thus, a start point of the bending of the fourth section may coincide with the end point of the third section while an end point of the bending of the fourth section may coincide with a start point of the fifth section. The fourth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0080] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, the start point of the fifth section may coincide with the end point of the bending of the fourth section while an end point of the fifth section may coincide with a start point of the bending of the sixth section.

[0081] The fifth section may be followed by the sixth section of the reinforcement folding. Thus, a start point of the bending of the sixth section may coincide with the end point of the fifth section while an end point of the bending of the sixth section may coincide with a start point of the bending of the seventh section. The sixth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0082] The sixth section may be followed by the seventh section of the reinforcement folding. Thus, a start point of the bending of the seventh section may coincide with the end point of the sixth section while an end point of the bending of the seventh section may coincide with a start point of the bending of the eighth section. The seventh section may be bent between its start point and end point by a bending angle between 160° to 200° , preferably by 180° .

[0083] The seventh section may be followed by the eighth section of the reinforcement folding. Thus, a start point of the bending of the eighth section may coincide with the end point of the seventh section while an end point of the bending of the eighth section may coincide with a start point of the ninth section. The eighth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0084] The eighth section may be followed by the ninth section of the reinforcement folding. Thus, the start point of the ninth section may coincide with the end point of the bending of the eighth section while an end point of the ninth section may coincide with a start point of the

bending of the tenth section.

[0085] The ninth section may be followed by the tenth section of the reinforcement folding. Thus, a start point of the bending of the tenth section may coincide with the end point of the ninth section while an end point of the bending of the tenth section may coincide with a start point of the eleventh section. The tenth section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0086] The tenth section may be followed by the eleventh section of the reinforcement folding. Thus, the start point of the eleventh section may coincide with the end point of the bending of the tenth section while an end point of the eleventh section may coincide with a start point of the bending of the twelfth section.

[0087] The eleventh section may be followed by the twelfth section of the reinforcement folding. Thus, a start point of the bending of the twelfth section may coincide with the end point of the eleventh section while an end point of the bending of the twelfth section may coincide with a start point of the bending of the thirteenth section. The twelfth section may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0088] The twelfth section may be followed by the thirteenth section of the reinforcement folding. Thus, the start point of the bending of the thirteenth section may coincide with the end point of the twelfth section while an end point of the bending of the thirteenth section may coincide with a part of the second longitudinal section. The thirteenth section may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0089] This embodiment increases the impact strength of the folded tube.

[0090] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first bead, the first bead is followed by a section being bent in a first bending direction with a bending radius, the section being followed by a second bead, a damping body in the fluid channel.

[0091] The first bead and the second bead may be arranged opposite each other and reduce the cross-section of the fluid channel at least in some sections. The first bead may protrude in the direction of the second bead while the second bead may protrude in the direction of the first bead. The damping body has a damping effect and converts kinetic energy into deformation energy.

[0092] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0093] The first longitudinal section may be followed by the first bead of the reinforcement folding. The first

bead may be followed by the bend section of the reinforcement folding. Thus, a start point of the bending of the section may coincide with a part of the first bead while an end point of the bending of the section may coincide with a part of the second bead. The section may be bent between its start point and end point by a bending angle between 150° to 260° , preferably by 200° . The second bead may be followed by the second longitudinal section.

[0094] This embodiment increases the impact strength of the folded tube.

[0095] In an advantageous embodiment of the solution according to the invention, the reinforcement folding comprises: a first section being bent in a first bending direction with a first bending radius, a second section being bent in the first bending direction with a second bending radius, the second bending radius being smaller than the first bending radius, a third section being bent in a second bending direction with a third bending radius, a fourth section being bent in the first bending direction with a fourth bending radius, a fifth section being bent in the first bending direction with a fifth bending radius, the fifth bending radius being greater than the fourth bending radius, the second section and the third section as well as the fourth section forming a hollow space.

[0096] The hollow space may be formed by an external surface of the tube. Additionally, the hollow space may be fluidically separated from the fluid channel.

[0097] The first bending direction and the second bending direction are opposite. The first bending direction may be clockwise while the second bending direction may be counterclockwise. The bending direction of the respective section is determined by considering the extension of the respective section starting from a start point up to an end point.

[0098] The first longitudinal section may be followed by the first section of the reinforcement folding. Thus, a start point of the bending of the first section may coincide with a part of the first longitudinal section while an end point of the bending of the first section may coincide with a start point of the bending of the second section. The first section may be bent between its start point and end point by a bending angle between 20° to 120° , preferably by 45° .

[0099] The first section may be followed by the second section of the reinforcement folding. Thus, the start point of the bending of the second section may coincide with the end point of the bending of the first section while an end point of the bending of the second section may coincide with a start point of the bending of the third section. The second section may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0100] The second section may be followed by the third section of the reinforcement folding. Thus, the start point of the bending of the third section may coincide with the end point of the bending of the second section while an end point of the bending of the third section may coincide

with a start point of the bending of the fourth section. The third section may be bent between its start point and end point by a bending angle between 280° to 355°, preferably by 345°.

[0101] The third section may be followed by the fourth section of the reinforcement folding. Thus, the start point of the bending of the fourth section may coincide with the end point of the bending of the third section while an end point of the bending of the fourth section may coincide with a start point of the bending of the fifth section. The fourth section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0102] The fourth section may be followed by the fifth section of the reinforcement folding. Thus, the start point of the bending of the fifth section may coincide with the end point of the fourth section while an end point of the bending of the fifth section may coincide with a part of the second longitudinal section. The fifth section may be bent between its start point and end point by a bending angle between 20° to 120°, preferably by 45°.

[0103] This embodiment increases the impact strength of the folded tube.

[0104] In an advantageous embodiment of the solution according to the invention, a damping body is inserted in the hollow space. The damping body has a damping effect and converts kinetic energy into deformation energy.

[0105] This embodiment increases the impact strength of the folded tube.

[0106] In an advantageous embodiment of the solution according to the invention, the tube comprises a plurality of fluid channels, preferably at least two fluid channels or four fluid channels. The plurality of fluid channels may be formed by folding the first longitudinal section and/or the second longitudinal section. The plurality of fluid channels may be formed by inserting a folded insert sheet. The use of plurality of fluid channel improves the heat transfer due to the larger surface area.

[0107] Further important features and advantages of the invention emerge from the dependent claims, from the drawings and from the associated description of the figures with reference to the drawings.

[0108] It goes without saying that the features mentioned above and those which have yet to be explained below can be used not only in the respectively stated combination, but also in different combinations or on their own without departing from the scope of the present invention.

[0109] Preferred exemplary embodiments of the invention are illustrated in the drawings and are explained in more detail in the description below, wherein the same reference signs refer to identical or similar or functionally identical components.

[0110] In the drawings, in each case schematically,

Fig. 1 shows a side view of a heat exchanger according to the invention,

Fig. 2 shows a single plate with a first end section and a second end section before folding,

Fig. 3 shows a cross-section of a first embodiment of the inventive tube,

Fig. 4 shows an enlarged cross-section view of the reinforcement folding of the first embodiment of the inventive tube,

Fig. 5 shows a cross-section of an embodiment of the inventive tube with the second end section forming a U-shaped socket,

Fig. 6 shows a cross-section of an embodiment of the inventive tube with the first end section forming a U-shaped socket,

Fig. 7 shows a cross-section of an embodiment of the inventive tube with two fluid channels,

Fig. 8 shows a cross-section of an embodiment of the inventive tube with four fluid channels,

Fig. 9 shows a cross-section of a second embodiment of the inventive tube,

Fig. 10 shows an enlarged cross-section view of the reinforcement folding of the second embodiment of the inventive tube,

Fig. 11 shows a cross-section of a third embodiment of the inventive tube,

Fig. 12 shows an enlarged cross-section view of the reinforcement folding of the third embodiment of the inventive tube,

Fig. 13 shows a cross-section of a fourth embodiment of the inventive tube,

Fig. 14 shows an enlarged cross-section view of the reinforcement folding of the fourth embodiment of the inventive tube,

Fig. 15 shows a cross-section of a fifth embodiment of the inventive tube,

Fig. 16 shows an enlarged cross-section view of the reinforcement folding of the fifth embodiment of the inventive tube,

Fig. 17 shows a cross-section of a sixth embodiment of the inventive tube,

Fig. 18 shows an enlarged cross-section view of the reinforcement folding of the sixth embodiment of the inventive tube,

- Fig. 19 shows a cross-section of a seventh embodiment of the inventive tube,
- Fig. 20 shows an enlarged cross-section view of the reinforcement folding of the seventh embodiment of the inventive tube,
- Fig. 21 shows a cross-section of an eighth embodiment of the inventive tube,
- Fig. 22 shows a cross-section of a ninth embodiment of the inventive tube,
- Fig. 23 shows an enlarged cross-section view of the reinforcement folding of the ninth embodiment of the inventive tube,
- Fig. 24 shows a cross-section of a tenth embodiment of the inventive tube.

[0111] According to Fig. 1, a heat exchanger 900 according to the invention has a first manifold 919 and a second manifold 920 being spaced apart and fluidically connected by at least one folded tube 901. The heat exchanger 900 comprises a plurality of tubes 901 which are spaced apart. Adjacent tubes 901 are interconnected by ribs 921 in order to increase the available surface area for heat transfer.

[0112] The heat exchanger 900 may be fluidically connected to fluid circuit of a vehicle which is not shown in the figures. This fluid circuit may have least one electrically driven conveying unit for driving a fluid and/or a coolant within the fluid circuit.

[0113] The first manifold 919 has an inlet 917 and the second manifold 920 has an outlet 918. The fluid and/or a coolant may flow through the inlet 917 into the heat exchanger 900 and may leave the heat exchanger 900 through the outlet 918. Within the folded tubes 901, the fluid and/or a coolant may flow parallel to a flow direction 916.

[0114] The fluid and/or a coolant flowing from the first manifold 919 to the second manifold 920 through the folded tubes 901 is in thermal contact with internal surfaces 914 of the folded tubes 901 while a second fluid like ambient air is in thermal contact with external surfaces 915 of the folded tubes 901. Additionally, the second fluid is in contact with the ribs 921. As long as the two fluids have different temperatures, a heat transfer from the warmer to the colder fluid can be achieved through folded tubes 901 and ribs 921.

[0115] The first manifold 919, the second manifold 920 and the folded tubes 901 are assembled such that the first manifold 919 and the second manifold 920 are fluidically connected by the folded tubes 901. This assembly may be brazed or furnace brazed in order to create brazed joints between the manifolds 919, 920 and the folded tubes 901. This provides a cost-efficient and modular production of the heat exchanger 900.

[0116] Fig. 2 shows a single plate 902 with a first end section 903 and a second end section 904 before folding. During a production process, the single plate 902 is bent in such a way that the first end section 903 and the second end section 904 contacting each other at least partially. As a result, the by the first end section 903 and the second end section 904 form a back section 907 of the folded tube 901.

[0117] The Figs. 3 to 24 show cross-sections of embodiments of the folded tube 901 along an A-A line in Fig. 1. The cross-sections are cross to a longitudinal extension direction of the folded tube 901. In Fig. 1, the longitudinal extension direction of the folded tubes 901 is substantially parallel to the flow direction 916.

[0118] Bending angles and bending radii shown in the Figs. 3 to 24 are only exemplary and symbolic. Thus, the lengths of the bending radii shown in the Fig. 3 to 24 do not correspond to lengths in technical drawings. Starting points and end points of respective sections of the folded tube 901 are indicated by dashed lines.

[0119] In the Figs. 3 to 24, a first bending direction 912 and the second bending direction 913 are indicated by curved arrows. The first bending direction 912 and the second bending direction 913 are opposite. The first bending direction 912 is clockwise while the second bending direction 913 is counterclockwise. Additionally, a longitudinal axis 911 is shown in the Figs. 3 to 24. External bodies like stones may impact the folded tube 901 along an impact direction 911.

[0120] In the Figs. 3, 7, 8, 9, 11, 13, 15, 17, 19, 21, 22 and 24 the cross-section shape of the respective folded tube 901 comprises a front section 906 and the back section 907 which are arranged opposite each other. The front section 906 and the back section 907 are connected by a first longitudinal section 908 and a second longitudinal section 909. The first longitudinal section 908 and the second longitudinal section 909 are substantially parallel to the longitudinal axis 911. The first longitudinal section 908 and the second longitudinal section 909 are spaced apart each other.

[0121] The front section 906, the back section 907, the first longitudinal section 908 and the second longitudinal section 909 define the at least one fluid channel 905. The fluid and/or a coolant which flows through the fluid channel 905 is in thermal contact with an internal surface 914 while a second fluid like ambient air is in thermal contact with an external surfaces 915.

[0122] The back section 907 is formed by a first end section 903 and a second end section 904 contacting each other at least partially. The first end section 903 and the second end section 904 are at least partially bent in an opposite direction. The first end section 903 is bent in the second bending direction 912 while the second end section 904 is bent in the first bending direction 912. The first end section 903 has a larger bending radius than the second end section 904.

[0123] Between a start point and an end point of the bending of the first end section 903, the first end section

903 may be bent by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°. Between a start point and an end point of the bending of the second end section 904, the second end section 904 may be bent by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°. The start point of the bending of first end section 903 coincides with a part of the first longitudinal section 908. The start point of the bending of second end section 904 coincides with a part of the second longitudinal section 909.

[0124] The folded tubes 901 in the Figs. 3, 7, 8, 9, 11, 13, 15, 17, 19, 21, 22 and 24 may have back sections 907 which are formed like the back sections shown in Fig. 5 or Fig. 6. The first end section 903 may form a U-shaped socket 925 in which a part of the second end section 904 is inserted. The second end section 904 may form a U-shaped socket 924 in which a part of the first end section 903 is inserted.

[0125] The folded tubes 901 in the Figs. 3, 7, 8, 9, 11, 13, 15, 17, 19, 21, 22 and 24 may have a plurality of fluid channels, preferably two or four fluid channels, which are formed like the fluid channels shown in Fig. 7 or Fig. 8.

[0126] Fig. 3 shows a cross-section of a first embodiment of the inventive tube while Fig. 4 shows an enlarged cross-section view of the reinforcement folding 910.

[0127] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0128] The reinforcement folding 910 comprises: a first section 1 being bent in the first bending direction 912 with a first bending radius 1a, a second section 2 being bent in the second bending direction 913 with a second bending radius 2a, a third section 3 being bent in the first bending direction 912 with a third bending radius 3a.

[0129] The first longitudinal section 908 is followed by the first section 1 of the reinforcement folding 910. Thus, a start point of the bending of the first section 1 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 1 coincides with a start point of the bending of the second section 2. The first section may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0130] The first section 1 is followed by the second section 2 of the reinforcement folding 910. Thus, the start point of the bending of the second section 2 coincides with the end point of the bending of the first section 1 while an end point of the bending of the second section 1 coincides with a start point of the bending of the third section 3. The second section 2 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0131] The second section 2 is followed by the third section 3 of the reinforcement folding 910. Thus, the start point of the bending of the third 3 section coincides with

the end point of the bending of the second section 2 while an end point of the bending of the third section 3 coincides with a part of the second longitudinal section 909. The third section 3 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0132] The first bending radius 1a, the second bending radius 2a and the third bending 3a radius may have the same length.

[0133] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0134] The folded tube 901 shown in Fig. 5 has a first end section 903 forming a U-shaped socket 925 in which a part of the second end section 904 is inserted. Additionally, the second end section 904 forms a U-shaped socket 924 in which a part of the first end section 903 is inserted. The U-shaped socket 924 and the U-shaped socket 925 are at least partially intertwined.

[0135] The folded tube 901 shown in Fig. 6 has a first end section 903 forming a U-shaped socket 925 in which a part of the second end section 904 is inserted. The folded tube 901 shown in Fig. 7 has a first fluid channel 905a and a second fluid channel 905b. The first fluid channel 905a and the second fluid channel 905b are separated by a first transverse folding 923a. The first transverse folding 923a may be formed by a folding of the first longitudinal section 908 or by a folding of the second longitudinal section 909. The first transverse folding 923a extends substantially transverse to the longitudinal axis 911.

[0136] The folded tube 901 shown in Fig. 8 has a first fluid channel 905a, a second fluid channel 905b, a third fluid channel 905c and a fourth fluid channel 905d. The first fluid channel 905a and the second fluid channel 905b are separated by a first transverse folding 923a. The second fluid channel 905b and the third fluid channel 905c are separated by a second transverse folding 923b. The third fluid channel 905c and the fourth fluid channel 905d are separated by a third transverse folding 923c. Each of the transverse folding 923a, 923b, 923c and/or 923d may be formed by a folding of the first longitudinal section 908 or by a folding of the second longitudinal section 909. Each of the transverse folding 923a, 923b, 923c and/or 923d extends substantially transverse to the longitudinal axis 911.

[0137] Fig. 9 shows a cross-section of a second embodiment of the inventive tube while Fig. 10 shows an enlarged cross-section view of the reinforcement folding 910.

[0138] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0139] The reinforcement folding 910 comprises: a first section 101 being bent in the first bending direction 912 with a first bending radius 101a, a second section 102

being bent in the first bending direction 912 with a second bending radius 102a, the second bending radius 102a being smaller than the first bending radius 101a, a third section 103 being bent in the second bending direction 913 with a third bending radius 103a, the third bending radius 103a being greater than the second bending radius 102a, a fourth section 104 being bent in the second bending direction 913 with a fourth bending radius 104a, the fourth bending radius 104a being smaller than the third bending radius 103a, a fifth section 105 being bent in the first bending direction 912 with a fifth bending radius 105a, the fifth bending radius 105a being greater than the fourth bending radius 104a, a sixth section 206 being bent in the second bending direction 913 with a sixth bending radius 206a, a seventh section 207 being bent in the first bending direction 912 with a seventh bending radius 207a.

[0140] The first longitudinal section 908 is followed by the first section 101 of the reinforcement folding 910. Thus, a start point of the bending of the first section 101 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 101 coincides with a start point of the bending of the second section 102. The first section 101 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0141] The first section 101 is followed by the second section 102 of the reinforcement folding 910. Thus, the start point of the bending of the second section 102 coincides with the end point of the bending of the first section 101 while an end point of the bending of the second section 102 coincides with a start point of the bending of the third section 103. The second section 102 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0142] The second section 102 is followed by the third section 103 of the reinforcement folding 910. Thus, the start point of the bending of the third section 103 coincides with the end point of the bending of the second section 102 while an end point of the bending of the third section 103 may coincide with a start point of the bending of the fourth section 104. The third section 103 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0143] The third section 103 is followed by the fourth section 104 of the reinforcement folding 910. Thus, the start point of the bending of the fourth section 104 coincides with the end point of the bending of the third section 103 while an end point of the bending of the fourth section 104 coincides with a start point of the bending of the fifth section 105. The fourth section 104 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0144] The fourth section 104 is followed by the fifth

section 105 of the reinforcement folding. Thus, the start point of the bending of the fifth section 105 coincides with the end point of the bending of the fourth section 104 while an end point of the bending of the fifth section 105 coincides with a start point of the bending of the sixth section 206. The fifth section 105 may be bent between its start point and end point by a bending angle between 80° to 180°, preferably by 100°.

[0145] The fifth section 105 is followed by the sixth section 106 of the reinforcement folding 910. Thus, the start point of the bending of the sixth section 106 coincides with the end point of the bending of the fifth section 105 while an end point of the bending of the sixth section 106 coincides with a start point of the bending of the seventh section 207. The sixth section 106 may be bent between its start point and end point by a bending angle between 20° to 90°, preferably by 45°.

[0146] The sixth section 106 is followed by the seventh section 107 of the reinforcement folding 910. Thus, the start point of the bending of the seventh section 107 coincides with the end point of the bending of the sixth section 106 while an end point of the bending of the seventh section 107 coincides with a part of the second longitudinal section 909. The seventh section 107 may be bent between its start point and end point by a bending angle between 20° to 90°, preferably by 45°.

[0147] Fig. 11 shows a cross-section of a third embodiment of the inventive tube while Fig. 12 shows an enlarged cross-section view of the reinforcement folding 910.

[0148] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0149] The reinforcement folding 910 comprises: a first section 101 being bent in the first bending direction 912 with a first bending radius 101a, a second section 102 being bent in the first bending direction 912 with a second bending radius 102a, the second bending radius 102a being smaller than the first bending radius 101a, a third section 103 being bent in the second bending direction 913 with a third bending radius 103a, the third bending radius 103a being greater than the second bending radius 102a, a fourth section 104 being bent in the second bending direction 913 with a fourth bending radius 104a, the fourth bending radius 104a being smaller than the third bending radius 103a, a fifth section 105 being bent in the first bending direction 912 with a fifth bending radius 105a, the fifth bending radius 105a being greater than the fourth bending radius 104a, a sixth section 306 forming a straight section, a seventh section 307 being bent in the first bending direction 912 with a seventh bending radius 307a.

[0150] The first longitudinal section 908 is followed by the first section 101 of the reinforcement folding 910. Thus, a start point of the bending of the first section 101 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 101

coincides with a start point of the bending of the second section 102. The first section 101 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0151] The first section 101 is followed by the second section 102 of the reinforcement folding 910. Thus, the start point of the bending of the second section 102 coincides with the end point of the bending of the first section 101 while an end point of the bending of the second section 102 coincides with a start point of the bending of the third section 103. The second section 102 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0152] The second section 102 is followed by the third section 103 of the reinforcement folding 910. Thus, the start point of the bending of the third section 103 coincides with the end point of the bending of the second section 102 while an end point of the bending of the third section 103 may coincide with a start point of the bending of the fourth section 104. The third section 103 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0153] The third section 103 is followed by the fourth section 104 of the reinforcement folding 910. Thus, the start point of the bending of the fourth section 104 coincides with the end point of the bending of the third section 103 while an end point of the bending of the fourth section 104 coincides with a start point of the bending of the fifth section 105. The fourth section 104 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0154] The fourth section 104 is followed by the fifth section 105 of the reinforcement folding. Thus, the start point of the bending of the fifth section 105 coincides with the end point of the bending of the fourth section 104 while an end point of the bending of the fifth section 105 coincides with a start point of the bending of the sixth section 206. The fifth section 105 may be bent between its start point and end point by a bending angle between 80° to 180°, preferably by 100°.

[0155] The fifth section 105 is followed by the sixth section 106 of the reinforcement folding 910. Thus, the start point of the sixth section 106 coincides with the end point of the bending of the fifth section 105 while an end point of the sixth section 106 coincides with a start point of the bending of the seventh section 107.

[0156] The sixth section 106 is followed by the seventh section 107 of the reinforcement folding 910. Thus, the start point of the bending of the seventh section 107 coincides with the end point of the sixth section 106 while an end point of the bending of the seventh section 107 coincides with a part of the second longitudinal section 909. The seventh section 107 may be bent between its start point and end point by a bending angle between 20°

to 90°, preferably by 45°.

[0157] Fig. 13 shows a cross-section of a fourth embodiment of the inventive tube while Fig. 14 shows an enlarged cross-section view of the reinforcement folding 910.

[0158] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0159] The reinforcement folding 910 comprises: a first section 401 being bent in the first bending direction 912 with a first bending radius 401a, a second section 402 being bent in the first bending direction 912 with a second bending radius 402a, the second bending radius 402a being smaller than the first bending radius 401a, a third section 403 being bent in the second bending direction 913 with a third bending radius 403a, the third bending radius 403a being smaller than the first bending radius 401a, a fourth section 404 forming a straight section, a fifth section 405 being bent in the second bending direction 913 with a fifth bending radius 405a, the fifth bending radius 405a being smaller than the first bending radius 401a, a sixth section 406 being bent in the first bending direction 912 with a sixth bending radius 406a, the sixth bending radius 406a being smaller than the first bending radius 401a, a seventh section 407 being bent in the first bending direction 912 with a seventh bending radius 407a, the seventh bending radius 407a being greater than the sixth bending radius 406a.

[0160] The first longitudinal section 908 is followed by the first section 401 of the reinforcement folding 910. Thus, a start point of the bending of the first section 401 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 401 coincides with a start point of the bending of the second section 402. The first section 401 may be bent between its start point and end point by a bending angle between 20° to 110°, preferably by 70°.

[0161] The first section 401 is followed by the second section 402 of the reinforcement folding 910. Thus, the start point of the bending of the second section 402 coincides with the end point of the bending of the first section 401 while an end point of the bending of the second section 402 coincides with a start point of the bending of the third section 403. The second section 402 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0162] The second section 402 is followed by the third section 403 of the reinforcement folding 910. Thus, the start point of the bending of the third section 403 coincides with the end point of the bending of the second section 402 while an end point of the bending of the third section 403 coincides with a start point of the fourth section 404. The third section 403 may be bent between its start point and end point by a bending angle between 150° to 190°, preferably by 170°.

[0163] The third section 403 is followed by the fourth

section 404 of the reinforcement folding 910. Thus, the start point of the fourth section 404 coincides with the end point of the bending of the third section 403 while an end point of the fourth section 404 coincides with a start point of the bending of the fifth section 405.

[0164] The fourth section 404 is followed by the fifth section 405 of the reinforcement folding 910. Thus, the start point of the bending of the fifth section 405 coincides with the end point of the fourth section 404 while an end point of the bending of the fifth section 405 coincides with a start point of the bending of a sixth section 406. The fifth section 405 may be bent between its start point and end point by a bending angle between 150° to 190° , preferably by 170° .

[0165] The fifth section 405 is followed by the sixth section 406 of the reinforcement folding 910. Thus, the start point of the bending of the sixth section 406 coincides with the end point of the bending of the fifth section 405 while an end point of the bending of the sixth section 406 coincides with a start point of the bending of the seventh section 407. The sixth section 406 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0166] The sixth section 406 is followed by the seventh section 407 of the reinforcement folding 910. Thus, the start point of the bending of the seventh section 407 coincides with the end point of the bending of the sixth section 406 while an end point of the bending of the seventh section 407 coincides with a part of the second longitudinal section 909. The seventh section 407 may be bent between its start point and end point by a bending angle between 20° to 110° , preferably by 70° .

[0167] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0168] Fig. 15 shows a cross-section of a fifth embodiment of the inventive tube while Fig. 16 shows an enlarged cross-section view of the reinforcement folding 910.

[0169] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0170] The reinforcement folding 910 comprises: a first section 501 being bent in the first bending direction 912 with a first bending radius 501a, a second section 502 being bent in the first bending direction 912 with a second bending radius 502a, the second bending radius 502a being smaller than the first bending radius 501a, a third section 503 being bent in the second bending direction 913 with a third bending radius 503a, the third bending radius 503a being greater than the second bending radius 502a, a fourth section 504 being bent in the second bending direction 913 with a fourth bending radius 504a, the fourth bending radius 504a being smaller than the third bending radius 503a, a fifth section 505 being bent

in the first bending direction 912 with a fifth bending radius 505a, the fifth bending radius 505a being smaller than the first bending radius 501a, a sixth section 506 being bent in the second bending direction 913 with a sixth bending radius 506a, the sixth bending radius 506a being smaller than the first bending radius 501a, a seventh section 507 being bent in the second bending direction 913 with a seventh bending radius 507a, the seventh bending radius 507a being greater than the sixth bending radius 506a, an eighth section 508 being bent in the first bending direction 912 with an eighth bending radius 508a, the eighth bending radius 508a being smaller than the seventh bending radius 507a, a ninth section 509 being bent in the first bending direction 912 with a ninth bending radius 509a, the ninth bending radius 509a being greater than the eighth bending radius 508a.

[0171] The first longitudinal section 908 is followed by the first section 501 of the reinforcement folding 910. Thus, a start point of the bending of the first section 501 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 501 coincides with a start point of the bending of the second section 502. The first section 501 may be bent between its start point and end point by a bending angle between 5° to 60° , preferably by 40° .

[0172] The first section 501 is followed by the second section 502 of the reinforcement folding 910. Thus, the start point of the bending of the second section 502 coincides with the end point of the bending of the first section 501 while an end point of the bending of the second section 502 coincides with a start point of the bending of the third section 503. The second section 502 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0173] The second section 502 is followed by the third section 503 of the reinforcement folding 910. Thus, the start point of the bending of the third section 503 coincides with the end point of the bending of the second section 502 while an end point of the bending of the third section 503 coincides with a start point of the bending of the fourth section 504. The third section 503 may be bent between its start point and end point by a bending angle between 5° to 80° , preferably by 15° .

[0174] The third section 503 is followed by the fourth section 504 of the reinforcement folding 910. Thus, the start point of the bending of the fourth section 504 coincides with the end point of the bending of the third section 503 while an end point of the bending of the fourth section 504 coincides with a start point of the bending of the fifth section 505. The fourth section 504 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0175] The fourth section 504 is followed by the fifth section 505 of the reinforcement folding 910. Thus, the start point of the bending of the fifth section 505 coincides with the end point of the bending of the fourth section

504 while an end point of the bending of the fifth section 505 coincides with a start point of the bending of a sixth section 506. The fifth section 505 may be bent between its start point and end point by a bending angle between 120° to 200°, preferably by 160°.

[0176] The fifth section 505 is followed by the sixth section 506 of the reinforcement folding 910. Thus, the start point of the bending of the sixth section 506 coincides with the end point of the bending of the fifth section 505 while an end point of the bending of the sixth section 506 coincides with a start point of the bending of the seventh section 507. The sixth section 506 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0177] The sixth section 506 is followed by the seventh section 507 of the reinforcement folding 910. Thus, the start point of the bending of the seventh section 507 coincides with the end point of the bending of the sixth section 506 while an end point of the bending of the seventh section 507 coincides with a start point of the bending of the eighth section 508. The seventh section 507 may be bent between its start point and end point by a bending angle between 5° to 80°, preferably by 15°.

[0178] The seventh section 507 is followed by the eighth section 508 of the reinforcement folding 910. Thus, the start point of the bending of the eighth section 508 coincides with the end point of the bending of the seventh section 507 while an end point of the bending of the eighth section 508 coincides with a start point of the bending of the ninth section 509. The eighth section 508 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0179] The eighth section 508 is followed by the ninth section 509 of the reinforcement folding 910. Thus, the start point of the bending of the ninth section 509 coincides with the end point of the bending of the eighth section 508 while an end point of the bending of the ninth section 509 coincides with a part of the second longitudinal section 909. The ninth section 509 may be bent between its start point and end point by a bending angle between 5° to 60°, preferably by 40°.

[0180] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0181] Fig. 17 shows a cross-section of a sixth embodiment of the inventive tube while Fig. 18 shows an enlarged cross-section view of the reinforcement folding 910.

[0182] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0183] The reinforcement folding 910 comprises: a first section 601 being bent in the first bending direction 912 with a first bending radius 601a, a second section 602

forming a straight section, a third section 603 being bent in the second bending direction 913 with a third bending radius 603a, a fourth section 604 forming a straight section, a fifth section 605 being bent in the first bending direction 912 with a fifth bending radius 605a, a sixth section 606 forming a straight section, a seventh section 607 being bent in the second bending direction 913 with a seventh bending radius 607a, an eighth section 608 forming a straight section, a ninth section 609 being bent in the first bending direction 912 with a ninth bending radius 609a.

[0184] The first longitudinal section 908 is followed by the first section 601 of the reinforcement folding 910. Thus, a start point of the bending of the first section 601 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 601 coincides with a start point of the second section 602. The first section 601 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0185] The first section 601 is followed by the second section 602 of the reinforcement folding 910. Thus, the start point of the second section 602 coincides with the end point of the bending of the first section 601 while an end point of the second section 602 coincides with a start point of the bending of the third section 603.

[0186] The second section 602 is followed by the third section 603 of the reinforcement folding 910. Thus, a start point of the bending of the third section 603 coincides with the endpoint of the second section 602 while an end point of the bending of the third section 603 coincides with a start point of the fourth section 604. The third section 603 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0187] The third section 603 is followed by the fourth section 604 of the reinforcement folding 910. Thus, the start point of the fourth section 604 coincides with the end point of the bending of the third section 603 while an end point of the fourth section 604 coincides with a start point of the bending of the fifth section 605.

[0188] The fourth section 604 is followed by the fifth section 605 of the reinforcement folding 910. Thus, a start point of the bending of the fifth section 605 coincides with the endpoint of the fourth section 604 while an end point of the bending of the fifth section 605 coincides with a start point of the sixth section 606. The fifth section 605 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0189] The fifth section 605 is followed by the sixth section 606 of the reinforcement folding 910. Thus, the start point of the sixth section 606 coincides with the end point of the bending of the fifth section 605 while an end point of the sixth section 606 coincides with a start point of the bending of the seventh section 607.

[0190] The sixth section 606 is followed by the seventh

section 607 of the reinforcement folding 910. Thus, a start point of the bending of the seventh section 607 coincides with the endpoint of the sixth section 606 while an end point of the bending of the seventh section 607 coincides with a start point of the eighth section 608. The seventh section 607 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0191] The seventh section 607 is followed by the eighth section 608 of the reinforcement folding 910. Thus, the start point of the eighth section 608 coincides with the end point of the bending of the seventh section 607 while an end point of the eighth section 608 coincides with a start point of the bending of the ninth section 609.

[0192] The eighth section 608 is followed by the ninth section 609 of the reinforcement folding 910. Thus, the start point of the bending of the ninth section 609 coincides with the end point of the eighth section 608 while an end point of the bending of the ninth section 609 coincides with a part of the second longitudinal section 909. The ninth section 609 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0193] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0194] Fig. 19 shows a cross-section of a seventh embodiment of the inventive tube while Fig. 20 shows an enlarged cross-section view of the reinforcement folding 910.

[0195] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0196] The reinforcement folding 910 comprises: a first section 701 being bent in the first bending direction 912 with a first bending radius 701a, a second section 702 being bent in the second bending direction 913 with a second bending radius 702a, a third section 703 forming a straight section, a fourth section 704 being bent in the second bending direction 913 with a fourth bending radius 704a, a fifth section 705 forming a straight section, a sixth section 706 being bent in the first bending direction 912 with a sixth bending radius 706a, a seventh section 707 being bent in the first bending direction 912 with a seventh bending radius 707a, an eighth section 708 being bent in the first bending direction 912 with an eighth bending radius 708a, the seventh bending radius 707a being greater than the sixth bending radius 706a, the seventh bending radius 707a being greater than the eighth bending radius 708a, a ninth section 709 forming a straight section, a tenth section 710 being bent in the second bending direction 913 with a tenth bending radius 710a, an eleventh section 711 forming a straight section, a twelfth section 712 being bent in the second bending direction 913

with a twelfth bending radius 712a, a thirteenth section 713 being bent in the first bending direction 912 with a thirteenth bending radius 713a.

[0197] The first longitudinal section 908 is followed by the first section 701 of the reinforcement folding 910. Thus, a start point of the bending of the first section 701 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 701 coincides with a start point of the bending of the second section 702. The first section 701 may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0198] The first section 701 is followed by the second section 702 of the reinforcement folding 910. Thus, a start point of the bending of the second section 702 coincides with the end point of the bending of the first section 701 while an end point of the bending of the second section 702 coincides with a start point of the third section 703. The second section 702 may be bent between its start point and end point by a bending angle between 30° to 120° , preferably by 90° .

[0199] The second section 702 is followed by the third section 703 of the reinforcement folding 910. Thus, the start point of the third section 703 coincides with the end point of the bending of the second section 702 while an end point of the third section 703 coincides with a start point of the bending of the fourth section 704.

[0200] The third section 703 is followed by the fourth section 704 of the reinforcement folding 910. Thus, a start point of the bending of the fourth section 704 coincides with the end point of the third section 703 while an end point of the bending of the fourth section 704 coincides with a start point of the fifth section 705. The fourth section 704 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0201] The fourth section 704 is followed by the fifth section 705 of the reinforcement folding 910. Thus, the start point of the fifth section 705 coincides with the end point of the bending of the fourth section 704 while an end point of the fifth section 705 coincides with a start point of the bending of the sixth section 706.

[0202] The fifth section 705 is followed by the sixth section 706 of the reinforcement folding 910. Thus, a start point of the bending of the sixth section 706 coincides with the end point of the fifth section 705 while an end point of the bending of the sixth section 706 coincides with a start point of the bending of the seventh section 707. The sixth section 706 may be bent between its start point and end point by a bending angle between 150° to 210° , preferably between 170° to 190° , more preferably by 180° .

[0203] The sixth section 706 is followed by the seventh section 707 of the reinforcement folding 910. Thus, a start point of the bending of the seventh section 707 coincides with the end point of the sixth section 706 while an end point of the bending of the seventh section 707 coincides with a start point of the bending of the eighth

section 708. The seventh section 707 may be bent between its start point and end point by a bending angle between 160° to 200°, preferably by 180°.

[0204] The seventh section 707 is followed by the eighth section 708 of the reinforcement folding 910. Thus, a start point of the bending of the eighth section 708 coincides with the end point of the seventh section 707 while an end point of the bending of the eighth section 708 coincide with a start point of the ninth section 709. The eighth section 708 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0205] The eighth section 708 is followed by the ninth section 709 of the reinforcement folding 910. Thus, the start point of the ninth section 709 coincides with the end point of the bending of the eighth section 708 while an end point of the ninth section 709 coincides with a start point of the bending of the tenth section 710.

[0206] The ninth section 709 is followed by the tenth section 710 of the reinforcement folding 910. Thus, a start point of the bending of the tenth section 710 coincides with the end point of the ninth section 709 while an end point of the bending of the tenth section 710 coincides with a start point of the eleventh section 711. The tenth section 710 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0207] The tenth section 710 is followed by the eleventh section 711 of the reinforcement folding 910. Thus, the start point of the eleventh section 711 coincides with the end point of the bending of the tenth section 710 while an end point of the eleventh section 711 coincides with a start point of the bending of the twelfth section 712.

[0208] The eleventh section 711 is followed by the twelfth section 712 of the reinforcement folding 910. Thus, a start point of the bending of the twelfth section 712 coincides with the end point of the eleventh section 711 while an end point of the bending of the twelfth section 712 coincides with a start point of the bending of the thirteenth section 713. The twelfth section 712 may be bent between its start point and end point by a bending angle between 30° to 120°, preferably by 90°.

[0209] The twelfth section 712 is followed by the thirteenth section 713 of the reinforcement folding 910. Thus, the start point of the bending of the thirteenth section 713 coincides with the end point of the twelfth section 712 while an end point of the bending of the thirteenth section 713 coincides with a part of the second longitudinal section 909. The thirteenth section 713 may be bent between its start point and end point by a bending angle between 30° to 120°, preferably by 90°.

[0210] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0211] Fig. 21 shows a cross-section of a eighth embodiment of the inventive tube. The front section 906 has

at least one reinforcement folding 910.

[0212] The reinforcement folding 910 comprises: a first bead 801, the first bead 801 is followed by a section 802 being bent in a first bending direction 912 with a bending radius 802a, the section 802 being followed by a second bead 803, a damping body 804 in the fluid channel 905.

[0213] The first bead 801 and the second bead 802 may be arranged opposite each other and reduce the cross-section of the fluid channel 905 at least in some sections. The first bead may 801 protrude in the direction of the second bead 805 while the second bead 805 may protrude in the direction of the first bead 801. The damping body 804 has a damping effect and converts kinetic energy into deformation energy.

[0214] The first longitudinal section 908 is followed by the first bead 801 of the reinforcement folding 910. The first bead 801 is followed by the bend section 802 of the reinforcement folding 910. Thus, a start point of the bending of the section 802 coincides with a part of the first bead 801 while an end point of the bending of the section 802 coincides with a part of the second bead 803. The section 802 may be bent between its start point and end point by a bending angle between 150° to 260°, preferably by 200°. The second bead 803 is followed by the second longitudinal section 909.

[0215] The bending angles and bending radii as well as the beads may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0216] Fig. 22 shows a cross-section of a ninth embodiment of the inventive tube while Fig. 23 shows an enlarged cross-section view of the reinforcement folding 910.

[0217] The front section 906 has at least one reinforcement folding 910. This reinforcement folding 910 provides a material thickness along the impact direction 922 which is larger than the thickness of the single plate 902.

[0218] The reinforcement folding 910 comprises: a first section 951 being bent in a first bending direction 912 with a first bending radius 951a, a second section 952 being bent in the first bending direction 912 with a second bending radius 952a, the second bending radius 952a being smaller than the first bending radius 951a, a third section being 953 bent in a second bending direction 913 with a third bending radius 953a, a fourth section 954 being bent in the first bending direction 912 with a fourth bending radius 954a, a fifth section 955 being bent in the first bending direction 912 with a fifth bending radius 955a, the fifth bending radius 955a being greater than the fourth bending radius 954a, the second section 952 and the third section 953 as well as the fourth section 954 forming a hollow space 956.

[0219] The hollow space 956 is formed by the external surface 915 of the tube 901. Additionally, the hollow space 956 is fluidically separated from the fluid channel 905.

[0220] The first longitudinal section 908 is followed by the first section 951 of the reinforcement folding 910.

Thus, a start point of the bending of the first section 951 coincides with a part of the first longitudinal section 908 while an end point of the bending of the first section 951 coincides with a start point of the bending of the second section 952. The first section 951 may be bent between its start point and end point by a bending angle between 20° to 120°, preferably by 45°.

[0221] The first section 951 is followed by the second section 952 of the reinforcement folding 910. Thus, the start point of the bending of the second section 952 coincides with the end point of the bending of the first section 951 while an end point of the bending of the second section 952 coincides with a start point of the bending of the third section 953. The second section 952 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0222] The second section 952 is followed by the third section 953 of the reinforcement folding 910. Thus, the start point of the bending of the third section 953 coincides with the end point of the bending of the second section 952 while an end point of the bending of the third section 953 coincides with a start point of the bending of the fourth section 954. The third section 953 may be bent between its start point and end point by a bending angle between 280° to 355°, preferably by 345°.

[0223] The third section 953 is followed by the fourth section 954 of the reinforcement folding 910. Thus, the start point of the bending of the fourth section 954 coincides with the end point of the bending of the third section 953 while an end point of the bending of the fourth section 954 coincides with a start point of the bending of the fifth section 955. The fourth section 954 may be bent between its start point and end point by a bending angle between 150° to 210°, preferably between 170° to 190°, more preferably by 180°.

[0224] The fourth section 954 is followed by the fifth section 955 of the reinforcement folding 910. Thus, the start point of the bending of the fifth section 955 coincides with the end point of the bending of the fourth section 954 while an end point of the bending of the fifth section 955 coincides with a part of the second longitudinal section 909. The fifth section 955 may be bent between its start point and end point by a bending angle between 20° to 120°, preferably by 45°.

[0225] The bending angles and bending radii may be selected such that the reinforcement folding 910 is mirror symmetric with respect to an axis parallel to the longitudinal axis 911.

[0226] Fig. 24 shows a cross-section of a tenth embodiment of the inventive tube with a reinforcement folding 910.

[0227] In contrast to the embodiment shown in Fig. 22 and Fig. 23, the embodiment shown in Fig. 24 comprises a damping body 1000 which is inserted in the hollow space 956. The damping body 1000 may contact the external surface 915 within the hollow space 956. The damping body 1000 has a damping effect and converts

kinetic energy into deformation energy.

Claims

1. A heat exchanger (900) comprising:

- at least one folded tube (901) formed of a single plate (902),
- the single plate (902) having a first end section (903) and a second end section (904),
- the folded tube (901) having at least one fluid channel (905),
- the folded tube (901) having a cross-section shape comprising:

- a front section (906) and a back section (907),
- the front section (906) and the back section (907) being arranged opposite each other,
- the front section (906) and the back section (907) being connected by a first longitudinal section (908) and a second longitudinal section (909),
- the front section (906), the back section (907), the first longitudinal section (908) and the second longitudinal (909) section define the at least one fluid channel (905),
- the back section (907) being formed by the first end section (903) and the second end section (904) contacting each other at least partially,
- the front section (906) having at least one reinforcement folding (910).

2. The heat exchanger (900) according to claim 1, wherein the first end section (903) and the second end section (904) being at least partially bent in a bending direction.

3. The heat exchanger (900) according to claim 1 or 2, wherein the reinforcement folding (901) is mirror symmetric with respect to an axis parallel to a longitudinal axis (911).

4. The heat exchanger (900) according to any of claims 1 to 3, wherein the reinforcement folding (910) comprises:

- a first section (1) being bent in a first bending direction (912) with a first bending radius (1a),
- a second section (2) being bent in a second bending direction (913) with a second bending radius (2a),
- a third section (3) being bent in the first bending direction (912) with a third bending radius (3a).

5. The heat exchanger (900) according to any of claims

1 to 3,

wherein the reinforcement folding (910) comprises:

- a first section (101) being bent in a first bending direction (912) with a first bending radius (101a), 5
- a second section (102) being bent in the first bending direction (912) with a second bending radius (102a),
- the second bending radius (102a) being smaller than the first bending radius (101a), 10
- a third section (103) being bent in a second bending direction (913) with a third bending radius (103a),
- the third bending radius (103a) being greater than the second bending radius (102a), 15
- a fourth section (104) being bent in the second bending direction (913) with a fourth bending radius (104a),
- the fourth bending radius (104a) being smaller than the third bending radius (103a), 20
- a fifth section (105) being bent in the first bending direction (912) with a fifth bending radius (105a),
- the fifth bending radius (105a) being greater than the fourth bending radius (104a). 25

6. The heat exchanger (900) according to claim 5, wherein the reinforcement folding (910) comprises:

- a sixth section (206) being bent in the second bending direction (913) with a sixth bending radius (206a), 30
- a seventh section (207) being bent in the first bending direction (912) with a seventh bending radius (207a). 35

7. The heat exchanger (900) according to claim 5, wherein the reinforcement folding (910) comprises:

- a sixth section (306) forming a straight section, 40
- a seventh section (307) being bent in the first bending direction (912) with a seventh bending radius (307a).

8. The heat exchanger (900) according to any of claims 1 to 3, wherein the reinforcement folding (910) comprises:

- a first section (401) being bent in a first bending direction (912) with a first bending radius (401a), 50
- a second section (402) being bent in the first bending direction (912) with a second bending radius (402a),
- the second bending radius (402a) being smaller than the first bending radius (401a), 55
- a third section (403) being bent in a second bending direction (913) with a third bending radius (403a),

- the third bending radius (403a) being smaller than the first bending radius (401a),
- a fourth section (404) forming a straight section,
- a fifth section (405) being bent in the second bending direction (913) with a fifth bending radius (405a),
- the fifth bending radius (405a) being smaller than the first bending radius (401a),
- a sixth section (406) being bent in the first bending direction (912) with a sixth bending radius (406a),
- the sixth bending radius (406a) being smaller than the first bending radius (401a),
- a seventh section (407) being bent in the first bending direction (912) with a seventh bending radius (407a),
- the seventh bending radius (407a) being greater than the sixth bending radius (406a).

9. The heat exchanger (900) according to any of claims 1 to 3, wherein the reinforcement folding (910) comprises:

- a first section (501) being bent in a first bending direction (912) with a first bending radius (501a),
- a second section (502) being bent in the first bending direction (912) with a second bending radius (502a),
- the second bending radius (502a) being smaller than the first bending radius (501a),
- a third section (503) being bent in a second bending direction (913) with a third bending radius (503a),
- the third bending radius (503a) being greater than the second bending radius (502a),
- a fourth section (504) being bent in the second bending direction (913) with a fourth bending radius (504a),
- the fourth bending radius (504a) being smaller than the third bending radius (503a),
- a fifth section (505) being bent in the first bending direction (912) with a fifth bending radius (505a),
- the fifth bending radius (505a) being smaller than the first bending radius (501a),
- a sixth section (506) being bent in the second bending direction (913) with a sixth bending radius (506a),
- the sixth bending radius (506a) being smaller than the first bending radius (501a),
- a seventh section (507) being bent in the second bending direction (913) with a seventh bending radius (507a),
- the seventh bending radius (507a) being greater than the sixth bending radius (506a),
- an eighth section (508) being bent in the first bending direction (912) with an eighth bending

- radius (508a),
 - the eighth bending radius (508a) being smaller than the seventh bending radius (507a),
 - a ninth section (509) being bent in the first bending direction (912) with a ninth bending radius (509a),
 - the ninth bending radius (509a) being greater than the eighth bending radius (508a).
- 5
10. The heat exchanger (900) according to any of claims 1 to 3,
 wherein the reinforcement folding (910) comprises:
- 10
- a first section (601) being bent in a first bending direction (912) with a first bending radius (601a),
 - a second section (602) forming a straight section,
 - a third section (603) being bent in a second bending direction (913) with a third bending radius (603a),
 - a fourth section (604) forming a straight section,
 - a fifth section (605) being bent in the first bending direction (912) with a fifth bending radius (605a),
 - a sixth section (606) forming a straight section,
 - a seventh section (607) being bent in the second bending direction (913) with a seventh bending radius (607),
 - an eighth section (608) forming a straight section,
 - a ninth section (609) being bent in the first bending direction (912) with a ninth bending radius (609a).
- 15
- 20
- 25
- 30
- 35
- 40
- 45
- 50
- 55
11. The heat exchanger (900) according to any of claims 1 to 3,
 wherein the reinforcement folding (910) comprises:
- a first section (701) being bent in a first bending direction (912) with a first bending radius (701a),
 - a second section (702) being bent in a second bending direction (913) with a second bending radius (702a),
 - a third section (703) forming a straight section,
 - a fourth section (704) being bent in the second bending direction (913) with a fourth bending radius (704a),
 - a fifth section (705) forming a straight section,
 - a sixth section (706) being bent in the first bending direction (912) with a sixth bending radius (706a),
 - a seventh section (707) being bent in the first bending direction (912) with a seventh bending radius (707a),
 - an eighth section (708) being bent in the first bending direction (912) with an eighth bending radius (708a),
 - the seventh bending radius (707a) being greater than the sixth bending radius (706a),
 - the seventh bending radius (707a) being greater than the eighth bending radius (708a),
 - a ninth section (709) forming a straight section,
 - a tenth section (710) being bent in the second bending direction (913) with a tenth bending radius (710a),
 - an eleventh section (711) forming a straight section,
 - a twelfth section (712) being bent in the second bending direction (913) with a twelfth bending radius (712a),
 - a thirteenth section (713) being bent in the first bending direction (912) with a thirteenth bending radius (713a).
12. The heat exchanger (900) according to any of claims 1 to 3,
 wherein the reinforcement folding (910) comprises:
- a first bead (801),
 - the first bead (801) is followed by a section (802) being bent in a first bending direction (912) with a bending radius (802a),
 - the section (802) being followed by a second bead (803),
 - a damping body (804) in the fluid channel (905).
13. The heat exchanger (900) according to any of claims 1 to 3,
 wherein the reinforcement folding (910) comprises:
- a first section (951) being bent in a first bending direction (912) with a first bending radius (951a),
 - a second section (952) being bent in the first bending direction (912) with a second bending radius (952a),
 - the second bending radius (952a) being smaller than the first bending radius (951a),
 - a third section (953) being bent in a second bending direction (913) with a third bending radius (953a),
 - a fourth section (954) being bent in the first bending direction (912) with a fourth bending radius (954a),
 - a fifth section (955) being bent in the first bending direction (912) with a fifth bending radius (955a),
 - the fifth bending radius (955a) being greater than the fourth bending radius (954a),
 - the second section (952), the third section (953) and the fourth section (954) forming a hollow space (956).
14. The heat exchanger (900) according to claim 13,
 wherein a damping body (1000) is inserted in the hollow space (956).

15. The heat exchanger (900) according to any of claims 1 to 14,
wherein the tube (901) comprises a plurality of fluid channels (905), preferably at least two fluid channels (905a, 905b) or four fluid channels (905a, 905b, 905c, 905d). 5

10

15

20

25

30

35

40

45

50

55

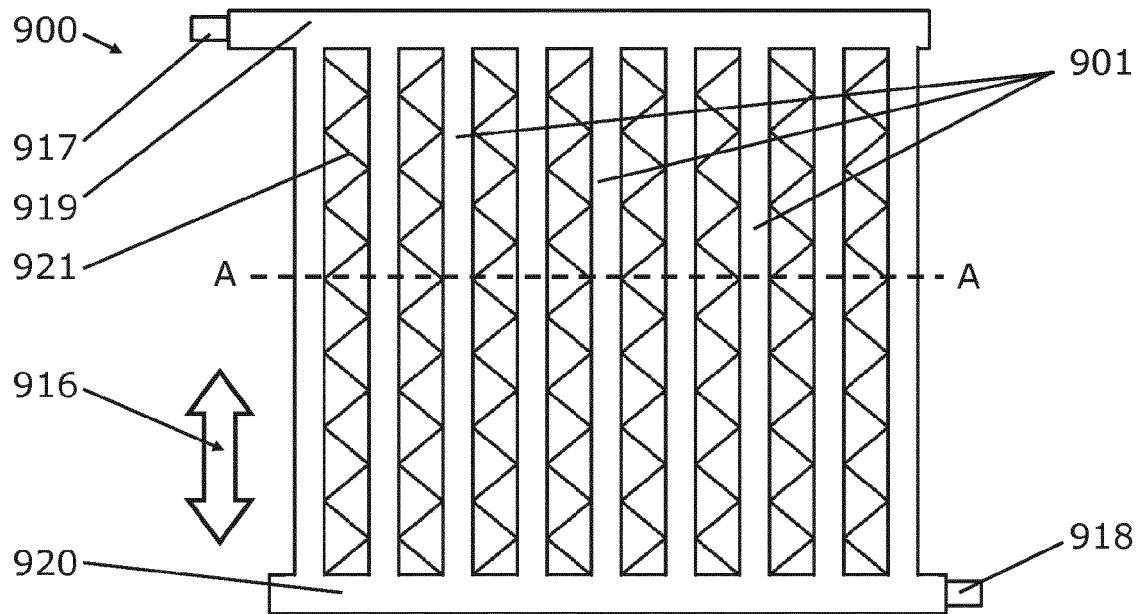


Fig. 1

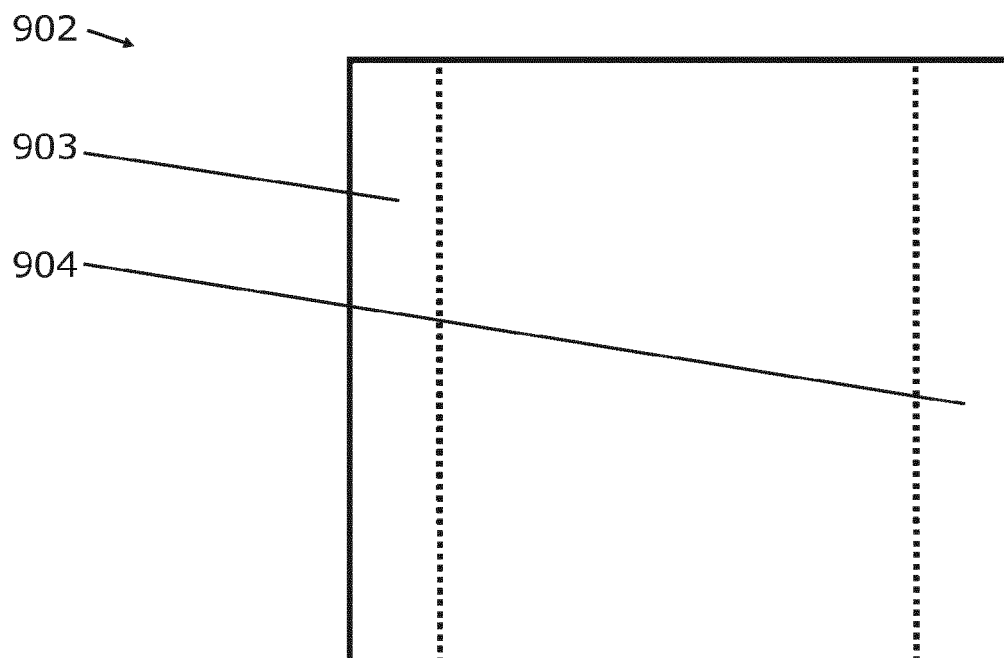


Fig. 2

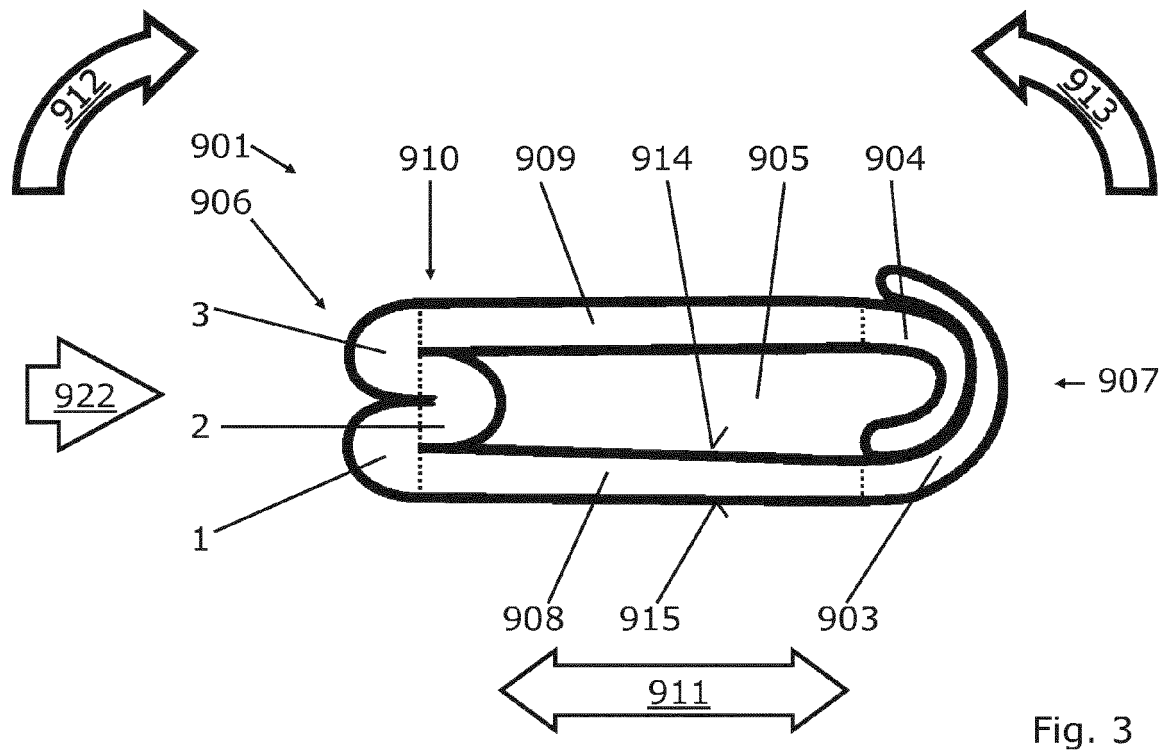


Fig. 3

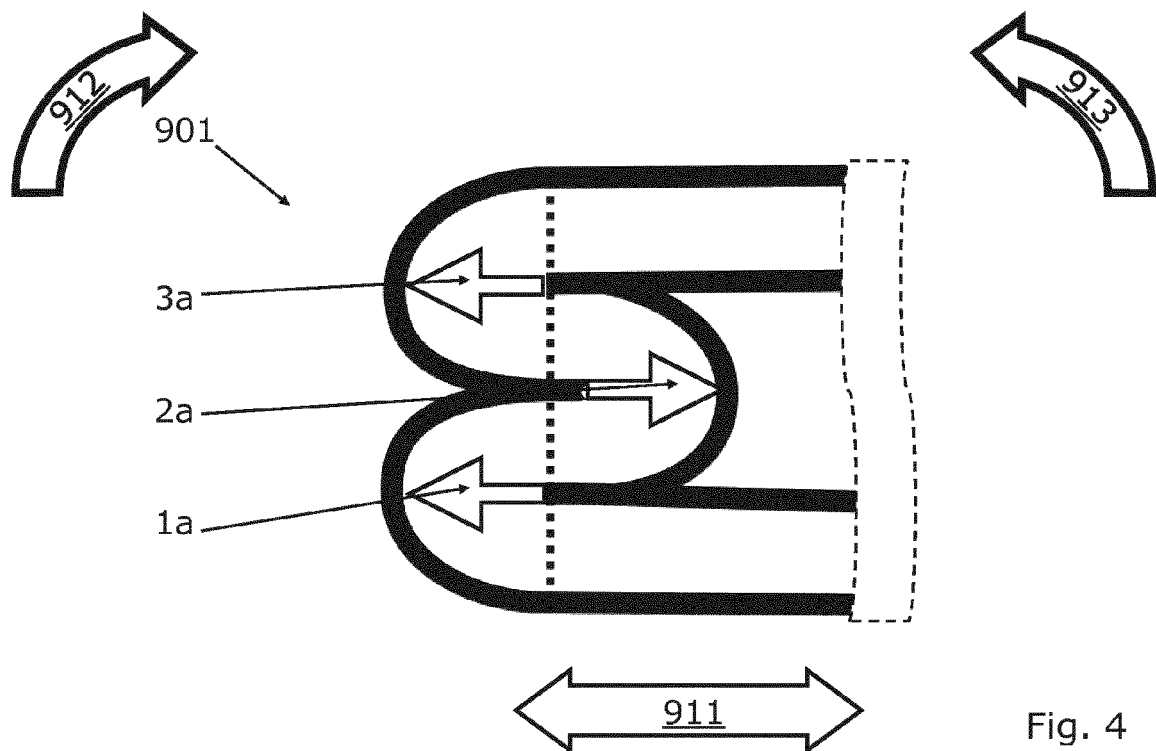
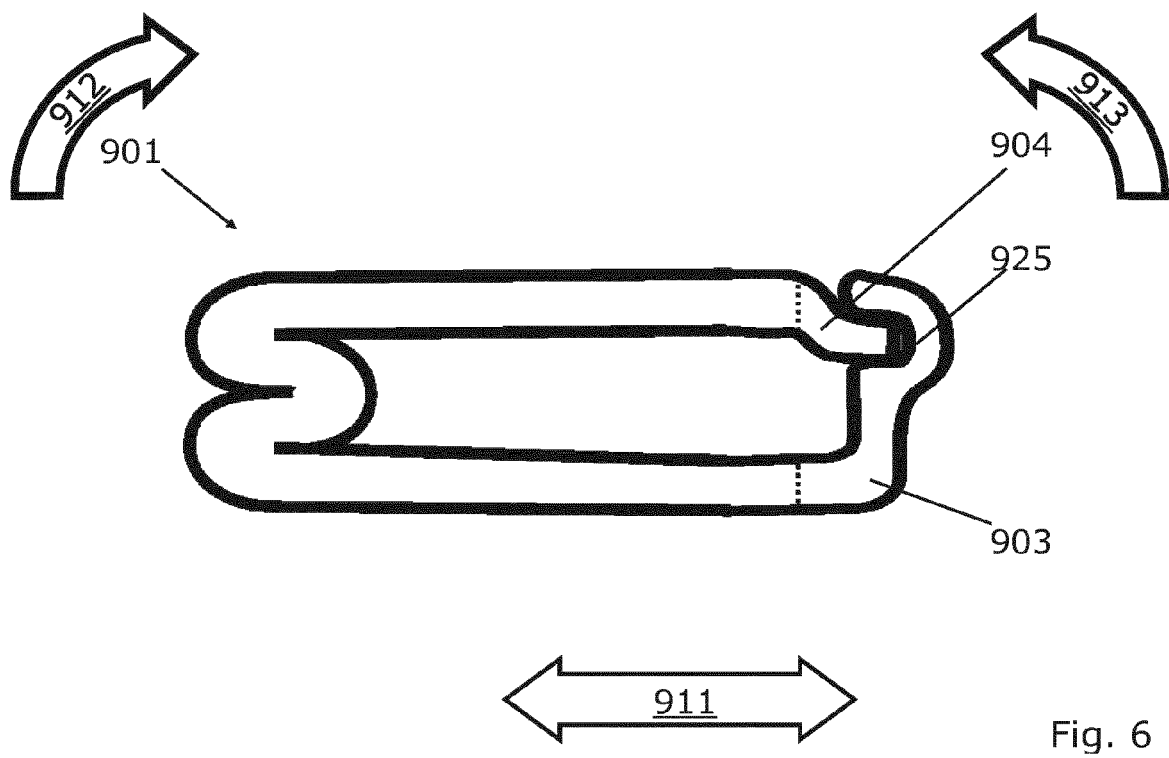
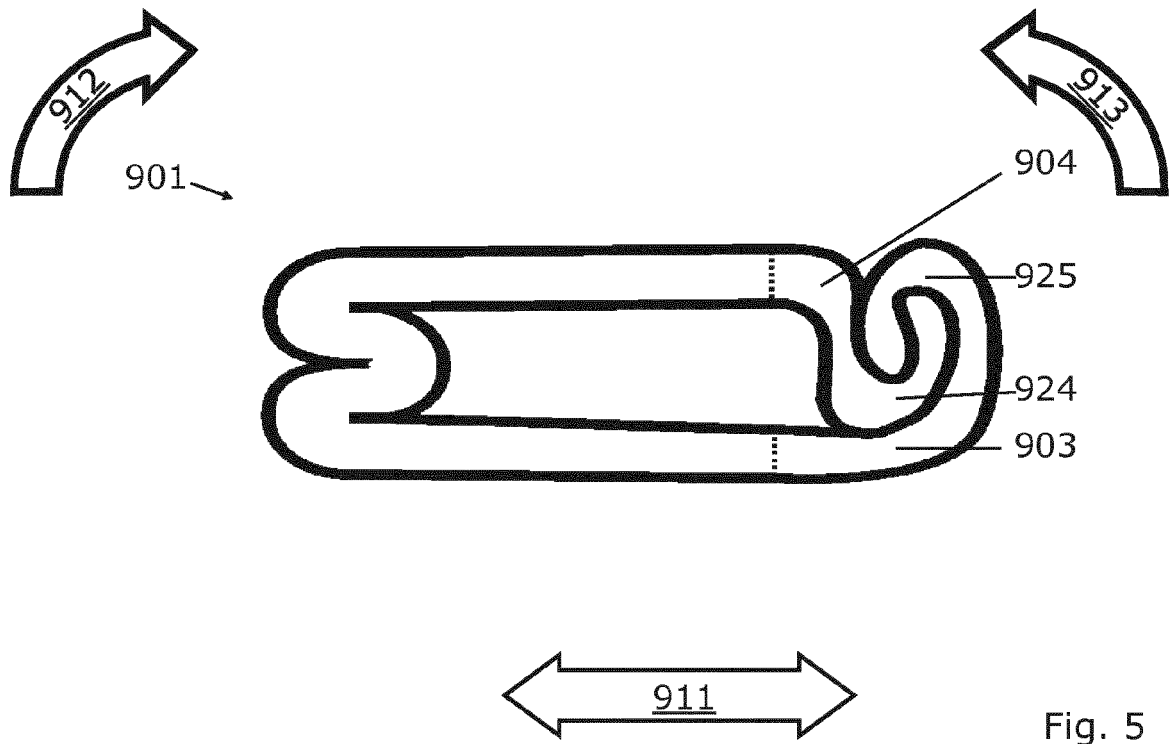
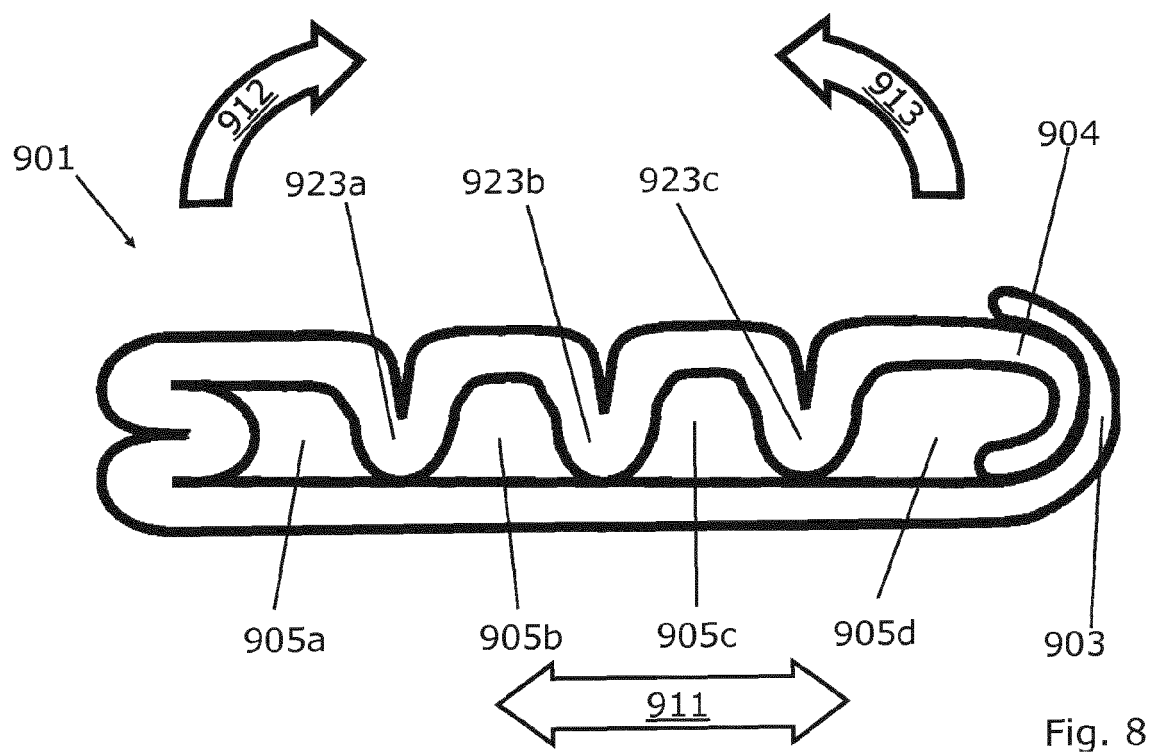
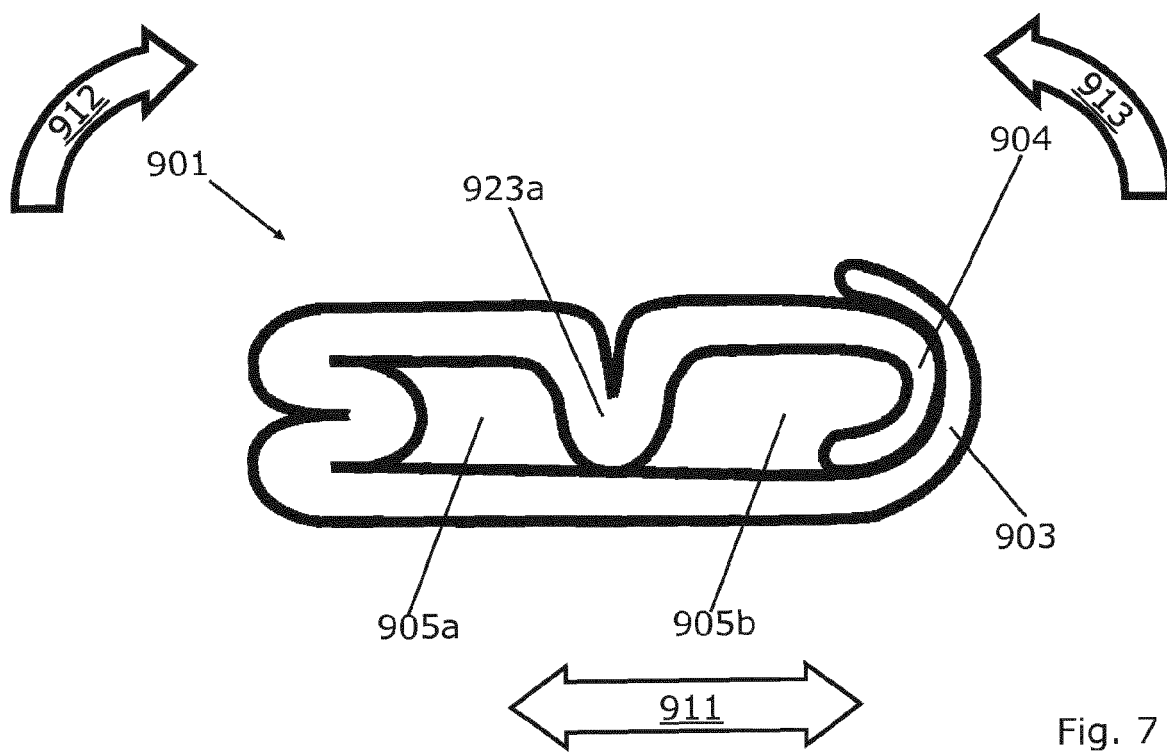
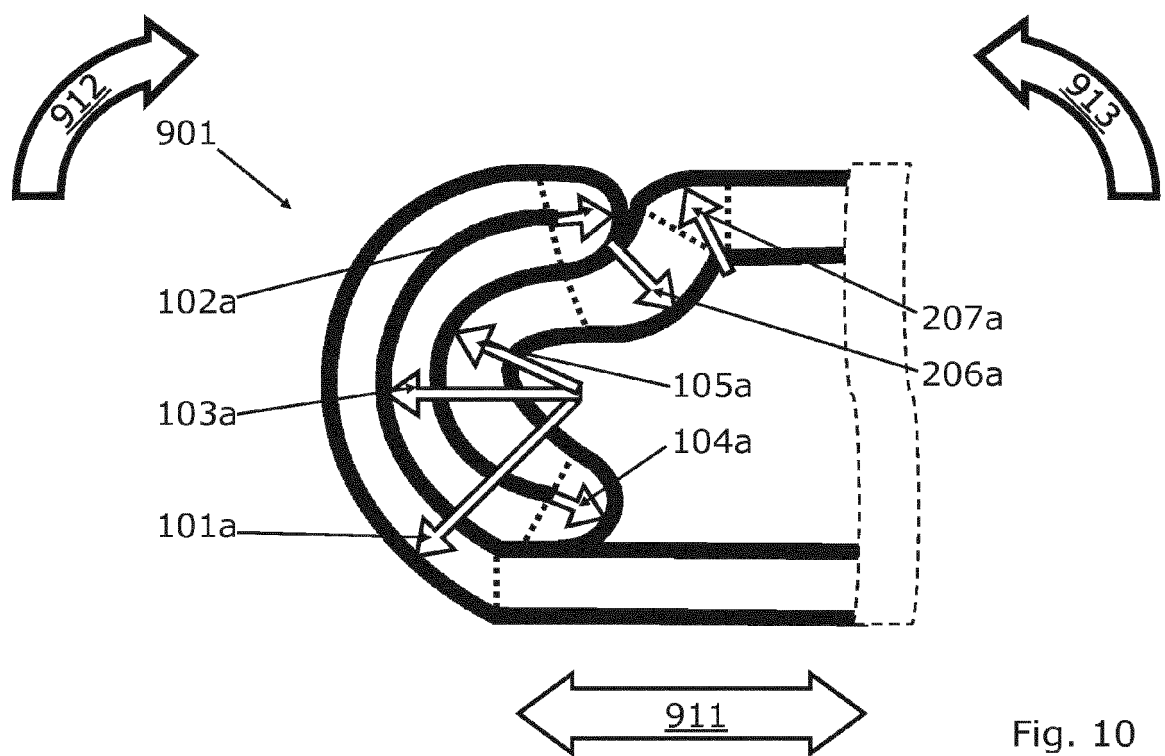
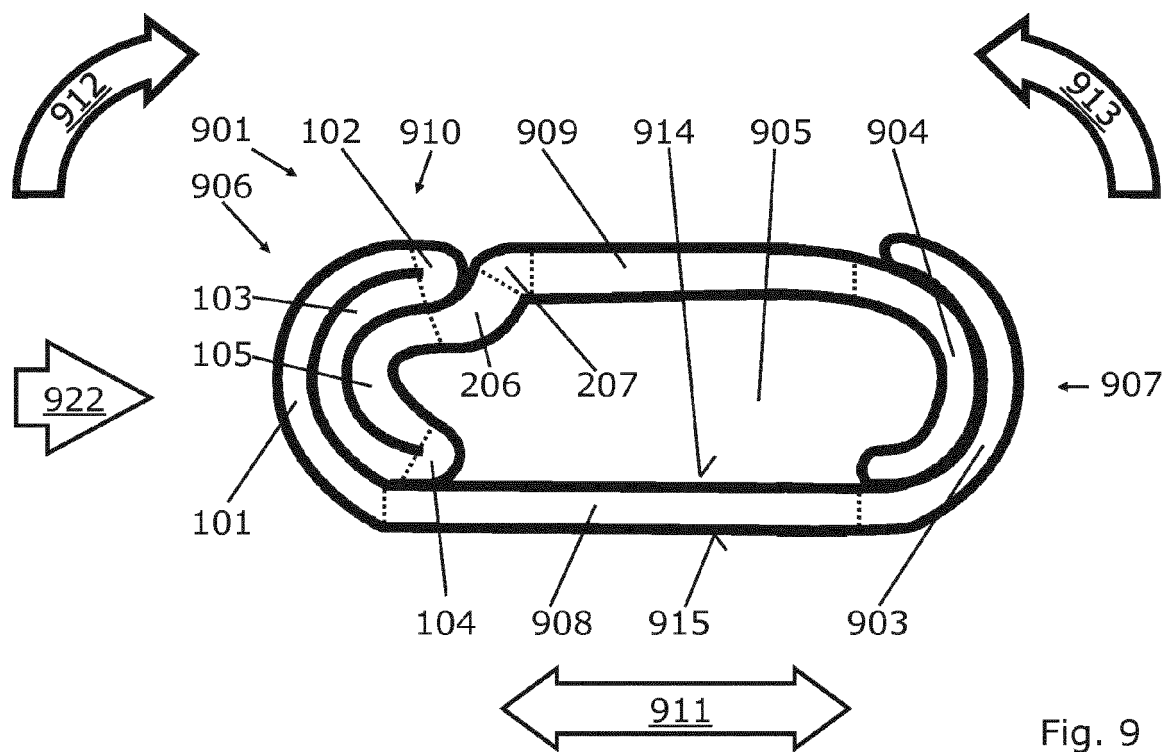


Fig. 4







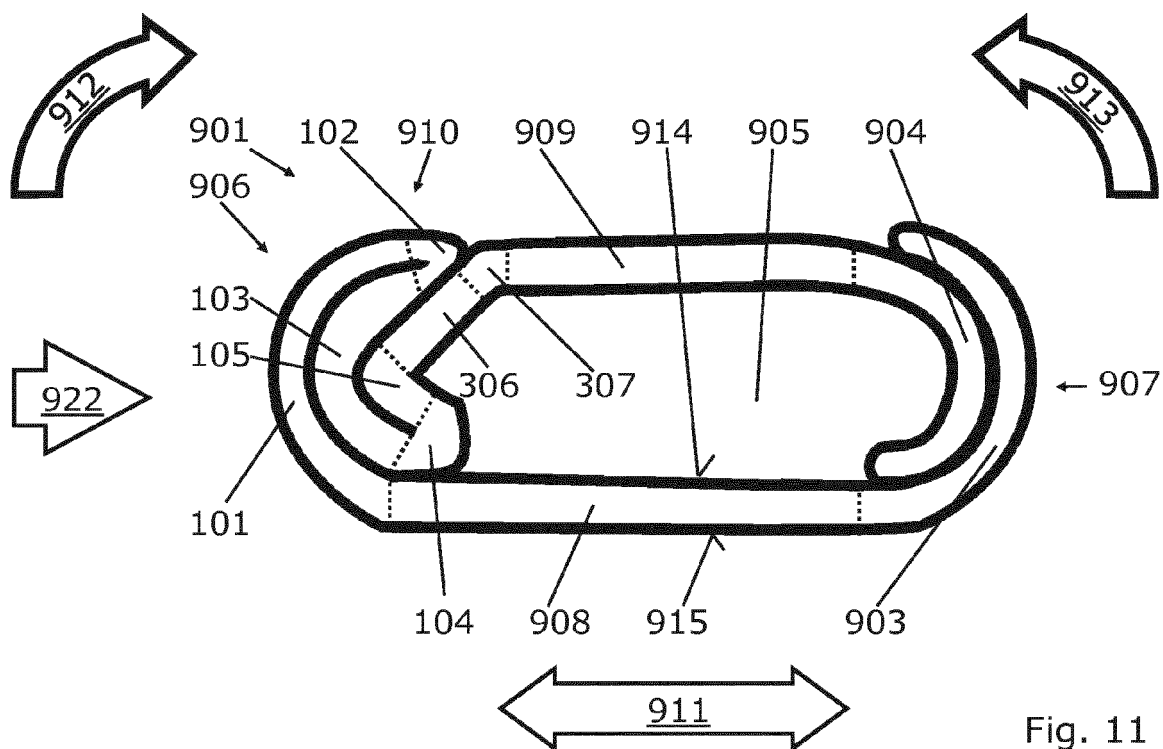


Fig. 11

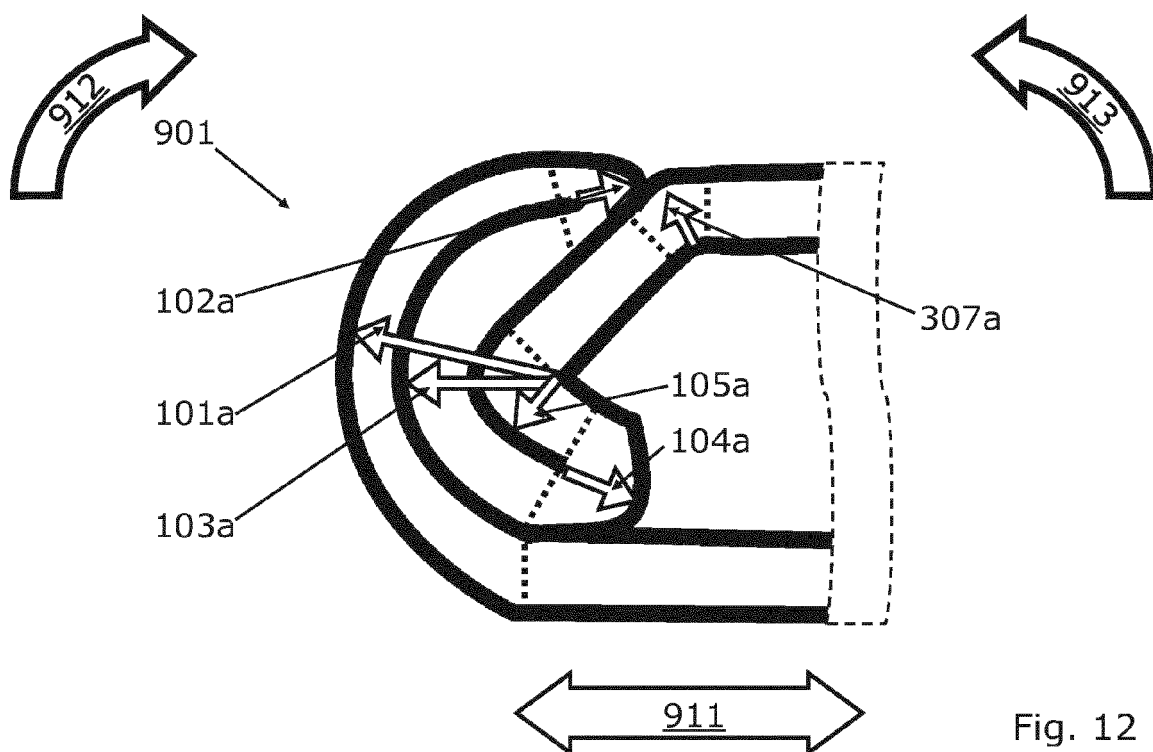


Fig. 12

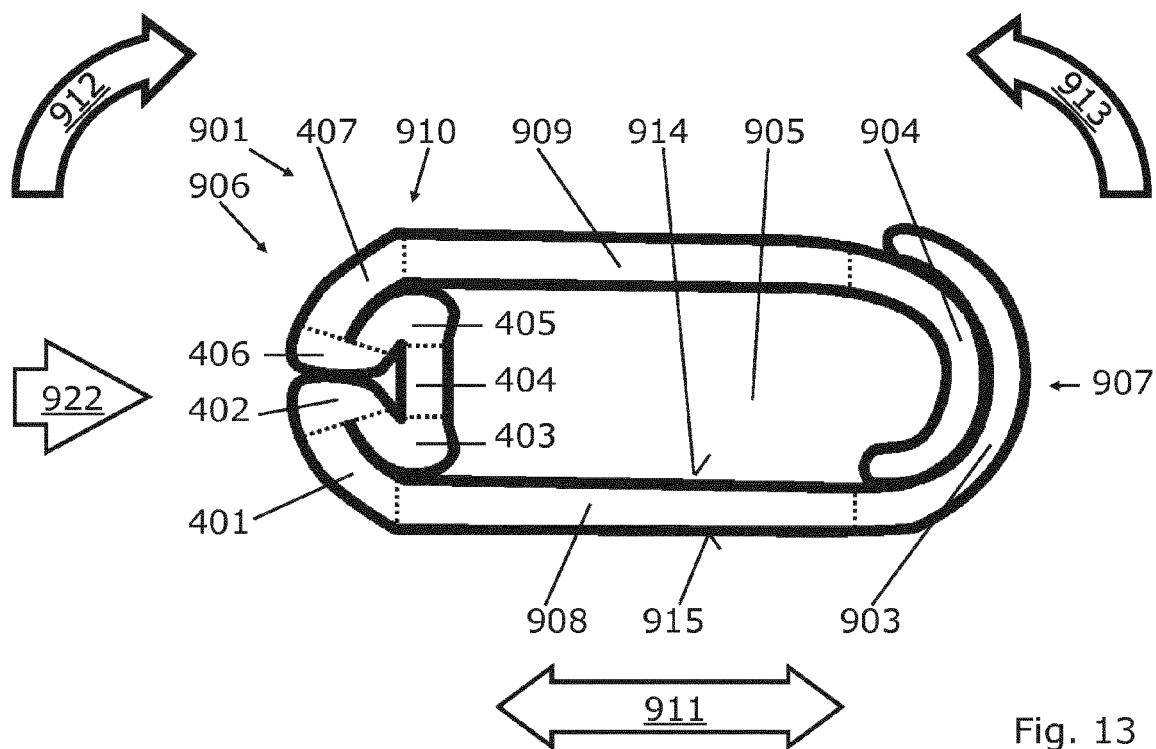


Fig. 13

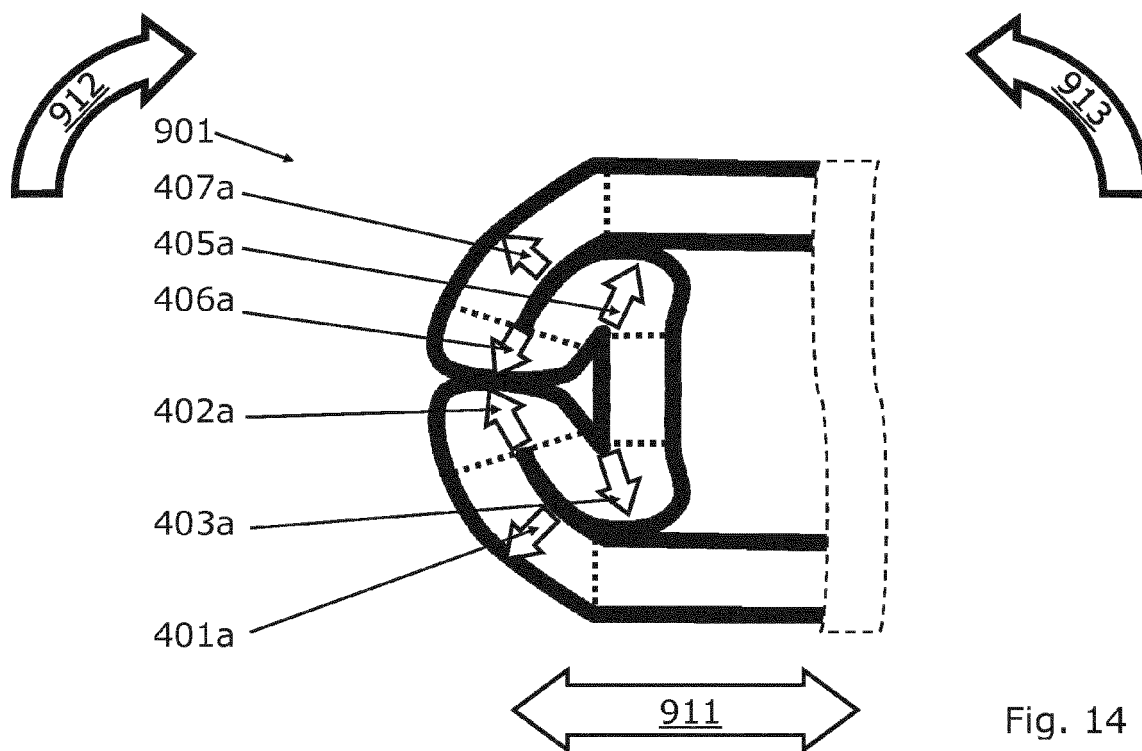
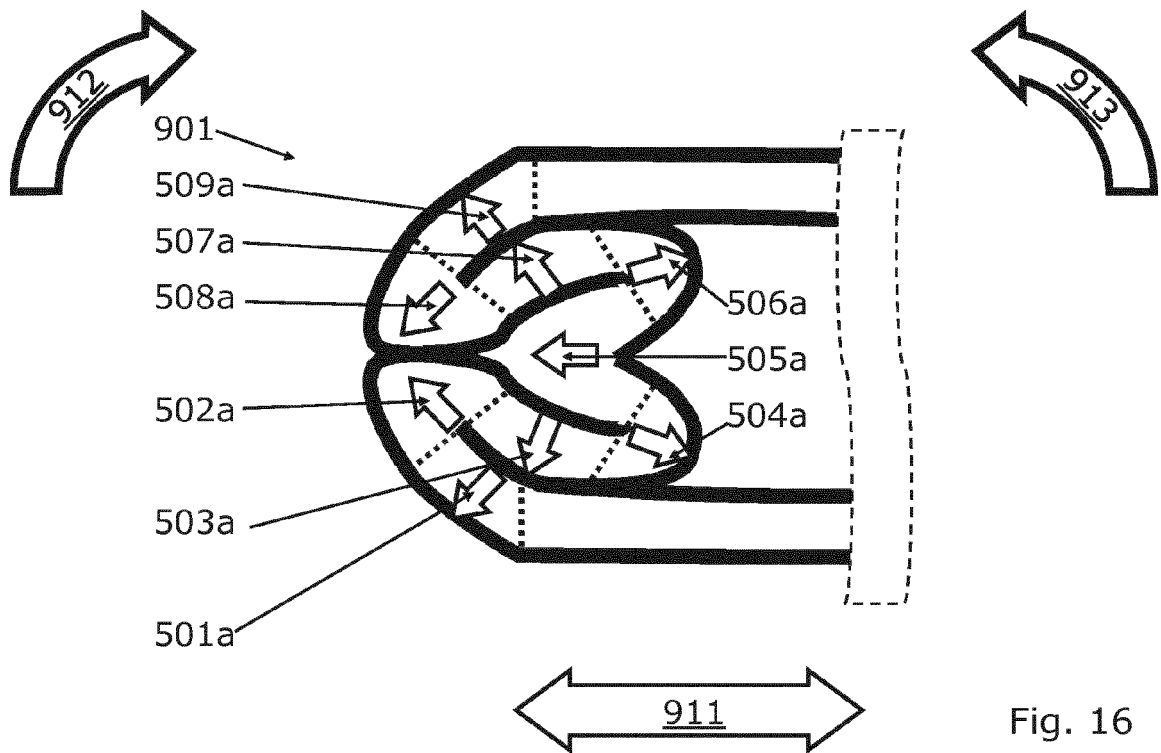
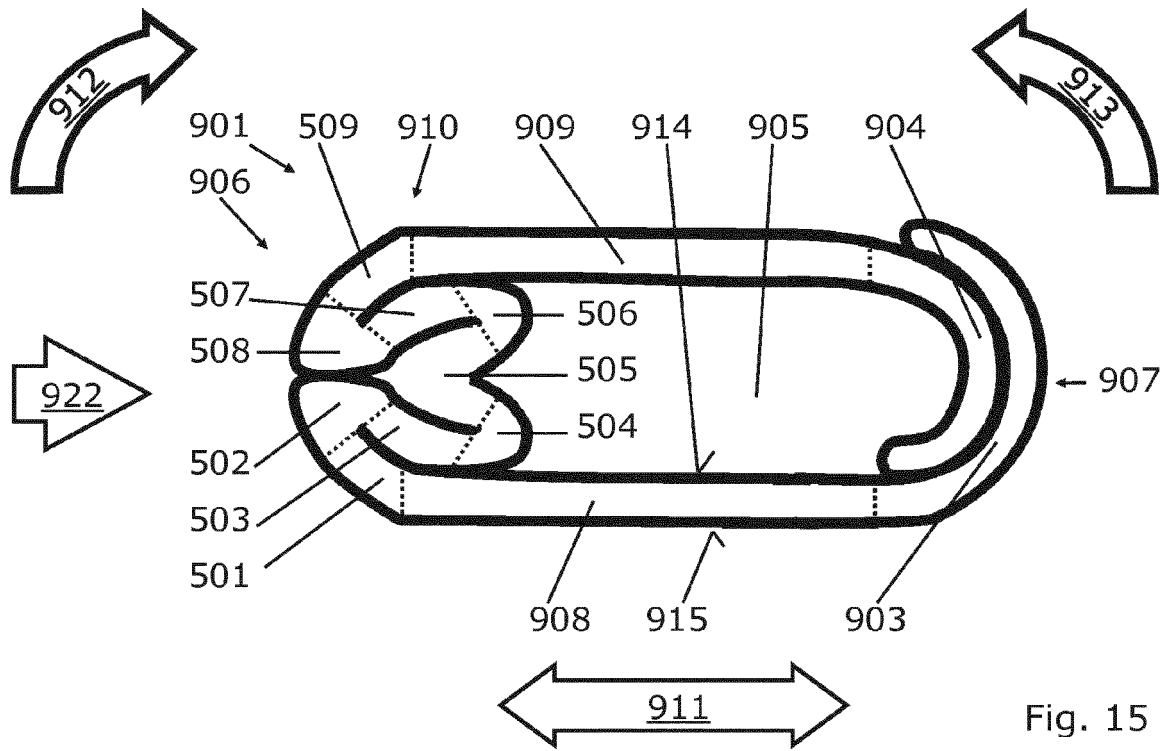
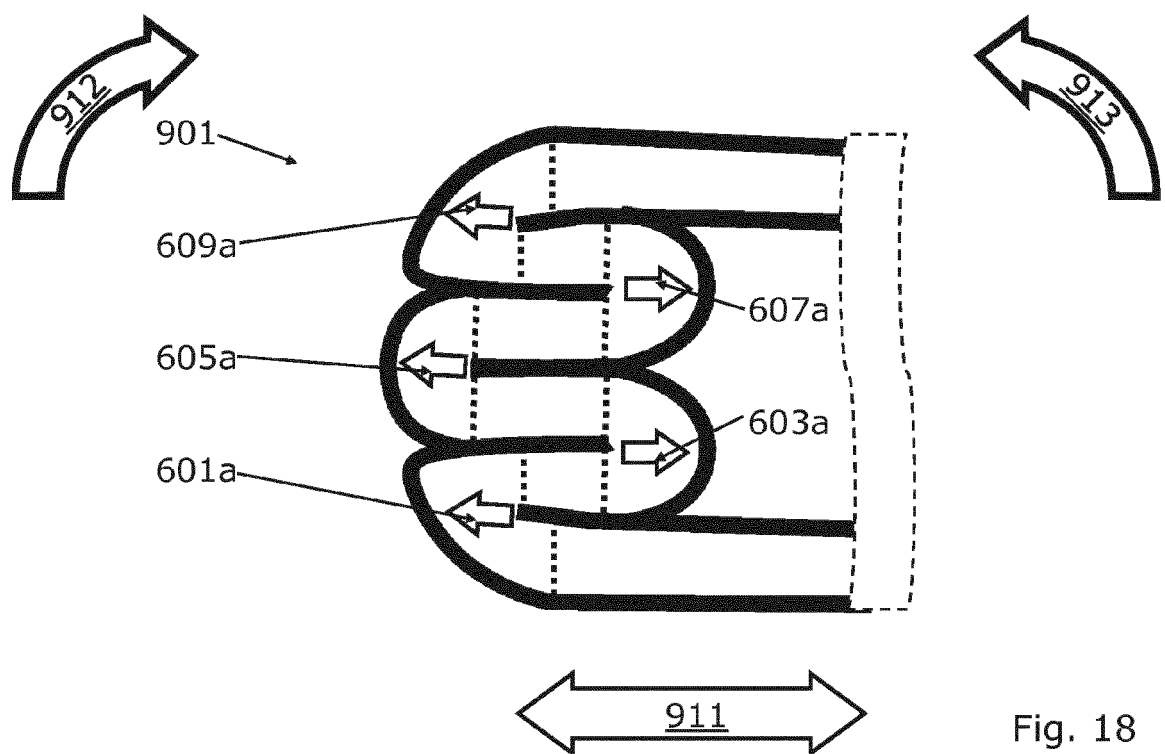
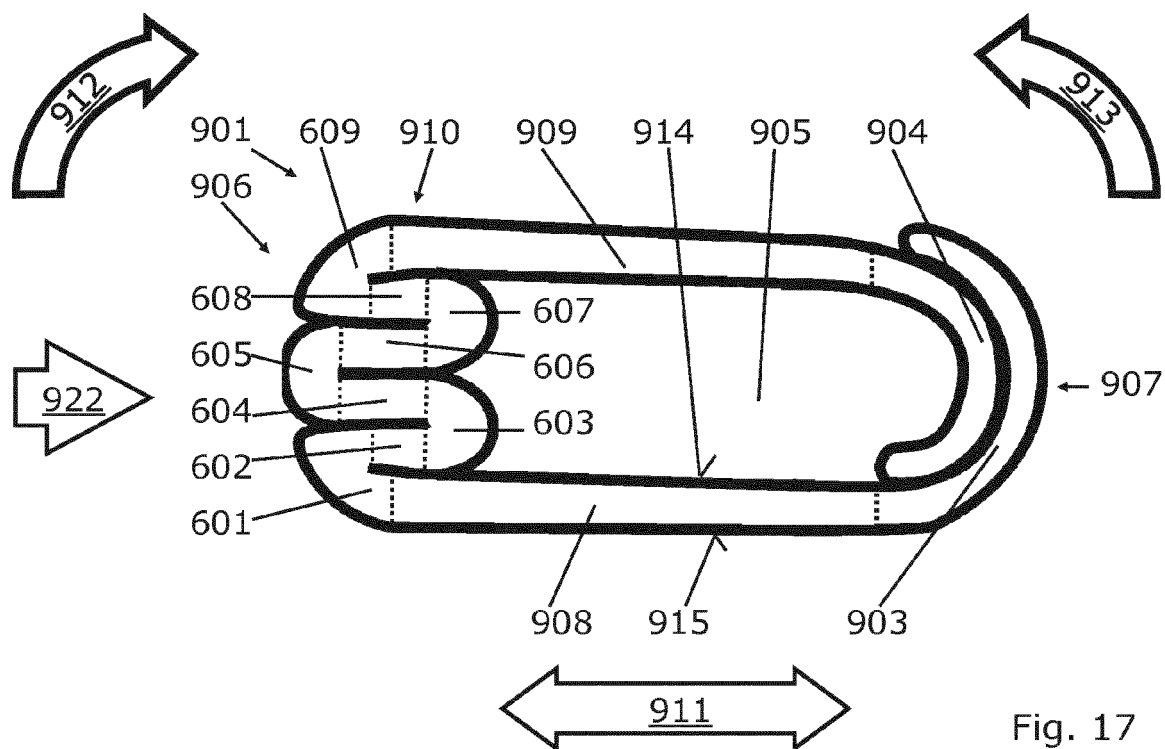
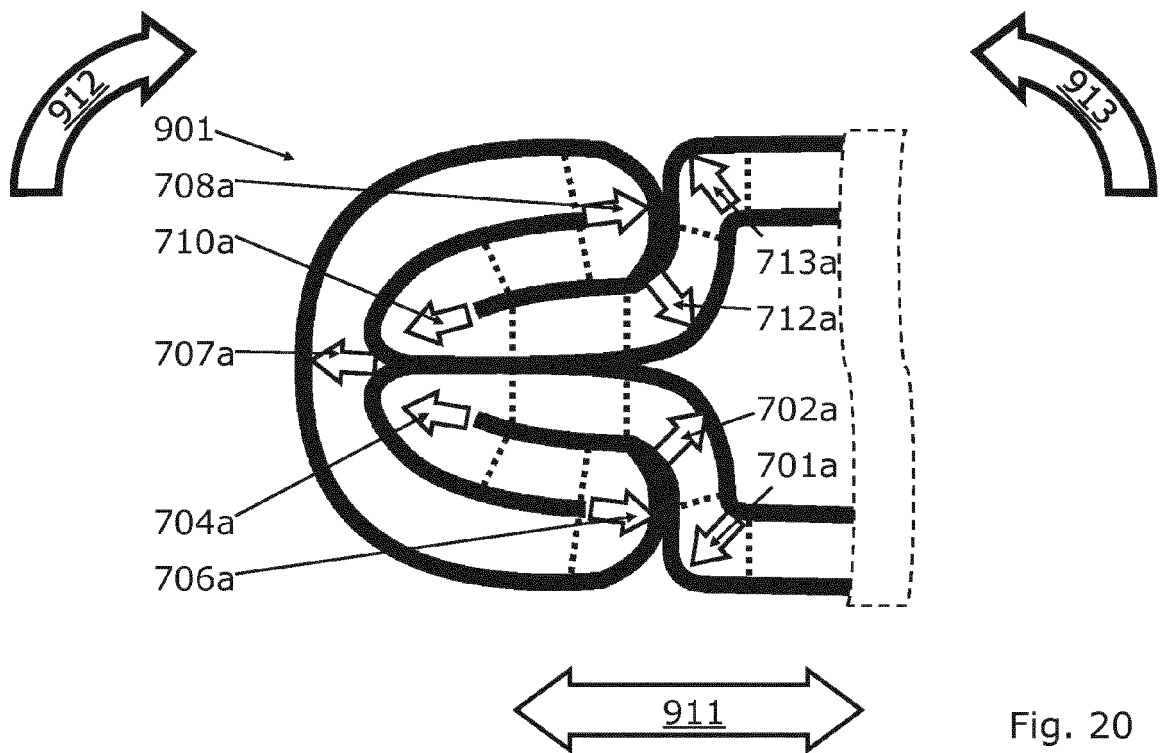
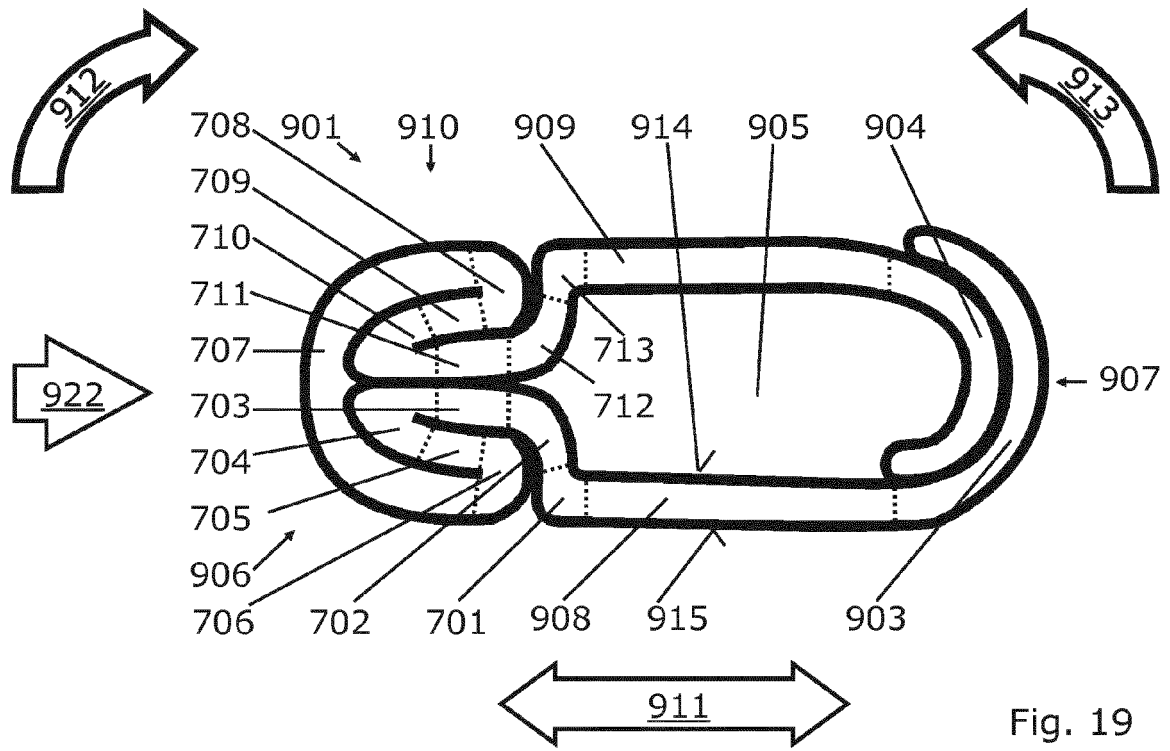
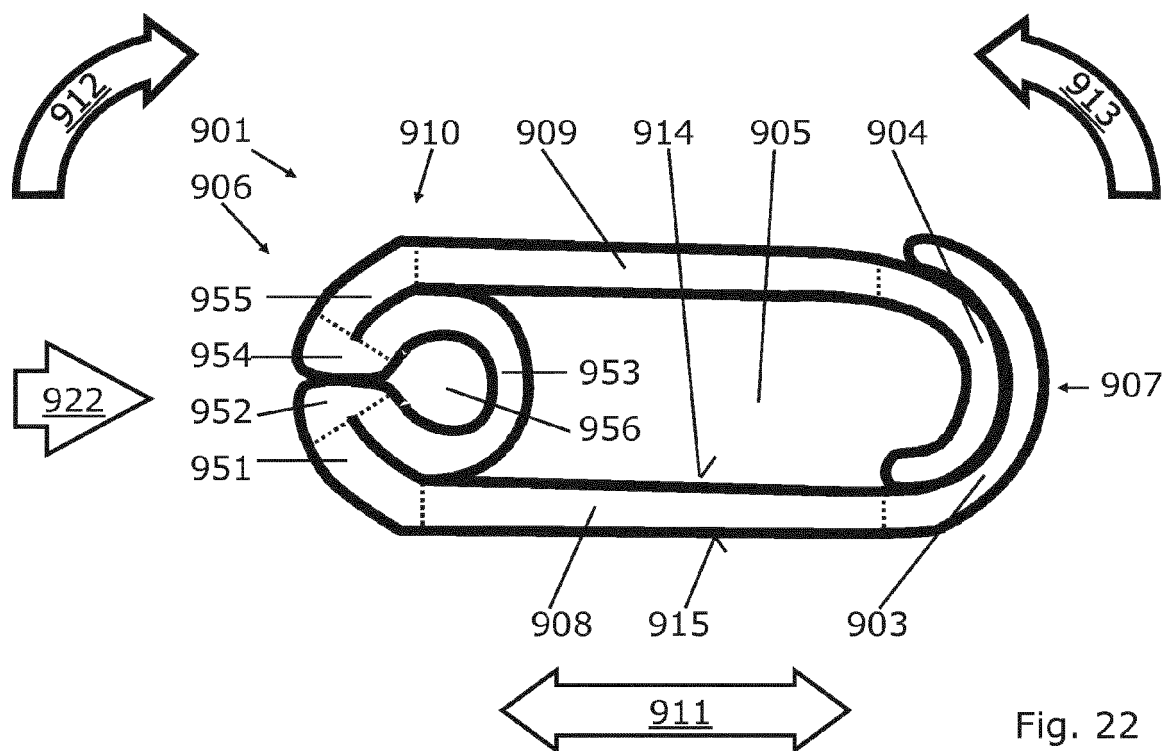
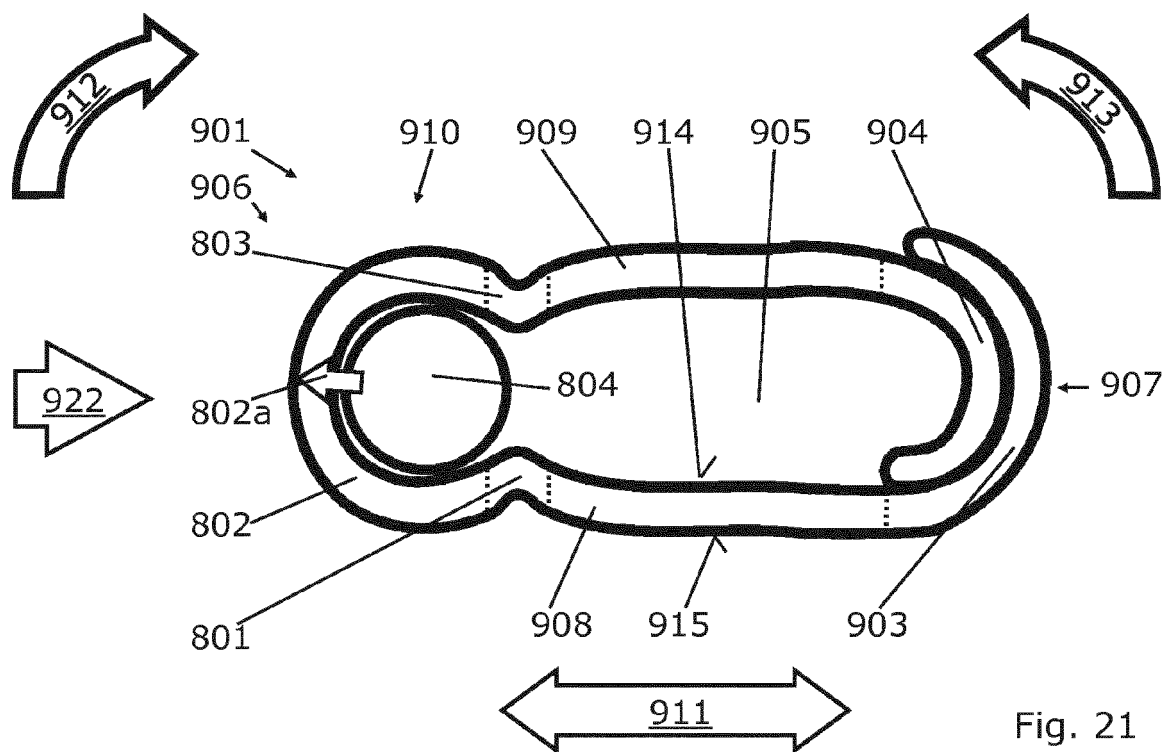


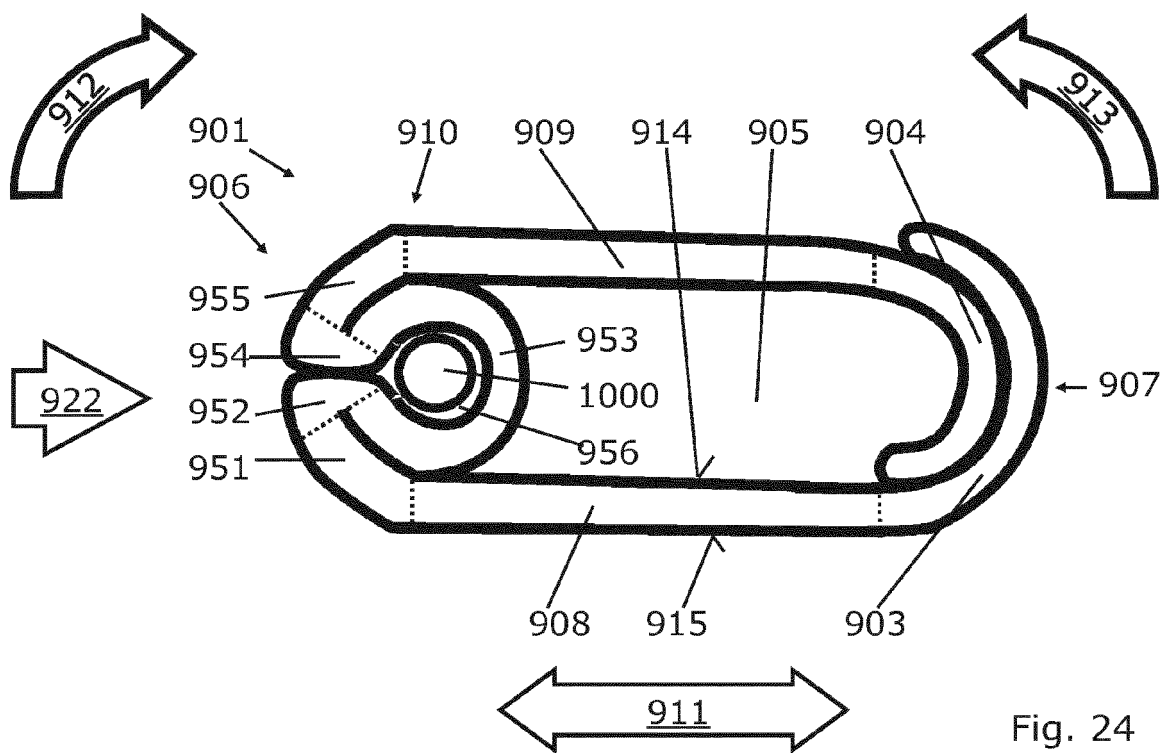
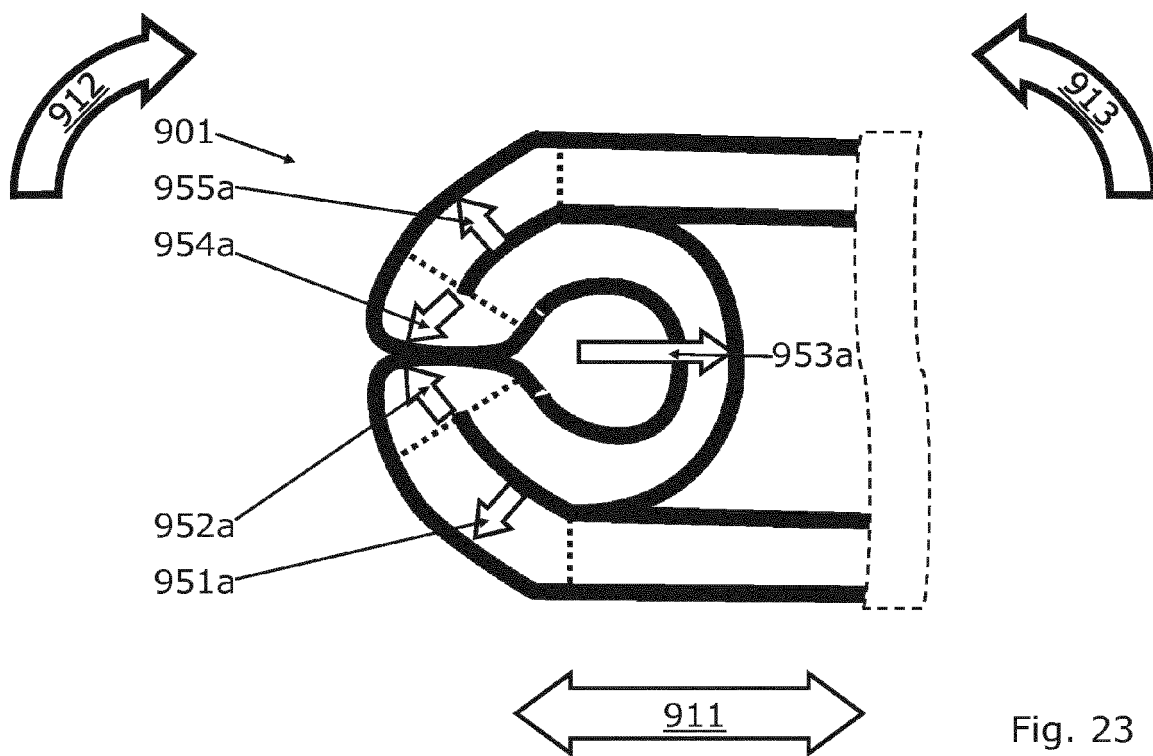
Fig. 14













EUROPEAN SEARCH REPORT

Application Number
EP 18 21 5581

5

10

15

20

25

30

35

40

45

50

55

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	DE 10 2006 035210 A1 (MODINE MFG CO [US]) 31 January 2008 (2008-01-31) * figure 1 *	1-4,10,15	INV. F28D1/03 F28F1/02
X	DE 10 2008 033883 A1 (BEHR GMBH & CO KG [DE]) 16 April 2009 (2009-04-16) * figures 7,9 *	1	
A	US 6 302 195 B1 (KATAOKA TAKAYOSHI [JP]) 16 October 2001 (2001-10-16) * figure 2 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 September 2019	Examiner Martínez Rico, Celia
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)



Application Number

EP 18 21 5581

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☒ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

1-7, 10, 15(all partially)

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



LACK OF UNITY OF INVENTION
SHEET B

Application Number

EP 18 21 5581

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 4, 10(completely); 1-3, 15(partially)

This invention comprises a reinforcement having three sections of different bending radius (claim 4) (see figures 3-8 and 17). According to dependent claim 10, the invention may further comprise straight portions between the between the bending portions. No relation between the bending radius is required.

2. claims: 5-7(completely); 1-3, 15(partially)

This invention comprises a reinforcement having five sections with a bending radius, the second bending radius being smaller than the first one, the third bending radius being greater than the second one, the fourth being smaller than the third, and the fifth being greater than the fourth (see figures 9 and 10). This invention comprises a reinforcement having five sections as defined in claim 5 and further comprising a straight sixth section (see figures 11 and 12). DE 10 2008 033 883 seems to disclose the features of claim 5.

3. claims: 8(completely); 1-3, 15(partially)

This invention comprises a reinforcement having seven sections with a bending radius, the fourth section forming a straight section and having a particular relation between the bending radius of each section (as defined in claim 8) (see figures 13 and 14)

4. claims: 9(completely); 1-3, 15(partially)

This invention comprises a reinforcement having nine sections with a bending radius, and having a particular relation between the bending radius of each section (as defined in claim 9) (see figures 15 and 16)

5. claims: 11(completely); 1-3, 15(partially)

This invention comprises a reinforcement having thirteen sections with a bending radius, and having a particular relation between the bending radius of each section (as defined in claim 11) (see figures 19 and 20)

6. claims: 12(completely); 1-3, 15(partially)

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 18 21 5581

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

This invention comprises a reinforcement having a first and a second bead and a damping body (as defined in claim 12) (see figure 21)

7. claims: 13, 14(completely); 1-3, 15(partially)

This invention comprises a reinforcement having five sections with a bending radius, having a particular relation between the bending radius of each section (as defined in claim 13), and a hollow space (see figures 22 and 24)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 21 5581

5 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.

18-09-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006035210 A1	31-01-2008	NONE	
DE 102008033883 A1	16-04-2009	NONE	
US 6302195 B1	16-10-2001	JP 3823584 B2	20-09-2006
		JP 2000234888 A	29-08-2000
		US 6302195 B1	16-10-2001

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- FR 2690228 [0004]
- EP 1158260 B1 [0004]
- US 20040206481 A1 [0004]