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(54) **HEAT EXCHANGER TUBE**

WÄRMETAUSCHERRÖHRE

TUBE D'ÉCHANGEUR DE CHALEUR

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Description

[0001] The present invention relates to heat exchangers adapted to vehicle air conditioning systems. More specifically, the present invention deals with heat exchanger tubes used for such heat exchangers and heat exchangers using such heat exchanger tubes.

[0002] Heat exchangers adapted to vehicle air conditioning systems are commonly used as evaporators. They are adapted to cool down an air flow, and this air flow is then transferred to a passenger compartment of the vehicle or any component of the vehicle that needs to be thermally controlled. For this purpose, heat exchangers are conventionally arranged in a Heating, Ventilation and Air-Conditioning (HVAC) device of the vehicle.

[0003] To cool down the air flow passing through it, a heat exchanger comprises a refrigerant fluid circulation circuit. This refrigerant fluid circulation circuit generates heat exchange between said refrigerant fluid and the air flow.

[0004] In conventional heat exchangers, heat exchanger tubes are stacked one another with heat dissipating elements arranged in-between. The refrigerant fluid circulates inside the tubes, racking up calories of air flow passing through the dissipating elements of the heat exchanger.

[0005] Heat exchanger tubes can adopt various structures. According to US 6,241,011 document, heat exchanger tubes are defined by two different plates joined together by contact. Thanks to this contact, a pair of plates delimits an elementary refrigerant fluid circulation volume part of the refrigerant fluid circulation circuit. The junction of both plates is obtained by brazing, sealing the elementary refrigerant fluid circulation volume. Side plates are arranged at each end of the stacked heat exchanger tubes to connect the heat exchanger tubes to a refrigerant fluid circuit of the vehicle.

[0006] Each elementary refrigerant fluid circulation volume communicates with a tank section created from openings arranged in the plates. When the heat exchanger tubes are assembled to form the heat exchanger, the tank sections form together a refrigerant fluid circulation tube extending throughout the heat exchanger tubes and connected to an entry point and to an exit point of the heat exchanger to allow the circulation of the refrigerant fluid in the whole refrigerant fluid circulation circuit.

[0007] When refrigerant fluid circulates through the tank sections and the elementary refrigerant fluid circulation volumes, the internal pressure of the refrigerant fluid can lead to mechanical deformation of the heat exchanger tubes, especially in the region of the tank sections, resulting in potential non-conformities in the exchanger dimensions and/or in mechanical resistance degradation and early failures from fatigue.

[0008] The invention aims to provide a solution at least to this issue, while also providing a heat exchanger tube easy to manufacture, at low cost, and achieving the best possible results in terms of heat exchange. EP 0 661 508 A1 for instance discloses a heat exchanger tube with the features of the preamble of claim 1.

[0009] For this purpose, the present invention provides a heat exchanger tube with the features of claim 1.

[0010] Advantageously, the reinforcement element may extend from the first plate to the second plate perpendicularly to said longitudinal plane.

[0011] In an aspect of the invention, the first opening and the second opening are aligned perpendicularly to said longitudinal plane.

[0012] In an example, the reinforcement element may extend from one of the plates, at an edge of the plate that surrounds respective opening, first opening or second opening, said opening being the one that defined the tank section.

[0013] The plates of a heat exchanger tube according to the invention comprise a main part elongating along the longitudinal plane and protruding brackets extending from edges of the main part slightly perpendicularly to the longitudinal plane. In an embodiment, the main part of the heat exchanger plates is slightly rectangular. To form the heat exchanger tube according to the invention, the first plate is placed so that its protruding brackets extend towards the second plate, and the second plate is placed so that its protruding brackets extend towards the first plate. When joined to each other, for example by brazing, the first and second plates and their protruding brackets define an inner volume dedicated to refrigerant fluid circulation. When the first and second plates are joined to each other, the longitudinal planes of the first and second plates are parallel and define the direction of a longitudinal plane of the heat exchanger tube according to the invention.

[0014] In this document, "inner" will refer to the parts and sides of the first and/or second plates and/or heat exchanger tube according to the invention located inside of said inner volume, and "outer" will refer to the parts and sides of the first and/or second plates and/or heat exchanger tube located outside of said inner volume.

[0015] In the heat exchanger tube according to the invention, the first and second plates have at least one opening arranged in their main part: the at least one opening arranged in the first plate will be hereafter referred to as first opening, and the at least one opening arranged in the second plate will be hereafter referred to as second opening. In an embodiment, the at least one opening arranged in each plate is circular or ellipsoidal.

[0016] Each opening is delimited by a thick collar coming with and protruding at the outer side of the main part of the considered plate, slightly perpendicularly to it. In other words, a thick collar is formed along the perimeter of each opening. In a heat exchanger tube according to the invention, the thick collar of the at least one first opening arranged in the first plate forms a protruding bead extending slightly perpendicularly to the main part of the first plate and directed away from the second plate, and the thick collar of the at least one second opening arranged in the second plate forms a protruding bead extending slightly perpendicularly to the main part of the second plate and directed away from the first plate. At the inner side of the first and second plates, the thick collars form recessed parts corresponding to the above-mentioned protruding beads.

[0017] When the first and second plates are joined to each other to form the heat exchanger tube according to the invention, the openings arranged in each plate are facing each other and are aligned perpendicularly to the main parts of the plates, and their thick collars protrude away from the previously-described inner volume. The openings and their thick collars define a tank section communicating with the inner volume and allowing refrigerant fluid circulation along with others heat exchanger tubes when the heat exchanger tube is associated with other similar heat exchanger tubes to form a heat exchanger for a motor vehicle.

[0018] More precisely, the tank section is formed by the facing openings arranged in the first and second plates and the recessed parts of the thick collars of these openings. It has to be noticed that when the first and second plates are joined to each other to form the heat exchanger tube according to the invention, the inner surfaces of the main parts of these plates are pressed against each other, especially in the region of the tank section, so that no refrigerant fluid leakage can occur.

[0019] According to an aspect of the invention, the tank section comprises at least one reinforcement element extending from the first plate to the second plate, perpendicularly to the longitudinal plane of each plate. The reinforcement element comes with the first and second plates and extends from one of them to the other one. In other words, the reinforcement element links the first and the second plates together in the region of the tank section. It must be understood here that the reinforcement element is arranged in the region of the previously-described openings, more precisely in the region of the thick collars of said openings.

[0020] The reinforcement element extends perpendicularly to the previously-described longitudinal plane of the heat exchanger tube, so that it allows refrigerant fluid circulation within the inner volume and the tank section without any loss in the refrigerant fluid flowrate. This reinforcement element reduces the mechanical deformation resulting from the internal pressure of the refrigerant fluid. Especially, the reinforcement element prevents the first and second plates to move away from each other under mechanical deformation resulting of said internal pressure.

[0021] According to the invention, the reinforcement element comprises a first female reinforcement portion extending from a thick collar of a first opening towards the previously-described inner volume and a second male reinforcement portion extending from a thick collar of a first opening towards said inner volume. More precisely, the first female reinforcement comes with and extends from a thick collar of the at least one first opening arranged in the first plate, and the second male reinforcement portion comes with and extends from a thick collar of the at least one second opening arranged in the second plate.

[0022] When the first and second plates are joined to each other, the second male reinforcement portion cooperates with the first female reinforcement portion so they can be joined to each other, for example by brazing, their assembly creating the reinforcement element.

[0023] In an embodiment, the length of the joined part of the first female and second male reinforcement portions is approximately two times the thickness of the first and second plates. The length of the joined part of the first female and second mal reinforcement portions is defined as the dimension of the cooperating part of these two portions, that is, the dimension, measured perpendicularly to the above-described longitudinal plane of the heat exchanger tube, on which the male second reinforcement portion cooperates with the female first reinforcement portion to form the reinforcement element. The thickness of the plates is defined as the dimension of these plates measured perpendicularly to the longitudinal plane along which these plates extend.

[0024] According to a first example of an embodiment in which the main parts of the first and second plates are slightly rectangular, the reinforcement element extends slightly parallel to the width of the first and second plates, that is, slightly parallel to the short side of their rectangular shape. According to this example, and considering the previously-described circular or ellipsoidal shape of the openings defining the tank section, the first female reinforcement portion and the second male reinforcement portion of the reinforcement element extend on approximately a quarter of the perimeter of the thick collars of these openings. Preferentially, each reinforcement portion is located in the region of the opening perimeter nearest of a width edge of the main part of the considered plate. According to an example, the first female reinforcement portion and the second male reinforcement portions show a slightly conical profile, in order to make the cooperation of these two parts easier.

[0025] According to another example of the same embodiment, the reinforcement element extends slightly parallel to a longitudinal edge of the first and second plates, that is, slightly parallel to the longest side of their rectangular shape. According to this example, the reinforcement element is made of reinforcement wings symmetrically arranged with respect to a longitudinal axis of the above-described openings. Referring to a circular openings shape, diametrically opposite reinforcement wings are arranged in the tank section. Referring to an ellipsoidal openings shape, reinforcement wings are symmetrically arranged along the axis, major or minor, of the ellipsoidal shape that is parallel to the width of the plates.

[0026] In an embodiment, at least two openings are arranged at a first distal extremity of each plate, the two openings being identical, circular or ellipsoidal, these at least two openings are aligned parallel to the width of the rectangular main part of the first and second plates, and at least two openings are arranged at a second distal extremity of each plate, the two openings being identical and aligned parallel to the width of the rectangular main part of the first and second plates. The result is that such a heat exchanger tube has at least four tank sections. According to the invention, each of these tank sections has a reinforcement element as previously described. Generally speaking, a heat exchanger tube according to the invention counts as many reinforcement elements as it counts tank sections.

[0027] The invention extends to a heat exchanger for a motor vehicle, the heat exchanger comprising a plurality of heat exchanger tubes as described above, stacked parallel to each other along a direction perpendicular to their longitudinal plane. Preferentially, side plates are arranged at each end of the plate stack, the side plates having an entry point and an exit point to connect the tank tube formed by the assembly of the tank sections of each heat exchanger tube to a refrigerant fluid circuit of a motor vehicle.

[0028] The invention also extends to a process for manufacturing a heat exchanger tube as described above. In an embodiment, the heat exchanger tube is made from aluminium plates of thickness in the range of 190 to 270 micrometres. According to an example, the plates of each heat exchanger tube, including the openings and their thick collars, are made for example by stamping an aluminium sheet in a press, the edges and protruding brackets of these plates, for example, cut and, then, folded, from the stamped sheet.

[0029] According to the invention, during this forming process, the material necessary to create the reinforcement portions of the reinforcement elements is kept, and the reinforcement portions are then folded towards the inner surface of the main part of the considered plate in a further step of the forming process. According to various examples, the shape of the reinforcement portions can be stamped from the aluminium foil when forming the tank section and its thick collar, or it can be cut from the foil, before or after stamping the tank section and its thick collar.

[0030] As described above, the invention reduces the risk of mechanical deformation of the heat exchanger tube, especially in the region of the tank section, in which constraints resulting from the refrigerant fluid pressure are high. This way, the invention achieves his goal.

[0031] Other specificities, details and characteristics of the present invention will be highlighted thanks to the following description, given for general guidance, in relation with the following figures :

- figure $_1$ is a general view of a heat exchanger including heat exchanger tubes according to the present invention,
- figures $_2$a and $_2$b respectively show a general view and a cross-section view of a detail of a heat exchanger tube illustrated on figure $_1$,
- figures $_3$a and $_3$b are close-up perspective views of a detail of a plate of a heat exchanger tube according to a first example of the invention,
- figure 4 is a general perspective view of a detail of a heat exchanger tube according to the first example of the invention illustrated by figures $_3$a and $_3$b,
- figure $_5$ is a general view of an embodiment of a heat exchanger tube according to the first example illustrated by figure $_3$a, figure $_3$b, and figure $_4$,
- figures 6a and 6b are close-up perspective views of a detail of a plate of a heat exchanger tube according to a second example of the invention,
- figure $_7$ is a general perspective view of a detail of a heat exchanger tube according to the second example of the invention illustrated by figures 6a and 6b,
- and figure 8 illustrates an example of a plate of a heat exchanger tube according to the invention during its forming process.

[0032] Note that features and different embodiments of the invention may be combined with one another in various combinations, as well as they are not incompatible or exclusive to one another. More particularly, it is possible to imagine variants of the invention comprising only a selection of the features described hereinafter, without the other characteristics described, if said selection of features provides a technical advantage or if it allows to distinguish the invention over the prior art.

[0033] Especially, the embodiments described hereafter are combinable if said combination is functional from a technical point of view.

[0034] In the following figures, features common to several figures have the same reference.

[0035] Starting from figure $_1$, a plurality of heat exchanger tubes $_1$ of the invention are stacked in-between a plurality of dissipation devices 2. Both heat exchanger tubes $_1$ and dissipation devices $_2$ are oriented parallel to each other, according to a longitudinal plane P of one of the heat exchanger tubes $_1$.

[0036] Heat exchanger tubes $_1$ and dissipation devices $_2$ are integrated inside a heat exchanger 500 and alternately stacked between two side mounting flanges 50, $_{51}$. The side mounting flanges 50, 51 also extend along a plane parallel to the longitudinal plane P of one of the heat exchanger tubes $_1$. Heat exchanger tubes $_1$ and dissipation devices $_2$ form a core 550 of the heat exchanger 500, said core 550 being the part which is crossed by an air flow 600 and where the refrigerant fluid 7oo flows.

[0037] A first side mounting flange 5o is blind. A second side mounting flange $_{51}$, opposed to the first side mounting flange 5o versus the core 55o, comprises a first mouth 52 and a second mouth 53 at a same distal extremity 54 of the second side mounting flange $_{51}$. The first mouth 52 receives an input plug $_{55}$, the second mouth 53 receives an output plug $_{5}$6. The input plug 55 and the output plug $_{5}$6 are intended to join the heat exchanger tubes $_{1}$ to a refrigerant circuit. The refrigerant fluid 7oo enters the heat exchanger 5oo under a liquid form thanks to the input plug $_{55}$, then it is progressively vaporized inside the heat exchanger tubes $_{1}$, and it finally exits the heat exchanger 5oo under a gaseous form thanks to the output plug $_{5}$6. Thus, the diameter of the input plug $_{55}$ is required to be smaller than the diameter of the output plug 56.

[0038] Each heat exchanger tube $_{1}$ has a globally flat shape. This shape optimizes the heat exchange between the heat exchanger tubes $_{1}$ and dissipation devices $_{2}$. Indeed, it ensures a good contact between heat exchanger tubes $_{1}$ and dissipation devices $_{2}$, since heat exchanger tubes $_{1}$ also supports the corrugated dissipation devices $_{2}$.

[0039] In the heat exchanger 5oo, heat exchange is made between the refrigerant fluid 7oo and the air flow 600 crossing along the dissipation devices 2. The air flow 600 licks heat exchanger tubes $_{1}$ and dissipation devices $_{2}$. The corrugated shape of dissipation devices $_{2}$ optimizes the heat transfer from the air flow 600 to the refrigerant fluid 7oo, since it considerably increases heat exchange surfaces comparing to a non-corrugated device.

[0040] While circulating through the heat exchanger tubes $_{1}$ of the heat exchanger 5oo operating as an evaporator, the refrigerant fluid 7oo collects calories from the air flow 600, and consequently cools this air flow 600 down.

[0041] Figure $_{2}$a shows a general view of a heat exchanger tube $_{1}$ according to a first example of embodiment of the present invention, and two adjacent dissipation devices 2. Figure $_{2}$b shows a cross-section of the heat exchanger tube $_{1}$ illustrated by figure $_{2}$a.

[0042] Referring to figure $_{2}$a and figure $_{2}$b, the heat exchanger tube $_{1}$ comprises a first plate $_{3}$ and a second plate $_{4}$, adapted to be joined and brazed.

[0043] According to the example shown in the figures, the first plate $_{3}$ has a main part 3o extending along a longitudinal plane P, and the second plate $_{4}$ has a main part $_{4}$o extending along a longitudinal plane parallel to the above-mentioned longitudinal plane P. According to this example, the main parts 3o, 4o, of plates $_{3}$, $_{4}$, have a slightly rectangular shape, taking the manufacturing tolerances into account. Based on the above, the main parts 3o, 4o, of the first plate $_{3}$ and second plate 4 are parallel in the heat exchanger tube $_{1}$.

[0044] The first and second plates $_{3}$, $_{4}$, also have a group of protruding brackets $_{31}$, $_{41}$, extending from the edges of the above-mentioned main parts 3o, $_{4}$o. The protruding brackets $_{31}$, $_{41}$, extend perpendicularly to the longitudinal plane P. More precisely, the protruding brackets 31 of the first plate $_{3}$ are oriented towards the second plate $_{4}$, and the protruding brackets $_{41}$ of the second plate $_{4}$ are oriented towards the first plate $_{3}$, so that, when assembled and joined to each other, for example by brazing, the first and the second plates $_{3}$, $_{4}$, delimit an inner volume $_{5}$ between their main parts 3o, 4o and protruding brackets $_{31}$, $_{41}$. The inner volume $_{5}$ is shown on figure $_{2}$b, which illustrates a cross section of the heat exchanger tube $_{1}$ shown in figure $_{2}$a along a transversal plane P1 perpendicular to the above-described longitudinal plane P.

[0045] Each plate $_{3}$, $_{4}$ is veined with ridges $_{32}$, 42 that extend along a longitudinal axis X of the considered plate, the longitudinal axis X is included in the longitudinal plane P. The ridges $_{32}$, $_{42}$ are continuous and straight lines. When the first plate $_{3}$ and the second plate $_{4}$ are joined to each other to form the heat exchanger tube $_{1}$, each ridge $_{32}$ of the first plate $_{3}$ is pressed against a ridge $_{42}$ of the second plate $_{4}$, so that they divide the inner volume 5 in channels 6 dedicated to refrigerant fluid circulation within the heat exchanger tube $_{1}$. This is shown on figure $_{2}$b. Channels 6 split the inner volume $_{5}$ and so, spread out the circulating refrigerant fluid 7oo inside the heat exchanger tube $_{1}$. This homogeneous splitting results in a better heat exchange.

[0046] According to the example shown in the figures, the first plate $_{3}$ has two first openings 80 located at a same first distal extremity $_{35}$ of the heat exchanger tube $_{1}$, and the second plate $_{4}$ has two second openings 81 located at the same first distal extremity 35 of the heat exchanger tube $_{1}$. According to the example shown in figure $_{2}$a and figure $_{2}$b, the first and second openings 80, 81, are slightly circular, and they are placed so that their centres are slightly aligned parallel to the first distal extremity $_{35}$ of the heat exchanger tube $_{1}$, that is, to the width of the rectangular main part 3o, 4o, of the first and second plates $_{3}$, $_{4}$.

[0047] In a heat exchanger tube 1 according to the invention, first openings 80 and second openings 81 are facing one another, that is, a first opening 80 is aligned with a second opening 81 perpendicularly to the above-mentioned longitudinal plane P and longitudinal axis X.

[0048] Each first opening 80 is surrounded by a first thick collar 82 and each second opening 81 is surrounded by a second thick collar 8_{3}, in the manner of an eyelet, both the first thick collar 82 and the second thick collar 8_{3} protruding from the longitudinal plane P of the heat exchanger tube $_{1}$. More precisely, the first thick collar 82 comes with the main part 3o of the first plate $_{3}$ and forms a protruding bead at the outer side of the main part 3o of the first plate $_{3}$, that is, on the side of this plate opposite to the above-described inner volume $_{5}$. The same way, the second thick collar 8_{3} comes with the main part 4o of the second plate $_{4}$ and forms a protruding bead at the outer side of said main part 4o, that is, on the side of the second plate $_{4}$ opposite to said inner volume $_{5}$.

[0049] On the inner side of both the first plate $_{3}$ and the second plate $_{4}$, that is, within the inner volume $_{5}$, the first thick collar 82 and the second thick collar 8_{3} form a recessed part, respectively 8_{4}, 85. The recessed parts

8_4, 8_5 formed by the first and second thick collars 82, 8_3, define a volume $_7$ communicating with the inner volume $_5$ and hereafter referred to as tank section $_7$. The tank section $_7$ is designed to connect different heat exchanger tubes $_1$ for allowing refrigerant fluid circulation along a heat exchanger $_5$oo as illustrated by figure 1.

[0050] For this purpose, the protruding bead of a first thick collar 82 and the protruding bead of a second thick collar 8_3 of a heat exchanger tube $_1$ match with the immediate adjacent protruding beads of first and second thick collars 82, 8_3, of an immediate adjacent heat exchanger tube $_1$. Then, both first thick collars 82 and second thick collars 8_3 are in contact and joined to each other, for example by brazing, to seal an inner volume dedicated to refrigerant fluid 7oo circulation, called a collector. In the heat exchanger $_5$oo as illustrated by figure $_1$, the tank sections 7 of each heat exchanger tube $_1$ and the collectors between each heat exchanger tube $_1$ form together a refrigerant fluid circulation tube, not visible on the figures, dedicated to the distribution of the refrigerant fluid 7oo along the heat exchanger 5oo. In the heat exchanger 5oo, the refrigerant fluid circulation tube is connected to both the previously-described input plug $_{55}$ and output plug $_5$6, so that the input plug $_{55}$ forms an entry point for the refrigerant fluid 7oo and the output plug 56 forms an exit point for the refrigerant fluid $_7$oo.

[0051] As shown on figure $_2$a, a dissipation device $_2$ extends in a plane parallel to the longitudinal plane P of the heat exchanger tube $_1$. Two dissipation devices $_2$ are distributed one both sides of the heat exchanger tube $_1$, in order to have a contact area between the plates $_3$, $_4$, and the dissipation devices $_2$. This contact area covers almost the entire plates 3, $_4$, except at the first distal extremity $_{35}$ of the heat exchanger tube $_1$, in order to have the first openings 80, the second openings 81, the first thick collars 82 and a second thick collars 8_3 free to face other first openings 80, second openings 81, first thick collars 82 and second thick collars 8_3 of an immediate adjacent heat exchanger tube $_1$.

[0052] The dissipation device $_2$ has periodic corrugation crests 20, $_{21}$ and a defined pitch 25. The pitch $_{25}$ is the distance between two adjacent corrugation crests 20, $_{21}$. In other words, the pitch $_{25}$ is the half of a distance between two adjacent corrugation crests 20 or crests $_{21}$, crests 20 or crests $_{21}$ considered on the same side of the plane of the dissipation device $_2$. The pitch 25 is measured according to the longitudinal axis X of plates $_3$, $_4$, between two adjacent corrugation crests 20 or crests 21. Crests 2O, $_{21}$, are organized so that each group faces a heat exchanger tube $_1$ or an immediate adjacent heat exchanger tube $_1$ in a heat exchanger 5oo. The periodic corrugation crests 20, $_{21}$, are symmetrically arranged regarding the plane of the dissipation device $_2$.

[0053] Figure $_3$a and figure $_3$b are close-up perspective views of the above-defined first distal extremity $_{35}$ of a plate $_3$, $_4$, of a heat exchanger tube $_1$ according to a first example of the invention. Figure $_3$a shows the inner face of a plate 3, $_4$, and figure $_3$b shows the outer face of a plate $_3$, $_4$, according to the previously-defined orientations "inner" and "outer" regarding the inner volume $_5$. Note that the details and characteristics exposed here generically apply to either a first or second plate $_3$, $_4$, of a heat exchanger tube $_1$ according to the first example of the invention.

[0054] Referring to figure $_3$a and figure 3b, a thick collar 82, 8_3 surrounding an opening 80, 81, comes with the main part 3o, 4o of a plate $_3$, $_4$, and forms a protruding bead at the outer face of the considered plate $_3$, $_4$. This protruding bead defines the above-mentioned recessed parts 8_4, 85, at the inner side of plates $_3$, $_4$. According to the invention, a reinforcement portion 90, 91, of a reinforcement element 9 comes with and extends from the protruding bead formed by the thick collar 82, 83. The reinforcement portion 90, 91, extends towards the inner volume 5. Referring to the example illustrated by figure 3a and figure 3b, the reinforcement portion 90, $_{91}$, extends on approximately one quarter to one half of the inner perimeter of the thick collar 82, 8_3. More precisely, the reinforcement portion 90, $_{91}$, extends slightly parallel to the above-described first distal extremity 35 of the heat exchanger tube $_1$, that is, to the width of the rectangular main part 3o, 4o, of the considered plate $_3$, $_4$. According to an example, the reinforcement portion 90, $_{91}$, extends on a portion of a slightly conical surface centred on the centre of the first opening 80, 81, and narrowing from the above-mentioned protruding bead to the inner volume $_5$.

[0055] In an embodiment visible in figure $_3$a or 6a, the length L of a soldering area $_9$6 of the reinforcement portion 90, $_{91}$, measured perpendicularly to the longitudinal plane P of plate 3, $_4$, is approximately two times the thickness T of the corresponding plate $_3$, $_4$, measured perpendicularly to the longitudinal plane P. More particularly, the plate $_3$, $_4$ comprises a peripheral edge 95 that extends into a plane R which is parallel to the longitudinal plane P, the length L of the soldering area 96 of the reinforcement portion 90, 91 being measured perpendicularly to the longitudinal plane P between a limit define by the plane R and a free end of the reinforcement portion 90, 91. The soldering area 96 of one reinforcement portion 90 is configured to superpose the soldering area 96 of the other soldering area 96 coming with the reinforcement portion 91 of the other plate. The peripheral edge of each plate 3, 4 is the location where the two plates are brazed together to delimit externally the inner volume 5 of the channel.

[0056] Figure 4 shows an assembled heat exchanger tube 1 according to the first example of the invention illustrated by figure 3a and figure 3b.

[0057] It appears from this figure that when a first plate 3 and a second plate 4 are joined to create a heat exchanger tube 1, the reinforcement portions 90, 91, cooperate to form a reinforcement element 9 extending across the above-described tank section 7. It comes from the above that the reinforcement element 9 extends from the first plate 3 to the second plate 4 and links these two plates together.

[0058] To make the cooperation between them possible, the reinforcement portions 90, 91, comprise a first female reinforcement portion 90 and a second male reinforcement portion 91. The respective dimensions of the first female reinforcement portion 90 and the second male reinforcement portion 91 are defined so that, when assembling the first plate 3 and second plate 4 to form the heat exchanger tube 1, the second male reinforcement portion 91 inserts in the first female reinforcement portion 90. The two reinforcement portions 90, 91, can then be joined to each other, for example by brazing.

[0059] According to an example, the diameters of the conical shape of the first female reinforcement portion 90 can be slightly greater than the diameters of the conical shape of the second male reinforcement portion 91. According to other examples, the first female reinforcement portion 90 can have a general cylindrical shape and the second male reinforcement portion 91 can have a conical shape designed so that it can lock within the cylindrical shape of the first female reinforcement portion 90.

[0060] Whatever the various shapes of the reinforcement portions 90, 91, it results from their design that the reinforcement element $_9$ links the first plate $_3$ and the first plate $_4$ of the heat exchanger tube $_1$ across the tank section $_7$. The reinforcement element $_9$ so prevents mechanical deformation of the heat exchanger tube 1 resulting from internal pressure of the refrigerant fluid 7oo in the tank section $_7$.

[0061] Figure $_5$ shows a whole plate $_3$, $_4$, of a heat exchanger tube $_1$ according to the first example of the invention illustrated by figures $_3$a, $_3$b and $_4$. According to this example, plates 3, $_4$, of the heat exchanger tube $_1$, also have openings 80', 81', arranged at a second distal extremity $_3$6 of the heat exchanger tube $_1$, opposed to the first distal extremity $_{35}$ with respect to the previously-described ridges $_{32}$, $_{42}$. The openings 80', 81', arranged at the second distal extremity $_3$6 are identical and disposed parallel to those arranged at the first distal extremity $_{35}$ of the heat exchanger tube 1. As shown by figure $_5$, each opening 80', 81', arranged at the second distal extremity $_3$6, has a reinforcement portion 90', 91'. This means that a reinforcement element $_9$ is arranged in each tank section $_7$' defined by the openings 80', 81', at the second distal extremity $_3$6. Generally speaking, the invention provides that the heat exchanger tube $_1$ has as many reinforcement elements $_9$, $_9$' as it has tank sections 7, 7'.

[0062] Referring to figure 5, it has to be noticed that the reinforcement portions 90, 91, at the first distal extremity $_{35}$ and the reinforcement portions 90', 91', at the second distal extremity $_3$6 are symmetrically arranged with respect to a median plane P2 of plate $_3$, $_4$, the median plane P2 being perpendicular to the above-described longitudinal axis X. In other words, according to this example, whatever the distal extremity $_{35}$, 36, where the reinforcement portions 90, 91, 90', 91', are located, they extend along the part of the perimeter of the openings 80, 81, 80', 81', the nearest of the edge of the main part 3o, 4o, of the considered plate $_3$, $_4$.

[0063] Figure 6a and figure 6b are close-up perspective views of one of the distal extremities $_{35}$, 36, arbitrarily designed as the first distal extremity $_{35}$, of a plate $_3$, $_4$, of a heat exchanger tube $_1$ according to a second example of the invention. Figure 6a shows the inner face of a plate $_3$, $_4$, and figure 6b shows the outer face of a plate $_3$, $_4$. Note that the details and characteristics exposed here generically apply to either a first or second plate $_3$, 4, of a heat exchanger tube $_1$ according to the first example of the invention.

[0064] Thick collars 82, 8$_3$, of openings 80, 81, are shown on figure 6a and figure 6b, together with the protruding beads these thick collars 82, 8$_3$, form at the outer side of the considered plate $_3$, $_4$. The corresponding recessed parts 84, 8$_5$, the thick collars 82, 8$_3$, define at the inner side of the considered plate $_3$, $_4$, are also shown on figure 6a and figure 6b. As previously described, a reinforcement portion 90, $_{91}$, of a reinforcement element $_9$ comes with and extends from the protruding bead formed by each thick collar 82, 8$_3$. The reinforcement element extends towards the inner volume 5.

[0065] According to this second example of the invention, the reinforcement portions 90, 91, extend parallel to the above-described longitudinal axis X of the heat exchanger tube 1. Moreover, according to this second example, each reinforcement portion 90, 91, is made of two wings $_9$oa, $_9$1a, 90b, 91b, symmetrically arranged regarding a longitudinal axis 800, 810, of the corresponding opening 80, 81, said longitudinal axis 800, 810, being parallel to said longitudinal axis X and running through the centre of the corresponding opening 80, 81. It has to be noticed that longitudinal axis 800, 810, of the openings 80, 81, arranged in plates $_3$, $_4$, are longitudinal axis for the corresponding tank sections 7.

[0066] Referring to figure 6a and figure 6b, the wings $_9$oa, 91a, $_9$ob, 91b, are slightly plane, they elongate parallel to a plane P$_3$ slightly perpendicular to the longitudinal plane P and parallel to the longitudinal axis X of plate 3, 4. Referring to figure 6a and figure 6b, the wings 90a, 91a, are the nearest of a longitudinal edge 33, 43, of the plate 3, 4, and the wings 90b, 91b, are the nearest of the above-mentioned longitudinal axis X.

[0067] Figure 7 shows an assembled heat exchanger tube 1 according to the second example of the invention illustrated by figure 6a and figure 6b.

[0068] It appears from this figure that when a first plate 3 and a second plate $_4$ are joined to each other to form a heat exchanger tube 1, the wings 90a, 91a, 90b, 91b, of the reinforcement portions 90 91, cooperate to form a reinforcement element 9 extending across the above-described tank section $_7$, from the first plate $_3$ to the second plate 4. More precisely, the wings $_9$oa of the first plate $_3$ cooperate with the wings $_{91}$a of the second plate $_4$, and the wings $_9$ob of the first plate $_3$ cooperate with the wings $_{91}$b of the second plate $_4$. As for the previously-described first example, in this second example, to make this cooperation possible, each reinforcement wing $_9$oa, 9ob constitutes a first female reinforcement portion regarding to the male reinforcement wing 91a, 91b, with which it cooperates. The wings can then be joined to each other, for example by brazing.

[0069] According to an example, the male reinforcement wings 91a, 91b, can be arranged nearer to the longitudinal axis 800, 810, of the openings 80, 81, than the female reinforcement wings $_9$oa, 91a, with which they cooperate. According to other examples, the male reinforcement wings $_{91}$a can be slightly oriented towards the longitudinal edges 43 of the second plate $_4$ and the male reinforcement wings 91b can be slightly oriented towards the longitudinal axis X of the second plate $_4$, so that, when the first and second plates $_3$, $_4$, are joined to each other to form the heat exchanger tube $_1$, the male reinforcement wings 91a, 91b, create a pressing constraint against the female reinforcement wings $_9$oa, $_9$ob.

[0070] As described previously for the first example of the invention, it results from the configuration of the reinforcement portions 90, 91, that the reinforcement element $_9$ links the first plate $_3$ and the first plate $_4$ of the heat exchanger tube $_1$ across the tank section $_7$. More precisely, according to this second example of the invention, two reinforcement elements $_9$ are arranged in each tank section $_7$, symmetrically disposed regarding the previously-defined longitudinal axis 800, 810, of each tank section $_7$. This results in higher reinforcement performance for the heat exchanger tube $_1$ according to this second example of the invention.

[0071] Figure 8 shows an example of a plate 3, $_4$, of a heat exchanger tube $_1$ during its forming process, according to the second example illustrated by figures 6a, 6b, and 7.

[0072] According to the invention, first and second plates $_3$, $_4$, of a heat exchanger tube $_1$ are formed from aluminium foils of thickness ranging from approximately 190 to 270 micrometres.

[0073] As shown by figure 8, the main part 3o, 4o, of a plate 3, $_4$, the openings 80, 81, and the thick collars 82, 8$_3$, previously described, are first formed from the aluminium foil, for example by stamping in a mould and cutting of the above-mentioned openings 80, 81.

[0074] According to the invention, the material necessary to create the reinforcement wings $_9$oa, $_9$ob, 91a, 91b, and, generally speaking, the reinforcement portions 90, 91, is kept during this first step of plates forming. This is shown by figure 8 where it can be seen that the wings $_9$oa, $_9$ob, 91a, 91b, are elongating parallel to the main part 30, 40, of the corresponding plate $_3$, $_4$.

[0075] In a further step of plates forming, the wings 90a, 90b, 91a, 91b, and, generally speaking, the reinforcement portions 90, 91, are folded towards the previously-described recessed parts 8$_4$, 8$_5$, defined by the protruding beads formed by the thick collars 82, 8$_3$. This folding direction is illustrated by the arrow F on figure 8.

[0076] The invention so provides a simple and low-cost means for manufacturing the plates of a heat exchanger tube according to the above-described characteristics.

[0077] We understand thanks to the above description, that the present invention proposes a simple design of heat exchanger tube resistant at working pressure and burst pressure thanks to the reinforcement elements, for a long term sustainability. This heat exchanger tube is easily manufactured, at a low cost. It allows good thermal exchange performance. This heat exchanger tube is dedicated to heat exchanger and can be found in a Heating, Ventilation and Air-Conditioning device of a motor vehicle. This kind of heat exchanger can be easily integrated into vehicle air conditioning systems in order to optimize the heat exchange between the air flow dedicated to the passenger compartment cool down and the refrigerant fluid circulating inside heat exchanger tubes of the invention.

[0078] However, the invention is not limited to resources and patterns described and illustrated here. It also include all equivalent resources or patterns and every technical associations including such as long as such equivalents have the features as defined in the claims. More particularly, the shape of the heat exchanger tube do not affect the invention, insofar as the heat exchanger tube for use in a motor vehicle, in *fine,* has the same functionality as describes in this document.

Claims

1. A heat exchanger tube (1) for use in a heat exchanger of a motor vehicle, the heat exchanger tube ($_1$) comprising a first plate ($_3$) and a second plate ($_4$) elongating along a longitudinal plane (P), joined to each other to form an inner volume (5) dedicated to refrigerant fluid (700) circulation, the inner volume (5) communicating with at least one tank section (7) created from one first opening (80) arranged in the first plate ($_3$) to one second opening (81) arranged in the second plate (4), wherein the tank section (7) comprises at least one reinforcement element ($_9$) extending from the first plate ($_3$) to the second plate (4), **characterised in that** the reinforcement element ($_9$) comprises a first female reinforcement portion (90) extending from a thick collar (82) of the first opening (80) towards said inner volume (5) and a second male reinforcement portion (91) extending from a thick collar (83) of the second opening (81) towards said inner volume (5).

2. The heat exchanger tube ($_1$) according to the previous claim, wherein the first male reinforcement portion (90) and the second female reinforcement portion (91) are joined to each other and the length (L) of the joined part is approximately two times the thickness (T) of the plates (3, 4).

3. The heat exchanger tube ($_1$) according to any of the previous claims, in which the plates ($_3$, $_4$) have a

rectangular shape, wherein the reinforcement element ($_9$) extends slightly parallel to a width of the plates (3, 4).

4. The heat exchanger tube ($_1$) according to the previous claim, wherein the first female reinforcement portion (90) extends on approximately a quarter of the perimeter of the primary opening (80) and the second male reinforcement portion (91) extends on approximately a quarter of the perimeter of the secondary opening (81).

5. The heat exchanger tube ($_1$) according to any of claims $_1$ and $_2$, in which the plates ($_3$, $_4$) have a rectangular shape, wherein the reinforcement element ($_9$) extends slightly parallel to a longitudinal edge (33, 43) of the plates (3, 4).

6. The heat exchanger tube ($_1$) according to the previous claim, wherein the reinforcement element ($_9$) is made of reinforcement wings (90a, 90b, 91a, 91b) symmetrically arranged with respect a longitudinal axis (800, 810) of the openings (80, 81).

7. The heat exchanger tube ($_1$) according to any of the previous claims, wherein the thickness (T) of the plates (3, 4) is in the range of 190 to 270 micrometres.

8. Process for manufacturing a heat exchanger tube ($_1$) according to any of the previous claims, in which the reinforcement portions (90, 91) of the reinforcement element ($_9$) are folded from the stamped thick collars (82, 83) of the openings (80, 81).

9. A heat exchanger (5oo) comprising a plurality of heat exchanger tubes (1) according to at least one claims 1 to 7 and having an input plug (55) and an output plug (56) for connecting the plurality of heat exchanger tubes ($_1$) to a refrigerant fluid circuit of a motor vehicle.

Patentansprüche

1. Wärmetauscherrohr (1) zur Verwendung in einem Wärmetauscher eines Kraftfahrzeugs, wobei das Wärmetauscherrohr (1) eine erste Platte (3) und eine zweite Platte (4) umfasst, die sich entlang einer Längsebene (P) erstrecken und miteinander verbunden sind, um ein inneres Volumen (5) für den Umlauf von Kältemittelfluid (700) zu bilden, wobei das innere Volumen (5) mit mindestens einem Tankabschnitt (7) kommuniziert, der von einer in der ersten Platte (3) angeordneten ersten Öffnung (80) zu einer in der zweiten Platte (4) angeordneten zweiten Öffnung (81) geschaffen ist, wobei der Tankabschnitt (7) mindestens ein Verstärkungselement (9) umfasst, das sich von der ersten Platte (3) zu der zweiten Platte (4) erstreckt,
dadurch gekennzeichnet, dass das Verstärkungselement (9) einen ersten weiblichen Verstärkungsabschnitt (90), der sich von einem dicken Bund (82) der ersten Öffnung (80) zu dem inneren Volumen (5) hin erstreckt, und einen zweiten männlichen Verstärkungsabschnitt (91), der sich von einem dicken Bund (83) der zweiten Öffnung (81) zu dem inneren Volumen (5) hin erstreckt, umfasst.

2. Wärmetauscherrohr (1) nach dem vorhergehenden Anspruch, wobei der erste männliche Verstärkungsabschnitt (90) und der zweite weibliche Verstärkungsabschnitt (91) miteinander verbunden sind und die Länge (L) des verbundenen Teils ungefähr das Doppelte der Dicke (T) der Platten (3, 4) beträgt.

3. Wärmetauscherrohr (1) nach einem der vorhergehenden Ansprüche, wobei die Platten (3, 4) eine rechteckige Gestalt haben, wobei sich das Verstärkungselement (9) leicht parallel zu einer Breite der Platten (3, 4) erstreckt.

4. Wärmetauscherrohr (1) nach dem vorhergehenden Anspruch, wobei sich der erste weibliche Verstärkungsabschnitt (90) über ungefähr ein Viertel des Umfangs der primären Öffnung (80) erstreckt und sich der zweite männliche Verstärkungsabschnitt (91) über ungefähr ein Viertel des Umfangs der sekundären Öffnung (81) erstreckt.

5. Wärmetauscherrohr (1) nach einem der Ansprüche 1 und 2, wobei die Platten (3, 4) eine rechteckige Gestalt haben, wobei sich das Verstärkungselement (9) leicht parallel zu einem Längsrand (33, 43) der Platten (3, 4) erstreckt.

6. Wärmetauscherrohr (1) nach dem vorhergehenden Anspruch, wobei das Verstärkungselement (9) aus Verstärkungsflügeln (90a, 90b, 91a, 91b) hergestellt ist, die symmetrisch bezüglich einer Längsachse (800, 810) der Öffnungen (80, 81) angeordnet sind.

7. Wärmetauscherrohr (1) nach einem der vorhergehenden Ansprüche, wobei die Dicke (T) der Platten (3, 4) im Bereich von 190 bis 270 Mikrometern liegt.

8. Verfahren zur Herstellung eines Wärmetauscherrohrs (1) nach einem der vorhergehenden Ansprüche, wobei die Verstärkungsabschnitte (90, 91) des Verstärkungselements (9) aus den gestanzten dicken Bünden (82, 83) der Öffnungen (80, 81) gefaltet sind.

9. Wärmetauscher (500), umfassend eine Vielzahl von Wärmetauscherrohren (1) nach mindestens einem der Ansprüche 1 bis 7 und mit einem Eingangsstopfen (55) und einem Ausgangsstopfen (56) zum Verbinden der Vielzahl von Wärmetauscherrohren (1) mit einem Kältemittelfluidkreislauf eines Kraftfahrzeugs.

Revendications

1. Tube d'échangeur de chaleur (1) destiné à être utilisé dans un échangeur de chaleur d'un véhicule à moteur, le tube d'échangeur de chaleur (1) comprenant une première plaque (3) et une seconde plaque (4) s'étendant le long d'un plan longitudinal (P), raccordées l'une à l'autre de façon à former un volume intérieur (5) consacré à la circulation de fluide frigorigène (700), le volume intérieur (5) communiquant avec au moins une section réservoir (7) créée d'une première ouverture (80) formée dans la première plaque (3) à une seconde ouverture (81) formée dans la seconde plaque (4), la section réservoir (7) comprenant au moins un élément de renforcement (9) s'étendant de la première plaque (3) à la seconde plaque (4),
caractérisé en ce que l'élément de renforcement (9) comprend une première partie de renforcement femelle (90) s'étendant à partir d'un col épais (82) de la première ouverture (80) en direction dudit volume intérieur (5) et une seconde partie de renforcement mâle (91) s'étendant à partir d'un col épais (83) de la seconde ouverture (81) en direction dudit volume intérieur (5).

2. Tube d'échangeur de chaleur (1) selon la revendication précédente, dans lequel la première partie de renforcement mâle (90) et la seconde partie de renforcement femelle (91) sont raccordées l'une à l'autre et la longueur (L) de la portion raccordée est égale à approximativement deux fois l'épaisseur (T) des plaques (3, 4) .

3. Tube d'échangeur de chaleur (1) selon l'une quelconque des revendications précédentes, dans lequel les plaques (3, 4) présentent une forme rectangulaire, dans lequel l'élément de renforcement (9) s'étend de manière légèrement parallèle à une largeur des plaques (3, 4).

4. Tube d'échangeur de chaleur (1) selon la revendication précédente, dans lequel la première partie de renforcement femelle (90) s'étend sur approximativement un quart du périmètre de l'ouverture primaire (80) et la seconde partie de renforcement mâle (91) s'étend sur approximativement un quart du périmètre de l'ouverture secondaire (81).

5. Tube d'échangeur de chaleur (1) selon l'une quelconque des revendications 1 et 2, dans lequel les plaques (3, 4) présentent une forme rectangulaire, dans lequel l'élément de renforcement (9) s'étend de manière légèrement parallèle à un bord longitudinal (33, 43) des plaques (3, 4).

6. Tube d'échangeur de chaleur (1) selon la revendication précédente, dans lequel l'élément de renforcement (9) est composé d'ailettes de renforcement (90a, 90b, 91a, 91b) agencées symétriquement par rapport à un axe longitudinal (800, 810) des ouvertures (80, 81).

7. Tube d'échangeur de chaleur (1) selon l'une quelconque des revendications précédentes, dans lequel l'épaisseur (T) des plaques (3, 4) est comprise dans la plage de 190 à 270 micromètres.

8. Procédé de fabrication d'un tube d'échangeur de chaleur (1) selon l'une quelconque des revendications précédentes, dans lequel les parties de renforcement (90, 91) de l'élément de renforcement (9) sont pliées à partir des cols épais estampés (82, 83) des ouvertures (80, 81).

9. Échangeur de chaleur (500) comprenant une pluralité de tubes d'échangeur de chaleur (1) selon au moins une des revendications 1 à 7 et comportant un bouchon d'entrée (55) et un bouchon de sortie (56) pour le raccordement de la pluralité de tubes d'échangeur de chaleur (1) à un circuit de fluide frigorigène d'un véhicule à moteur.

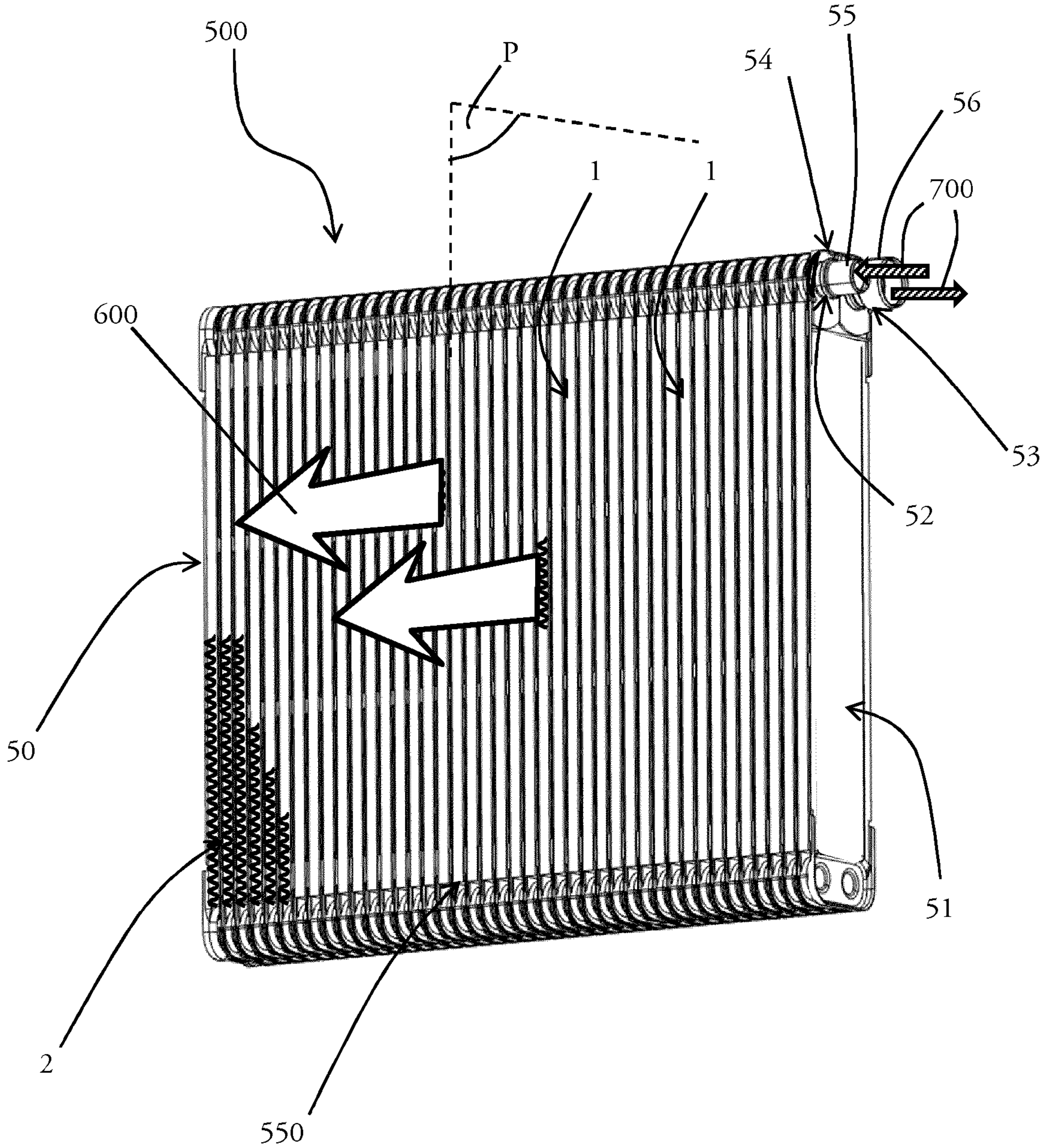

Figure 1

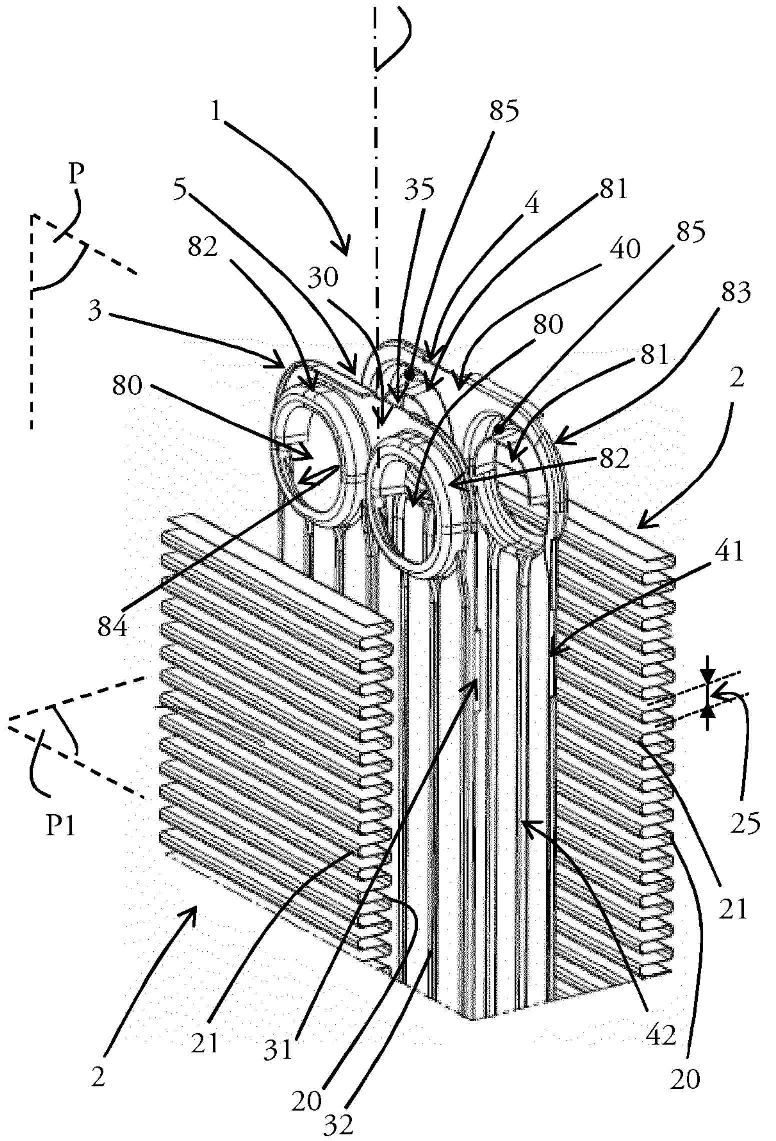

Figure 2a

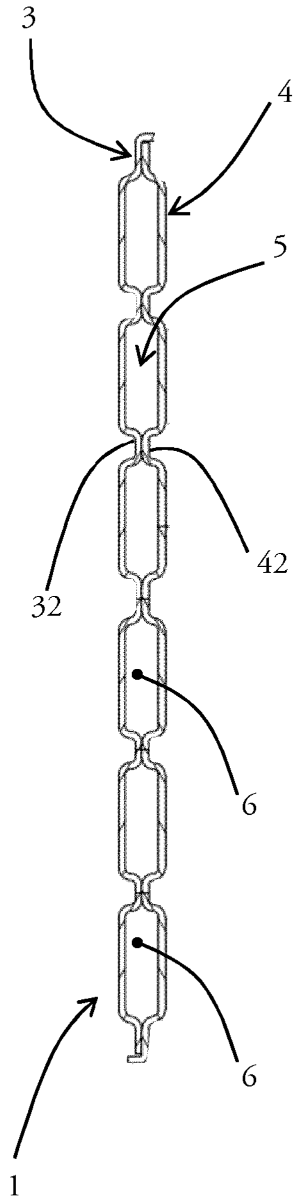

Figure 2b

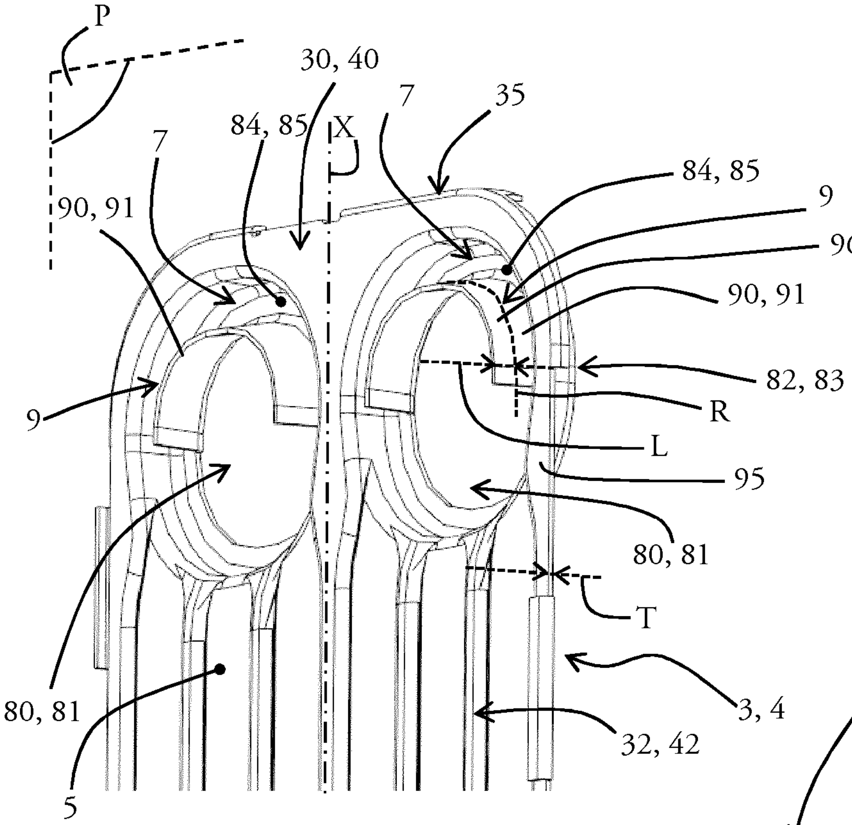

Figure 3a

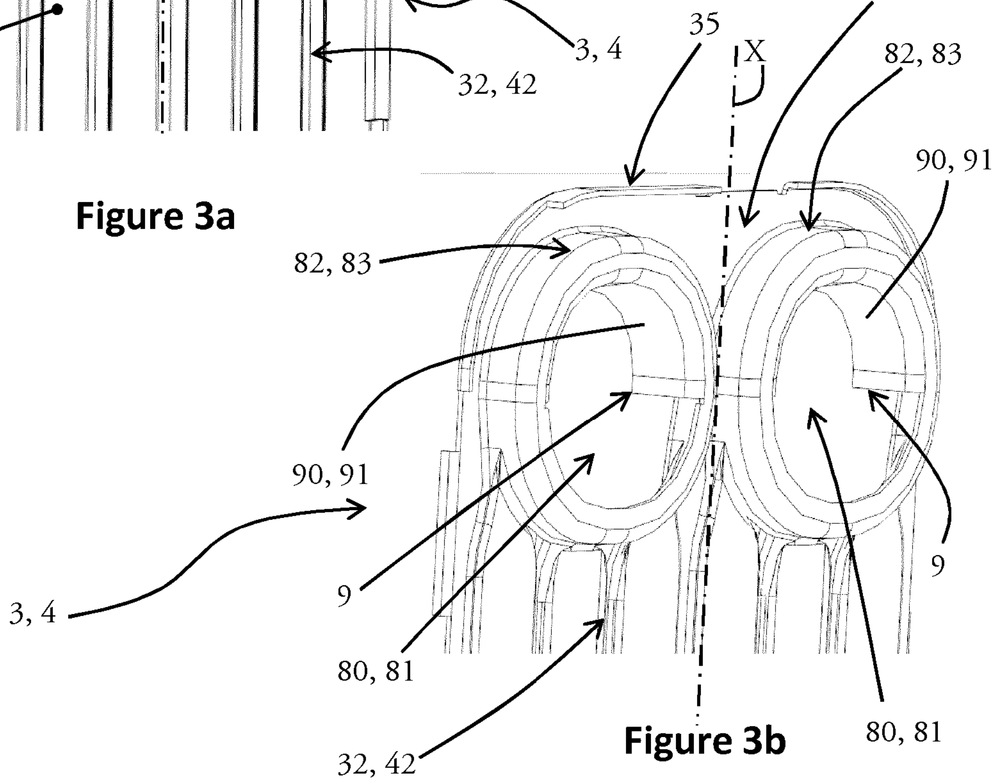

Figure 3b

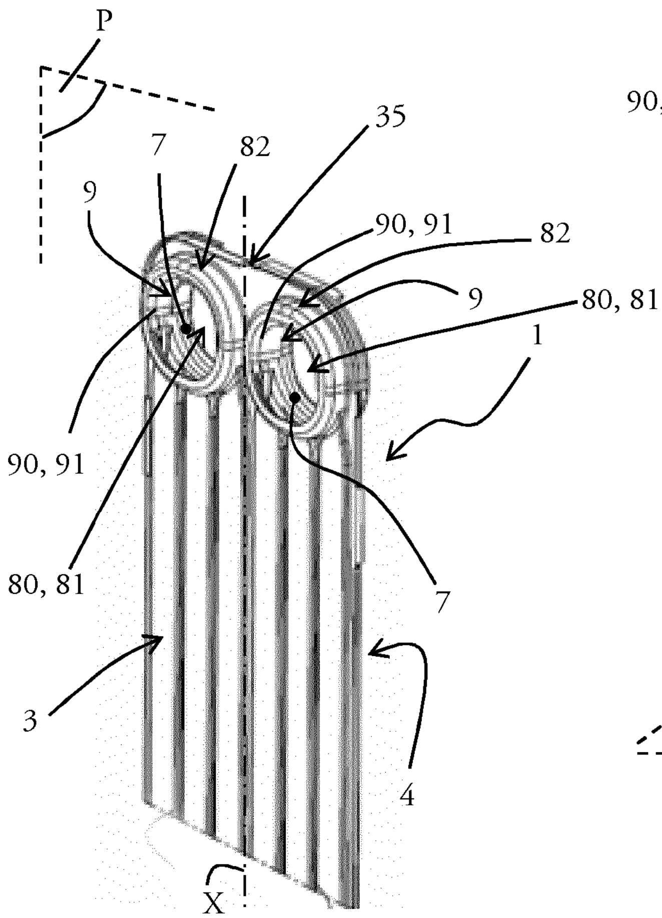

Figure 4

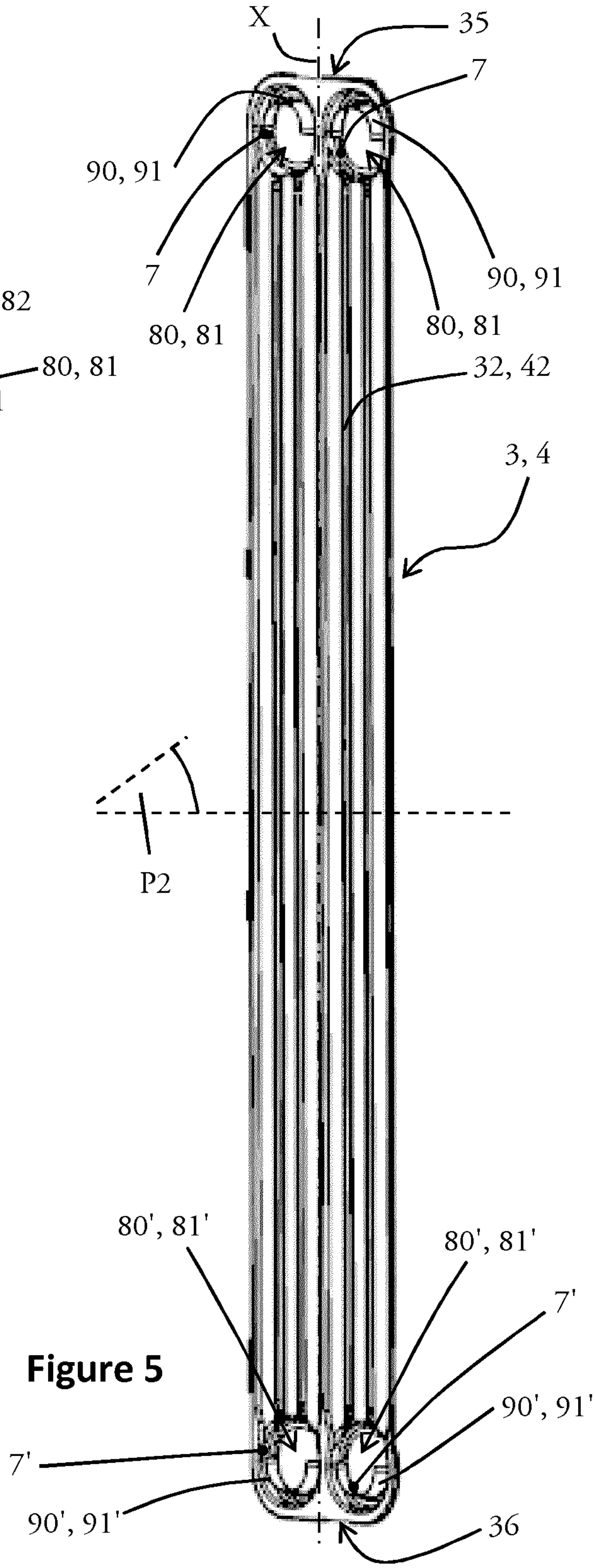

Figure 5

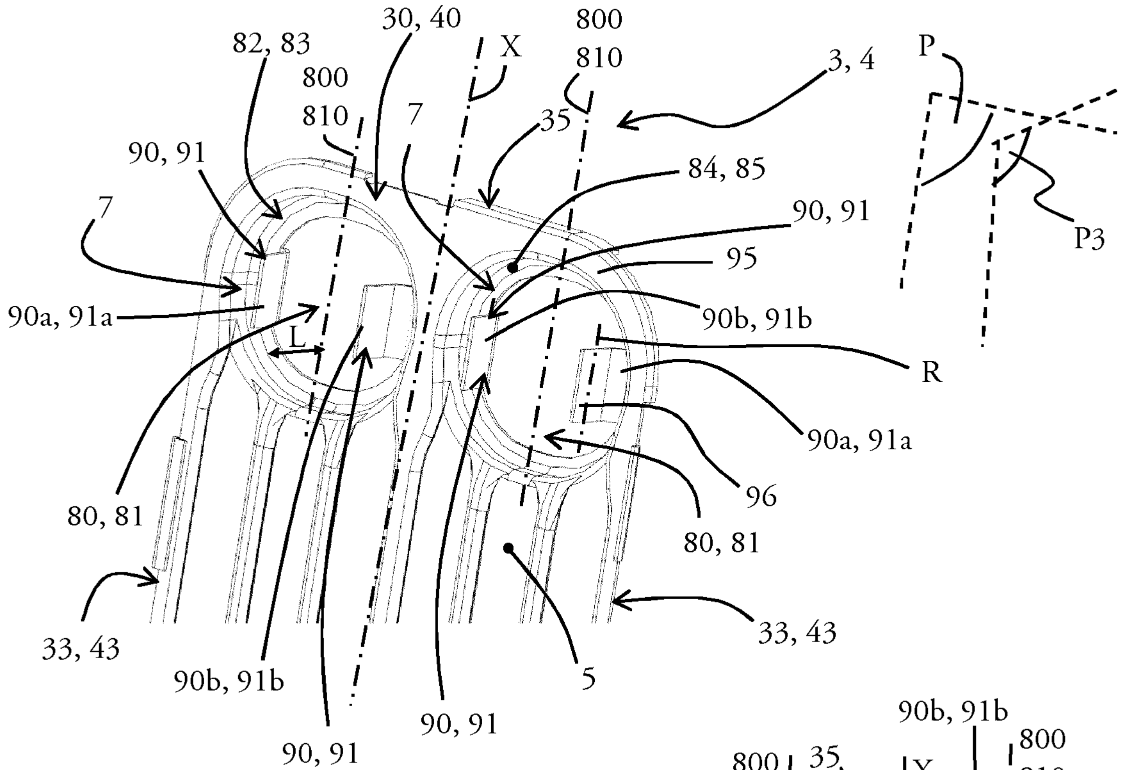

Figure 6a

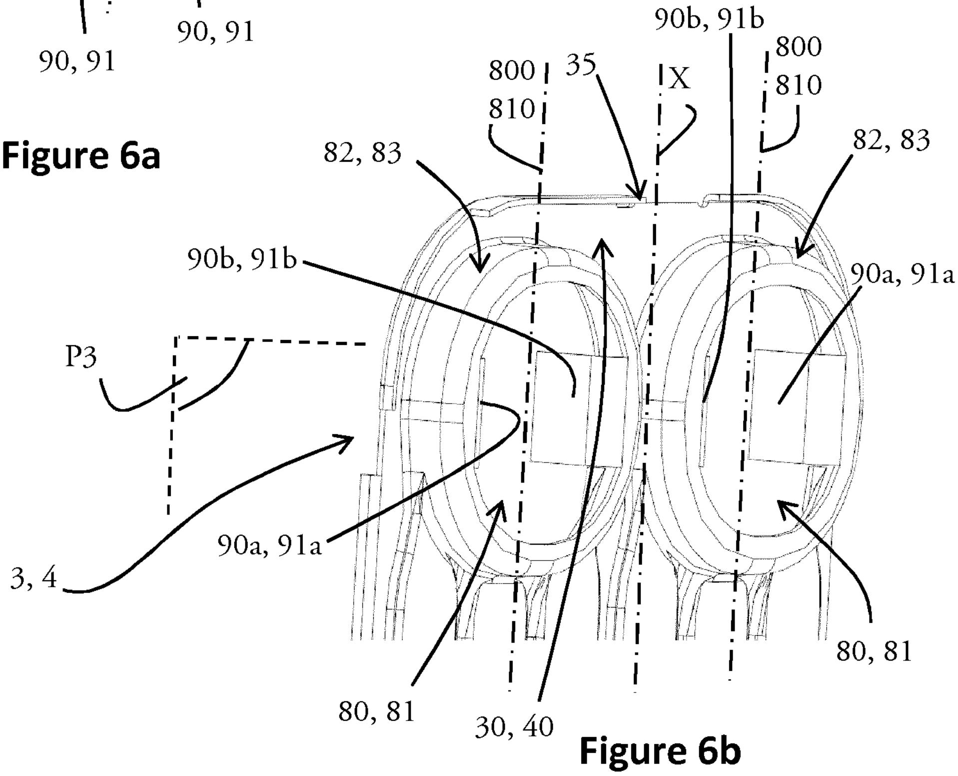

Figure 6b

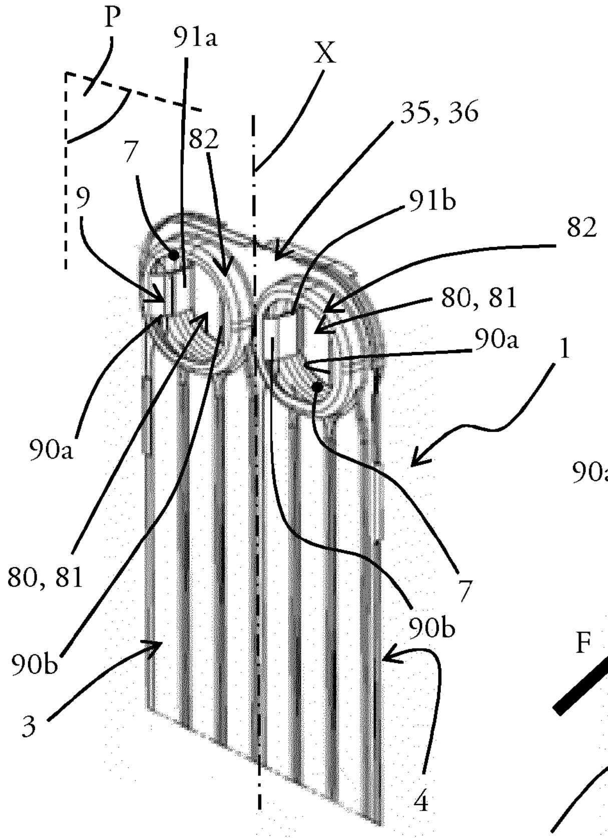

Figure 7

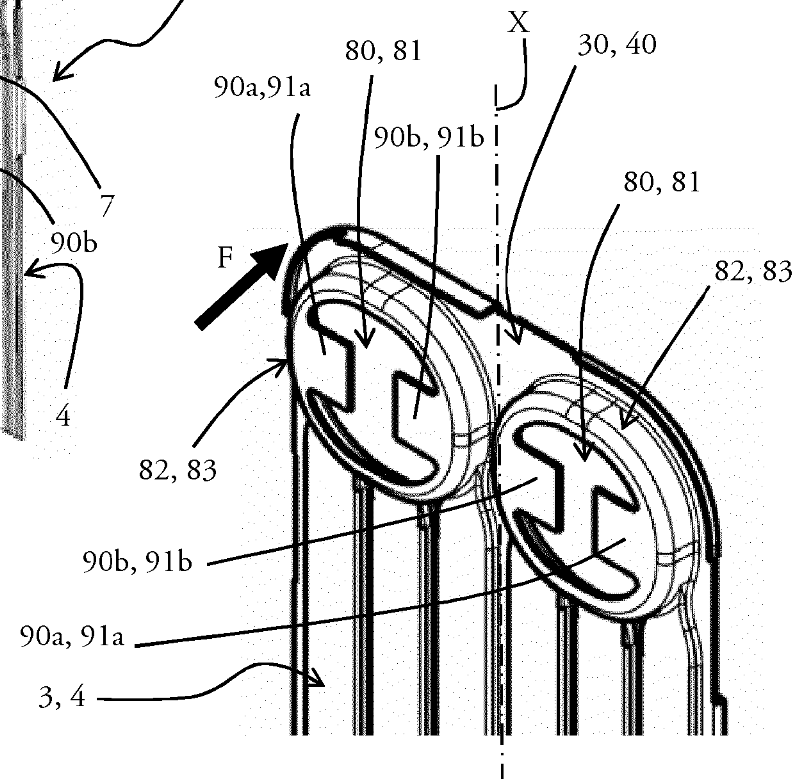

Figure 8

REFERENCES CITED IN THE DESCRIPTION

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