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(72) Inventors:

- **LI, Yanxing**
6430 Nordborg (DK)
- **ZHOU, Jing**
6430 Nordborg (DK)
- **YANG, Jing**
6430 Nordborg (DK)

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(74) Representative: **Kuhnen & Wacker**
Patent- und Rechtsanwaltsbüro PartG mbB
Prinz-Ludwig-Straße 40 A
85354 Freising (DE)

(71) Applicant: **Danfoss A/S**
6430 Nordborg (DK)

(54) **HEAT EXCHANGER**

(57) Disclosed is a heat exchanger. The heat exchanger includes a plurality of heat exchange tubes; at least some of the heat exchange tubes including a first straight tube segment, a second straight tube segment and a bent tube segment connecting the first straight tube segment and the second straight tube segment. The first straight tube segment and the second straight tube segment extend in a first direction, the first straight tube segment is offset from the second straight tube segment in a second direction and a third direction, the second direction is perpendicular to the first direction, and the third direction is perpendicular to both the first direction and the second direction. The bent tube seg-

ment includes a first bent portion which is bent such that the first straight tube segment is offset from the second straight tube segment in the second direction, a projection of the first bent portion on a plane defined by both the first direction and the second direction is U-shaped, and the first bent portion is in the same plane with the first straight tube segment. The heat exchanger of the present disclosure reduces the bending complexity of the heat exchange tube, improves the bending precision of the dimension of the heat exchange tube, and thereby enhances the assembly convenience of the heat exchanger.

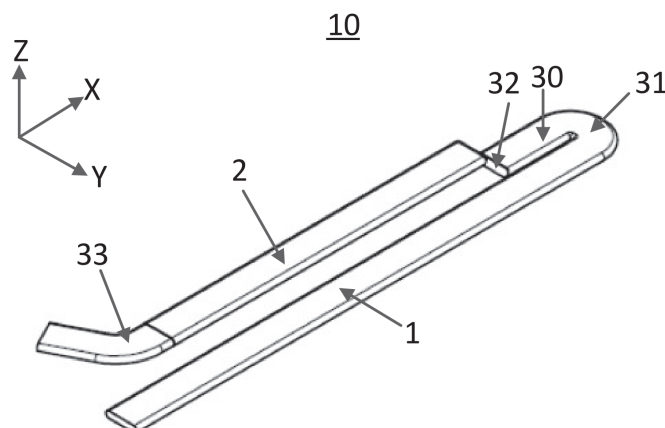


Fig.1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Chinese Patent Application No. CN 202520711098.5 filed on April 15, 2025 in the China National Intellectual Property Administration, the whole disclosure of which is incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] Embodiments of the present disclosure relate to a heat exchanger.

DESCRIPTION OF THE RELATED ART

[0003] A heat exchanger includes a heat exchange tube, a header and a fin.

SUMMARY

[0004] At least one objective of the present disclosure is to provide a heat exchanger, which can, for example, improve the bending precision of a dimension of a heat exchange tube, and thereby enhance the assembly convenience of the heat exchanger.

[0005] According to one aspect of the present disclosure, there is provided a heat exchanger, including: a plurality of heat exchange tubes; wherein at least some of the heat exchange tubes include a first straight tube segment, a second straight tube segment and a bent tube segment connecting the first straight tube segment and the second straight tube segment; wherein the first straight tube segment and the second straight tube segment extend in a first direction, and the first straight tube segment is offset from the second straight tube segment in a second direction and a third direction, wherein the second direction is perpendicular to the first direction, and the third direction is perpendicular to both the first direction and the second direction; wherein, the bent tube segment includes a first bent portion which is bent such that the first straight tube segment is offset from the second straight tube segment in the second direction, a projection of the first bent portion on a plane defined by both the first direction and the second direction is U-shaped, and the first bent portion is in the same plane with the first straight tube segment.

[0006] According to some exemplary embodiments of the present disclosure, the bent tube segment further includes a second bent portion which is bent such that the second straight tube segment is offset from the first straight tube segment in the third direction.

[0007] According to some exemplary embodiments of the present disclosure, the bent tube segment further includes a first bent straight segment extending in the first direction, wherein the first bent portion and the

second bent portion are connected via the first bent straight segment.

[0008] According to some exemplary embodiments of the present disclosure, a spacing between the projection of the first straight tube segment on the plane defined by both the first direction and the second direction and a projection of the second straight tube segment on the plane is within a range of plus or minus one-half of a width of the heat exchange tube.

[0009] According to some exemplary embodiments of the present disclosure, the spacing between the projection of the first straight tube segment and the projection of the second straight tube segment on the plane is zero.

[0010] According to some exemplary embodiments of the present disclosure, at least some of the heat exchange tubes further include a third bent portion which is bent such that an end of the second straight tube segment away from the bent tube segment and an end of the first straight tube segment away from the bent tube segment are away from each other in the second direction.

[0011] According to some exemplary embodiments of the present disclosure, a first end of the first bent portion is directly connected to the first straight tube segment, and a second end of the first bent portion is connected to the second straight tube segment via the first bent straight segment and the second bent portion in sequence.

[0012] According to some other exemplary embodiments of the present disclosure, the first bent portion includes a protruding portion which protrudes to one side relative to the first straight tube segment or the second straight tube segment in the second direction.

[0013] According to some other exemplary embodiments of the present disclosure, the protruding portion includes a fourth bent portion and a fifth bent portion; wherein, the fourth bent portion and the fifth bent portion are bent such that a first end of the fourth bent portion is connected to a first end of the first bent portion, a second end of the fourth bent portion is connected to a first end of the fifth bent portion, and a second end of the fifth bent portion is connected to the first straight tube segment.

[0014] According to some other exemplary embodiments of the present disclosure, the fourth bent portion and the fifth bent portion have different bending directions, and the fifth bent portion is bent such that the first straight tube segment and the second straight tube segment are close to each other.

[0015] According to some other exemplary embodiments of the present disclosure, the bent tube segment further includes a second bent straight segment, wherein the fourth bent portion is connected to the first bent portion via the second bent straight segment.

[0016] According to some exemplary embodiments of the present disclosure, the heat exchanger further includes a plurality of wavy fins; wherein one wavy fin

is disposed between the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes, and one wavy fin is disposed between the first straight tube segment of at least some of the heat exchange tubes and the first straight tube segment or the second straight tube segment of another adjacent heat exchange tube.

[0017] According to some exemplary embodiments of the present disclosure, a distance between the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes in the third direction is equal to a height of one wavy fin, and a distance between the first straight tube segment of at least some of the heat exchange tubes and the first straight tube segment or the second straight tube segment of another adjacent heat exchange tube in the third direction is equal to the height of one wavy fin.

[0018] According to some exemplary embodiments of the present disclosure, the heat exchanger further includes a plurality of insert fins, each insert fin having a plurality of insertion slots; wherein the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes are located in different insertion slots of the insert fins, respectively, and the first straight tube segment of at least some of the heat exchange tubes and the second straight tube segment of another adjacent heat exchange tube are located in adjacent insertion slots of the insert fins, respectively.

[0019] According to some exemplary embodiments of the present disclosure, the heat exchanger further includes a first header and a second header; wherein an end, which is away from the bent tube segment, of the first straight tube segment of at least some of the heat exchange tubes is connected to and in fluid communication with the first header, and an end, which is away from the bent tube segment, of the second straight tube segment of at least some of the heat exchange tubes away from the bent tube segment is connected to and in fluid communication with the second header.

[0020] According to some other exemplary embodiments of the present disclosure, the plurality of heat exchange tubes are arranged in an array; the heat exchanger further includes a first header, a second header, and at least one common header; wherein an end, which is away from the bent tube segment, of one of the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes of at least one column of heat exchange tubes is connected to and in fluid communication with the first header, and an end, which is away from the bent tube segment, of one of the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes of another column of heat exchange tubes adjacent to the at least one column of heat exchange tubes is connected to and in fluid communication with the second header; wherein an end,

which is away from the bent tube segment, of the other of the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes of the at least one column of heat exchange tubes, and an end, which is away from the bent tube segment, of the other of the first straight tube segment and the second straight tube segment of at least some of the heat exchange tubes of the another column of heat exchange tubes adjacent to the at least one column of heat exchange tubes are connected to and in fluid communication with the at least one common header.

[0021] According to some other exemplary embodiments of the present disclosure, the heat exchanger further includes a plurality of wavy fins; wherein one wavy fin is disposed and shared between at least some adjacent two rows of straight tube segments.

[0022] According to some other exemplary embodiments of the present disclosure, the heat exchanger further includes a plurality of first wavy fins and a plurality of second wavy fins; wherein one first wavy fin and one second wavy fin are disposed and shared between at least some adjacent two rows of straight tube segments, and the one first wavy fin and the one second wavy fin are aligned in the second direction.

[0023] According to some other exemplary embodiments of the present disclosure, the first straight tube segment of at least some of the heat exchange tubes of at least one column of heat exchange tubes is aligned with the first straight tube segment or the second straight tube segment of at least some of the heat exchange tubes in at least another column of heat exchange tubes in the second direction, and the second straight tube segment of at least some of the heat exchange tubes of the at least one column of heat exchange tubes are aligned with the first straight tube segment or the second straight tube segment of at least some of the heat exchange tubes of at least another column of heat exchange tubes in the second direction.

[0024] According to some exemplary embodiments of the present disclosure, the heat exchange tube is a micro-channel flat heat exchange tube with a plurality of flow holes therein, the first direction is a length direction of the first straight tube segment or the second straight tube segment of the heat exchange tube, the second direction is a width direction of the first straight tube segment or the second straight tube segment of the heat exchange tube, and the third direction is a thickness direction of the first straight tube segment or the second straight tube segment of the heat exchange tube.

[0025] With the adoption of the heat exchanger of the present disclosure, the bending complexity of the heat exchange tube is reduced, improving the bending precision of the dimension of the heat exchange tube, and thereby enhancing the assembly convenience of the heat exchanger.

[0026] Other objectives and advantages of the present disclosure will become apparent from the following description of the present disclosure with reference to the accompanying drawings, which will also help to provide a comprehensive understanding of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1 is a schematic perspective structural view showing a single heat exchange tube of a heat exchanger according to a first embodiment of the present disclosure;

Fig. 2 is a schematic front structural view showing the heat exchange tube shown in Fig. 1;

Fig. 3 is a schematic side structural view showing the heat exchange tube shown in Fig. 1;

Fig. 4 is a schematic bottom structural view showing the heat exchange tube shown in Fig. 1;

Fig. 5 is a schematic perspective structural view showing a heat exchanger according to the first embodiment of the present disclosure;

Fig. 6 is a schematic front structural view showing the heat exchanger shown in Fig. 5;

Fig. 7 is a schematic cross-sectional structural view showing the heat exchanger shown in Fig. 6 taken along line B-B in Fig. 6;

Fig. 8 is a schematic perspective structural view showing a single heat exchange tube of a heat exchanger according to a second embodiment of the present disclosure;

Fig. 9 is a schematic front structural view showing the heat exchange tube shown in Fig. 8;

Fig. 10 is a schematic side structural view showing the heat exchange tube shown in Fig. 8;

Fig. 11 is a schematic bottom structural view showing the heat exchange tube shown in Fig. 8;

Fig. 12 is a schematic perspective structural view showing the heat exchanger according to the second embodiment of the present disclosure;

Fig. 13 is a schematic front structural view showing the heat exchanger shown in Fig. 12;

Fig. 14 is a schematic side structural view showing the heat exchanger shown in Fig. 12;

Fig. 15 is a schematic perspective structural view showing a heat exchanger according to a third embodiment of the present disclosure;

Fig. 16 is a schematic front structural view showing the heat exchanger shown in Fig. 15;

Fig. 17 is a schematic side structural view showing the heat exchanger shown in Fig. 15;

Fig. 18 is a schematic cross-sectional structural view showing the heat exchanger shown in Fig. 15 taken along line D-D in Fig. 17;

Fig. 19 is a schematic perspective structural view showing a heat exchanger according to a fourth embodiment of the present disclosure;

Fig. 20 is a schematic front structural view showing the heat exchanger shown in Fig. 19; and

Fig. 21 is a schematic side structural view showing the heat exchanger shown in Fig. 19.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0028] The present disclosure is described in detail below, and examples of the embodiments are shown in the accompanying drawings. The embodiments described below with reference to the accompanying drawings are exemplary and intended to explain the present disclosure, and should not be construed as limiting the present disclosure. In the specification, the same or similar reference numerals indicate the same or similar components.

[0029] In the description of the present application, it should be understood that the terms that indicate orientation or position relations, such as "central", "longitudinal", "transverse", "length", "width", "thickness", "upper", "lower", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "inner", "outer", "clockwise", "anticlockwise", "axial", "radial" and "circumferential", are based on the orientation or position relations shown in the drawings, and are merely for conveniently describing the present application and simplifying the description, rather than indicating or implying that the device or element must have the specific orientation and be constructed and operated according to the specific orientation. Therefore, they should not be construed as a limitation on the present application.

[0030] In addition, in the following detailed description, for the convenience of explanation, numerous specific details are set forth to provide a comprehensive understanding of the embodiments of the present

disclosure. However, it is obvious that one or more embodiments can also be implemented without these specific details. In other cases, well-known structures and devices are embodied in a schematic manner to simplify the drawings.

[0031] Referring to Figs. 1 to 7, according to a first exemplary embodiment of the present disclosure, there is provided a heat exchanger 100. The heat exchanger includes a plurality of heat exchange tubes 10, fins 20, and headers 51, 52. As shown in Figs. 1 to 4, at least some of the heat exchange tubes 10 include a first straight tube segment 1, a second straight tube segment 2, and a bent tube segment 3 connecting the first straight tube segment 1 and the second straight tube segment 2. As shown in Figs. 1 to 4, in the heat exchange tube 10, the first straight tube segment 1 and the second straight tube segment 2 extend in a first direction X, and the first straight tube segment 1 is offset from the second straight tube segment 2 in a second direction Y and a third direction Z, wherein the second direction Y is perpendicular to the first direction X, and the third direction Z is perpendicular to both the first direction X and the second direction Y. According to the design concept of the present disclosure, as shown in Figs. 1 to 4, the bent tube segment 3 includes a first bent portion 31 which is bent such that the first straight tube segment 1 is offset from the second straight tube segment 2 in the second direction Y, a projection of the first bent portion 31 on a plane defined by both the first direction X and the second direction Y is U-shaped, and the first bent portion 31 and at least the first straight tube segment 1 are substantially in the same plane, for example, substantially simultaneously in the plane defined by the first direction X and the second direction Y.

[0032] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 1 to 4, in the heat exchange tube 10, the bent tube segment 3 further includes a second bent portion 32 which is bent such that the second straight tube segment 2 is offset from the first straight tube portion 31 in the third direction Z. Meanwhile, the bent tube segment 3 further includes a first bent straight segment 30 extending in the first direction X, wherein the first bent portion 31 and the second bent portion 32 are connected via the first bent straight segment 30. With the design of the first bent portion 31, the second bent portion 32 and the first bent straight segment 30, the second straight tube segment 2 is offset from the first straight tube segment 1 in the second direction Y and the third direction Z, and the first straight tube segment 1 and the second straight tube segment 2 are substantially parallel in the first direction X. More specifically, in the heat exchange tube 10, a first end of the first bent portion 31 is directly connected to the first straight tube segment 1, and a second end of the first bent portion 31 is connected to the second straight tube segment 2 via the first bent straight segment 30 and the second bent portion 32 in

sequence.

[0033] It should be noted that in the present disclosure, the heat exchange tube 10 may be a micro-channel flat heat exchange tube with a plurality of flow holes therein, and the flow holes allow a flowing medium, such as a coolant, to circulate therethrough. Herein, the first direction X is a length direction of the first straight tube segment 1 or the second straight tube segment 2 of the heat exchange tube 10, the second direction Y is a width direction of the first straight tube segment 1 or the second straight tube segment 2 of the heat exchange tube 10, and the third direction Z is a thickness direction of the first straight tube segment 1 or the second straight tube segment 2 of the heat exchange tube 10.

[0034] According to the present disclosure, a first U-shaped bending is directly performed on the heat exchange tube 10 to form the first bent portion 31, and the first straight tube segment 1 and the second straight tube segment 2 which are parallel to each other. Then, a second bending is performed on the second straight tube segment 2, such that the first straight tube segment 1 and the second straight tube segment 2 are staggered in the second direction Y to form a stepped structure. Such a bending method greatly reduces the bending complexity because it does not require multi-dimensional bending control in space, and is relatively easy to implement. In addition, the reduction of complexity also greatly improves the control of dimensional accuracy, increasing the convenience of assembling the heat exchanger 100.

[0035] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 1 to 4, in the heat exchange tube 10, the first straight tube segment 1 and the second straight tube segment 2 may have the same width and/or the same thickness. A spacing between a projection of the first straight tube segment 1 on the plane defined by both the first direction X and the second direction Y and a projection of the second straight tube segment 2 on this plane is within a range of plus or minus one-half of the width of the heat exchange tube 10. The range of "plus one-half" described herein means that the projection of the first straight tube segment 1 on the plane defined by both the first direction X and the second direction Y and the projection of the second straight tube segment 2 on this plane may be immediately adjacent to each other or even partially overlapped, but the overlapping portion cannot exceed one-half of the width of the first straight tube segment 1 and/or the second straight tube segment 2. Similarly, the range of "minus one-half" described herein means that the projection of the first straight tube segment 1 on the plane defined by both the first direction X and the second direction Y and the projection of the second straight tube segment 2 on this plane may be immediately adjacent to each other or spaced apart from each other in the second direction Y, but the distance spaced cannot exceed one-half of

the width of the first straight tube segment 1 and/or the second straight tube segment 2. Preferably, the spacing between the projection of the first straight tube segment 1 on the plane defined by both the first direction X and the second direction Y and the projection of the second straight tube segment 2 on this plane is zero; that is, their projections on the plane are immediately adjacent to each other.

[0036] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 1 to 4, at least some of the heat exchange tubes 10 further include a third bent portion 33 which is bent such that an end of the second straight tube segment 2 away from the bent tube segment 3 and an end of the first straight tube segment 1 away from the bent tube segment 3 are away from each other in the second direction Y. Considering that the end of the first straight tube segment 1 away from the bent tube segment 3 and the end of the second straight tube segment 2 away from the bent tube segment 3 are connected to the headers, respectively, the problem of collision between one end of the two ends and the header connected to the other end of the two ends is solved by making the aforementioned two ends of the heat exchange tube 10 away from each other in the second direction Y, thereby avoiding the risk of the leakage of the heat exchange tube caused by subsequent friction.

[0037] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 5 to 7, the heat exchanger 100 further includes a plurality of wavy fins 20. One wavy fin 20 is provided between the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes 10, and one wavy fin 20 is provided between the first straight tube segment 1 of at least some of the heat exchange tubes 10 and the second straight tube segment 2 or the first straight tube segment 1 of another adjacent heat exchange tube 10. Meanwhile, a distance between the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes 10 in the third direction Z is substantially equal to a height of one wavy fin 20, and a distance between the first straight tube segment 1 of at least some of the heat exchange tubes 10 and the first straight tube segment 1 or the second straight tube segment 2 of another adjacent heat exchange tube 10 in the third direction Z is substantially equal to the height of one wavy fin 20. As shown in Fig. 7, the heat exchange tubes 10 are arranged in a staggered manner, that is, a heat exchange tube groove for placing the heat exchange tube 10 is formed between two wavy fins 20, and the heat exchange tube 10 do not occupy the entire heat exchange tube groove after being placed. The projections of two adjacent heat exchange tubes 10 in the first direction X are not completely coincident. The beneficial effect of the above configuration is that when the heat exchanger is used as an evaporator, condensed water is formed on a surface of the heat

exchanger, and if the condensed water is not discharged in time, there is a risk that the condensed water is blown out of the heat exchanger. When the heat exchanger 100 according to the present disclosure is used as the evaporator, the heat exchange tube does not occupy the entire heat exchange tube groove, and the free space of the heat exchange tube groove forms a drainage channel for the condensed water to be discharged at a high speed, making the drainage smoother and reducing the risk of water blowing. It should be noted that in the illustrated exemplary embodiment, only the straight tube segment of one heat exchange tube is placed in one heat exchange tube groove, and the straight tube segments of a plurality of heat exchange tubes may also be placed in one heat exchange tube groove (for example, when a width of the fin is wide enough to place the straight tube segments of the plurality of heat exchange tubes while still leaving a drainage gap).

[0038] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 5 to 7, the heat exchanger 100 further includes a first header 51 and a second header 52. The end, which is away from the bent tube segment 3, of the first straight tube segment 1 of at least some of the heat exchange tubes 10 is connected to and in fluid communication with the first header 51, and the end, which is away from the bent tube segment 3, of the second straight tube segment 2 of at least some of the heat exchange tubes 10 is connected to and in fluid communication with the second header 52. As mentioned above, the problem of collision between one end of the two ends of the heat exchange tube 10 and the header connected to the other end is solved by making the aforementioned two ends of the heat exchange tube 10 away from each other in the second direction Y, thereby avoiding the risk of the leakage of the heat exchange tube caused by subsequent friction.

[0039] Although the basic configuration of the heat exchanger according to the present disclosure is described above in conjunction with the first exemplary embodiment shown in Figs. 1 to 7, various modified and alternative embodiments of the heat exchanger provided by the present disclosure may exist in terms of the configuration of the heat exchange tubes (such as parameters including width, height, length, number of holes, etc.), the bending method of the heat exchange tubes, the layout relationship of the heat exchange tubes, the connection relationship between the heat exchange tubes, the type and layout relationship of the fins, the structure and type of the headers, the connection relationship between the headers and the heat exchange tubes, and the like without departing from the design concept and spirit of the present disclosure. Various alternative solutions of the heat exchanger provided by the present disclosure are described below in conjunction with various exemplary embodiments shown in Figs. 8 to 21.

[0040] According to the heat exchanger provided by the present disclosure, in the second exemplary embodiment shown in Figs. 8 to 14, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 7 are adopted. Only the differences between the second exemplary embodiment and the first exemplary embodiment are described below, and the remaining parts may refer to the technical content described in the first exemplary embodiment. Referring to Figs. 8 to 14, according to the second exemplary embodiment, in the bent tube segment 3 of some of the heat exchange tubes 10, the first bent portion 31 includes a protruding portion which protrudes to one side in the second direction Y relative to the first straight tube segment 1 or the second straight tube segment 2. Specifically, as shown in Figs. 8 to 9, the protruding portion includes a fourth bent portion 34 and a fifth bent portion 35. The fourth bent portion 34 and the fifth bent portion 35 are bent such that a first end of the fourth bent portion 34 is connected to a first end of the first bent portion 31, a second end of the fourth bent portion 34 is connected to a first end of the fifth bent portion 35, and a second end of the fifth bent portion 35 is connected to the first straight tube segment 1. As shown in Figs. 8 to 9, the fourth bent portion 34 and the fifth bent portion 35 have different bending directions, and the fifth bent portion 35 is bent such that the first straight tube segment 1 and the second straight tube segment 2 are close to each other and parallel to each other. With the above configuration, excessive tensile force on the bending outer edge of the first bent portion and excessive extrusion on the bending inner edge of the first bent portion are avoided while ensuring the basic U-shape of the first bent portion 31, and the thickness of the entire heat exchanger is reduced at the same time.

[0041] According to the heat exchanger provided by the present disclosure, in the third exemplary embodiment shown in Figs. 15 to 18, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 7 are adopted. Only the differences between the third exemplary embodiment and the first exemplary embodiment are described below, and the remaining parts may refer to the technical content described in the first exemplary embodiment. Referring to Figs. 15 to 18, according to the third exemplary embodiment, the heat exchanger 100 adopts a plurality of insert fins 20'. Each insert fin 20' has a plurality of insertion slots 21'. Specifically, the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes 10 are located in different or adjacent insertion slots 21' of each insert fin 20', respectively, and the first straight tube segment 1 of at least some of the heat exchange tubes 10 and the second straight tube segment 2 of another adjacent heat exchange tube 10 are located in different or adjacent insertion slots 21' of each insert fin 20', respectively. The arrangement of the insert fins 20'

makes the connection between the heat exchange tubes 10 and the fins firmer, and also facilitates the assembly and maintenance of the heat exchanger 100. With the provision of the plurality of insertion slots 21' in the insert fins 20', the first straight tube segment 1 and the second straight tube segment 2 of the heat exchange tube 10 can be conveniently inserted into the insertion slots 21' to form a stable connection.

[0042] According to the heat exchanger provided by the present disclosure, in the fourth exemplary embodiment shown in Figs. 19 to 21, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 7 are adopted. Only the differences between the fourth exemplary embodiment and the first exemplary embodiment are described below, and the remaining parts may refer to the technical content described in the first exemplary embodiment. Referring to Figs. 19 to 21, in the heat exchanger 100 according to the fourth exemplary embodiment, the plurality of heat exchange tubes 10 are arranged in an array. The heat exchanger 100 further includes a first header 51, a second header 52, and at least one common header 53. The end, which is away from the bent tube segment 3, of one of the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes 10 of at least one column of heat exchange tubes is connected to and in fluid communication with the first header 51, and the end, which is away from the bent tube segment 3, of one of the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes of another column of heat exchange tubes adjacent to the at least one column of heat exchange tubes is connected to and in fluid communication with the second header 52, and the end, which is away from the bent tube segment 3, of the other of the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes of the at least one column of heat exchange tubes and the end, which is away from the bent tube segment 3, of the other of the first straight tube segment 1 and the second straight tube segment 2 of at least some of the heat exchange tubes of the another column of heat exchange tubes adjacent to the at least one column of heat exchange tubes 10 are connected to and in fluid communication with the at least one common header 53. In addition, the first straight tube segment of at least some of the heat exchange tubes of at least one column of heat exchange tubes is aligned with the first straight tube segment or the second straight tube segment of at least some of the heat exchange tubes of at least another column of heat exchange tubes in the second direction, and the second straight tube segment of at least some of the heat exchange tubes of the at least one column of heat exchange tubes is aligned with the first straight tube segment or the second straight tube segment of at least some of the heat exchange tubes of the at least

another column of heat exchange tubes in the second direction. According to this embodiment, the plurality of heat exchange tubes 10 are arranged in an array, which can reduce the non-uniformity of the air outlet temperature and also reduce the risk of being blown out of the heat exchanger due to excessive local condensed water. With the adoption of the common header, taking the structure shown in Fig. 19 as an example, the refrigerant in the second column of heat exchange tubes flows into the common header, and the gaseous refrigerant and the incompletely evaporated liquid refrigerant are mixed in a cavity of the common header before entering a third column of heat exchange tubes. In addition, in the exemplary embodiment shown in Figs. 19 to 21, the common header 53 is a single integral cavity. In another unillustrated embodiment, the common header 53 may also be composed of two or more header cavities connected and in fluid communication via a connection tube, wherein one header cavity is connected and in fluid communication with the second column of heat exchange tubes, and then connected and in fluid communication to another header cavity via a connecting tube, and the another header cavity is connected and in fluid communication with the third column of heat exchange tubes. In this way, the uniformity of refrigerant distribution to the third column of heat exchange tubes can be improved, and the heat exchange performance can be enhanced. In addition, according to the present embodiment, the heat exchange tubes 10 are arranged vertically, and the headers 51, 52 and 53 are arranged horizontally. Such an arrangement allows the condensed water to be smoothly discharged along the drainage channel formed between the heat exchange tubes and the fins by the action of gravity.

[0043] Specifically, in the exemplary embodiment shown in Figs. 19 to 21, the first straight tube segments of two columns of heat exchange tubes 10 are connected to and in fluid communication with the common header 53, and the second straight tube segments of the two columns of heat exchange tubes 10 are located on both sides and connected to and in fluid communication with the first header 51 and the second header 52, respectively. In another unillustrated embodiment, it is also possible that the second straight tube segments of two columns of heat exchange tubes 10 are connected to and in fluid communication with the common header 53, and the first straight tube segments of the two columns of heat exchange tubes 10 are located on both sides and connected to and in fluid communication with the first header 51 and the second header 52, respectively. In another unillustrated embodiment, it is also possible that the first straight tube segments of one column of heat exchange tubes 10 and the second straight tube segments of the adjacent column of heat exchange tubes 10 are connected to and in fluid communication with the common header 53, and the second straight tube segments of the one column of heat

exchange tubes 10 and the first straight tube segments of the adjacent column of heat exchange tubes 10 are connected to and in fluid communication with the first header 51 and the second header 52, respectively.

[0044] In addition, the heat exchanger may include a plurality of wavy fins, wherein one wavy fin is disposed and shared between at least some adjacent two rows of straight tube segments. In the exemplary embodiment shown in Figs. 19 to 21, in the third direction Z, the straight tube segments of the front and rear rows of heat exchange tubes 10 may share one fin 20. Correspondingly, the first straight tube segment of one column of heat exchange tubes 10 is aligned with one of the first straight tube segment and the second straight tube segment of another column of heat exchange tubes 10 in the second direction Y, and the second straight tube segment of the column of heat exchange tubes 10 is aligned with the other of the first straight tube segment and the second straight tube segment of the another column of heat exchange tubes 10 in the second direction Y. The heat exchanger may also include a plurality of first wavy fins and a plurality of second wavy fins; wherein one first wavy fin and one second wavy fin are disposed and shared between at least some adjacent two rows of straight tube segments, and the one first wavy fin and the one second wavy fin are aligned in the second direction. In another unillustrated embodiment, it is also possible that the straight tube segments of the front and rear rows of heat exchange tubes 10 in the third direction Z share two separate fins 20, and the two separate fins 20 are aligned in the second direction Y.

[0045] Those skilled in the art can understand that the embodiments described above are all exemplary, and those skilled in the art can make improvements without departing from the principle and spirit of the general concept of the present disclosure, and the structures described in the various embodiments can be freely combined without structural or principle conflicts. The scope of the present disclosure is defined by the claims and their equivalents.

REFERENCE LIST

[0046]

- | | |
|-----|-------------------------------------|
| 1 | <u>First straight tube segment</u> |
| 2 | <u>Second straight tube segment</u> |
| 3 | <u>Bent tube segment</u> |
| 10 | <u>Heat exchange tube</u> |
| 20 | <u>Wavy fin</u> |
| 20' | <u>Insert fin</u> |
| 21' | <u>Insertion slot</u> |
| 30 | <u>First bent straight segment</u> |
| 31 | <u>First bent portion</u> |

32 Second bent portion
 33 Third bent portion
 34 Fourth bent portion
 35 Fifth bent portion
 36 Second bent straight segment

51 First header
 52 Second header
 53 Common header

100 Heat exchanger

X First direction
Y Second direction
Z Third direction

Claims

1. Heat exchanger (100) comprising: a plurality of heat exchange tubes (10); wherein at least some of the heat exchange tubes (10) comprise a first straight tube segment (1), a second straight tube segment (2) and a bent tube segment (3) connecting the first straight tube segment (1) and the second straight tube segment (2); wherein the first straight tube segment (1) and the second straight tube segment (2) extend in a first direction (X), and the first straight tube segment (1) is offset from the second straight tube segment (2) in a second direction (Y) and a third direction (Z), wherein the second direction (Y) is perpendicular to the first direction (X), and the third direction (Z) is perpendicular to both the first direction (X) and the second direction (Y); wherein, the bent tube segment (3) comprises a first bent portion (31) which is bent such that the first straight tube segment (1) is offset from the second straight tube segment (2) in the second direction (Y), a projection of the first bent portion (31) on a plane defined by both the first direction (X) and the second direction (Y) is U-shaped, and the first bent portion (31) is in the same plane with the first straight tube segment (1).
2. Heat exchanger (100) according to claim 1, wherein, the bent tube segment (3) further comprises a second bent portion (32) which is bent such that the second straight tube segment (2) is offset from the first straight tube segment (1) in the third direction (Z).
3. Heat exchanger (100) according to claim 2, wherein, the bent tube segment (3) further comprises a first bent straight segment (30) extending in the first direction (X), wherein the first bent portion (31)

and the second bent portion (32) are connected via the first bent straight segment (30).

4. Heat exchanger (100) according to claim 2, wherein, a spacing between the projection of the first straight tube segment (1) on the plane defined by both the first direction (X) and the second direction (Y) and a projection of the second straight tube segment (2) on the plane is within a range of plus or minus one-half of a width of the heat exchange tube (10).
5. Heat exchanger (100) according to claim 2, wherein, at least some of the heat exchange tubes (10) further comprise a third bent portion (33) which is bent such that an end of the second straight tube segment (2) away from the bent tube segment (3) and an end of the first straight tube segment (1) away from the bent tube segment (3) are away from each other in the second direction (Y).
6. Heat exchanger (100) according to claim 3, wherein, a first end of the first bent portion (31) is directly connected to the first straight tube segment (1), and a second end of the first bent portion (31) is connected to the second straight tube segment (2) via the first bent straight segment (30) and the second bent portion (32) in sequence.
7. Heat exchanger (100) according to claim 3, wherein, the first bent portion (31) comprises a protruding portion which protrudes to one side relative to the first straight tube segment (1) or the second straight tube segment (2) in the second direction (Y).
8. Heat exchanger (100) according to claim 7, wherein, the protruding portion comprises a fourth bent portion (34) and a fifth bent portion (35); wherein, the fourth bent portion (34) and the fifth bent portion (35) are bent such that a first end of the fourth bent portion (34) is connected to a first end of the first bent portion (31), a second end of the fourth bent portion (34) is connected to a first end of the fifth bent portion (35), and a second end of the fifth bent portion (35) is connected to the first straight tube segment (1).
9. Heat exchanger (100) according to claim 8, wherein, the fourth bent portion (34) and the fifth bent por-

tion (35) have different bending directions, and the fifth bent portion (35) is bent such that the first straight tube segment (1) and the second straight tube segment (2) are close to each other.

10. Heat exchanger (100) according to claim 8, wherein,

the bent tube segment (3) further comprises a second bent straight segment (36), wherein the fourth bent portion (34) is connected to the first bent portion (31) via the second bent straight segment (36).

11. Heat exchanger (100) according to any one of claims 1 to 10, wherein,

the plurality of heat exchange tubes (10) are arranged in an array;
the heat exchanger (100) further comprises a first header (51), a second header (52), and at least one common header (53);
wherein an end, which is away from the bent tube segment (3), of one of the first straight tube segment (1) and the second straight tube segment (2) of at least some of the heat exchange tubes (10) of at least one column of heat exchange tubes (10) is connected to and in fluid communication with the first header (51), and an end, which is away from the bent tube segment (3), of one of the first straight tube segment (1) and the second straight tube segment (2) of at least some of the heat exchange tubes (10) of another column of heat exchange tubes (10) adjacent to the at least one column of heat exchange tubes (10) is connected to and in fluid communication with the second header (52); and wherein an end, which is away from the bent tube segment (3), of the other of the first straight tube segment (1) and the second straight tube segment (2) of at least some of the heat exchange tubes (10) of the at least one column of heat exchange tubes (10), and an end, which is away from the bent tube segment (3), of the other of the first straight tube segment (1) and the second straight tube segment (2) of at least some of the heat exchange tubes (10) of the another column of heat exchange tubes (10) adjacent to the at least one column of heat exchange tubes (10) are connected to and in fluid communication with the at least one common header (53).

12. Heat exchanger (100) according to claim 11, wherein,

the heat exchanger (100) further comprises a

plurality of wavy fins (20);

wherein one wavy fin (20) is disposed and shared between at least some adjacent two rows of straight tube segments.

13. Heat exchanger (100) according to claim 11, wherein,

the heat exchanger (100) further comprises a plurality of first wavy fins (20) and a plurality of second wavy fins (20);
wherein one first wavy fin (20) and one second wavy fin (20) are disposed and shared between at least some adjacent two rows of straight tube segments, and the one first wavy fin (20) and the one second wavy fin (20) are aligned in the second direction (Y).

14. Heat exchanger (100) according to claim 11, wherein,

the first straight tube segment (1) of at least some of the heat exchange tubes (10) of at least one column of heat exchange tubes (10) is aligned with the first straight tube segment (1) or the second straight tube segment (2) of at least some of the heat exchange tubes (10) in at least another column of heat exchange tubes (10) in the second direction (Y), and the second straight tube segment (2) of at least some of the heat exchange tubes (10) of the at least one column of heat exchange tubes (10) are aligned with the first straight tube segment (1) or the second straight tube segment (2) of at least some of the heat exchange tubes (10) of at least another column of heat exchange tubes (10) in the second direction (Y).

15. Heat exchanger (100) according to any one of claims 1 to 10, wherein,

the heat exchange tube (10) is a micro-channel flat heat exchange tube (10) with a plurality of flow holes therein, the first direction (X) is a length direction of the first straight tube segment (1) or the second straight tube segment (2) of the heat exchange tube (10), the second direction (Y) is a width direction of the first straight tube segment (1) or the second straight tube segment (2) of the heat exchange tube (10), and the third direction (Z) is a thickness direction of the first straight tube segment (1) or the second straight tube segment (2) of the heat exchange tube (10).

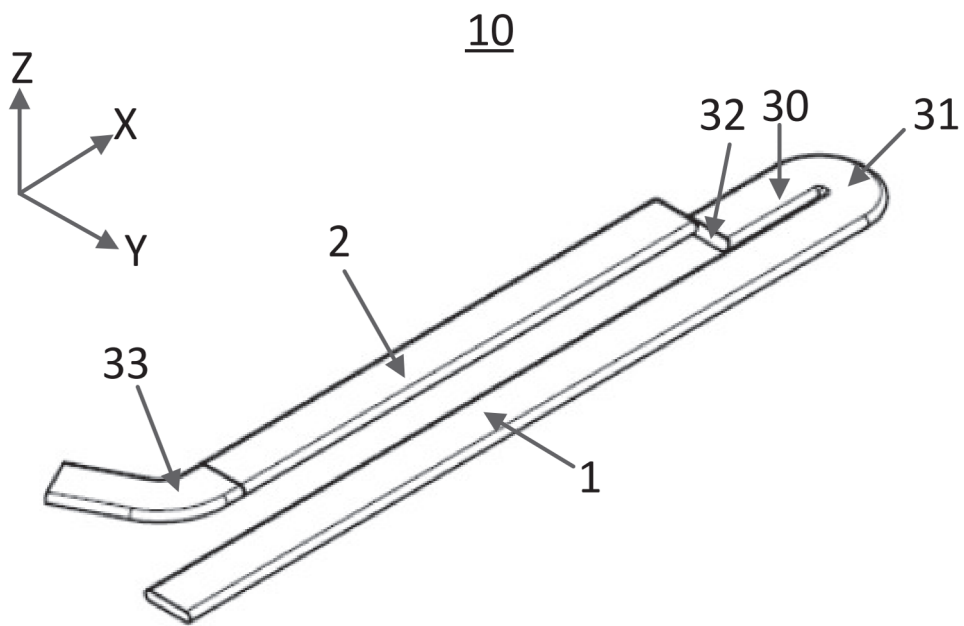


Fig.1

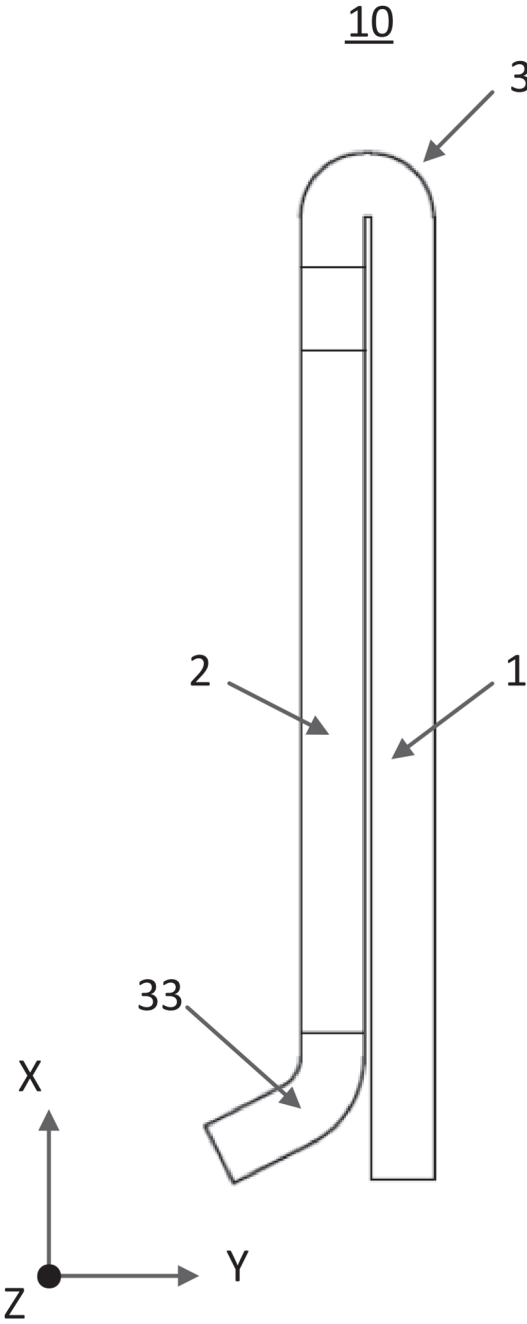


Fig.2

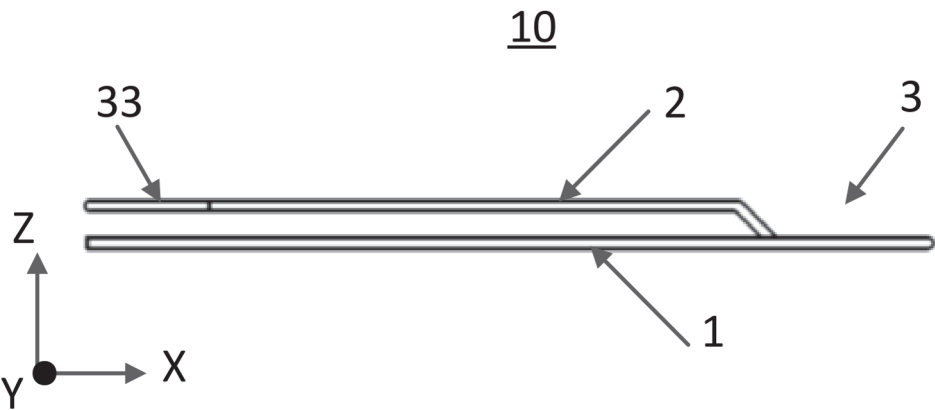


Fig.3

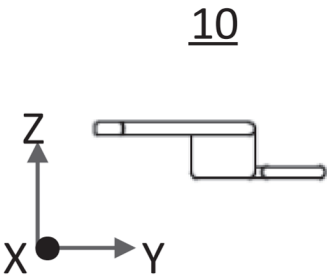


Fig.4

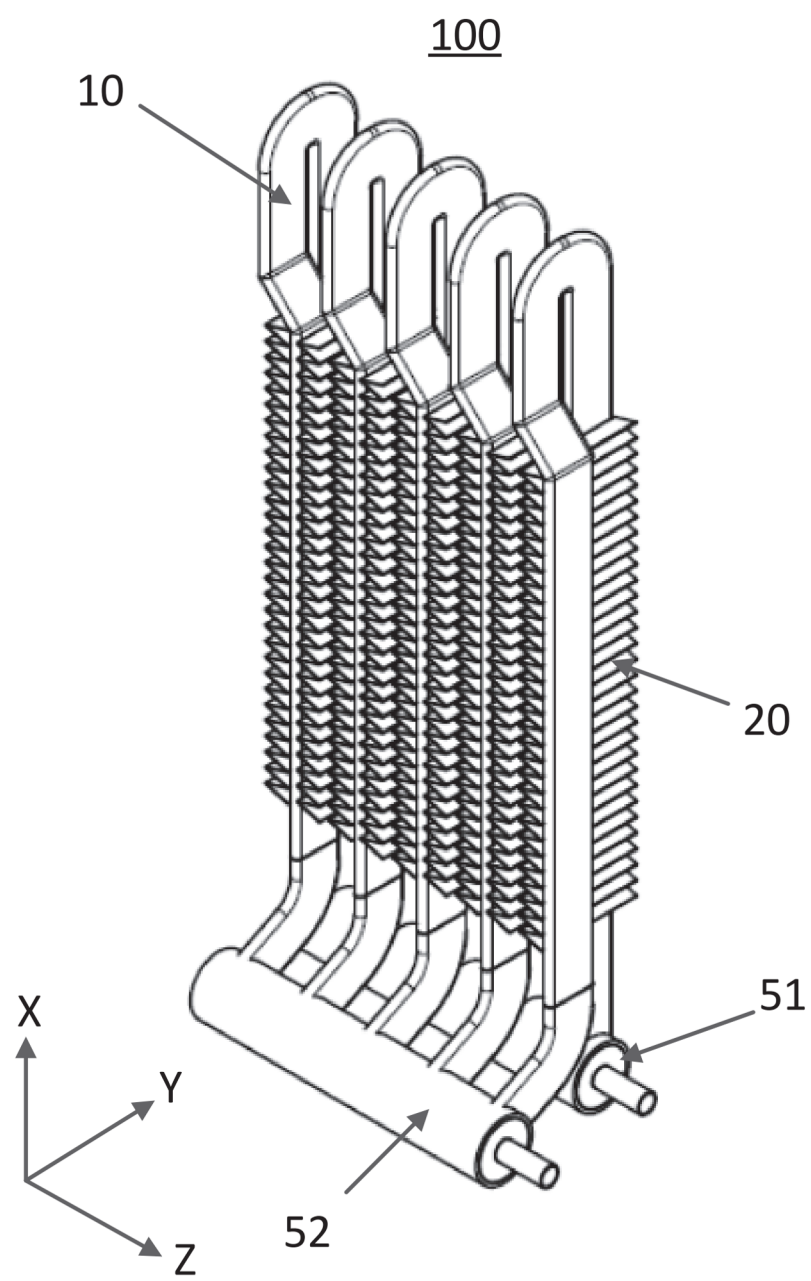


Fig.5

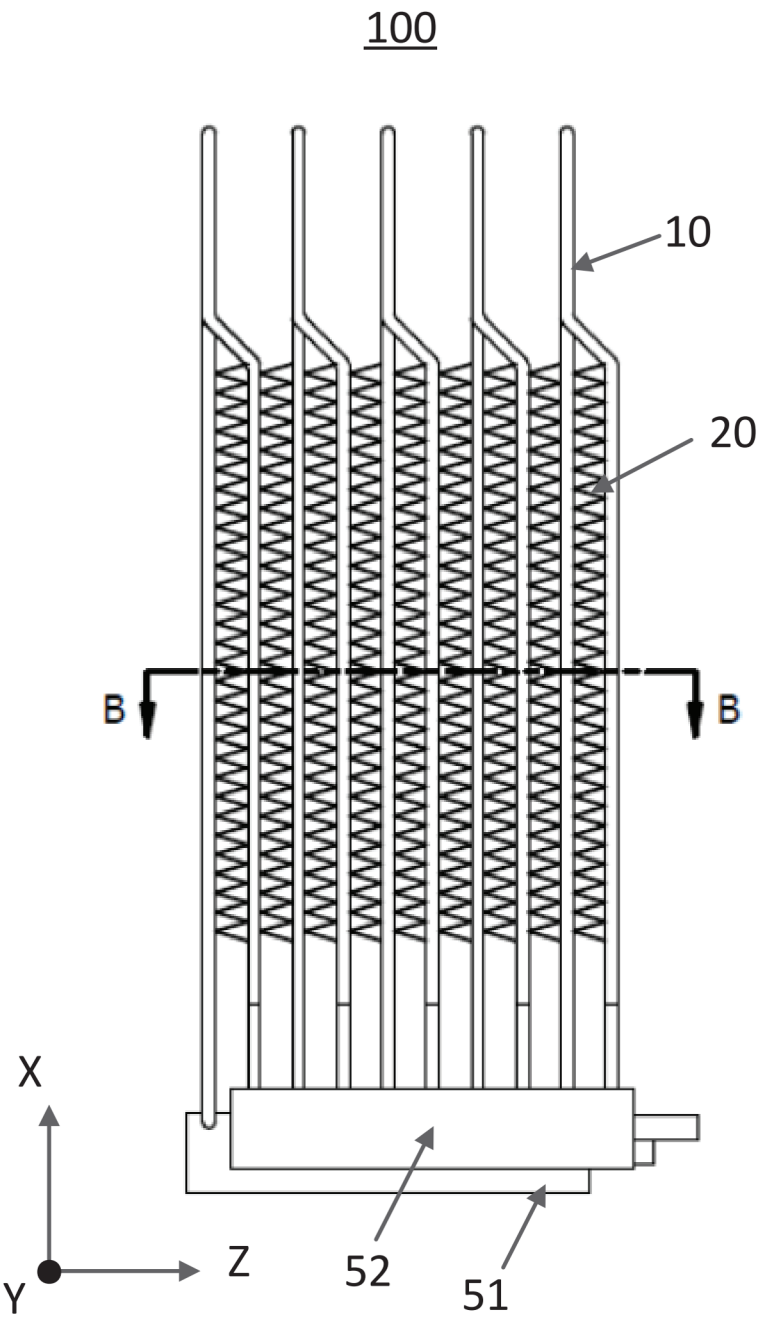


Fig.6

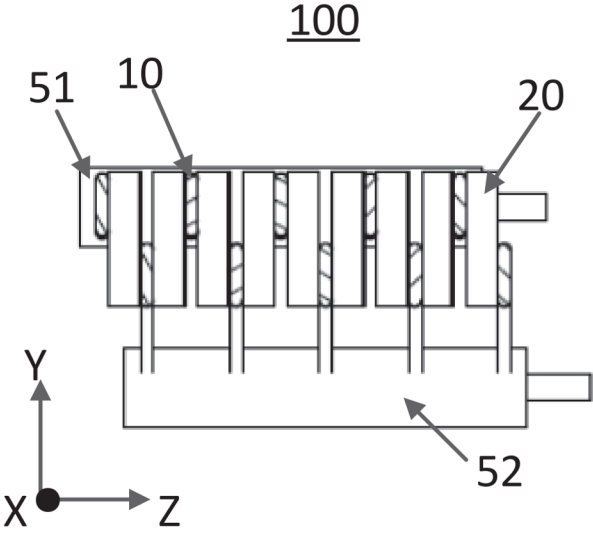


Fig.7

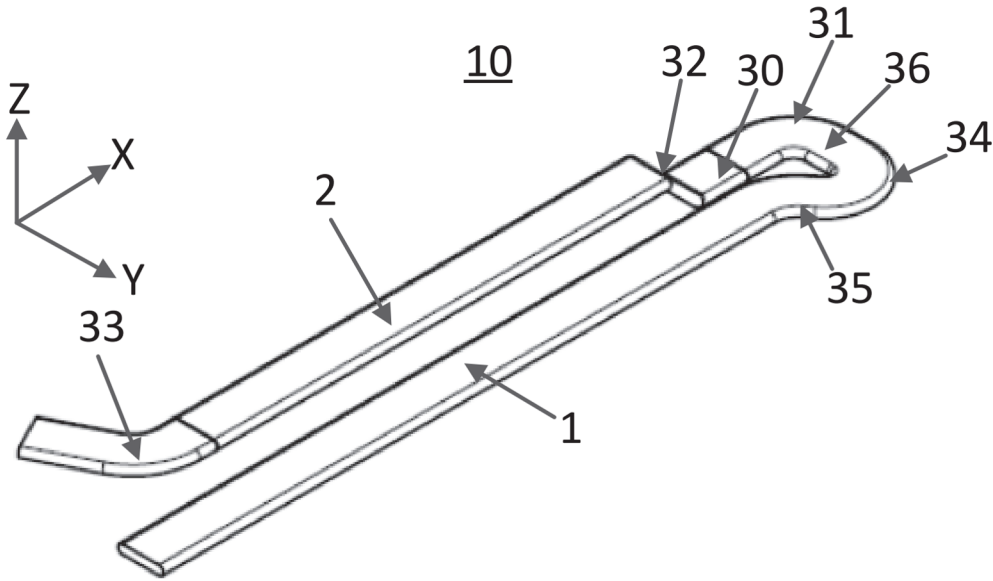


Fig.8

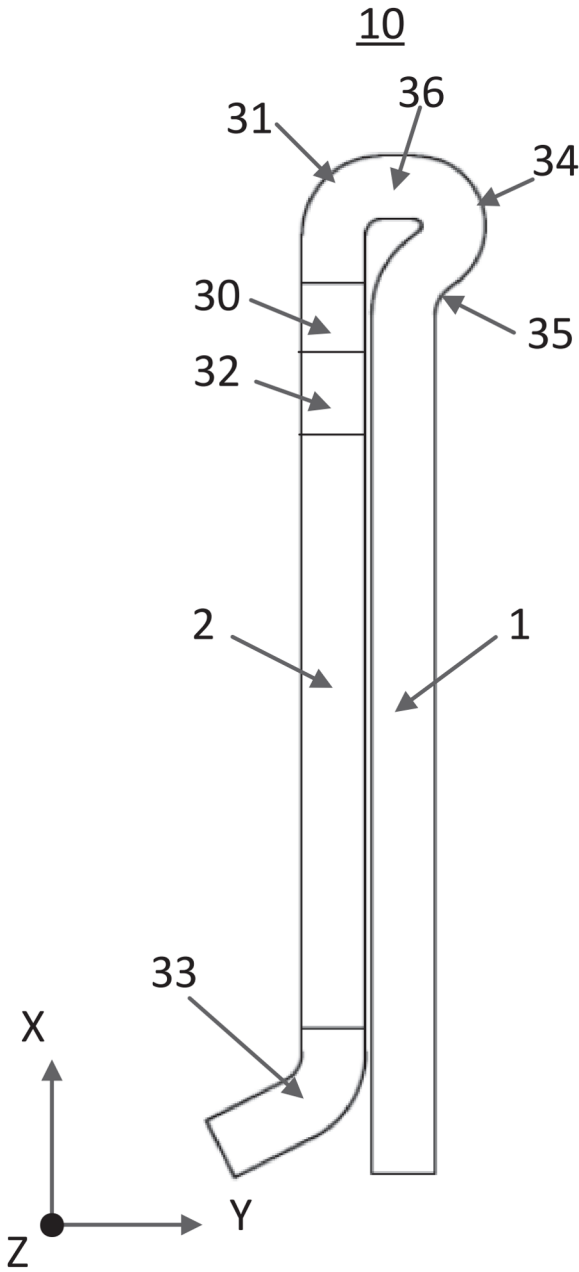


Fig.9

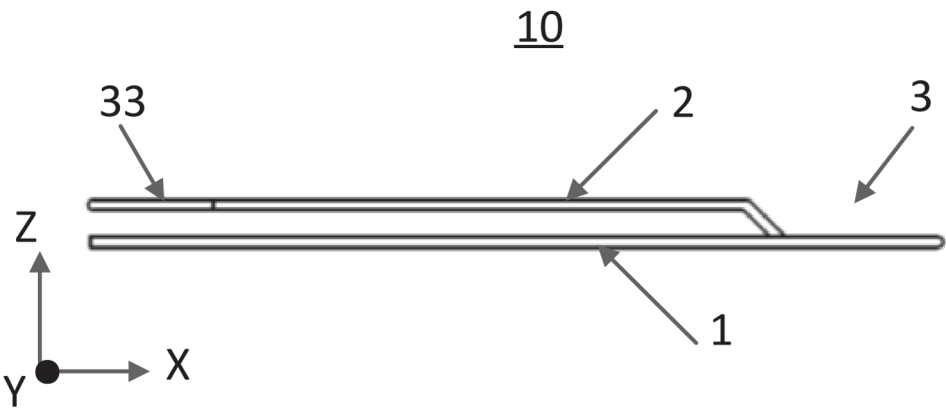


Fig.10

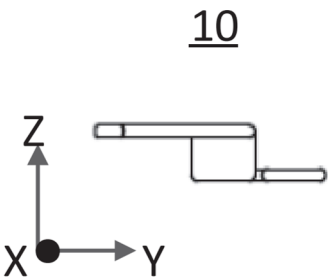


Fig.11

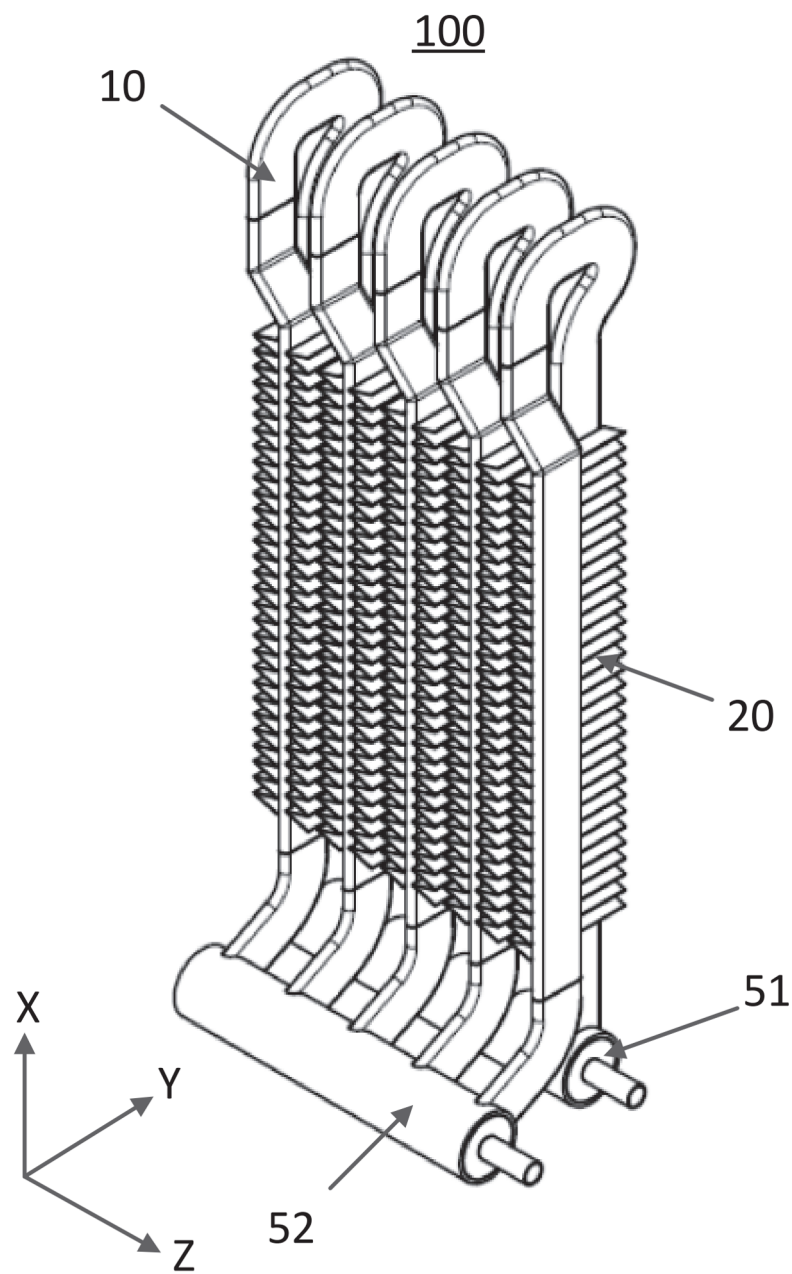


Fig.12

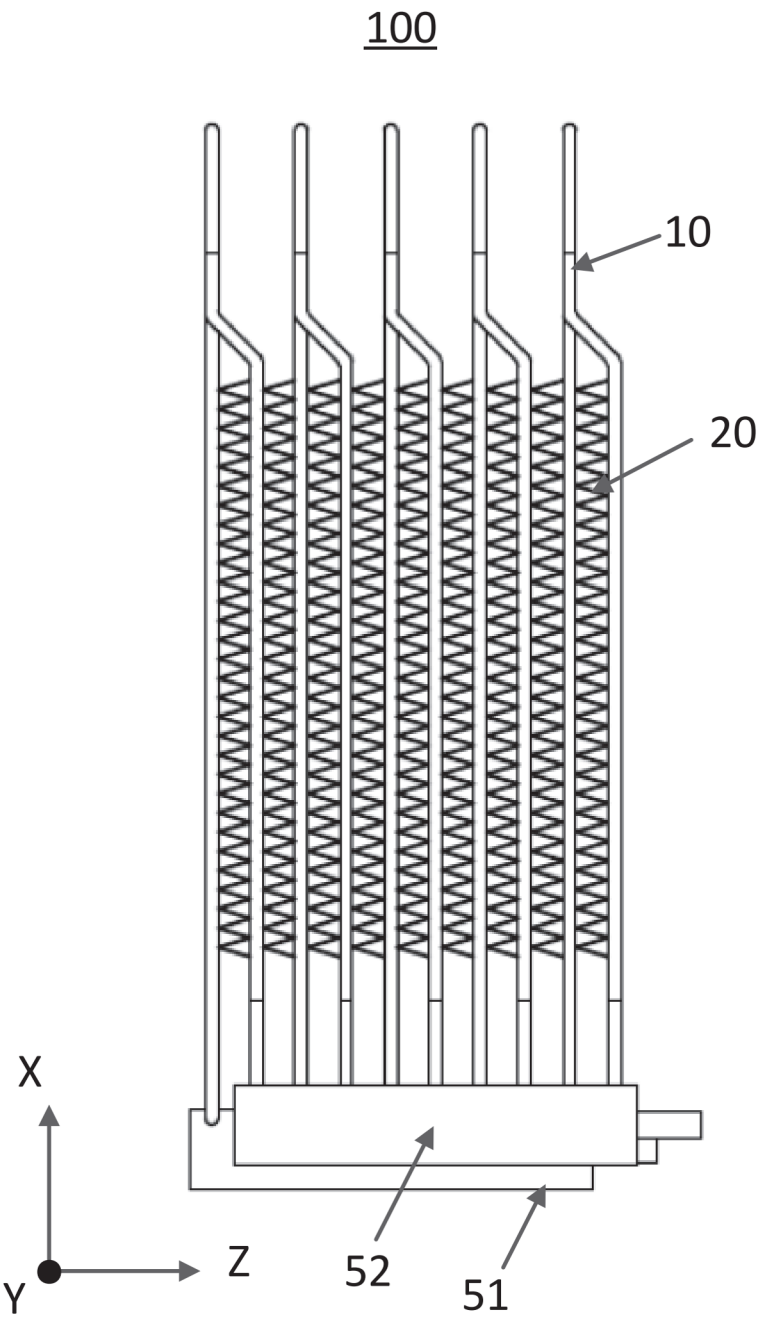


Fig.13

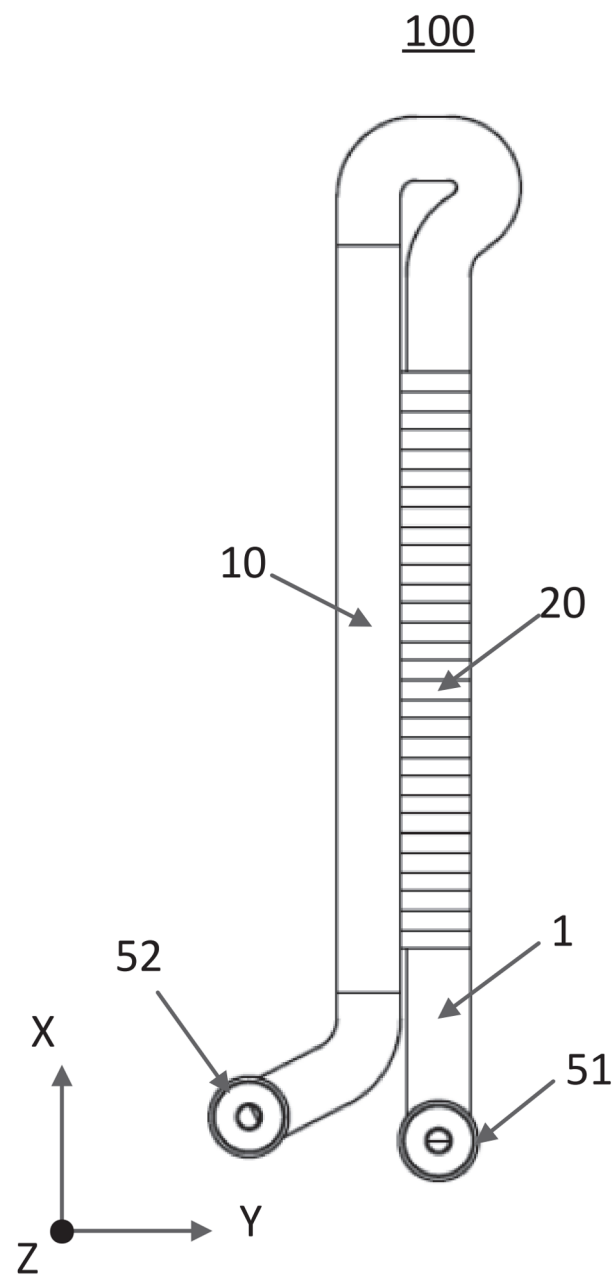


Fig.14

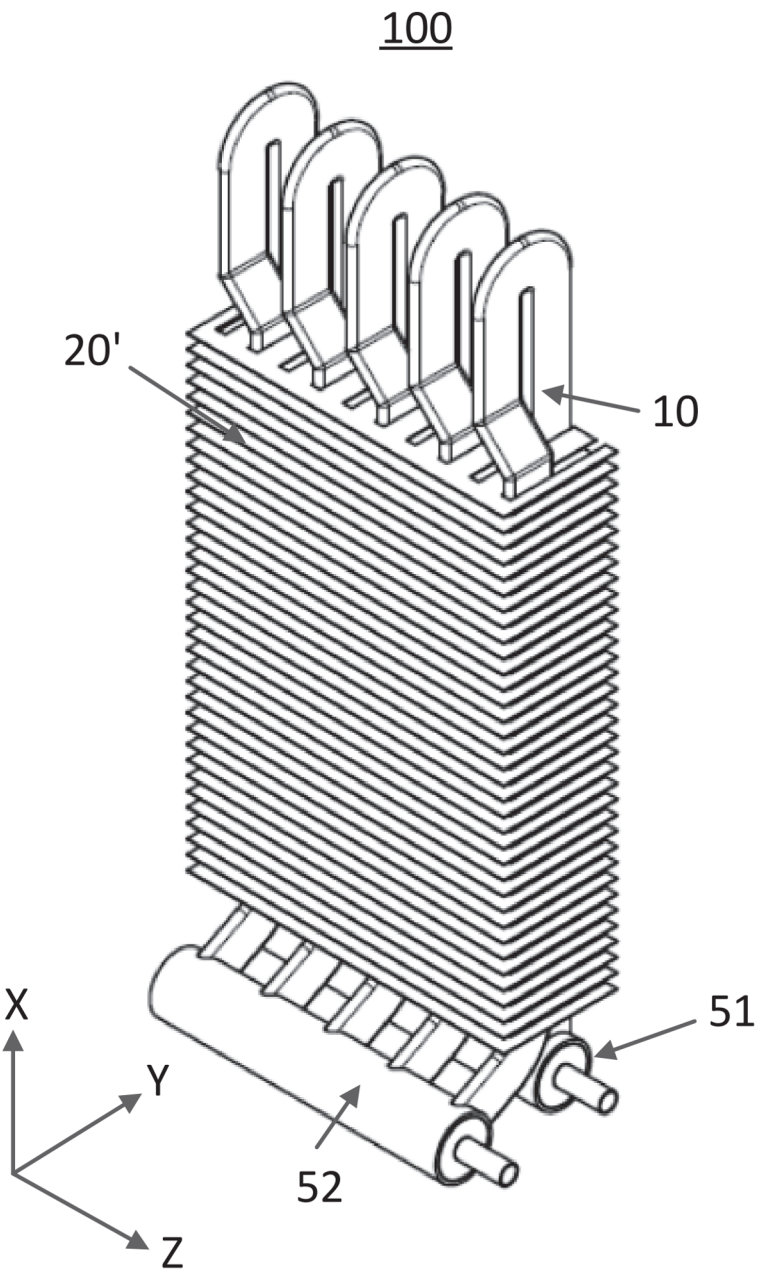


Fig.15

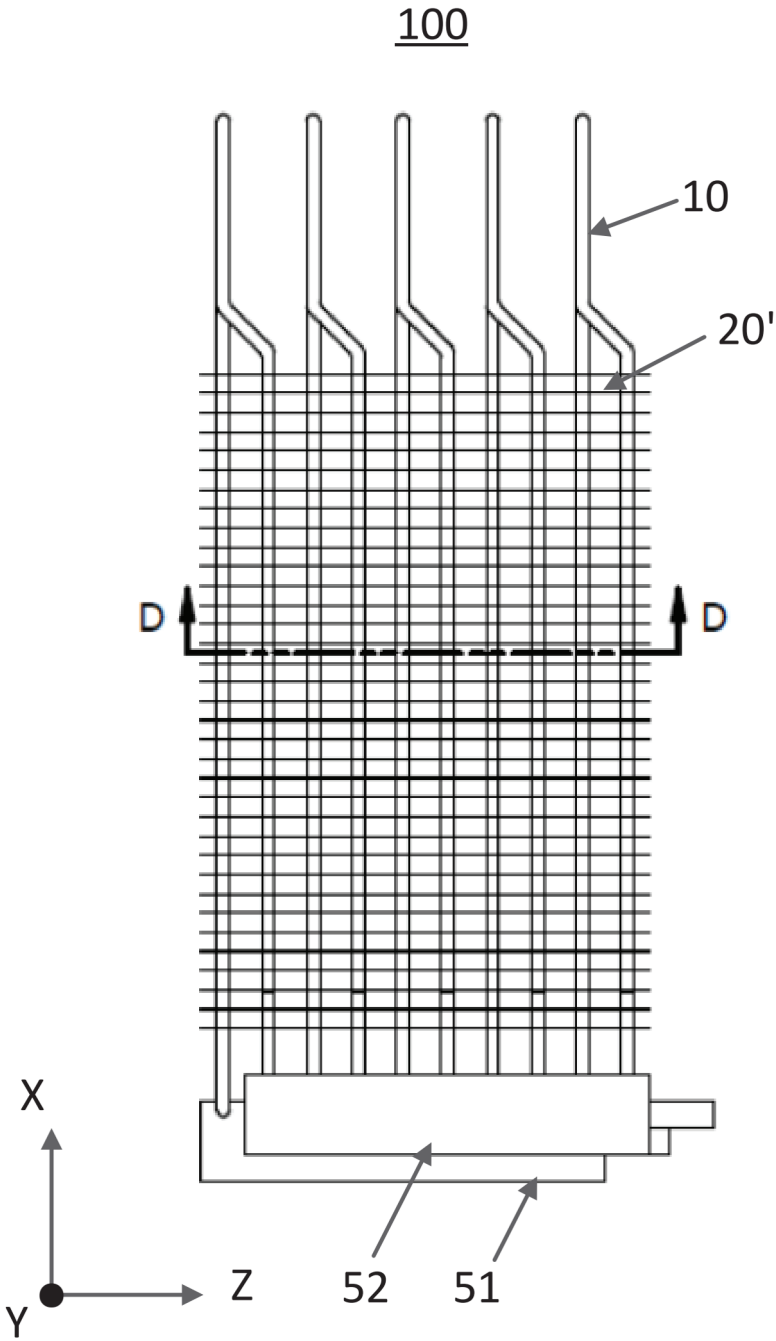


Fig.16

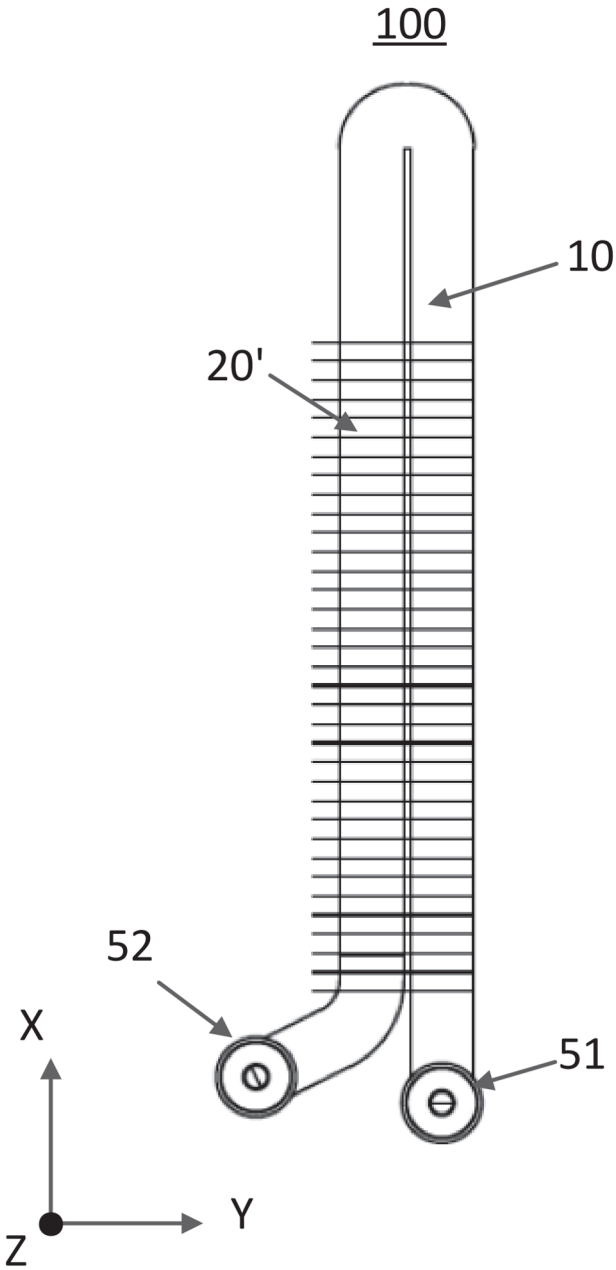


Fig.17

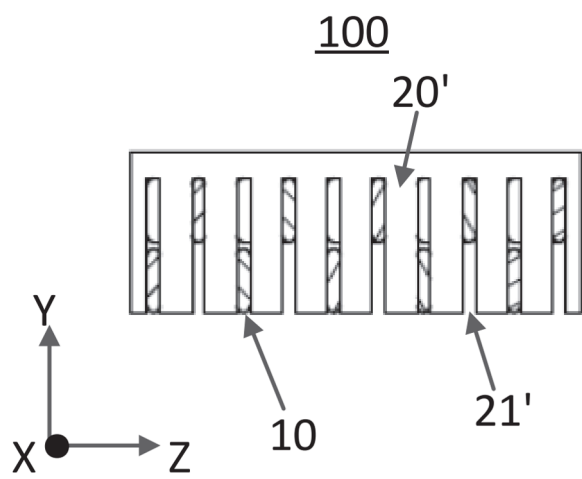


Fig.18

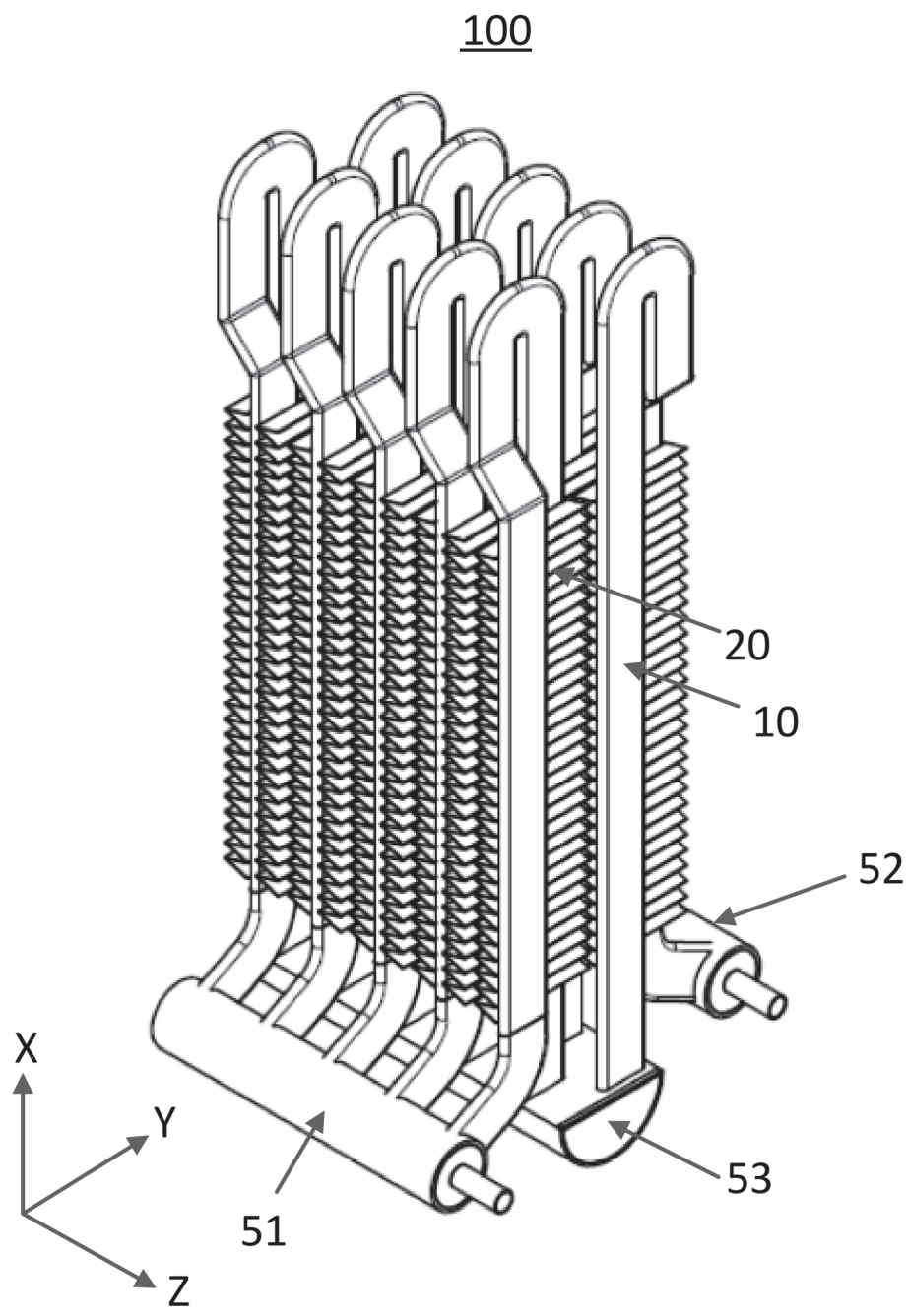


Fig.19

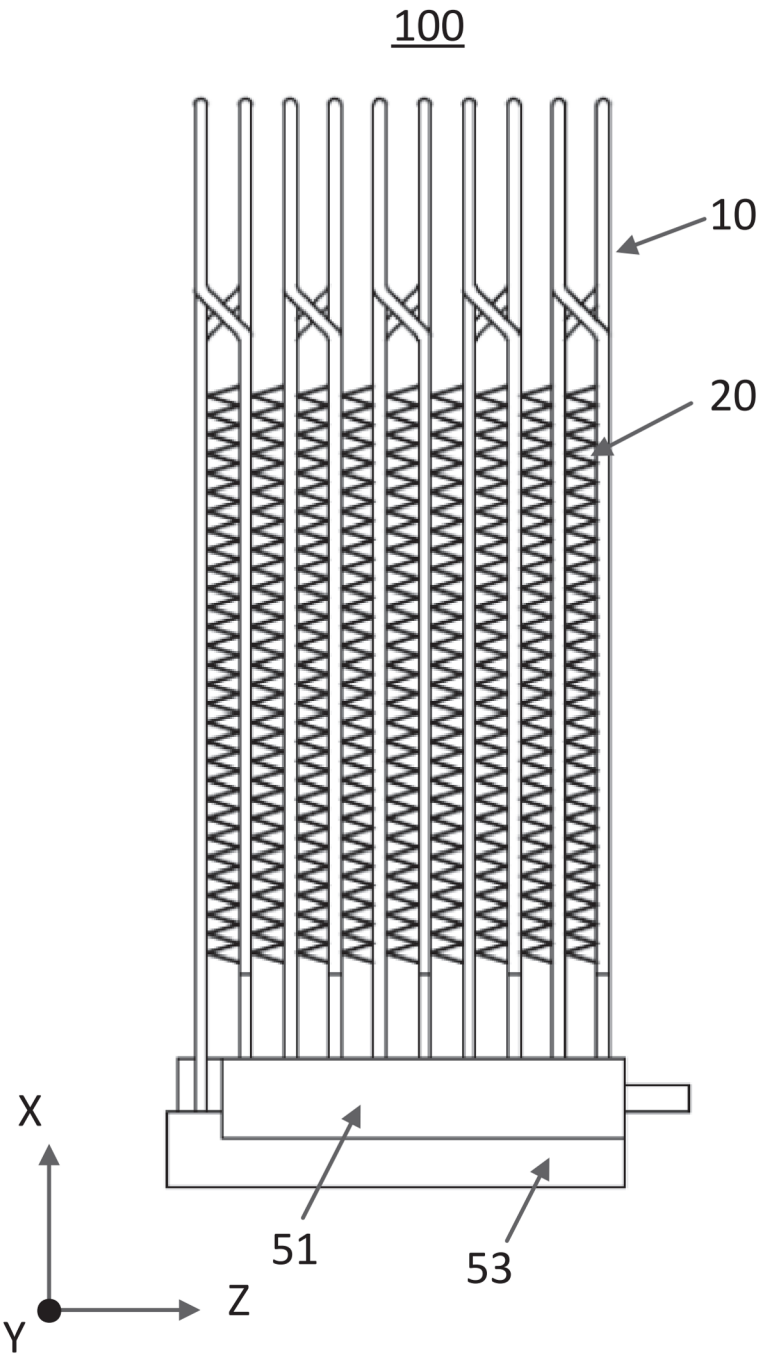


Fig.20

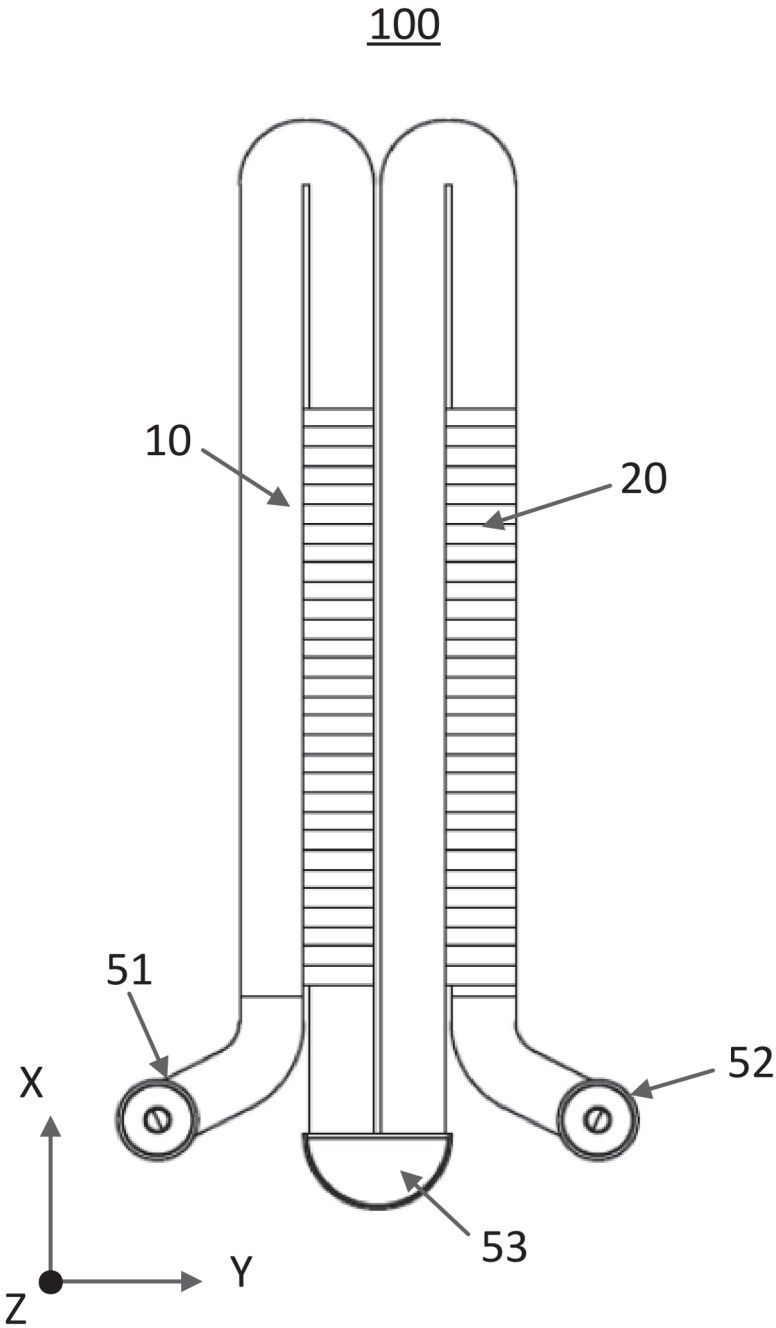


Fig.21



EUROPEAN SEARCH REPORT

Application Number

EP 26 16 8589

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/289921 A1 (DETHIER ALFRED [BE] ET AL) 1 December 2011 (2011-12-01)	1,2,15	INV.
A	* figures 3-6 *	3-14	F28D1/04 F28D1/02
A	----- CN 115 479 483 A (ZHEJIANG DUNAN ARTIFICIAL ENV EQUIPMENT CO LTD) 16 December 2022 (2022-12-16) * figure 8 *	1-15	

			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		24 June 2026	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			

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

EP 26 16 8589

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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
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24-06-2026

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011289921 A1	01-12-2011	AT E505693 T1	15-04-2011
		AU 2010215639 A1	14-07-2011
		BR PI1005407 A2	12-06-2018
		CL 2011002000 A1	27-01-2012
		CN 102292607 A	21-12-2011
		CY 1111632 T1	07-10-2015
		DK 2218978 T3	01-08-2011
		EP 2218978 A1	18-08-2010
		ES 2363740 T3	12-08-2011
		HR P20110461 T1	31-08-2011
		IL 214590 A	30-04-2015
		JP 2012518147 A	09-08-2012
		KR 20120004968 A	13-01-2012
		MA 33125 B1	01-03-2012
		PE 20120611 A1	26-05-2012
		PL 2218978 T3	30-09-2011
		PT 2218978 E	20-07-2011
		RS 51738 B	31-10-2011
		SI 2218978 T1	31-08-2011
		TN 2011000314 A1	17-12-2012
		US 2011289921 A1	01-12-2011
		WO 2010094618 A1	26-08-2010
		ZA 201105787 B	30-01-2013

CN 115479483 A	16-12-2022	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202520711098 [0001]