



(11)

EP 4 826 322 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
F28D 1/04 ^(2006.01) **F28F 1/02** ^(2006.01)
F28F 9/02 ^(2006.01)

(21) Application number: **26168562.2**

(52) Cooperative Patent Classification (CPC):
F28D 1/0417; F28D 1/0471; F28D 1/0476;
F28F 1/025; F28F 9/0246; F28F 2215/02;
F28F 2215/12

(22) Date of filing: **27.03.2026**

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

(72) Inventors:
• **LI, Yanxing**
6430 Nordborg (DK)
• **ZHOU, Jing**
6430 Nordborg (DK)
• **YANG, Jing**
6430 Nordborg (DK)

(30) Priority: **15.04.2025 CN 202520711091 U**

(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 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 third direction, and a projection of an edge of the first bent portion away from the first straight tube segment and/or the second straight tube segment on a plane defined by both the first direction and the second direction is perpendicular to the first direction. The heat exchanger of the present disclosure can, for example, improve the bending precision of a dimension of the heat exchange tube, thereby enhancing the assembly convenience of the heat exchanger.

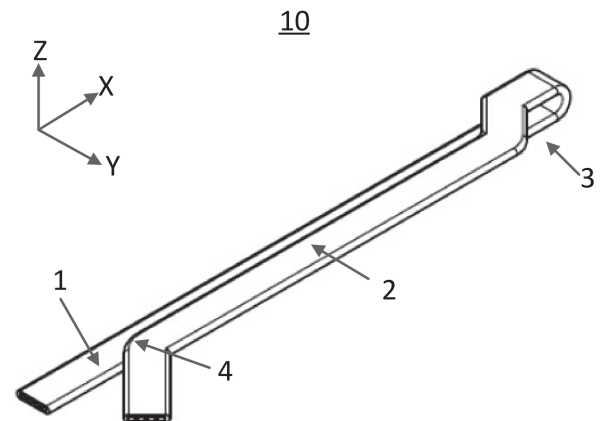


Fig.1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Chinese Patent Application No. CN 202520711091.3 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] The present disclosure relates 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 third direction, and a projection of an edge of the first bent portion away from the first straight tube segment and/or the second straight tube segment on a plane defined by both the first direction and the second direction is perpendicular to the first direction.

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

[0007] According to some exemplary embodiments of the present disclosure, the bent tube segment further

includes a third bent straight segment and 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, and the second bent portion and the third bent portion are connected via the third bent straight segment.

[0008] According to some exemplary embodiments of the present disclosure, a spacing between a 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 fourth bent portion, and the fourth bent portion 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, the second bent portion and the third bent portion in sequence.

[0012] According to some other exemplary embodiments of the present disclosure, the bent tube segment further includes a fifth bent portion, a sixth bent portion and a second bent straight segment extending in the first direction; wherein the fifth bent portion and the sixth bent portion are bent such that the first straight tube segment is offset from the second straight tube segment and the first bent straight segment in the second direction; and wherein a first end of the first bent portion is connected to the first straight tube segment via the second bent straight segment, the fifth bent portion and the sixth bent portion in sequence, and a second end of the first bent portion is connected to the second straight tube segment via the first bent straight segment, the second bent portion and the third bent portion in sequence.

[0013] 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 second straight tube segment or the first straight tube segment of an-

other adjacent heat exchange tube.

[0014] 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 second straight tube segment or the first straight tube segment of another adjacent heat exchange tube in the third direction is equal to the height of one wavy fin.

[0015] According to some other 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 adjacent insertion slots of each insert fin, 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 each insert fin, respectively.

[0016] 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 is connected to and in fluid communication with the second header.

[0017] 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; and 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] According to some exemplary embodiments of the present disclosure, a portion of the first straight tube segment adjacent to the first bent portion is aligned with the first bent straight segment in the third direction.

[0023] 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.

[0024] 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

[0025]

Fig. 1 is a schematic perspective structural view showing a single heat exchange tube of a heat exchanger according to a first exemplary 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 exemplary 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 side structural view showing the heat exchanger shown in Fig. 5 ;

Fig. 8 is a schematic cross-sectional structural view showing the heat exchanger shown in Fig. 6 taken along line A-A in Fig. 6;

Fig. 9 is a schematic perspective structural view showing a single heat exchange tube of a heat exchanger according to a second exemplary embodiment of the present disclosure;

Fig. 10 is a schematic front structural view showing the heat exchange tube shown in Fig. 9;

Fig. 11 is a schematic side structural view showing the heat exchange tube shown in Fig. 9;

Fig. 12 is a schematic bottom structural view showing the heat exchange tube shown in Fig. 9;

Fig. 13 is a schematic perspective structural view showing the heat exchanger according to the second exemplary embodiment of the present disclosure;

Fig. 14 is a schematic front structural view showing the heat exchanger shown in Fig. 13;

Fig. 15 is a schematic side structural view showing the heat exchanger shown in Fig. 13;

Fig. 16 is a schematic perspective structural view showing a heat exchanger according to a third exemplary embodiment of the present disclosure;

Fig. 17 is a schematic front structural view showing the heat exchanger shown in Fig. 16;

Fig. 18 is a schematic side structural view showing the heat exchanger shown in Fig. 16;

Fig. 19 is a schematic cross-sectional structural view showing the heat exchanger shown in Fig. 17 taken along line C-C in Fig. 17;

Fig. 20 is a schematic perspective structural view showing a heat exchanger according to a fourth exemplary embodiment of the present disclosure;

Fig. 21 is a schematic front structural view showing the heat exchanger shown in Fig. 20; and

Fig. 22 is a schematic side structural view showing the heat exchanger shown in Fig. 20.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0026] 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.

[0027] 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.

[0028] 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.

[0029] Referring to Figs. 1 to 8, 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 third direction Z, and a projection of an edge of the first bent portion 31 away from the first straight tube segment 1 and/or the second straight tube segment 2 on a plane defined by both the first direction X and the second direction Y is perpendicular to the first direction X. That is to say, the projection of the edge of the first bent portion 31 away from the first straight tube segment 1 and/or the second straight tube segment 2 on the plane defined by both the first direction X and the second direction Y extends in the second direction Y.

[0030] 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.

[0031] In the heat exchange tube 10 provided by the

present disclosure, the above configuration of the first bent portion 31 can be formed by directly bending the heat exchange tube 10 in the thickness direction, which results in small stretching of the holes on both sides of the heat exchange tube, can reduce residual stress, can reduce the wall thickness reduction of the heat exchange tube, and improve the reliability of the heat exchange tube.

[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 and a third bent portion 33, and the second bent portion 32 and the third bent portion 33 are bent such that the second straight tube segment 2 is offset from the first straight tube segment 1 in the second direction Y. In the exemplary embodiment shown in Figs. 1 to 4, the bent tube segment 3 further includes a third bent straight segment 39 and a first bent straight segment 37 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 37, and the second bent portion 32 and the third bent portion 33 are connected via the third bent straight segment 39. 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 37, the second bent portion 32 and the third bent portion 33 in sequence. In addition, a portion of the first straight tube segment 1 adjacent to (the first end of) the first bent portion 31 is aligned with the first bent straight segment 37 in the third direction Z. With the design of the first bent portion 31, the second bent portion 32 and the third bent portion 33, 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.

[0033] 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.

[0034] 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 fourth bent portion 4, which is formed at the second straight tube segment 2 to bend the second straight tube segment 2 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.

[0035] It should be noted that according to the present disclosure, in the heat exchange tube 10, the second straight tube segment 2, the second bent portion 32, the third bent portion 33, the first bent straight segment 37, the third bent straight segment 39 and the fourth bent portion 34 are substantially located in the same plane and have substantially the same thickness in the third direction Z.

[0036] It can be seen from the above that in the heat exchanger provided by the present disclosure, the bending operation of the heat exchange tube is only performed in a thickness plane of the heat exchange tube, without an overly complex spatial structure, which is relatively easy to operate, and the dimensional accuracy is relatively easy to control. In addition, the first bent portion is formed by folding the heat exchange tube in half, which results in smaller stretching of the heat exchange tube material compared with bending along the outer edges of both sides of the heat exchange tube, reduces the wall thickness reduction of

the heat exchange tube, and improves the reliability of the heat exchange tube. Therefore, the heat exchanger provided by the present disclosure reduces the bending complexity of the heat exchange tube, thereby improving the bending precision of the dimension of the heat exchange tube and further enhancing the assembly convenience of the heat exchanger.

[0037] According to the first exemplary embodiment of the present disclosure, as shown in Figs. 5 to 8, 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 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 equal to the height of one wavy fin. As shown in Fig. 8, 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 8, 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 8, 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. 9 to 22.

[0040] According to the heat exchanger provided by the present disclosure, in the second exemplary embodiment shown in Figs. 9 to 15, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 8 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. 9 to 15, according to the second exemplary embodiment, in some of the heat exchange tubes 10, the bent tube segment 3 further includes a fifth bent portion 35, a sixth bent portion 36, and a second bent straight segment 38 extending in the first direction X. Specifically, as shown in Figs. 9 to 12, the fifth bent portion 35 and the sixth bent portion 36 are bent such that the first straight tube segment 1 is offset from the second straight tube segment 2 and the first bent straight segment 37 in the second direction Y. A first end of the first bent portion 31 is connected to the first straight tube segment 1 via the second bent

straight segment 38, the fifth bent portion 35 and the sixth bent portion 36 in sequence, 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 37, the second bent portion 32 and the third bent portion 33 in sequence. In addition, the second bent straight segment 38 is aligned with the first bent straight segment 37 in the third direction Z. With the above configuration, the heat exchange area is increased and the heat exchange efficiency is improved; at the same time, the arrangement of a plurality of bent portions and bent straight segments also makes the structure of the heat exchange tube 10 more stable and less prone to deformation.

[0041] According to the heat exchanger provided by the present disclosure, in the third exemplary embodiment shown in Figs. 16 to 19, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 8 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. 16 to 19, according to the third exemplary embodiment, the heat exchanger 100 adopts a plurality of insert fins 20'. Each insert fin 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 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 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. 20 to 22, the same basic structure and configuration as those of the first exemplary embodiment shown in Figs. 1 to 8 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. 20 to 22, 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 com-

mon header 53. The 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 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, 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 52, and the 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 the 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 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. 20 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. 20 to 22, 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. 20 to 22, 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. 20 to 22, 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 sec-

ond 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 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 First straight tube segment
- 2 Second straight tube segment
- 3 Bent tube segment

10 Heat exchange tube

20 Wavy fin

20' Insert fin

21' Insertion slot

31 First bent portion

32 Second bent portion

33 Third bent portion

34 Fourth bent portion

35 Fifth bent portion

36 Sixth bent portion

37 First bent straight segment

38 Second bent straight segment

39 Third 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;

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 third direction (Z), and a projection of an edge of the first bent portion (31) away from the first straight tube segment (1) and/or the second straight tube segment (2) on a plane defined by both the first direction (X) and the second direction (Y) is perpendicular to the first direction (X).

2. Heat exchanger (100) according to claim 1, wherein,

the bent tube segment (3) further comprises a second bent portion (32) and a third bent portion (33), and the second bent portion (32) and the third bent portion (33) are bent such that the second straight tube segment (2) is offset from the first straight tube segment (1) in the second direction (Y).

3. Heat exchanger (100) according to claim 2, wherein,

the bent tube segment (3) further comprises a third bent straight segment (39) and a first bent straight segment (37) 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 (37), and the second bent portion (32) and the third bent portion (33) are connected via the third bent straight segment (39).

4. Heat exchanger (100) according to claim 2, wherein,

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 the plane is within a range of plus or minus one-half of a width of the heat exchange tube.

5. Heat exchanger (100) according to claim 2, wherein,

at least some of the heat exchange tubes (10) further comprise a fourth bent portion (4), and the

fourth bent portion 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. 5

6. Heat exchanger (100) according to claim 3, wherein, 10
a first end of the first bent portion (31) is directly connected to the first straight tube segment, 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, the second bent portion (32) and the third bent portion (33) in sequence. 15

7. Heat exchanger (100) according to claim 3, wherein, 20
the bent tube segment (3) further comprises a fifth bent portion (35), a sixth bent portion (36) and a second bent straight segment (38) extending in the first direction (X); wherein the fifth bent portion (35) and the sixth bent (36) 25
portion are bent such that the first straight tube segment (1) is offset from the second straight tube segment (2) and the first bent straight segment in the second direction; and wherein a first end of the first bent portion (31) 30
is connected to the first straight tube segment (1) via the second bent straight segment, the fifth bent portion (35) and the sixth bent portion (36) in sequence, and a second end of the first bent portion (31) is connected to the second 35
straight tube segment (2) via the first bent straight segment (37), the second bent portion (32) and the third bent portion (33) in sequence. 40

8. Heat exchanger (100) according to any one of claims 1 to 7, wherein, 45

the heat exchanger (100) further comprises a plurality of wavy fins (20); 45
wherein one wavy fin (20) is disposed 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 disposed between the first straight 50
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). 55

9. Heat exchanger (100) according to any one of claims 1 to 7, wherein,

the heat exchanger (100) further comprises a plurality of insert fins (20'), each insert fin (20') having a plurality of insertion slots (21'); wherein 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 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 adjacent insertion slots (21') of each insert fin (20'), respectively.

10. Heat exchanger (100) according to any one of claims 1 to 7, 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.

11. Heat exchanger (100) according to claim 10, 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 (1, 2).

5

12. Heat exchanger (100) according to claim 10, 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 (1, 2), and the one first wavy fin (20) and the one second wavy fin (20) are aligned in the second direction (Y).

10

15

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

20

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).

25

30

35

14. Heat exchanger (100) according to any one of claims 1 to 7, wherein,

the heat exchange tube (10) is a micro-channel flat heat exchange tube 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).

40

45

50

15. Heat exchanger (100) according to any one of claims 1 to 7, wherein,

a portion of the first straight tube segment (1) adjacent to the first bent portion (31) is aligned with the first bent straight segment (37) in the third direction (Z).

55

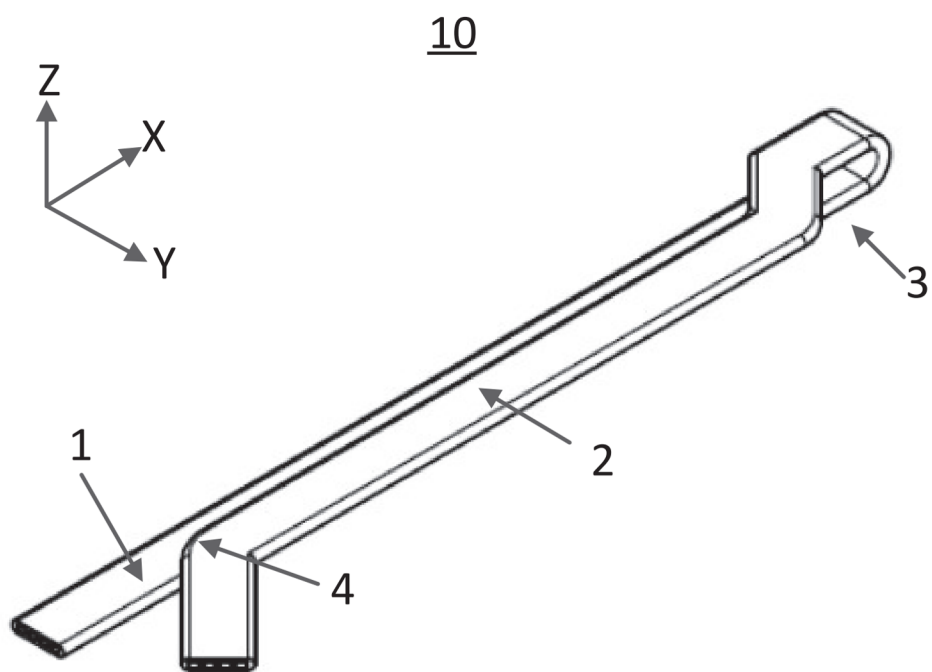


Fig.1

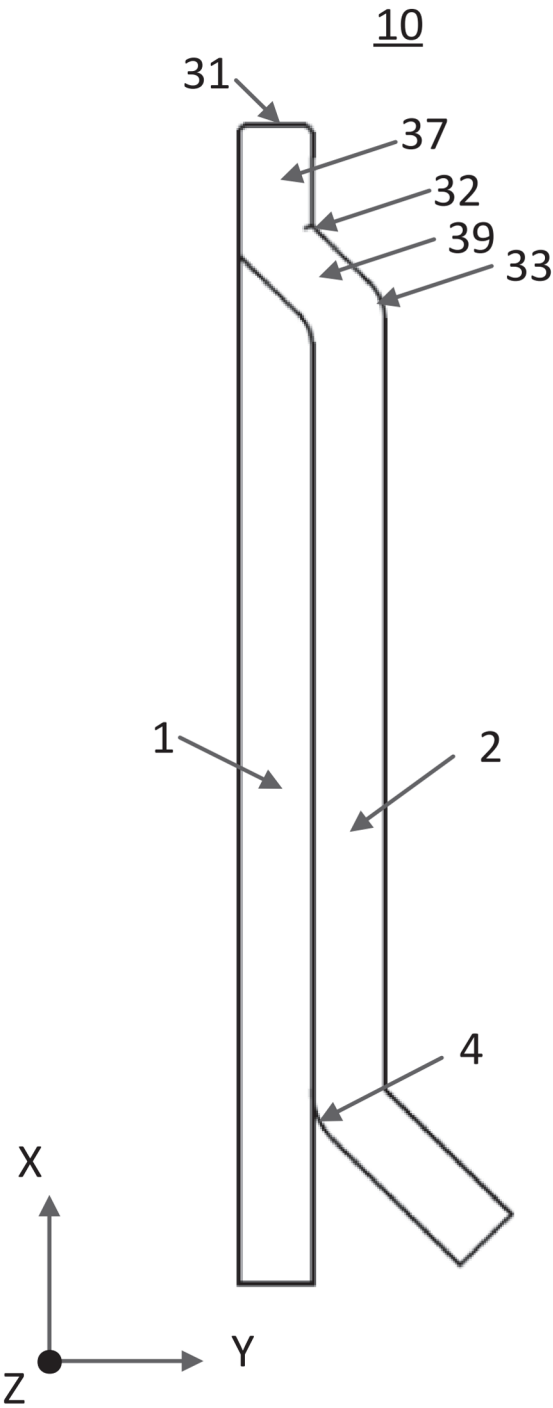


Fig.2

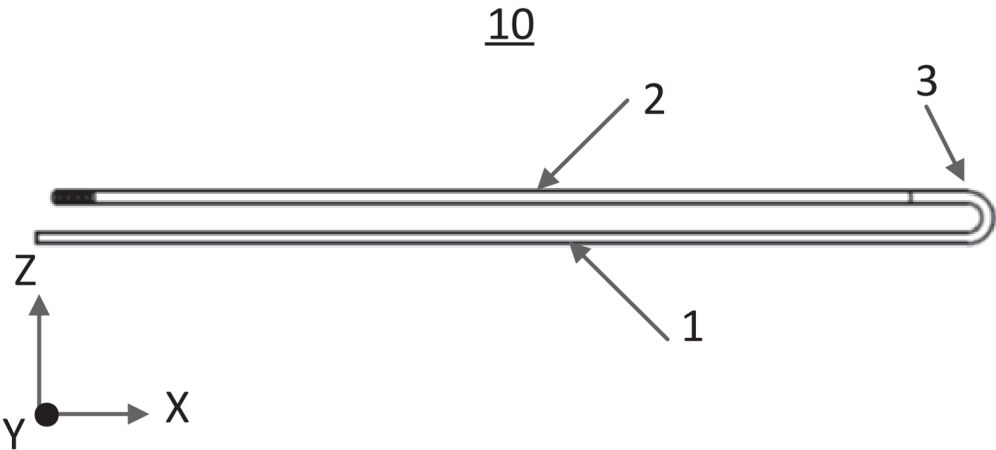


Fig.3

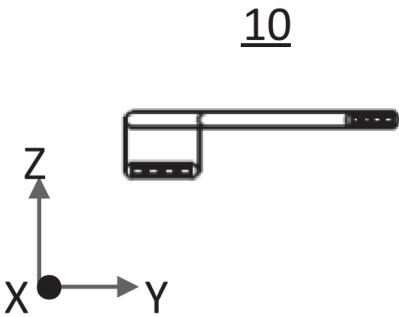


Fig.4

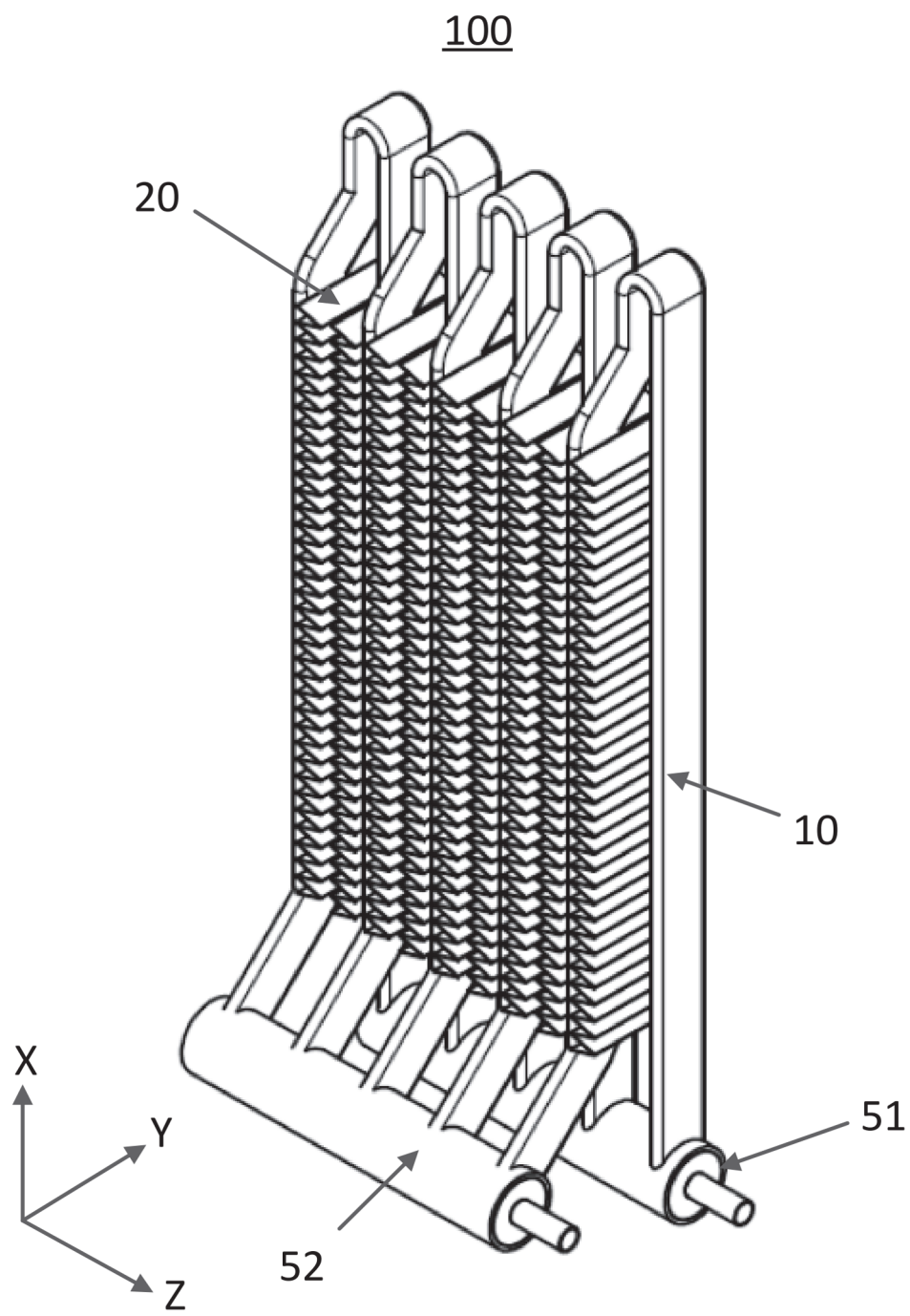


Fig.5

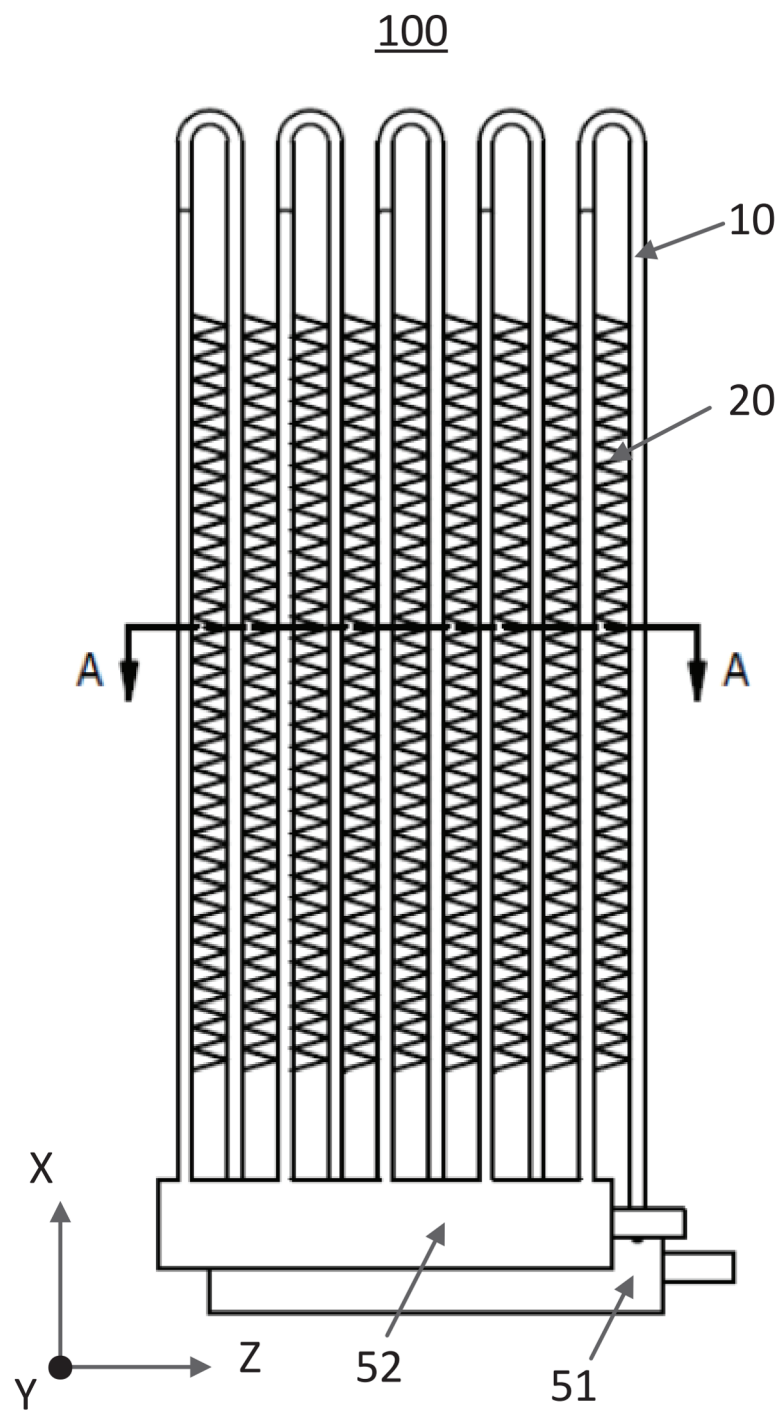


Fig.6

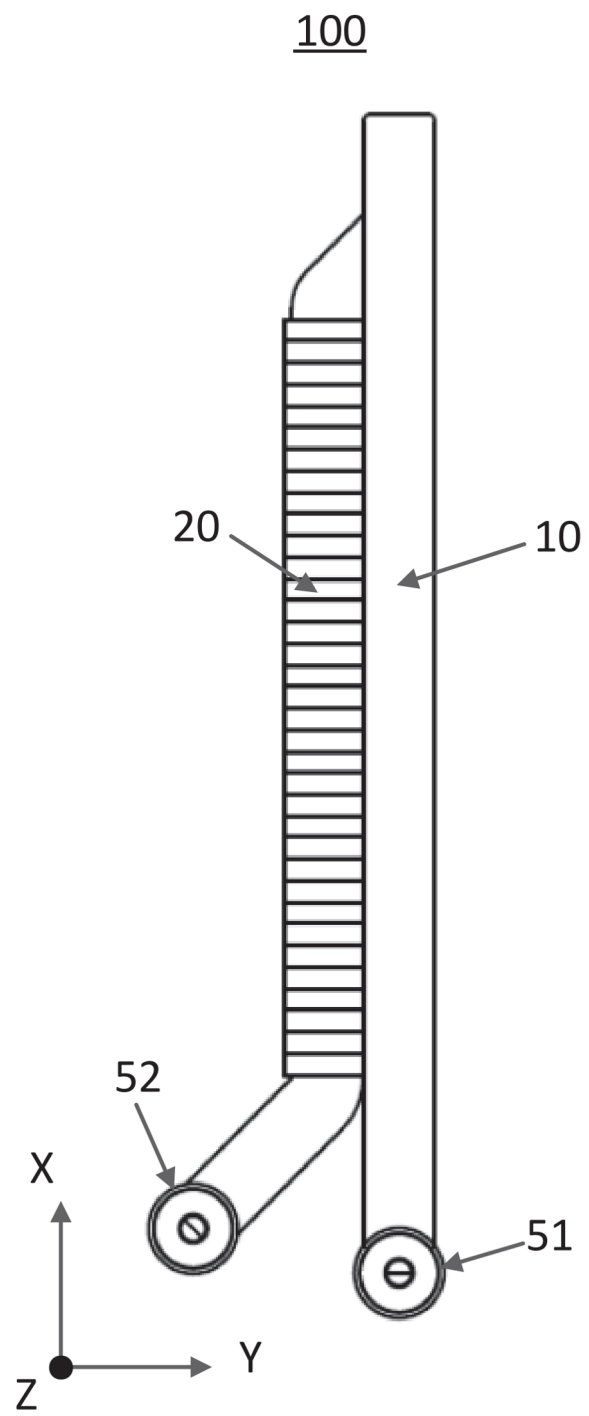


Fig.7

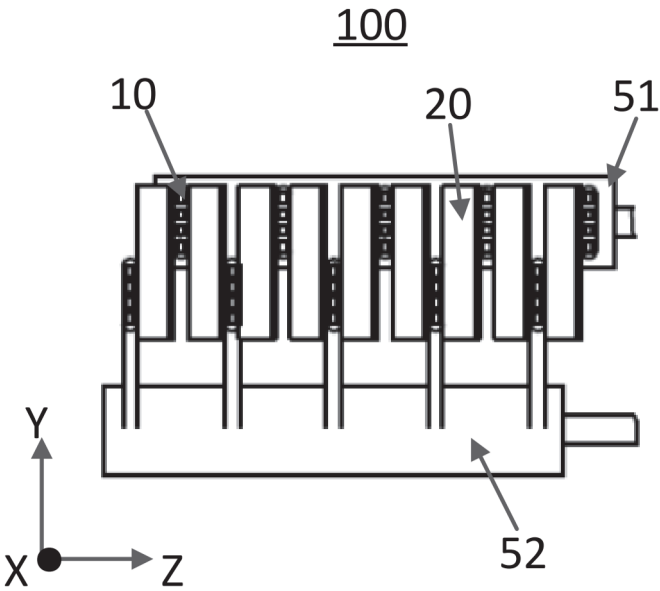


Fig.8

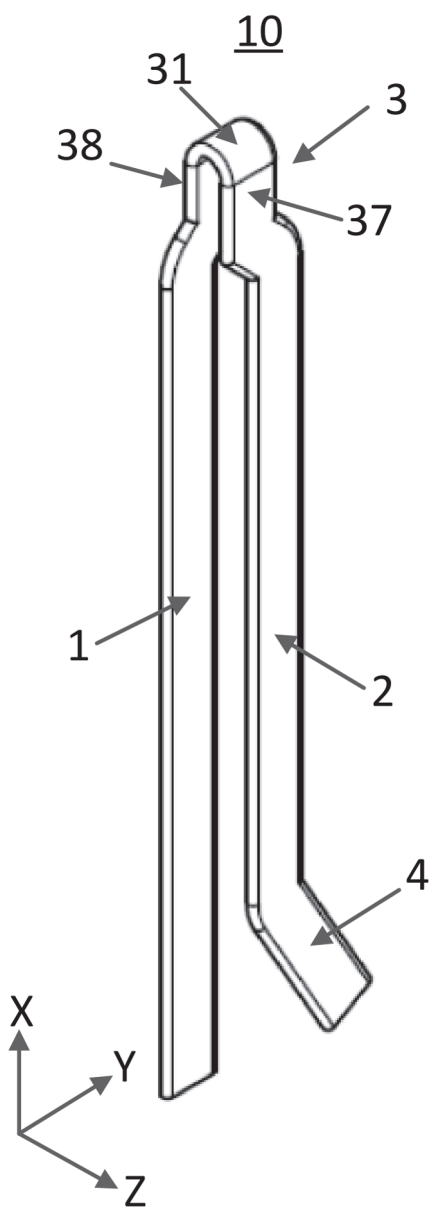


Fig.9

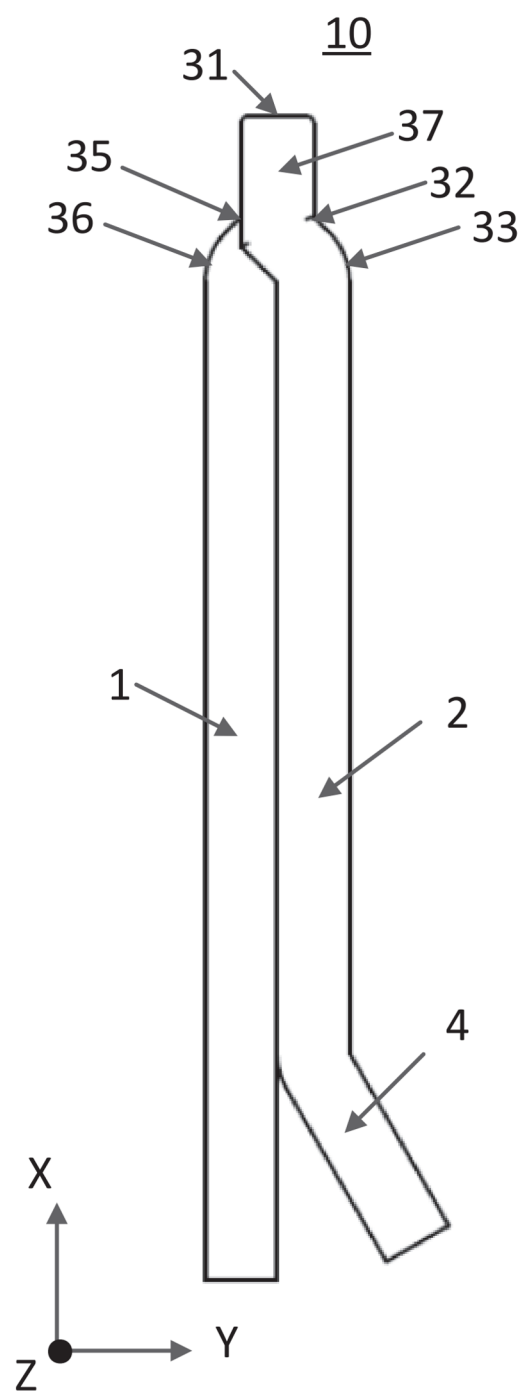


Fig.10

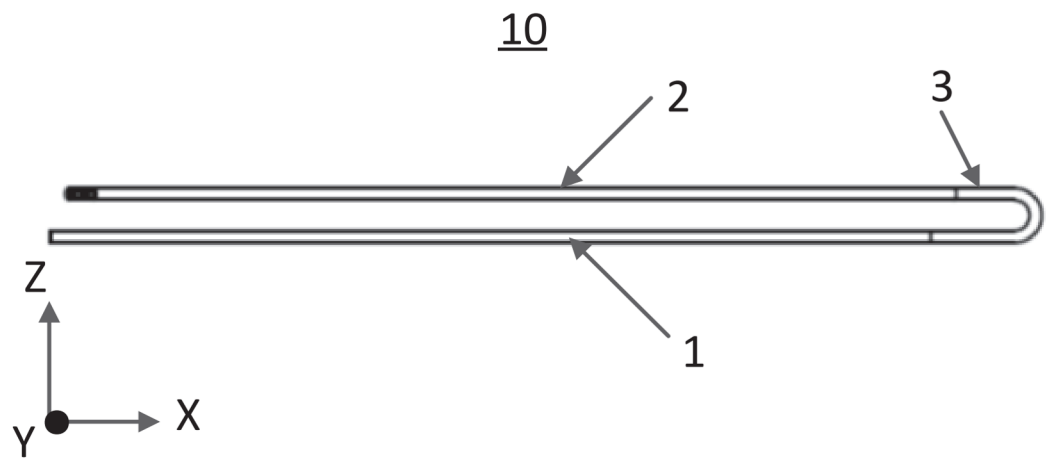


Fig.11

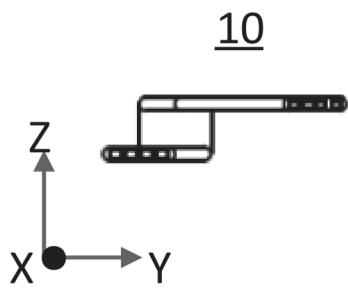


Fig.12

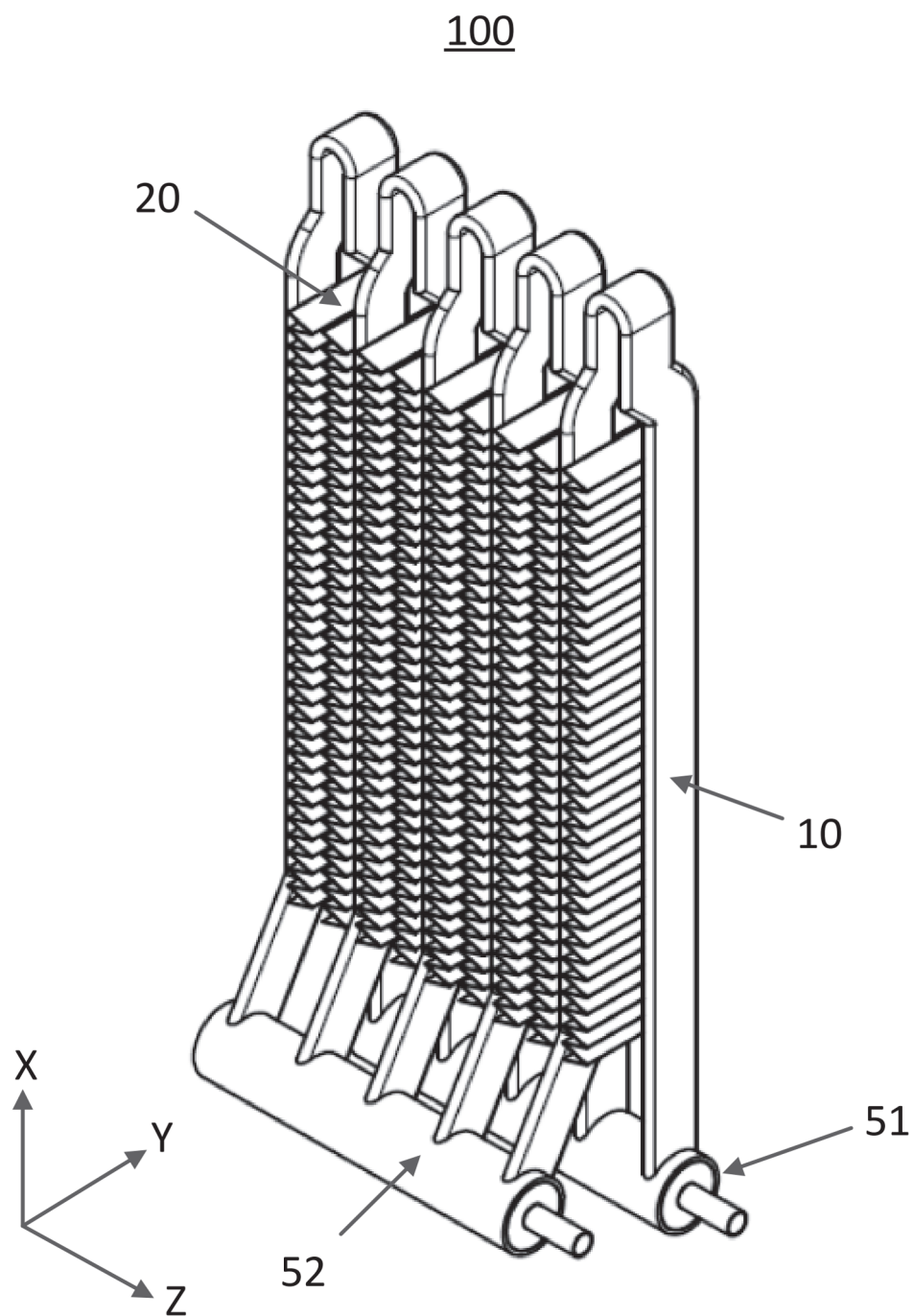


Fig.13

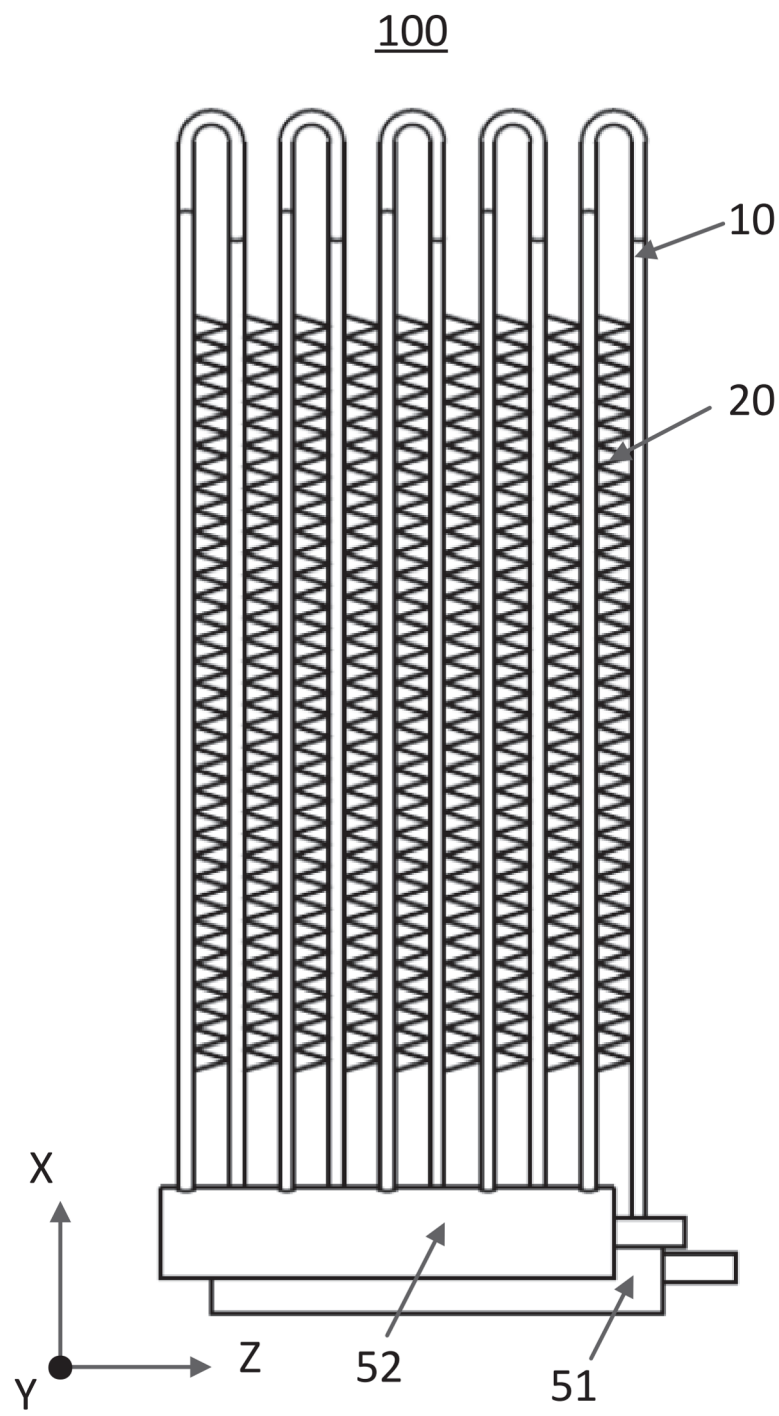


Fig.14

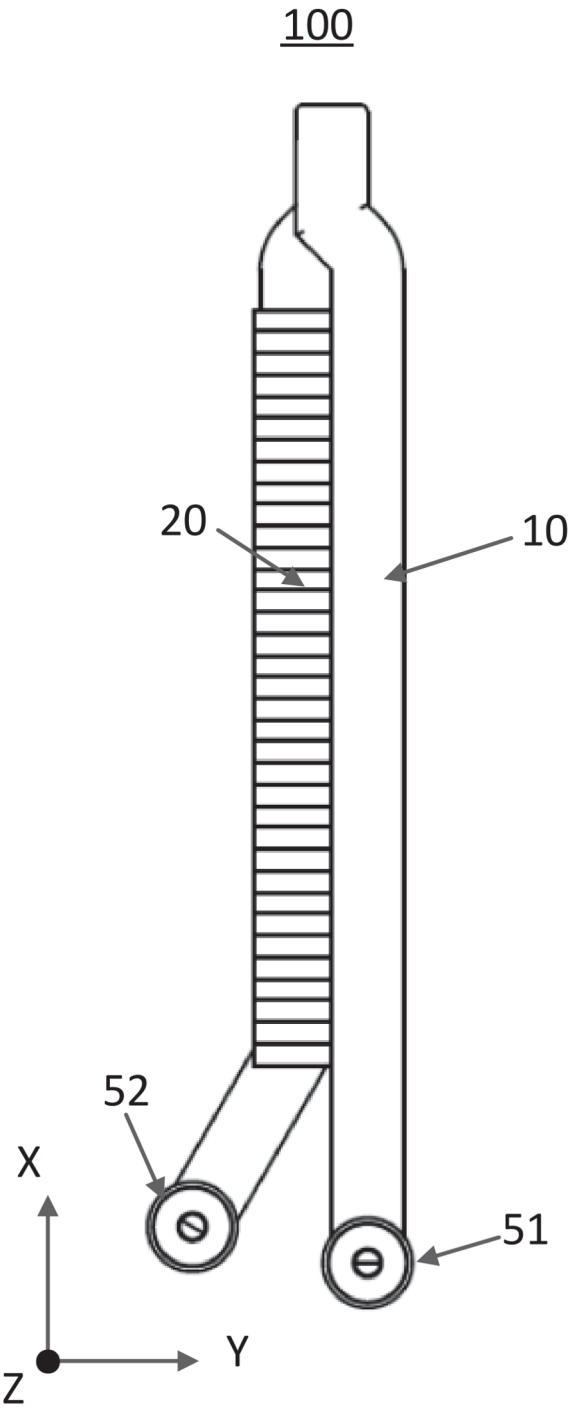


Fig.15

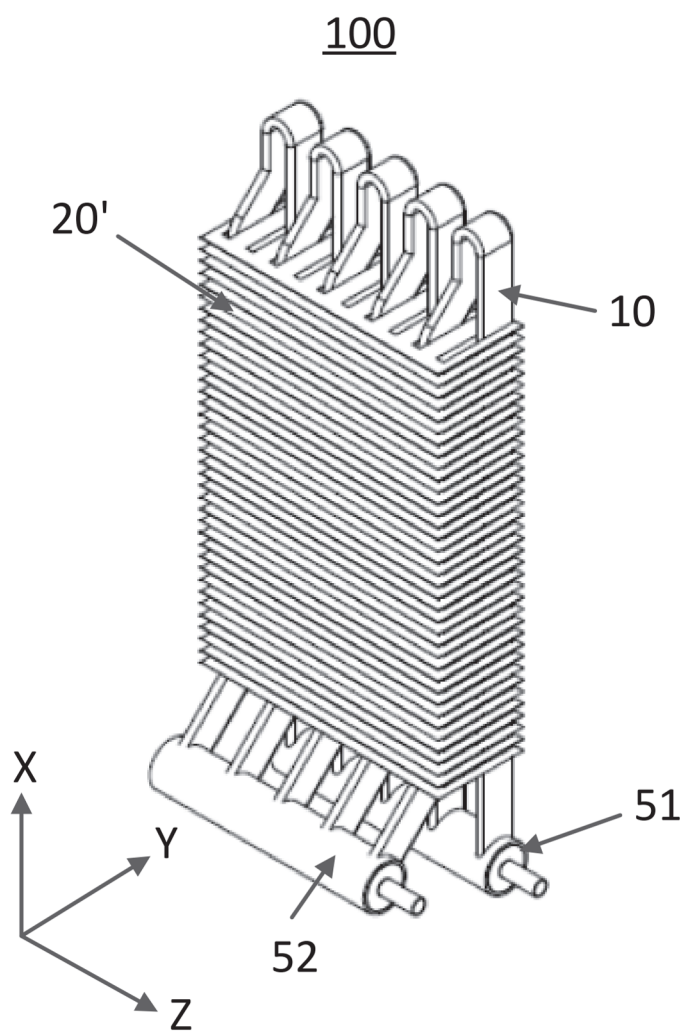


Fig.16

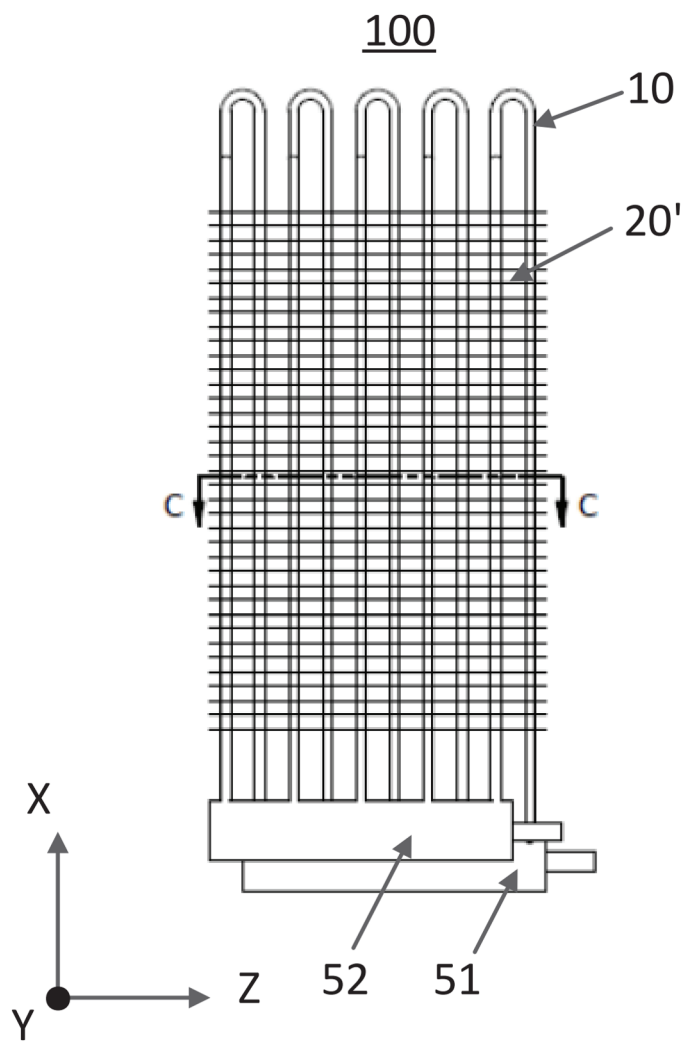


Fig.17

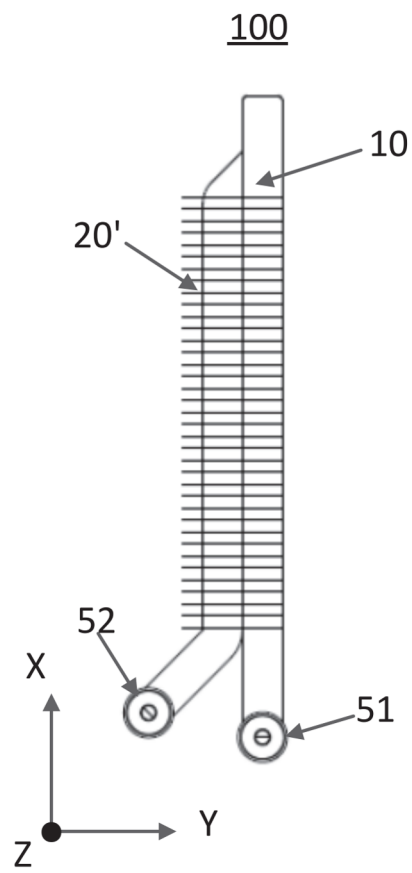


Fig.18

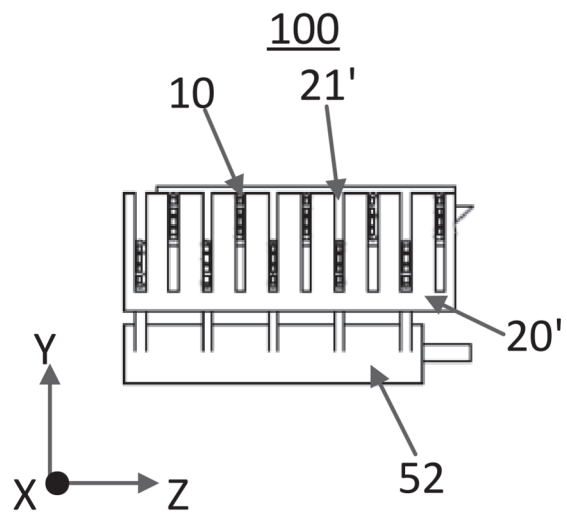


Fig.19

100

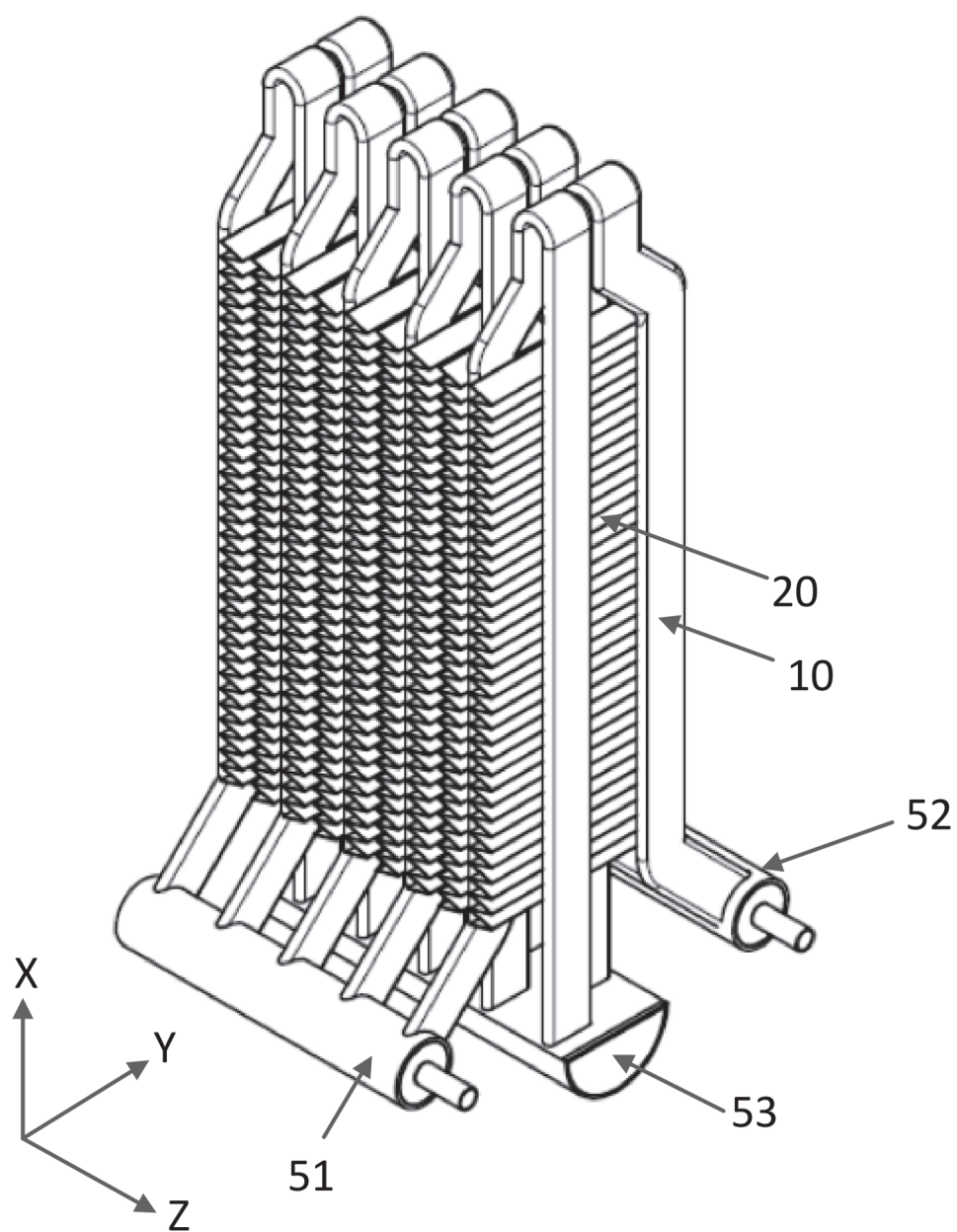


Fig.20

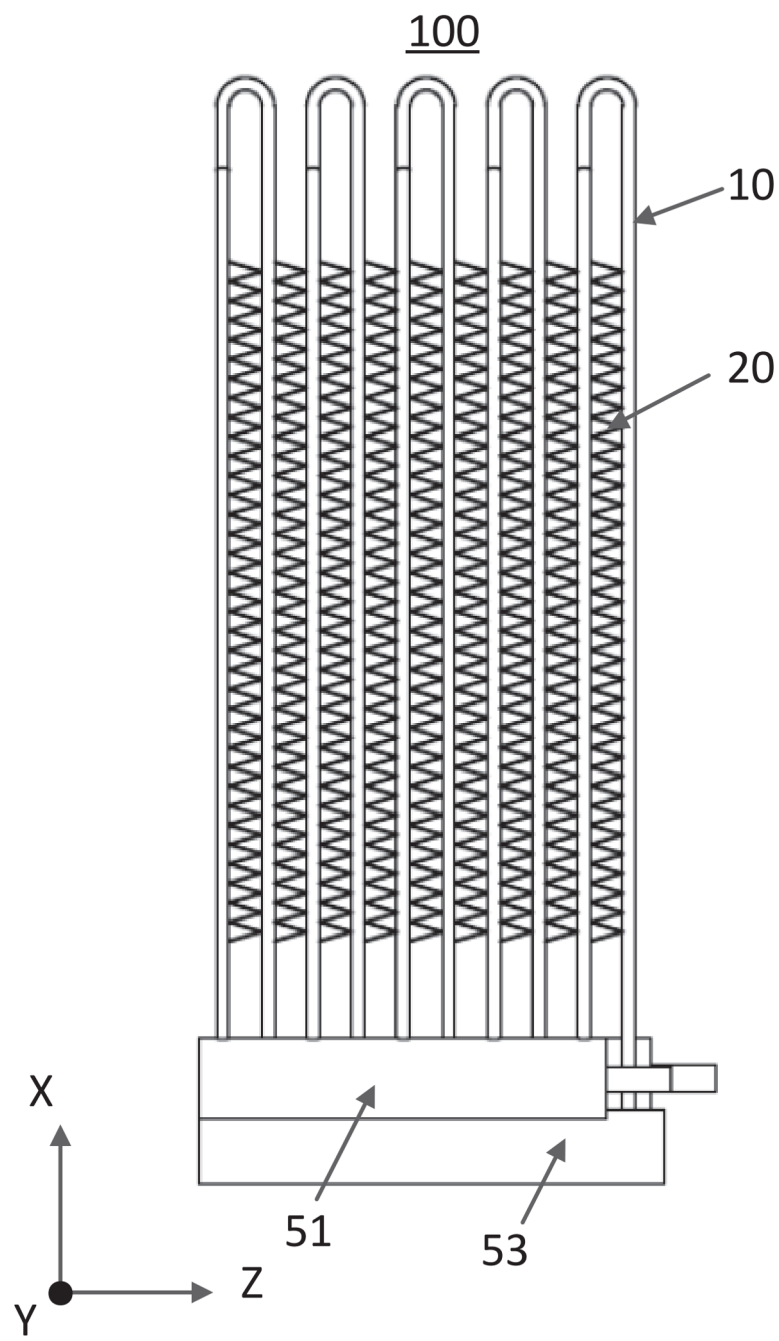


Fig.21

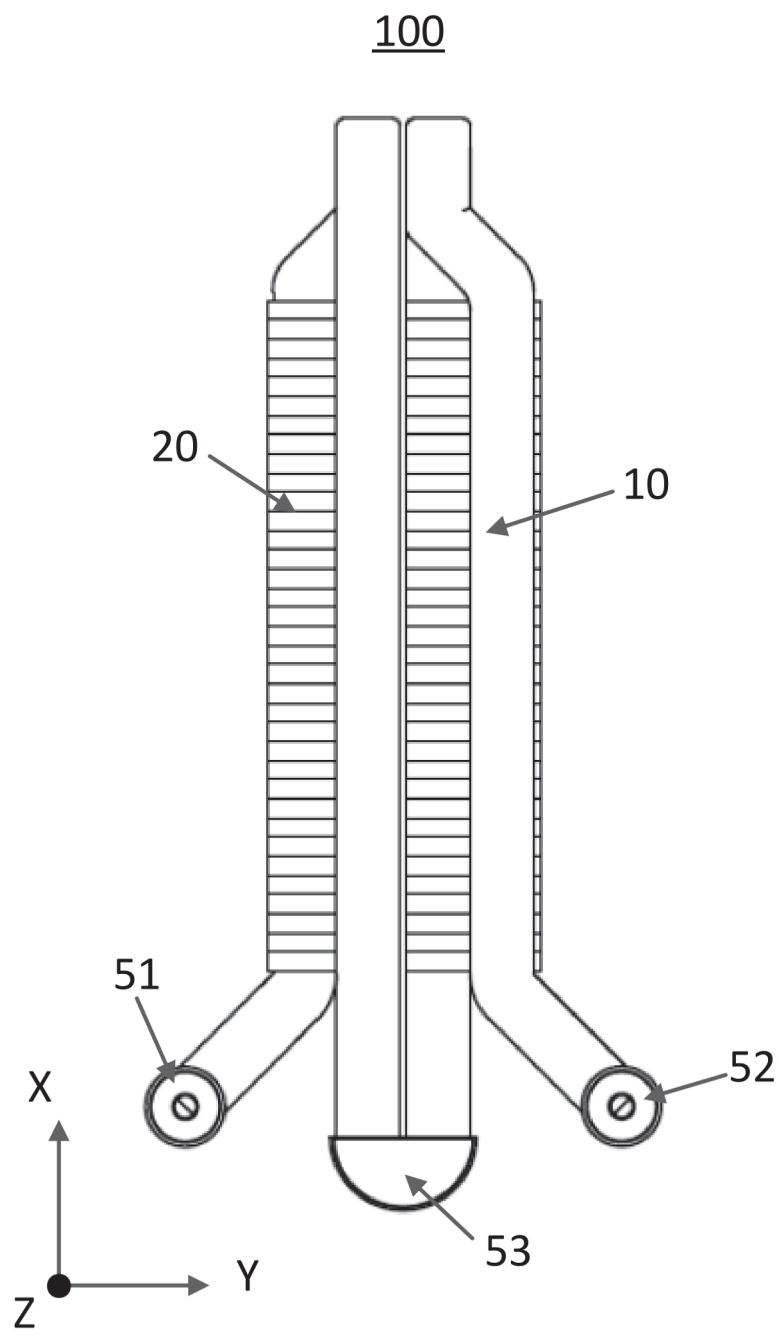


Fig.22



EUROPEAN SEARCH REPORT

Application Number

EP 26 16 8562

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
1 X	JP 2010 169289 A (NIKKEI NEKKO KK) 5 August 2010 (2010-08-05) * figures 1-5,10 *	1,14	INV. F28D1/04 F28F1/02 F28F9/02
Y		10-13	
A		2-8,15	
1 X	----- CN 115 479 483 A (ZHEJIANG DUNAN ARTIFICIAL ENV EQUIPMENT CO LTD) 16 December 2022 (2022-12-16) * figures 7,8 *	1,9	
1 X,P	----- DE 10 2024 127867 A1 (MAHLE INT GMBH [DE]) 26 March 2026 (2026-03-26) * figures 1-9,1-10 *	1	
7 Y	----- CN 114 576 884 A (DANFOSS CO LTD) 3 June 2022 (2022-06-03) * figure 1 *	10-13	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 July 2026	Examiner Martínez Rico, Celia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

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

EP 26 16 8562

5

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

14-07-2026

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2010169289 A	05-08-2010	NONE	

CN 115479483 A	16-12-2022	NONE	

DE 102024127867 A1	26-03-2026	NONE	

CN 114576884 A	03-06-2022	NONE	

15

20

25

30

35

40

45

50

55

EPO FORM P459

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

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- CN 202520711091 [0001]