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(54) **HEAT EXCHANGER**

(57) Stress concentration on a specific part of a header is alleviated in a heat exchanger including the header having an Ω-shaped cross section. A first member (20) of a header (10) in the heat exchanger includes a first opening (O1) extending in a first direction (dr1). A cross-sectional shape of the first member (20) perpendicular to the first direction (dr1) is an Ω-shape. A second member (30) includes a plurality of second openings (O2) each having a width (W2) larger than a width (W1) of the first opening (O1) in a third direction (dr3).

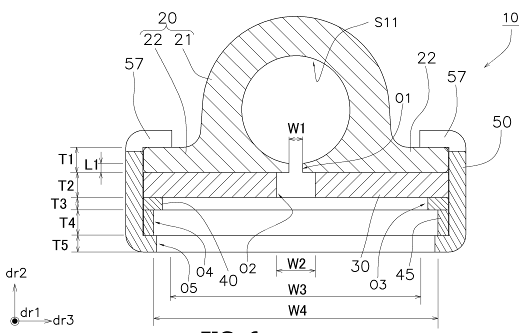

FIG. 6

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Description

Technical Field

[0001] The present disclosure relates to a heat exchanger.

Background Art

[0002] In a conventional heat exchanger that exchanges heat between a refrigerant flowing in the heat exchanger and air uses an aluminum member extruded into a shape having an Ω-shaped cross section as described in PTL 1 (International Publication No. WO2016/152127) in some cases. An aluminum elongated member having an Ω-shaped cross section described in PTL 1 is used as a component of a header tank.

Summary of Invention

Technical Problem

[0003] In the heat exchanger of PTL 1, heat exchange occurs between a high-pressure refrigerant such as carbon dioxide, for example, and air. In this case, a high pressure is also applied from the refrigerant to the elongated member having an Ω-shaped cross section that forms the heat exchanger. The heat exchanger is expensive if sufficient safety is imparted against stress concentrated on a part of the heat exchanger due to a high pressure applied to the elongated member having the Ω-shaped cross section. If such stress concentration can be alleviated in the heat exchanger, sufficient safety can be imparted to the heat exchanger while avoiding an increase in the cost of the heat exchanger.

[0004] In a heat exchanger provided with a header including an elongated member having an Ω-shaped cross section as a component, there is an issue of improving pressure resistance strength of the heat exchanger by alleviating stress concentration on a specific portion within the header.

Solution to Problem

[0005] A heat exchanger of a first aspect includes a header and a plurality of multi-hole heat transfer tubes. The header extends in a first direction and has an inside where a refrigerant flows. The plurality of multi-hole heat transfer tubes are inserted into the header in a second direction intersecting the first direction, each of the multi-hole heat transfer tubes having a width in a third direction intersecting the first direction larger than a height in the first direction at a portion inserted into the header and including a plurality of holes communicating with the inside of the header. The header includes a first member that includes a first opening extending in the first direction and having an Ω-shaped cross section perpendicular to the first direction, a second member that includes a plurality of second openings each having a larger width than the first opening in the third direction, and a third member that includes a plurality of third openings each having a larger width than the plurality of second openings in the third direction and communicating with the plurality of multi-hole heat transfer tubes, and with which the plurality of multi-hole heat transfer tubes are in contact. The first member, the second member, and the third member are disposed in the order of the first member, the second member, and the third member, and are joined such that each of the second openings overlaps each of the third openings within a range of a width of each of the third openings in the third direction, and the first opening overlaps each of the second openings within a range of a width of each of the second openings in the third direction.

[0006] In the heat exchanger of the first aspect, the stress concentration at the joint portion between the multi-hole heat transfer tube and the header can be alleviated by the second member, thus improving the pressure resistance strength of the heat exchanger.

[0007] A heat exchanger of a second aspect is the heat exchanger of the first aspect, in which the first member is an extruded member extruded so as to have an Ω-shaped cross section.

[0008] In the heat exchanger of the second aspect, the extruded member, which is extruded into a complicated Ω-shaped cross section, can be used as a part of the first member and the manufacturing cost of the heat exchanger can be suppressed to be low.

[0009] A heat exchanger of a third aspect is the heat exchanger of the first aspect or the second aspect, in which the first member includes a flat plate portion having a flat plate shape in which a thickness is larger than a length of the first opening in the second direction.

[0010] In the heat exchanger of the third aspect, since the thickness of the flat plate portion of the first member is larger than the length of the first opening in the second direction, the pressure receiving area that receives pressure from a refrigerant can be made smaller as compared with a case where the thickness of the flat plate portion is the same as the length of the first opening in the second direction. In the heat exchanger in which the thickness of the flat plate portion is larger than the length of the first opening in the second direction, it is easier to ensure pressure resistance strength.

[0011] A heat exchanger of a fourth aspect is the heat exchanger of any one of the first aspect to the third aspect, in which the first member in the header and the plurality of multi-hole heat transfer tubes are made of aluminum or an aluminum alloy.

[0012] A heat exchanger of a fifth aspect is the heat exchanger of any one of the first aspect to the fourth aspect, in which the refrigerant flowing through the inside of the header is a carbon dioxide refrigerant.

[0013] A heat exchanger of a sixth aspect is the heat exchanger of any one of the first aspect to the fifth aspect, further including a fourth member and a fifth member. The fourth member includes a plurality of fourth openings through which the plurality of multi-hole heat transfer tubes pass, and is joined to the third member. The fifth member includes a plurality of fifth openings through which the plurality of multi-hole heat transfer tubes fit and penetrate, and is joined to side surfaces of the first member, the second member, and the third member, and to the fourth member.

[0014] A heat exchanger of a seventh aspect is the heat exchanger of any one of the first aspect to the sixth aspect, in which a width of each of the second openings in the third direction is larger than twice a width of the first opening in the third direction.

[0015] In the heat exchanger of the seventh aspect, since the width of each of the second openings is larger than twice the width of the first opening, the first opening is less likely to be narrowed by brazing when the first member and the second member are brazed, for example.

[0016] A heat exchanger of an eighth aspect is the heat exchanger of any one of the first aspect to the seventh aspect, in which a width of each of the third openings in the third direction is larger than twice a width of each of the second openings in the third direction.

[0017] In the heat exchanger of the eighth aspect, since the width of each of the third openings is larger than twice the width of each of the second openings, it is possible to sufficiently obtain the effect, by the second member having the second openings, of alleviating stress concentration.

Brief Description of Drawings

[0018]

[Fig. 1] Fig. 1 is a schematic view of an example of the configuration of a heat exchanger according to an embodiment as viewed in a third direction.

[Fig. 2] Fig. 2 is a schematic view of the heat exchanger of Fig. 1 as viewed in a first direction.

[Fig. 3] Fig. 3 is a schematic view of a heat exchanging part of the heat exchanger of Fig. 1 as viewed obliquely.

[Fig. 4] Fig. 4 is a partially enlarged sectional view showing a part of the heat exchanger taken along line I-I in Fig. 1.

[Fig. 5] Fig. 5 is an exploded perspective view showing a part of a disassembled header of the heat exchanger of Fig. 1.

[Fig. 6] Fig. 6 is a cross-sectional view of the header of Fig. 5 taken along a plane perpendicular to the first direction.

[Fig. 7] Fig. 7 is a cross-sectional view showing a state in which a multi-hole heat transfer tube is fitted to the header of Fig. 6.

[Fig. 8] Fig. 8 is a partially enlarged plan view showing a part of the header and the multi-hole heat transfer tube of Fig. 7 cut at a central portion in the third direction.

[Fig. 9] Fig. 9 is a perspective view showing the periphery of a joint portion between the header and the multi-hole heat transfer tube shown in Fig. 8.

[Fig. 10] Fig. 10 is a schematic view for explaining stress concentration in the vicinity of the joint portion between the header and the multi-hole heat transfer tube shown in Fig. 9.

[Fig. 11] Fig. 11 is an exploded perspective view partially showing the disassembled header without a second member.

[Fig. 12] Fig. 12 is a cross-sectional view of the header of Fig. 11 taken along a plane perpendicular to the first direction.

[Fig. 13] Fig. 13 is a perspective view showing the periphery of the joint portion between the header and the multi-hole heat transfer tube shown in Fig. 12.

[Fig. 14] Fig. 14 is a schematic view for explaining stress concentration in the vicinity of the joint portion between the header and the multi-hole heat transfer tube shown in Fig. 13.

Description of Embodiments

[0019] Hereinafter, a heat exchanger according to an embodiment will be described. A first direction dr1 shown in the drawings is a direction in which a header 10 extends, and a second direction dr2 is a direction intersecting the first direction dr1. Here, a case where the first direction dr1 and the second direction dr2 are orthogonal to each other will be described. A multi-hole heat transfer tube 60 is inserted into the header 10 in the second direction dr2. A third direction dr3 is a direction intersecting both the first direction dr1 and the second direction dr2. Here, a case where the third direction dr3 is orthogonal to the first direction dr1 and the second direction dr2 will be described. The third direction dr3 is a width direction of the multi-hole heat transfer tube 60 at a portion where the multi-hole heat transfer tube 60 is inserted into the header 10. The third direction dr3 is a direction in which a fluid, as an object of heat exchange with a refrigerant, passes through the heat exchanger 1 at a portion where the multi-hole heat transfer tube 60 is inserted into the header 10. The fluid as an object of heat exchange is, for example, air. For example, in a case where the first direction dr1 is a vertical direction, the second direction dr2 and the third direction dr3 are horizontal directions. In the following description, the expression "extending in a direction" or "arranged in a direction" includes not only the case where the extending direction or the arranged direction of an extending object coincides with either of the above-described directions, but also the case where the smaller angle between the extending direction or the arranged direction of the object and the above-described direction is equal to or smaller than 45 degrees. For example, a case where the multi-hole heat transfer tube 60 extending linearly extends at an inclination of 45 degrees with respect to the second direction dr2 also corresponds to a case where the multi-hole heat transfer tube 60 extends in the second direction dr2. In addition, a case where the multi-hole heat transfer tube 60 is curved also corresponds to a case where the multi-hole heat transfer tube 60 extends in the second direction dr2 if the inclination of the tangent line with respect to the second direction dr2 is equal to or smaller than 45 degrees.

(1) Overall configuration

[0020] Fig. 1 shows the heat exchanger 1 as viewed in the third direction dr3. Fig. 2 shows the heat exchanger 1 as viewed in the first direction dr1. The heat exchanger 1 is, for example, an air heat exchanger that exchanges heat between a refrigerant and air. A refrigeration cycle apparatus including the heat exchanger 1 is used for, for example, air-conditioning. For example, the heat exchanger 1 is applied to a refrigeration cycle apparatus that performs a refrigeration cycle in which a refrigerant is brought into a supercritical state. The heat exchanger 1 can be used as an evaporator for evaporating a refrigerant or a radiator for radiating heat from a refrigerant in the refrigeration cycle apparatus. The radiator here includes a condenser for condensing a refrigerant. The refrigerant heat-exchanged in the heat exchanger 1 is, for example, a high-pressure refrigerant having a high pressure of 4.5 MPa or more in the heat exchanger 1. The high-pressure refrigerant is, for example, carbon dioxide.

[0021] The heat exchanger 1 includes a plurality of headers 10, a plurality of multi-hole heat transfer tubes 60, and a plurality of fins 70. To distinguish the plurality of headers 10 from each other, one of them is referred to as a first header 11, and the other is referred to as a second header 12. The header 10 has a main body internal space S1 that is a long hollow portion extending in the first direction dr1. The refrigerant flows through the main body internal space S1. Here, the cross-sectional shape of the main body internal space S1 taken along a plane orthogonal to the first direction dr1 is a combination of a circular shape and a small rectangular shape. The cross-sectional shape of the main body internal space S1 is not necessarily a combination of a circular shape and a small rectangular shape, and may be a combination of an elliptical shape and a trapezoidal shape, for example. However, the sectional shape of the main body internal space S1 is preferably a combination of a circular shape and another shape in order to avoid concentration of stress applied to the header 10 from a refrigerant.

[0022] The first header 11 distributes a refrigerant to the plurality of multi-hole heat transfer tubes 60, and the second header 12 merges the refrigerant flowing out from the plurality of multi-hole heat transfer tubes 60. A refrigerant sent from another device to the heat exchanger 1 flows into the first header 11. The refrigerant merged in the second header 12 is sent from the heat exchanger 1 to another device. Therefore, an inlet pipe (not shown) through which the refrigerant sent to the heat exchanger 1 passes is connected to the first header 11, and an outlet pipe (not shown) through which the refrigerant sent out from the heat exchanger 1 passes is connected to the second header 12.

[0023] In the heat exchanger 1 shown in Fig. 1, one end and the other end of ten or more multi-hole heat transfer tubes 60 are respectively inserted into the two headers 10 (first header 11 and second header 12). Here, the multi-hole heat transfer tubes 60 are inserted into the header 10 so that the multi-hole heat transfer tubes 60 are orthogonal to the header 10. However, the multi-hole heat transfer tubes 60 are not necessarily inserted so as to be orthogonal to the header 10, and an angle formed by the multi-hole heat transfer tubes 60 and the header 10 can be set to any angle. Each multi-hole heat transfer tube 60 extends between the two headers 10. In other words, the two headers 10 and a large number of the multi-hole heat transfer tubes 60 are assembled in a shelf form. Here, each of the multi-hole heat transfer tubes 60 is arranged so as to be parallel to other adjacent multi-hole heat transfer tubes 60. However, the multi-hole heat transfer tubes 60 adjacent to each other are not necessarily arranged in parallel to each other, and the positional relationship between the adjacent multi-hole heat transfer tubes 60 can be set to any form. Here, ten or more multi-hole heat transfer tubes 60 are arranged side by side at equal intervals. However, the multi-hole heat transfer tubes 60 are not necessarily arranged at equal intervals, and may be arranged side by side at irregular intervals, for example.

[0024] Fig. 3 shows a heat exchanging part 100 including a plurality of multi-hole heat transfer tubes 60 and a plurality of fins 70. The heat exchanging part 100 will be described later in detail. Fig. 4 shows a section of the header 10 taken along line I-I in Fig. 1. As shown in Fig. 3 and Fig. 4, one multi-hole heat transfer tube 60 has a plurality of holes 65 that are flow paths of a refrigerant. Each multi-hole heat transfer tube 60 has a width of a length LA and a thickness of a length LB. Each multi-hole heat transfer tube 60 is manufactured by, for example, extrusion. The multi-hole heat transfer tube 60 is made of, for example, aluminum or an aluminum alloy. Here, the third direction dr3 coincides with the width direction of the multi-hole heat transfer tube 60. Here, the plurality of holes 65 extend in the second direction dr2 and are arranged in the third direction dr3. Here, the plurality of holes 65 are arranged parallel to each other at equal intervals. The main body internal space S1 of the header 10 communicates with the plurality of holes 65 of the multi-hole heat transfer tube 60. A refrigerant flows out from the main body internal space S1 of the first header 11 to the plurality of holes 65 of the plurality of multi-hole heat transfer tubes 60. The refrigerant flows into the main body internal space S1 of the second header 12 from the plurality of holes 65 of the plurality of multi-hole heat transfer tubes 60. The refrigerant flowing through the plurality of holes 65 of the multi-hole heat transfer tube 60 exchanges heat with the air passing on the surface of the multi-hole heat transfer tube 60.

[0025] The fin 70 is a member that accelerates heat exchange between the refrigerant flowing through the holes 65 of the multi-hole heat transfer tube 60 and the air passing through the heat exchanger 1. The plurality of fins 70 increase a heat transfer area of the heat exchanger 1 for the air passing through the heat exchanger 1. Each fin 70 is formed by deforming a thin plate-shaped member by press working or the like. The fin 70 is made of, for example, aluminum or an aluminum alloy. Each fin 70 extends in the first direction dr1. Here, the plurality of fins 70 are arranged side by side at equal intervals in the second direction dr2. However, the fins 70 are not necessarily arranged at equal intervals, and may be arranged side by side at irregular intervals, for example. Each fin 70 is thermally connected to the plurality of multi-hole heat transfer tubes 60. Each multi-hole heat transfer tube 60 is thermally connected to the plurality of fins 70. The plurality of multi-hole heat transfer tubes 60 are inserted into a plurality of notches 75 of each fin 70, whereby the plurality of multi-hole heat transfer tubes 60 and each fin 70 are in contact with each other directly or via a brazing material, and are thermally connected to each other. The heat exchanger 1 is manufactured, for example, by furnace brazing.

[0026] The plurality of multi-hole heat transfer tubes 60 and the plurality of fins 70 between the first header 11 and the second header 12 of the heat exchanger 1 function as the heat exchanging part 100. The heat exchange performed in the heat exchanger 1 is mainly performed in the heat exchanging part 100. The shape of the heat exchanging part 100 shown in Fig. 3 is configured to extend in the first direction dr1 and the second direction dr2. In other words, the heat exchanging part 100 in Fig. 3 has an I-shape when viewed in the first direction dr1. However, the shape of the heat exchanging part 100 is not limited to the shape shown in Fig. 3. The shape of the heat exchanging part 100 may be, for example, a shape that extends in the second direction dr2 when viewed in the first direction dr1 and then curves to extend in the third direction dr3. For example, the heat exchanging part 100 may have an L-shape, a U-shape, or a polygonal shape when viewed in the first direction dr1. The shape of the heat exchanging part 100 may be such that the flow of air passing through the heat exchanging part 100 is limited to one direction, or may be such that the flow of air passing through the heat exchanging part 100 is directed in multiple directions.

(2) Detailed configuration of header 10

[0027] Fig. 5 shows the header 10 disassembled into components and viewed obliquely. Fig. 6 shows the shape of a cross section of the header 10 perpendicular to the longitudinal direction (first direction dr1). In the following description of the header 10, the terms "first header 11" and "second header 12" are used only in a case where the first header 11 and the second header 12 need to be distinguished from each other.

(2-1) Components of header 10

[0028] The header 10 includes a first member 20 which is a main body member, a second member 30 which is a reinforcing member, a third member 40 which is a stiffening plate member, a fourth member 45 which is an insertion margin adjusting member, and a fifth member 50 which is a support. Although not shown in Fig. 5, the header 10 also includes closing plates disposed at both ends of the header 10 in the first direction dr1. The closing plates are attached to attachment holes 59 of the fifth member 50. The closing plates attached to the attachment holes 59 of the fifth member 50 close both ends of the main body internal space S1. In the header 10, the first member 20, the second member 30, the third member 40, the fourth member 45, and the fifth member 50 are joined together. The joining in the header 10 is, for example, fixing of members to each other by brazing. For example, the fifth member 50 is a cladding member, and a brazing material is supplied from the fifth member 50 to the first member 20, the second member 30, the third member 40, and the fourth member 45, whereby the members can be fixed to each other by brazing. For example, a cladding member may be used for all or some of the second member 30, the third member 40, and the fourth member 45 other than the fifth member 50. Moreover, a brazing material may be supplied from other than the second member 30, the third member 40, the fourth member 45, and the fifth member 50, for example. Further, here, the first member 20, the second member 30, the third member 40, and the fourth member 45 are fixed by being physically held by a claw portion 57 of the fifth member 50. Although the fixing by the claw portion 57 can be omitted, it is preferable to also perform the fixing by the claw portion 57 in order to withstand the use of the high-pressure refrigerant. However, the physical fixing method is not limited to the holding by the claw portion 57.

[0029] In a case where the fifth member 50 is a cladding member, the first member 20, the second member 30, the third member 40, and the fourth member 45 can be joined to each other even if they are made of, for example, aluminum or an aluminum alloy. In a case where the fifth member 50 is a cladding member, a member in which a portion excluding the brazing material is made of aluminum or an aluminum alloy, for example, can be used as the fifth member 50. In this way, in a case where aluminum or an aluminum alloy is used for the header 10, it is preferable to set the pressure of a refrigerant to smaller than 110 MPa. The first member 20 is formed by extrusion. In the extrusion, the first member 20 is formed by being extruded so that the cross-sectional shape is Ω-shaped. The first member 20 formed by such extrusion is an extruded member. Each of the second member 30, the third member 40, the fourth member 45, and the fifth member 50 is formed by, for example, pressing a metal plate. Here, the press working is processing of punching a metal plate to form a hole or bending a metal plate by a press machine.

(2-1-1) First member 20 (main body member)

[0030] Fig. 6 shows a cross-sectional shape of the first member 20 taken along a plane extending in the second direction dr2 and the third direction dr3. Moreover, Fig. 7 shows a state where the first member 20 in which the multi-hole heat transfer tubes 60 are fitted is cut along a plane extending in the second direction dr2 and the third direction dr3. Since the first member 20 extends in the first direction dr1, the longitudinal direction of the first member 20 coincides with the first direction dr1. As shown in Fig. 6 and Fig. 7, the main body internal space S1 of the first member 20 includes a columnar space S11 that is a portion having a circular cross-section and a first opening O1 that is a portion having a rectangular cross-section. The columnar space S11 and the first opening O1 are connected to each other, and both the columnar space S11 and the first opening O1 extend in the first direction dr1. The first member 20 includes a cylindrical portion 21 around the columnar space S11, and two flat plate portions 22 protruding from the cylindrical portion 21 in the third direction dr3. In other words, the flat plate portions 22 extend in the first direction dr1 and the third direction dr3. A cross section of the cylindrical portion 21 and the two flat plate portions 22 taken along a plane perpendicular to the first direction dr1 is an Ω-shape.

[0031] The first opening O1 has a width W1 in the third direction dr3. The width W1 of the first openings O1 is set, for example, within a range of 0.8 mm $\leq$ W1 $\leq$ 2.0 mm. The first opening O1 has a length L1 in the second direction dr2. The first opening O1 is an opening communicating with the holes 65 of the multi-hole heat transfer tube 60. Each flat plate portion 22 has a thickness T1 in the second direction dr2. The thickness T1 of the flat plate portion 22 is set, for example, within a range of 2 mm $\leq$ T1 $\leq$ 4.5 mm. In order to reduce a pressure receiving area of the first opening O1, the length L1 of the first opening O1 is set to be smaller than the thickness T1 of the flat plate portion 22.

(2-1-2) Second member 30 (reinforcing member)

[0032] The second member 30, which is a reinforcing member, is a flat plate having a plurality of second openings O2 arranged in the first direction dr1. The second member 30, which is a reinforcing member, has a function of alleviating the stress concentration occurring around the joint portion between the header 10 and the multi-hole heat transfer tube 60. The second member 30 and the flat plate portions 22 of the first member 20 are brazed to each other at the surfaces of the second member 30 and the flat plate portions 22 extending in the first direction dr1 and the third direction dr3. The thickness T2 of the second member 30 is set, for example, within a range of 2 mm $\leq$ T2 $\leq$ 4.5 mm. The second member 30 is manufactured by, for example, processing a metal flat plate of aluminum or an aluminum alloy by press working. In a case where the thickness T2 is in the above-described range, the second member 30 can be easily processed by press working. The second member 30 can be formed by punching out the portion of the second openings O2 from a metal flat plate by press working.

[0033] Each second opening O2 has a width W2 in the third direction dr3. The second opening O2 has an oval shape obtained by connecting two semi-circles with straight lines. In order to form the second opening O2 by press working, the width W2 of the second opening O2 is preferably 1.5 times or more the thickness T2. If the thickness T2 is 2 mm $\leq$ T2 $\leq$ 4.5 mm, for example, the width W2 of the second opening O2 is set within a range of 3 mm $\leq$ W2 $\leq$ 6.75 mm. In order to obtain a high pressure resistance strength, the width W2 of the second opening O2 is preferably narrow, and is preferably equal to or less than 10 mm. In order to prevent the first opening O1 from being blocked by the brazing material during brazing, the width W2 of the second opening O2 is preferably set to be equal to or more than the length obtained by adding a length of the brazing material protruding from the end of the second opening O2 (for example, equal to or more than 0.8 mm and equal to or less than 2 mm) to the width W1 of the first opening O1. For example, if the width W1 of the first opening O1 is 1.6 mm, the width W2 of the second opening O2 is preferably set within a range of 3.2 mm $\leq$ W2 $\leq$ 5.6 mm in consideration of the pressure resistance strength and the protrusion of the brazing material.

[0034] The length L2 of the second openings O2 in the first direction dr1 is, for example, longer than the length LB of the multi-hole heat transfer tube 60 in the first direction dr1 and shorter than twice the length LB (LB $\leq$ L2 $\leq$ {LB$\times$2}).

(2-1-3) Third member 40 (stiffening plate member)

[0035] The third member 40, which is a stiffening plate member, is a flat plate having a plurality of third openings O3 arranged in the first direction dr1. Each third opening O3 is oval. The third member 40, which is a stiffening plate member, is a member that is in contact with the distal ends of the multi-hole heat transfer tubes 60 fitted to the header 10 to allow all the holes 65 to communicate with the first opening O1. Surfaces of the second member 30 and the third member 40 extending in the first direction dr1 and the third direction dr3 are brazed to each other. The thickness T3 of the third member 40 is set, for example, within a range of 2 mm $\leq$ T3 $\leq$ 4.5 mm. The third member 40 is manufactured by, for example, processing a metal flat plate of aluminum or an aluminum alloy by press working. If the thickness T3 is in the above-described range, the third member 40 can be easily processed by press working. The third member 40 can be formed by punching out the portion of the third openings O3 from the metal flat plate by press working.

[0036] Each third opening O3 has a width W3 in the third direction dr3.

[0037] In order to form the third opening O3 by press working, the width W3 of the third opening W3 is preferably 1.5 times or more the thickness T3. The width W3 of the third opening O3 is set to be shorter than the length LA of the multi-hole heat transfer tube 60. However, in order to allow all the holes 65 of the multi-hole heat transfer tube 60 to communicate with the third opening O3, the width W3 is set such that the ends of the third opening O3 are located outside the width W6 (see Fig. 7) including the outermost holes 65. In order to obtain a high pressure resistance strength, the width W3 of the third opening O3 is preferably narrow. In order to prevent the second opening O2 from being narrowed by the brazing material during brazing, the width W3 of the third opening O3 is preferably set to equal to or more than the length obtained by adding a length of the brazing material protruding from the ends of the third opening O3 (for example, equal to or more than 0.8 mm and equal to or less than 2 mm) to the width W2 of the second opening O2. In addition, it is preferable that the length from the hole 65 of the multi-hole heat transfer tube 60 to the end of the third opening O3 is longer than the protruding length of the brazing material.

[0038] The length L3 of the third openings O3 in the first direction dr1 is, for example, longer than the length LB of the multi-hole heat transfer tube 60 in the first direction dr1 and shorter than three times the length LB ($LB \leq L2 \leq \{LB \times 3\}$).

(2-1-4) Fourth member 45 (insertion margin adjusting member)

[0039] The fourth member 45, which is an insertion margin adjusting member, is a flat plate having a plurality of fourth openings O4 arranged in the first direction dr1. Each fourth opening O4 is oval. The fourth member 45, which is an insertion margin adjusting member, is a member for determining the length (insertion margin) from the fifth member 50, which is a support, to the distal end of the header 10. Surfaces of the third member 40 and the fourth member 45 extending in the first direction dr1 and the third direction dr3 are brazed to each other. The multi-hole heat transfer tube 60 is brazed to the inner surface of the fourth opening O4. The thickness T4 of the fourth member 45 is set, for example, within a range of 2 mm $\leq$ T4 $\leq$ 4.5 mm. The fourth member 45 is manufactured by, for example, processing a metal flat plate of aluminum or an aluminum alloy by press working. If the thickness T4 is in the above-described range, the fourth member 45 can be easily processed by press working. The fourth member 45 can be formed by punching out the portion of the fourth openings O4 from the metal flat plate by press working.

[0040] Each fourth opening O4 has a width W4 in the third direction dr3. In order to form the fourth opening O4 by press working, the width W4 of the fourth opening O4 is preferably 1.5 times or more the thickness T4. The width W4 of the fourth opening O4 is set to be longer than the length LA of the multi-hole heat transfer tube 60. The width W4 of the fourth opening O4 is preferably close to the length LA of the multi-hole heat transfer tube 60 so that side surfaces 60s of the multi-hole heat transfer tube 60 and the inner surface of the fourth opening O4 are brazed to each other.

[0041] The length L4 of the fourth opening O4 in the first direction dr1 is, for example, longer than the length LB of the multi-hole heat transfer tube 60 in the first direction dr1 and shorter than three times the length LB ($LB \leq L2 \leq \{LB \times 3\}$).

(2-1-5) Fifth member 50 (support)

[0042] The fifth member 50, which is a support, has a plurality of fifth openings O5 arranged in the first direction dr1. Each fifth opening O5 is oval. The fifth member 50 has a shape in which both ends of a flat plate in the third direction dr3 are bent in the second direction dr2. Thus, a cross section of the fifth member 50 taken along a plane orthogonal to the first direction dr1 is C-shaped. With the C-shape, the fifth member 50 can be in contact with the flat plate portions 22 of the first member 20, the second member 30, and the third member 40. The fifth member 50 includes a heat transfer tube support portion 51 in which a plurality of fifth openings O5 are formed, and a first side portion 52 and a second side portion 53 that are in contact with the flat plate portions 22 of the first member 20, the second member 30, and the third member 40 (see Fig. 7). The heat transfer tube support portion 51, the first side portion 52, and the second side portion 53 each have a flat plate shape.

[0043] The fifth member 50, which is a support, is a member that supports the multi-hole heat transfer tube 60 fitted in the fifth opening O5 by the inner surface of the fifth opening O5. The entire inner surface of the fifth opening O5 is brazed to the outer peripheral surface of the multi-hole heat transfer tube 60. Such brazing prevents a refrigerant from leaking from the boundary between the fifth member 50 and the multi-hole heat transfer tube 60. Surfaces of the fourth member 45 and the heat transfer tube support portion 51 of the fifth member 50 extending in the first direction dr1 and the third direction dr3 are brazed to each other. The first side portion 52 is brazed to one side surface 22s of the flat plate portion 22 of the first member 20, one side surface 30s of the second member 30, one side surface 40s of the third member 40, and one side surface 45s of the fourth member 45. Similarly, the second side portion 53 is brazed to the other side surface 22s of the flat plate portion 22 of the first member 20, the other side surface 30s of the second member 30, the other side surface 40s of the third member 40, and the other side surface 45s of the fourth member 45.

[0044] The thickness T5 of the fifth member 50 is set, for example, within a range of 2 mm $\leq$ T5 $\leq$ 4.5 mm. The fifth member 50 is manufactured by, for example, processing a metal flat plate of aluminum or an aluminum alloy by press working. If the thickness T5 is in the above-described range, the fifth member 50 can be easily processed by press working. The fifth member 50 can be formed by punching out the portion of the fifth openings O5 and the portion of an attachment hole 59 from the metal flat plate by press working, and then bending the portions corresponding to the first side portion 52 and the second side portion 53 by press working.

[0045] Each fifth opening O5 has a width W5 in the third direction dr3. In order to form the fifth opening O5 by press working, the width W5 of the fifth opening O5 is preferably equal to or more than 1.5 times the thickness T5. The width W5 of the fifth opening O5 is set to coincide with the length LA of the multi-hole heat transfer tube 60. However, the outer shape of the multi-hole heat transfer tube 60 is set to be slightly smaller than the shape of the fifth opening O5 so that the multi-hole heat transfer tube 60 is smoothly inserted into the fifth opening O5 when the multi-hole heat transfer tube 60 is assembled. Therefore, the length L5 of the fifth opening O5 in the first direction dr1 coincides with the length LB of the multi-hole heat transfer tube 60 in the first direction dr1.

(2-1-6) Ratio between widths of openings

[0046] In order to prevent the width W1 of the first opening O1 of the first member 20 from being blocked by brazing, the width W2 of the second opening O2 of the second member 30 is preferably equal to or larger than a value obtained by adding twice the protruding length La of the brazing material (Lαx2) to the width W1. For example, in a case where the width O1 of the first opening W1 is 1.6 mm and the protruding length La of the brazing material is 0.8 mm to 2 mm, the width W2 of the second opening O2 is preferably set to 3.2 mm to 5.6 mm or more. From the viewpoint of brazing, it is preferable to set the ratio between W1 and W2 so as to be $2/1 \leq W2/W1$ if the width W2 is 3.2 mm, and so as to be $3.5/1 \leq W2/W1$ if the width W2 is 5.6 mm. If the width W2 of each second opening O2 is larger than twice the width W1 of the first opening O1, the first opening O1 is less likely to be narrowed by brazing when the first member 20 and the second member 30 are brazed. In addition, even if the first member 20 and the second member 30 are misaligned and brazed at the time of manufacturing, it is possible to prevent the first opening O1 from being narrowed by the second member 30.

[0047] As the second member 30, which is a reinforcing member, a metal plate made of aluminum or an aluminum alloy having a plate thickness (thickness) of 2 mm to 4.5 mm is usually used. In order to press such a second member 30, the width W2 is preferably 1.5 times or more the plate thickness of the metal plate. Therefore, in general, it is preferable that the width W2 is set to be equal to or more than 3 mm if the plate thickness is 2 mm, and is set to be equal to or more than 6.75 mm if the plate thickness is 4.5 mm. From the viewpoint of the relationship between the plate thickness of the metal plate and the width W2, the ratio between W1 and W2 is preferably set so as to be, for example, $1.88/1 \leq W2/W1$ if the width W1 of the first opening O1 is 1.6 mm and the plate thickness is 2 mm, and so as to be $4.2/1 \leq W2/W1$ if the plate thickness is 4.5 mm.

[0048] From the viewpoint of the pressure resistance strength, the width W2 of the second openings O2 is preferably equal to or less than 10 mm. Therefore, if the width W1 of the first opening O1 is 1.6 mm, for example, it is preferable to set the ratio between W1 and W2 so as to be $W2/W1 \leq 6.25/1$.

[0049] With the consideration as described above on the width W1 of the first opening O1 that is usually used, it is preferable that the width W1 satisfies the condition of $2/1 \leq W2/W1 \leq 6/1$, and it is more preferable that the width W1 satisfies the condition of $2.5/1 \leq W2/W1 \leq 4/1$.

[0050] The width W3 of each third opening O3 in the third direction is larger than twice the width W2 of each second opening O2 in the third direction. In other words, the width W2 of each second opening O2 is smaller than half the width W3 of each third opening O3 ($W2/W3 \leq 1/2$) . With the setting satisfying $W2/W3 \leq 1/2$, it is possible to suppress deterioration of the reinforcing effect of the second member 30, as compared with a case where the width W2 of each second opening O2 is larger than half the width W3 of each third opening O3. For example, when the width W3 of the third opening O3 is the same as the width W2 of the second opening O2, it is not possible to obtain the effect of alleviating stress concentration by providing the second member 30 having the second opening O2.

(3) Characteristics

[0051] (3-1)

The heat exchanger 1 of the above-described embodiment includes the second member 30 with the plurality of second openings O2 each having the width W2 larger than the width W1 of the first opening O1 in the third direction dr3. With the second member 30, stress concentration on the joint portion between the multi-hole heat transfer tube 60 and the header 10 can be alleviated, thus improving the pressure resistance strength of the heat exchanger 1.

[0052] The improvement of the pressure resistance strength in the heat exchanger 1 will be described with reference to Fig. 8 to Fig. 14. Fig. 8 shows a part of the multi-hole heat transfer tube 60 and a part of the header 10 cut along a plane passing through the center of the multi-hole heat transfer tube 60 in the third direction dr3 and the center axis of the columnar space S11 of the header 10 in the above-described embodiment. Fig. 9 shows the periphery of one multi-hole heat transfer tube 60 in the part of the header 10 shown in Fig. 8. Fig. 10 shows a stress-concentrated portion Ar1 indicated by hatching where particularly high stress is generated in a simulation result in a case where a high-pressure refrigerant is caused to flow through the header 10 and the multi-hole heat transfer tube 60.

[0053] A header 210 shown in Fig. 11 to Fig. 14 has a configuration in which the second member 30 as a reinforcing member is removed from the header 10 of the embodiment. Fig. 11 shows the header 210 disassembled and viewed obliquely. The first member 20, the third member 40, the fourth member 45, and the fifth member 50 shown in Fig. 11 are the same members as the members with the same reference numerals described in the above embodiment. As shown in Fig. 11, in the header 210, the third member 40 is brazed to the surface of the first member 20 extending in the first direction dr1 and the third direction dr3. Fig. 12 shows a part of the multi-hole heat transfer tube 60 and a part of the header 210 cut along a plane passing through the center of the multi-hole heat transfer tube 60 in the third direction dr3 and the center axis of the cylindrical space S11 of the header 210 to be compared. Fig. 13 shows the periphery of one multi-hole heat transfer tube 60 in the part of the header 210 shown in Fig. 12. Fig. 14 shows a stress-concentrated portion Ar2 indicated by hatching where particularly high stress is generated in a simulation result in a case where a high-pressure refrigerant is caused to flow through the header 210 and the multi-hole heat transfer tube 60. The simulation results shown in Fig. 10 and Fig. 14 are results obtained by performing simulations under the same conditions except the shapes of the headers 10, 210.

[0054] As can be seen from comparison between Fig. 10 and Fig. 14, when a high-pressure refrigerant is caused to flow, stress-concentrated portions Ar1, Ar2 where particularly high stress is generated occurring around the first opening O1 of the headers 10, 210. In the header 210, a stress-concentrated portion Ar2 where particularly high stress is generated also occurring around the joint portion between the multi-hole heat transfer tube 60 and the header 210. However, in the header 10, a stress-concentrated portion Ar1 where particularly high stress is generated not occurring around the joint portion between the multi-hole heat transfer tube 60 and the header 10. The simulation results shown in Fig. 10 and Fig. 14 indicate the function of the second member 30 as a reinforcing member alleviating stress around the joint portion between the multi-hole heat transfer tube 60 and the header 10.

(3-2)

[0055] In a case where the first member 20 of the above-described embodiment is an extruded member extruded so as to have an Ω-shaped cross section, the extruded member formed by extrusion can be used as it is for the first member 20 having a complicated shape. With the use of an extruded member for the first member 20 having a complicated shape, it is possible to save time and effort for manufacturing the heat exchanger 1 and to suppress the manufacturing cost to be low.

(3-3)

[0056] As shown in Fig. 6, the first member 20 has the flat plate portions 22 having a flat plate-shape and having a thickness T1 larger than the length L1 of the first opening O1 in the second direction dr2. Since the thickness T1 of the flat plate portions of the first member 20 is larger than the length L1 of the first opening O1 in the second direction dr2, the pressure receiving area that receives pressure from a refrigerant can be made smaller as compared with a case where the thickness T1 of the flat plate portions 22 is the same as the length L1 of the first opening O1 in the second direction dr2. In this way, in the heat exchanger 1 in which the thickness T1 of the flat plate portions 22 is larger than the length L1 of the first opening O1 in the second direction dr2, a pressure resistance strength can be ensured easily.

(3-4)

[0057] If the width W2 of each second opening O2 of the second member 30 is larger than twice the width W1 of the first opening O1 of the first member 20, the first opening O1 is less likely to be narrowed by brazing when the first member 20 and the second member 30 are brazed.

(3-5)

[0058] With the width W2 of each second opening O2 smaller than half the width W3 of each third opening O3, it is possible to suppress deterioration of the reinforcing effect of the second member 30, as compared with a case where the width W2 is larger than half the width W3.

(4) Modification

(4-1) Modification A

[0059] In the above-described embodiment, in the heat exchanger 1, the air to be heat-exchanged passes through only one heat exchanging part 100, as shown in Fig. 2. However, the number of heat exchanging parts 100 through which the air to be heat-exchanged passes is not limited to one. For example, two structures shown in Fig. 2 may be arranged double in the third direction dr3 to form one heat exchanger 1.

(4-2) Modification B

[0060] In the above-described embodiment, the case where the first member 20 is an extruded member has been described. However, the first member 20 is not necessarily formed by extrusion, and may be formed by another method.

(4-3) Modification C

[0061] In the above-described embodiment, the case where the heat exchanger 1 is manufactured by brazing in a furnace has been described. However, the members forming the heat exchanger 1 may be joined to each other by a method other than furnace brazing. For example, the members forming the heat exchanger 1 may be joined to each other by welding.

(4-4) Modification D

[0062] In the above-described embodiment, the case where each component of the header 10 is made of aluminum or an aluminum alloy has been described. However, any or all of the components of the header 10 may be made of a metal other than aluminum or an aluminum alloy.

(4-5) Modification E

[0063] In the above-described embodiment, the case where the heat exchanger 1 is an air heat exchanger that exchanges heat between the refrigerant and the air. However, the heat exchanger 1 is not necessarily limited to an air heat exchanger. The heat exchanger 1 may be configured to exchange heat between the refrigerant and another heat medium.

(4-6) Modification F

[0064] In the above-described embodiment, the case where the fin 70 has a plurality of notches 75 and the multi-hole heat transfer tube 60 is inserted into each of the notches 75 has been described. However, other forms of fin may be used for the fin 70. For example, the fin 70 may have a plurality of through holes arranged in the first direction dr1, and the multi-hole heat transfer tubes 60 may be inserted into the through holes. The header 10 can also be applied to a heat exchanger of a type without the fin 70.

(4-7) Modification G

[0065] In the above-described embodiment, the case where the high-pressure refrigerant flowing through the heat exchanger 1 is the CO_2 refrigerant (carbon dioxide refrigerant) has been described. However, the refrigerant flowing through the heat exchanger 1 is not necessarily limited to CO_2 refrigerant and may be other refrigerants.

(4-8) Modification H

[0066] In the above-described embodiment, the case where one fourth member 45 as an insertion margin adjusting member is provided has been described. However, the number of the fourth members 45 is not limited to one, and may be two or more.

(4-9) Modification I

[0067] In the above-described embodiment, the case where the second opening O2, the third opening O3, the fourth opening O4, and the fifth opening O5 have an oval shape has been described. However, the shapes of the second opening O2, the third opening O3, the fourth opening O4, and the fifth opening O5 are not limited to an oval shape. The shapes of the second opening O2, the third opening O3, the fourth opening O4, and the fifth opening O5 may be, for example, an elliptical shape, a rectangle shape, or a trapezoid shape.

[0068] While embodiments of the present disclosure have been described above, it will be understood that various changes in forms and details may be made therein without departing from the spirit and scope of the present disclosure as set forth in the appended claims.

Reference Signs List

[0069]

1	heat exchanger
10	header
20	first member
21	cylindrical portion
22	flat plate portion
30	second member
40	third member
45	fourth member
50	fifth member
60	multi-hole heat transfer tube
65	hole
O1	first opening
O2	second opening
O3	third opening
O4	fourth opening
O5	fifth opening

Citation List

Patent Literature

[0070] PTL 1: International Publication No. 2016/152127

Claims

1. A heat exchanger (1), comprising:

a header (10) that extends in a first direction and has an inside where a refrigerant flows; and
a plurality of multi-hole heat transfer tubes (60) inserted into the header in a second direction intersecting the first direction, each of the multi-hole heat transfer tubes having a flat shape in which a width in a third direction intersecting the first direction is larger than a height in the first direction at a portion inserted into the header and including a plurality of holes (65) communicating with the inside of the header, wherein
the header includes
a first member (20) that includes a first opening (O1) extending in the first direction and having an Ω-shaped cross section perpendicular to the first direction,

a second member (30) that includes a plurality of second openings (O2) each having a larger width than the first opening in the third direction, and

a third member (40) that includes a plurality of third openings (O3) each having a larger width than the plurality of second openings in the third direction and communicating with the plurality of multi-hole heat transfer tubes, and with which the plurality of multi-hole heat transfer tubes are in contact, and

the first member, the second member, and the third member are disposed in an order of the first member, the second member, and the third member, and are joined such that each of the second openings overlaps each of the third openings within a range of a width of each of the third openings in the third direction, and the first opening overlaps each of the second openings within a range of a width of each of the second openings in the third direction.

2. The heat exchanger (1) according to claim 1, wherein the first member is an extruded member extruded so as to have an Ω-shaped cross section.

3. The heat exchanger (1) according to claim 1 or 2, wherein the first member includes a flat plate portion (22) having a flat plate-shape in which a thickness is larger than a length of the first opening in the second direction.

4. The heat exchanger (1) according to any one of claims 1 to 3, wherein the first member in the header and the plurality of multi-hole heat transfer tubes are made of aluminum or an aluminum alloy.

5. The heat exchanger (1) according to any one of claims 1 to 4, wherein the refrigerant flowing through the inside of the header is a carbon dioxide refrigerant.

6. The heat exchanger (1) according to any one of claims 1 to 5, further comprising:

a fourth member (45) that includes a plurality of fourth openings (O4) through which the plurality of multi-hole heat transfer tubes pass and is joined to the third member; and

a fifth member (50) that includes a plurality of fifth openings (O5) through which the plurality of multi-hole heat transfer tubes fit and penetrate and is joined to side surfaces of the first member, the second member, and the third member, and to the fourth member.

7. The heat exchanger (1) according to any one of claims 1 to 6, wherein a width of each of the second openings in the third direction is larger than twice a width of the first opening in the third direction.

8. The heat exchanger (1) according to any one of claims 1 to 7, wherein a width of each of the third openings in the third direction is larger than twice a width of each of the second openings in the third direction.

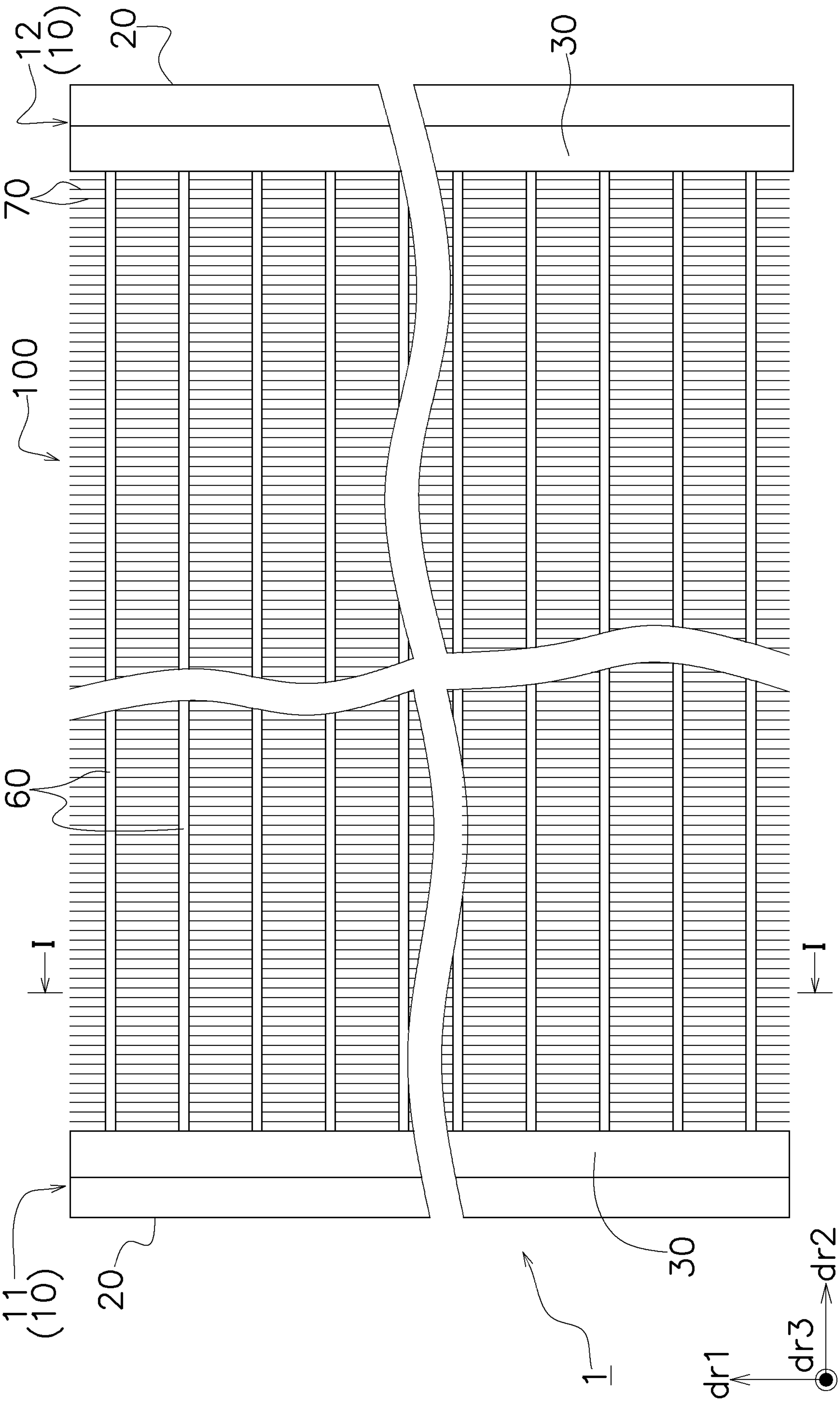


FIG. 1

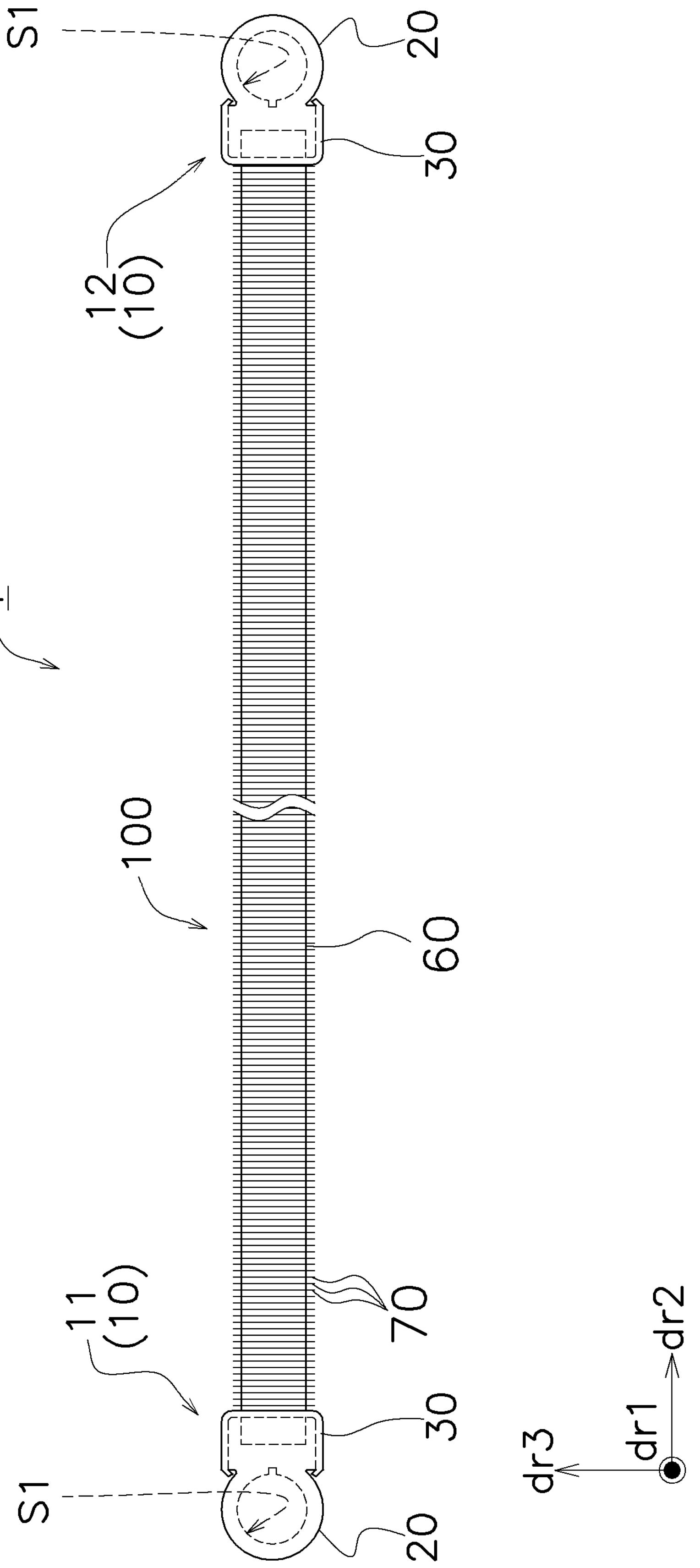


FIG. 2

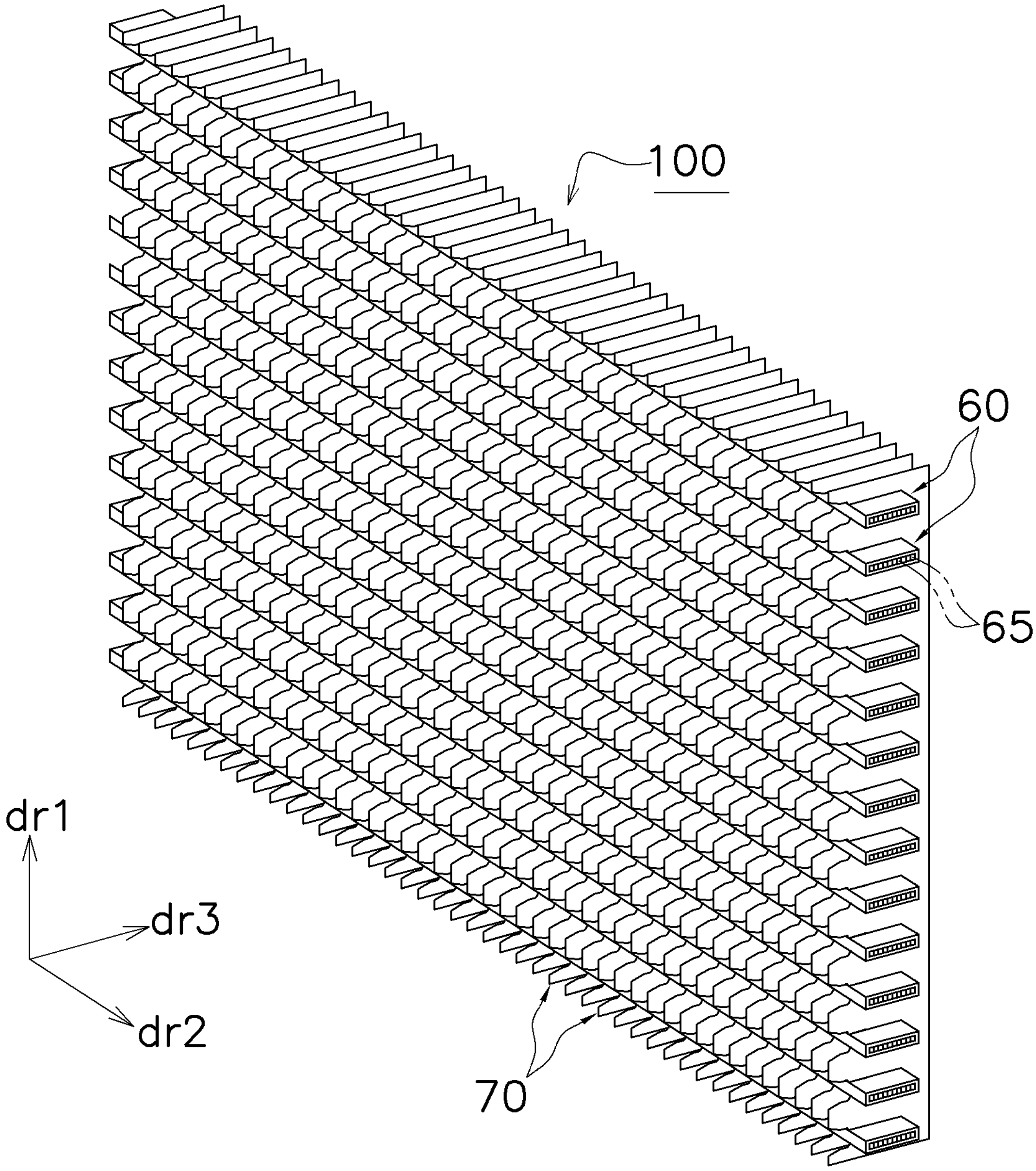


FIG. 3

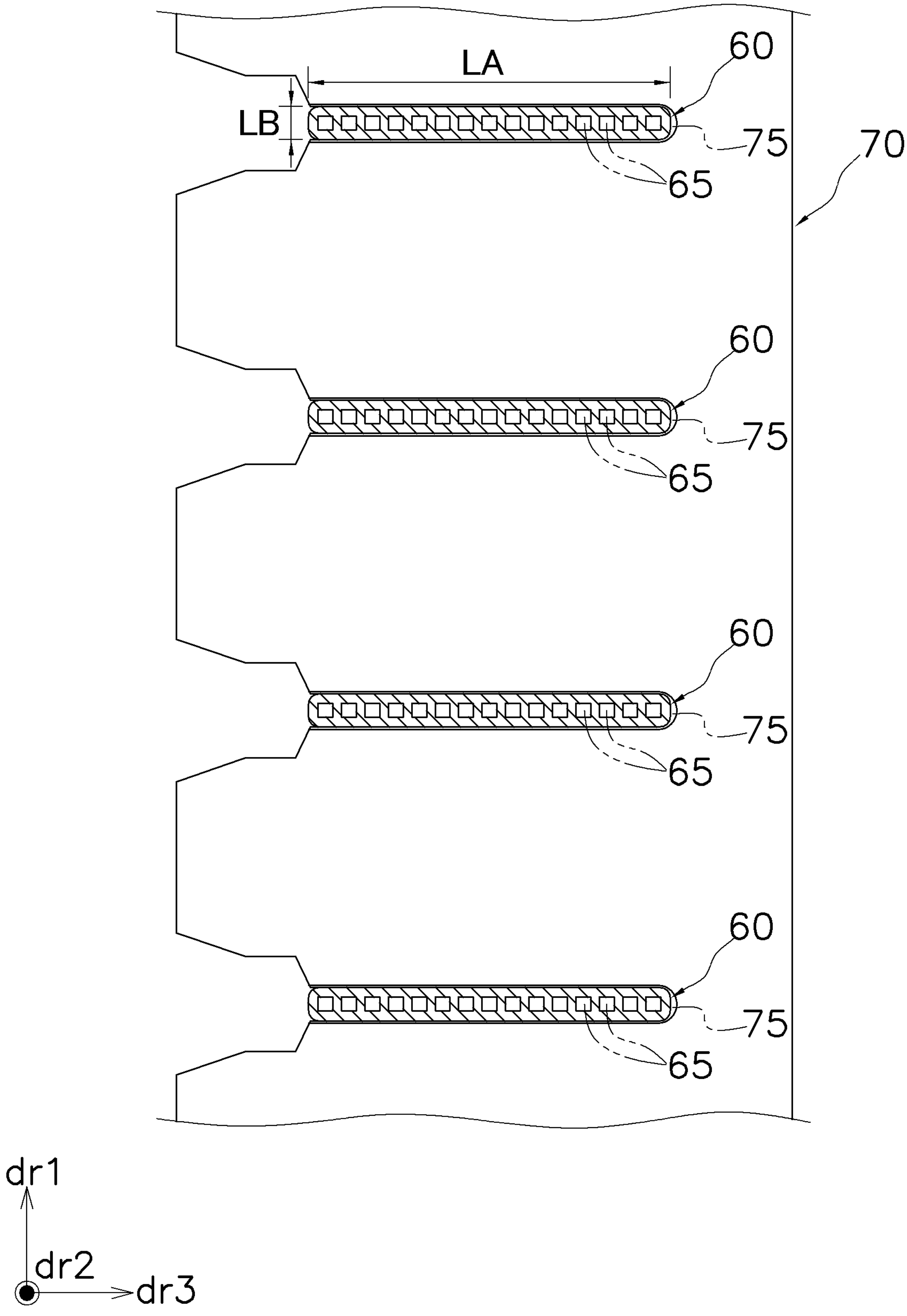


FIG. 4

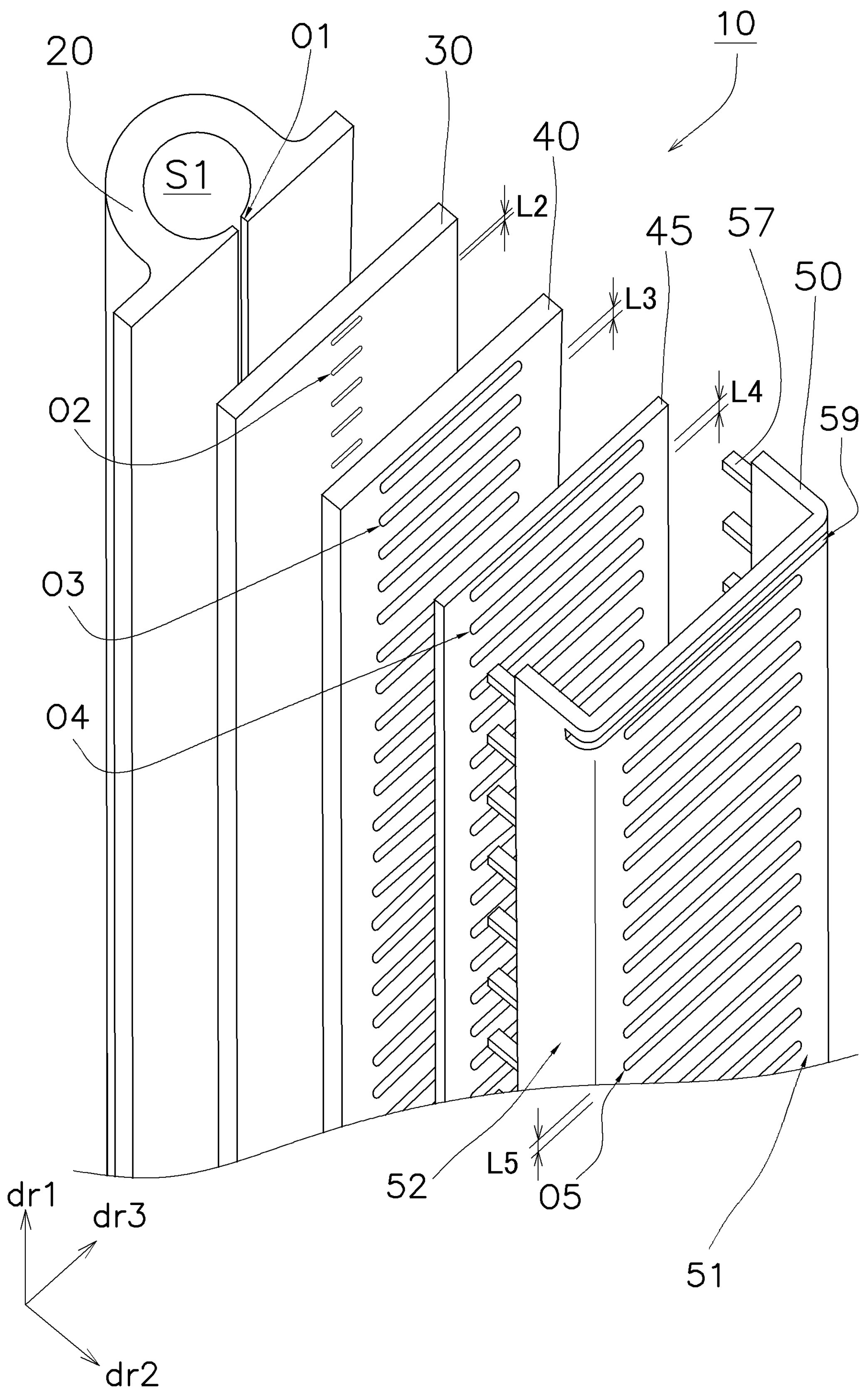
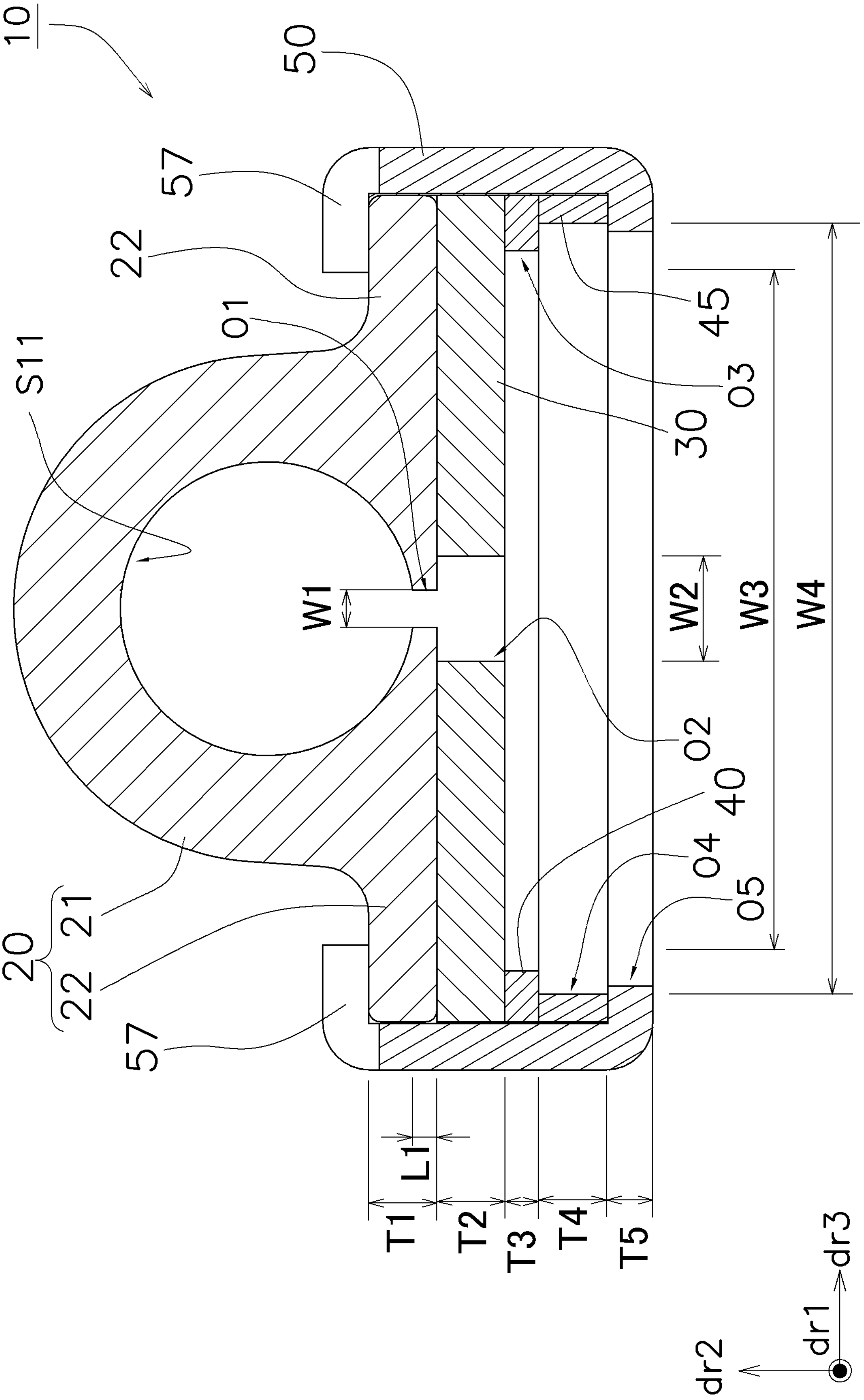


FIG. 5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dr1
dr2
dr3

FIG. 6

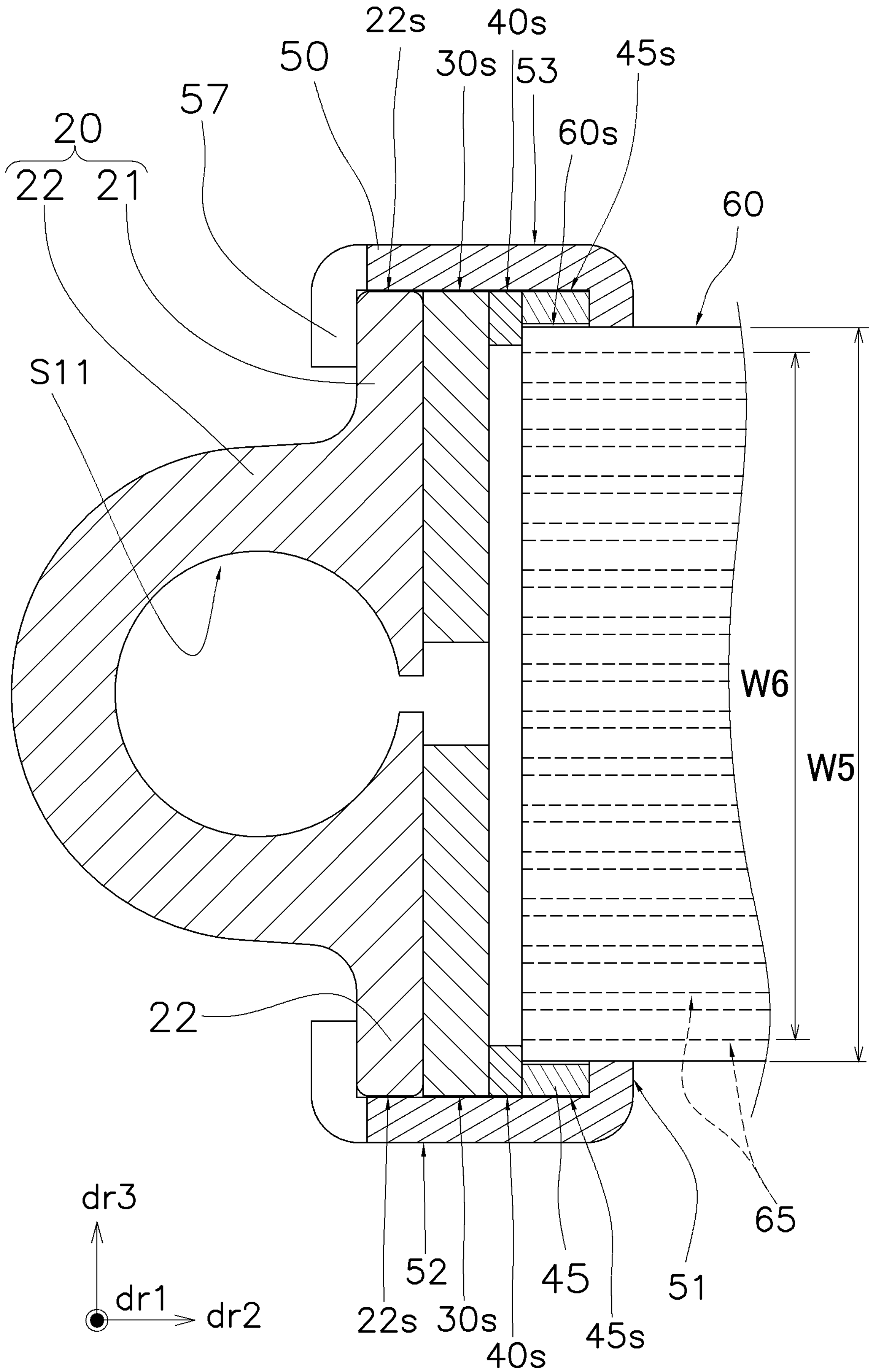
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FIG. 7

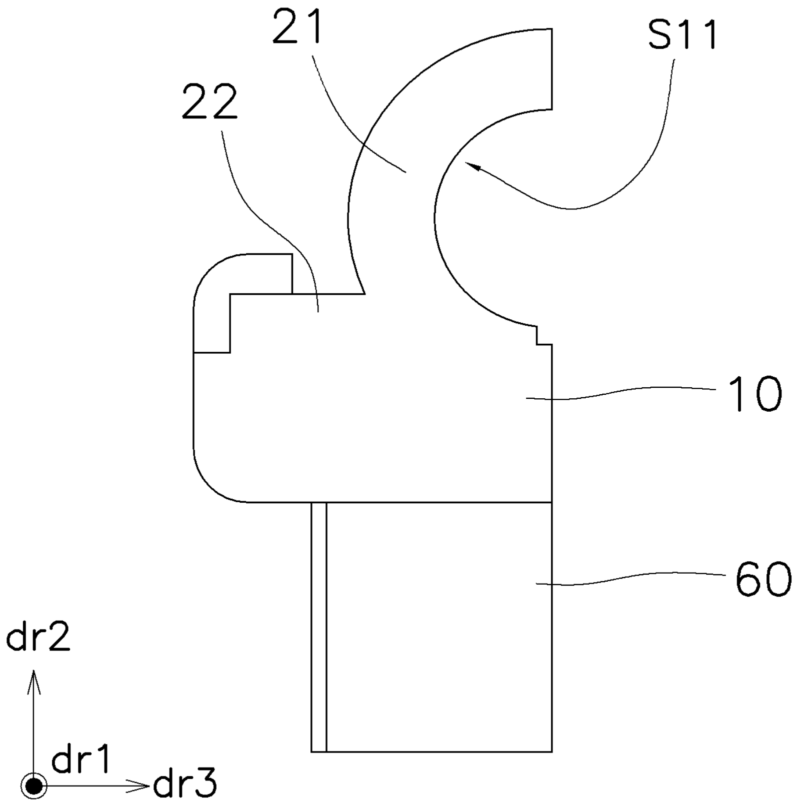

FIG. 8

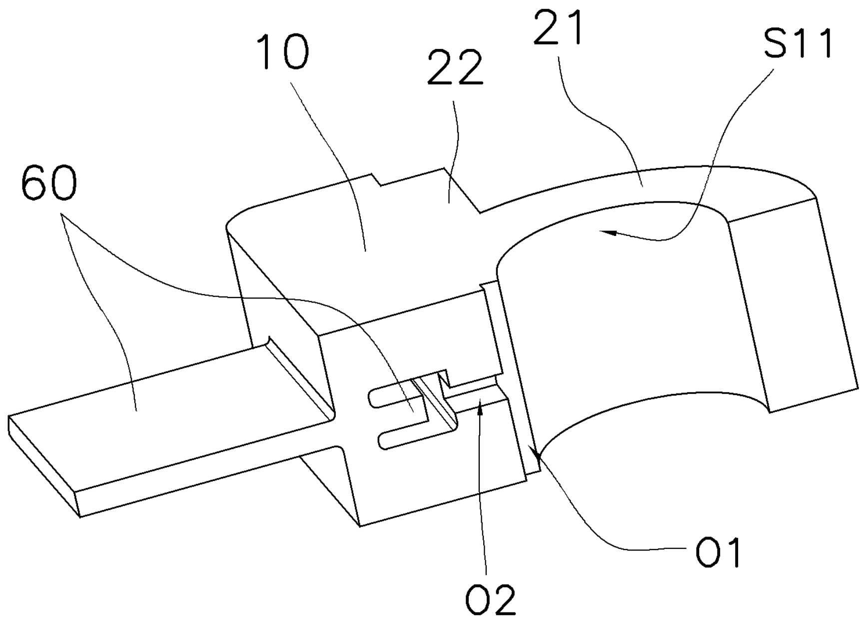

FIG. 9

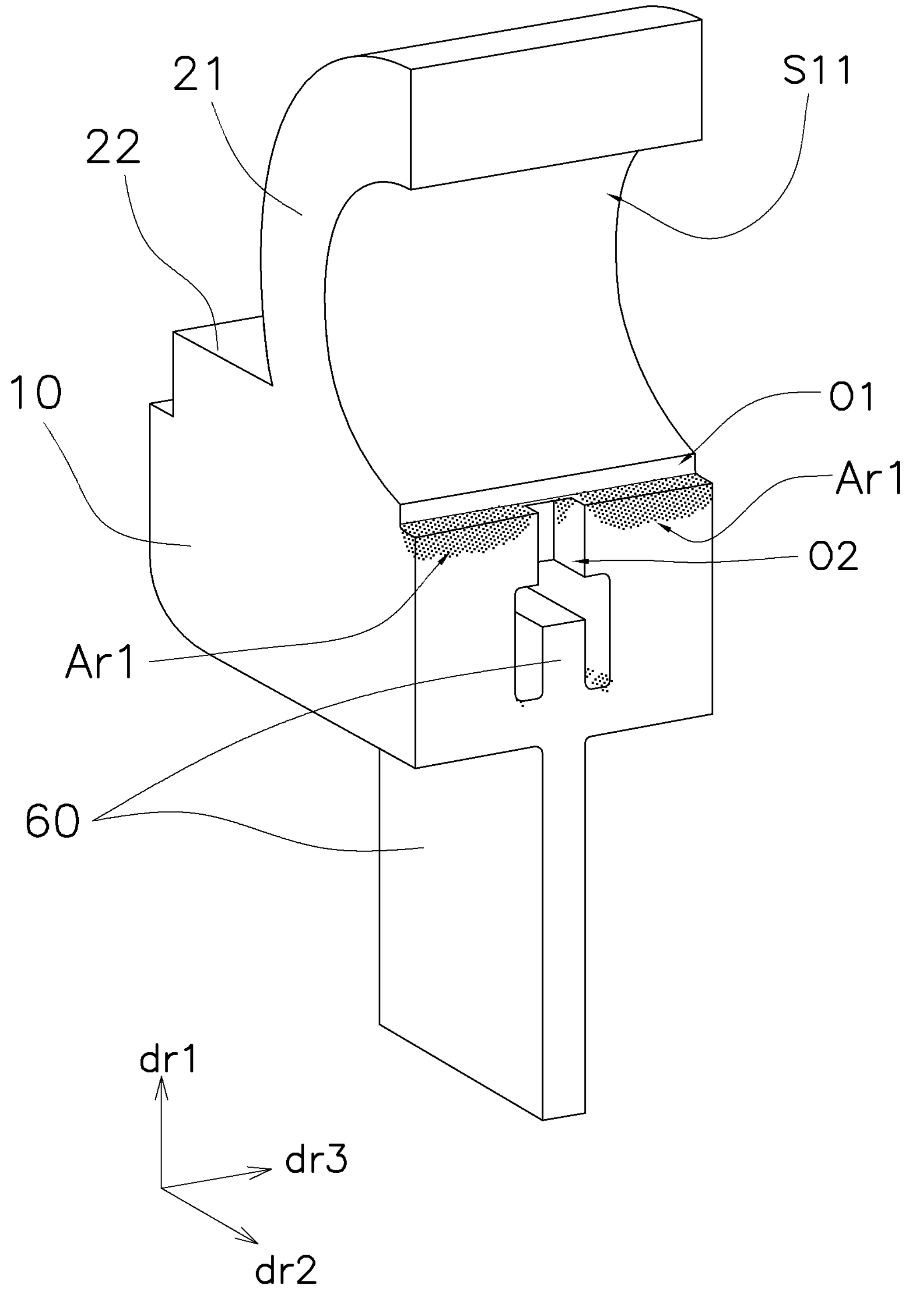

FIG. 10

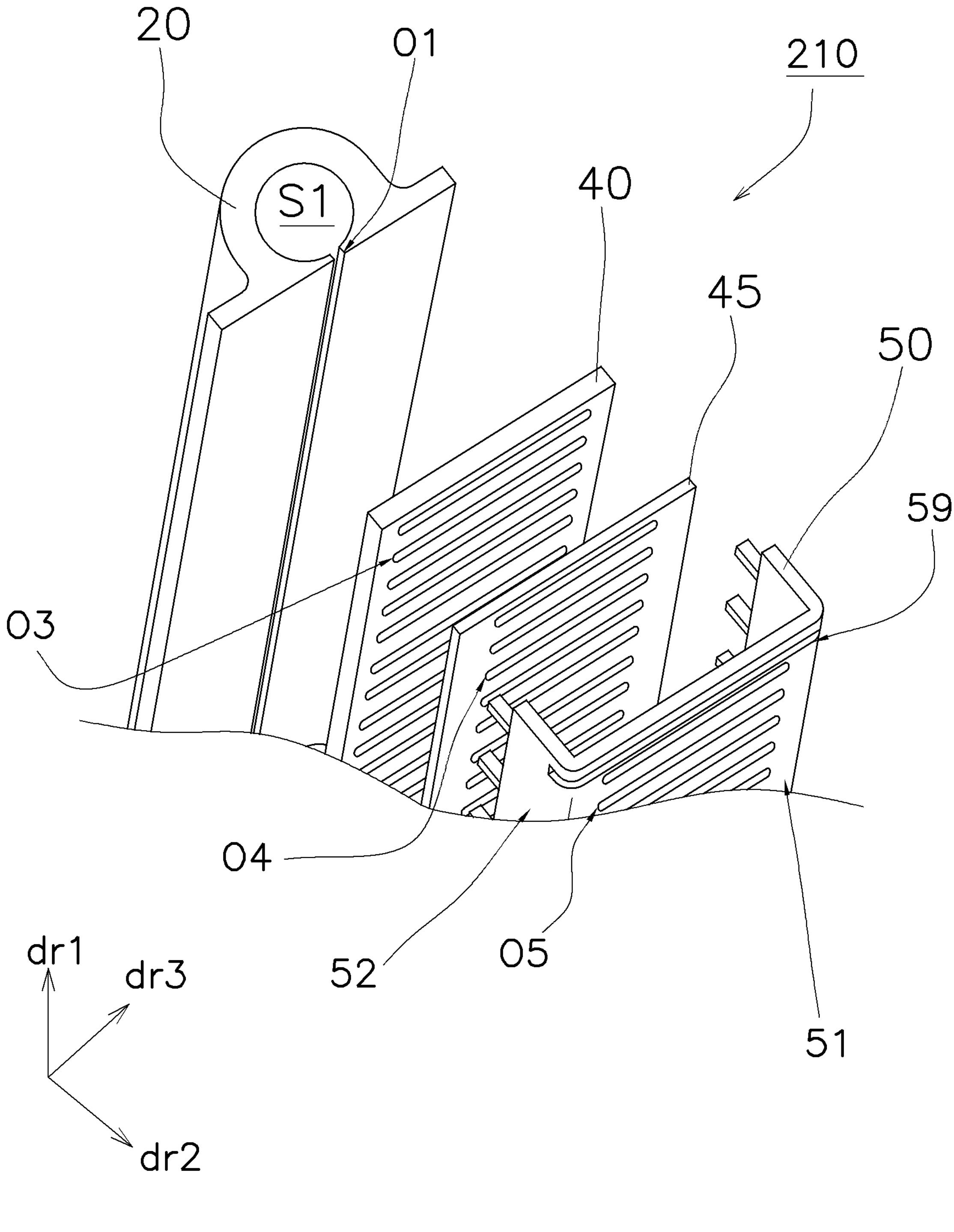

FIG. 11

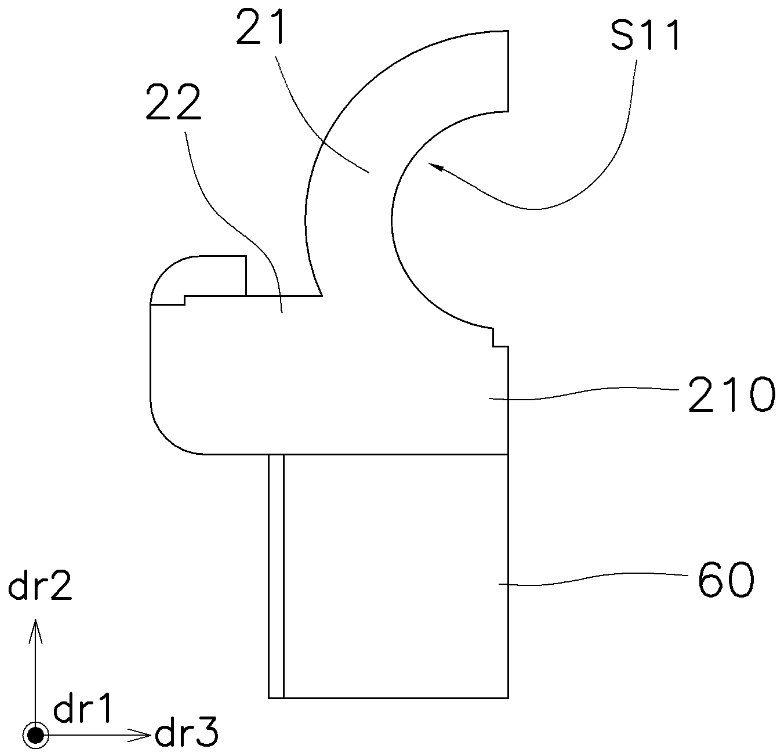

FIG. 12

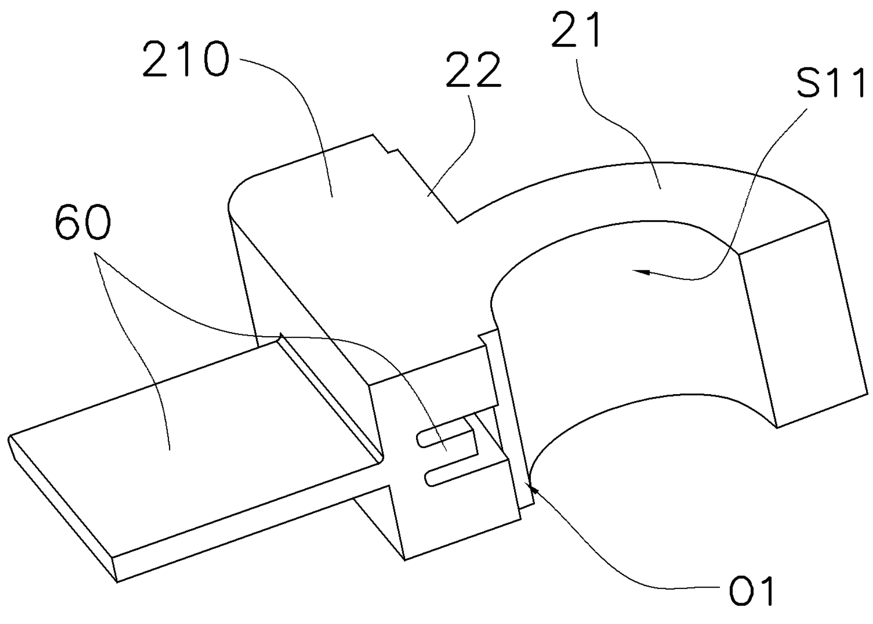

FIG. 13

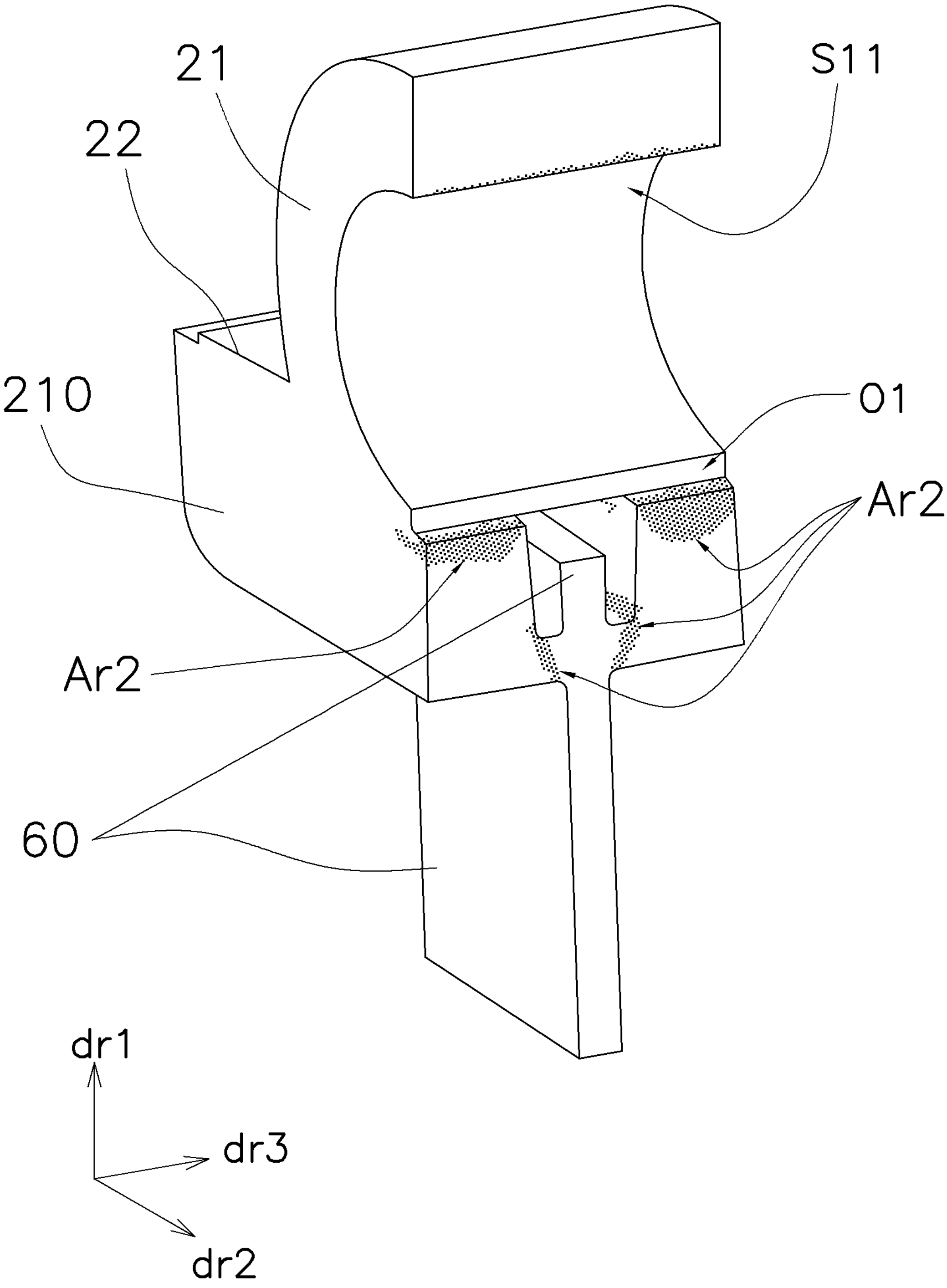

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/039233

A. CLASSIFICATION OF SUBJECT MATTER

F28F 9/02(2006.01)i; ***F28D 1/053***(2006.01)i; ***F28F 21/08***(2006.01)i
FI: F28F9/02 301A; F28F21/08 A; F28D1/053 A

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F1/00-99/00; F28D1/00-13/00; F25B39/00-39/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2020-56518 A (DAIKIN INDUSTRIES, LTD.) 09 April 2020 (2020-04-09) particularly, paragraphs [0025]-[0101], fig. 1-12	1-2, 4-8 3
Y	WO 2015/063875 A1 (MITSUBISHI ELECTRIC CORPORATION) 07 May 2015 (2015-05-07) particularly, paragraphs [0011]-[0050], fig. 6	1-2, 4-8
Y	JP 2012-93075 A (DAIKIN INDUSTRIES, LTD.) 17 May 2012 (2012-05-17) particularly, paragraphs [0140]-[0148], fig. 18, 19	6-8
Y	JP 2013-249993 A (DAIKIN INDUSTRIES, LTD.) 12 December 2013 (2013-12-12) particularly, paragraphs [0045]-[0047], fig. 5, 6	6-8

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2023	**09 January 2024**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/039233

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2020-56518 A	09 April 2020	(Family: none)	
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