(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 767 790 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
20.08.2014 Bulletin 2014/34

(21) Application number: **12839875.7**

(22) Date of filing: **12.10.2012**

(51) Int Cl.:
F28F 1/32 *(2006.01)*

(86) International application number:
PCT/JP2012/006562

(87) International publication number:
WO 2013/054540 (18.04.2013 Gazette 2013/16)

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **14.10.2011 JP 2011227334**

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(54) FINNED TUBE HEAT EXCHANGER

(57) A fin tube heat exchanger (100) includes a plurality of fins (31) arranged in parallel and a heat transfer tube (21) configured to allow a medium to flow through the heat transfer tube to exchange heat with air. Each of the fins (31) is a corrugated fin formed to have a peak portion (34) at at least one position in an air flow direction, and has a tube surrounding portion (35 or 37) formed around the heat transfer tube (21), a first inclined portion (38) inclined with respect to the air flow direction to form the peak portion (34), a second inclined portion (39) connecting the tube surrounding portion (35) and the first inclined portion (38) to each other, and a slit (23) formed in the second inclined portion (39).

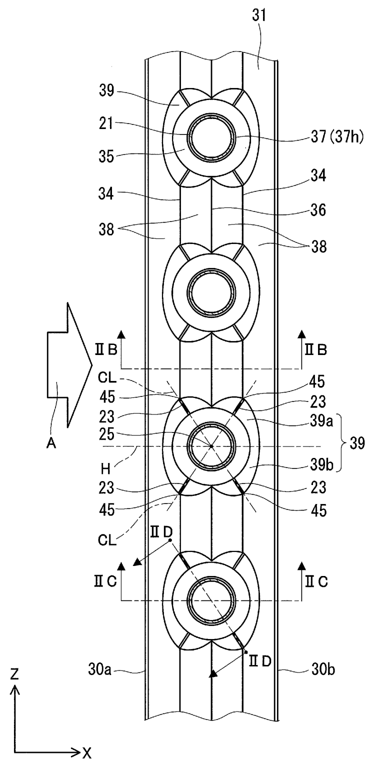

FIG.2A

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Description

TECHNICAL FIELD

[0001] The present invention relates to fin tube heat exchangers.

BACKGROUND ART

[0002] A fin tube heat exchanger includes a plurality of fins arranged at a predetermined spacing and a heat transfer tube penetrating the fins. Air flows between the fins and exchanges heat with a fluid in the heat transfer tube.

[0003] FIG. 15 is a plan view of a fin used in a conventional fin tube heat exchanger. A fin 1 is formed to have a peak portion 4 and a valley portion 6 alternately in the air flow direction. This type of fin is commonly called a "corrugated fin". The corrugated fin is effective not only in increasing the heat transfer area but also in reducing the thickness of the thermal boundary layer by allowing the flow of air 3 to meander.

[0004] One common technical problem of fin tube heat exchangers is a problem associated with drainage performance. Since efficient heat exchange is inhibited when water (condensed water) is adsorbed on the surface of the fin, it is desirable to immediately remove the water from the surface of the fin. For example, Patent Literature 1 describes a fin with drainage slits. FIG. 16 shows the fin described in Patent Literature 1. A fin 11 is provided with drainage slits 8 each extending obliquely downward from a water accumulation region below a heat transfer tube 7.

CITATION LIST

Patent Literature

[0005] Patent Literature 1 JP 64(1989)-022186 U

SUMMARY OF INVENTION

Technical Problem

[0006] The technique described in Patent Literature 1 is intended to be used for unbent fins (so-called flat fins), and does not necessarily have a wide range of applications. Therefore, there is a demand for techniques applicable to corrugated fins.

[0007] It is an object of the present invention to improve the drainage performance of a fin tube heat exchanger using corrugated fins.

Solution to Problem

[0008] The present disclosure provides a fin tube heat exchanger including: a plurality of fins arranged in parallel to form flow passages for air; and a heat transfer tube penetrating the fins and configured to allow a medium to flow through the heat transfer tube to exchange heat with the air. Each of the fins is a corrugated fin formed to have a peak portion at at least one position in an air flow direction, and has a tube surrounding portion formed around the heat transfer tube, a first inclined portion inclined with respect to the air flow direction to form the peak portion, a second inclined portion connecting the tube surrounding portion and the first inclined portion to each other, and a slit formed in the second inclined portion.

Advantageous Effects of Invention

[0009] According to the above fin tube heat exchanger, a slit is formed in the second inclined portion. Water is introduced from the front side of the fin to the back side of the fin through the slit and collected in the valley portion on the back side of the fin. The water collected in the valley portion flows downward along the valley portion. As a result, the water is removed from the surface of the fin efficiently.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a perspective view of a fin tube heat exchanger according to a first embodiment of the present invention.
FIG. 2A is a plan view of a fin used in the fin tube heat exchanger of FIG. 1.
FIG. 2B is a cross-sectional view of the fins shown in FIG. 2A, taken along the line IIB-IIB.
FIG. 2C is a cross-sectional view of the fins shown in FIG. 2A, taken along the line IIC-IIC.
FIG. 2D is a cross-sectional view of the fins shown in FIG. 2A, taken along the line IID-IID.
FIG. 3 is a plan view of a fin according to a first modification.
FIG. 4A is a plan view of a fin according to a second modification.
FIG. 4B is a cross-sectional view of the fins shown in FIG. 4A, taken along the line IVB-IVB.
FIG. 5A is a plan view showing another example of the positions of the ends of a slit.
FIG. 5B is a plan view showing still another example of the positions of the ends of the slit.
FIG. 5C is a plan view showing still another example of the positions of the ends of the slit.
FIG. 5D is a plan view showing still another example of the positions of the ends of the slit.
FIG. 6A is an enlarged cross-sectional view of a slit.
FIG. 6B is an enlarged cross-sectional view of another slit.
FIG. 7A is a diagram illustrating the function of a conventional fin.
FIG. 7B is a diagram illustrating the function of the

fin according to the first embodiment.

FIG. 8A is a plan view of a fin according to a third modification.

FIG. 8B is a cross-sectional view of the fins shown in FIG. 8A, taken along the line VIIIB-VIIIB.

FIG. 8C is a plan view of a fin obtained by omitting some of the slits of the fin according to the third modification.

FIG. 9A is a diagram illustrating the function of the fin obtained by omitting some of the slits of the fin according to the third modification.

FIG. 9B is a diagram illustrating the function of the fin of the third modification.

FIG. 10A is a plan view of a fin according to a second embodiment.

FIG. 10B is a cross-sectional view of the fins shown in FIG. 10A, taken along the line XB-XB.

FIG. 10C is a cross-sectional view of the fins shown in FIG. 10A, taken along the line XC-XC.

FIG. 10D is a cross-sectional view of the fins shown in FIG. 10A, taken along the line XD-XD.

FIG. 11 is a plan view of a fin according to a fourth modification.

FIG. 12 is a partial plan view of a fin according to a fifth modification.

FIG. 13A is a plan view of a fin according to a sixth modification.

FIG. 13B is a cross-sectional view of the fins shown in FIG. 13A, taken along the line XIIIB-XIIIB.

FIG. 13C is a cross-sectional view of the fins shown in FIG. 13A, taken along the line XIIIC-XIIIC.

FIG. 13D is a cross-sectional view of the fins shown in FIG. 13A, taken along the line XIIID-XIIID.

FIG. 14A is a plan view of a fin according to a seventh modification.

FIG. 14B is a cross-sectional view of the fins shown in FIG. 14A, taken along the line XIVB-XIVB.

FIG. 14C is a cross-sectional view of the fins shown in FIG. 14A, taken along the line XIVC-XIVC.

FIG. 14D is a cross-sectional view of the fins shown in FIG. 14A, taken along the line XIVD-XIVD.

FIG. 15 is a plan view of a conventional corrugated fin.

FIG. 16 is a plan view of a fin described in Patent Literature 1.

DESCRIPTION OF EMBODIMENTS

[0011] A first aspect of the present disclosure provides a fin tube heat exchanger including: a plurality of fins arranged in parallel to form flow passages for air; and a heat transfer tube penetrating the fins and configured to allow a medium to flow through the heat transfer tube to exchange heat with the air. Each of the fins is a corrugated fin formed to have a peak portion at at least one position in an air flow direction, and has a tube surrounding portion formed around the heat transfer tube, a first inclined portion inclined with respect to the air flow direction to form the peak portion, a second inclined portion connecting the tube surrounding portion and the first inclined portion to each other, and a slit formed in the second inclined portion.

[0012] Water adsorbed on the surface of the fin usually flows downward by its own weight. However, a portion of the water sometimes accumulates on the surface of the fin. Water is likely to accumulate in a corrugated fin. In the corrugated fin, the water is likely to accumulate, for example, in the tube surrounding portion and the second inclined portion. The portion of water that can not climb over the peak portion accumulates in the tube surrounding portion and the second inclined portion in such a form as to minimize the surface area, and then stabilizes there.

[0013] In contrast, in the fin tube heat exchanger of the first aspect, a slit is formed in the second inclined portion. The slit introduces water from the tube surrounding portion and the second inclined portion to the peak portion. At the same time, the water is introduced from the front side of the fin to the back side of the fin through the slit. Thus, the water is collected in the valley portion on the back side of the fin. The water collected in the valley portion flows downward along the valley portion. As a result, the water is removed from the surface of the fin efficiently.

[0014] A second aspect of the present disclosure provides the fin tube heat exchanger as set forth in the first aspect, wherein a longitudinal direction of the slit is inclined with respect to the air flow direction or is perpendicular to the air flow direction, and the slit extends from a side of the tube surrounding portion to a side of the peak portion. With the slit configured in this manner, the water can be introduced efficiently from the tube surrounding portion and the second inclined portion to the peak portion.

[0015] A third aspect of the present disclosure provides the fin tube heat exchanger as set forth in the first or second aspect, wherein the slit has a center line parallel to a longitudinal direction of the slit, and a center of the heat transfer tube is located on an extension of the center line. The slit extending in this direction is less likely to inhibit the heat conduction in the fin.

[0016] A fourth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to third aspects, wherein the slit has a width enough to introduce water from a front side of the fin to a back side of the fin by capillary action. This configuration allows the water to be removed efficiently from the surface of the fin.

[0017] A fifth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to fourth aspects, wherein the slit has a width ranging from 0.01 to 1 mm. With the slit having a width adjusted to this range, the water is smoothly introduced from the front side of the fin to the back side of the fin.

[0018] A sixth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to fifth aspects, wherein an end of the slit is in contact with the tube surrounding portion or the peak portion. Since the slit extends from the side of the flat portion to the side of the peak portion, it can perform the function of introducing the water to the peak portion.

[0019] A seventh aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to fifth aspects, wherein ends of the slit are in contact with the tube surrounding portion and the peak portion respectively. This configuration allows the water to be collected efficiently in the peak portion from the flat portion and the second inclined portion.

[0020] An eighth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to seventh aspects, wherein the fin is a V-shaped corrugated fin formed to have the peak portion at only one position in the air flow direction. This configuration allows all the water introduced from the front side to the back side of the fin through the slit to be collected in one valley portion. More water is collected in one valley portion, the collected water easily flows downward.

[0021] A ninth aspect of the present disclosure provides the fin tube heat exchanger as set forth in the eighth aspect, wherein the slit has a center line parallel to a longitudinal direction of the slit, and in a plan view of the fin, a ridge line of the peak portion, a center of the heat transfer tube, and a center line of the slit are located on a straight line perpendicular to the air flow direction. In this positional relationship, very little water remains in the flat portion and the second inclined portion. Therefore, the drainage performance is expected to improve dramatically.

[0022] A tenth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to seventh aspects, wherein the fin is an M-shaped corrugated fin formed to have the peak portion at each of a plurality of positions along the air flow direction, and the slits are formed in the second inclined portion in a one-to-one correspondence to the peak portions. This configuration allows high drainage effect to be obtained.

[0023] An eleventh aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to tenth aspects, wherein when a direction perpendicular to both the air flow direction and a direction in which the fins are arranged is defined as a row direction, the second inclined portion has an upper part and a lower part, with a plane perpendicular to the row direction and passing through a center of the heat transfer tube as a boundary between the upper part and the lower part, and the slit is formed in each of the upper part and the lower part. This configuration allows the drainage effect of the slit to be obtained sufficiently.

[0024] A twelfth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to eleventh aspects, wherein in a cross section perpendicular to a longitudinal direction of the slit, the slit is formed by providing a level difference between a part of the second inclined portion on one side of the slit and a part of the second inclined portion on the other side of the slit. With the slit having this shape, the effect of improving the drainage performance of the fin can be obtained.

[0025] A thirteenth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to eleventh aspects, wherein in a cross section perpendicular to a width direction of the slit, the slit is formed by arcuately bending a part of the second inclined portion on one side of the slit and a part of the second inclined portion on the other side of the slit. With the slit having this shape, the effect of improving the drainage performance of the fin can be obtained.

[0026] A fourteenth aspect of the present disclosure provides the fin tube heat exchanger as set forth in any one of the first to thirteenth aspects, wherein the tube surrounding portion is a flat portion formed around a cylindrical fin collar being in close contact with the heat transfer tube, or is a cylindrical fin collar being in close contact with the heat transfer tube.

[0027] Hereinafter, the embodiments of the present invention are described with reference to the drawings. The present invention is not limited by the following embodiments.

(First Embodiment)

[0028] As shown in Fig. 1, a fin tube heat exchanger 100 of the present embodiment includes a plurality of fins 31 arranged in parallel to form flow passages for air A (gas) and a heat transfer tube 21 penetrating these fins 31. The fin tube heat exchanger 100 is configured to exchange heat between a medium B flowing in the heat transfer tube 21 and the air A flowing along the surfaces of the fins 31. The medium B is, for example, a refrigerant such as carbon dioxide or hydrofluorocarbon. One continuous heat transfer tube 21 may be used, or a plurality of separate transfer tubes 21 may be used.

[0029] The fins 31 each has a leading edge 30a and a trailing edge 30b. The leading edge 30a and the trailing edge 30b are each linear. In the present embodiment, the fin 31 has a left and right symmetrical configuration with respect to the center of the heat transfer tube 21. Therefore, there is no need to consider the orientation of the fin 31 when the heat exchanger 100 is assembled.

[0030] In this description, a direction in which the fins 31 are arranged is defined as a height direction, a direction parallel to the leading edge 30a is defined as a row direction, and a direction perpendicular to the height direction and the row direction is defined as an air flow direction (a direction in which the air A flows). In other words, the row direction is a direction perpendicular to both the height direction and the air flow direction. The air flow direction is perpendicular to the longitudinal direction of the fin 31 and is parallel to the horizontal direction when the fin tube heat exchanger 100 is actually used. The air flow direction, the height direction and the row direction correspond to X direction, Y direction and Z direction, respectively.

[0031] As shown in FIG. 2A to FIG. 2D, the fin 31 typically has a rectangular and flat plate shape. The longitudinal direction of the fin 31 coincides with the row direction. In the present embodiment, the fins 31 are arranged at a constant spacing (fin pitch FP). However, the spacing between two fins 31 adjacent to each other in the height direction does not necessarily have to be constant and may vary. The fin pitch FP is adjusted to, for example, a range of 1.0 to 1.5 mm. As shown in FIG. 2B, the fin pitch FP is represented by the distance between two adjacent fins 31.

[0032] A constant width portion including the leading edge 30a and a constant width portion including the trailing edge 30b are parallel to the air flow direction. These portions are used to fix the fin 31 to a mold to form the fin 31, and do not significantly affect the performance of the fin 31.

[0033] As the material of the fins 31, a punched-out aluminum flat plate with a thickness of 0.05 to 0.8 mm can be used suitably. The surface of the fin 31 may be subjected to hydrophilic treatment such as boehmite treatment or coating with a hydrophilic paint. Water repellent treatment may be applied instead of hydrophilic treatment.

[0034] The fin 31 is provided with a plurality of through holes 37h formed in a row at equal distances along the row direction. A straight line passing through the center of each of the through holes 37h is parallel to the row direction. The heat transfer tube 21 is fitted through each of the through holes 37h. A part of the fin 31 forms a fin collar 37 around the through hole 37h, and this fin collar 37 is in close contact with the heat transfer tube 21. The diameter of the through hole 37h is, for example, 1 to 20 mm, and it may be 4 mm or less. The diameter of the through hole 37h is the same as the outer diameter of the heat transfer tube 21. The center-to-center distance (tube pitch) between two through holes 37h adjacent to each other in the row direction is, for example, 2 to 3 times larger than the diameter of the through hole 37h. The length of the fin 31 in the air flow direction is, for example, 15 to 25 mm.

[0035] As shown in FIG. 2A to FIG. 2D, the fin 31 is formed to have a peak portion 34 and a valley portion 36 alternately in the air flow direction. The peak portions 34 and the valley portion 36 are located between the adjacent heat transfer tubes 21. The ridge lines of the peak portions 34 and the valley line of the valley portion 36 are each parallel to the row direction. That is, the fin 31 is a so-called corrugated fin. When a portion of the fin 31 protruding in the same direction as the protruding direction of the fin collar 37 is defined as a "peak portion 34", the fin 31 has two peak portions 34 and one valley portion 36 in the air flow direction in the present embodiment. In the air flow direction, the position of the valley portion 36 coincides with the center of the heat transfer tube 21. The positional relationship between the valley portion 36 and the heat transfer tube 21 and the positional relationship between the peak portion 34 and the heat transfer tube 21 are not particularly limited. The number of peak portions 34 and the number of valley portions 36 also are not particularly limited.

[0036] The fin 31 further has flat portions 35, first inclined portions 38, and second inclined portions 39 (surrounding inclined portions). The flat portion 35 is a tube surrounding portion formed adjacent to the fin collar 37 around the through hole 37h. The flat portion 35 is formed between the through hole 37h and the second inclined portion 39, and has an annular shape in plan view. The surface of the flat portion 35 is parallel to the air flow direction and perpendicular to the height direction. The flat portion 35 may be slightly inclined with respect to the air flow direction. The first inclined portion 38 is a portion inclined with respect to the air flow direction to form the peak portion 34 and the valley portion 36. The first inclined portion 38 has the largest area in the fin 31. The surface of the first inclined portion 38 is flat. The second inclined portion 39 is a portion that connects the flat portion 35 smoothly to the first inclined portion 38 so as to eliminate the level difference between the flat portion 35 and the first inclined portion 38. The surface of the second inclined portion 39 is a gently curved surface. That is, the second inclined portion 39 is an inclined portion raised from the through hole 37h to the side of the peak portion 34. The flat portion 35 and the second inclined portion 39 form a concave portion around the fin collar 37 and the through hole 37h. In the present embodiment, the second inclined portion 39 looks like two portions separated at the position of the valley portion 36, but it is regarded as one annular second inclined portion 39 formed around one flat portion 35.

[0037] The edge portion between the first inclined portion 38 and the second inclined portion 39 may be rounded with an appropriate radius of curvature (for example, R = 0.5 mm to 2.0 mm). Likewise, the edge portion between the peak portion 34 and the second inclined portion 39 may be rounded with an appropriate radius of curvature (for example, R = 0.5 mm to 2.0 mm).

[0038] As shown in FIG. 2A and FIG. 2D, the fin 31 further has slits 23 formed in the second inclined portions 39. Each of the slit 23 penetrates the fin 31 and extends from the side of the through hole 37h to the side of the peak portion 34. Specifically, the slit 23 extends from the side of the flat portion 35 to the side of the peak portion 34. The slit 23 has a longitudinal direction inclined with respect to or perpendicular to the air flow direction. In the present embodiment, the end 45 of the ridge line of the peak portion 34 is located on an extension of the slit 23. From another viewpoint, the slit 23 is formed on an imaginary line extending from the center of the through hole 37h (the center 25 of the heat transfer tube 21) to the end 45 of the ridge line of the peak portion 34. With the slit 23 configured in this manner, water can be introduced from the flat portion 35 and the second inclined portion 39 to the peak portion 34. At the same time, the water is introduced from the front side of the fin 31 to the back side of the fin 31 through the slit 23. Thus, the water is collected in the valley portion on the back side of the fin 31. The water collected in the valley portion flows downward along the valley portion. As a result, the water is removed from the surface of the fin 31 efficiently.

[0039] In actual use of the fin tube heat exchanger 100 (FIG. 1), the slit 23 is formed at least in the lower half of the second inclined portion 39. Specifically, the second inclined portion 39 has an upper part 39a and a lower part 39b with a plane H perpendicular to the row direction and passing through the center 25 of the heat transfer tube 21 as a boundary between the upper part and the lower part. In the present embodiment, the slits 23 are formed in each of the upper part 39a and the lower part 39b. Thus, the drainage effect of the slits 23 can be obtained sufficiently. Since the fin 31 has an upper and lower symmetrical configuration, it is easy to assemble the fin tube heat exchanger 100.

[0040] The slit 23 may be formed in at least one selected from the upper part 39a and the lower part 39b. As shown in FIG. 3, in a fin 31B according to the first modification, the slits 23 are formed in the lower part 39b. Specifically, the slits 23 are formed only in the lower part 39b. This configuration also allows the drainage effect of the slits 23 to be obtained sufficiently.

[0041] The phrase "in the actual use of the fin tube heat exchanger 100" refers to a state in which the fin tube heat exchanger 100 is placed in such a manner that the longitudinal direction of the fin 31 is approximately parallel to the vertical direction. When the fin tube heat exchanger 100 is placed in this manner and used, water is less likely to accumulate on the surface of the fin 31.

[0042] In the present embodiment, the fin 31 is an M-shaped corrugated fin formed to have the peak 34 at each of a plurality of positions in the air flow direction. The slits 23 are formed in the second inclined portion 39 in a one-to-one correspondence to the peak portions 34. In the present invention, two peak portions 34 are present in the air flow direction, and a plurality of slits 23 are formed in the second inclined portion 39 so as to introduce water to each of the two peak portions 34. Specifically, four slits 23 are formed around one flat portion 35. That is, four slits 23 are formed in the second inclined portion 39. This configuration allows high drainage effect to be obtained. Two slits 23 may be formed in the second inclined portion 39, of course, like the fin 31B shown in FIG. 3. This configuration also allows sufficient drainage effect to be obtained.

[0043] In the present embodiment, at least one slit 23 is formed around each of all the flat portions 35. Thus, the drainage effect of the slits 23 can be obtained around all the flat portions 35. However, this is not necessarily required. For example, the slit 23 may be formed around only one selected from the adjacent two flat portions 35. Also in this case, a certain level of drainage effect can be obtained.

[0044] It is desirable that the longitudinal direction of the slit 23 be approximately along the gravity direction. Thereby, not only the water on the flat portion 35 and the second inclined portion 39 can be introduced immediately to the peak portion 34, but also the water on the flat portion 35 and the second inclined portion 39 can be introduced immediately from the front side to the back side of the fin 31. For example, the longitudinal direction of the slit 23 can be determined so that a straight line parallel to the longitudinal direction of the slit 23 and a straight line parallel to the longitudinal direction of the fin 31 form an angle of 45 degrees or less. In the present embodiment, the slit 23 has a center line CL parallel to its longitudinal direction. The center 25 of the heat transfer tube 21 (center of the through hole 37h) is located on an extension of the center line CL. The slit 23 extending in this direction is less likely to inhibit the heat conduction in the fin 31. The reason is as follows.

[0045] The temperature distribution of the fin 31 usually is in an approximately concentric form in the vicinity of the heat transfer tube 21. When the center 25 of the heat transfer tube 21 is located on an extension of the center line CL of the slit 23, the temperature of the fin 31 on the left side of the center line CL is almost equal to the temperature of the fin 31 on the right side of the center line CL. Even if the slit 23 is not provided, heat is hardly transferred in a direction transverse to the slit 23. Therefore, according to the present embodiment, the heat transfer performance of the fin 31 is maintained.

[0046] The longitudinal direction of the slit 23 is not particularly limited as long as the drainage performance can be improved. As shown in FIG. 4A and FIG. 4B, in a fin 31C according to the second modification, the longitudinal direction of the slit 23 is parallel to the vertical direction (the longitudinal direction of the fin 31C). In other words, the longitudinal direction of the slit 23 is perpendicular to the air flow direction. The slit 23 is formed on an extension EL of the ridge line of the peak portion 34.

[0047] As shown in FIG. 2A, in the present embodiment, the ends of the slit 23 are in contact with the flat portion 35 and the peak portion 34 respectively. This configuration allows the water to be collected efficiently in the peak portion 34 from the flat portion 35 and the second inclined portion 39. The positions of the ends of the slit 23 are not particularly limited as long as the slit 23 can perform a certain level of the water collecting function.

[0048] For example, as shown in FIG. 5A, the ends of the slit 23 may be spaced from the flat portion 35 and the peak portion 34 respectively. As shown in FIG. 5B, the slit 23 may have one end in contact with the flat portion 35 and the other end spaced from the peak portion 34. As shown in FIG. 5C, the slit 23 may have one end spaced from the flat portion 35 and the other end in contact with the peak portion 34 (specifically, the end 45 of the ridge line of the peak portion 34). As shown in FIG. 5D, the other end of the slit 23 may be located on the ridge line between the first inclined portion 38 and the second inclined portion 39. In other words, the end 45 of the ridge line of the peak portion 34 may be located at a position other than the extension of the slit 23. Furthermore, the ridge line of the peak portion 34 may be spaced from the extension of the slit 23. Also in these cases, the slit 23 extends from the side of the flat portion 35 to the side of the peak portion 34. In other words, in FIG. 5A to FIG. 5D, the slit 23 is formed on an imaginary line extending from the center of the through hole 37h (the center 25 of the heat transfer tube 21) to the side of the peak portion 34. Therefore, the slit 23 can perform the function of introducing water to the peak portion 34. It is desirable, however, that the end of the slit 23 be in contact with the flat portion 35 or the peak portion 34 because such a slit 23 can perform the water collecting function more effectively.

[0049] The slit 23 is not necessarily required to be formed on an imaginary line extending from the center of the through hole 37h to the end 45 of the ridge line of the peak portion 34. For example, the slit 23 may be formed on an imaginary line extending from a position displaced from the center of the through hole 37h to the side of the peak portion 34. Furthermore, the slit 23 may be formed on an imaginary line extending from a position displaced from the center of the through hole 37h to the end 45 of the ridge line of the peak portion 34. Desirably, the slit 23 is formed in the second inclined portion 39 so as to extend toward the end 45 of the ridge line of the peak portion 34.

[0050] The width of the slit 23 is not particularly limited. It is desirable that the slit 23 have a width G enough to introduce water from the front side of the fin 31 to the back side of the fin 31 by capillary action. This configuration allows the water to be removed efficiently from the surface of the fin 31.

[0051] The width G of the slit 23 can be adjusted, for example, to the range of 0.01 to 1 mm (desirably, 0.05 to 0.3 mm). The width G of the slit can be adjusted to satisfy the relationship of $0.005 FP < G < FP$ (desirably, $0.025 FP < G < 0.3 FP$), with respect to the fin pitch FP. When the width G is adjusted to this range, water is introduced smoothly from the front side of the fin 31 to the back side of the fin 31. The "fin pitch FP" refers to the spacing between adjacent fins.

[0052] The cross-sectional shape of the slit 23 also is not particularly limited. FIG. 6A and FIG. 6B show specific examples of the cross-sectional shape of the slit 23. The example shown in FIG. 6A can be formed by applying shear load to the fin 31 along its thickness direction. In a cross section perpendicular to the longitudinal direction of the slit 23, the slit 23 is formed by providing a level difference between a part of the second inclined portion 39 on one side (left side) of the slit 23 and a part of the second inclined portion 39 on the other side (right side) of the slit 23. The slit 23 shown in FIG. 6B can be formed by piercing the fin 31 from one surface of the fin 31 with a sharp knife (for example, a knife provided in a mold). In a cross section perpendicular to the longitudinal direction of the slit 23, the slit 23 may be formed by arcuately bending a part of the second inclined portion 39 on one side (left side) of the slit 23 and a part of the second inclined portion 39 on the other side (right side) of the slit 23. With the slit 23 having either shape, the effect of improving the drainage performance of the fin 31 can be obtained. The working direction to form the slit 23 also is not particularly limited.

[0053] Next, the function of the slit 23 is described in detail with reference to FIG. 7A and FIG. 7B. FIG. 7A and FIG. 7B each show the time course of the surface condition of a fin.

[0054] As shown in FIG. 7A, in the conventional fin 1, water W is adsorbed on the surface of the fin 1 around the heat transfer tube 2 (left diagram). The water W flows downward (in the gravity direction) along the fold of the fin 1 and begins to accumulate on the flat portion 5 and the inclined portion 9. A portion of the water W overflows along the valley portion 6 and further flows downward (center diagram). However, the rest of the water W is left on the flat portion 5 and the inclined portion 9 by surface tension, and accumulates around the heat transfer tube 2 without flowing downward (right diagram). Then, in the subsequent operation, the water W impedes the air flow and produces a high thermal resistance. As a result, the performance of the heat exchanger decreases significantly.

[0055] In contrast, the fin 31 of the present invention provides the following function and effect. As shown in FIG. 7B, water W is adsorbed on the surface of the fin 31 around the heat transfer tube 21 (left diagram). The water W flows downward along the fold of the fin 31 and begins to accumulate on the flat portion 35 and the inclined portion 39. A portion of the water W overflows along the valley portion 36 and further flows downward. The rest of the water W moves from the front side of the fin 31 to the back side of the fin 31 through the slit 23 by surface tension (capillary action) and by gravity. On the back side of the fin 31, the peak portion 34 serves as a valley portion and the valley portion 36 serves as a peak portion. Therefore, when the water W passes through the slit 23, there is the valley portion ahead of the water W. After moving to the back side of the fin 31 through the slit 23, the water W flows downward along the valley portions (dashed lines in a central diagram). Thus, the water W is removed sufficiently from the surface of the fin 31 (right diagram). As a result, the fin tube heat exchanger 100 continues to exhibit its original performance.

[0056] When the fin tube heat exchanger 100 of the present embodiment is used in an outdoor unit of a heat pump system, the benefits obtained by improving the drainage performance are increased dramatically.

[0057] In general, when an outdoor temperature falls to almost 0°C, frost begins to be deposited on the surface of a fin of a fin tube heat exchanger incorporated in an outdoor unit. Frost impairs the performance of the fin tube heat exchanger significantly. Therefore, an operation for melting and removing the frost, so-called defrosting operation, needs to be performed periodically. However, water from the melted frost cannot be removed sufficiently from the surface of the conventional fin 1. Therefore, a portion of the water from the melted frost remains on the surface of the fin 1 and refreezes after the defrosting operation is completed. That is, extra energy is consumed to melt the frost and freeze the remaining water. If frost (or ice) deposited by refreezing accumulates on the surface of the fin 1, the interval between the defrosting operations has to be shortened.

[0058] In contrast, the fin tube heat exchanger 100 of the present embodiment has superior drainage performance, as described with reference to FIG. 7B. Therefore, water produced by the defrosting operation is removed from the surface of the fin 31 immediately. Thus, drawbacks such as consumption of extra energy and shortening of the interval between defrosting operations can be avoided. Since the water is sufficiently removed from the surface of the fin 31 after the defrosting operation, the fin tube heat exchanger 100 can reliably exhibit its original performance.

[0059] In the fin 31 described with reference to FIG. 2A to FIG. 2D, the flat portion 35 and the valley portion 36 are on the same level in the height direction (Y direction). This configuration allows some of the water W to move from the flat portion 5 and the second inclined portion 9 to the valley portion 6 even without the slit 23, as described with reference to FIG. 7A. However, this configuration is not necessarily required.

[0060] As shown in FIG. 8A and FIG. 8B, in a fin 31D according to the third modification, the flat portion 35 is on the same level as the leading edge 30a and the trailing edge 30b but on a different level from the valley portion 36 in the height direction. In the height direction, the valley portion 36 is located between the flat portion 35 and the peak portion 34, and a level difference is formed between the valley portion 36 and the flat portion 35. The level difference between the valley portion 36 and the flat portion 35 is eliminated by the annular second inclined portion 39 formed around the flat portion 35.

[0061] In the fin 31D, the slit 23 is formed at a position defined below. A flat plane passing through the center 25 of the heat transfer tube 21 (center of the through hole 37h) and perpendicular to the air flow direction is defined as a first central plane P1. The slit 23 is formed in the second inclined portion 39 so as to be located on the first central plane P1. Specifically, the slit 23 is located on the first central plane P1 and extends in the row direction. That is, the longitudinal direction of the slit 23 is parallel to the valley line of the valley portion 36. The slit 23 extends from the side of the through hole 37h to the side of the valley portion 36. Specifically, the slit 23 extends from the side of the flat portion 35 to the side of the valley portion 34. Furthermore, in the present modification, the slits 23 may be formed in both the upper part 39a and the lower part 39b. The slit 23 may be formed in only one selected from the upper part 39a and the lower part 39b. That is, two slits 23 may be formed in the second inclined portion 39, as shown in FIG. 8A, and one slit 23 may be formed in the second inclined portion 39, as shown in FIG. 8C. In the latter case, the slit 23 is typically formed only in the lower part 39b.

[0062] In the case where the slit 23 is not formed, as shown in FIG. 9A, a portion of the water W overflows along the valley portion 6 and flows downward (left and central diagrams). However, the rest of the water W is left on the flat portion 5 and the inclined portion 9 by surface tension, and accumulates around the heat transfer tube 2 without flowing downward (right diagram). Since there is a level difference between the flat portion 5 and the valley portion 6, a large amount of water W is likely to accumulate.

[0063] As shown in FIG. 9B, in the fin 31D according to the present modification, the water W moves from the front side to the back side of the fin 31D through the slit 23, spreads from the peak portion to the valley portion, and then flows downward along the valley portion (left and central diagrams). Therefore, the water W is sufficiently removed from the surface of the fin 31D (right diagram). The fin 31D performs the same function as that of the fin 31 described with reference to FIG. 7B.

(Second Embodiment)

[0064] As shown in FIG. 10A to FIG. 10D, a fin 31F according to the second embodiment is a V-shaped corrugated fin formed to have the peak portion 34 at only one position in the air flow direction. The fin 31F of the present embodiment has the flat portions 35, the first inclined portions 38, the second inclined portions 39 and the slits 23, like the fin 31 of the first embodiment. The slits 23 are formed in the second inclined portion 39, and each of them extends from the side of the through hole 37h to the side of the peak portion 34. Specifically, the slit 23 extends from the side of the flat portion 35 to the side of the peak portion 34. That is, the fin 31F of the present embodiment has the same components as those of the fin 31 of the first embodiment, as designated by the same reference numerals, except that the former has the peak portion 34 formed at only one position in the air flow direction. Therefore, all the descriptions of the first embodiment and its modifications apply to the fin 31F of the present embodiment and its modifications, as long as no technical inconsistency is involved.

[0065] In the fin 31F of the present embodiment, the drainage performance is improved by the slits 23 in the same manner as in the fin 31 of the first embodiment.

[0066] As shown in FIG. 10A, the longitudinal direction of the slit 23 is perpendicular to the air flow direction. Specifically, the slit 23 has a center line CL parallel to the longitudinal direction of the slit 23. Since the longitudinal direction of the slit 23 is parallel to the gravity direction and the row direction, the center line CL also is parallel to the gravity direction and the row direction. In the plan view of the fin 31F, the ridge line of the peak portion 34, the center 25 of the heat transfer tube 21, and the center line CL of the slit 23 are located on a straight line perpendicular to the air flow direction. One end (upper end) of the slit 23 is located at or near the lower end of the annular flat portion 35. In this positional relationship, very little water remains in the flat portion 35 and the second inclined portion 39. Therefore, the drainage performance is expected to improve dramatically.

[0067] In the present embodiment, as in the first embodiment, the slit 23 is formed on an imaginary line extending from the center of the through hole 37h (the center 25 of the heat transfer tube 21) to the side of the peak portion 34. The end 45 of the ridge line of the peak portion 34 is located on an extension of the slit 23. Therefore, the same effect as described in the first embodiment can also be obtained in the present embodiment.

[0068] The fin 31F of the present embodiment is a V-shaped corrugated fin. Therefore, all the water introduced from the front side to the back side of the fin 31F through the slit 23 is collected in one valley portion. Since more water is collected in one valley portion than in the M-shaped corrugated fin (of the first embodiment), the collected water easily flows downward. Thus, the drainage performance of the fin 31F of the present embodiment is equal or superior to that of the fin 31 (M-shaped corrugated fin) of the first embodiment. The surface area of the V-shaped corrugated fin is larger than that of the M-shaped corrugated fin, when they have the same length in the air flow direction. Thus, the heat exchange performance of the V-shaped corrugated fin is equal or superior to that of the M-shaped corrugated fin.

[0069] Also in the fin 31F of the present embodiment, the slit 23 is formed in each of the upper part 39a and the lower part 39b of the second inclined portion 39. That is, two slits 23 are formed in the second inclined portion 39. The slit 23 may be formed at least one selected from the upper part 39a and the lower part 39b, as described in the first embodiment. As shown in FIG. 11, in a fin 31G according to the fourth modification, the slit 23 is formed in the lower part 39b. Specifically, the slit 23 is formed only in the lower part 39b.

[0070] Also in the present embodiment, the configuration of the slit 23 is not particularly limited as long as the slit 23 provides the water collecting effect. For example, the slit 23 may be inclined with respect to both the air flow direction and the row direction, like the fin 31 of the first embodiment. The positions of the ends of the slit 23 are not particularly limited, as described with reference to FIG. 5A to FIG. 5D. Further as shown in FIG. 12, in a fin 31H according to the fifth modification, a plurality of slits 23 (for example, two slits 23) extending to one peak portion 34 are formed.

(Other Modifications)

[0071] As shown in FIG. 13A to FIG. 13D, a fin 31I according to the sixth modification has no flat portion 35. The second inclined portion 39 (surrounding inclined portion) is adjacent to the fin collar 37, and is raised gently upward from the side of the through hole 37h toward the peak portion 34. The fin 31I has the same configuration as the fin 31 of the first embodiment, except that the former has no flat portion 35. As shown in FIG. 14A to FIG. 14D, a fin 31J according to the seventh modification also has no flat portion 35. The fin 31J has the same configuration as the fin 31F of the second embodiment, except that the former has no flat portion 35. As just described, the flat portion 35 is not necessarily required, and may be omitted. In each of the sixth and seventh modifications, the cylindrical fin collar 37 formed to protrude in the height direction can be a tube surrounding portion formed around the heat transfer tube 21.

[0072] In each of the fins shown in FIG. 4A, FIG. 5A to FIG. 5D, and FIG. 12, the slit 23 is formed only in the lower part 39b of the second inclined portion 39. However, one or a plurality of slits 23 may also be formed in the upper part 39a of the second inclined portion 39 so that the fins shown in FIG. 4A, FIG. 5A to FIG. 5D, and FIG. 12 each have an upper and lower symmetrical configuration.

INDUSTRIAL APPLICABILITY

[0073] The fin tube heat exchanger of the present invention is useful for heat pumps used in air conditioners, water heaters, heating apparatuses, etc. In particular, it is useful for evaporators for evaporating a refrigerant.

Claims

1. A fin tube heat exchanger comprising:

a plurality of fins arranged in parallel to form flow passages for air; and
a heat transfer tube penetrating the fins and configured to allow a medium to flow through the heat transfer tube to exchange heat with the air,
wherein each of the fins is a corrugated fin formed to have a peak portion at at least one position in an air flow direction, and has a tube surrounding portion formed around the heat transfer tube, a first inclined portion inclined with respect to the air flow direction to form the peak portion, a second inclined portion connecting the tube surrounding portion and the first inclined portion to each other, and a slit formed in the second inclined portion.

2. The fin tube heat exchanger according to claim 1, wherein
a longitudinal direction of the slit is inclined with respect to the air flow direction or is perpendicular to the air flow direction, and
the slit extends from a side of the tube surrounding portion to a side of the peak portion.

3. The fin tube heat exchanger according to claim 1, wherein

the slit has a center line parallel to a longitudinal direction of the slit, and
a center of the heat transfer tube is located on an extension of the center line.

4. The fin tube heat exchanger according to claim 1, wherein the slit has a width enough to introduce water from a front side of the fin to a back side of the fin by capillary action.

5. The fin tube heat exchanger according to claim 1, wherein the slit has a width ranging from 0.01 to 1 mm.

6. The fin tube heat exchanger according to claim 1, wherein an end of the slit is in contact with the tube surrounding portion or the peak portion.

7. The fin tube heat exchanger according to claim 1, wherein ends of the slit are in contact with the tube surrounding portion and the peak portion respectively.

8. The fin tube heat exchanger according to claim 1, wherein the fin is a V-shaped corrugated fin formed to have the peak portion at only one position in the air flow direction.

9. The fin tube heat exchanger according to claim 8, wherein
the slit has a center line parallel to a longitudinal direction of the slit, and
in a plan view of the fin, a ridge line of the peak portion, a center of the heat transfer tube, and a center line of the slit are located on a straight line perpendicular to the air flow direction.

10. The fin tube heat exchanger according to claim 1, wherein
the fin is an M-shaped corrugated fin formed to have the peak portion at each of a plurality of positions along the air flow direction, and
the slits are formed in the second inclined portion in a one-to-one correspondence to the peak portions.

11. The fin tube heat exchanger according to claim 1, wherein
when a direction perpendicular to both the air flow direction and a direction in which the fins are arranged is defined as a row direction,
the second inclined portion has an upper part and a lower part, with a plane perpendicular to the row direction and passing through a center of the heat transfer tube as a boundary between the upper part and the lower part, and
the slit is formed in each of the upper part and the lower part.

12. The fin tube heat exchanger according to claim 1, wherein in a cross section perpendicular to a longitudinal direction of the slit, the slit is formed by providing a level difference between a part of the second inclined portion on one side of the slit and a part of the second inclined portion on the other side of the slit.

13. The fin tube heat exchanger according to claim 1, wherein in a cross section perpendicular to a width direction of the slit, the slit is formed by arcuately bending a part of the second inclined portion on one side of the slit and a part of the second inclined portion on the other side of the slit.

14. The fin tube heat exchanger according to claim 1, wherein the tube surrounding portion is a flat portion formed around a cylindrical fin collar being in close contact with the heat transfer tube, or is a cylindrical fin collar being in close contact with the heat transfer tube.

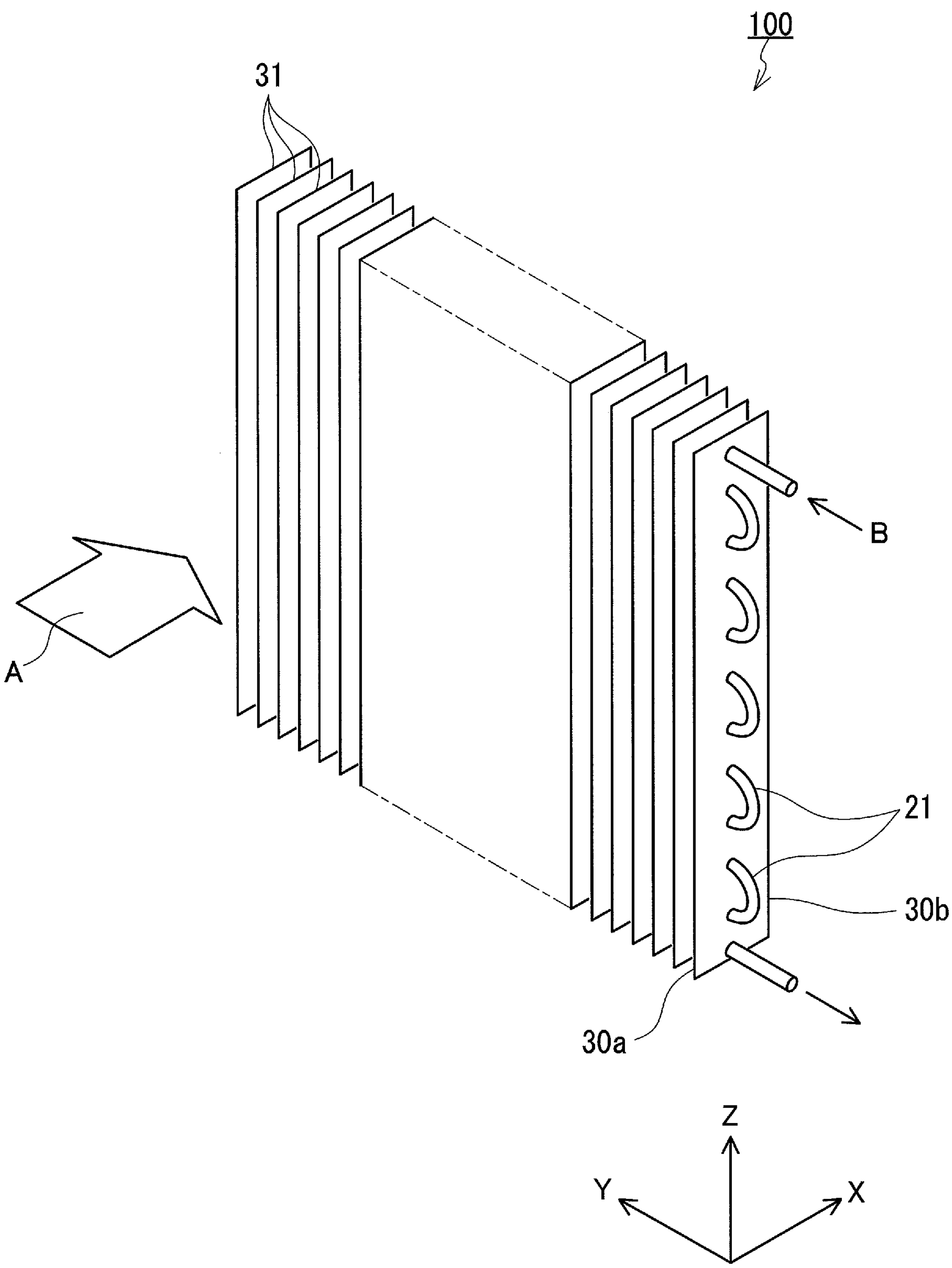


FIG.1

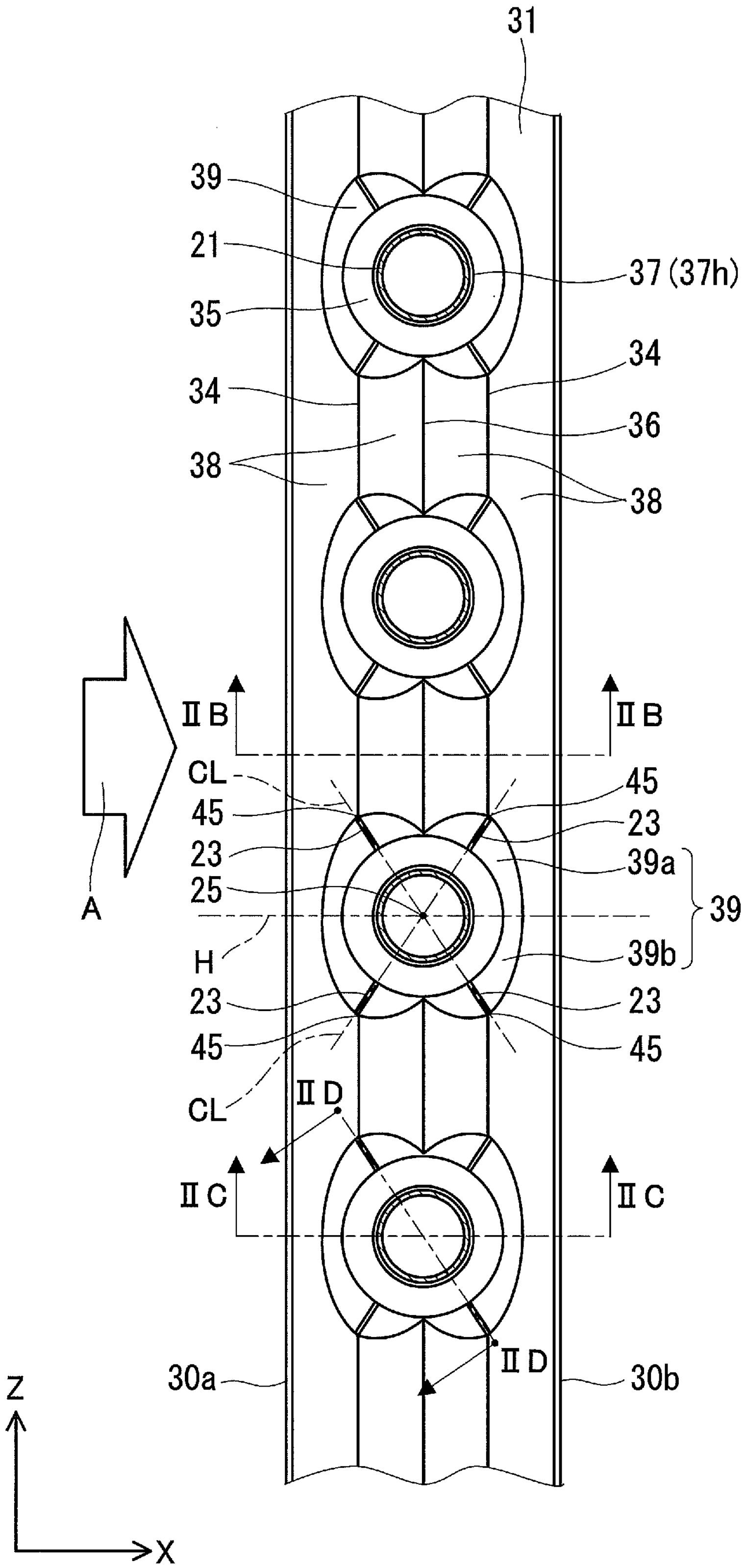

31
39
21
37 (37h)
35
34
34
36
38
38
ⅡB
ⅡB
CL
45
45
23
23
39a
25
39
A
H
39b
23
23
45
45
CL
ⅡD
ⅡC
ⅡC
ⅡD
Z
30a
30b
X

FIG.2A

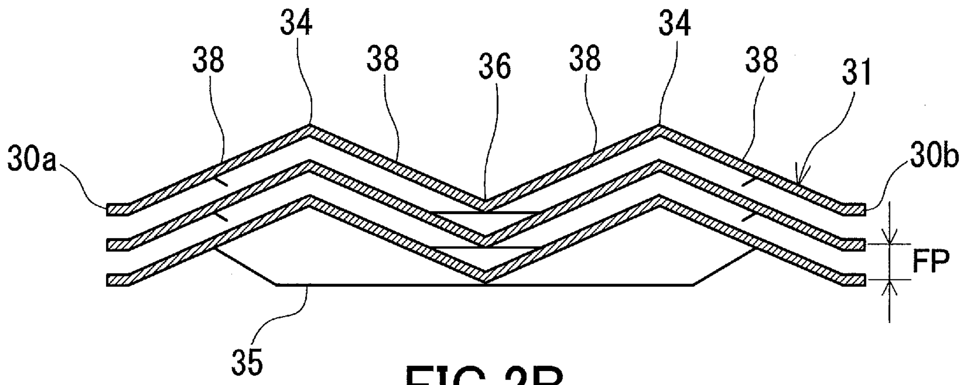


FIG.2B

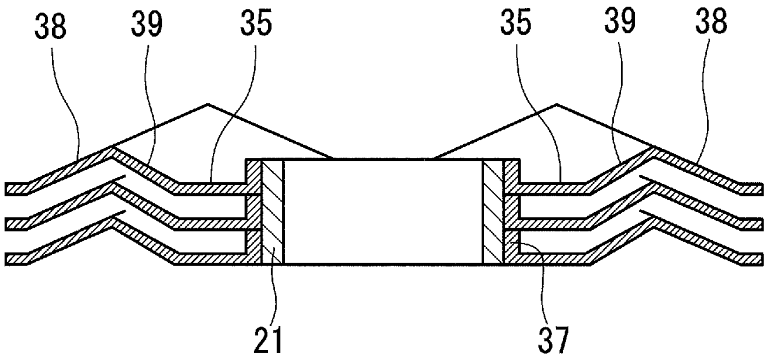


FIG.2C

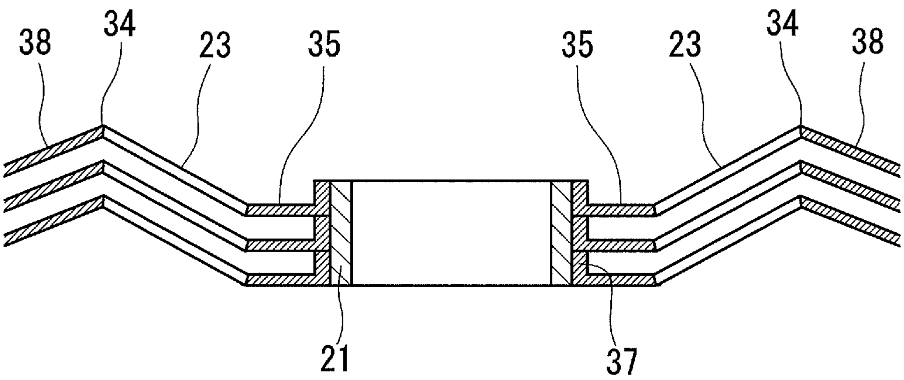


FIG.2D

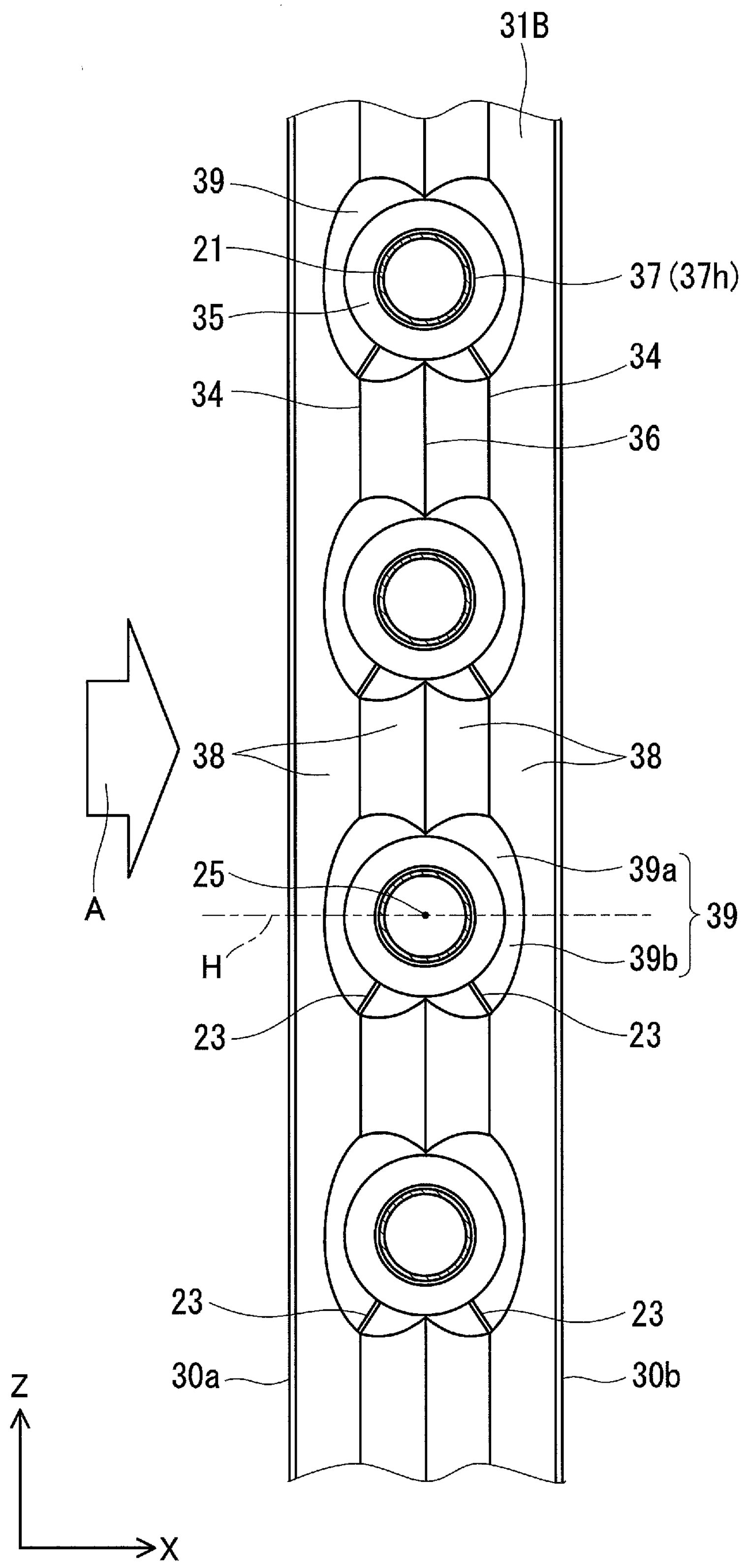

31B
39
21
35
37 (37h)
34
34
36
38
38
A
39a
25
39
H
39b
23
23
23
23
30a
30b
Z
X

FIG.3

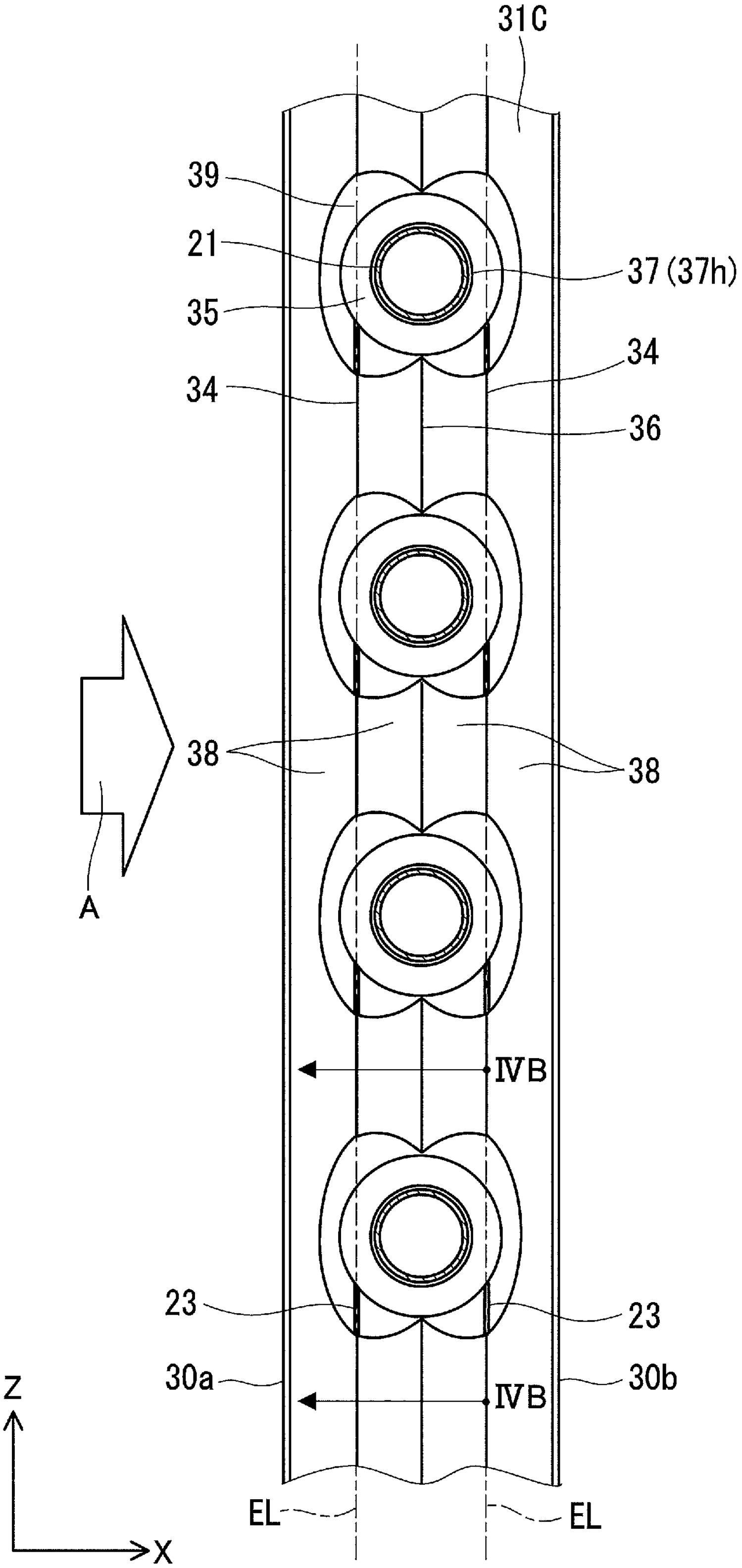


FIG.4A

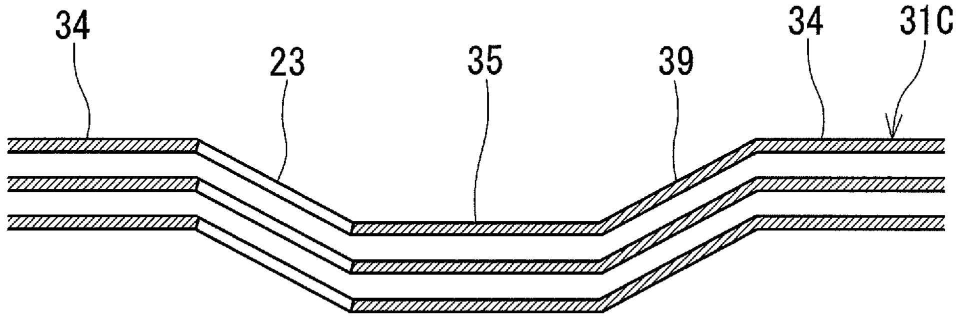
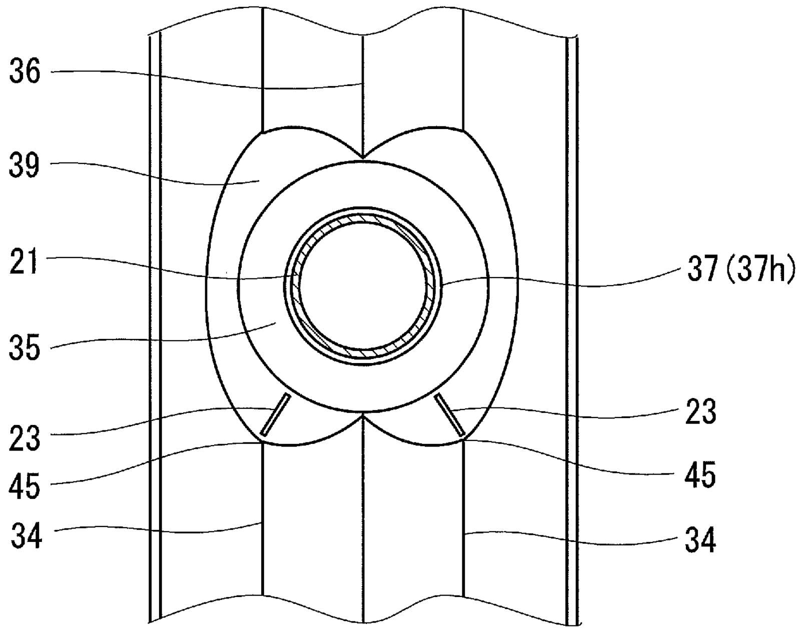


FIG.4B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21
35
23
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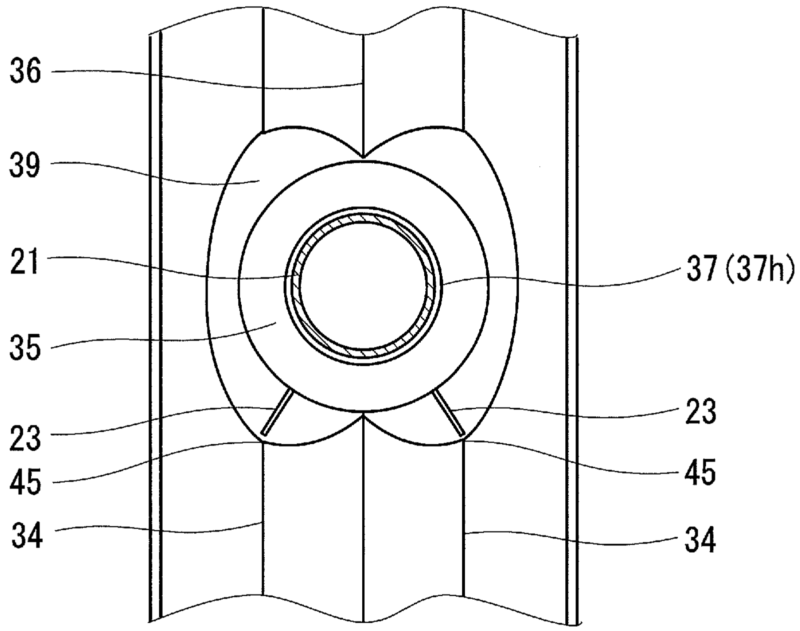
34
37 (37h)
23
45
34

FIG.5A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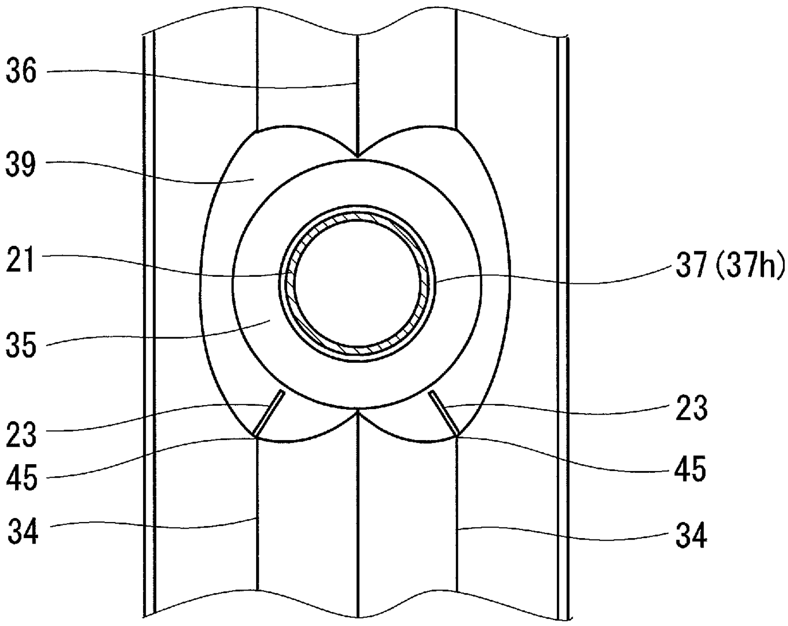
37 (37h)
23
45
34

FIG.5B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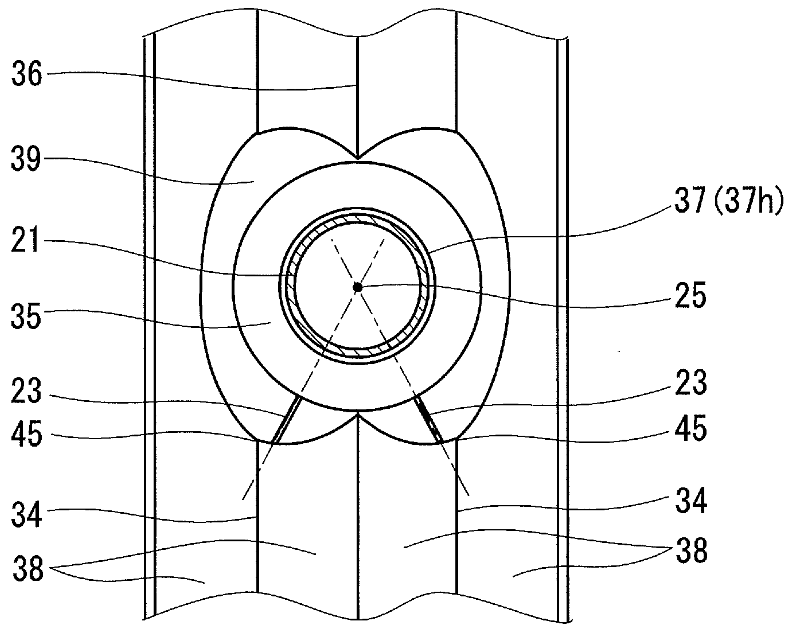
34
37 (37h)
23
45
34

FIG.5C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45
34
38
37 (37h)
25
23
45
34
38

FIG.5D

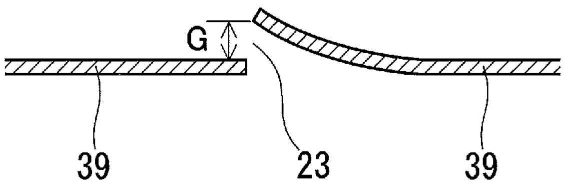


FIG.6A

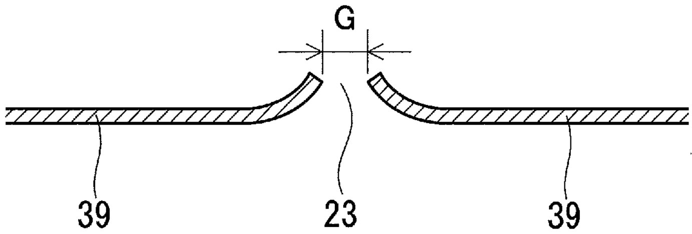
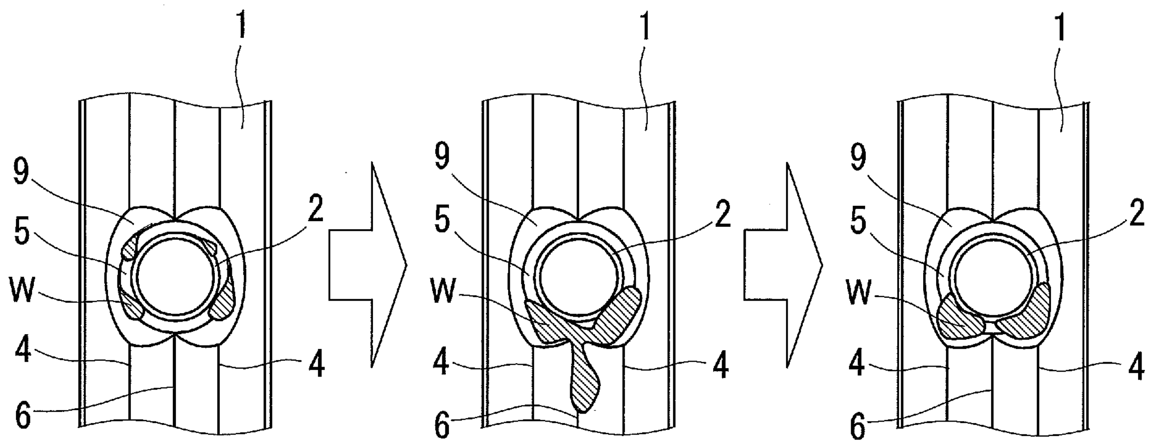


FIG.6B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W
4
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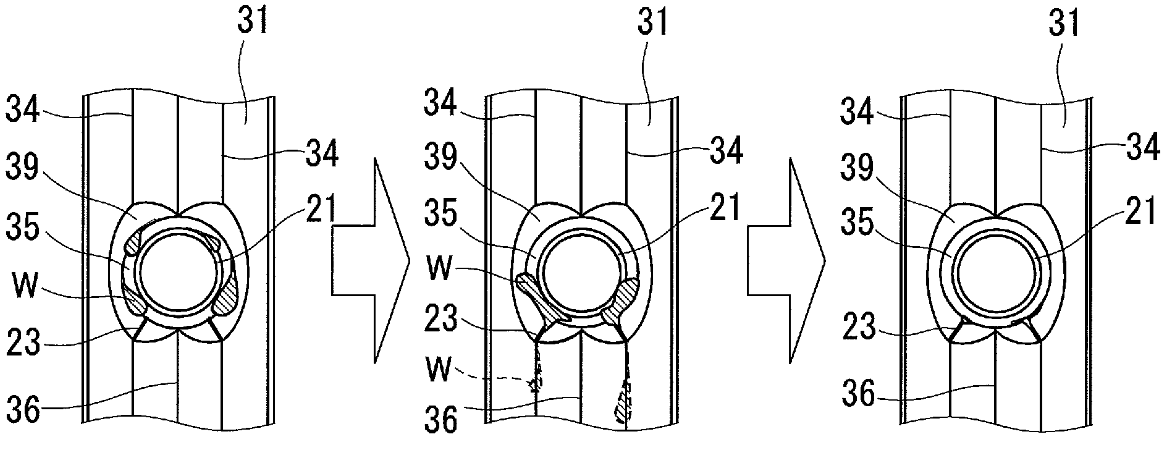
2
4

FIG.7A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21

FIG.7B

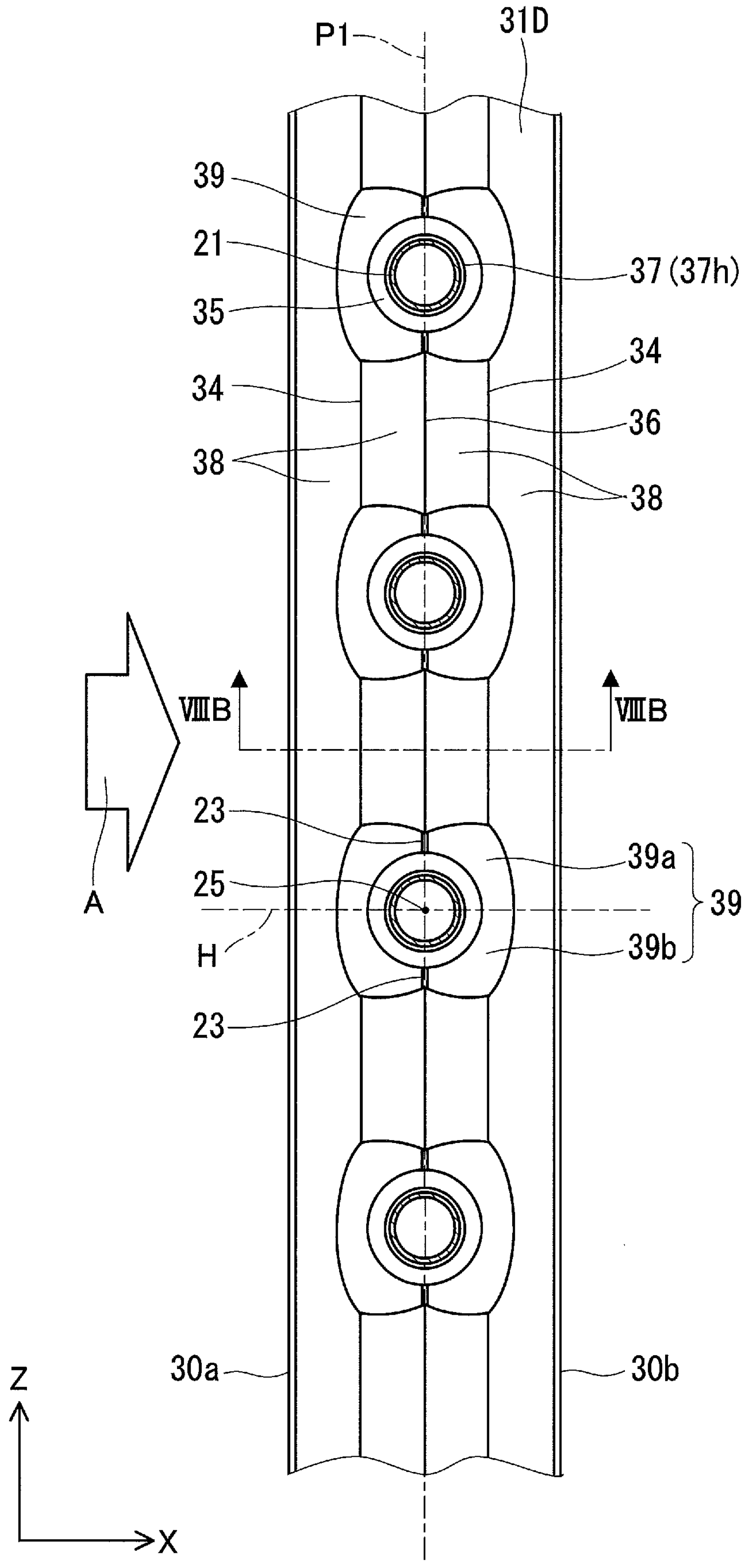

P1
31D
39
21
35
37 (37h)
34
34
36
38
38
VIIIB
VIIIB
A
23
25
H
23
39a
39
39b
30a
30b
Z
X

FIG.8A

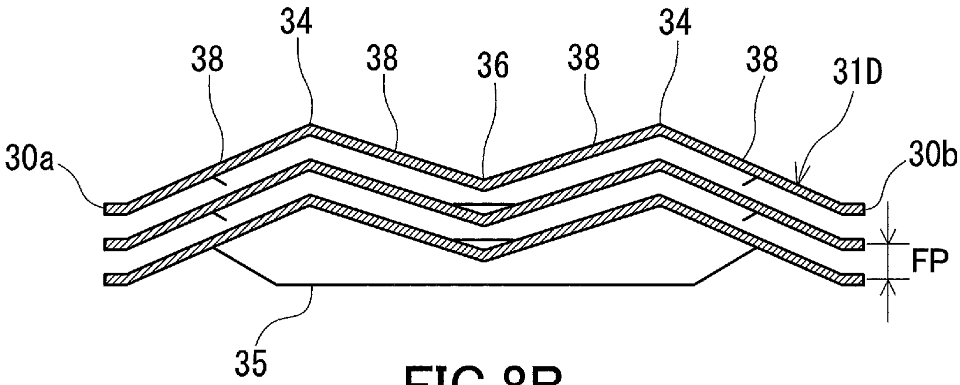


FIG.8B

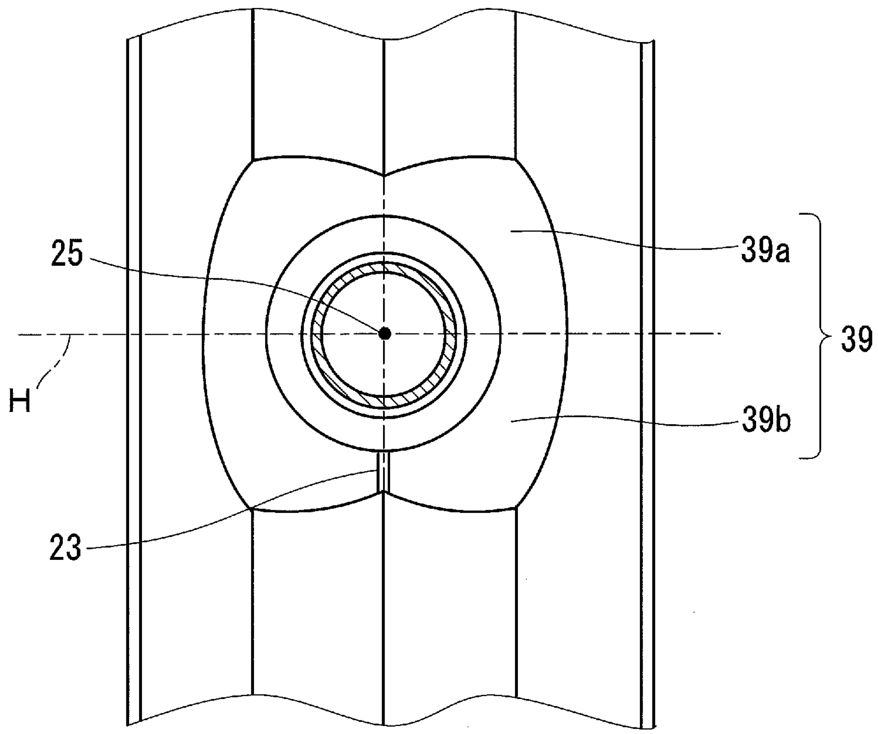
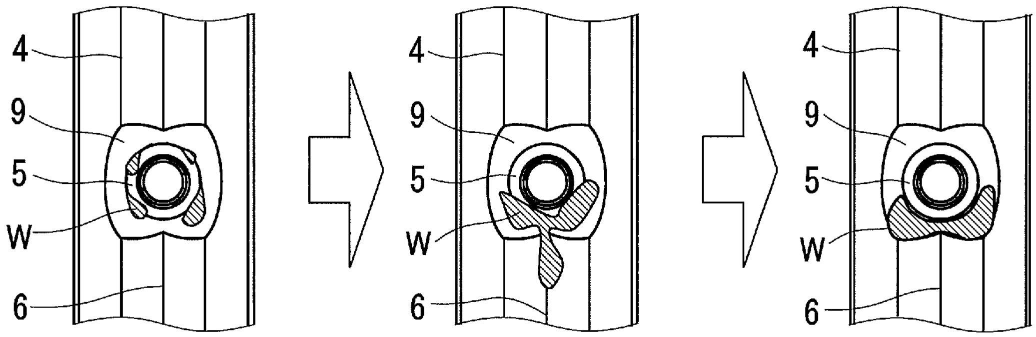


FIG.8C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9
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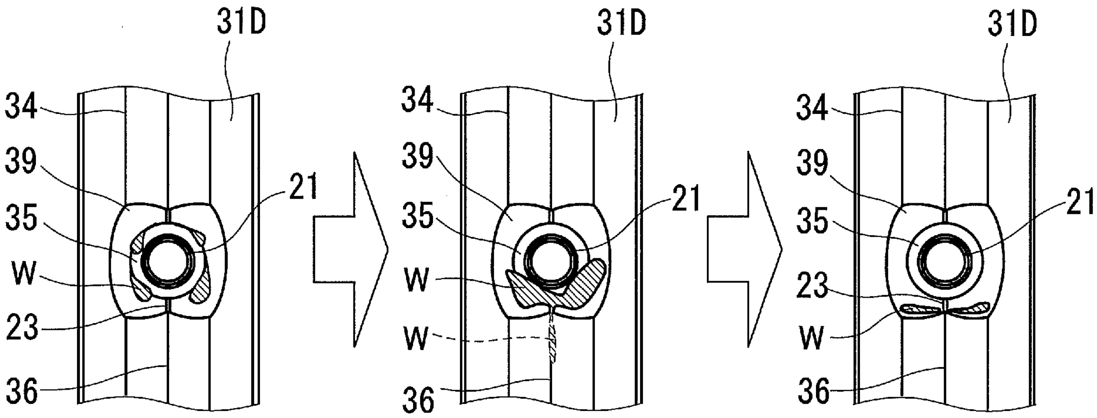
W
6
4
9
5
W
6
4
9
5
W
6

FIG.9A


31D
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39
35
W
23
36
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31D
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39
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W
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31D
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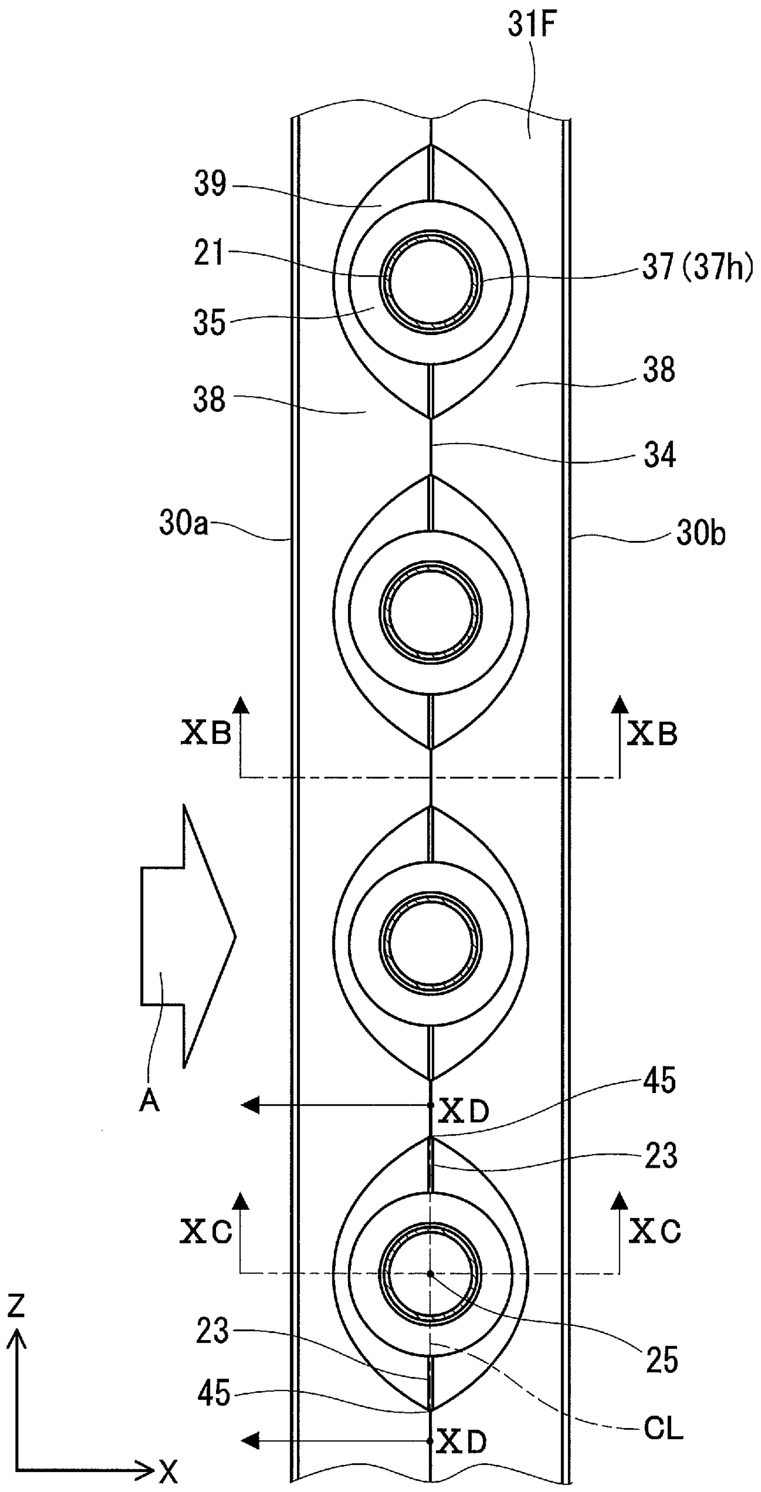
W
36
21

FIG.9B


31F
39
21
37 (37h)
35
38
38
34
30a
30b
XB
XB
A
45
XD
23
XC
XC
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23
25
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CL
XD
X

FIG.10A

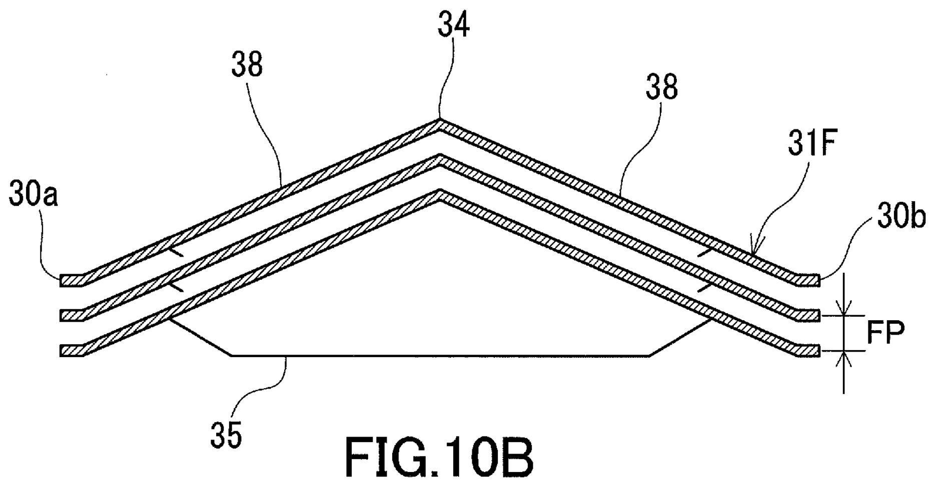


FIG.10B

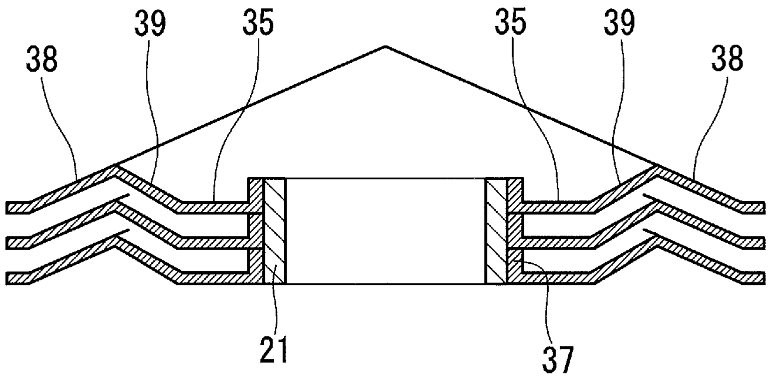


FIG.10C

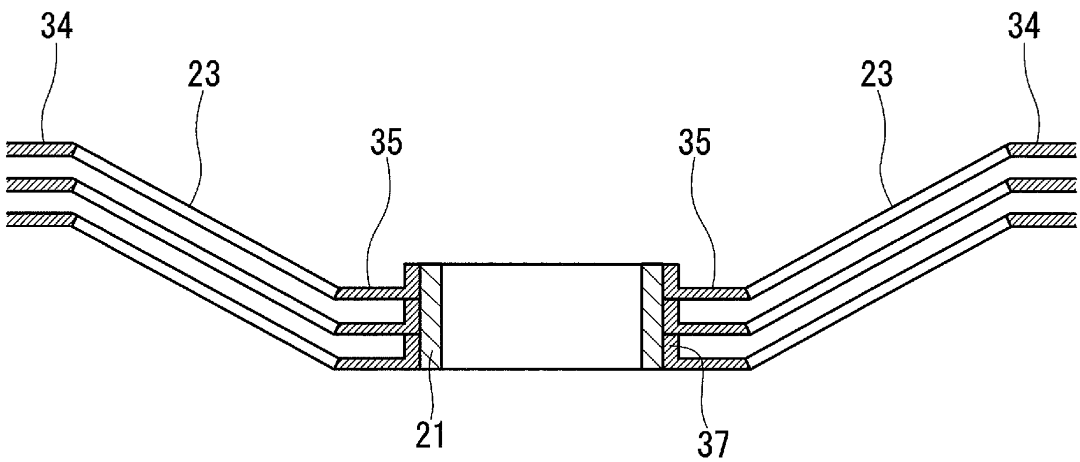


FIG.10D

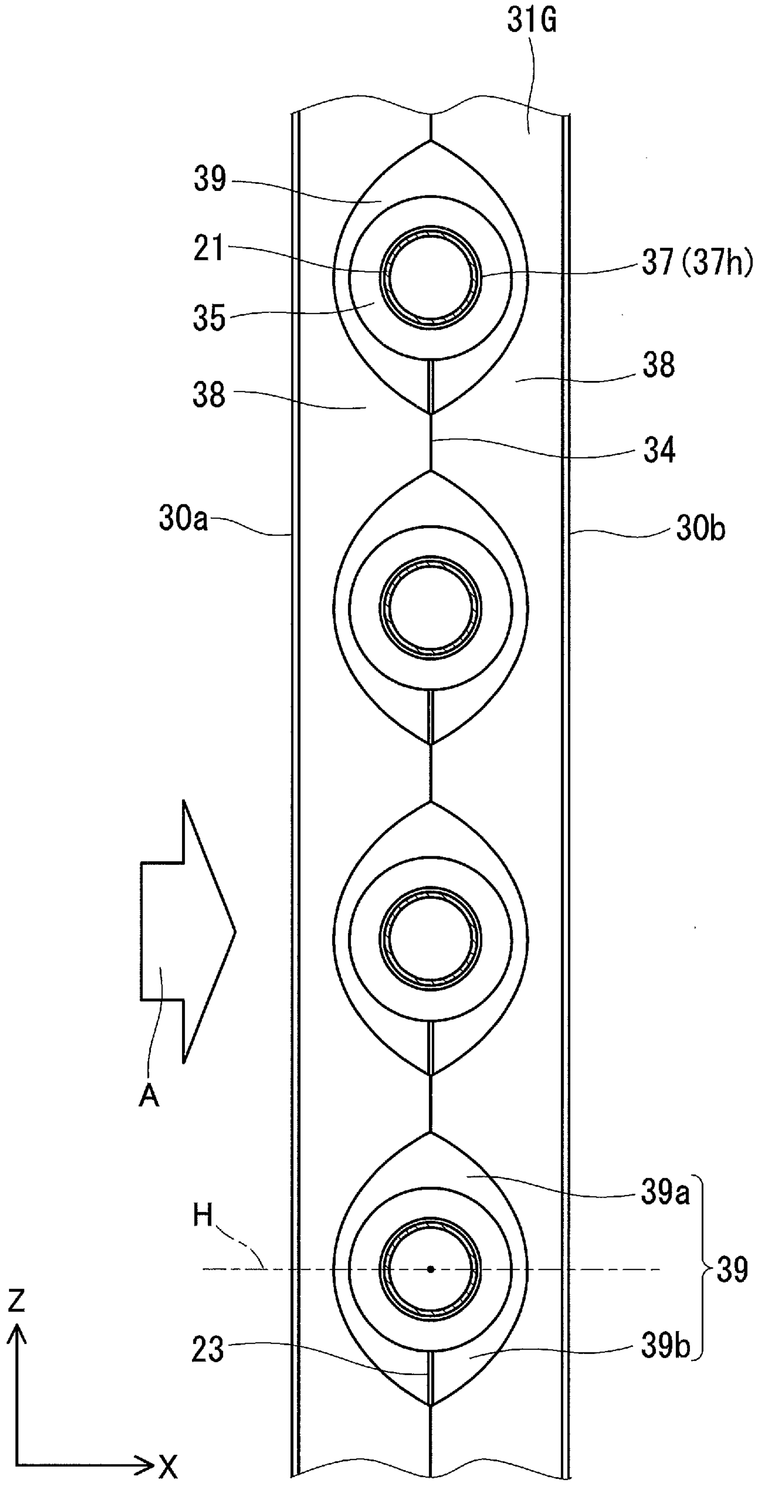


FIG.11

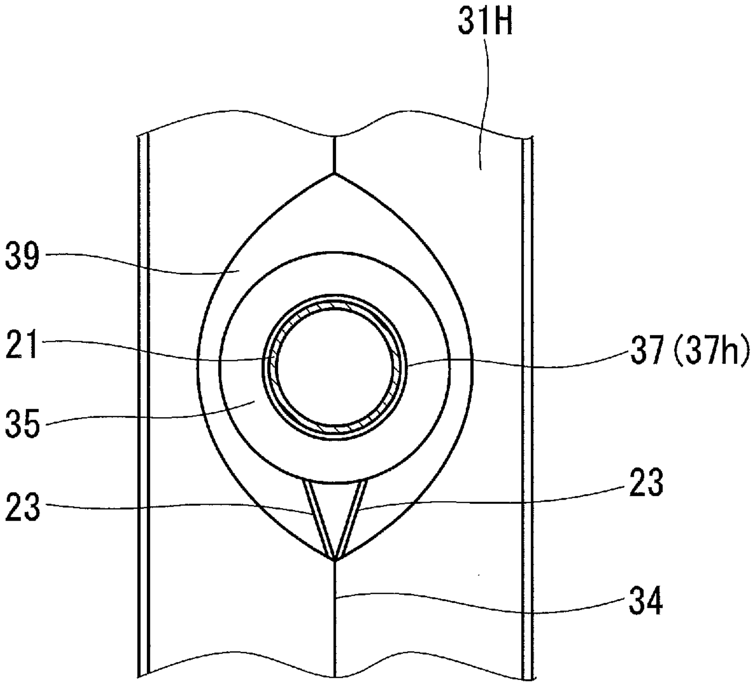
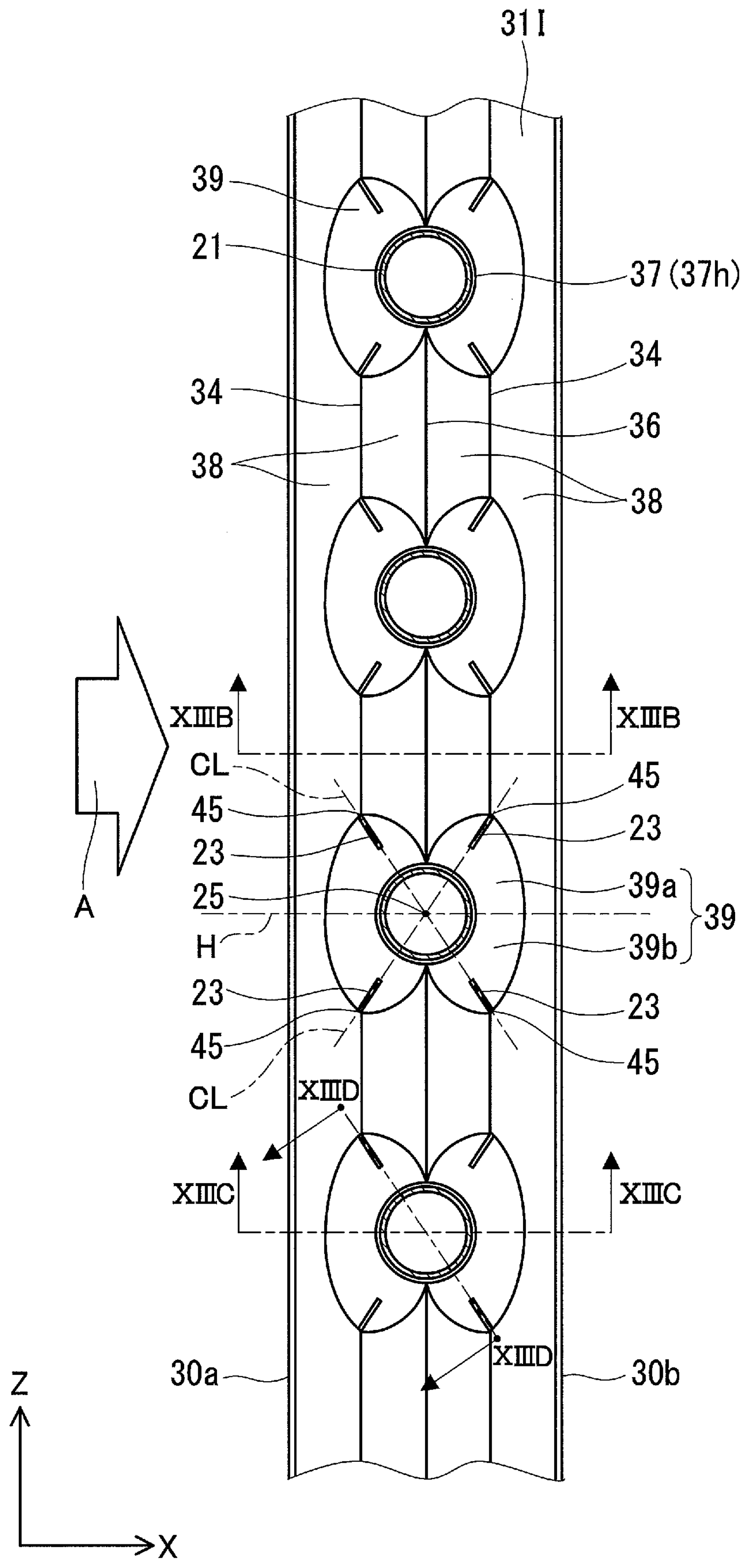


FIG.12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XIIIB
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39
A
H
39b
23
23
45
45
CL
XIIID
XIIIC
XIIIC
XIIID
30a
30b
Z
X

FIG.13A

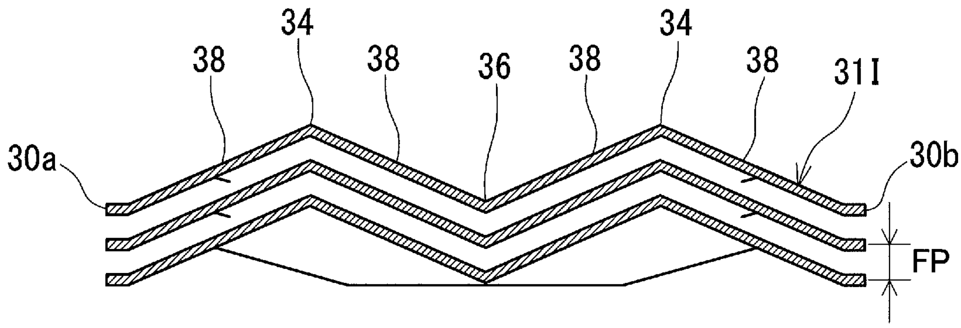

FIG.13B

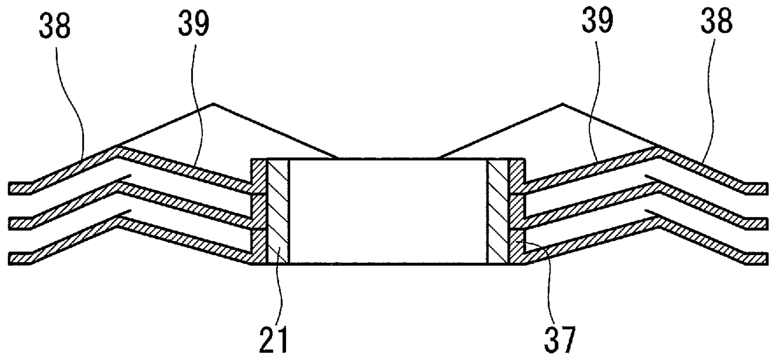

FIG.13C

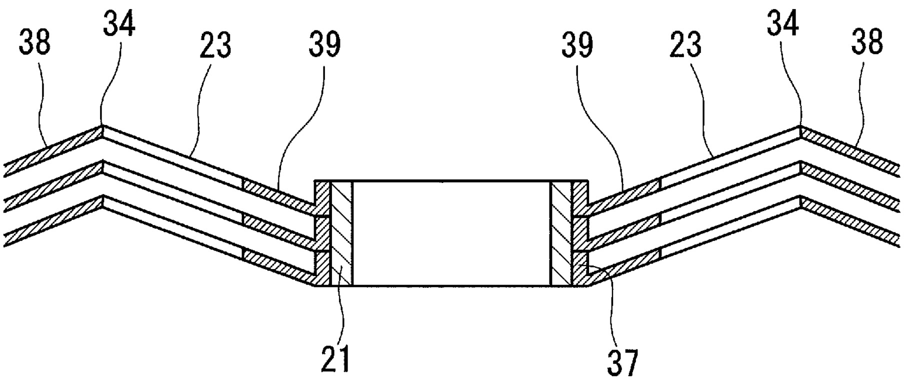

FIG.13D

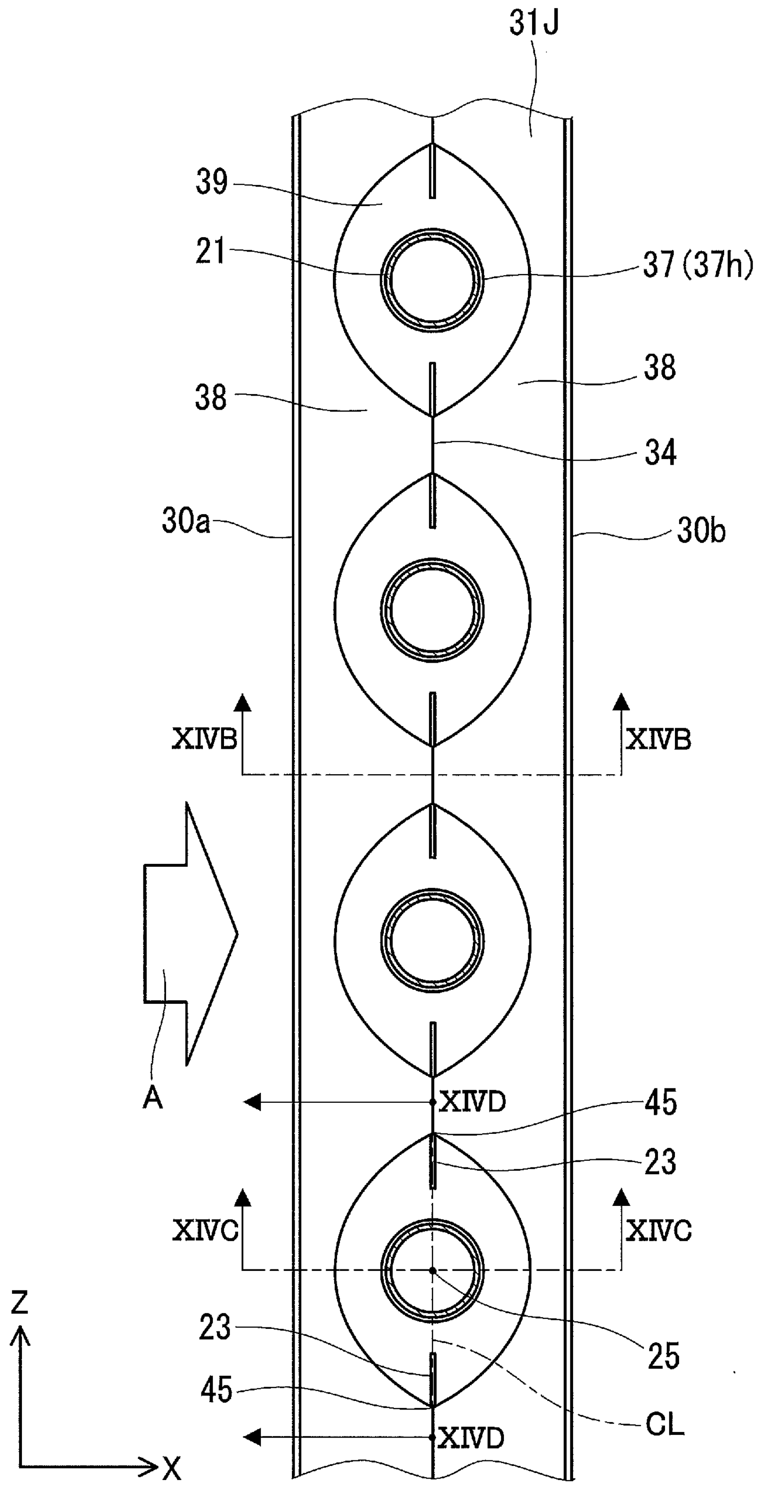
31J
39
21
37 (37h)
38
38
34
30a
30b
XIVB
XIVB
A
XIVD
45
23
XIVC
XIVC
Z
23
25
45
CL
XIVD
X

FIG.14A

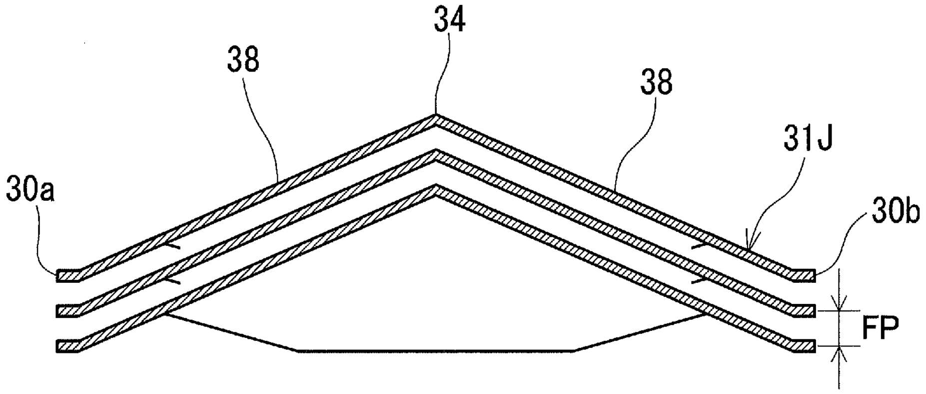

FIG.14B

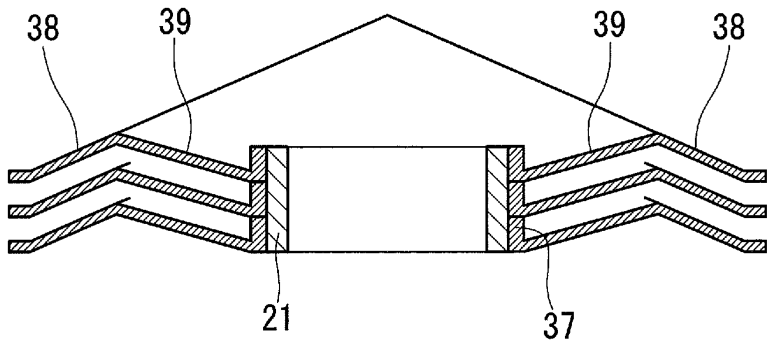

FIG.14C

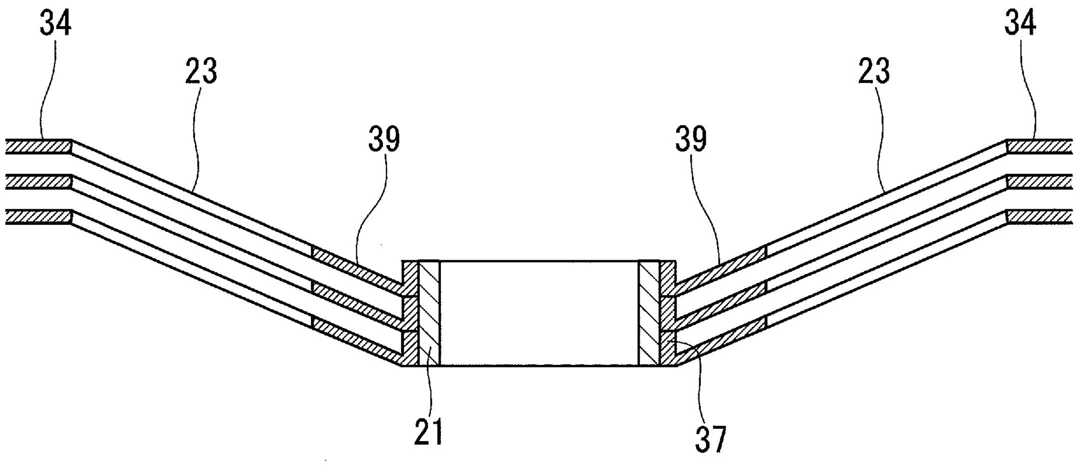

FIG.14D

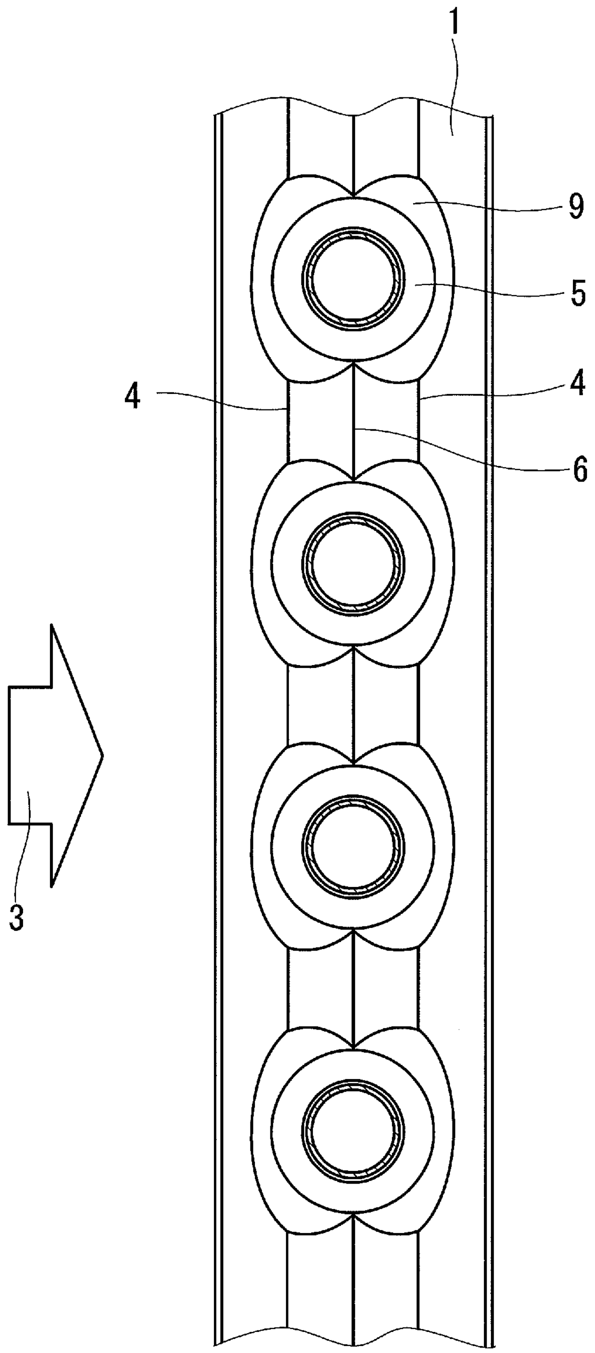

FIG.15

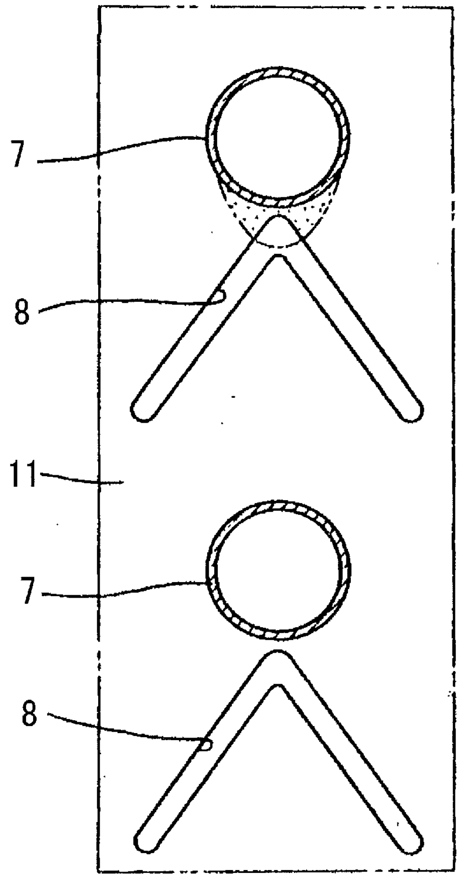

FIG.16

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2012/006562

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/32(2006.01)i

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)
F28F1/32

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
X Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 1334402/1980(Laid-open No. 61375/1982) (Sanyo Electric Co., Ltd.), 12 April 1982 (12.04.1982), fig. 3; specification, page 2, line 16 to page 3, line 6 (Family: none)	1-7,10,11,14 8,12,13
Y	JP 11-125495 A (Matsushita Electric Industrial Co., Ltd.), 11 May 1999 (11.05.1999), fig. 1 to 3 (Family: none)	8

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 November, 2012 (06.11.12)	13 November, 2012 (13.11.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/006562

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/033767 A1 (Panasonic Corp.), 24 March 2011 (24.03.2011), fig. 13 to 15; paragraphs [0041] to [0045] & CN 102472599 A	12
Y	JP 2009-192174 A (T. RAD Co., Ltd.), 27 August 2009 (27.08.2009), fig. 11; paragraph [0021] (Family: none)	13
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 180192/1980(Laid-open No. 104185/1982) (Sanyo Electric Co., Ltd.), 26 June 1982 (26.06.1982), fig. 4 to 7 (Family: none)	1-14
A	JP 2008-111646 A (Daikin Industries, Ltd.), 15 May 2008 (15.05.2008), entire text; all drawings & US 2010/0089557 A1 & EP 2072939 A1 & WO 2008/041635 A1 & AU 2007303342 A & KR 10-2009-0075706 A & CN 101523148 A	1-14
A	US 4545428 A (Toshiya ONISHI), 08 October 1985 (08.10.1985), entire text; all drawings & JP 55-167091 U	1-14
A	JP 2011-89656 A (Panasonic Corp.), 06 May 2011 (06.05.2011), entire text; all drawings & CN 102032819 A	1-14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 641989022186 U **[0005]**