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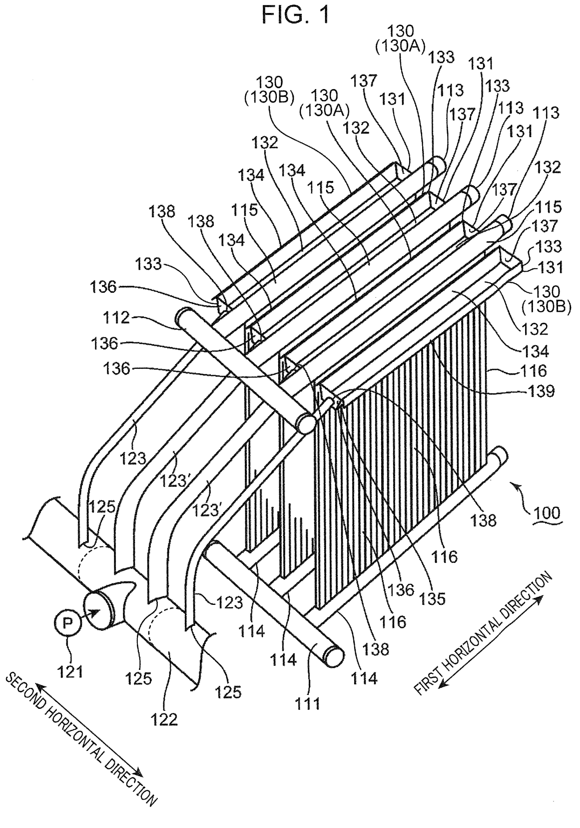
(54) **VAPORIZATION DEVICE**

(57) The present application discloses a vaporizing apparatus for vaporizing a liquefied gas by a way of heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas. The vaporizing apparatus includes: a plurality of heat transfer panels; a first trough and a second trough each for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes; a manifold allowing the heating liquid to flow in; a first supplying pipe connecting the manifold with the first trough for supplying the heating liquid from the manifold to the first trough; and a second supplying pipe connecting the manifold with the second trough for supplying the heating liquid from the manifold to the second trough, the second supplying pipe having a smaller flow path cross-sectional area than the first trough.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a vaporizing apparatus for vaporizing a liquefied gas.

Background Art

[0002] Various vaporizing apparatuses for vaporizing a cryogenic liquefied gas have been developed. A vaporizing apparatus disclosed in Patent Literature 1 includes a plurality of heat transfer panels each including a plurality of heat transfer tubes vertically provided to guide a liquefied gas upward, and a plurality of troughs each configured to sprinkle heating liquid having a higher temperature than the liquefied gas over the heat transfer panels. The plurality of heat transfer panels and the plurality of troughs are alternately arranged in a direction perpendicularly intersecting a lining-up direction of the plurality of heat transfer tubes. For the supply of the heating liquid to the plurality of troughs, a plurality of supplying pipes extending from a manifold are connected to the corresponding troughs.

[0003] The heating liquid is supplied to the plurality of troughs through the manifold and the plurality of supplying pipes. The heating liquid overflows from the troughs and is supplied to the plurality of heat transfer tubes of the heat transfer panels adjacent to each of the troughs. While the heating liquid is flowing down along the outer surface of each of the heat transfer tubes, the liquefied gas does heat exchange with the heating liquid with flowing upward in the heat transfer tubes. Owing to the heat exchange, the heating liquid has a decreased temperature, and the liquefied gas having an increased temperature vaporizes.

[0004] A part of the plurality of troughs may need a smaller amount of the heating liquid than other remaining troughs to supply the heating liquid to a corresponding heat transfer panel. For example, an outermost trough disposed in an outermost position of a row of the heat transfer panels is adjacent to an outermost heat transfer panel. In contrast, a trough provided between two heat transfer panels adjacent to each other is adjacent to the two heat transfer panels. In this case, the outermost trough may supply a smaller amount of the heating liquid than the remaining troughs.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Publication No. 2017-40296

Summary of Invention

[0006] An object of the present invention is to provide a vaporizing apparatus having a configuration that enables to differentiate supply amounts of heating liquid among a plurality of troughs.

[0007] A vaporizing apparatus according to an aspect of the present invention is configured to vaporize a liquefied gas by a way of heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas. The vaporizing apparatus includes: a plurality of heat transfer panels each including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas; a first trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of one of the plurality of heat transfer panels; a second trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of another of the plurality of heat transfer panels; a manifold allowing the heating liquid to flow in; a first supplying pipe connecting the manifold with the first trough for supplying the heating liquid from the manifold to the first trough; and a second supplying pipe connecting the manifold with the second trough for supplying the heating liquid from the manifold with the second trough, the second supplying pipe having a smaller flow path cross-sectional area than the first trough.

[0008] The aforementioned vaporizing apparatus has a configuration that enables to differentiate supply amounts of heating liquid among a plurality of troughs.

[0009] The object, features, and advantages of the present invention will be further clarified by the following detailed description and the accompanying drawings.

Brief Description of Drawings

[0010]

Fig. 1 is a schematic perspective view of a vaporizing apparatus of an open rack type.

Fig. 2 is a schematic cross-sectional view of the vaporizing apparatus.

Fig. 3 is a schematic cross-sectional view of a box used in the vaporizing apparatus.

Fig. 4 is a schematic perspective view of an obstructor provided in the box.

Fig. 5 is a schematic perspective view of another obstructor provided in the box.

Fig. 6 is a schematic cross-sectional view of a box having a single lid member.

Fig. 7 is a schematic cross-sectional view of a box having a single lid member.

Fig. 8 is a schematic cross-sectional view of a box having a single lid member.

Fig. 9 is a schematic cross-sectional view of a box having a single lid member.

Fig. 10 is a schematic cross-sectional view of a manifold used in a vaporizing apparatus.

Fig. 11 is a schematic cross-sectional view of a trough having two inflow ports.

Fig. 12 is a schematic cross-sectional view of a trough including a bottom wall having an inflow port.

Fig. 13 is a schematic cross-sectional view of a trough including a bottom wall having inflow ports.

Fig. 14 is a schematic cross-sectional view of a trough which receives a supply of the heating liquid through an upper portion of the trough.

Fig. 15 is a schematic cross-sectional view of a second trough connected with a second supplying pipe to which a closing member is fixedly attached.

Fig. 16 is a schematic cross-sectional view of a manifold in which a closing member is fixedly provided.

FIG. 17 is a schematic cross-sectional view of a vaporizing apparatus including a box in which a porous plate is mounted on an inflow port.

Description of Embodiments

[0011] Fig. 1 is a schematic perspective view illustrating a vaporizing apparatus (ORV) 100 of an open rack type. Fig. 2 is a schematic cross-sectional view of the vaporizing apparatus 100, being taken along a vertical plane. The vaporizing apparatus 100 will be described with reference to Fig. 1 and Fig. 2.

[0012] The vaporizing apparatus 100 is configured to vaporize a liquefied natural gas (hereinafter referred to as "liquefied gas") by making heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas. A vaporized natural gas obtained by the way of heat exchange is hereinafter referred to as "vaporized gas." As the heating liquid, seawater is used in the embodiment. Alternatively, other liquid having a higher temperature than the liquefied gas may serve as the heating liquid.

[0013] The vaporizing apparatus 100 includes a lower manifold 111 in which liquefied gas flows, an upper manifold 112 in which vaporized gas flows, and a plurality of heat transfer panels 113. The lower manifold 111 and the upper manifold 112 extend in a horizontal direction. The upper manifold 112 extends above and substantially in parallel with the lower manifold 111. The plurality of heat transfer panels 113 are connected with the upper manifold 112 and the lower manifold 111. The plurality of heat transfer panels 113 line up in the horizontal direction and spaced away from one another. The extending direction of the lower manifold 111 and the upper manifold 112 is the same as the lining-up direction of the plurality of heat transfer panels 113.

[0014] The lower manifold 111 is adapted for distributing the liquefied gas to the plurality of heat transfer panels 113. The plurality of heat transfer panels 113 are adapted for making heat exchange between the liquefied gas and the seawater. The upper manifold 112 is adapted for collecting the vaporized gas obtained by the way of heat exchange between the liquefied gas and the seawater. The upper manifold 112 is connected to a supplying device (not illustrated) for supplying the vaporized gas to a predetermined demanding destination (not illustrated).

[0015] Each of the plurality of heat transfer panels 113 includes a lower header pipe 114, an upper header pipe 115, and a plurality of heat transfer tubes 116. Each of the lower header pipe 114 and the upper header pipe 115 extends in a horizontal direction perpendicularly intersecting the extending direction of the lower manifold 111 and the upper manifold 112, and spaced away vertically from each other. The plurality of heat transfer tubes 116 extend vertically between the lower header pipe 114 and the upper header pipe 115. The lower header pipe 114 extends from the lower manifold 111 and defines a lower end of the heat transfer panel 113, and the upper header pipe 115 extends from the upper manifold 112 and defines an upper end of the heat transfer panel 113. The plurality of heat transfer tubes 116 extend upward from the lower header pipe 114 and joins the upper header pipe 115. The plurality of heat transfer tubes 116 line up in the extending direction of the lower header pipe 114 and the upper header pipe 115. The lining-up direction of the plurality of heat transfer tubes 116 is hereinafter referred to as a "first horizontal direction." The horizontal direction that perpendicularly intersects the first horizontal direction and is the extending direction of the lower manifold 111 and the upper manifold 112 is hereinafter referred to as a "second horizontal direction."

[0016] The vaporizing apparatus 100 has a pump 121 for discharging the seawater, and a manifold 122 for guiding the seawater discharged from the pump 121 in the second horizontal direction. The vaporizing apparatus 100 further has: a plurality of first supplying pipes 123' and a plurality of second supplying pipes 123 respectively connected with the manifold 122 and a plurality of troughs 130. The manifold 122 defines flow paths with the plurality of first supplying pipes 123' and the plurality of second supplying pipes 123 respectively for supplying the seawater to the troughs 130.

[0017] The manifold 122 extends in the second horizontal direction, and spaced away from the plurality of heat transfer panels 113 in the first horizontal direction. The manifold 122 has a plurality of outflow ports 125 from which the seawater having flowed into the manifold 122 flows out. The plurality of outflow ports 125 are on a line in the second horizontal direction and spaced away from one another.

[0018] The plurality of troughs 130 and the plurality of heat transfer panels 113 are disposed alternately in the second horizontal direction. In the vertical direction, each of the plurality of troughs 130 is disposed at a lower position than the upper header pipe 115. The trough 130 neighbors an upper portion of the plurality of heat transfer tubes 116 of the corresponding heat transfer panel 113 in the second horizontal direction, the upper portion being at a higher position than a middle of the plurality of heat transfer tubes 116 in the vertical direction. The trough 130 is disposed at a higher position than the manifold 122 having the outflow port 125.

[0019] Each of the plurality of troughs 130 includes a box body 131 for storing the seawater, and a guiding portion 139 for guiding the seawater having overflowed from the box body 131 to an outer surface of each of the plurality of heat transfer tubes of the corresponding heat transfer panel 113.

[0020] The box body 131 has a rectangular-shaped casing that is long in the first horizontal direction and short in the second horizontal direction. The box body 131 opens upward. The box body 131 has a substantially rectangular bottom wall 132 elongated in the first horizontal direction, and a peripheral wall 133 standing upward from an outer peripheral edge of the bottom wall 132. The peripheral wall 133 has an upper end entirely lying on a substantially horizontal plane.

[0021] The peripheral wall 133 includes a pair of side walls 134, 135 standing upward from a pair of longitudinally extending end edges of the bottom wall 132, and a pair of a first end wall 136 and a second end wall 137 standing upward from a pair of widthwise extending end edges of the bottom wall 132. The side walls 134, 135 stand at the opposite positions spaced away from each other in the second horizontal direction while the first end wall 136 and the second end wall 137 stand at the opposite positions spaced away from each other in the first horizontal direction.

[0022] The dimension of the side walls 134, 135 and the bottom wall 132 in the first horizontal direction is set to be larger than the lining-up dimension of the plurality of heat transfer tubes 116 in the first horizontal direction. The box body 131 is arranged in such a way that the side walls 134, 135 overlap the whole of the plurality of heat transfer tubes 116 in the second horizontal direction.

[0023] The first end wall 136 is arranged closer to the outflow port 125 of the manifold 122 than the second end wall 137. The first end wall 136 has an inflow port 138 for allowing the seawater to flow in (see Fig. 1). A center of the inflow port 138 is located below a center of the first end wall. In the second horizontal direction, a position of the inflow port 138 of the first end wall 136 substantially coincides with a position of the outflow port 125 of the manifold 122. The trough 130 is disposed at a higher position than the manifold 122. Accordingly, the position of the inflow port 138 formed in the first end wall 136 of the trough 130 is also higher than that of the outflow port 125 of the manifold 122.

[0024] In the four troughs 130 lining up in the second horizontal direction and spaced away from one another, each of the inner troughs 130 that is disposed between the transfer panels 113 adjacent to each other is hereinafter referred to as a "first trough 130A". Further, each of the two troughs 130 in outermost positions of a row of the heat transfer panels 113 is hereinafter referred to as a "second trough 130B". Each of the two second troughs 130B is adjacent only to one of heat transfer panels 113. In contrast, each of the two first troughs 130A is disposed between two of the heat transfer panels 113 that are adjacent to each other, and thus is adjacent to the two heat transfer panels 113.

[0025] In each of the second troughs 130B, the first end wall 136 and the second end wall 137 are higher than the side walls 134, 135. Specifically, each of the first end wall 136 and the second end wall 137 has an upper end extending at a higher position than upper ends of the side walls 134, 135.

[0026] In the right second trough 130B, the first end wall 136, the second end wall 137, and the right side wall 135 are higher than the left side wall 134 (i.e., the side wall 134 facing the heat transfer panel 113). Specifically, each of the first end wall 136, the second end wall 137, and the side wall 135 has an upper end extending at a higher position than an upper end of the side wall 134. In other words, one side wall closer to the heat transfer panel 113 is shorter than the other side wall opposite to the one side wall.

[0027] In the left second trough 130B, the first end wall 136, the second end wall 137, and the left side wall 134 are higher than the right side wall 135 (i.e., the side wall 135 facing the heat transfer panel 113). Specifically, each of the first end wall 136, the second end wall 137, and the side wall 134 has an upper end extending at a higher position than the upper end of the side wall 135.

[0028] The guiding portion 139 has an inclined surface inclining downward from an upper end edge of at least one of the side walls 134, 135 to the heat transfer panel 113 that is the supply destination of the seawater. The guiding portion 139 is used to guide the seawater having flowed over the upper end edge of the side walls 134, 135 of the box body 131 after supplied beyond the capacity of the box body 131 to the plurality of heat transfer tubes 116 of the corresponding heat transfer panel 113.

[0029] In the left second trough 130B, the guiding portion 139 protrudes rightward from the upper end of the side wall 135 closer to the heat transfer panel 113. No guiding portion 139 is provided to the opposite side wall 134. In the right second trough 130B, the guiding portion 139 protrudes leftward from the upper end of the left side wall 134. No guiding portion 139 is provided to the opposite side wall 135. In each of the first troughs 130A, the guiding portion 139 protrudes outward from both the upper ends of the side walls 134, 135.

[0030] Each of the first supplying pipes 123' and the second supplying pipes 123 has an upstream end joining the outflow port 125 of the manifold 122, and a downstream end joining the inflow port 138 of the corresponding trough 130, and defines a flow path between the upstream end and the downstream end for allowing the seawater to pass through the flow path. The first supplying pipe 123' extends from the manifold 122 to reach the inflow port 138 of the first trough 130A. The second supplying pipe 123 extends from the manifold 122 to reach the inflow port 138 of the second trough 130B. The second supplying pipe 123 has a smaller flow path cross-sectional area than the first supplying pipe 123'.

[0031] There will be described below flows of the liquefied gas and the seawater in the vaporizing apparatus 100.

[0032] The liquefied gas is supplied to the lower manifold 111 by a pump (not illustrated). The liquefied gas having flowed into the lower manifold 111 flows to the lower header pipe 114 of each of the plurality of heat transfer panels 113. The liquefied gas having flowed to the lower header pipe 114 flows upward through the plurality of heat transfer tubes 116. In the meantime, the liquefied gas vaporizes by the way of heat exchange between the liquefied gas and the seawater. The vaporized gas flows upward to the upper header pipe 115. Subsequently, the vaporized gas flows through the upper header pipe 115, and is collected in the upper manifold 112.

[0033] The seawater is supplied to the manifold 122 by the pump 121. The seawater is guided in the second horizontal direction by the manifold 122, and distributed to the plurality of first supplying pipes 123' and the plurality of second supplying pipes 123 respectively connected with the manifold 122. The seawater having flowed through the plurality of first and second supplying pipes 123', 123 flows into the corresponding first troughs 130A and second troughs 130B. The seawater having flowed into each of the first and second troughs 130A, 130B forms a liquid layer in the space defined by the bottom wall 132 and the peripheral wall 133. When the inflow of the seawater into the trough 130 exceeds the capacity of the box body 131, the seawater overflows from the upper end edge of the side walls 134, 135. Subsequently, the seawater flows down over the inclined surface of the guiding portion 139. Consequently, the seawater scatters over the upper portion of the plurality of heat transfer tubes 116 extending along the side of the box body 131.

[0034] In the vaporizing apparatus 100, each of the two first troughs 130A is required to supply the heating liquid to two of the heat transfer panels 113, whereas each of the two second troughs 130B supplies the heating liquid to one of the heat transfer panels 113. In other words, the first troughs 130A are required to send out the heating liquid having a larger flow than that sent out from the second troughs 130B. Accordingly, each of the first troughs 130A needs a larger supply amount of the heating liquid than the second troughs 130B.

[0035] The supplying pipes 123' are set to have the larger flow path cross-sectional area than the supplying pipes 123 to differentiate supply amounts of the heating liquid between the first troughs 130A and the second troughs 130B. This configuration eliminates the necessity of attaching any valve to each of the first and second supplying pipes 123, 123' to achieve the aforementioned magnitude relationship of the flows.

[0036] The conventional structure has the flow path to allow the seawater to flow in from the bottom surface of the trough. A tube member defining the flow path extends from the manifold beyond the first end wall and joins the inflow port formed in the bottom surface of the trough. Unlike the conventional structure, the first and second supplying pipes 123', 123 are connected to the first end wall 136 without extending beyond the first end wall 136, which thus reduces not only the cost for the material of the first and second supplying pipes 123', 123 but also the resistance to the flow of the seawater flowing through the first and second supplying pipe 123', 123.

[0037] The configurations described with reference to the above-mentioned embodiments are merely for illustrative purpose and should not be construed limitatively. Various modifications or improvements may be additionally applied to the configurations described with reference to the above-mentioned embodiments.

[0038] In the above-mentioned embodiments, a liquefied natural gas is exemplified as the liquefied gas. However, the liquefied gas may be liquefied petroleum gas, liquid nitrogen, or the like.

[0039] In the embodiment, the box body 131 of the trough 130 may contain various components with the aim of regulating the inflow of the seawater into the trough 130 or suppressing a liquid surface rising of the seawater in the trough 130. An exemplary internal structure of the box body 131 is illustrated in Fig. 3. Fig. 3 is a schematic longitudinal cross-sectional view of the box body 131.

[0040] The vaporizing apparatus 100 includes a closing member 140 mounted on an inner surface of the box body 131 in order to close a part of the inflow port 138. The closing member 140 is used to ensure a substantially uniformed inflow of the seawater with the other troughs 130.

[0041] As the closing member 140, an orifice in which an opening 141 is formed in the first horizontal direction may be preferably used. The opening 141 has a smaller area than the inflow port 138. The closing member 140 may be mounted on an inner surface of the first end wall 136 and/or the side walls 134, 135. Further, the closing member 140 may be removable from the first end wall 136 and/or the side walls 134, 135. For example, the side walls 134,135 may be formed with grooves in the inner surfaces of the side walls 134, 135, side ends of the closing member 140 being inserted into the grooves.

[0042] When an orifice member is replaced with another orifice member having a smaller opening area in the box body 131 of one of the plurality of troughs 130, the trough 130 which is replacedly mounted with the another orifice member receives a decreased seawater inflow, while the other troughs 130 receive an increased seawater inflow. On the contrary, when the orifice member is replaced with still another orifice member having a larger opening area, the trough 130 which is mounted with the still another orifice member having the larger opening area receives an increased seawater inflow, while the other troughs 130 receive a decreased seawater inflow. To distribute a uniform amount of seawater to the plurality of troughs 130, it is preferable to choose an orifice as the closing member 140 for each of the plurality of troughs 130, the orifice having a proper opening area for the plurality of troughs 130.

[0043] In the conventional structure, fluidic devices, such as butterfly valves and orifice members, are generally provided in the flow passage extending from the manifold to the plurality of troughs. These devices are used to suppress a variation of a flow amount of seawater into a plurality of troughs. In the embodiment, the closing member 140 is used to suppress the variation of a flow amount of the seawater among the plurality of troughs.

[0044] In the replacement of the closing member 140, an operator who performs a replacement operation can easily access the closing member 140 owing to an upward opening of the box body 131. The operator can remove the mounted closing member 140 from the box body 131, and mount another closing member in the box body 131. Unlike the configuration in which the butterfly valves and the orifice members are mounted in the supplying pipes, the replacement of the closing member 140 does not require the disassembly of the first and second supplying pipes 123', 123. Additionally, the operator can perform the replacement operation in a larger space above the trough 130, not in a smaller space defined by the first and second supplying pipes 123', 123. Accordingly, the operator can replace the closing member 140 more easily.

[0045] In the above-mentioned configuration, the inflow port 138 is formed in the first end wall 136. In this case, the heating liquid having flowed in through the inflow port 138 collides against the opposite second end wall 137. A part of the heating liquid having collided against the second end wall 137 flows upward, and causes the liquid surface of the heating liquid to rise at a location closer to the second end wall 137. To suppress such a liquid surface rising, the vaporizing apparatus 100 may include a rise suppressing portion for suppressing a liquid surface rising in the trough 130.

[0046] The rise suppressing portion has an obstructor provided between the first end wall 136 and the second end wall 137. The obstructor is provided in such a way that the seawater having flowed in from the inflow port 138 collides against the obstructor before colliding against the second end wall 137. The obstructor includes a baffle plate (or obstructive pieces) 151 standing upward from the bottom wall 132. It is shown in Fig. 3 that three baffle plates 151 are provided.

[0047] A plurality of baffle plates 151 line up in the first horizontal direction between the first end wall 136 and the second end wall 137, and spaced away from one another. The plurality of baffle plates 151 are mounted on the bottom wall 132 and/or the side walls 134, 135. The plurality of baffle plates 151 may be removable from the bottom wall 132 and/or the side walls 134, 135.

[0048] A height dimension of the baffle plate 151 is smaller than a height dimension of the peripheral wall 133, so that a space is defined above the baffle plates 151, the space allowing the seawater to flow in the first horizontal direction.

[0049] The flow path of the seawater from the manifold 122 to the plurality of troughs 130 will be described below in comparison to the structure of the conventional vaporizing apparatus.

[0050] The seawater having flowed into the box body 131 collides against the plurality of baffle plates 151. The effect which the baffle plates 151 bring on the seawater flowing in the box body 131 will be described below.

[0051] Fig. 3 shows a straight line (solid line) extending in the first horizontal direction above the plurality of baffle plates 151 and a dotted curved line. The solid line schematically illustrates a presumed liquid surface of the seawater in a configuration having the plurality of baffle plates 151. The dotted line schematically illustrates a presumed liquid surface of the seawater in a configuration having no baffle plates 151.

[0052] In the configuration having no baffle plates 151, the seawater having sequentially passed through the inflow port 138 and the opening 141 of the closing member (orifice member) 140 will vigorously collide against an inner surface of the second end wall 137. Apart of the seawater having collided against the second end wall 137 energetically flows upward along the inner surface of the second end wall 137. This results in a liquid surface upward rising of the seawater at a location closer to the inner surface of the second end wall 137 in the box body 131, as shown in the dotted line.

[0053] On the other hand, in the configuration having the plurality of baffle plates 151, a part of the seawater having sequentially passed through the inflow port 138 and the opening 141 of the closing member (orifice member) 140 will collide against a baffle plate 151 provided most upstream (i.e., a baffle plate 151 provided closest to the first end wall 136). A part of the seawater having collided against the baffle plate 151 turns its direction to flow in directions other than the first horizontal direction, while the other seawater passes over the baffle plate 151 to flow to the second end wall 137. The seawater having passed over the most-upstream baffle plate 151 collides against the next baffle plate 151. The seawater collides against the plurality of baffle plates 151 one after another, resulting in a less amount of the seawater flowing energetically to the second end wall 137. The collisional force between the seawater and the second end wall 137 is smaller in the configuration having the plurality of baffle plates 151 than the configuration having no baffle plates 151, which then reduces the upward flowing force of the seawater caused by the collision of the seawater against the second end wall 137. This results in a lowered liquid surface rising at the location closer to the inner surface of the second end wall 137.

[0054] The number of provided baffle plates 151 may be preferably determined on the basis of the flow of the seawater into the trough 130 and a flowing condition of the seawater in the trough 130 to make the liquid surface of the seawater in the trough 130 substantially flat. Accordingly, the obstructor may have one or two baffle plates 151, further may have three or more baffle plates 151.

[0055] Instead of the baffle plate 151, other obstructors may allow the seawater having flowed in from the inflow port 138 to collide against the other obstructors. Alternative members usable as an obstructor will be described with reference to Figs. 4 and 5. Figs. 4 and 5 are schematic perspective views of an alternative obstructor.

[0056] Instead of the baffle plate 151 having no through hole, a porous plate 152 having many through holes in the first horizontal direction may be used as an obstructor (see Fig. 4). The through holes of the porous plate 152 allow the seawater to pass through. Accordingly, the porous plate 152 may have substantially the same height dimension as the peripheral wall 133.

[0057] Instead of the baffle plate 151 being thin in the first horizontal direction, a small block 153 whose dimensional differences in the first horizontal direction, second horizontal direction, and the vertical direction are smaller than those of the baffle plate 151 may be used (see Fig. 5). The shape and size of a member serving as the rise suppressing portion may be preferably determined so as to make the liquid surface of the seawater in the box body 131 substantially flat.

[0058] The rise suppressing portion may be configured to have a plate-like lid member 154 provided at a location closer to the second end wall 137 in the box body 131. The lid member 154 has many through holes. Accordingly, the lid member 154 may be preferably made of a porous plate (plate). The lid member 154 may be used singly as the rise suppressing portion (see Fig. 6), or may be used in a combination with an obstructor (a baffle plate 151, for example) as the rise suppressing portion.

[0059] The lid member 154 is provided to lie on a substantially horizontal plane with extending from a vicinity of the second end wall 137 in the first horizontal direction. The lid member 154 partitions vertically a part of an inner space of the box body 131 at the location closer to the second end wall 137. A pair of side ends of the lid member 154 may be attached to the inner surfaces of the side walls 134, 135. A downstream end of the lid member 154 may be attached to and made contact with the inner surface of the second end wall 137 (see Fig. 6). Alternatively, the downstream end of the lid member 154 may be placed at a location slightly away in the first horizontal direction from the inner surface of the second end wall 137 (see Fig. 7). The downstream end of the lid member 154 is close to the inner surface of the second end wall 137, while an upstream end of the lid member 154 is far away from the inner surface of the first end wall 136. The lid member 154 may be preferably removable from the box body 131.

[0060] The lid member 154 is provided at a position higher than the inflow port 138. Accordingly, most of the seawater having flowed from the inflow port 138 through the opening of the closing member (orifice member) 140 into the box body 131 collides against the inner surface of the second end wall 137 below the lid member 154.

[0061] The seawater flowing upward due to a collision below the lid member 154 collides against a bottom surface of the lid member 154. Consequently, most of the seawater having collided against the lid member 154 flows along the bottom surface of the lid member 154 to the first end wall 136 at the upstream. Accordingly, the liquid surface rising at the location closer to the downstream second end wall 137 can be effectively suppressed.

[0062] A part of the seawater having collided against the lid member 154 flows upward to a space above the lid member 154 through the through holes passing in the vertical direction through the lid member 154. Accordingly, the lid member 154 does not hinder excessively the seawater from forming a liquid layer over the lid member 154. In other words, the lid member 154 does not perform excessive suppression of overflowing of the seawater from the downstream end edge of the trough 130.

[0063] As long as a suppression effect to a liquid surface rising at a specific location is achievable over the entire trough 130, it is not required that the lid member has through holes. In this case, the seawater flows to the space above the lid member through a space between the upstream end of the lid member and the upstream first end wall 136.

[0064] Figs. 6 and 7 show a single porous plate serving as the lid member 154. However, a plurality of porous plates (plates) 155 may serve as the lid member 154 in the box body 131 (see Fig. 8). These porous plates 155 are spaced away from one another in the first horizontal direction. Additionally, these porous plates 155 are provided at substantially the same vertical position (at a position higher than the inflow port and lower than an upper end of the box body 131). The most-downstream porous plate 155 is equivalent to the lid member 154 described above with reference to Figs. 6 and 7. In other words, the most-downstream porous plate 155 contributes to suppression of the liquid surface rising at a location closer to the second end wall 137. The other porous plates 155 contribute to suppression of the liquid surface waving due to the seawater from the inflow port 138. An inflow port 138 which is formed in a lower portion of the first end wall 136 serves to hinder the liquid surface waving to some extent. Further, these porous plates 155 hinder the liquid surface waving more effectively.

[0065] Instead of the plurality of porous plates 155, a plurality of thin plates each having no through holes may be mounted at the same position as the porous plates 155. In this case, the seawater flows to a space above the thin plates through a gap between the neighboring thin plates. The plurality of thin plates can exert the suppression effect to the liquid surface waving and rising.

[0066] A single porous plate 156 that is long in the first horizontal direction may serve as the lid member 154 (see Fig. 9) to obtain the suppression effect to the liquid surface waving and rising. The single porous plate 156 shown in Fig. 9 partitions vertically the inner space of the box body 131 between the inner surface of the first end wall 136 and the inner surface of the second end wall 137. The porous plate 156 lies at vertically the same position as the porous plate 155 in Fig. 8. The seawater flows to the space above the porous plate 156 through the through holes of the porous plate 156.

[0067] The vertical arrangement of the manifold 122 may be modified to various layouts. Other layouts for the manifold 122 are described with reference to Fig. 1 and Fig. 10. Fig. 10 is a schematic cross-sectional view of the manifold 122.

[0068] In the layout shown in Fig.1, the inflow port 1 38 of the first end wall 136 is arranged at a vertical position different from that of the outflow port 125 of the manifold 122. However, the relative positional relationship of the manifold 122 to the plurality of troughs 130 may be determined so that the inflow port 138 of the first end wall 136 substantially coaxially aligns with the outflow port 125 of the manifold 122 (see Fig. 10). In other words, the manifold 122 may be arranged at a position higher than that shown in Fig. 1 so that the vertical position of the manifold 122 substantially coincides with the vertical position of the plurality of troughs 130. In this case, the first and second supplying pipes 123 each of a straight type can be suitably used as the supplying pipe connected to the manifold, consequently forming a flow path shorter than the bended flow path.

[0069] The vaporizing apparatus 100 may additionally include another manifold 122 and another first supplying pipe 123' (and/or another second supplying pipe 123) (see FIG. 11). In this case, the second end wall 137 has an inflow port 138 as well. Moreover, the vaporizing apparatus 100 additionally includes another closing member 140 adjacently and fixedly attached to the inner surface of the second end wall 137 for closing a part of the inflow port 138 of the second end wall 137.

[0070] The heating liquid flows in through the inflow ports 138 of the first end wall 136 and the second end wall 137, resulting in generating opposite directional flows in the trough 130. The flows meet at a substantially intermediate location in the longitudinal direction of the trough 130. Although the flows having met may be likely to cause a liquid surface rising of the heating liquid at the intermediate location, for example, when the liquid member 154 described with reference to FIG. 9 is adopted, it is possible to suppress the liquid surface rising.

[0071] Regarding a supply amount of the heating liquid to the first trough 130A, the structure of the trough 130 illustrated in FIG. 11 may be applied only to the first trough 130A to differentiate supply amounts of the heating liquid between the first trough 130A and the second trough 130B by adding another first supplying pipe 123' to the second end wall 137 as well as providing the first supplying pipe 123' with a flow path cross-sectional area larger than that of the second supplying pipe 123.

[0072] The bottom wall 132 may have an inflow port 138' to prevent the heating liquid from colliding against the first end wall 136 or the second end wall 137 (see FIG. 12). In this case, the heating liquid flows into the trough 130 through the inflow port 138' in the bottom wall 132, and thereafter advances in the longitudinal direction of the trough 130. Since the inflow port 138' does not face the peripheral wall 133 of the trough 130, a liquid surface rising attributed to a collision of the heating liquid against the peripheral wall 1 33 is suppressed.

[0073] In FIG. 12, the bottom wall 132 of the trough 130 has the single inflow port 138'. In this case, the liquid surface may rise at a specific location above the inflow port 138' as shown in FIG. 12. The bottom wall 132 may have a plurality of inflow ports 138' to suppress the liquid surface rising at the specific location. In FIG. 13, the first supplying pipe 123' and/or the second supplying pipe 123 connected to the trough 130 has a header tube 126 longitudinally extending from the manifold 122 under the trough 130. The first supplying pipe 123' and/or the second supplying pipe 123 has a plurality of connection tubes 127 extending upward from the header tube 126 and respectively joining the corresponding inflow ports 138' in the bottom wall 132. Each of the connection tubes 127 and the header tube 126 has a flow path cross-sectional area which varies depending on use of either the first supplying pipe 123' or the second supplying pipe 123.

[0074] Owing to the plurality of inflow ports 138', the amount of the heating liquid flowing into the trough 130 through each of the inflow ports 138' decreases. A liquid surface rising is accordingly suppressed above each of the inflow ports 138'.

[0075] The plurality of connection tubes 127 may have flow path cross-sectional areas different from each other to achieve a flatter liquid surface of the heating liquid in the trough 130. For example, in a case that a large liquid surface rising of the heating liquid generates at a specific location, the connection tube 127 at the specific location may have a relatively small flow path cross-sectional area. In this case, a resistance increases in the smaller flow path cross-sectional area 127, and hence, the inflow of the heating liquid from the connection tube 127 decreases. In this manner, the liquid surface rising of the heating liquid is reduced above the connection tube 127.

[0076] In the above-described embodiment, each of the inflow ports 138, 138' is formed to supply the heating liquid to the trough 130. In a case that the trough 130 has an opening-upward region for allowing the heating liquid to flow in, the trough 130 may exclude the inflow ports 138, 138'. In this case, the first supplying pipe 123' (and/or the second supplying pipe 123) is arranged in a space above the trough 130 (see FIG. 14).

[0077] Further, even in the case that the trough 130 receives the supply of the heating liquid through the opening-upward region, the liquid surface rising attributed to the collision of the heating liquid against the peripheral wall 133 is suppressed. Besides, the trough 130 including no inflow port 138, 138' has a simpler structure.

[0078] FIG. 14 illustrates a single manifold 122. A plurality of manifolds 122 may be arranged above the trough 130 to increase the inflow of the heating liquid into the trough 130.

[0079] In the above-described embodiment, the closing member 140 is provided in the trough 130. Instead, a closing member 140' for closing a part of the flow path of the second supplying pipe 123 may be provided in the second supplying pipe 123 as shown in FIG. 15. In Fig. 15, the closing member 140' is fixedly attached to an upstream end of the second supplying pipe 123. Alternatively, the closing member 140’ may be mounted at another portion, e.g., a downstream end or an intermediate portion, of the second supplying pipe 123.

[0080] Such arrangement of the closing member 140’ in the second supplying pipe 123 makes it possible to further decrease the flow of the heating liquid in the second supplying pipe 123. The inflow of the heating liquid into the second supplying pipe 123 is finely regulated by adjusting an area to be closed by the closing member 140’ relative to the flow path cross-sectional area of the second supplying pipe 123.

[0081] As shown in FIG. 16, two closing members 140" may be fixedly provided in the manifold 122. The closing members 140" are configured to close a part of the flow path in the manifold 122. Each of the closing members 140" is fixedly kept at a position (indicated by a dashed line in FIG. 1) between a connection portion of the manifold 122 with the first supplying pipe 123’ and another connection portion of the manifold 122 with the second supplying pipe 123. An inflow portion which allows the heating liquid to flow from a pump 121 into the manifold 122 is mounted to the manifold 122 within the range of the flow path between the closing members 140". In other words, the inflow portion is at a location closer to the connection portion for the first supplying pipe 123’ than the connection portion for the second supplying pipe 123.

[0082] The heating liquid flows into the second supplying pipe 123 after passing through each of the closing members 140", while flowing into the first supplying pipe 123’ without passing through the closing members 140". The configuration including the closing members 140" in the manifold 122 makes it possible to finely regulate the flow difference between the first supplying pipe 123’ and the second supplying pipe 123 due to the different flow path cross-sectional areas of the first supplying pipe 123’ and the second supplying pipe 123.

[0083] In the above-mentioned embodiment, the closing member 140 (as well as the closing members 140’, 140") is made up of an orifice member. However, the closing member 140 (as well as the closing members 140’, 140") may be made up of a porous plate 142 as shown in Fig. 17.

[0084] In the above-mentioned embodiments, a plurality of baffle plates 151 are used as the rise suppressing portion. However, a single baffle plate may be used as the rise suppressing portion. The number of provided baffle plates serving as the rise suppressing portion may be determined on the basis of the flow of the seawater into the trough 130 and the dimension of the inflow port 138. An arrangement interval between the plurality of baffle plates 151 and the height of the plurality of baffle plates 151 may be determined on the basis of these design conditions.

[0085] The vaporizing apparatus described in connection with the various embodiments mainly has the following features.

[0086] A vaporizing apparatus according to an aspect of the embodiment is configured to vaporize a liquefied gas by a way of heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas. The vaporizing apparatus includes: a plurality of heat transfer panels each including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas; a first trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of one of the plurality of heat transfer panels; a second trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of another of the plurality of heat transfer panels; a manifold allowing the heating liquid to flow in; a first supplying pipe connecting the manifold with the first trough for supplying the heating liquid from the manifold to the first trough; and a second supplying pipe connecting the manifold with the second trough for supplying the heating liquid from the manifold to the second trough, the second supplying pipe having a flow path cross-sectional area smaller than a flow path cross-sectional area of the first trough.

[0087] In the above-mentioned configuration, the first and second troughs receive the heating liquid through the first and second supplying pipes connected with the manifold. Thus, the supply amounts of the heating liquid to the troughs differ from each other depending on the flow path cross-sectional area of the corresponding supplying pipe. When it is allowed that the second trough supplies a smaller amount of the heating liquid to the corresponding transfer heat panel than that of the heating liquid from the first trough to the corresponding heat transfer panel, the second trough may receive a relatively small supply amount of the heating liquid without a complicated structure of the vaporizing apparatus.

[0088] With the above-mentioned configuration, the second trough may lie in an outermost position of a row of the plurality of heat transfer panels, and the first trough may lie between the heat transfer panels adjacent to each other.

[0089] In the above-mentioned configuration, the second trough is adjacent to one of the heat transfer panels, and the first trough is adjacent to two of the heat transfer panels. In this configuration, the second trough allows the heating liquid to flow downward to the one heat transfer panel. In contrast, the first trough allows the heating liquid to flow downward to the two heat transfer panels. Since the supplying pipe connected with the second trough has the smaller flow path cross-sectional area than the supplying pipe for the first trough, the supply amount of the heating liquid to the second trough is relatively small. Since the first and second troughs receive the heating liquid through the plurality of supplying pipes connected with the manifold, the supply amounts of the heating liquid to the troughs thus differ from each other depending on the flow path cross-sectional area of the corresponding supplying pipe. In this way, a suitable flow is obtainable for the number of heat transfer panels to which the heating liquid is supplied. This configuration eliminates the necessity of attaching any valve for regulating the supply amount of the heating liquid to the supplying pipe for the second trough.

[0090] With the above-mentioned configuration, the first trough may include a bottom wall extending in a lining-up direction of the plurality of heat transfer tubes, a first end wall extending upward from one end of the bottom wall, the one end being closer to the manifold in the lining-up direction, and a second end wall extending upward from the other end of the bottom wall, and away from the first end wall in the lining-up direction. The first end wall may have an inflow port for allowing the heating liquid to flow in.

[0091] In the above-mentioned configuration, the manifold for supplying the heating liquid into the first trough is arranged on the first end wall side of the trough, and the first end wall has the inflow port. Therefore, the flow path of the heating liquid from the manifold to the first trough is shortened. In other words, it is not required that the flow path of the heating liquid from the manifold to the first trough reaches an inflow port formed in a bottom wall beyond the first end wall, unlike a structure in which heating liquid flows from a manifold into a first trough through an inflow port formed in the bottom wall.

[0092] With the above-mentioned configuration, the second end wall may have an inflow port for allowing the heating liquid to flow in.

[0093] In the case that only the first end wall has the inflow port, the heating liquid collides against the second end wall and may cause the liquid surface of the heating liquid to rise at a location closer to the second end wall. In this case, the outflow of the heating liquid from the location closer to the second end wall to the heat transfer panel is larger than the outflow of the heating liquid from a location closer to the first end wall to the heat transfer panel. The above-mentioned configuration which includes the first and second end walls each having the inflow port makes it possible to substantially equalize the outflow of the heating liquid to the heat transfer panel between the location closer to the first end wall and the location closer to the second end wall.

[0094] With the above-mentioned configuration, the first trough may include a bottom wall having an inflow port for allowing the heating liquid to flow in.

[0095] In the above-mentioned configuration, the bottom wall having the inflow port allows the heating liquid to flow in each of the first trough and the second trough without any collision against the inner surface of the first trough.

[0096] With the above-mentioned configuration, the first supplying pipe may be arranged above the first trough.

[0097] In the above-mentioned configuration, the first supplying pipe arranged above the first trough allows the heating liquid to flow into the first trough through an opening-upward region of the first trough. The first trough having no inflow port can have a simpler structure.

[0098] With the above-mentioned configuration, the vaporizing apparatus may further include a closing member provided in the first trough for closing a part of the inflow port. The closing member may be removable from the first trough.

[0099] In the above-mentioned configuration, the closing member can regulate an inflow of the heating liquid into the trough by closing a part of the inflow port by applying the resistance to the heating liquid at the inflow port of the trough. Moreover, the closing member is removable from the trough. Accordingly, this configuration makes it is possible to lower the resistance in the heating liquid passing through the inflow port by removing the closing member.

[0100] With the above-mentioned configuration, the first trough may include a side wall standing and facing one of the plurality of heat transfer panels. The side wall may have an inner surface formed with a groove into which the closing member is inserted.

[0101] In the above-mentioned configuration, the closing member is mounted to the first trough by fitting in the groove formed in the inner surface of the side wall.

[0102] With the above-mentioned configuration, the vaporizing apparatus may include a closing member for closing a part of a flow path in the manifold between a connection portion connecting the second supplying pipe and the manifold with each other and a connection portion connecting the first supplying pipe and the manifold with each other; and an inflow portion which allows the heating liquid to flow into the manifold. The inflow portion which allows the heating liquid to flow into the manifold may be at a position closer to the connection portion for the first supplying pipe than the connection portion for the second supplying pipe in such a way as to allow the heating liquid to flow into the second supplying pipe through the closing member.

[0103] In the above-mentioned configuration, the inflow portion which allows the heating liquid to flow into the manifold is at the position closer to the connection portion for the first supplying pipe than the connection portion for the second supplying pipe. Hence, the heating liquid flows into the second supplying pipe through the closing member in the manifold. As receiving a resistance due to the closing member, the heating liquid has a smaller inflow to the second supplying pipe than to the first supplying pipe.

[0104] With the above-mentioned configuration, the vaporizing apparatus may further include a closing member for closing a part of a flow path in the second supplying pipe.

[0105] In the above-mentioned configuration, the closing member which closes a part of the flow path in the second supplying pipe reduces the inflow of the heating liquid to the second supplying pipe.

[0106] With the above-mentioned configuration, the vaporizing apparatus may further include a rise suppressing portion configured to suppress a liquid surface rising of the heating liquid due to a collision of the heating liquid having flowed in the first trough against the second end wall.

[0107] In the above-mentioned configuration, the heating liquid having flowed into the trough through the inflow port formed in the first end wall flows to and collides against the second wall. A part of the heating liquid having collided against the second end wall flows upward at a location closer to the second end wall. The upward flow is likely to cause the liquid surface of the heating liquid to rise. When the liquid surface of the heating liquid rises, the flow of the heating liquid overflowing from the trough at the location where the rising generates is larger than that of the heating liquid overflowing from the trough at other locations. In this case, rates of the heat exchange between the heating liquid and the liquefied gas largely vary among the plurality of heat transfer tubes. However, the rise suppressing portion for suppressing the liquid surface rising keeps the heating liquid away from being excessively supplied to the outer surfaces of the heat transfer tubes closer to the second end wall. This configuration thus suppresses varying heat exchange rates among the plurality of heat transfer tubes.

[0108] With the above-mentioned configuration, the rise suppressing portion may include a lid member extending in the first trough and from the second end wall in the lining up direction at a position higher than the inflow port.

[0109] In the above-mentioned configuration, most of the heating liquid having flowed in through the inflow port advances to reach a region below the lid member at a position higher than the inflow port. Thereafter, the heating liquid collides against the second end wall and then has an upward flow generated by the collision. The lid member suppresses a liquid surface rising of the heating liquid by allowing the heating liquid having the upward flow to collide against the lid member.

[0110] With the above-mentioned configuration, the lid member may have a through hole passing through the lid member in a vertical direction.

[0111] In the above-mentioned configuration, a part of the heating liquid flowing upward can flow into the space above the lid member through the through hole of the lid member. The heating liquid receives a resistance when passing through the through hole. Accordingly, the heating liquid having flowed into the space above the lid member has a decreased pressure. Consequently, the liquid surface rising is suppressed at a location closer to the second end wall.

[0112] With the above-mentioned configuration, the rise suppressing portion may include an obstructor provided between the first end wall and the second end wall so that the heating liquid having flowed in the first trough through the inflow port collides against the obstructor before the collision against the second end wall to thereby reduce a collisional force of the heating liquid against the second end wall.

[0113] In the above-mentioned configuration, the heating liquid having flowed in through the inflow port collides against the obstructor before a collision against the second end wall. Therefore, the velocity components of the heating liquid in the direction from the first end wall toward the second end wall decrease before the collision against the second end wall. The flow rate of the heating liquid is reduced by the obstructor before the collision against the second end wall. Consequently, when the heating liquid collides against the second end wall, a decreased collisional force generates, which makes it unlikely to cause a heating liquid flow having greater upward velocity components. In other words, the liquid surface rising is suppressed at a location closer to the second end wall.

[0114] With the above-mentioned configuration, the obstructor may have a through hole for permitting the heating liquid flowing toward the second end wall to pass through the through hole.

[0115] In the above-mentioned configuration, the obstructor having the through hole allows a part of the heating liquid having flowed in through the inflow port formed in the first end wall to pass through the through hole of the obstructor and flow toward the second end wall. As receiving a high resistance when passing through the through hole, the heating liquid flowing toward the second end wall has a decreased pressure. As a result, the liquid surface rising is suppressed at a location closer to the second end wall.

Industrial Applicability

[0116] The techniques described in connection with the embodiments are preferably used in various technical fields in which a form change from a liquefied gas to a vaporized gas is required.

Claims

1. A vaporizing apparatus for vaporizing a liquefied gas by a way of heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas, the vaporizing apparatus comprising:

    a plurality of heat transfer panels each including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas;
    a first trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of one of the plurality of heat transfer panels;
    a second trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of another of the plurality of heat transfer panels;
    a manifold allowing the heating liquid to flow in;
    a first supplying pipe connecting the manifold with the first trough for supplying the heating liquid from the manifold to the first trough; and

a second supplying pipe connecting the manifold with the second trough for supplying the heating liquid from the manifold to the second trough, the second supplying pipe having a smaller flow path cross-sectional area than the first trough.

2. The vaporizing apparatus according to claim 1, wherein
the second trough lies in an outermost position of a row of the plurality of heat transfer panels, and
the first trough lies between the heat transfer panels adjacent to each other.

3. The vaporizing apparatus according to claim 1 or 2, wherein
the first trough includes:

a bottom wall extending in a lining-up direction of the plurality of heat transfer tubes,
a first end wall extending upward from one end of the bottom wall, the one end being closer to the manifold in the lining-up direction, and
a second end wall extending upward from the other end of the bottom wall, and away from the first end wall in the lining-up direction,

the first end wall has an inflow port for allowing the heating liquid to flow in.

4. The vaporizing apparatus according to claim 3, wherein
the second end wall has an inflow port for allowing the heating liquid to flow in.

5. The vaporizing apparatus according to claim 1 or 2, wherein
the first trough includes a bottom wall having an inflow port for allowing the heating liquid to flow in.

6. The vaporizing apparatus according to claim 1 or 2, wherein
the first supplying pipe is arranged above the first trough.

7. The vaporizing apparatus according to claim 3, further comprising:

a closing member provided in the first trough for closing a part of the inflow port,
the closing member being removable from the first trough.

8. The vaporizing apparatus according to claim 7, wherein

the first trough includes a side wall standing and facing one of the plurality of heat transfer panels, the side wall having an inner surface formed with a groove into which the closing member is inserted.

9. The vaporizing apparatus according to claim 1 or 2, further comprising:

a closing member for closing a part of a flow path in the manifold between a connection portion connecting the second supplying pipe and the manifold with each other and a connection portion connecting the first supplying pipe and the manifold with each other; and
an inflow portion which allows the heating liquid to flow into the manifold,
the inflow portion being at a position closer to the connection portion for the first supplying pipe than the connection portion for the second supplying pipe in such a way as to allow the heating liquid to flow into the second supplying pipe through the closing member.

10. The vaporizing apparatus according to claim 1 or 2, further comprising:

a closing member for closing a part of a flow path in the second supplying pipe.

11. The vaporizing apparatus according to claim 3, further comprising
a rise suppressing portion configured to suppress a liquid surface rising of the heating liquid due to a collision of the heating liquid having flowed in the first trough against the second end wall.

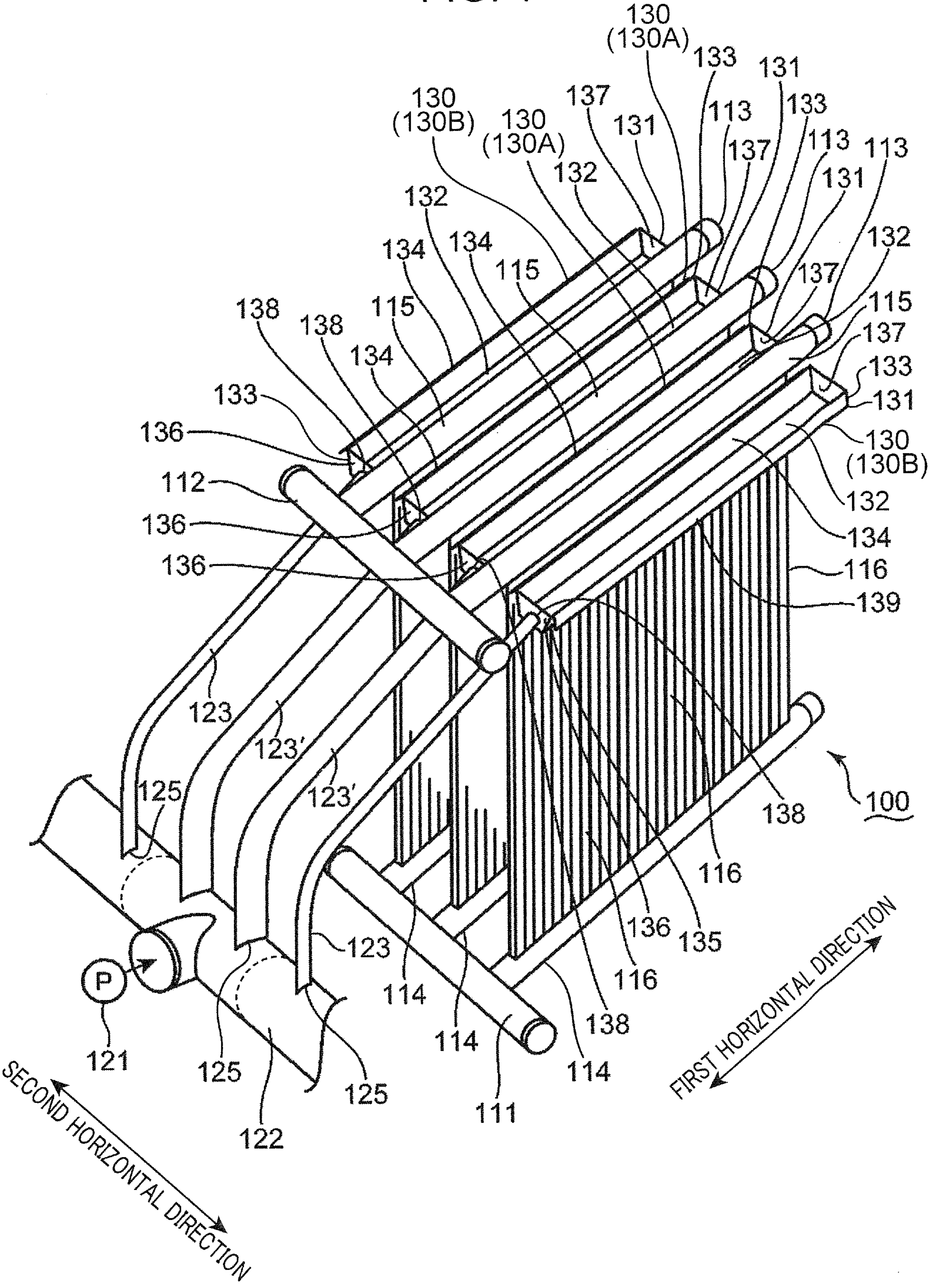
12. The vaporizing apparatus according to claim 11, wherein
the rise suppressing portion includes a lid member extending in the first trough and from the second end wall in the lining-up direction at a position higher than the inflow port.

13. The vaporizing apparatus according to claim 12, wherein
the lid member has a through hole passing through the lid member in a vertical direction.

14. The vaporizing apparatus according to any one of claim 11, wherein
the rise suppressing portion includes an obstructor provided between the first end wall and the second end wall so that the heating liquid having flowed in the first trough through the inflow port collides against the obstructor before the collision against the second end wall to thereby reduce a collisional force of the heating liquid against the second end wall.

15. The vaporizing apparatus according to claim 14, wherein
the obstructor has a through hole for permitting the heating liquid flowing toward the second end wall to pass through the obstructor.

FIG. 1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133
131
130
(130B)
130
(130A)
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136
116
139
123
123′
123′
125
100
138
116
125
123
114
136
135
P
116
121
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138
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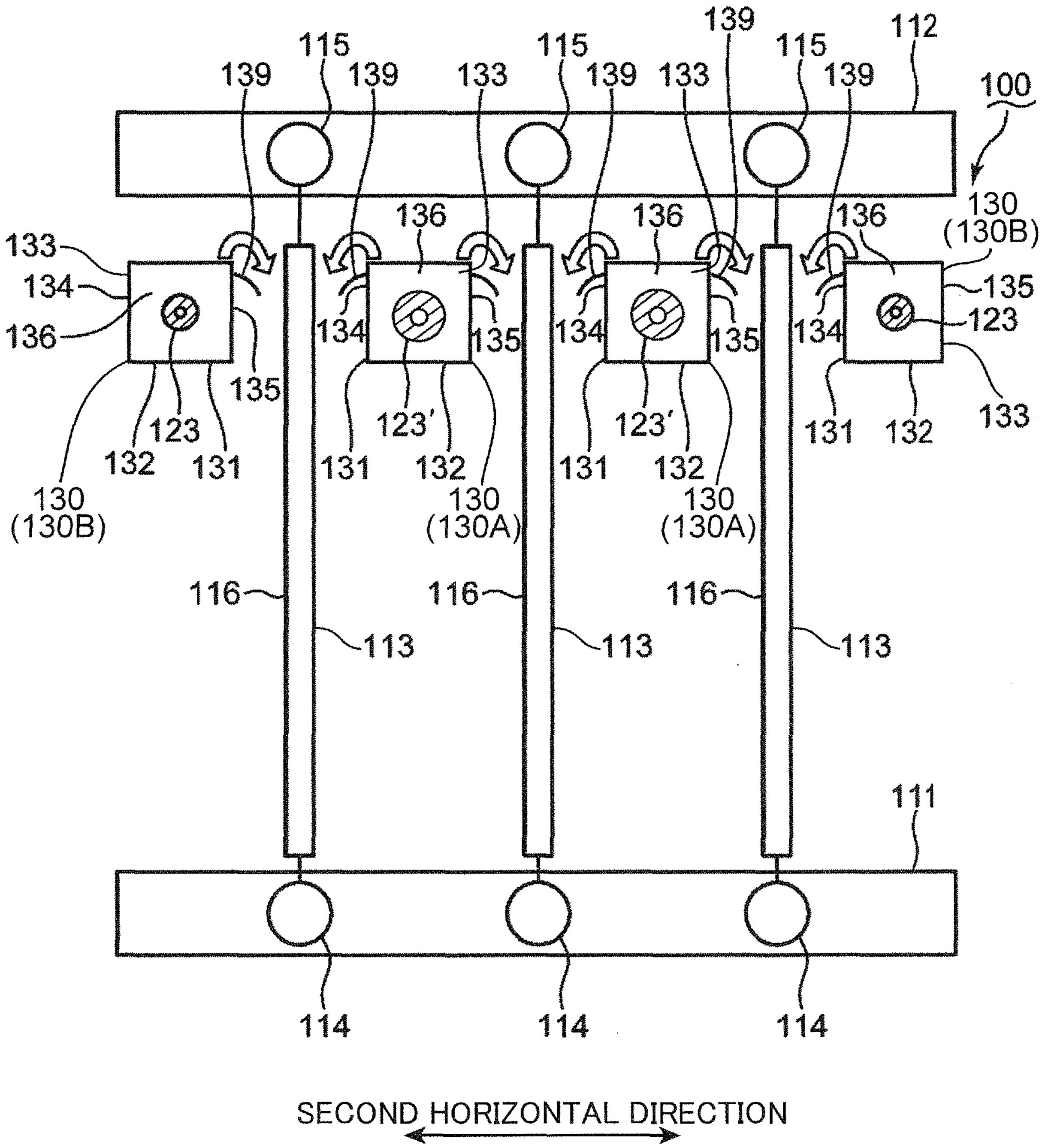
122
111
SECOND HORIZONTAL DIRECTION
FIRST HORIZONTAL DIRECTION

FIG. 2



100
112
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133
136
134
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(130B)
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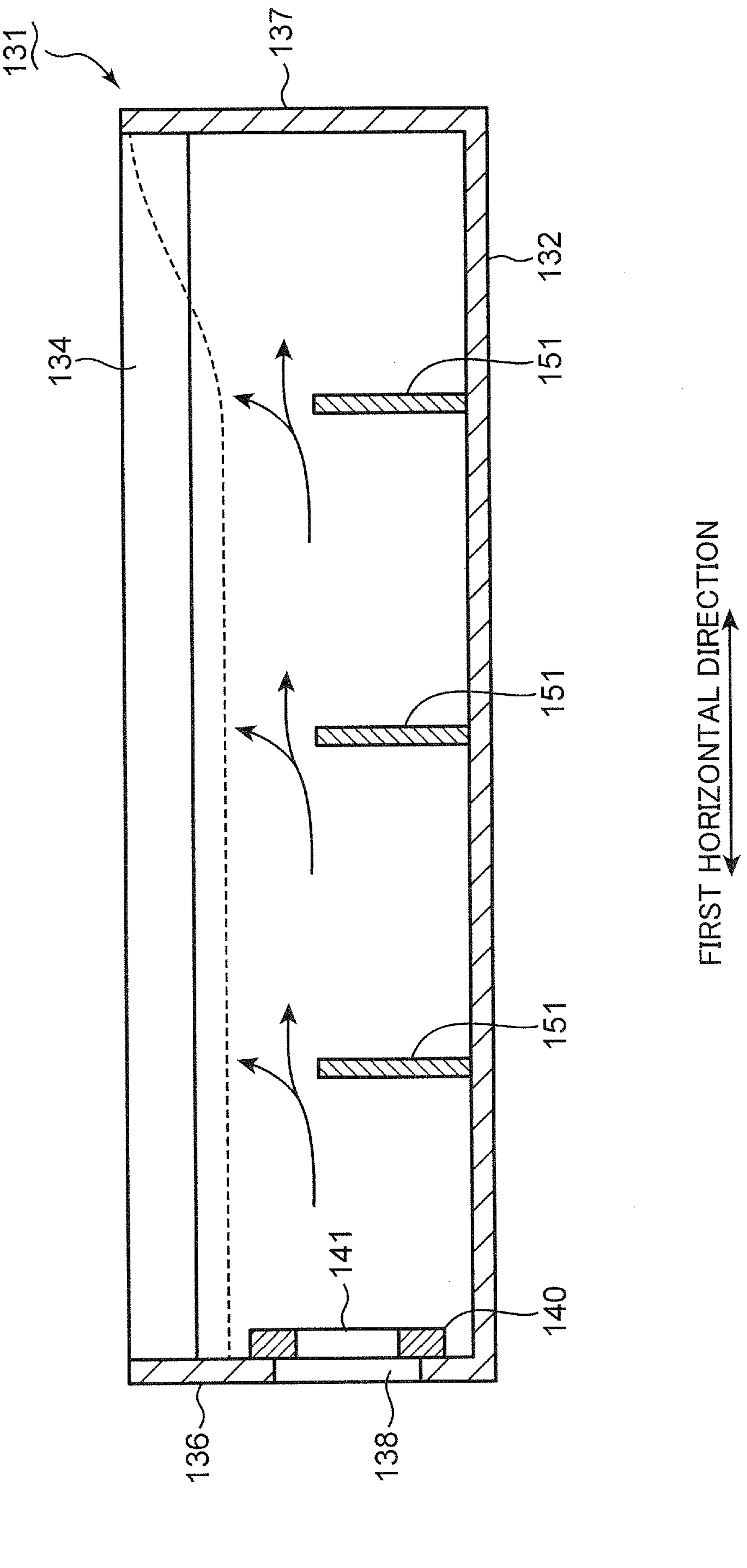
113
114
SECOND HORIZONTAL DIRECTION

FIG. 3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138
FIRST HORIZONTAL DIRECTION

FIG. 4

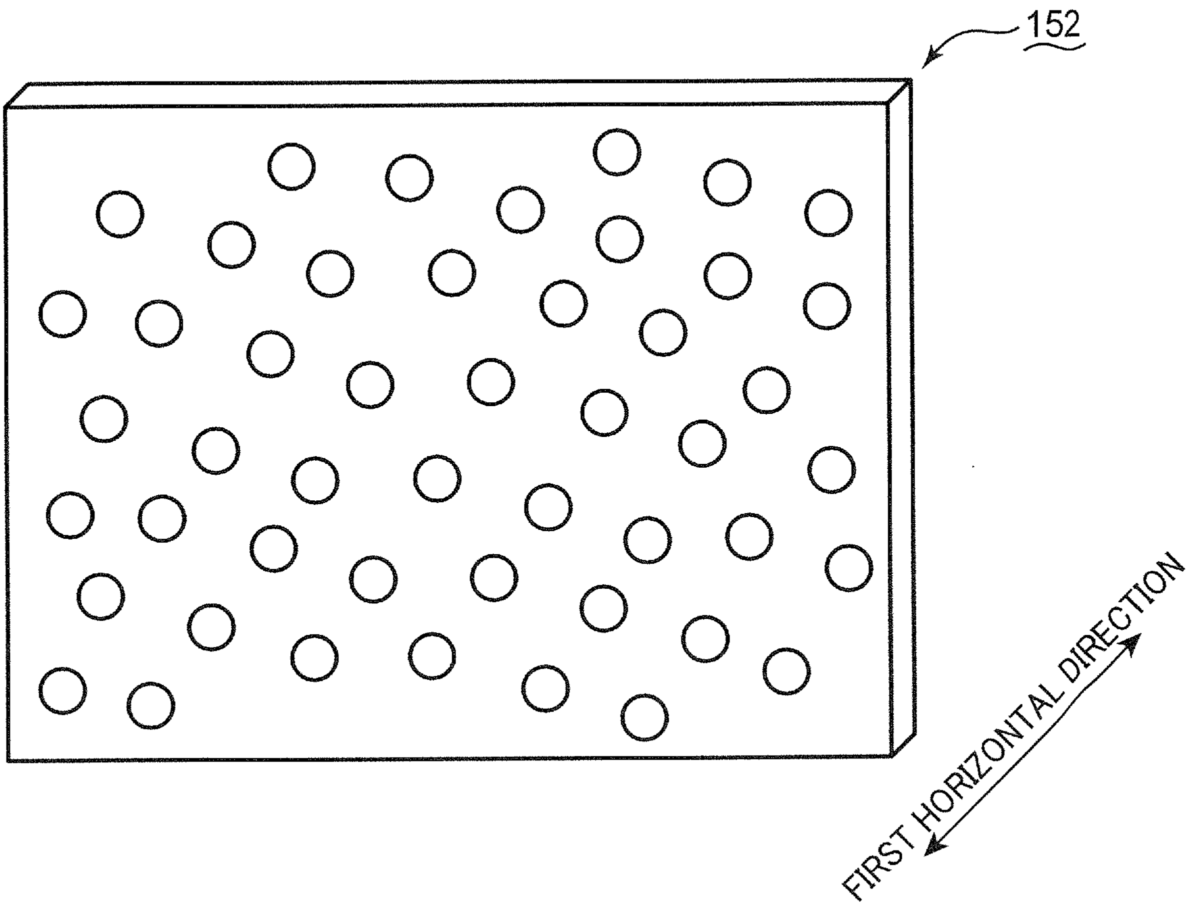


FIG. 5

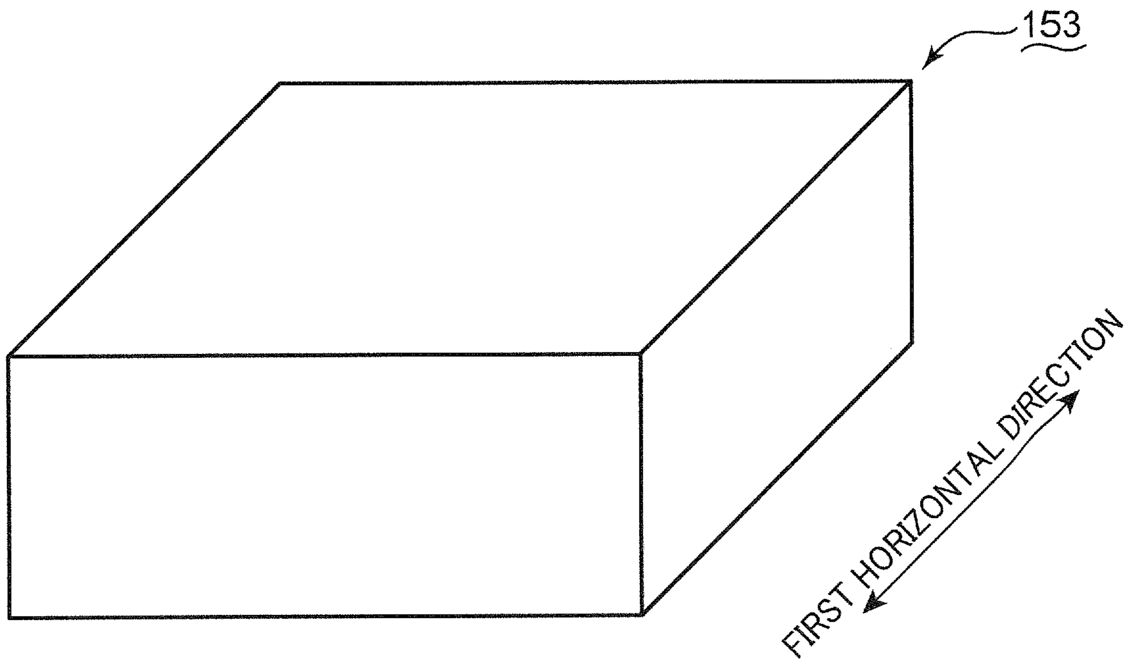


FIG. 6

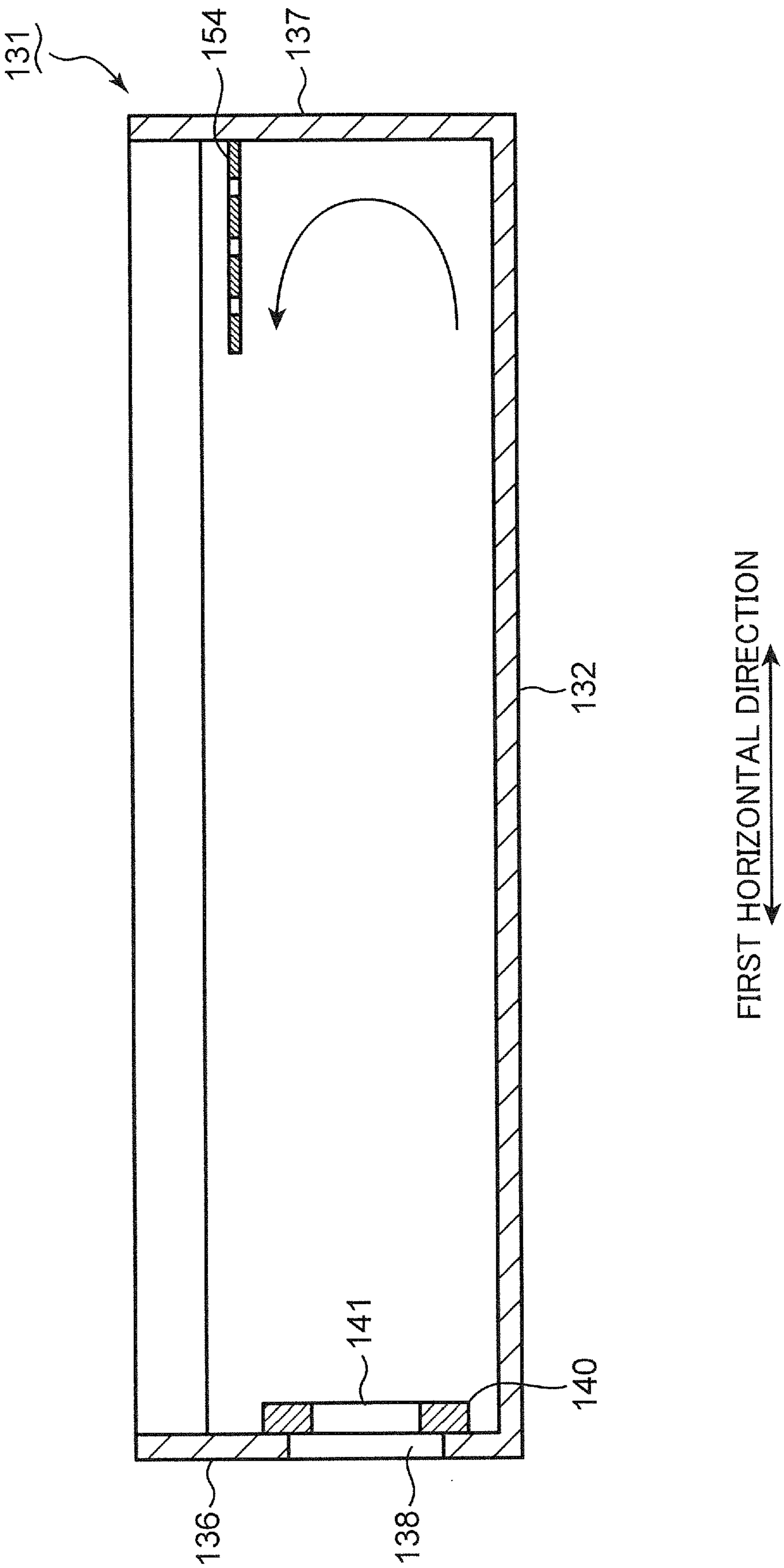
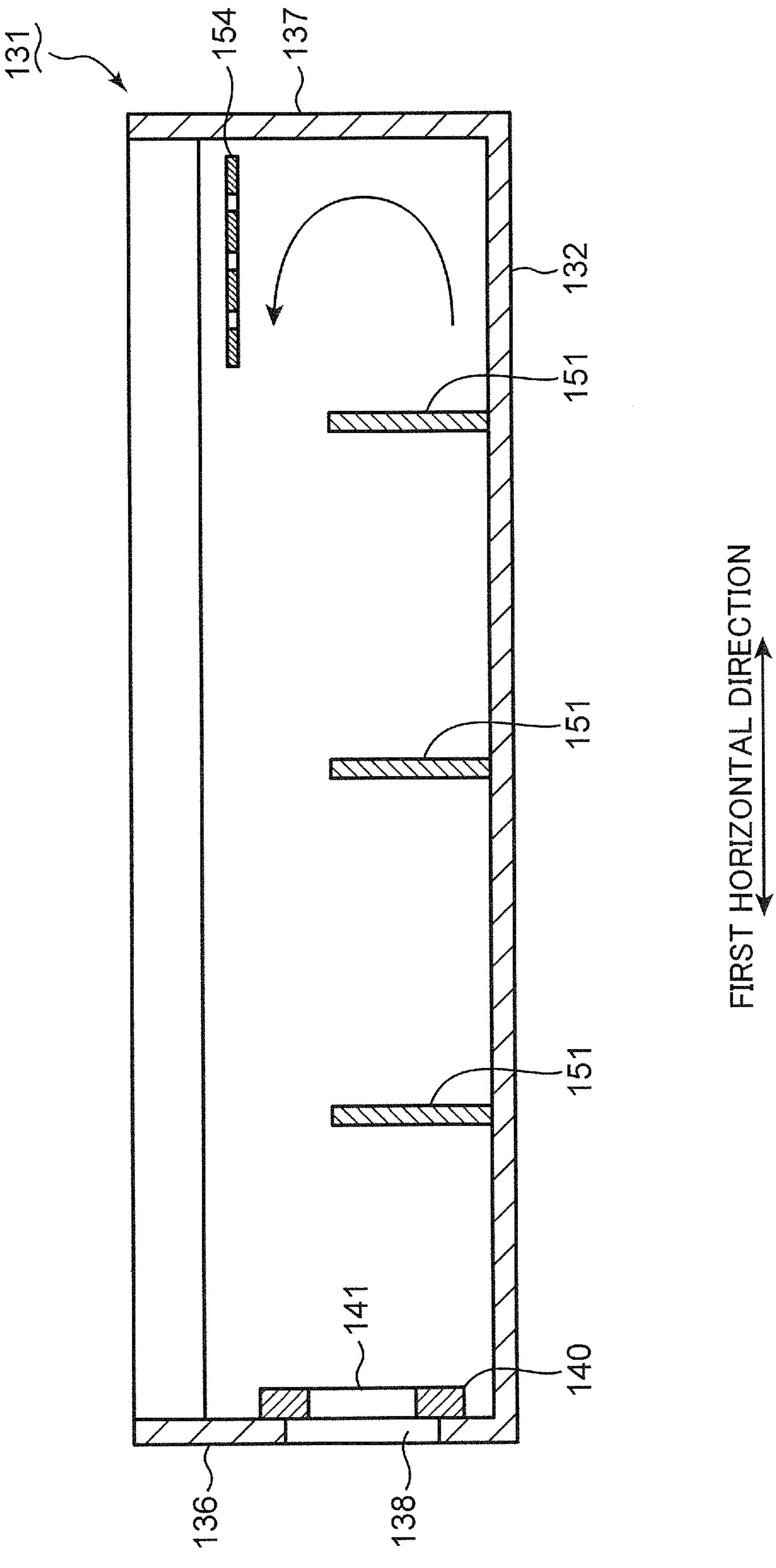


FIG. 7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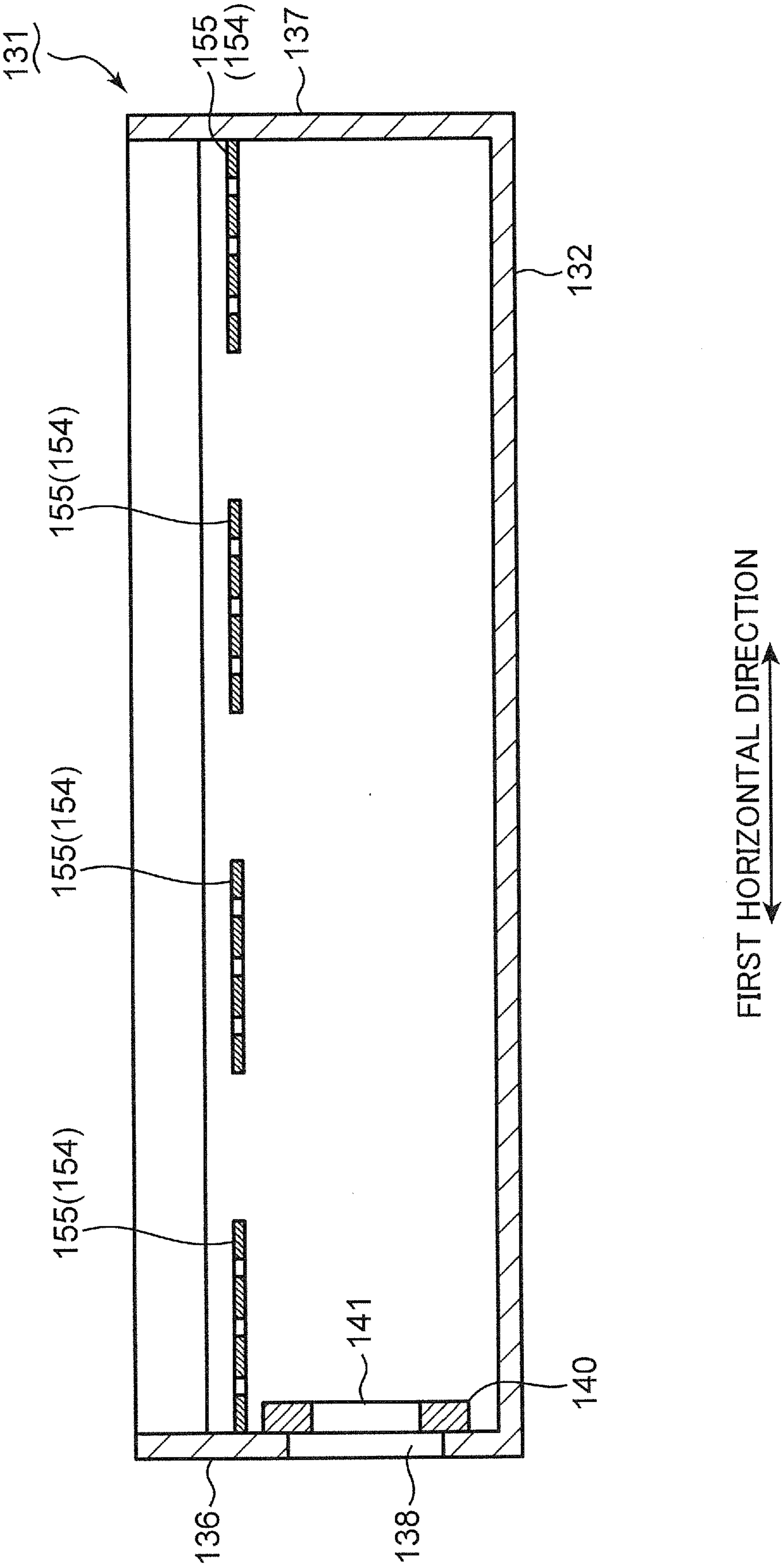
154
137
132
151
151
151
141
140
136
138
FIRST HORIZONTAL DIRECTION

FIG. 8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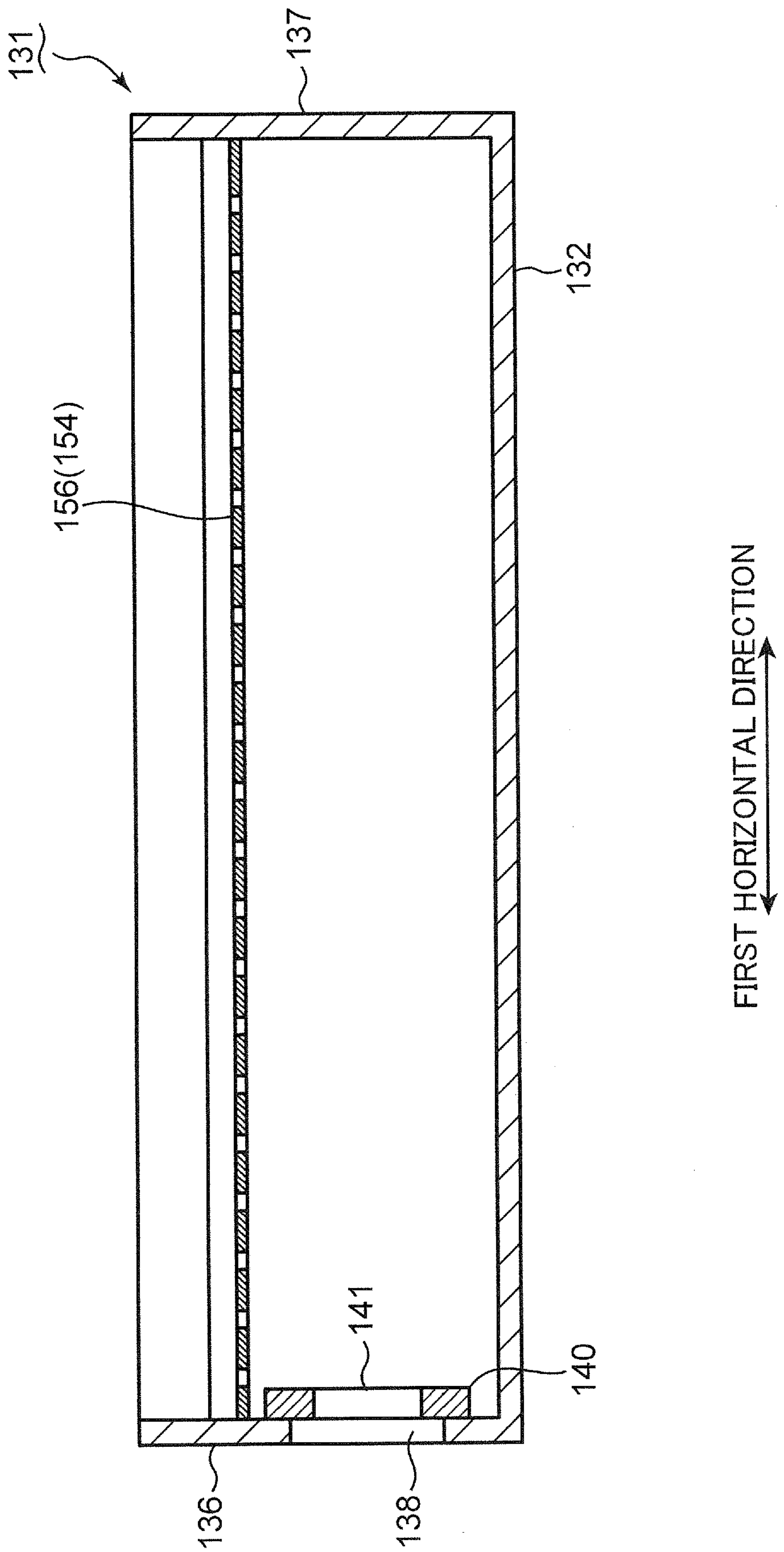
155(154)
155(154)
141
140
136
138
FIRST HORIZONTAL DIRECTION

FIG. 9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156(154)
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138
FIRST HORIZONTAL DIRECTION

FIG. 10

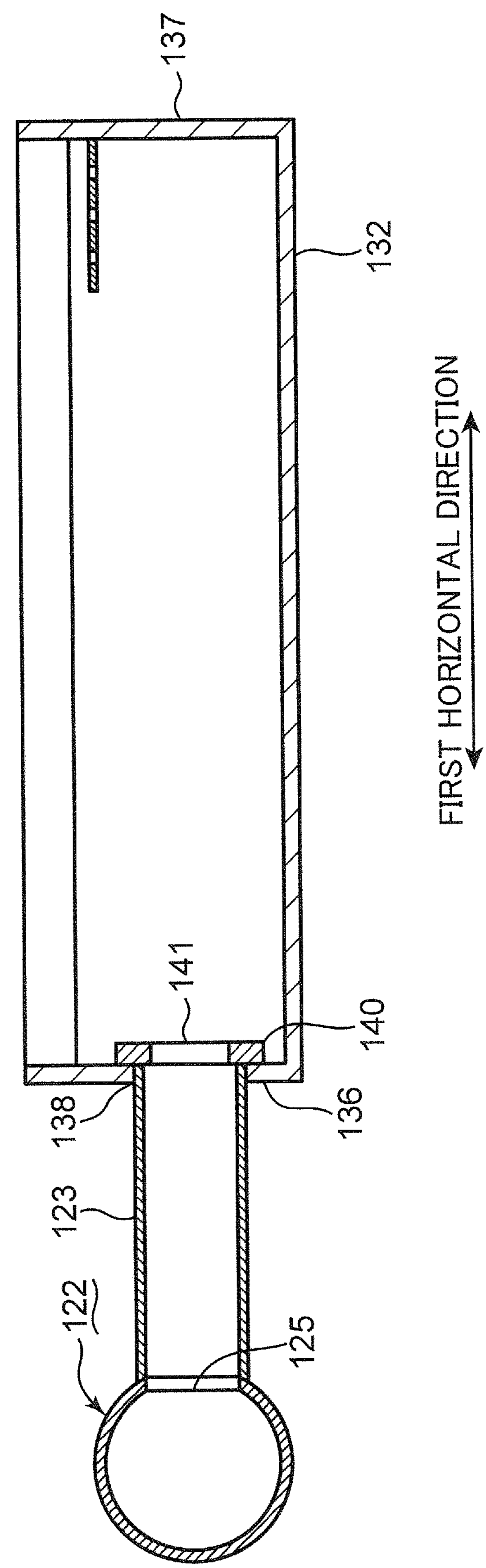
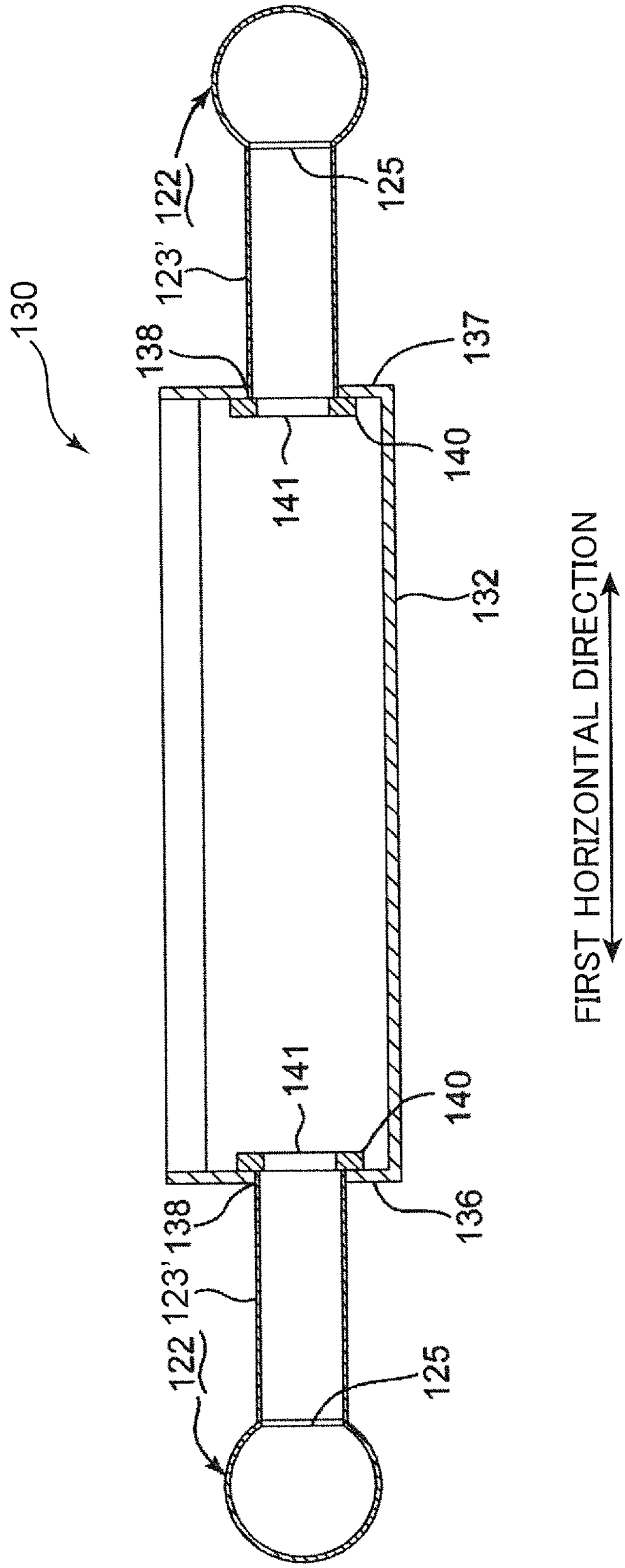

137
132
FIRST HORIZONTAL DIRECTION
141
140
138
136
123
122
125

FIG. 11


130
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FIRST HORIZONTAL DIRECTION
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136
138
123'
122
125

FIG. 12

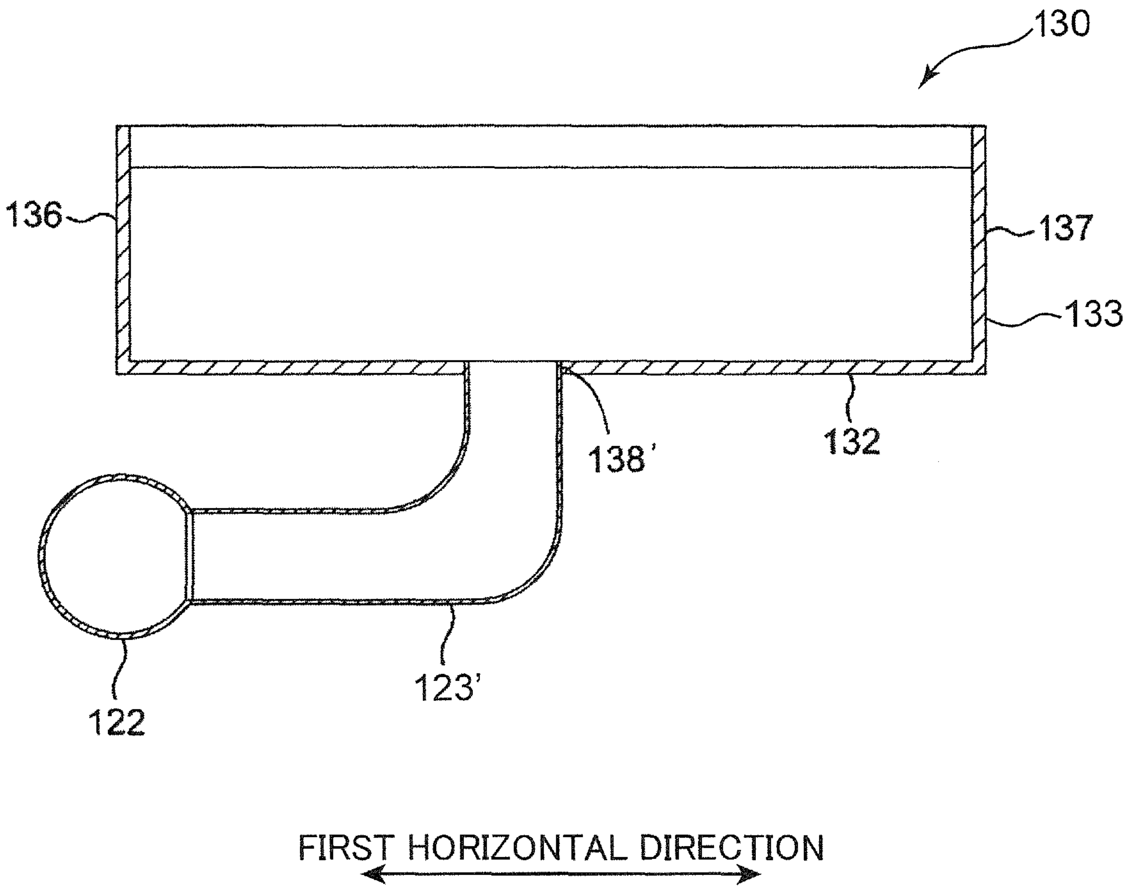


FIG. 13

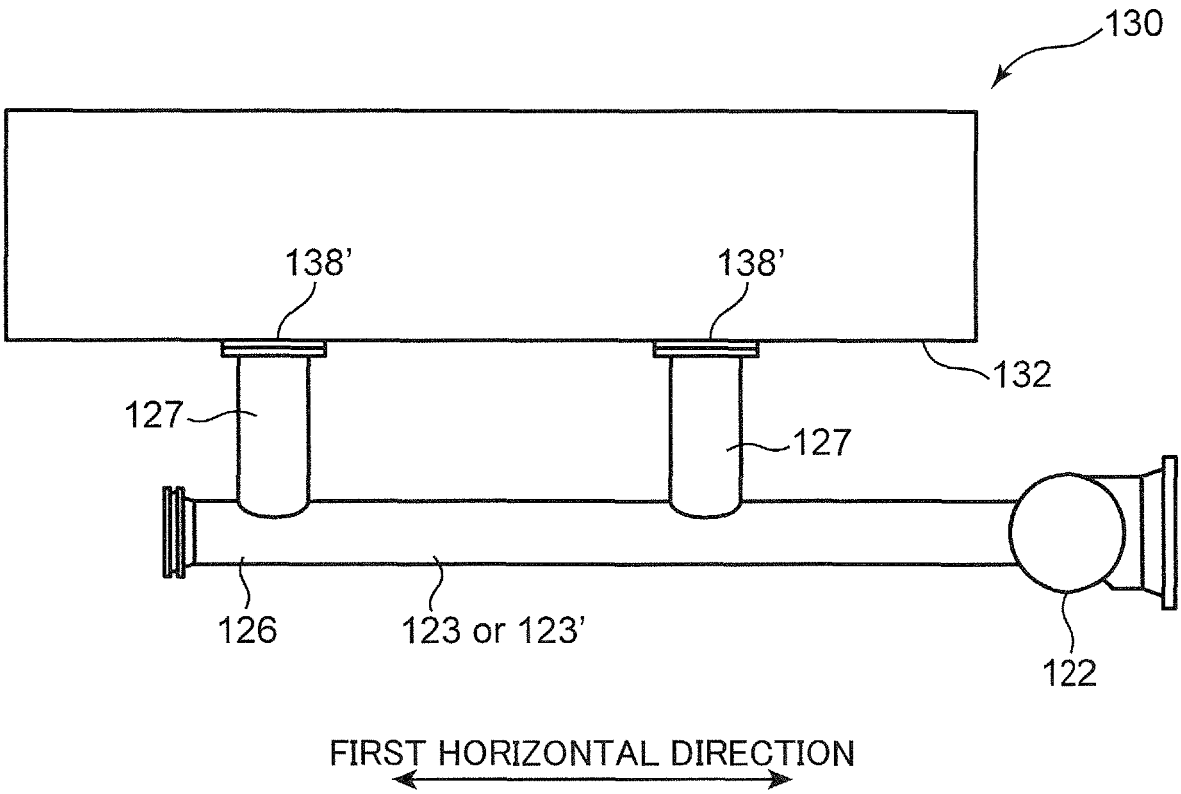

130
138'
138'
132
127
127
126
123 or 123'
122
FIRST HORIZONTAL DIRECTION

FIG. 14

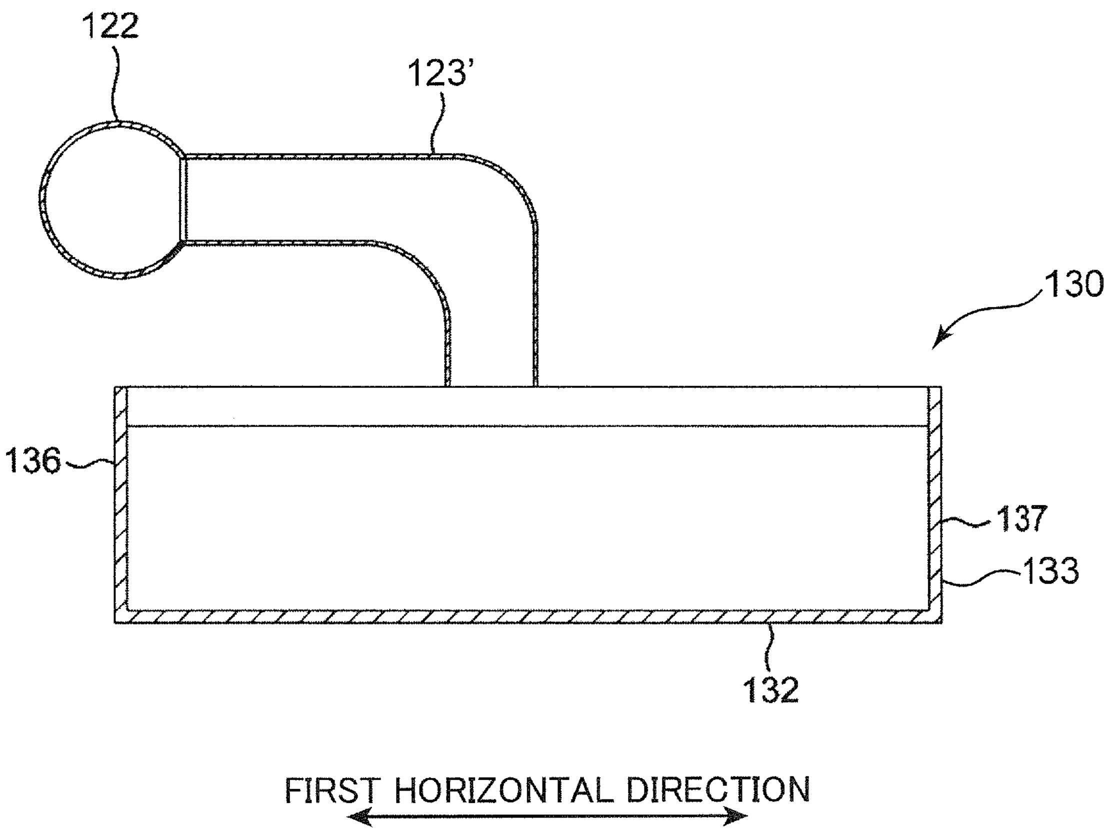


FIG. 15

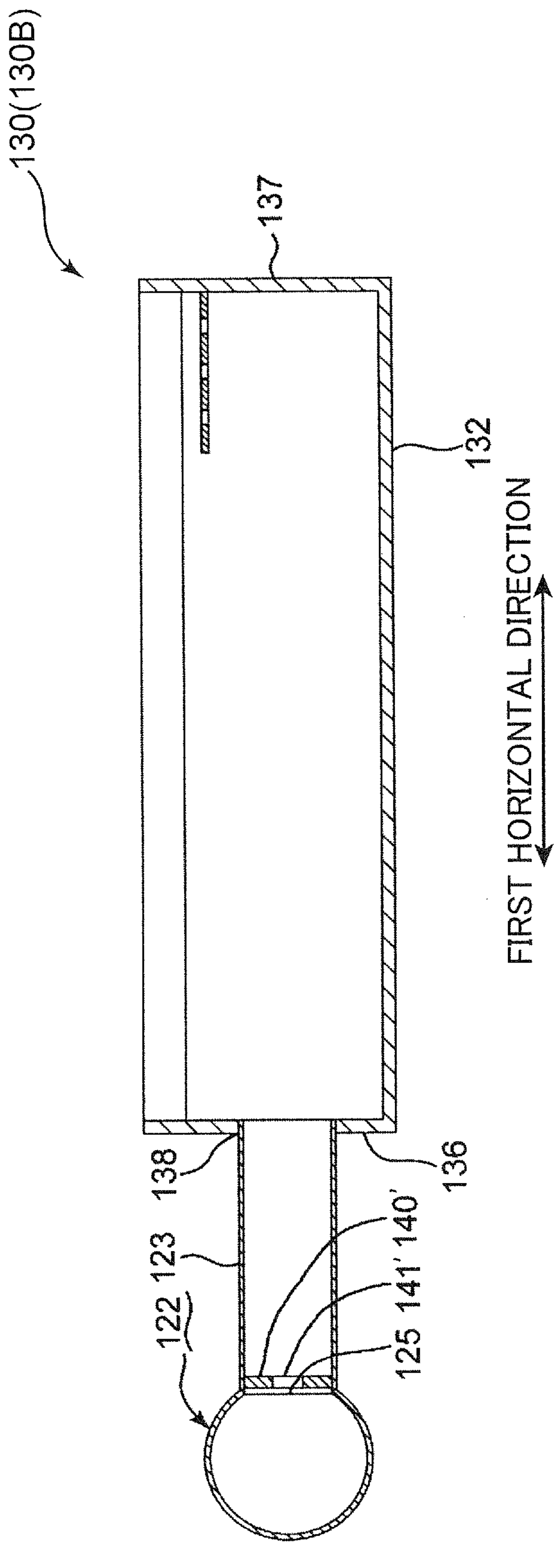

130(130B)
137
132
FIRST HORIZONTAL DIRECTION
138
136
122
123
140'
141'
125

FIG. 16

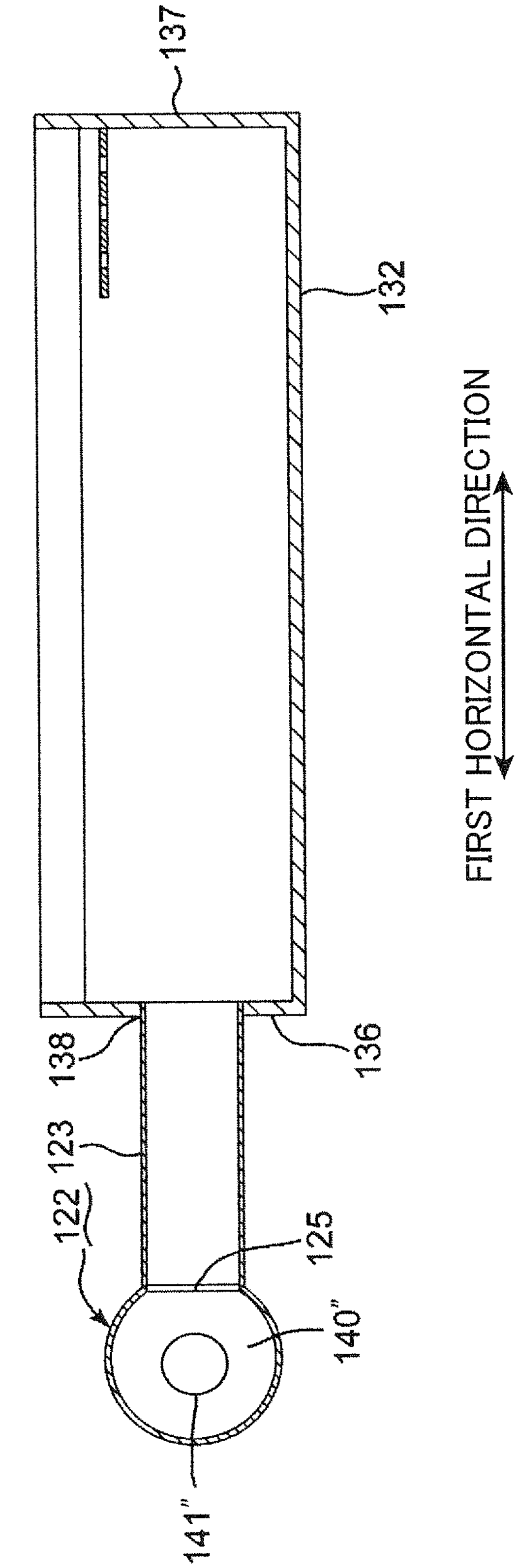
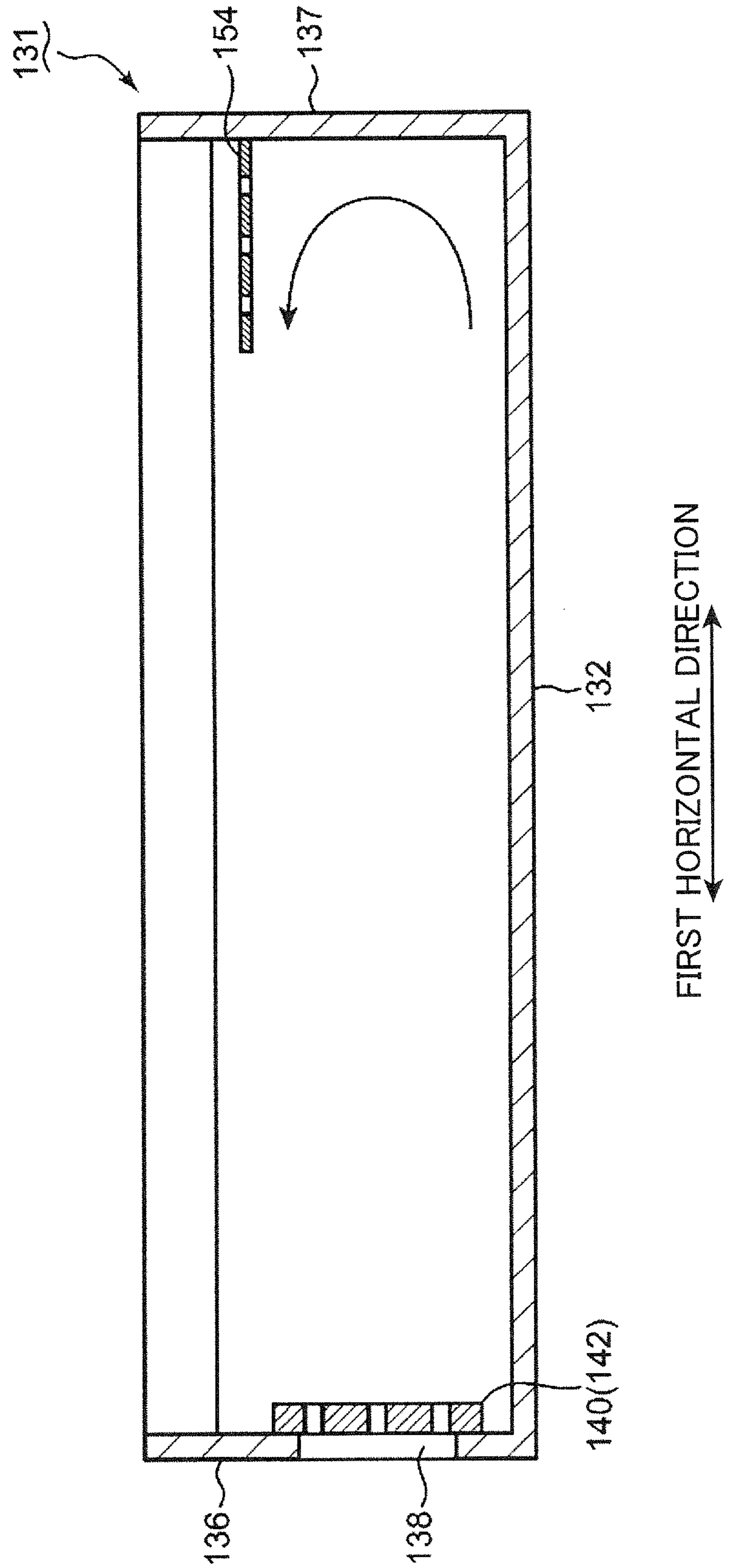

137
132
FIRST HORIZONTAL DIRECTION
138
136
122
123
125
140"
141"

FIG. 17



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/037863

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F28D3/02(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)
Int. Cl. F28D3/02

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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 2015-178880 A (SUMITOMO PRECISION PRODUCTS CO., LTD.) 08 October 2015, paragraphs [0001]-[0068], fig. 1-9 (Family: none)	1-6, 11-12, 14 7-10, 13, 15
Y	JP 57-57998 A (SUMITOMO PRECISION PRODUCTS CO., LTD.) 07 April 1982, page 1, lower right column, line 1 to page 3, lower left column, line 8, fig. 1-3 (Family: none)	1-6, 11-12, 14
Y A	JP 2014-202320 A (KOBE STEEL, LTD.) 27 October 2014, paragraphs [0001]-[0051], fig. 1-10 & US 2015/0369425 A1, paragraphs [0001]-[0062], fig. 1-10 & WO 2014/167779 A1 & TW 201502442 A & KR 10-2015-0122212 A & CN 105102876 A	3-4, 11-12, 14 1-2, 5-10, 13, 15

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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"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
11.11.2019	26.11.2019

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/037863

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 011793/1981 (Laid-open No. 124700/1982) (TOKYO GAS CO., LTD.) 03 August 1982, description, page 1, line 11 to page 5, line 5, all drawings (Family: none)	6
A	JP 7-75087 A (TOKYO GAS CO., LTD.) 17 March 1995, paragraphs [0001]-[0024], fig. 1-8 (Family: none)	1-15

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2017040296 A **[0005]**