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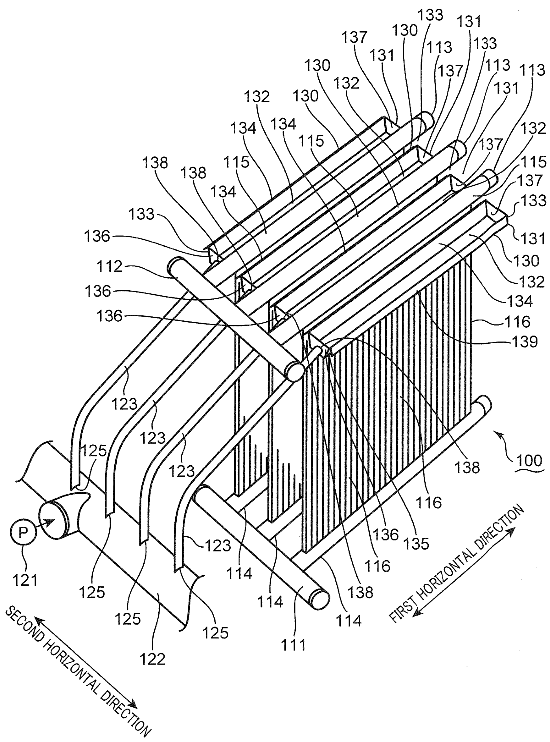
(54) VAPORIZATION DEVICE

(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. The vaporizing apparatus includes a heat transfer panel including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas; a trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes; and a manifold having an outflow port from which the heating liquid to be supplied to the trough flows out. The trough includes a bottom wall extending in the lining-up direction of the plurality of heat transfer tubes, and a first end wall and a second end wall respectively extending upward at positions away from each other in the lining-up direction of the plurality of transfer panels. The first end wall has an inflow port for allowing the heating liquid to flow in. The manifold is attached to the first end wall.

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 trough for sprinkling heating liquid having a higher temperature than the liquefied gas over an outer surface of each of a plurality of heat transfer tubes vertically provided to guide the liquefied gas upward. While the heating liquid sprinkled by the trough is flowing down along the outer surfaces of the plurality of heat transfer tubes, the liquefied gas flowing through the plurality of heat transfer tubes does heat exchange with the heating liquid on the outer surfaces of the plurality of heat transfer tubes. Owing to the heat exchange with the heating liquid, the liquefied gas vaporizes.

[0003] The trough is disposed at a position adjacent to each of the plurality of heat transfer tubes in a horizontal direction orthogonal to the lining-up direction of the plurality of heat transfer tubes, and is configured to store the heating liquid. The trough has a shape of a box extending in the lining-up direction of the plurality of heat transfer tubes. The trough includes a bottom wall having a rectangular shape extending in the lining-up direction of the plurality of heat transfer tubes, and an outer peripheral wall standing upward from the outer peripheral edge of the bottom wall. The bottom wall and the outer peripheral wall define a storage space for storing the heating liquid. When the heating liquid is supplied beyond the capacity of the trough, the heating liquid having exceeded the capacity overflows from the box-shaped trough. The heating liquid having overflowed from the trough subsequently flows down over the outer surfaces of the plurality of heat transfer tubes.

[0004] For the supply of the heating liquid to the trough, the bottom wall of the trough is formed with an inflow port through which the heating liquid flows in. A water supplying pipe extending from a manifold is connected to the inflow port of the trough. The water supplying pipe extends substantially in parallel with the bottom wall of the trough below the bottom wall, thereby guiding the heating liquid to a position below the inflow port of the trough. The leading end portion of the water supplying pipe bends upward below the inflow port of the trough, and joins the inflow port of the trough.

[0005] The water supplying pipe extends in a longitudinal direction of the trough, which consequently forms a long flow path for the heating liquid. In the case that a long water supplying pipe is formed to guide the heating liquid, not only a resistance occurs to the flow of the heating liquid, but also the cost for the material of the water supplying pipe increases.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Publication No. 2017-150784

Summary of Invention

[0007] An object of the present invention is to provide a vaporizing apparatus having a configuration that enables to supply heating liquid at a shorter path to a trough.

[0008] A vaporizing apparatus according to an aspect of the present invention is configured to vaporize 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 heat transfer panel including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas; a trough lying at a position lower than an upper end of the heat transfer panel for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes; and a manifold arranged on one end side of the trough in a lining-up direction of the plurality of heat transfer tubes for supplying the heating liquid into the trough. The trough includes a bottom wall extending in the 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.

[0009] The above-described vaporizing apparatus makes it possible to supply the heating liquid at a shorter path to a trough where the heating liquid is stored.

[0010] 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

[0011]

Fig. 1 is a schematic perspective view of a vaporizing apparatus of an open rack type according to a first embodiment.

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 box having a single lid member.

Fig. 11 is a schematic cross-sectional view of a box having a single lid member.

Fig. 12 is a schematic cross-sectional view of a box having two lid members.

Fig. 13 is a schematic cross-sectional view of a box having two lid members.

Fig. 14 is a schematic cross-sectional view of a box having two lid members.

Fig. 15 is a schematic cross-sectional view of a box having two lid members.

Fig. 16 is a schematic cross-sectional view of a box having two lid members.

Fig. 17 is a schematic cross-sectional view of a box having two lid members.

Fig. 18 is a schematic cross-sectional view of a box having two lid members.

Fig. 19 is a schematic cross-sectional view of a box having two lid members.

Fig. 20 is a schematic cross-sectional view of a box having two lid members.

Fig. 21 is a schematic cross-sectional view of a box having two lid members.

Fig. 22 is a schematic cross-sectional view of a box in which an obstructor is in contact with a lid member.

Fig. 23 is a schematic cross-sectional view of a box in which an obstructor is in contact with a lid member.

Fig. 24 is a schematic cross-sectional view of a box in which an obstructor is in contact with a lid member;

Fig. 25 is a schematic cross-sectional view of a box in which an obstructor is in contact with a lid member.

Fig. 26 is a schematic cross-sectional view of a box in which a vertical lid is provided on lid members.

Fig. 27 is a schematic cross-sectional view of a box in which vertical lids are provided on lid members.

Fig. 28 is a schematic cross-sectional view of a box in which a vertical lid is provided on lid members.

Fig. 29 is a schematic cross-sectional view of a manifold used in the vaporizing apparatus.

Fig. 30 is a schematic cross-sectional view of a box in which a porous plate is mounted at an inflow port.

Fig. 31 is a schematic cross-sectional view showing another obstructor.

Fig. 32 is a schematic cross-sectional view showing another obstructor.

Fig. 33 is a schematic cross-sectional view showing another obstructor.

Fig. 34 is a schematic perspective view of a vaporizing apparatus of an open rack type according to a second embodiment.

Fig. 35 is a schematic cross-sectional view of the vaporizing apparatus shown in FIG. 34.

Description of Embodiments

First Embodiment

[0012] Fig. 1 is a schematic perspective view illustrating a vaporizing apparatus (ORV) 100 of an open rack type according to a first embodiment. 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.

[0013] 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.

[0014] The vaporizing apparatus 100 includes a gas flowing part in which the liquefied gas and the vaporized gas flow and a seawater flowing part where the seawater flows.

[0015] The gas flowing part includes a lower manifold 111, an upper manifold 112, 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.

[0016] 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 supplied from the seawater flowing part. 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).

[0017] 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."

[0018] The seawater flowing part is configured to sprinkle the seawater to the plurality of heat transfer tubes 116 of each of the plurality of heat transfer panels 113. The seawater flowing part includes a sprinkling section for storing and sprinkling the seawater and a supplying section for supplying the seawater to the sprinkling section. The seawater flowing part further includes a flow regulating portion for regulating the flow of the seawater from the supplying section to the sprinkling section, and a rise suppressing portion for suppressing a seawater liquid surface rising occurring in the sprinkling section.

[0019] The supplying section has a pump 121 for discharging the seawater, a manifold 122 for guiding the seawater discharged from the pump 121 in the second horizontal direction, and a plurality of supplying pipes 123 connected with the manifold 122. The manifold 122 extends in the second horizontal direction, and spaced away from the plurality of heat transfer panels 1 13 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. The plurality of outflow ports 125 join the plurality of supplying pipes 123 respectively. An end of the supplying pipe 123 connected to the outflow port 125 is hereinafter referred to as an "upstream end." The opposite end of the supplying pipe 123 is hereinafter referred to as a "downstream end." The downstream end is connected to the sprinkling section.

[0020] The sprinkling section has a plurality of troughs 130 disposed in correspondence to the plurality of supplying pipes 123, respectively. The plurality of troughs 130 and the plurality of heat transfer panels 113 are disposed alternately in the second horizontal direction.

[0021] 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.

[0022] Each of the plurality of troughs 130 includes a box body 131 for storing the seawater having flowed in through the corresponding supplying pipe 123, 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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 connected with the downstream end of the supplying pipe 123 (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.

[0027] In the four troughs 130 lining-up in the second horizontal direction and spaced away from one another, each of remaining troughs 130 other than two outermost troughs 130 has the first end wall 136 and the second end wall 137 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.

[0028] In the right trough 130 of the two outermost troughs 130, 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.

[0029] In the left trough 130 of the two outermost troughs 130, 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.

[0030] 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 inclined surface 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.

[0031] In the left trough 130 of the two outermost troughs 130, the guiding portion 139 protrudes rightward from the upper end of the side wall 1 35 closer to the heat transfer panel 113. No guiding portion 139 is provided to the opposite side wall 134. In the right trough 130 of the two outermost troughs 130, the guiding portion 139 protrudes leftward from the upper end of the left side wall 134. In each of the remaining troughs, the guiding portion 139 protrudes outward from both the upper ends of the side walls 134, 135.

[0032] The flow regulating portion and the rise suppressing portion are provided in the box body 131. The flow regulating portion and the rise suppressing portion will be described below with reference to Fig. 1 and Fig. 3. Fig. 3 is a schematic longitudinal cross-sectional view of the box body 131.

[0033] The flow regulating portion 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.

[0034] As the closing member 140, an orifice is preferably used, the orifice being formed with an opening 141 in the first horizontal direction. 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, a vertical groove may be formed in the inner surfaces of the side walls 134, 135, a side end of the closing member 140 being inserted into the vertical groove.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] There will be described below flows of the liquefied gas and the seawater in the vaporizing apparatus 100.

[0040] With reference to the flow of the liquefied gas in the gas flowing part, 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 extending upward from the lower header pipe 114. In the meantime, the liquefied gas vaporizes by the way of heat exchange between the liquefied gas and the seawater supplied from the seawater flowing section. 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.

[0041] With reference to the flow of the seawater in the seawater flowing part, 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 supplying pipes 123 connected with the manifold 122. The seawater having flowed through the supplying pipe 123 flows into the corresponding trough 130. The seawater having flowed into the trough 130 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 at the side of the box body 131.

[0042] The scattering seawater flows down with forming a liquid film on the outer surface of each of the plurality of the heat transfer tubes 116. The liquefied gas flows upward inside each of the plurality of heat transfer tubes 116. Accordingly, heat exchange is made between the seawater and the liquefied gas. In other words, the liquefied gas is vaporized. The vaporized gas passes through the plurality of upper header pipes 115, and is collected in the upper manifold 112 as described above.

[0043] 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.

[0044] The conventional structure has the flow path to allow the seawater to flow in from the bottom surface of the trough. 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 supplying pipe 123 does not extend beyond the first end wall 136 from the manifold 122, which thus reduces not only the cost for the material of the supplying pipe 123 but also the resistance to the flow of the seawater flowing through the supplying pipe 123.

[0045] 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 the seawater into a plurality of troughs. In the embodiment, the closing member 140 is used to suppress a variation of a flow amount of the seawater among the plurality of troughs. The closing member 140 will be described below in comparison to the conventional fluidic devices.

[0046] 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 pipe 123, the replacement of the closing member 140 does not require the disassembly of the supplying pipe 123. Additionally, the operator can perform the replacement operation in a larger space above the trough 130, not in a smaller space defined by shorter supplying pipes 123. Accordingly, the operator can replace the closing member 140 more easily.

[0047] The seawater having passed through the closing member 140 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.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] 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.

[0052] 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.

[0053] 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 therethrough. Accordingly, the porous plate 152 may have substantially the same height dimension as the peripheral wall 133.

[0054] 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 as an obstructor (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.

[0055] The baffle plate 151, the porous plate 152, and the block 153, which are examples of the rise suppressing portion, weaken the force of the seawater toward the second end wall 137 before the seawater collides against the second end wall 137, thus suppressing the liquid surface rising. However, the rise suppressing portion may be configured to have a member which is provided so as to allow the heating liquid having an upward flow that has generated due to the collision of the heating liquid to collide against the member. The rise suppressing portion that is provided so as to allow the heating liquid having the upward flow due to the collision of the seawater against the second end wall 137 to collide against the rise suppression portion will be described with reference to Fig. 1 and Figs. 6 to 25. Figs. 6 to 25 are schematic cross-sectional views of the box body 131.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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.

[0062] In Figs. 6 and 7, the lid member 154 is provided at a location closer to the second end wall 137 than the first end wall 136. However, the lid member 154 may be provided at a location closer to the first end wall 136 than the second end wall 137 (see Fig. 8). In this case, the heating liquid having an upward flow collides against the lid member 154, the upward flow having generated at a location closer to the first end wall having the inflow port 138. In this manner, the intensity of the upward flow of the heating liquid at the location closer to the first end wall is accordingly decreased. Consequently, the liquid surface rising of the heating liquid is suppressed at the location closer to the first end wall.

[0063] In Figs. 6 to 9, the lid member 154 is provided at a location closer to the first end wall 136 or the second end wall 137. However, the lid member 154 may be provided at a location between the first end wall 136 and the second end wall 137 with a substantially equal distance from the first end wall 136 and the second end wall 137, i.e., at a substantially intermediate location, in the longitudinal direction of the box body 131 or the first horizontal direction (see Fig. 9). This configuration achieves suppression of the liquid surface rising of the heating liquid at the substantially intermediate location in the longitudinal direction of the box body 131.

[0064] Figs. 6 to 8 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. 10). 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 to 8. 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 thinner 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. 11) to obtain the suppression effect to the liquid surface waving and rising. The single porous plate 156 shown in Fig. 11 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. 10. The seawater flows up to the space above the porous plate 156 through the through holes of the porous plate 156.

[0067] In Figs. 6 to 11, the lid member 154 is singly provided in the box body 131. However, a plurality of lid members 154 may be provided in the box body 131 (see Figs. 12 to 15). Specifically, another lid member 154 is arranged above and away from the lid member 154. Figs. 12 to 21 illustrate two lid members 154 vertically spaced away from each other. The lid members 154 are disposed above the inflow port 138 and below the liquid surface of the heating liquid in the box body 131.

[0068] Both the two lid members 154 in Fig. 12 entirely extend from the inner surface of the first end wall 136 to the inner surface of the second end wall 137, and vertically partition the internal space of the box body 131. Each of the lid members 154 may be made of the porous plate 156 described with reference to Fig. 11.

[0069] When an upward flow of the heating liquid generates below the lower lid member 154, the heating liquid having the upward flow sequentially collides against the lower lid member 154 and the upper lid member 154. Accordingly, the two lid members 154 in Fig. 12 decreases the intensity of the upward flow of the heating liquid more effectively than the single lid member 154 in Fig. 11. In this manner, a liquid surface rising of the heating liquid is reliably suppressed. In Fig. 12, the lid members 154 extending over the entire length of the box body 131 suppresses a liquid surface waving and rising over the entire length of the box body 131.

[0070] In a case that such an intensive upward flow of the heating liquid can be presumed to generate at a specific region, the structure of the two lid members 154 may be applied only to the specific region (see Figs. 13 to 15). The lower lid member 154 in Figs. 13 to 15 has the same structure as the lower lid member 154 in Fig. 12. However, in Figs. 13 to 15, the upper lid member 154 is shorter than the lower lid member 154 in the longitudinal direction of the box body 131.

[0071] In a case that the intensive upward flow of the heating liquid can be presumed to generate at a location closer to the first end wall 136, the lid members 154 is provided at the location closer to the first end wall 136 (see Fig. 13). In a case that the intensive upward flow of the heating liquid can be presumed to generate at an intermediate location in the longitudinal direction of the box body 131, the upper lid member 154 is provided at the intermediate location of the box body 131 (Fig. 14). In a case that the intensive upward flow of the heating liquid can be presumed to generate at a location closer to the second end wall 137, the upper lid member 154 is provided at the location closer to the second end wall 137 (see Fig. 15).

[0072] In Figs. 13 to 15, the shorter lid member 154 is arranged above the longer lid member 154. However, the shorter lid member 154 may be arranged below the longer lid member 154 (see Figs. 16 to 18). In Fig. 16, the shorter lid member 154 is disposed at a location closer to the first end wall 136. In Fig. 17, the shorter lid member 154 is disposed at an intermediate location in the box body 131. In Fig. 18, the shorter lid member 154 is disposed at a location closer to the second end wall 137.

[0073] In the case that the shorter lid member 154 is arranged above the longer lid member 154 (Figs. 13 to 15), a region including the shorter lid member 154 and another region including no shorter lid member 154 are defined near the liquid surface of the heating liquid. In this case, the liquid surface is likely to receive in its shape an influence of existence or absence of the shorter lid member 154 on the flow of the heating liquid. In contrast, in the case that the shorter lid member 154 is arranged below the longer lid member 154 as shown in Figs. 16 to 18, the liquid surface is unlikely to receive in its shape the influence of existence or absence of the shorter lid member 154 on the flow of the heating liquid owing to the longer lid member 154.

[0074] In a case that an upward flow of the heating liquid can be presumed to be intensive at a specific location in the box body 131, a long lid member 154 is not necessarily required (see Figs. 19 to 21). In a case that a single lid member 154 can be presumed to be insufficient to suppress a liquid surface rising due to an excessively intensive upward flow generating at a location closer to first end wall 136, two short lid members 154 may be vertically lined up and spaced away from each other at the location closer to the first end wall 136 (see Fig. 19). In a case that the intensive upward flow can be presumed to generate at an intermediate location of the box body 131, the two short lid members 154 may be vertically lined up and spaced away from each other at the intermediate location of the box body 131 (see Fig. 20). In a case that the intensive upward flow can be presumed to generate at a location closer to the second end wall 137, the two short lid members 154 may be vertically lined up and spaced away from each other at the location closer to the second end wall 137 (see Fig. 21).

[0075] Each of Figs. 12 to 21 illustrates the two lid members 154. However, in the box body 131, there may be more than two lid members 154 which are vertically arrayed.

[0076] One of the lid members 154 disposed in the box body 131 may be used for fixedly attaching a baffle plate 151 (see Figs. 22 to 24). The lid members 154 in Figs. 22 to 24 have the same structure as the lid members 154 in Fig. 13.

[0077] In Figs. 22 to 24, the baffle plate 151 standing substantially upright is fixedly attached to the lower long lid member 154. The baffle plate 151 has an upper end connected to the bottom surface of the lower long lid member 154. The baffle plate 151 has a lower end spaced upward from the bottom wall 132 of the box body 131. A space is defined between the lower end of the baffle plate 151 and the bottom wall 132 for permitting the heating liquid to pass through the space toward the second end wall 137.

[0078] In Fig. 22, the baffle plate 151 is fixedly attached to the lower long lid member 154 at a location closer to the first end wall 136 than the second end wall 137. In Fig. 23, the baffle plate 151 is fixedly attached to the lower long lid member 154 around the intermediate location of the box body 131. In Fig, 24, the baffle plate 151 is fixedly attached to the lower long lid member 154 at a location closer to the second end wall 137 than the first end wall 136.

[0079] In Figs. 22 to 24, the baffle plate 151 has no through hole. Hence, the space between the lower end of the baffle plate 151 and the bottom wall 132 permits the heating liquid to pass through the space toward the second end wall 137. Since the space is away from the liquid surface, the liquid surface is unlikely to be influenced by a change in a flowing direction of the heating liquid, the change being accompanied by the passing of the heating liquid through the space.

[0080] In place of the baffle plate 151, a baffle plate 151a having a through hole may be adopted to increase the space permitting the heating liquid to pass through toward the second end wall 137 (see Fig. 25). The baffle plate 151a in Fig. 25 is fixedly attached to the bottom surface of the lower long lid member 154 at the same position as the baffle plate 151 in Fig. 22.

[0081] In adoption of the baffle plate 151a, the baffle plate 151a may be connected to the bottom wall 132.

[0082] In the case that at least one of the lid members 154 vertically arrayed and spaced away from each other is shorter than the entire length of the box body 131, the heating liquid having a horizontal flow advancing in a space between the lid members 154 is likely to cause the liquid surface of the heating liquid to rise. The heating liquid having the horizontal flow subsequently advances while vertically spreading after passing through the space or region defined between the arrayed lid members 154. Since the lid members 154 are disposed near the liquid surface, the heating liquid having the vertically spreading flow is likely to cause a liquid surface rising.

[0083] A vertical lid or vertical lids 157 (see Figs. 26 to 27) may be provided to prevent or suppress occurrence of such a vertically spreading flow of the heating liquid. The lid members 154 in Fig. 26 have the same structure as the lid members in Fig. 13. In Fig. 26, the vertical lid 157 fixedly connects one end (closer to the second end wall 137) of the upper short lid member 154 and the top surface of the lower long lid member 154 with each other at a location closer to the second end wall. In this way, the vertical lid 157 closes a space between the lid members 154. The lid members 154 in Fig. 27 have the same structure as the lid members 154 in Fig. 20. In Fig. 27, one of the vertical lids 157 is fixedly attached to one ends (closer to the first end wall 136) of the lid members 154 and the other of the vertical lids 157 is attached to the other ends (closer to the second end wall 137) of the lid members 154. In this way, the vertical lids 157 close a space between the lid members 154. The lid members 154 in Fig. 28 have the same structure as the lid members 154 in Fig. 21. In Fig. 28, the vertical lid 157 fixedly connects one ends (closer to the first end wall 136) of the lid members 154 with each other. In this way, the vertical lid 157 closes a space between the lid members 154.

[0084] The vertical lid 157 may fully or partly close the space, i.e., horizontally opening space, between the lid members 154. The vertical lid 157 connecting the lid members 154 with each other may have a through hole to partly close the space between the lid members 154. Alternatively, the upper or lower end of the vertical lid 157 having the through hole or having no through hole may be spaced away from the bottom surface of the upper lid member 154 or from the top surface of the lower lid member 154. Even the vertical lid 157 partly closing the space between the lid members 154 can weaken the force of the horizontal flow of the liquid passing through the space between the lid members 154. In this configuration, the heating liquid having passed through the space between the lid members 154 leads to a vertically spreading flow having a decreased intensity. Consequently, a liquid surface rising is suppressed.

[0085] 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.

[0086] 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.

[0087] In the above-mentioned embodiments, seawater is exemplified as the heating liquid. However, other liquid having a higher temperature than the liquefied gas may be used as the heating liquid.

[0088] 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. 29. Fig. 29 is a schematic cross-sectional view of the manifold 122.

[0089] In the layout shown in Fig.1, the inflow port 138 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. 29). 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, a straight-tube type supplying pipe 123 can be suitably used as the supplying pipe connected to the manifold, consequently forming a flow path shorter than the bended flow path.

[0090] In the above-mentioned embodiment, the flow of the seawater into the plurality of troughs 130 is uniformed by means of the closing member140. A flow regulating device such as a valve or an orifice member may be mounted on the plurality of supplying pipes 123 to increase the regulation range for the flow of the seawater into each of the plurality of troughs 130.

[0091] In the above-mentioned embodiment, the closing member 140 is made up of an orifice member. However, the closing member 140 may be made up of a porous plate 142 as shown in Fig. 30.

[0092] 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.

[0093] In the above-described embodiment, the baffle plate 151 is fixedly kept substantially upright in the box body 131. However, the vaporizing apparatus 100 may employ a baffle plate 151' fixedly kept tilting in the box body 131 (see Figs. 31 and 32). In Figs. 31 and 32, the baffle plate 151' is fixedly mounted on the bottom wall 132. In FIG. 31, the baffle plate 151' tilts in such a way that the upper end of the baffle plate 151' is closer to the second end wall 137 than the lower end at the bottom wall 132. In contrast, in Fig. 32, the baffle plate 151' tilts in such a way that the upper end of the baffle plate 151' is closer to the first end wall 136 than the lower end of the bottom wall 132. The baffle plate 151' may be spaced away from the bottom wall 132. In this case, the baffle plate 151' is fixedly attached to the side walls 134, 135.

[0094] In the case that the baffle plate 151' tilts toward the second end wall 137 (Fig. 31), the heating liquid having collided against the baffle plate 151' is likely to flow diagonally upward. This configuration makes it possible to increase the amount of the heating liquid overflowing from the box body 131 around the baffle plate 151'.

[0095] In the case that the baffle plate 151' tilts toward the first end wall 136 (Fig. 32), the heating liquid having collided against the baffle plate 151' is likely to flow diagonally downward. In this case, the flow rate of the heating liquid is likely to increase around the bottom wall 132 of the box body 131. This results in reducing a biased flow rate distribution of the heating liquid in the depth direction of the box body 131. Accordingly, a liquid surface waving of the heating liquid is suppressed.

[0096] The obstructor may include a plurality of baffle plate pieces (obstructive pieces) 151" separating away from each other (see Fig. 33) at a specific interval therebetween. In Fig. 33, corresponding sets of the baffle plate pieces 151" are provided at three locations in the first horizontal direction. Each set at each location has two baffle plate pieces 151" vertically aligned and separating away from each other at a specific interval therebetween. A part of the heating liquid having collided against the baffle plate pieces 151" can flow downstream through a gap between the baffle plate pieces 151". The dimension of the gap is adjusted depending on an interval between the two vertically aligned baffle plate pieces 151". Owing to the adjustment of the interval between the plate pieces, it is possible to set the amount of the heating liquid flowing beyond the baffle plate pieces

151" at an appropriate value in consideration of the influence on the heating liquid by the baffle plate pieces 151".

Second Embodiment

[0097] Fig. 34 is a schematic perspective view of a vaporizing apparatus 100' of an open rack type according to a second embodiment. Fig. 35 is a schematic cross-sectional view of the vaporizing apparatus 100'. The vaporizing apparatus 100' will be described with reference to Figs. 34 and 35.

[0098] The vaporizing apparatus 100' according to the second embodiment differs from the vaporizing apparatus 100 according to the first embodiment in use of two supplying pipes 123 and two supplying pipes 123' respectively serving as supplying passages for supplying the heating liquid from the manifold 122 to four troughs 130, the supplying pipes 123, 123' having flow path cross-sectional areas which are different from each other. The supplying pipes 123 are connected with corresponding two outermost troughs 130 among the four troughs 130 lining-up in the second horizontal direction and spaced away from one another. The supplying pipes 123' used to supply the heating liquid to the remaining troughs 130 have a larger flow path cross-sectional area than the supplying pipes 123.

[0099] Each of the two outermost troughs 130 is adjacent to one of heat transfer panels 113. In contrast, each of the two remaining troughs 130 is adjacent to two of the heat transfer panels 113. In this configuration, each of the two remaining troughs 130 is required to supply the heating liquid to the two heat transfer panels 113, whereas it is sufficient that each of the two outermost troughs 130 supplies the heating liquid to the one heat transfer panel 113. In other words, the two remaining troughs 130 are required to send out the heating liquid having a larger flow than that sent out from the two outermost troughs 130. Accordingly, each of the two remaining troughs 130 needs a larger supply amount of the heating liquid than the two outermost troughs 130.

[0100] In the embodiment, the supplying pipes 123' having the larger flow path cross-sectional area than the supplying pipes 123 can supply to the two remaining troughs 130 a larger supply amount of the heating liquid than that to the two outermost troughs 130. This configuration eliminates the necessity of attaching any fluidic device, such as a flow regulating valve or an orifice member, for regulating the flow to the supplying pipes 123, 123' to achieve the aforementioned magnitude relationship of the flows.

[0101] The vaporizing apparatus described in connection with the various embodiments mainly has the following features.

[0102] A vaporizing apparatus according to an aspect of the embodiment is configured to vaporize liquefied gas by way of heat exchange between the liquefied gas and heating liquid having a higher temperature than the liquefied gas. The vaporizing apparatus includes a heat transfer panel including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas; a trough lying at a position lower than an upper end of the heat transfer panel for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes; and a manifold arranged on one end side of the trough in a lining-up direction of the plurality of heat transfer tubes for supplying the heating liquid into the trough. The trough includes a bottom wall extending in the 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 having an inflow port for allowing the heating liquid to flow in.

[0103] In the above-mentioned configuration, the manifold for supplying the heating liquid into the 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 trough is shortened. In other words, the flow path of the heating liquid from the manifold to the trough is not required to reach 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 trough through an inflow port formed in the bottom wall.

[0104] 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 trough against the second end wall.

[0105] In the above-mentioned configuration, the heating liquid having flowed in through the inflow port flows toward the second end wall, and collides against the second end 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, and causes the liquid surface of the heating liquid to rise. In this case, the rise suppressing portion suppresses the liquid surface rising, and thus prevents an excessive supply of the heating liquid to the outer surfaces of heat transfer tubes closer to the second end wall. Accordingly, this configuration keeps the heat exchange from varying among the plurality of heat transfer tubes.

[0106] With the above-mentioned configuration, the rise suppressing portion may include a lid member lying at a position higher than the inflow port between the first end wall and the second end wall and extending in the trough in the lining-up direction.

[0107] In the above-mentioned configuration, most of the heating liquid having flowed in the trough through the inflow port flows in a region below the lid member that is disposed at a higher position than the inflow port. After the heating liquid collides against the second end wall, an upward flow of the heating liquid generates. The liquid surface rising of the heating liquid is suppressed by the lid member against which the heating liquid having the upward flow collides.

[0108] With the above-mentioned configuration, the lid member may lie at a location closer to the first end wall, a location closer to the second end wall, or an intermediate location between the first end wall and the second end wall.

[0109] In the above-mentioned configuration, the lid member suppresses a liquid surface rising near the inflow port when disposed at a location closer to the first end wall. The lid member suppresses the liquid surface rising attributed to the collision of the heating liquid against the second wall when disposed at a location closer to the second end wall. The lid member suppresses the liquid surface rising at an intermediate location between the first end wall and the second end wall when disposed at the intermediate location.

[0110] With the above-mentioned configuration, the lid member may include a plate entirely extending in the lining-up direction from the first end wall to the second end wall, or a plurality of plates lying between the first end wall and second end wall and spaced away from one another in the lining-up direction.

[0111] In the above-mentioned configuration, the lid member including the plate entirely extending in the lining-up direction from the first end wall to the second end wall suppresses a liquid surface waving or rising over the entire length of the trough. Alternatively, the lid member including the plurality of plates lying between the first end wall and the second end wall and spaced away from one another in the lining-up direction suppresses a liquid surface rising of the heating liquid over a wide range of the trough in the longitudinal direction thereof without any excessive increase in the weight of the trough.

[0112] With the above-mentioned configuration, the lid member may have a through hole vertically passing through the lid member.

[0113] In the above-mentioned configuration, a part of the heating liquid flowing upward can flow into a space above the lid member through the through hole of the lid member. A resistance occurs in the heating liquid when the heating liquid passes through the through hole. As a result, the liquid surface rising of the heating liquid is suppressed at a location closer to the second end wall.

[0114] With the above-mentioned configuration, the rise suppressing portion may include an obstructor provided between the first end wall and the second end wall. The obstructor may allow the heating liquid having flowed in the trough through the inflow port to collide 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.

[0115] In the above-mentioned configuration, the heating liquid having flowed in through the inflow port collides against the obstructor 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.

[0116] With the above-mentioned configuration, the obstructor may stand upright or tilt with respect to the bottom wall of the trough.

[0117] In the above-mentioned configuration, when being kept standing upright with respect to the bottom wall of the trough, the obstructor effectively decreases the intensity of the heating liquid by allowing the heating liquid to collide against the obstructor. Alternatively, when being kept tilting with respect to the bottom wall of the trough, the obstructor can decreases the intensity of the heating liquid and change the flowing direction of the heating liquid.

[0118] With the above-mentioned configuration, the obstructor may be spaced away from the bottom wall of the trough.

[0119] In the above-mentioned configuration, a part of the heating liquid can flow downstream through a gap between the obstructor and the bottom wall of the trough. Since the gap is away from the liquid surface of the heating liquid, the liquid surface avoids excessively rising even due to the flow of the heating liquid passing through the gap. Further, the heating liquid can flow toward the second end wall by passing through the gap. Thus, no excessive decrease in the flow occurs at a location closer to the second end wall.

[0120] With the above-mentioned configuration, the obstructor may include a plurality of obstructive pieces separating from each other.

[0121] In the above-mentioned configuration, the obstructor including the plurality of obstructive pieces separating from each other can provide in the trough a plurality of regions at which the heating liquid collides against the obstructive pieces. As the interval between the obstructive pieces is smaller, the resistance in the heating liquid is higher. Conversely, as the interval between the obstructive pieces is larger, the resistance in the heating liquid is lower. This configuration makes it possible to set the resistance in the heating liquid at an appropriate value by adjusting the interval between the obstructive pieces.

[0122] With the above-mentioned configuration, the obstructer may have a through hole passing through the obstructor in the lining-up direction.

[0123] In the above-mentioned configuration, the through hole passing through the obstructor is formed in the lining-up direction of the plurality of the heat transfer tubes. Therefore, a part of the heating liquid having flowed through the inflow port formed in the first end wall can flow from an upstream region to a downstream region of the obstructor through the through hole. A higher resistance occurs in the heating liquid when the heating liquid passes through the through hole, thus reducing the flow pressure of the heating liquid from the first end wall toward the second end wall. As a result, the liquid surface rising of the heating liquid is suppressed at a location closer to the second end wall.

[0124] With the above-mentioned configuration, the vaporizing apparatus may include a closing member provided in the trough for closing a part of the inflow port. The closing member is removable from the trough.

[0125] 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 and thus 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 possible to lower the resistance in the heating liquid passing through the inflow port by removing the closing member.

[0126] With the above-mentioned configuration, the vaporizing apparatus may include: another heat transfer panel including a plurality of heat transfer tubes and disposed away from the heat transfer panel; another trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of the another heat transfer panel; and a plurality of supplying pipes respectively connected to the trough and the another trough for supplying the heating liquid from the manifold to the trough and the another trough. One of the heat transfer panel and the another heat transfer panel is adapted for the heat exchange between the liquefied gas and the heating liquid having a flow rate smaller than a flow rate of the heating liquid of the other of the heat transfer panel and the another heat transfer panel. The supplying pipe connected to the trough of the one heat transfer panel has a smaller flow path cross-sectional area than the supplying pipe connected to the trough of the other heat transfer panel.

[0127] In the above-mentioned configuration, the troughs receive the heating liquid through the plurality of 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. The supplying pipe connected to the trough configured to supply the heating liquid to the heat transfer panel which requires the heating liquid having a relatively small flow for the heat exchange between the heating liquid and the liquefied gas has a relatively small flow path cross-sectional area. In this way, the supplying pipe avoids supplying too much amount of the heating liquid to the trough.

[0128] With the above-mentioned configuration, the vaporizing apparatus may further include: at least two heat transfer panels including the heat transfer panel, and disposed away from each other; three troughs including the trough; and a plurality of supplying pipes respectively connected to the three troughs for supplying the heating liquid from the manifold to the three troughs. Specified two troughs among the at least three troughs lie in outermost positions of a row of the at least two heat transfer panels in such a way that each of the specified two troughs in the outermost positions is adjacent to one of the at least two heat transfer panels, a remaining trough is placed between the heat transfer panels adjacent to each other. A pair of the supplying pipes connected to the specified two troughs have a smaller flow path cross-sectional area than the supplying pipe connected to the remaining trough.

[0129] In the above-mentioned configuration, each of the two outermost troughs is adjacent to one of the heat transfer panels, and the remaining trough is adjacent to two of the heat transfer panels. In this configuration, the outermost two troughs allow the heating liquid to flow downward to the one heat transfer panel. In contrast, the remaining trough allows the heating liquid to flow downward to the two heat transfer panels. Since the supplying pipes connected with the two outermost troughs have the smaller flow path cross-sectional area than the supplying pipe for the remaining trough, the supply amount of the heating liquid to the two outermost trough is relatively small. Further, the 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 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 fluidic device, such as a valve, for reducing the supply amount of the heating liquid to the supplying pipes for the two outermost troughs.

[0130] With the above-mentioned configuration, the vaporizing apparatus may further include another lid member lying at a position vertically away from the lid member.

[0131] In the above-mentioned configuration, even an intensive upward flow of the heating liquid is decreased owing to the sequential collisions of the heating liquid having the upward flow against the lid member and the another lid member. In this manner, a liquid surface rising of the heating liquid is suppressed.

[0132] With the above-mentioned configuration, at least one of the lid member and the another lid member may entirely extend in the trough.

[0133] In the above-mentioned configuration, a liquid surface waving or rising of the heating liquid is suppressed over the entire length of the trough.

[0134] With the above-mentioned configuration, the vaporizing apparatus may further include a vertical lid disposed between the lid member and the another lid member.

[0135] In above-mentioned configuration, a part of the heating liquid having collided against the upper lid member which is either the lid member or the another lid member flows in the space between the lid members. However, the heating liquid flowing in the space between the lid members receives a resistance from the vertical lid disposed between the lid members. Consequently, the heating liquid has a decreased intensity.

[0136] With the above-mentioned configuration, the rise suppressing portion may include an obstructor between the first end wall and the second end wall. The obstructor may be in contact with a bottom surface of the lid member. The obstructor may suppress a collisional force of the heating liquid against the second end wall by allowing the heating liquid having flowed in the trough through the inflow port to collide against the obstructor before the collision against the second wall. The obstructor may have a through hole passing through the obstructor in the lining-up direction.

[0137] In the above-mentioned configuration, the obstructor is attachable to the lid member by a contact with the bottom surface of the lid member. The obstructor having the through hole allows the heating liquid to flow toward the second end wall through the through hole. This configuration thus avoids excessive lowering of the surface level of the heating liquid at a location closer to the second end wall.

Industrial Applicability

[0138] 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 heat transfer panel including a plurality of heat transfer tubes standing and horizontally lining up for guiding the liquefied gas;
    a trough lying at a position lower than an upper end of the heat transfer panel for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes; and
    a manifold arranged on one end side of the trough in a lining-up direction of the plurality of heat transfer tubes for supplying the heating liquid into the trough, wherein
    the trough includes

        a bottom wall extending in the 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 having an inflow port for allowing the heating liquid to flow in.

2. The vaporizing apparatus according to claim 1, 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 trough against the second end wall.

3. The vaporizing apparatus according to claim 2, wherein
the rise suppressing portion includes a lid member lying at a position higher than the inflow port between the first end wall and the second end wall and extending in the trough in the lining-up direction.

4. The vaporizing apparatus according to claim 3, wherein
the lid member lies at a location closer to the first end wall, a location closer to the second end wall, or an intermediate location between the first end wall and the second end wall.

5. The vaporizing apparatus according to claim 3, wherein
the lid member includes a plate entirely extending in the lining-up direction from the first end wall to the second end wall, or a plurality of plates lying between the first end wall and the second end wall and spaced away from one another in the lining-up direction.

6. The vaporizing apparatus according to any one of claims 3 to 5, wherein
the lid member has a through hole vertically passing through the lid member.

7. The vaporizing apparatus according to claim 2, 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 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.

8. The vaporizing apparatus according to claim 7, wherein
the obstructor stands upright or tilts with respect to the bottom wall of the trough.

9. The vaporizing apparatus according to claim 7, wherein
the obstructor is spaced away from the bottom wall of the trough.

10. The vaporizing apparatus according to claim 7, wherein
the obstructor includes a plurality of obstructive pieces separating from each other.

11. The vaporizing apparatus according to any one of claims 7 to 10, wherein
the obstructor has a through hole passing through the obstructor in the lining-up direction.

12. The vaporizing apparatus according to any one of claims 1 to 5, 7 and 10 further comprising:
a closing member provided in the trough for closing a part of the inflow port, the closing member being removable from the trough.

13. The vaporizing apparatus according to any one of claims 1 to 5, 7 and 10, further comprising:

another heat transfer panel including a plurality of heat transfer tubes and disposed away from the heat transfer panel;
another trough for supplying the heating liquid to an outer surface of each of the plurality of heat transfer tubes of the another heat transfer panel; and
a plurality of supplying pipes respectively connected to the trough and the another trough for supplying the heating liquid from the manifold to the trough and the another trough, wherein
one of the heat transfer panel and the another heat transfer panel is adapted for the heat exchange between the liquefied gas and the heating liquid having a flow rate smaller than a flow rate of the heating liquid of the other of the heat transfer panel and the another heat transfer panel, and
the supplying pipe connected to the trough of the one heat transfer panel has a smaller flow path cross-sectional area than the supplying pipe connected to the through of the other heat transfer panel.

14. The vaporizing apparatus according to any one of claims 1 to 5 and 7 to 10, further comprising:

at least two heat transfer panels including the heat transfer panel, and disposed away from each other;
three troughs including the trough; and
a plurality of supplying pipes respectively connected to the three troughs for supplying the heating liquid from the manifold to the three troughs, wherein
specified two troughs among the at least three troughs lie in outermost positions of a row of the at least two heat transfer panels in such a way that each of the specified two troughs in the outermost positions is adjacent to one of the at least two heat transfer panels,
a remaining trough is placed between the heat transfer panels adjacent to each other, and
a pair of the supplying pipes connected to the specified two troughs have a smaller flow path cross-sectional area than the supplying pipe connected to the remaining trough.

15. The vaporizing apparatus according to any one of claims 3 to 5, further comprising another lid member lying at a position vertically away from the lid member.

16. The vaporizing apparatus according to claim 15, wherein
at least one of the lid member and the another lid member entirely extends in the trough.

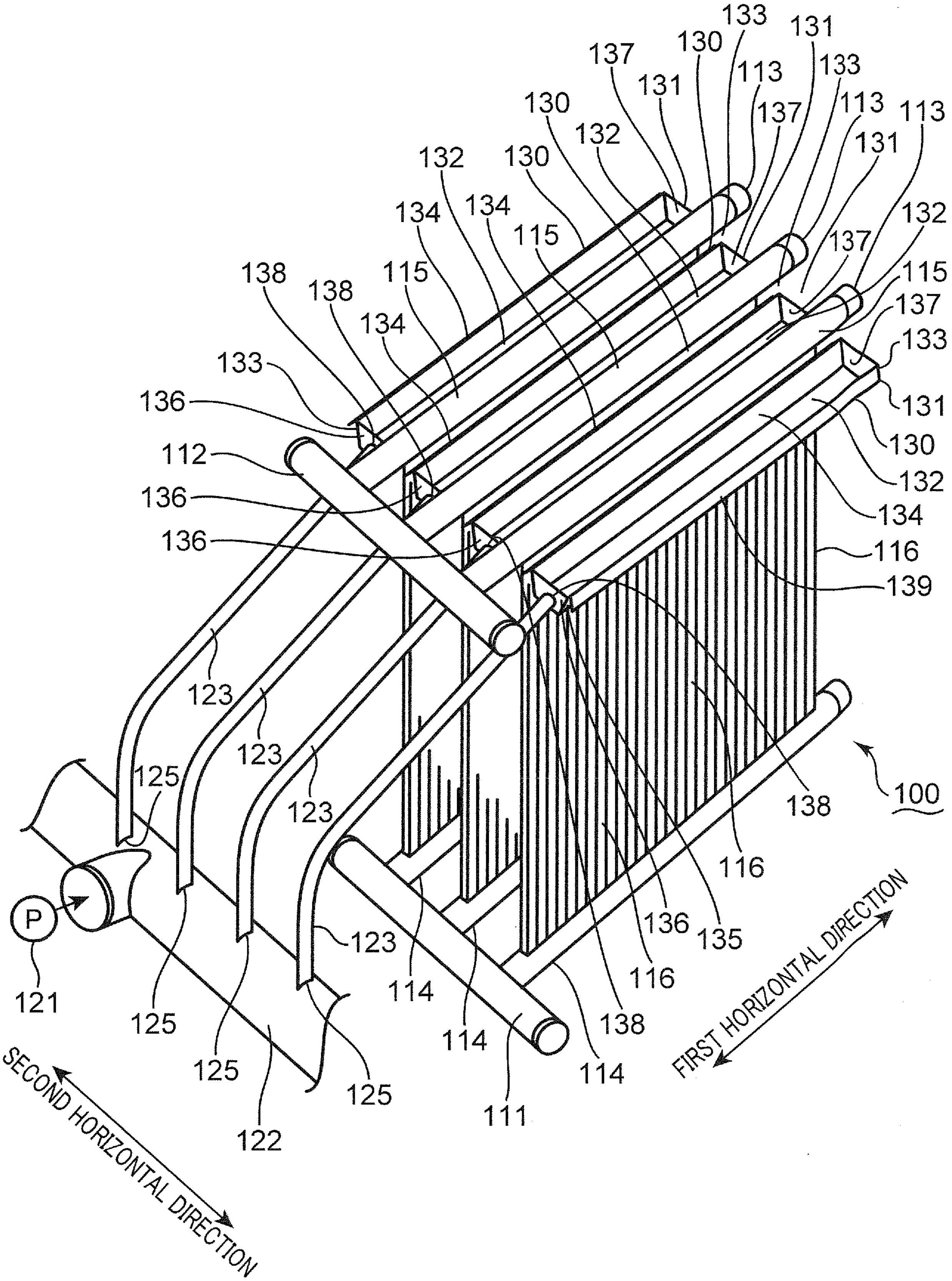
17. The vaporizing apparatus according to the claim 15, further comprising a vertical lid disposed between the lid member and the another lid member.

18. The vaporizing apparatus according to claim 15, wherein

the rise suppressing portion includes an obstructor between the first end wall and the second end wall,
the obstructor being in contact with a bottom surface of the lid member,

suppressing a collisional force of the heating liquid against the second end wall by allowing the heating liquid having flowed in the trough through the inflow port to collide against the obstructor before the collision against the second wall, and
having a through hole passing through the obstructor in the lining-up direction.

FIG. 1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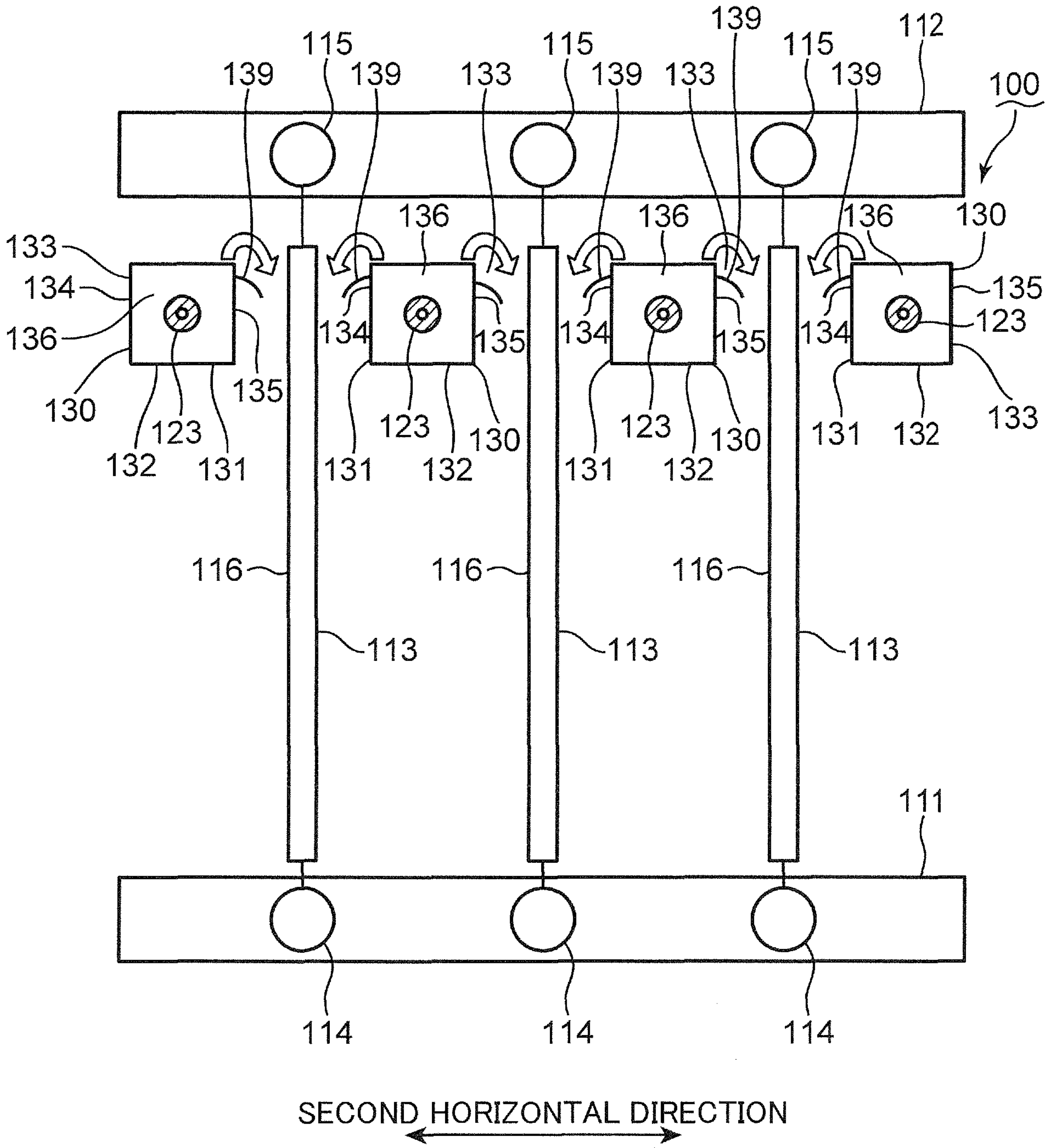
FIRST HORIZONTAL DIRECTION
SECOND HORIZONTAL DIRECTION

FIG. 2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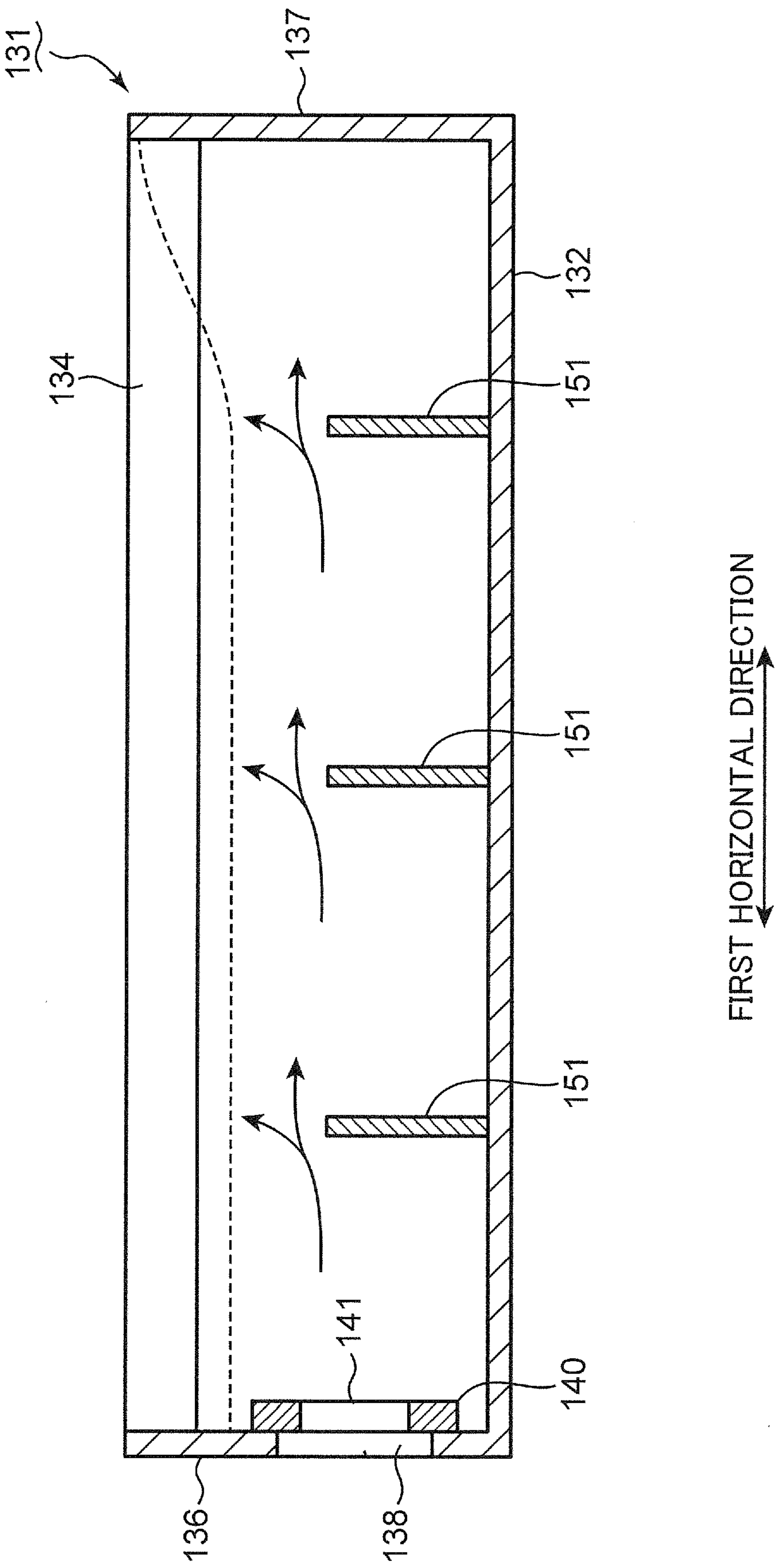
SECOND HORIZONTAL DIRECTION

FIG. 3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FIRST HORIZONTAL DIRECTION

FIG. 4

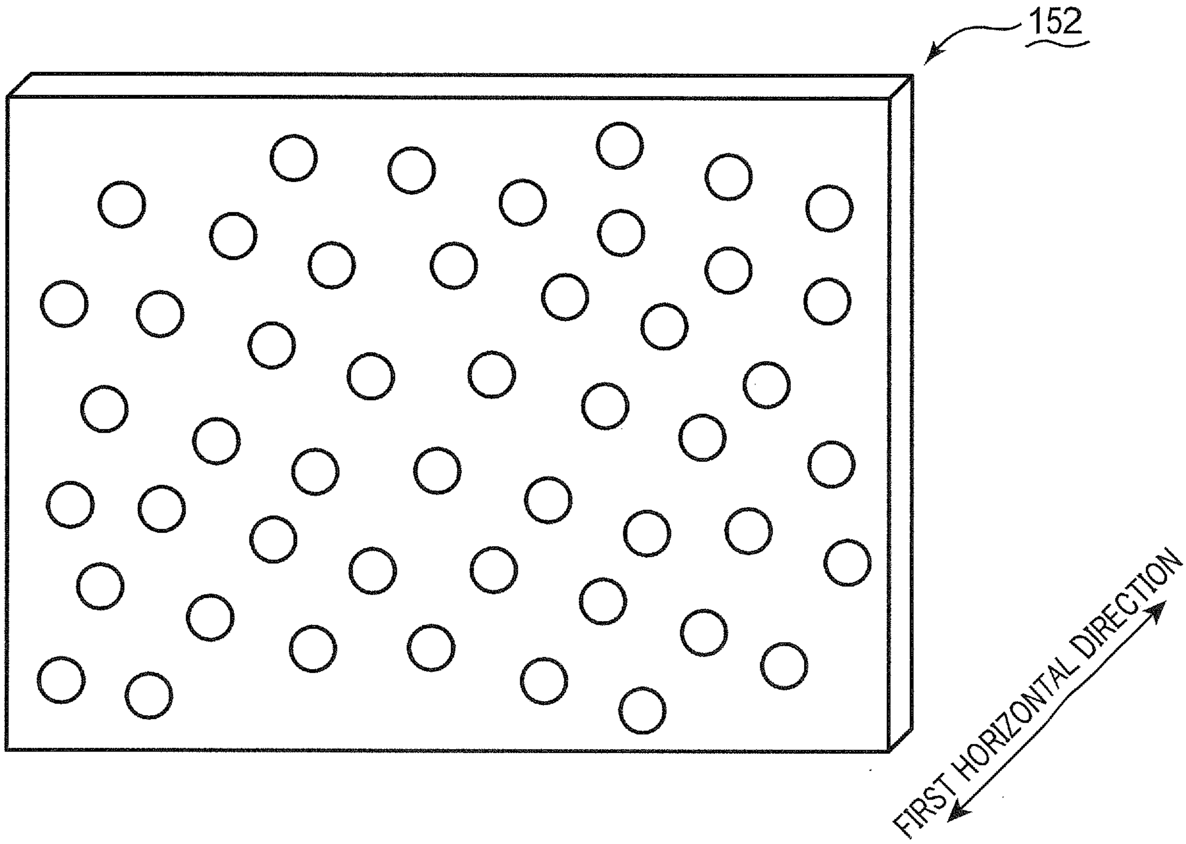


FIG. 5

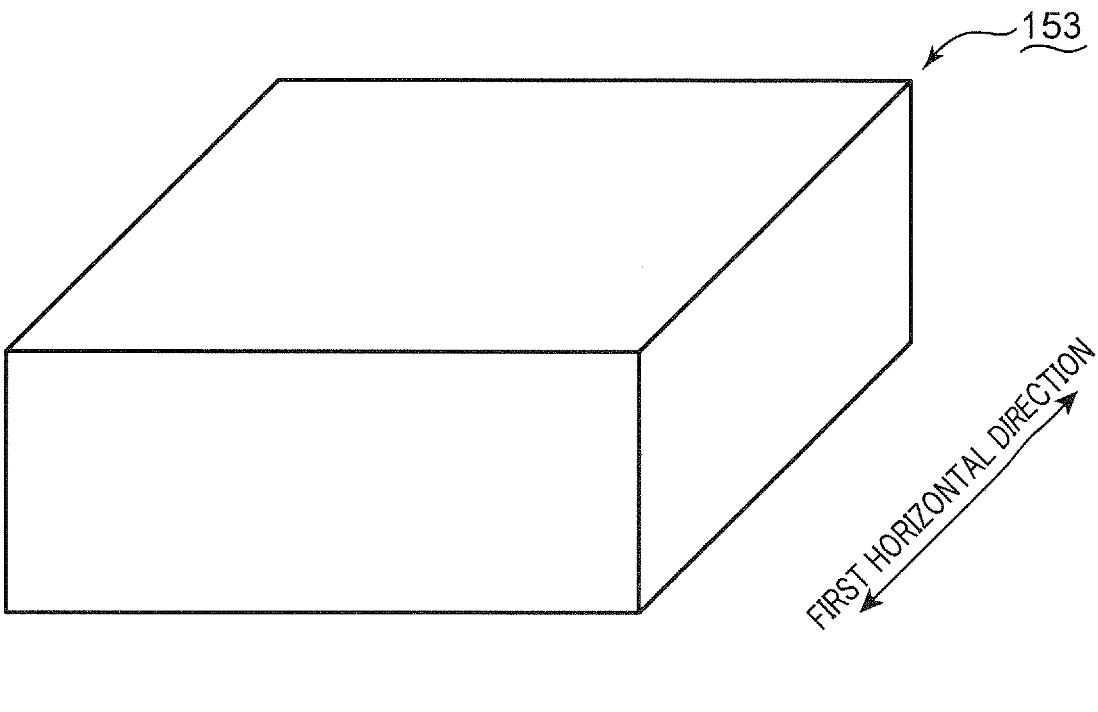


FIG. 6

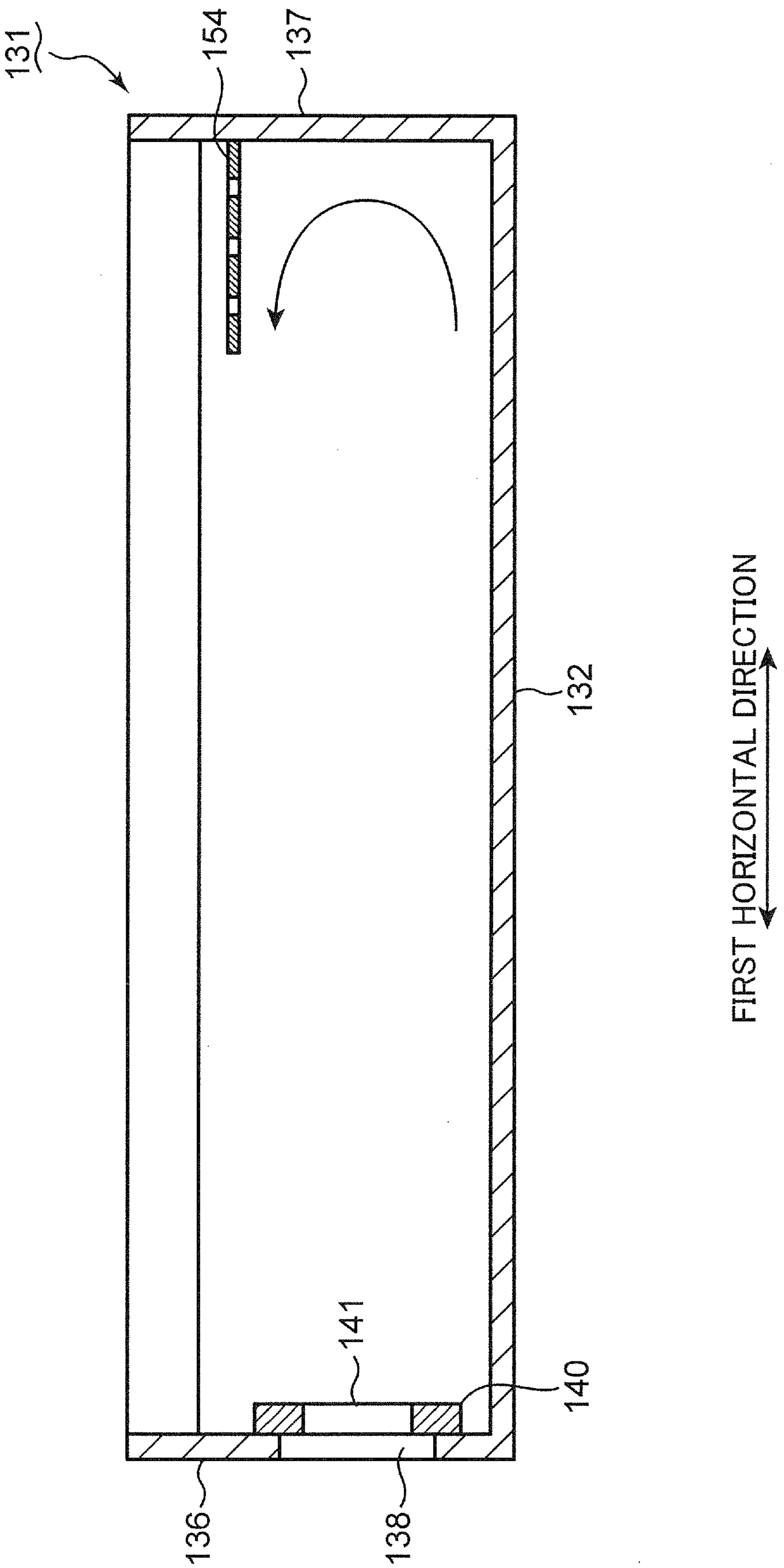
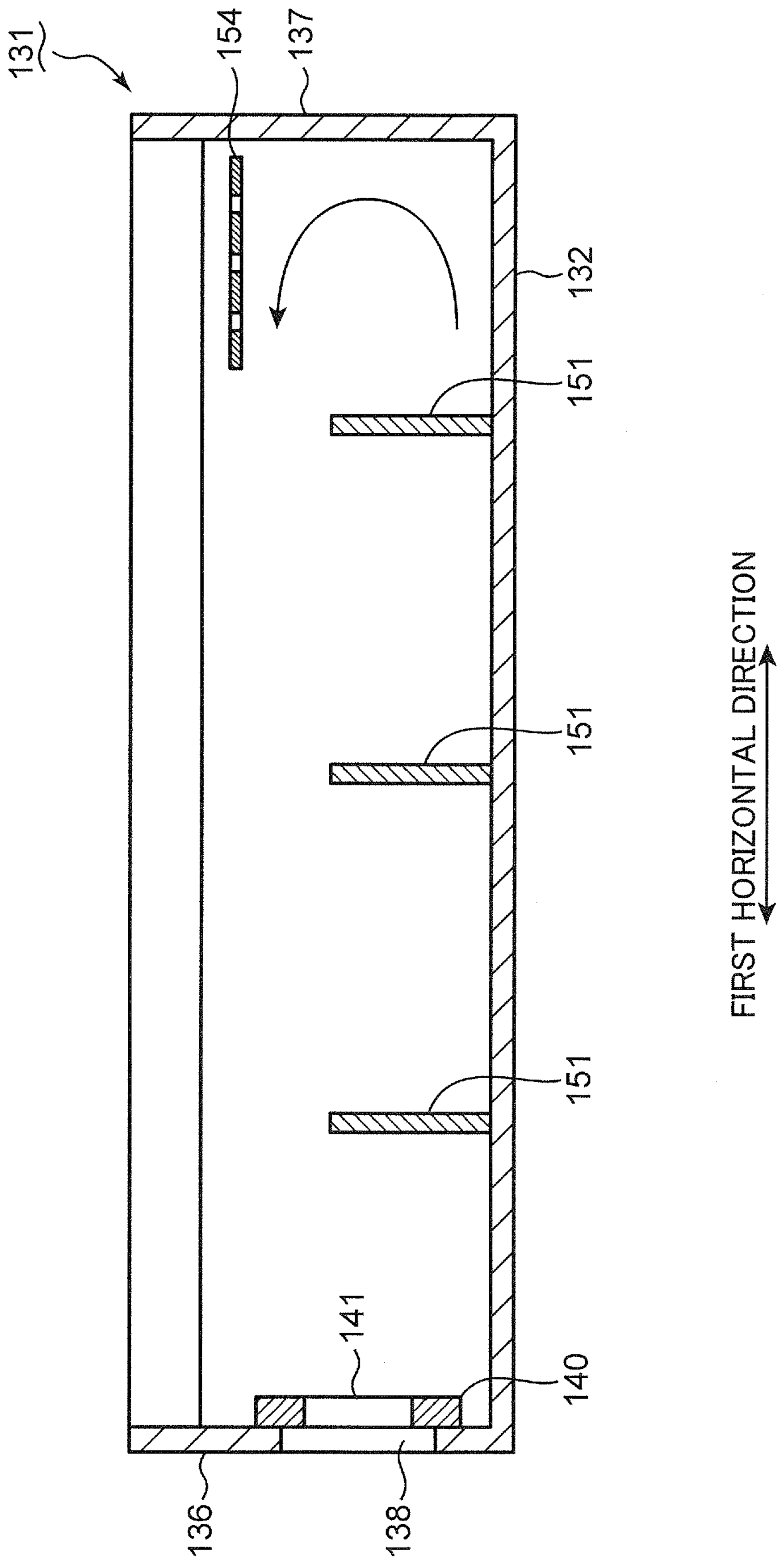


FIG. 7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FIRST HORIZONTAL DIRECTION

FIG. 8

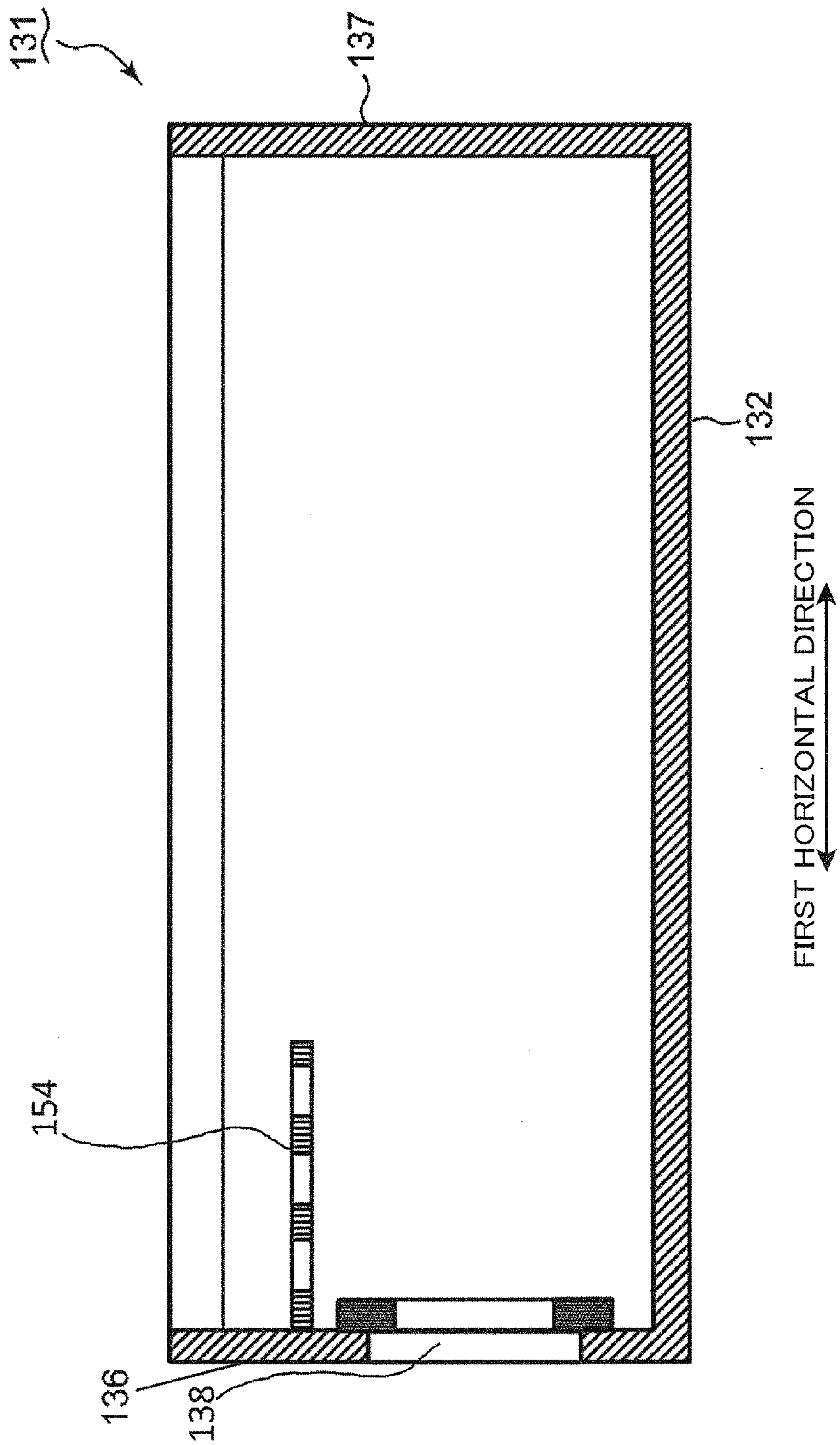


FIG. 9

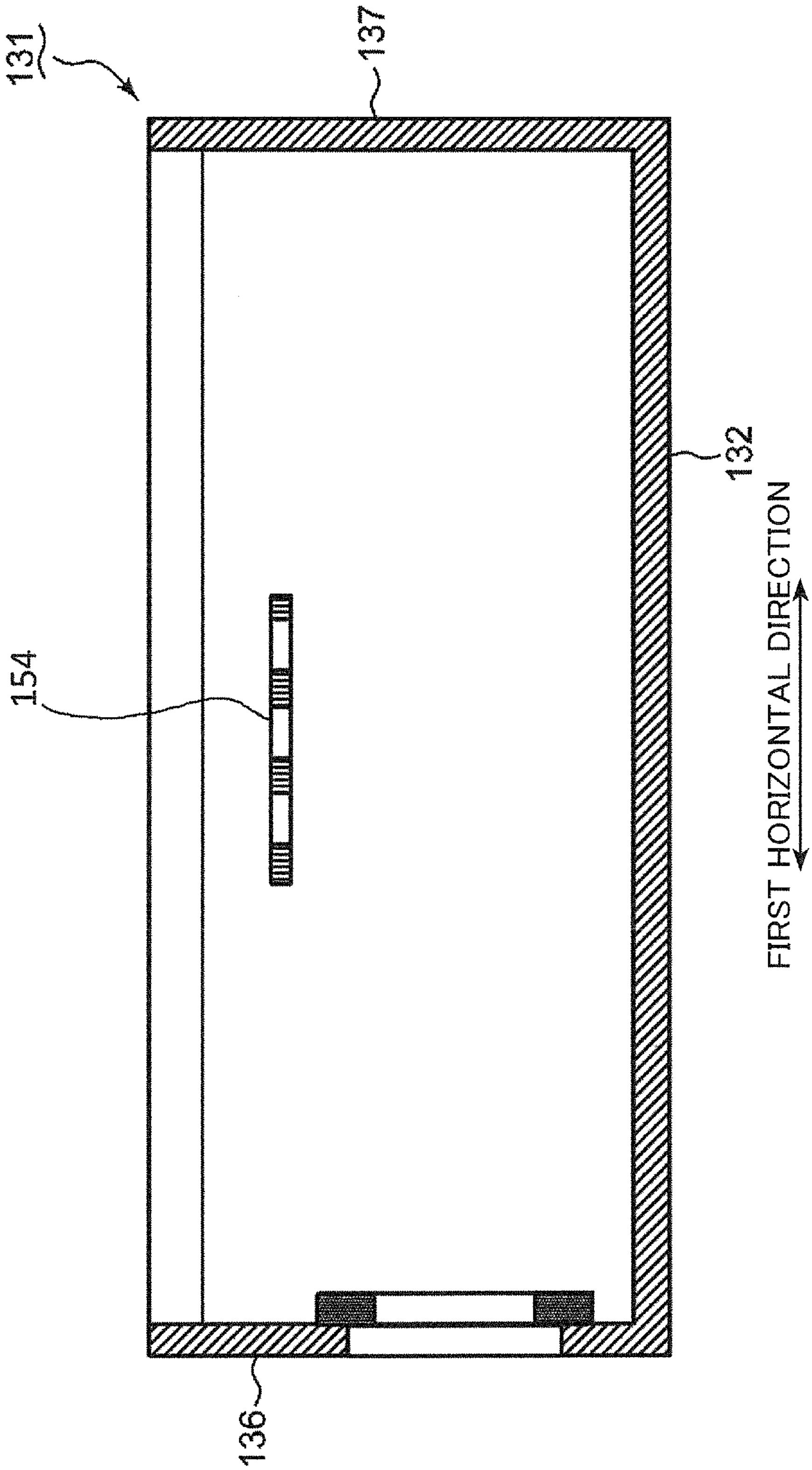
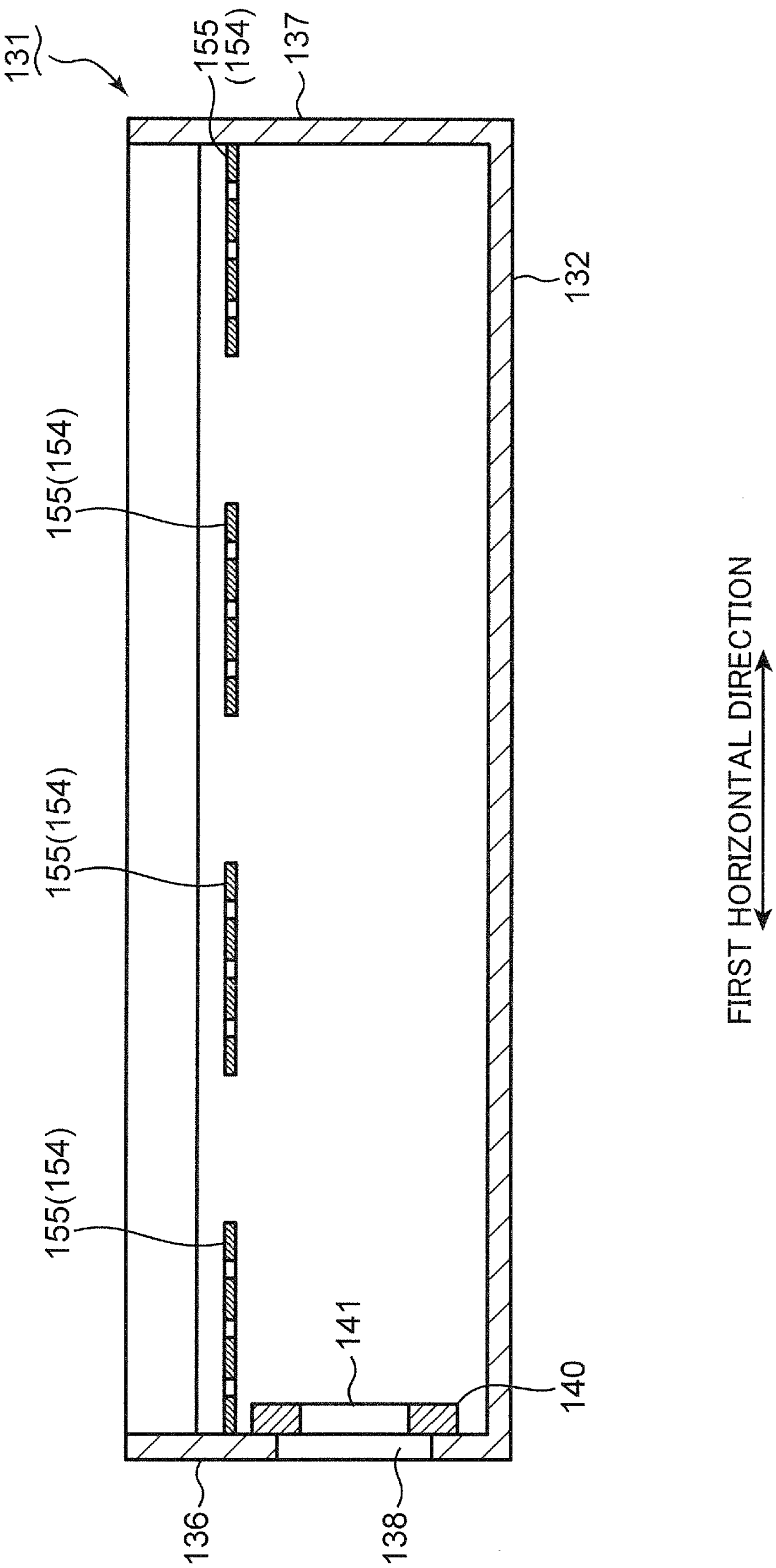


FIG. 10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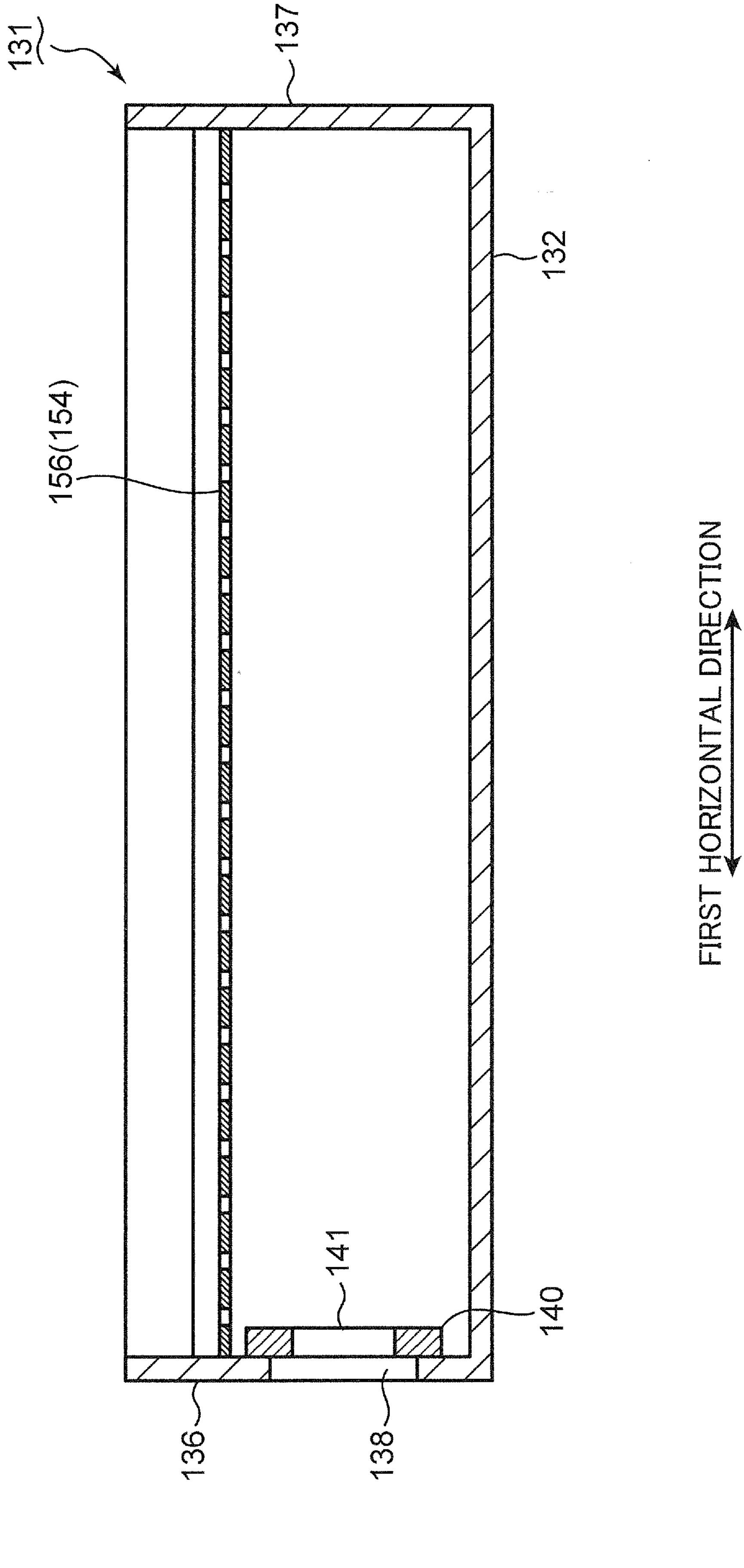
FIRST HORIZONTAL DIRECTION

FIG. 11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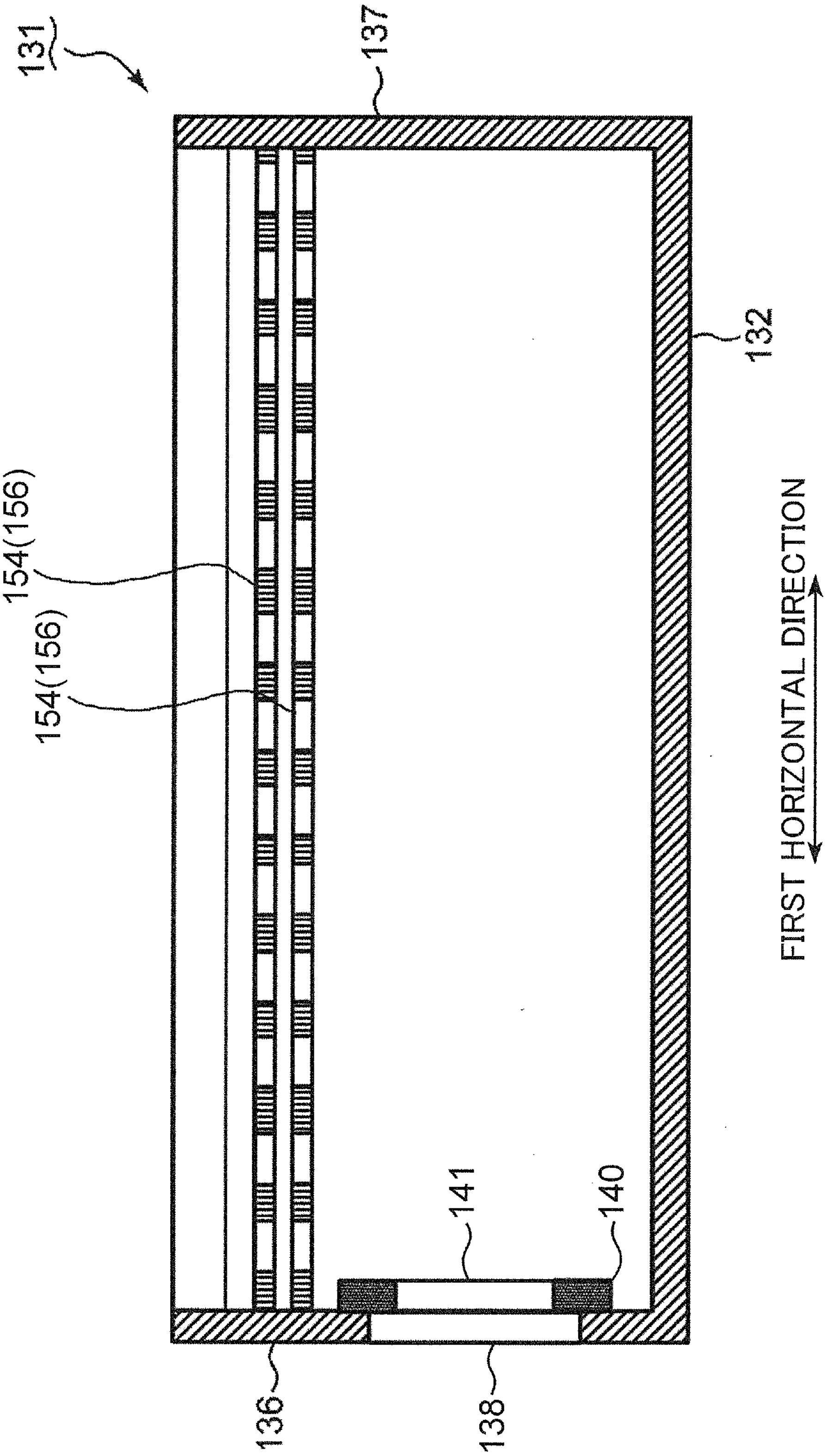
FIRST HORIZONTAL DIRECTION

FIG. 12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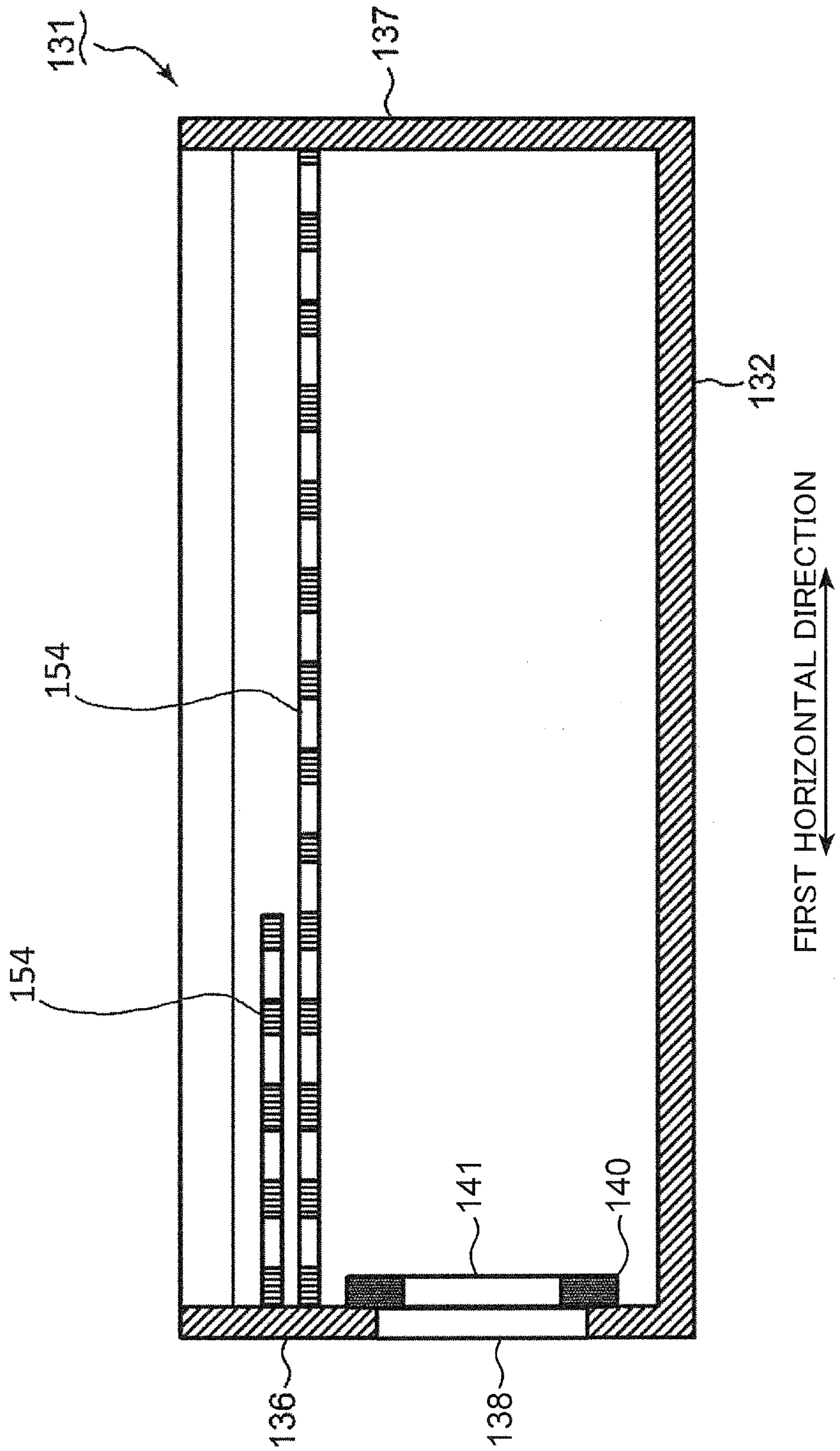
FIRST HORIZONTAL DIRECTION

FIG. 13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FIRST HORIZONTAL DIRECTION
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FIG. 14

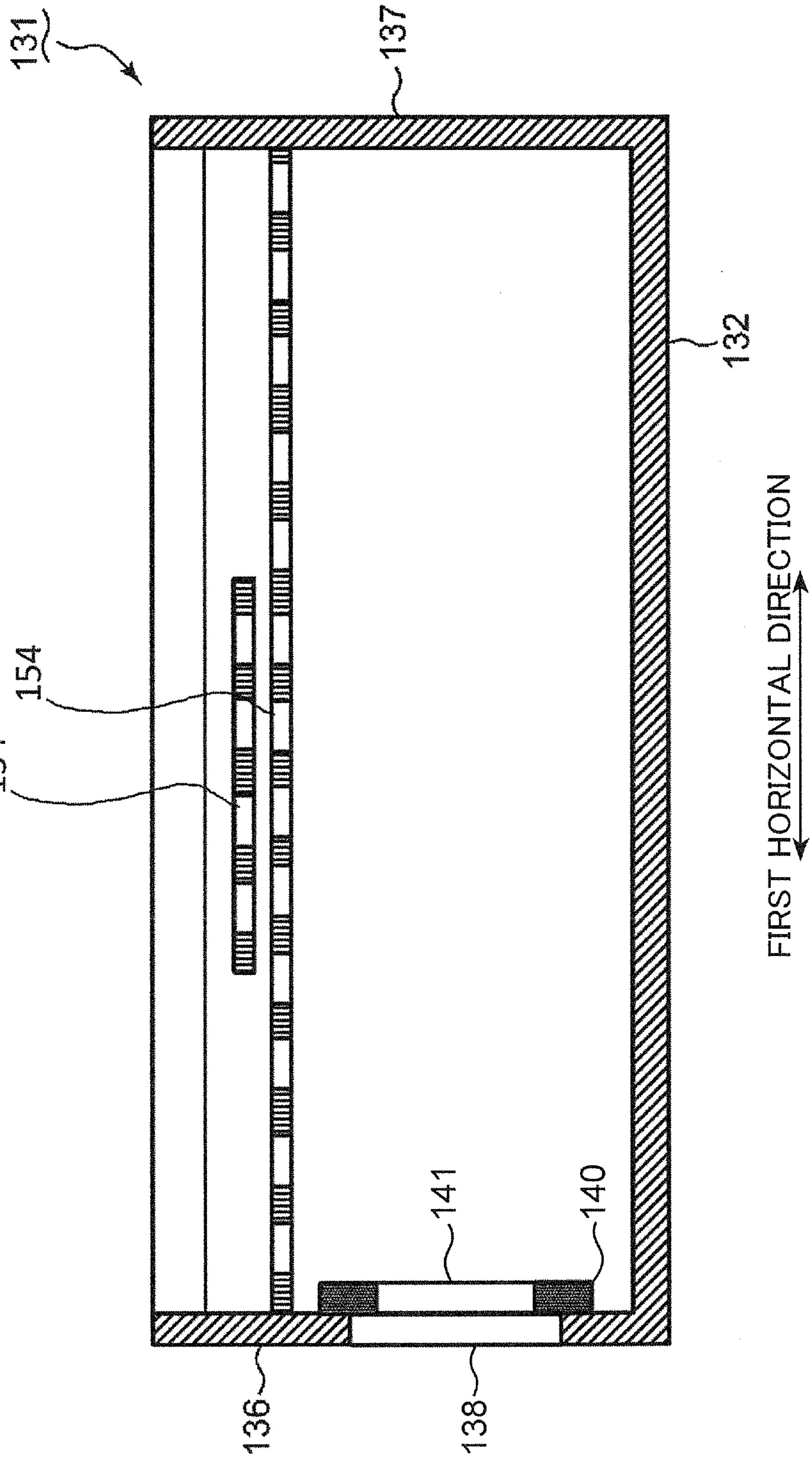
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FIG. 15

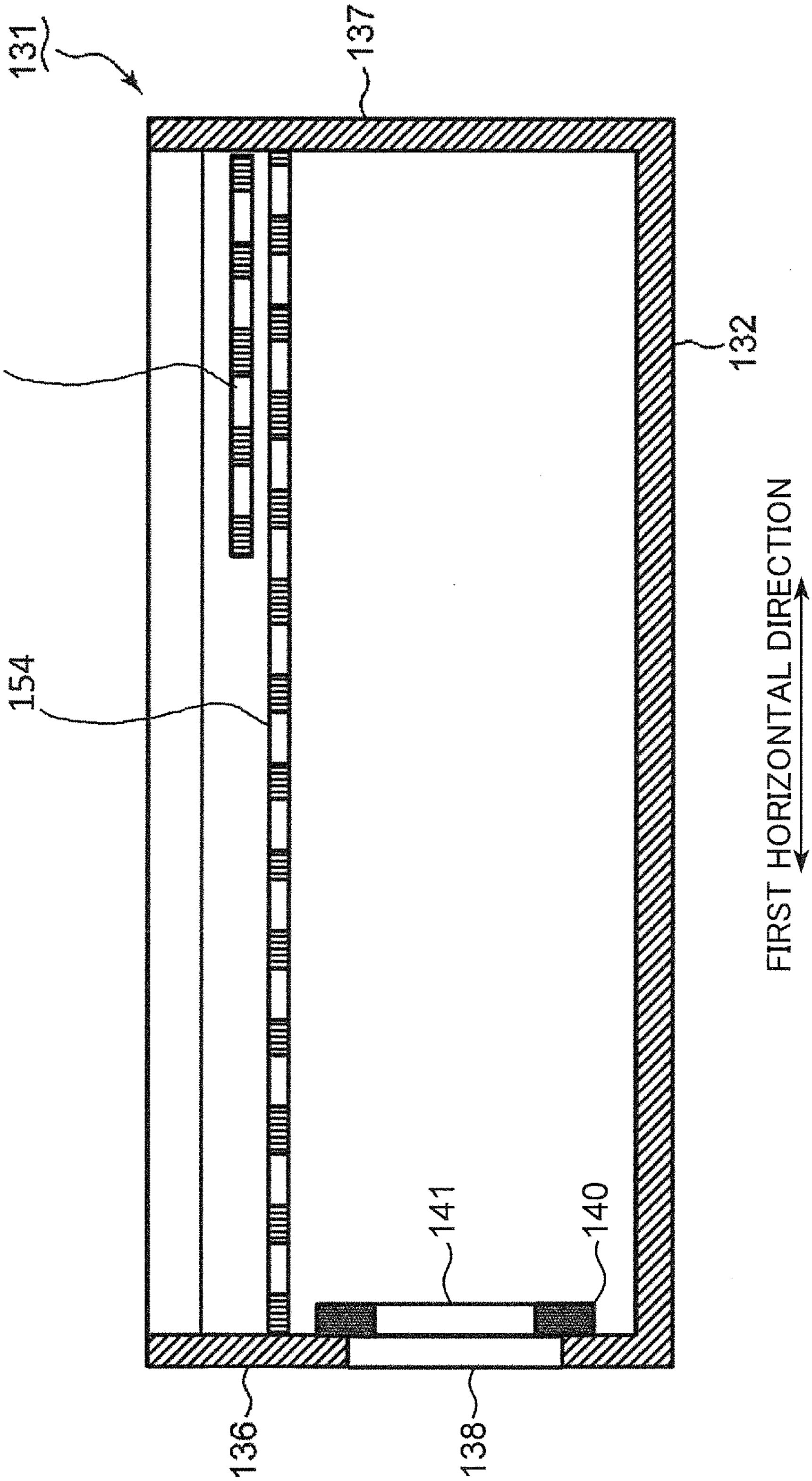
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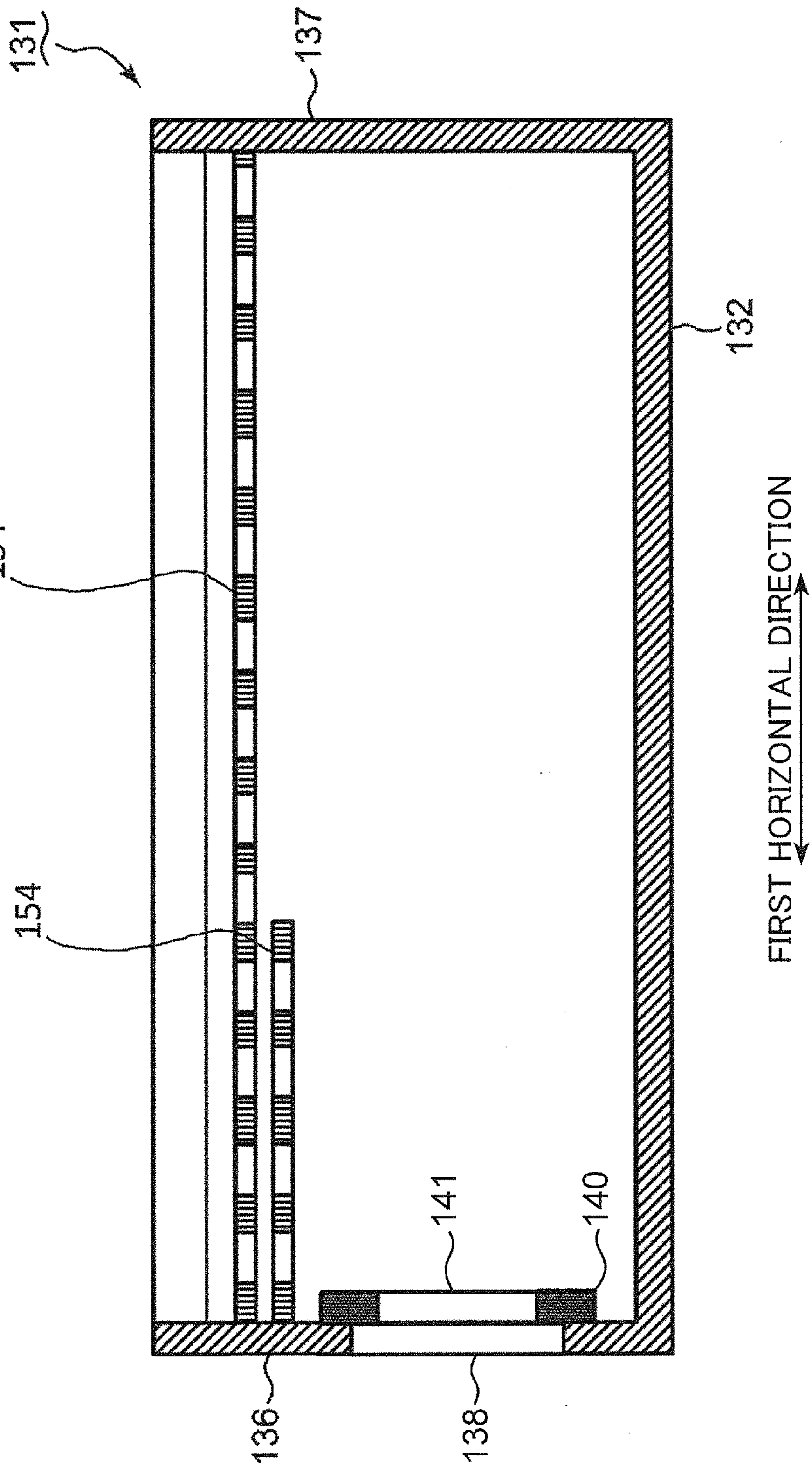
FIG. 16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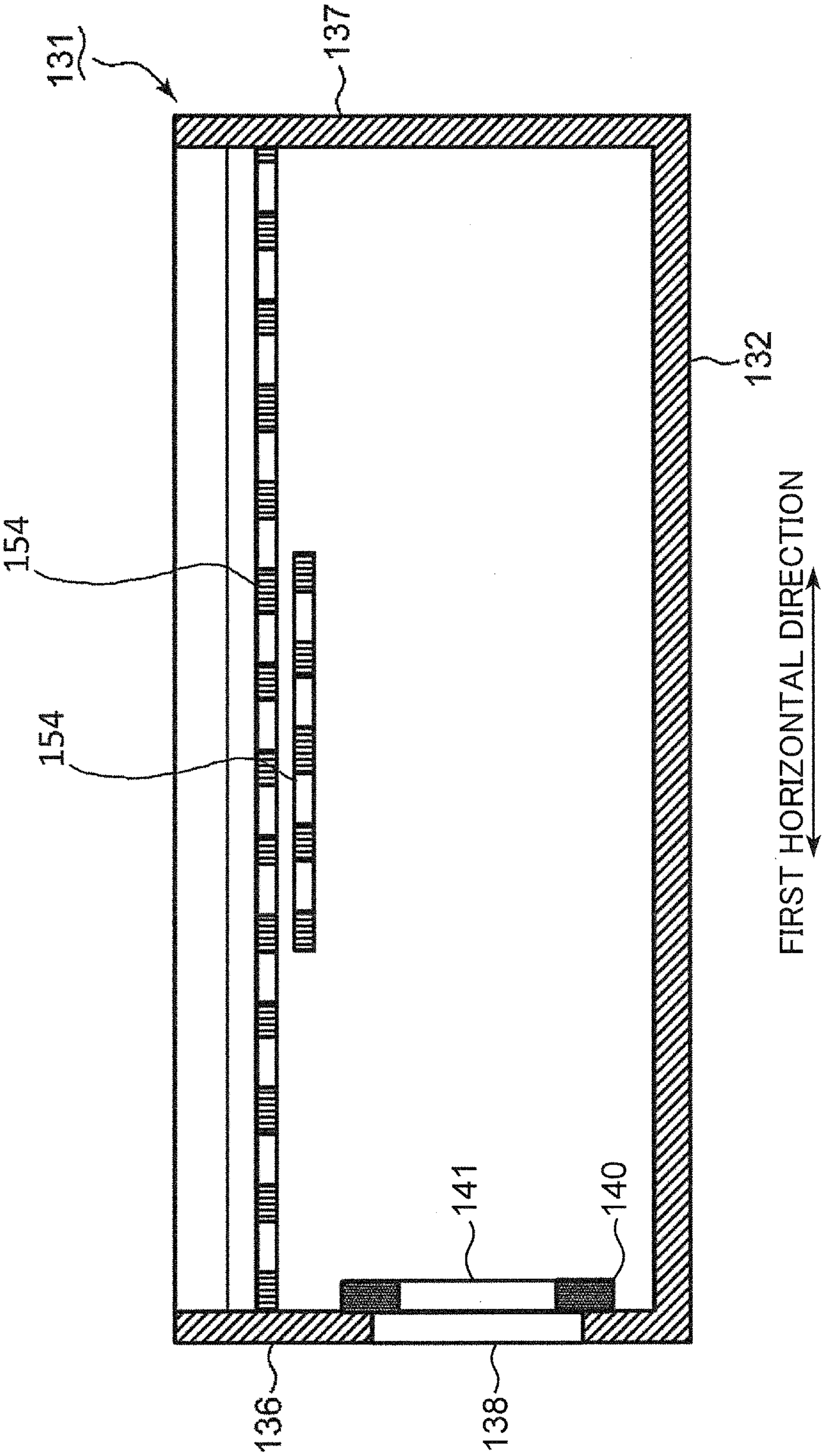
FIRST HORIZONTAL DIRECTION

FIG. 17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FIRST HORIZONTAL DIRECTION
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FIG. 18

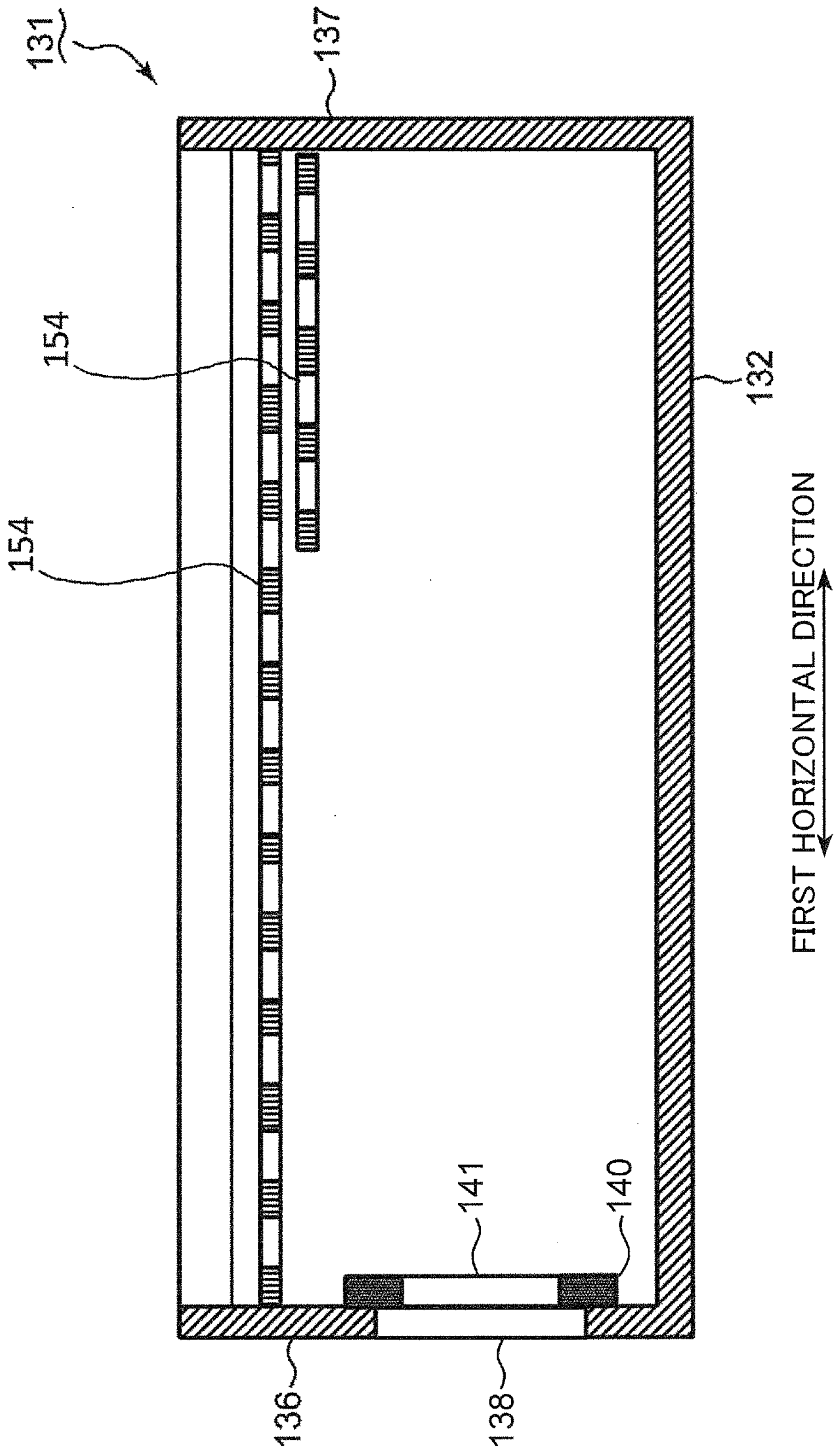
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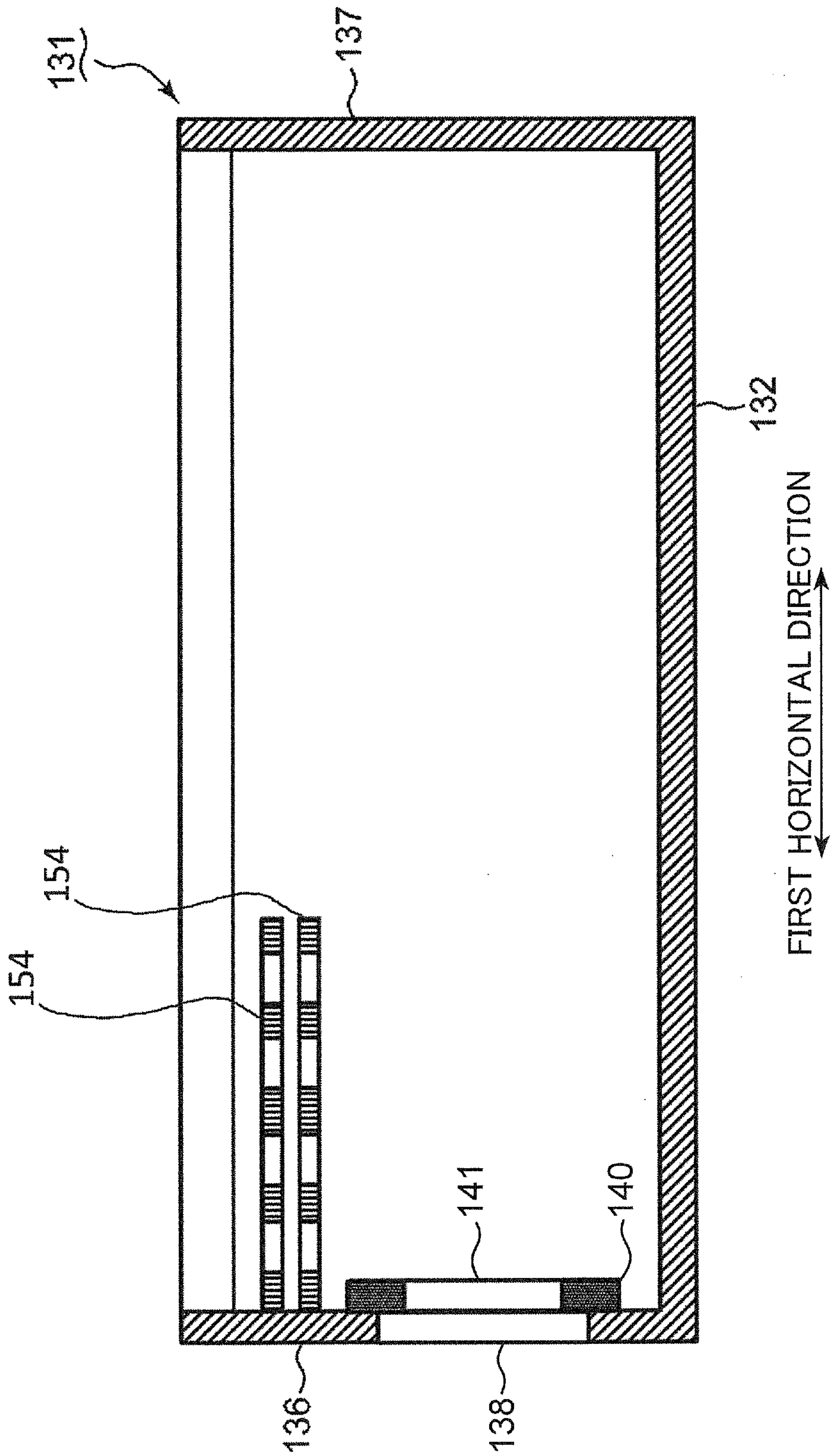
FIG. 19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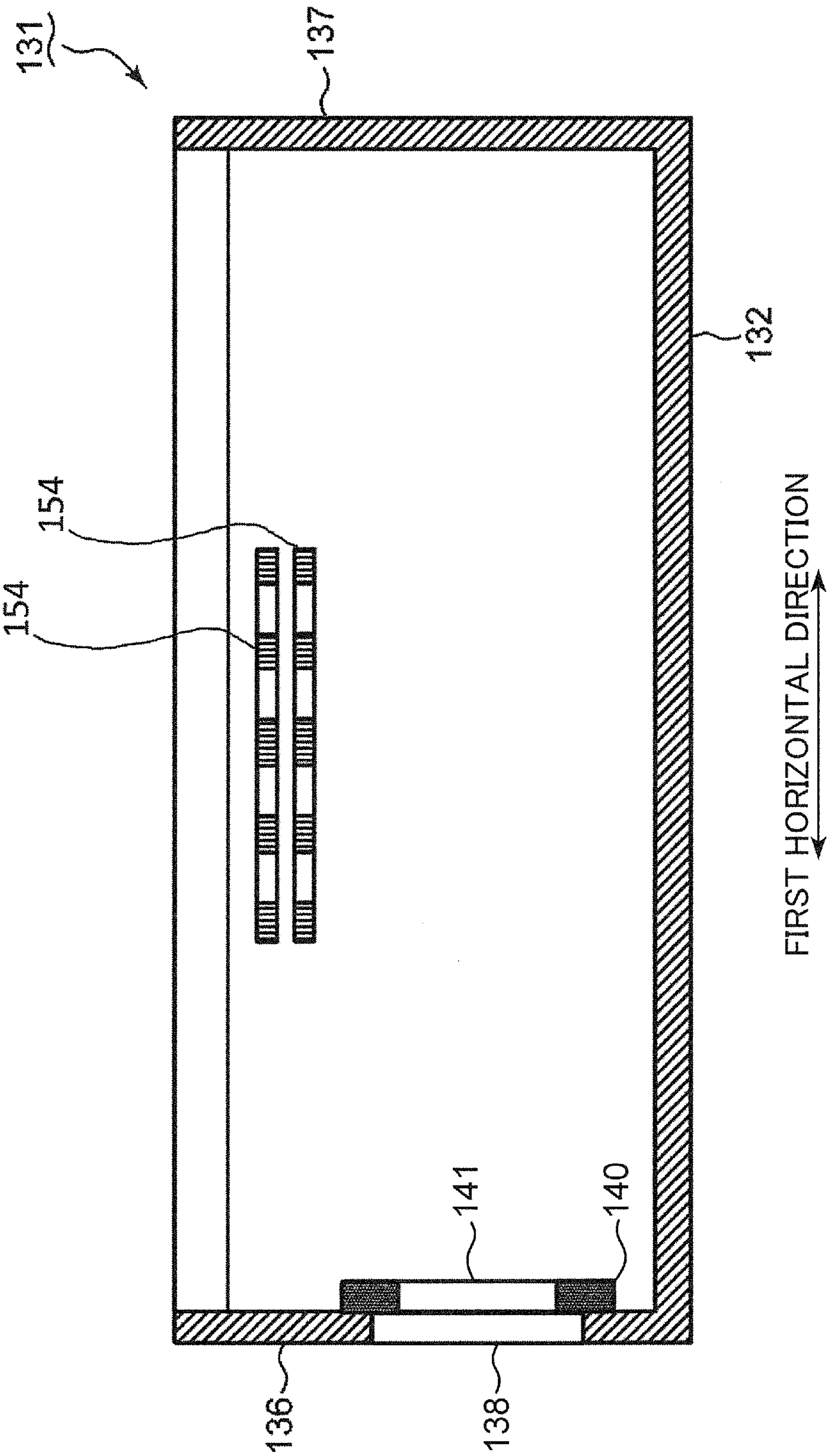
FIRST HORIZONTAL DIRECTION

FIG. 20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FIRST HORIZONTAL DIRECTION

FIG. 21

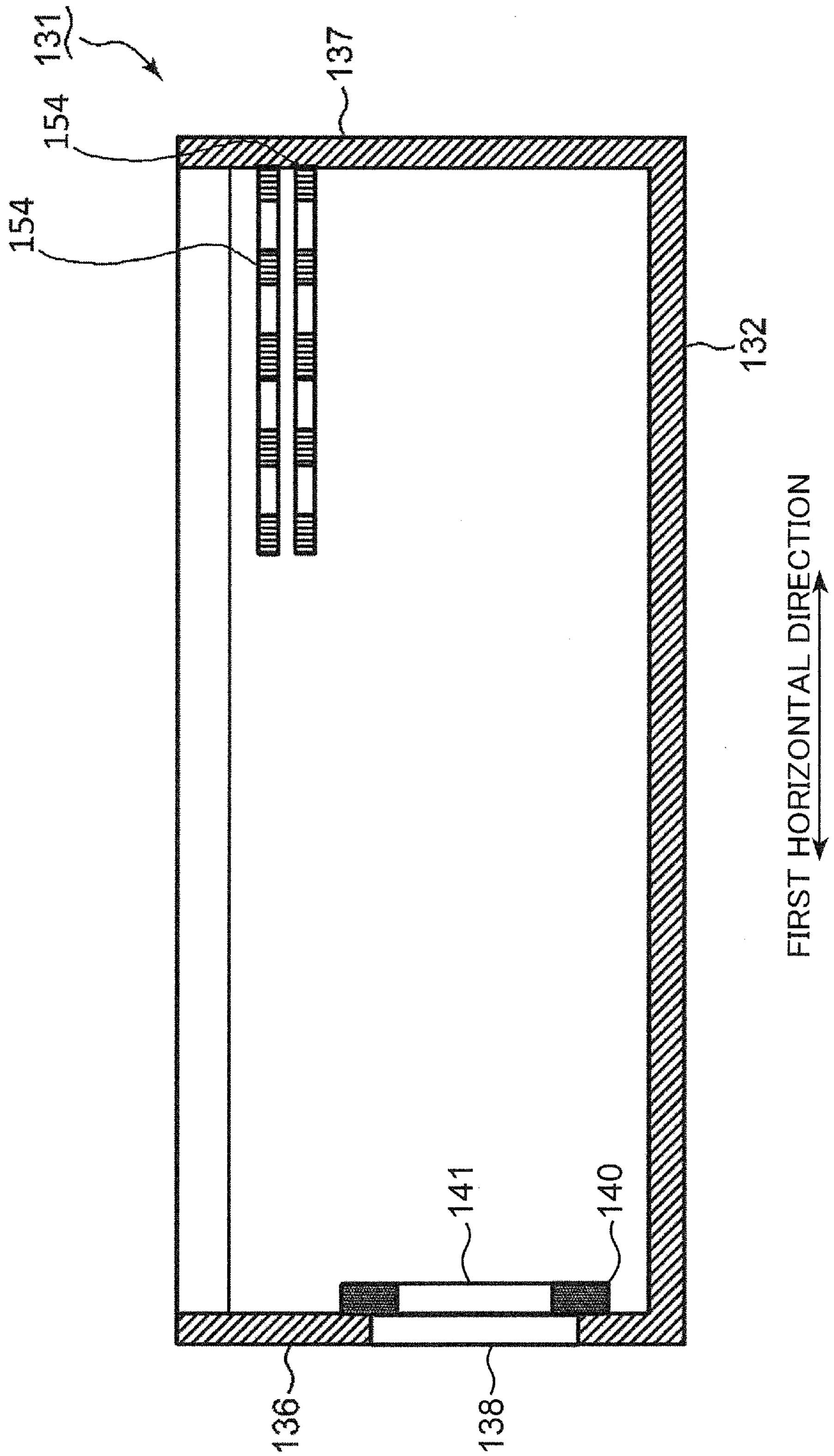
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FIG. 22

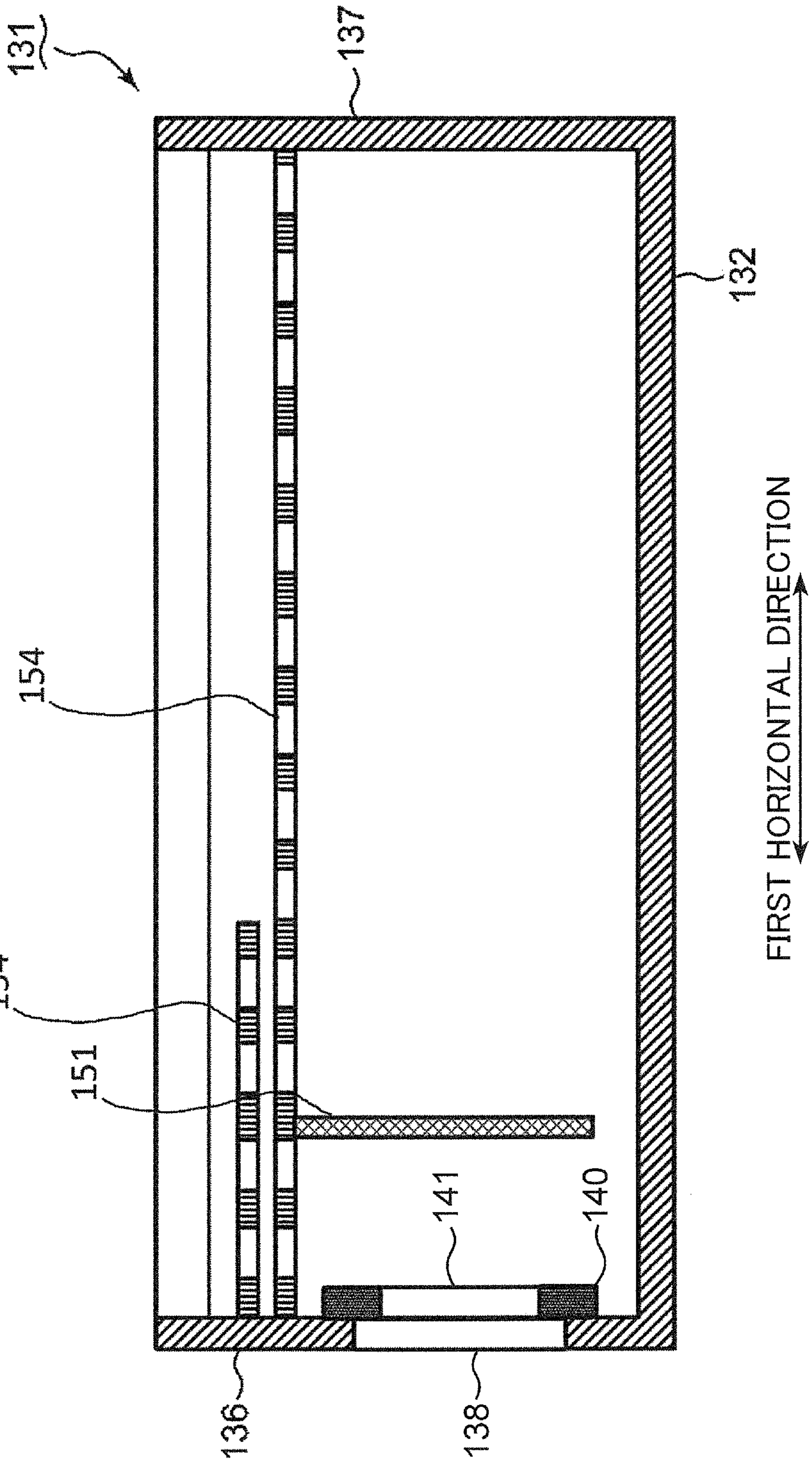
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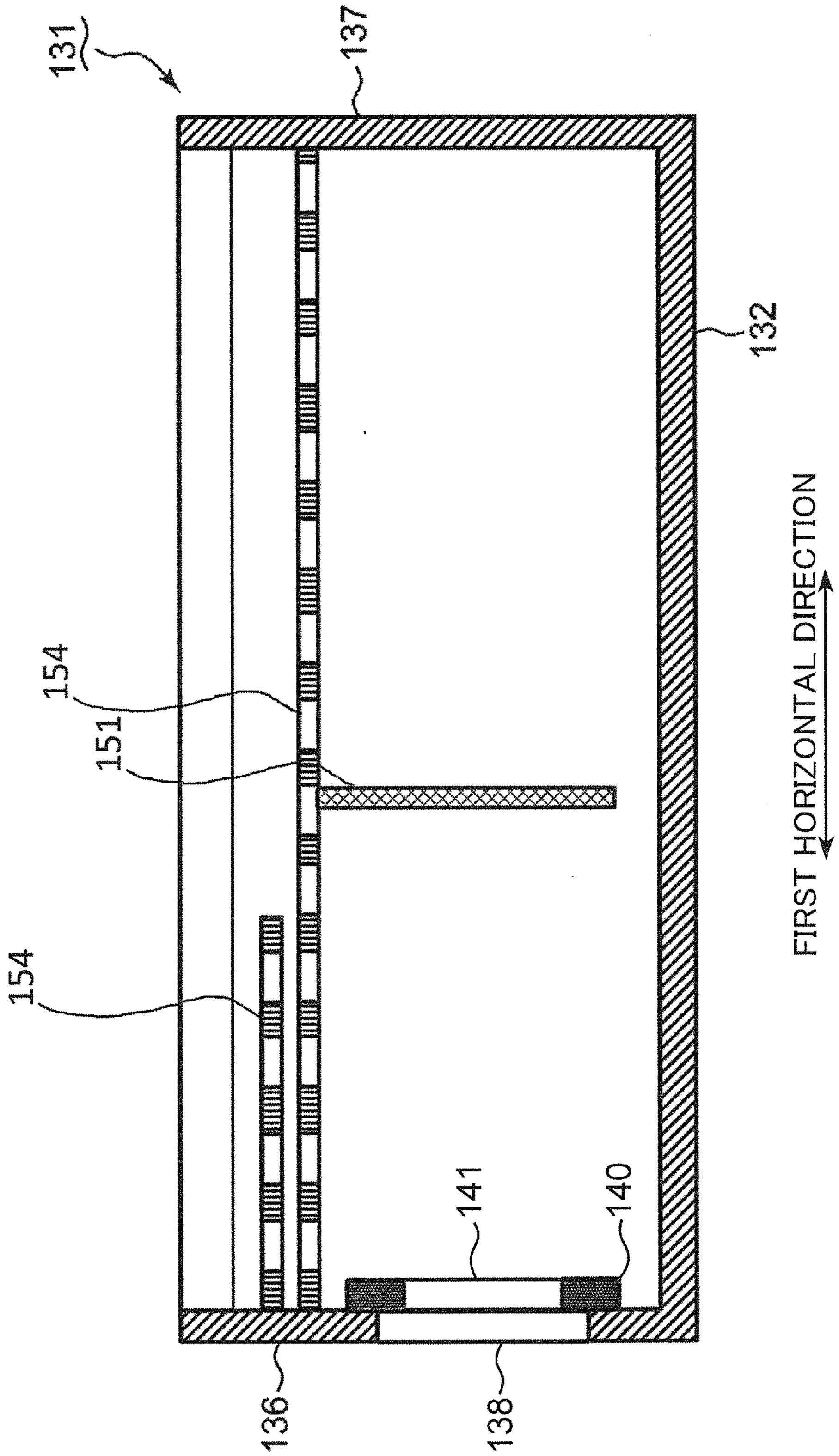
FIG. 23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FIRST HORIZONTAL DIRECTION

FIG. 24

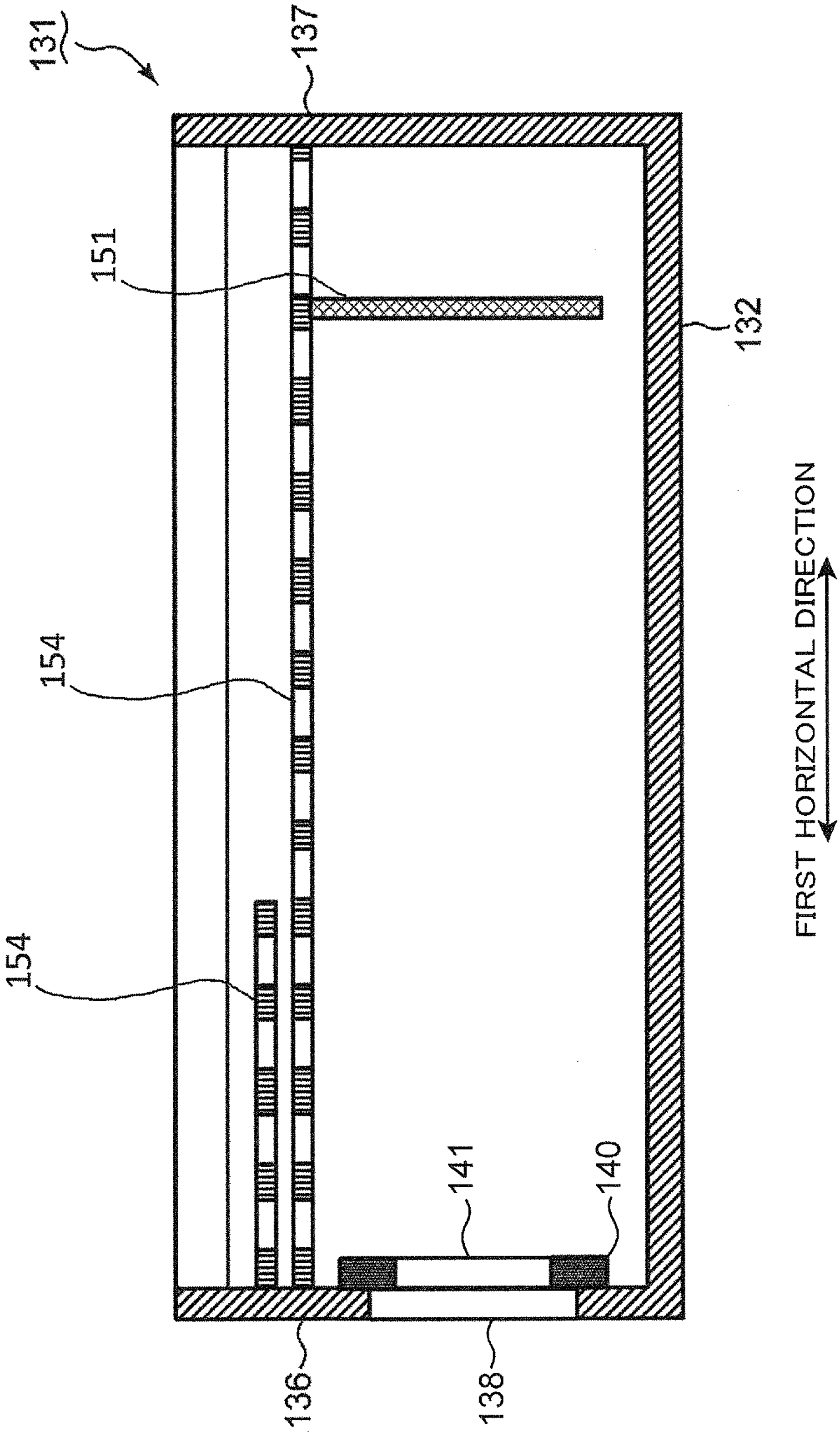
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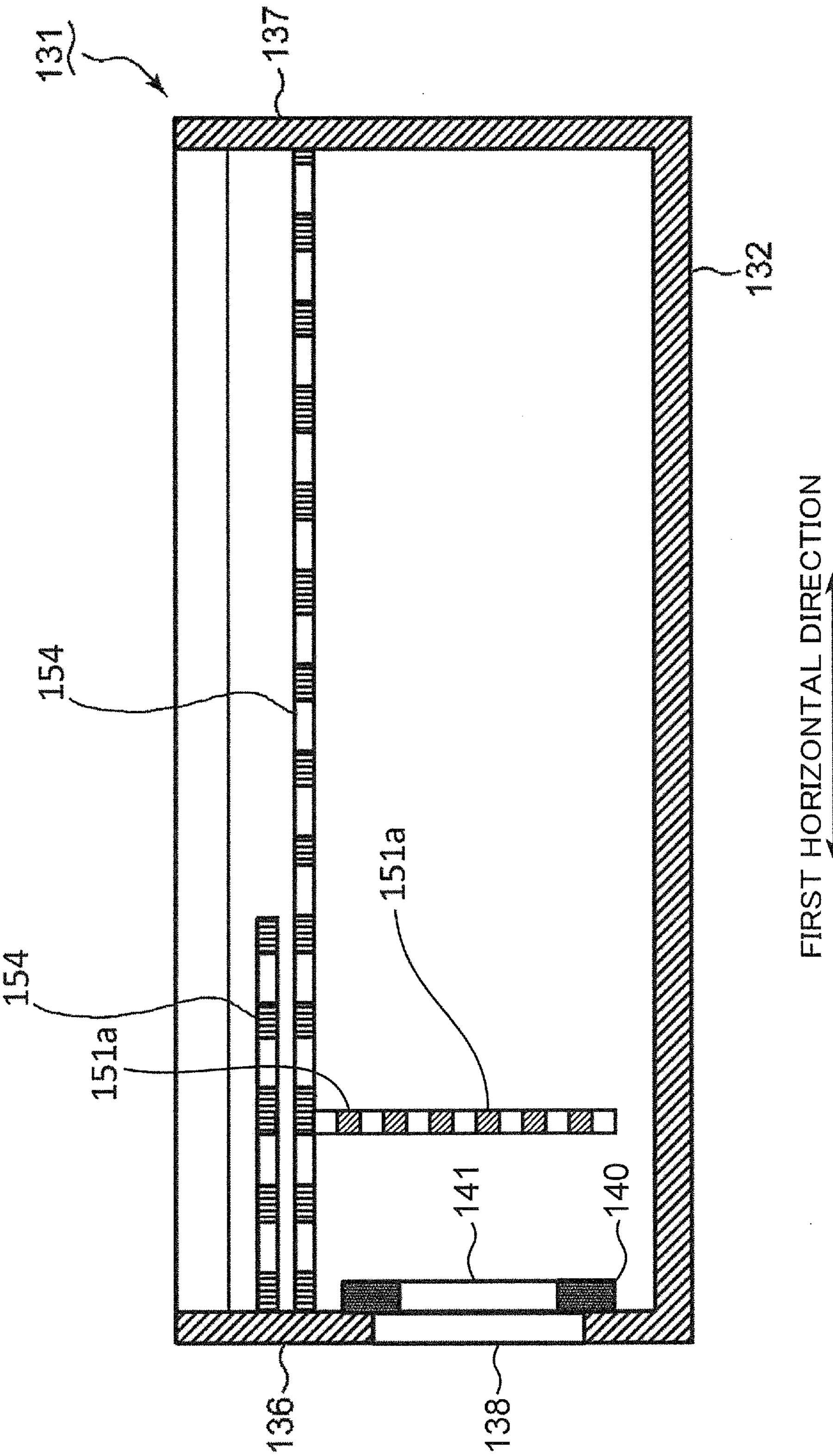
FIG. 25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FIRST HORIZONTAL DIRECTION

FIG. 26

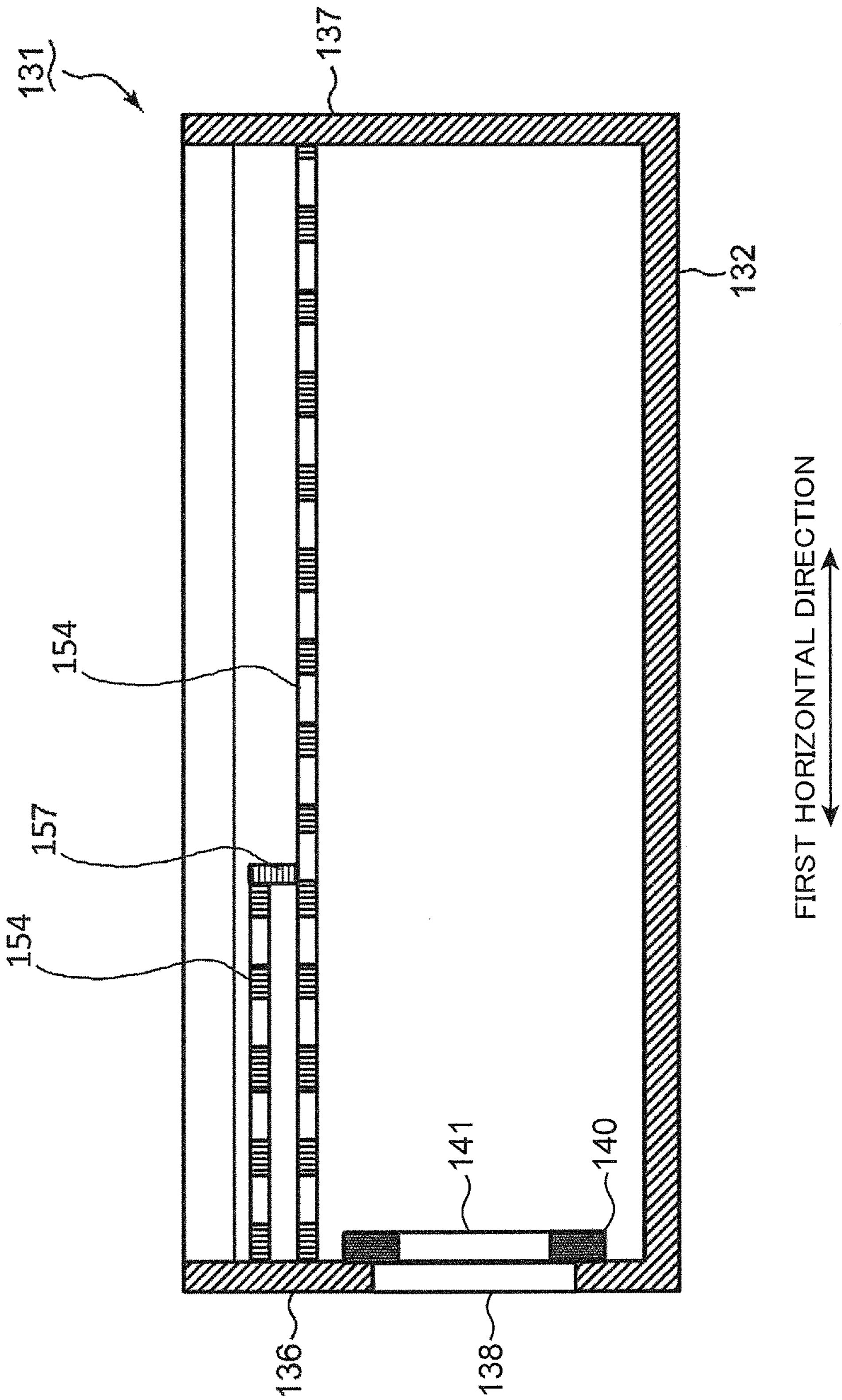
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FIG. 27

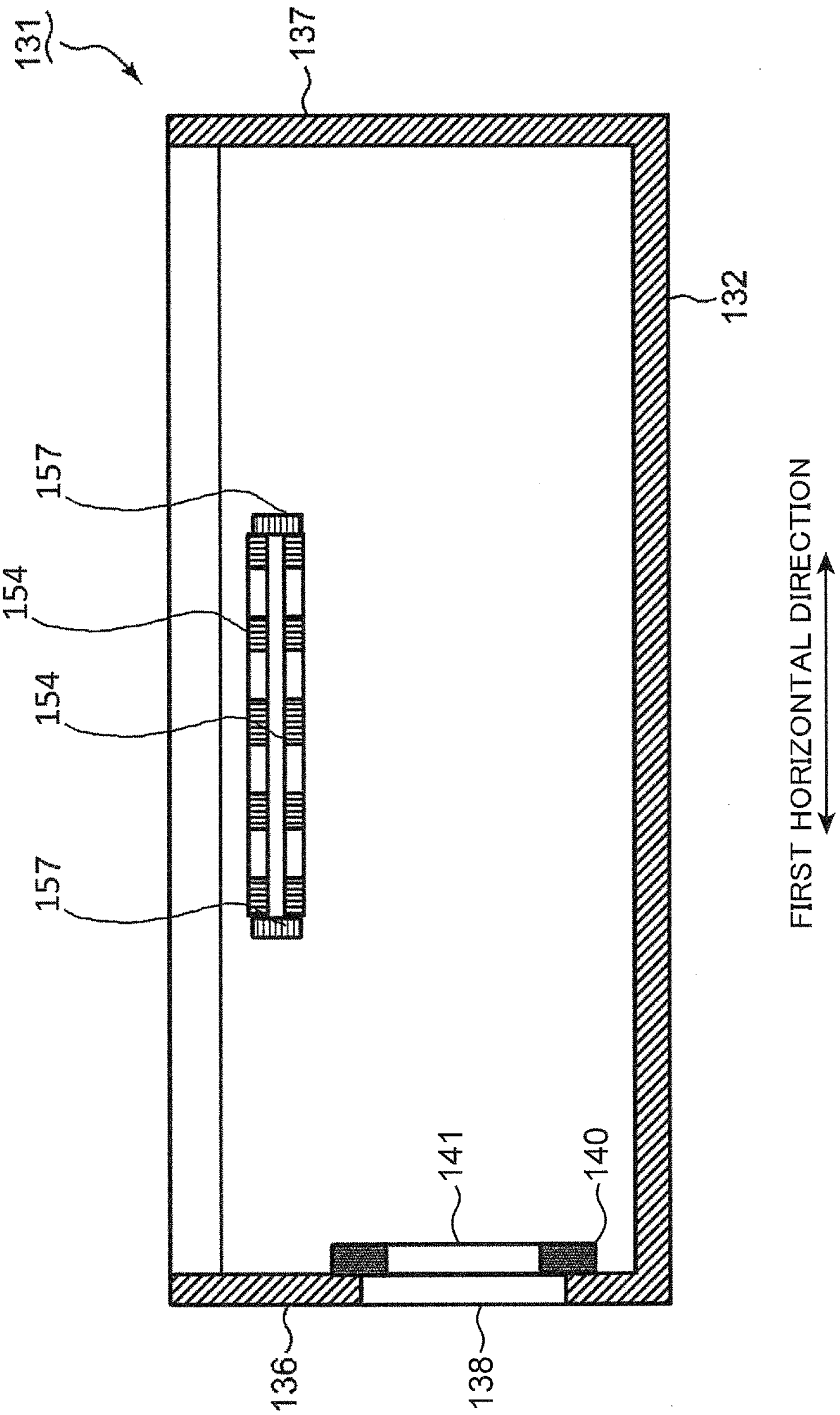
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FIG. 28

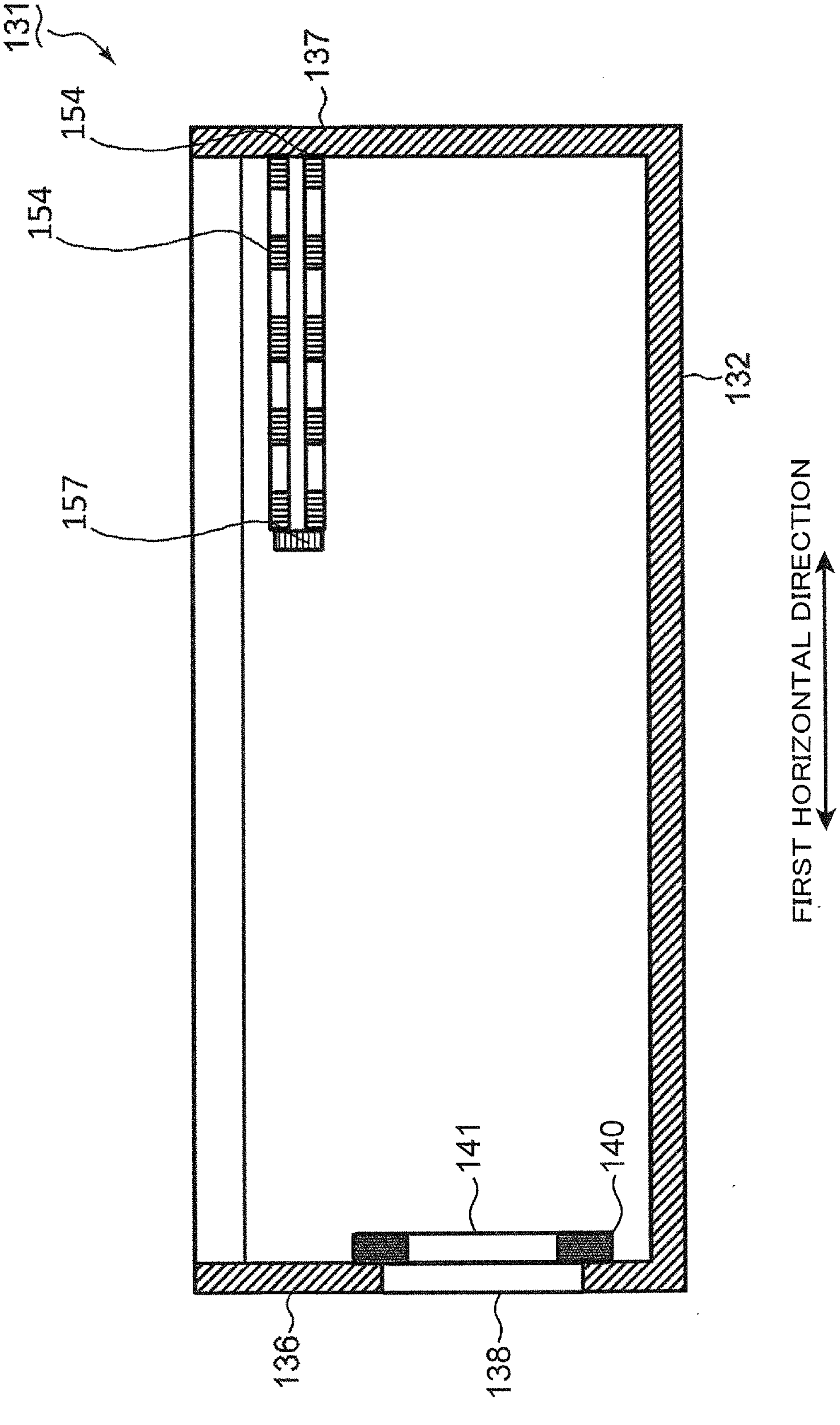
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FIG. 29

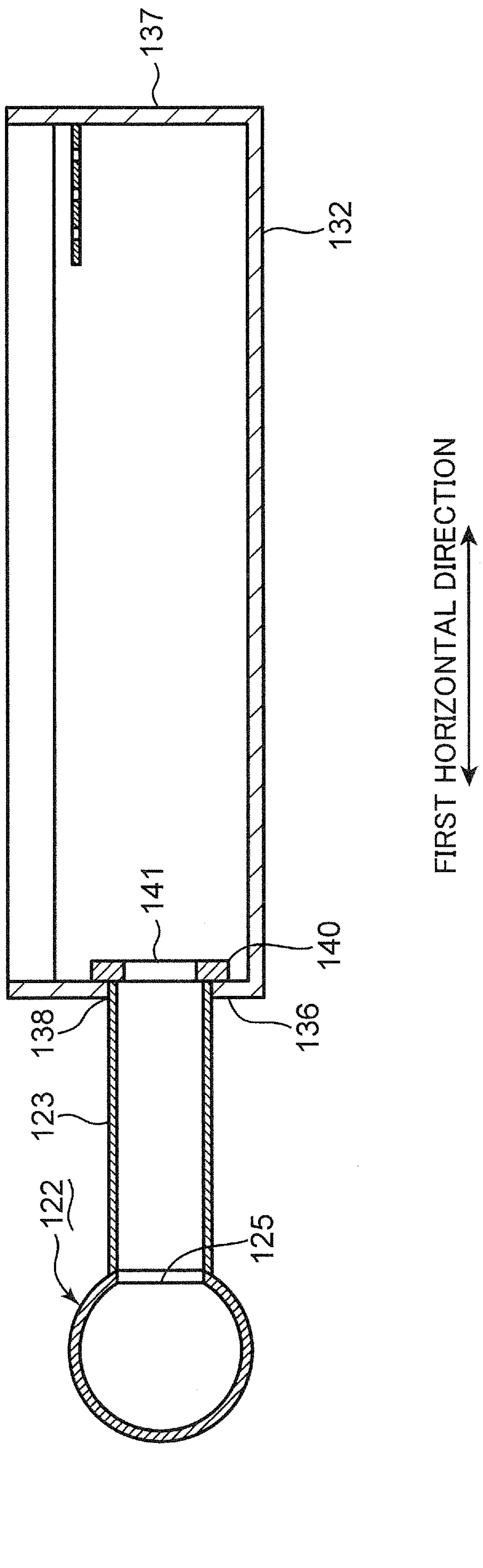
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FIG. 30

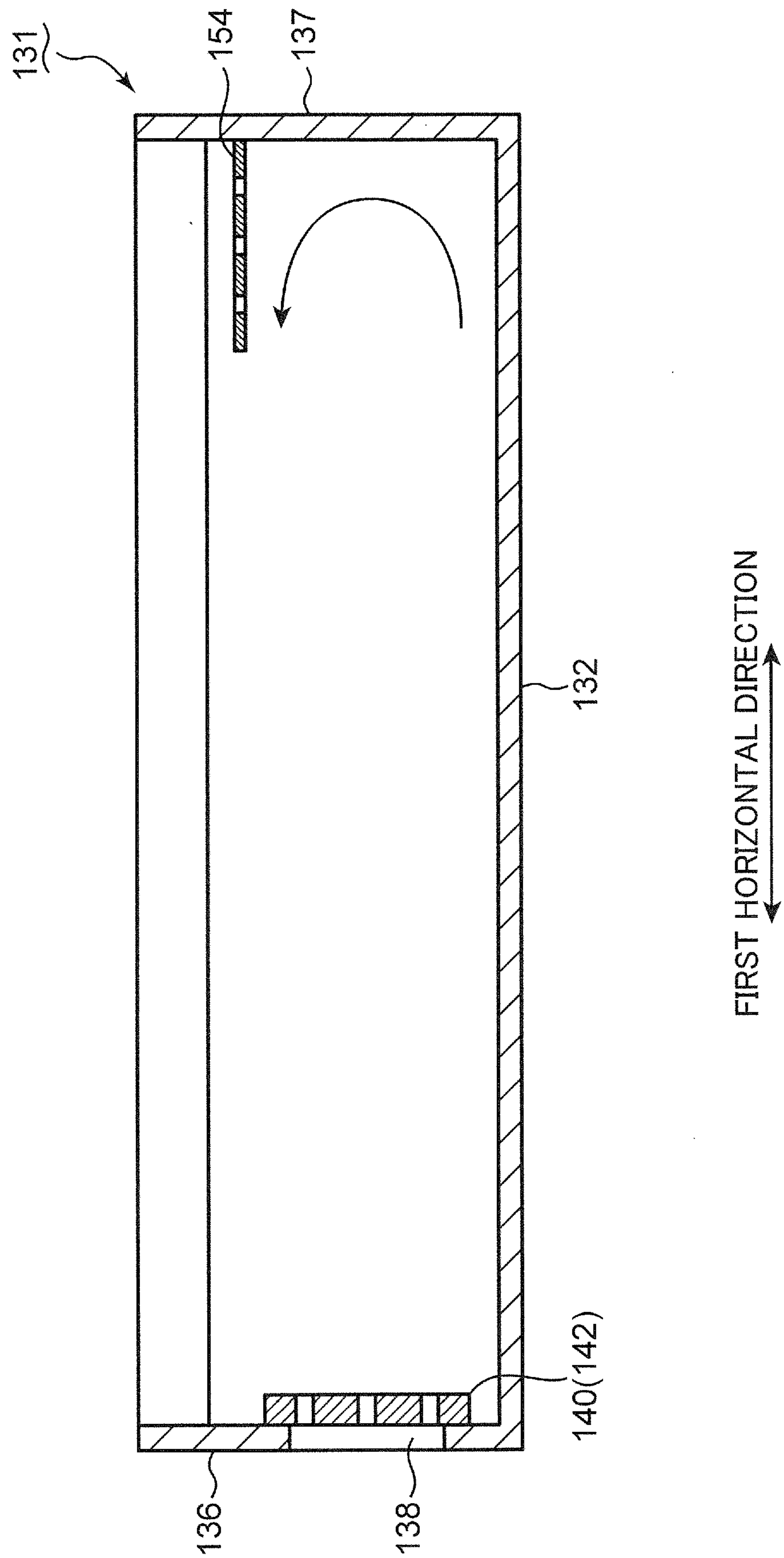

FIG. 31

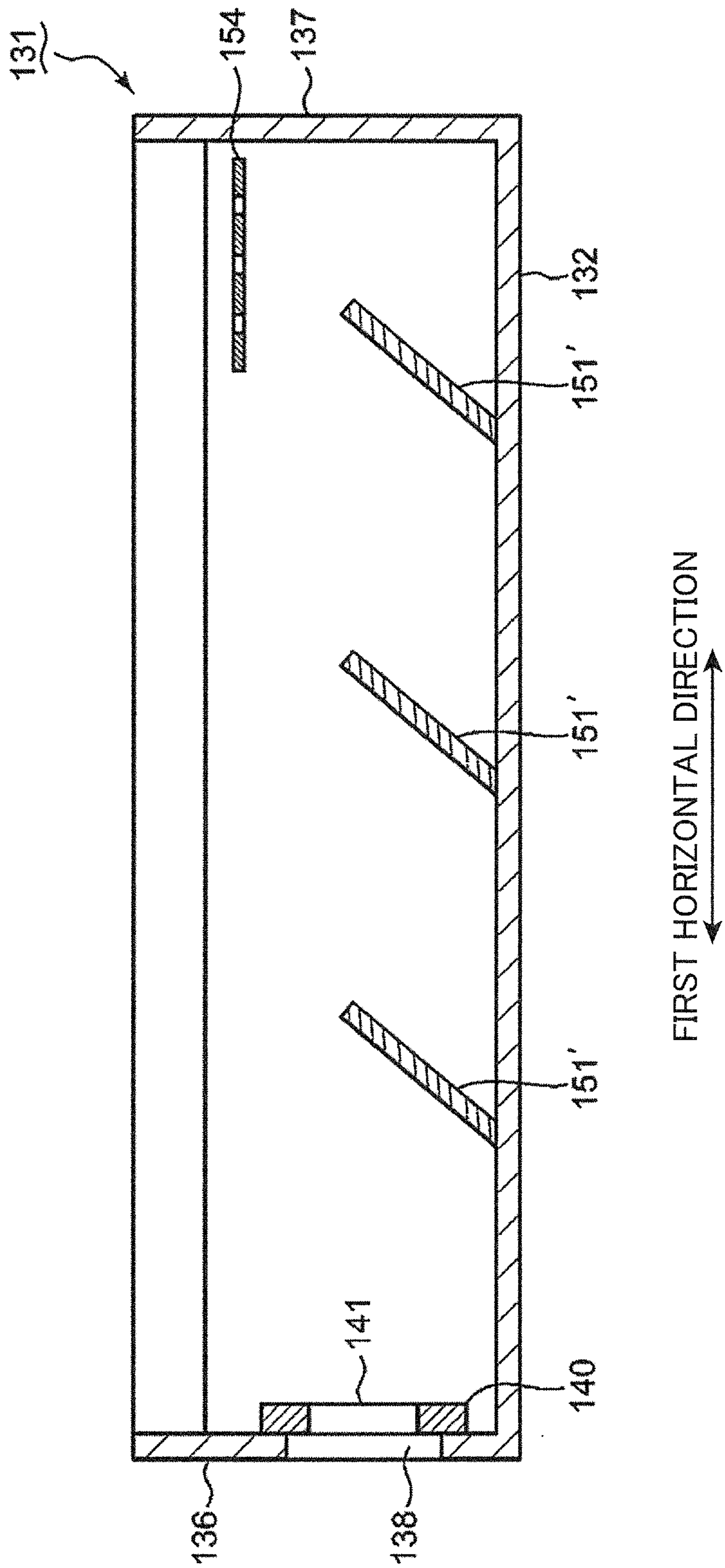
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FIG. 32

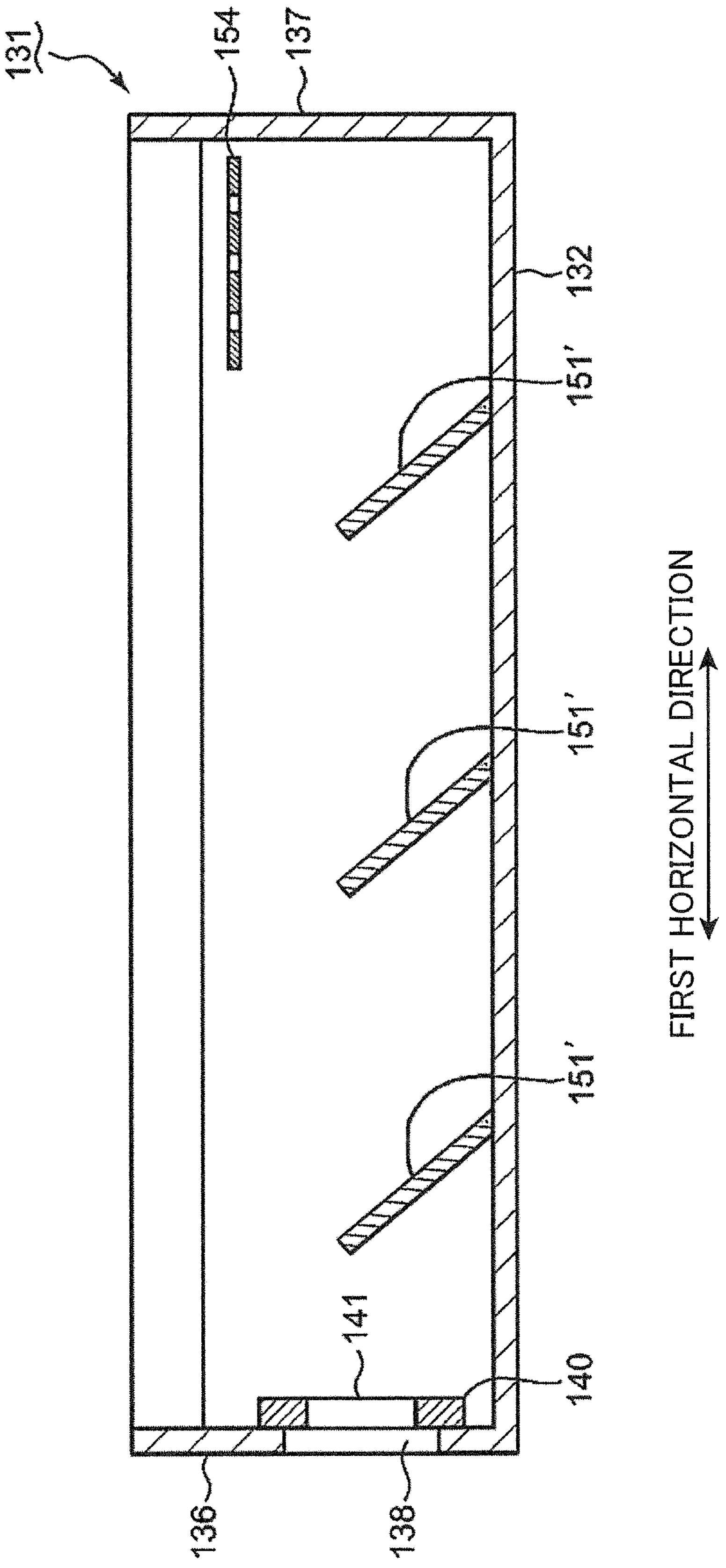
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FIG. 33

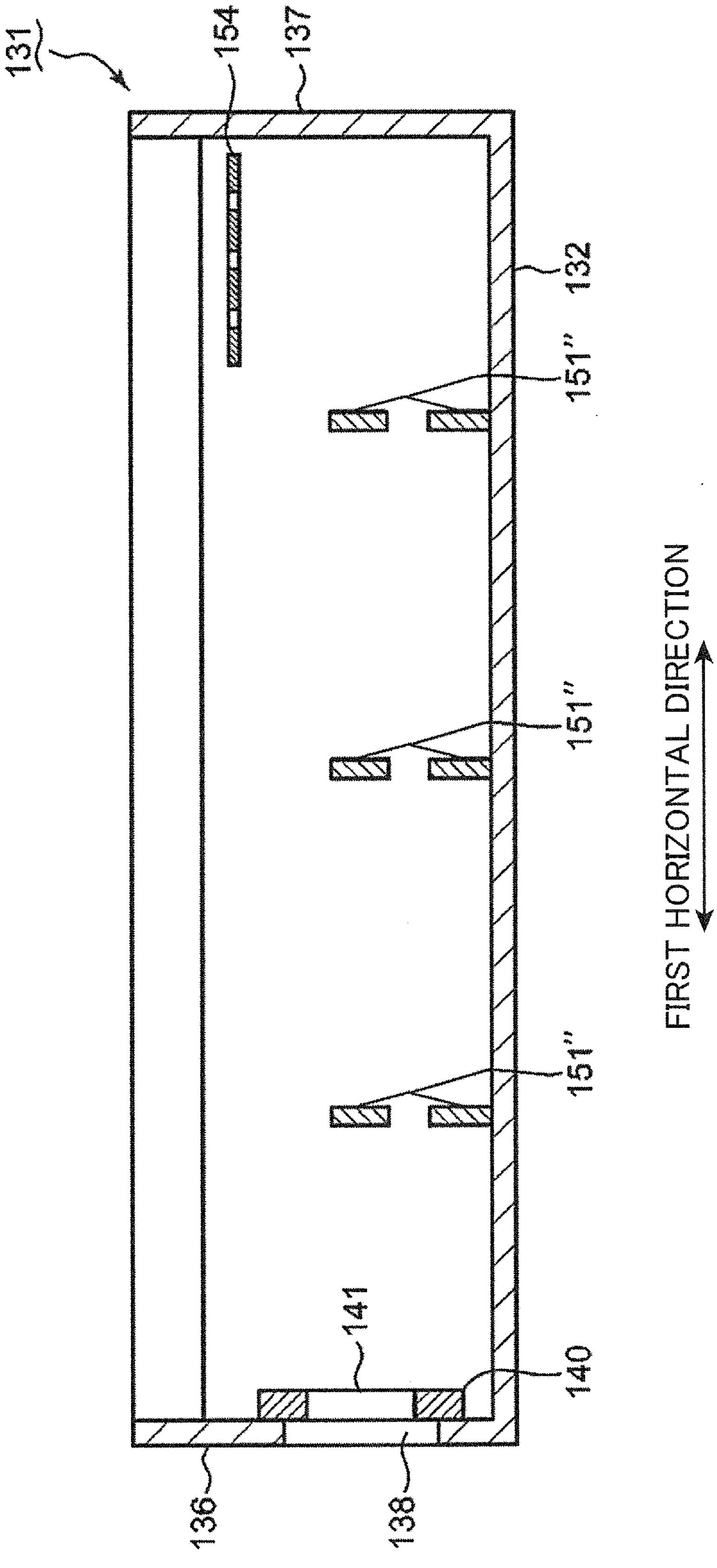
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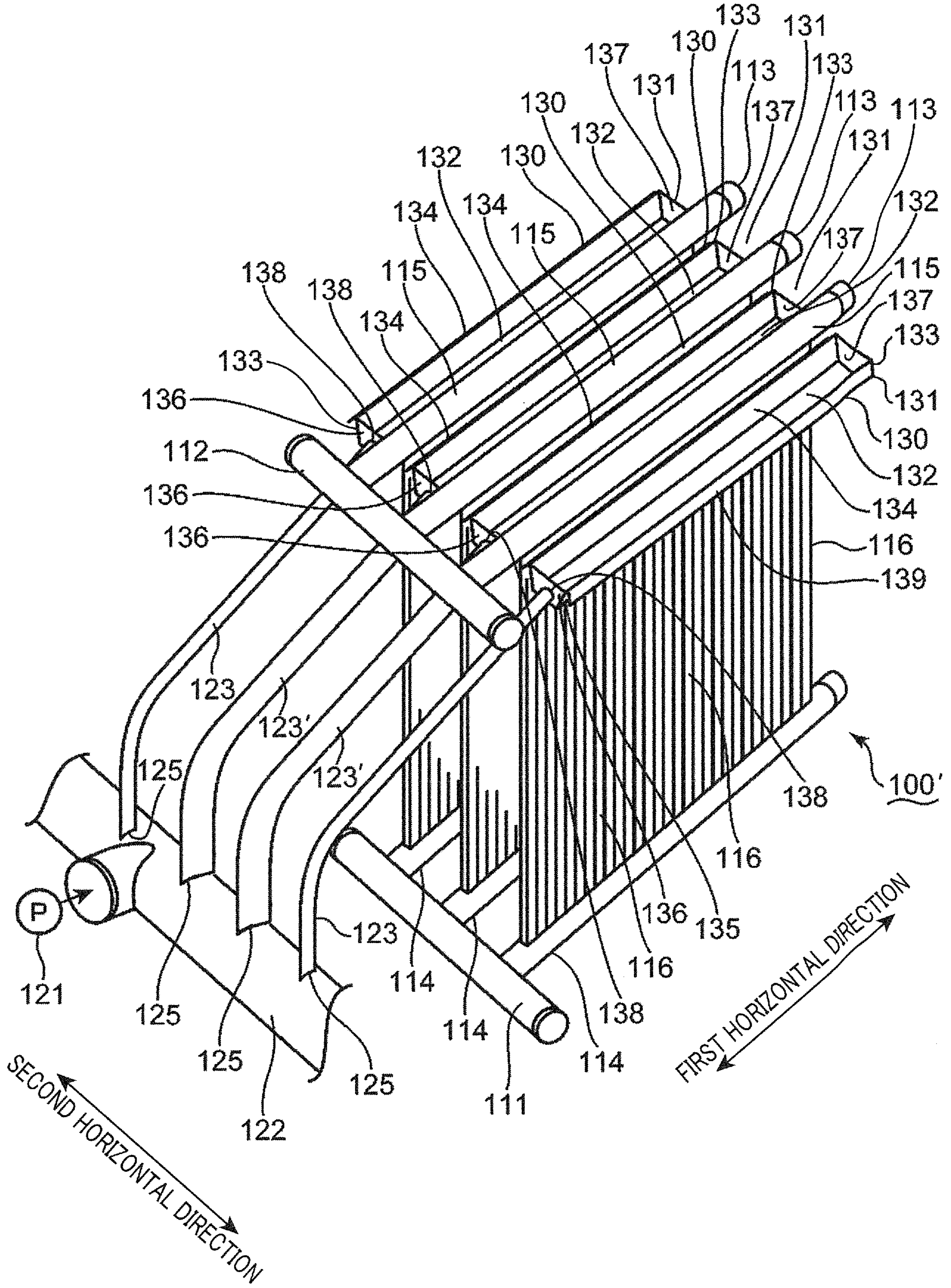
FIG. 34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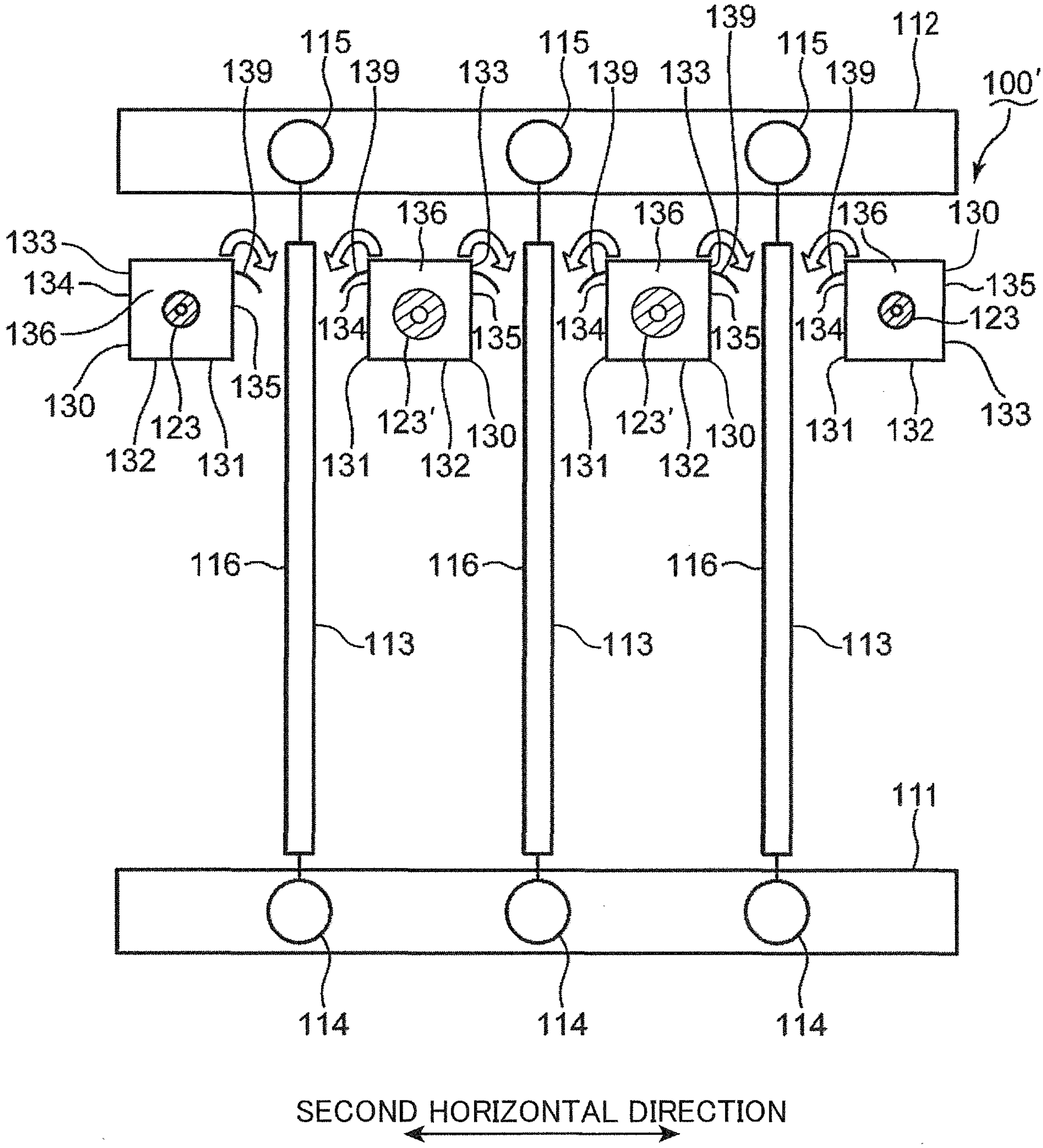
SECOND HORIZONTAL DIRECTION

FIG. 35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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/037842

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)	1-5, 7-10, 13-14 6, 11-12, 15-18
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	1-5, 7-10, 13-14 6, 11-12, 15-18
Y A	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)	13-14 1-12, 15-18

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08.11.2019	19.11.2019

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

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/037842

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	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)	1-18
A	JP 7-75087 A (TOKYO GAS CO., LTD.) 17 March 1995, paragraphs [0001]-[0024], fig. 1-8 (Family: none)	1-18

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2017150784 A **[0006]**