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(54) **VAPOR CHAMBER DEVICE**

(57) A vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) includes a first casing (110, 110e, 110f, 110h), a first capillary structure (130), and a second casing (120, 120a, 120b, 120c, 120h). The first casing (110, 110e, 110f, 110h) includes a first plate portion (111), multiple first protrusions (117a, 117d, 117e, 117f), and a first side wall (117). The first capillary structure (130) is disposed above an inner surface (1112) of the first plate portion (111) and surrounds the first protrusions (117a, 117d, 117e, 117f). The second casing (120, 120a, 120b, 120c, 120h) is stacked on the first casing (110, 110e, 110f, 110h), and the second casing (120, 120a, 120b, 120c, 120h) includes a second plate portion (121), multiple second protrusions (122, 122a, 122b), and a second side wall (128). The first side wall (117) is connected to the second side wall (128), and multiple steam passages (124) are formed between the second protrusions (122, 122a, 122b). The second plate portion (121) includes multiple connecting regions (129) yielded by the second protrusions (122, 122a, 122b), and the first protrusions (117a, 117d, 117e, 117f) are connected to the connecting regions (129). The second protrusions (122, 122a, 122b) rest against the first capillary structure (130).

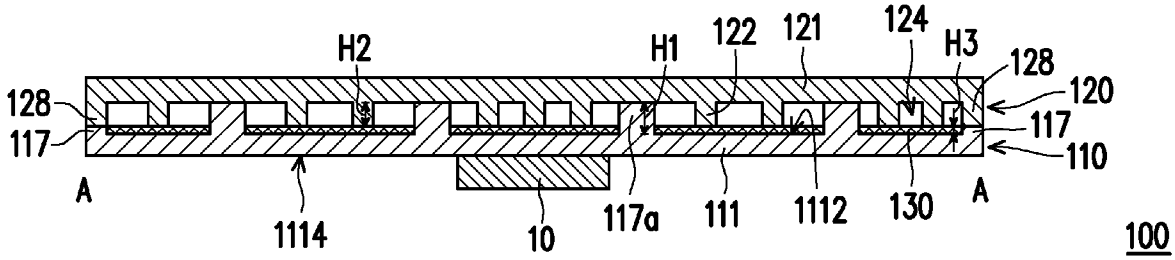

FIG. 1B

Description

BACKGROUND

Technical Field

[0001] This disclosure relates to a vapor chamber device, in particular to a vapor chamber device not easily deformed.

Description of Related Art

[0002] A vapor chamber is a common heat dissipation device. The vapor chamber mainly includes a flat closed casing, a capillary structure formed in the flat closed casing, and a working fluid filled inside the flat closed casing. The flat closed casing is exposed to a heat source, such as a central processing unit (CPU), and the heat source is dissipated by the vapor-liquid phase change of the working fluid inside the vapor chamber. When the heat source is in operation, the working fluid inside the vapor chamber is heated and expands, which may cause the pressure inside the flat closed casing greater than 1 atmosphere, and may cause the casing of the vapor chamber to deform.

SUMMARY

[0003] The disclosure provides a vapor chamber device, which has good structural strength, is not easily deformed, and is easy to manufacture when sealing an upper plate and a lower plate because the vapor chamber device does not require precise alignment.

[0004] A vapor chamber device of the disclosure is adapted to be thermally coupled to a heat source. The vapor chamber device includes a first casing, a first capillary structure, and a second casing. The first casing includes a first plate portion, multiple first protrusions protruding from an inner surface of the first plate portion, and a first side wall protruding from the inner surface and surrounding the first protrusions. The heat source is adapted to contact an outer surface of the first plate portion. The first capillary structure is disposed above the inner surface of the first plate portion and surrounds the first protrusions. The second casing is stacked on the first casing, and the second casing includes a second plate portion, multiple second protrusions protruding from the second plate portion, and a second side wall protruding from the second plate portion and surrounding the second protrusions. The first side wall is connected to the second side wall, multiple steam passages are formed between the second protrusions, the second plate portion includes multiple connecting regions yielded by the second protrusions, the first protrusions are connected to the connecting regions, and the second protrusions rest against the first capillary structure.

[0005] In an embodiment of the disclosure, a number of the second protrusions is greater than a number of the first protrusions, and a size of the first protrusion is greater than a size of the second protrusion.

[0006] In an embodiment of the disclosure, a difference value between a height of the first protrusion protruding from the first plate portion and a height of the second protrusion protruding from the second plate portion is a height of a capillary layer.

[0007] In an embodiment of the disclosure, each of the first protrusions is columnar or strip-shaped, and the first protrusions are evenly distributed on the inner surface.

[0008] In an embodiment of the disclosure, the second protrusions include multiple first support columns and multiple second support columns, a shape of the first support columns is different from a shape of the second support columns, the first support columns are disposed at positions corresponding to the heat source, and the second support columns are located next to the first support columns and extend in an axial direction.

[0009] In an embodiment of the disclosure, a part of the second protrusions is disposed at a position corresponding to the heat source, and the other part of the second protrusions is arranged radially around the part.

[0010] In an embodiment of the disclosure, the first capillary structure is a mesh structure woven by multiple wires, a non-woven mesh structure, or a metal foam layer, and sintered metal powder, and the first capillary structure includes multiple holes.

[0011] In an embodiment of the disclosure, the first casing includes a second capillary structure protruding integrally from the inner surface of the first plate portion, the second capillary structure includes multiple grooves formed between multiple convex bars to serve as fluid channels, and the first capillary structure is disposed between the second capillary structure and the second protrusions of the second casing.

[0012] In an embodiment of the disclosure, at least a part of the grooves are radially arranged.

[0013] In an embodiment of the disclosure, the first protrusions and at least a part of the convex bars are radially arranged.

[0014] In an embodiment of the disclosure, the vapor chamber device further includes a third capillary structure filled in the grooves in regions corresponding to the heat source, and the third capillary structure includes metal powder, non-woven metal wool, or chemically produced nanostructures.

[0015] In an embodiment of the disclosure, the vapor chamber device further includes multiple extended capillary layers extending from the first capillary structure and integrated with the first capillary structure, and the extended capillary layers surround the first protrusions.

[0016] In an embodiment of the disclosure, one of the first side wall and the second side wall includes a ring-shaped convex bar, the ring-shaped convex bar surrounds corresponding first protrusions or second protrusions, and the other one of the first side wall and the second side wall includes a ring-shaped groove surrounding corresponding first protrusions or second protrusions, and the ring-shaped convex bar is embedded in the ring-shaped groove.

[0017] In an embodiment of the disclosure, the first side wall and the second side wall have a sealing region at edges, the sealing region seals the edges of the first side wall and the second side wall by pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding, and the sealing region surrounds or covers the ring-shaped convex bar and the ring-shaped groove.

[0018] In an embodiment of the disclosure, the first side wall and the second side wall have a sealing region at edges, and the sealing region seals the edges of the first side wall and the second side wall by pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding.

[0019] In an embodiment of the disclosure, a material of the first casing and the second casing includes aluminum or aluminum alloy.

[0020] Based on the above, the first side wall of the vapor chamber device of the disclosure is connected to the second side wall, and the first protrusions of the first casing are connected to the connecting regions of the second plate portion to increase the structural strength of the first casing and second casing and avoid expansion and deformation due to the increase of internal pressure during operation. In cold working, the first protrusions may be connected to the second plate portion by applying resistance welding to an upper outer wall and a lower outer wall of a vapor chamber in the connecting region of the first protrusion and the second plate portion; in hot working, the first protrusion may be connected to the second plate portion by a diffusion connecting process in a high temperature furnace. In addition, since the first protrusions and the second protrusions are staggered from each other, there is no need for precise alignment between the first casing and the second casing, and even if there is any offset between the first casing and the second casing during the manufacturing process, there is no effect on the connection between the first protrusion and the connecting regions of the second plate portion, and the process is convenient. Furthermore, the first capillary structure is disposed above the inner surface of the first plate portion, and the second protrusions of the second casing rest against the first capillary structure, which may avoid collapse and deformation due to the low pressure of the vacuum inside the vapor chamber device. Therefore, the vapor chamber device of the disclosure may have better structural strength and is easy to manufacture.

[0021] To make the aforementioned more comprehensive, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

FIG. 1A is a schematic view of an appearance of a vapor chamber device according to an embodiment of the disclosure.

FIG. 1B is a schematic cross-sectional view of the vapor chamber device in FIG. 1A along a line A-A.

FIG. 1C is a schematic top view of a first casing of the vapor chamber device in FIG. 1A.

FIG. 1D is a schematic view of an inner surface of a second casing of the vapor chamber device in FIG. 1A.

FIG. 1E to FIG. 1G are schematic views of inner surfaces of the second casings of various vapor chamber devices according to other embodiments of the disclosure.

FIG. 2 is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure.

FIG. 3A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure.

FIG. 3B is a schematic top view of a first casing of the vapor chamber device in FIG. 3A.

FIG. 3C is a schematic view of an inner surface of a first casing of a vapor chamber device according to another embodiment of the disclosure.

FIG. 4A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure.

FIG. 4B is a schematic top view of a first casing of the vapor chamber device in FIG. 4A.

FIG. 5A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure.

FIG. 5B is a schematic top view of a first casing of the vapor chamber device in FIG. 5A.

FIG. 5C is a schematic view of an inner surface of a second casing of the vapor chamber device of FIG. 5A.

FIG. 6 is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0023] FIG. 1A is a schematic view of an appearance of a vapor chamber device according to an embodiment of the disclosure. FIG. 1B is a schematic cross-sectional view of the vapor chamber device in FIG. 1A along a line A-A. FIG. 1C is a schematic top view of a first casing of the vapor chamber device in FIG. 1A. FIG. 1D is a schematic view of an inner surface of a second casing of the vapor chamber device in FIG. 1A.

[0024] Referring to FIG. 1A to FIG. 1D, an appearance shape of a vapor chamber device 100 in this embodiment is, for example, a rectangular plate shape, but the appearance shape of the vapor chamber device 100 may be any shape, not limited by the drawings. The vapor chamber device 100 is adapted to be thermally coupled to a heat source 10 (FIG. 1B). The heat source 10 is, for example, a central processing unit of a motherboard, but the heat source 10 may also be other chips, and the type and number of the heat source 10 are not limited thereto.

[0025] As shown in FIG. 1B, the vapor chamber device 100 of this embodiment includes a first casing 110, a first capillary structure 130, and a second casing 120. A material of the first casing 110 and the second casing 120 is metal, such as aluminum or aluminum alloy, but it is not limited thereto. In other embodiments, the material of the first casing 110 and the second casing 120 may also include other metals such as copper or copper alloy.

[0026] The first casing 110 includes a first plate portion 111, multiple first protrusions 117a protruding from an inner surface 1112 of the first plate portion 111, and a first side wall 117 protruding from the inner surface 1112 and surrounding the first protrusions 117a. The heat source 10 is adapted to contact an outer surface 1114 of the first plate portion 111, and heat energy generated by the heat source 10 is transferred to the vapor chamber device 100.

[0027] As can be seen from FIG. 1B and FIG. 1C, in this embodiment, the first protrusion 117a is columnar, and the first protrusions 117a are evenly distributed on the inner surface 1112. Of course, in other embodiments, the first protrusion 117a may also be strip-shaped, and the first protrusions 117a may also be unevenly distributed, and the shape and distribution of the first protrusions 117a are not limited thereto. In the embodiment shown in FIG. 1B and FIG. 1C, although the first protrusions 117a are not placed in an evaporation zone corresponding to the heat source 10, the first protrusions 117a may be partially placed in the evaporation zone corresponding to the heat source 10, and second protrusions 122 are partially removed from positions corresponding to the first protrusions 117a on a second plate portion 121 to form connecting regions 129.

[0028] In this embodiment, the first plate portion 111 and the first protrusions 117a are integrally formed, and such a design may have a simpler structure. Moreover, since there is no thermal contact resistance between the first plate portion 111 and the first protrusions 117a, the heat transfer effect is better. The first plate portion 111 and the first protrusions 117a are made, for example, by stamping, chemical etching, extruding, forging, or die-casting processes, but not limited thereto.

[0029] The first capillary structure 130 is disposed on the inner surface 1112 of the first plate portion 111 and surrounds the first protrusions 117a. In this embodiment, the first capillary structure 130 is a mesh structure woven by multiple wires, for example, a metal mesh such as a copper or aluminum mesh. Of course, in other embodiments, the first capillary structure 130 may also be a non-woven mesh, or a porous foamed metal-type capillary structure. The first capillary structure 130 may also be sintered metal powder capillary, and the form of the first capillary structure 130 is not limited thereto. Since the first capillary structure 130 includes multiple holes, capillary force may be provided within the holes.

[0030] The second casing 120 is stacked on the first casing 110. The second casing 120 includes a second plate portion 121, multiple second protrusions 122 protruding from the second plate portion 121, and a second side wall 128 protruding from the second plate portion 121 and surrounding the second protrusions 122. In this embodiment, the second protrusions 122 are equal in height and flush with the second side wall 128, but the relationship between the second protrusions 122 and the second side wall 128 is not limited thereto.

[0031] The first side wall 117 is connected to the second side wall 128. In this embodiment, the first side wall 117 and the second side wall 128 may be connected by pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding to achieve a sealing effect.

[0032] In order to increase a structural strength of the vapor chamber device 100, the vapor chamber device 100 of this embodiment is deliberately provided with the first protrusions 117a in a region within the first side wall 117 of the first casing 110. In addition, as shown in FIG. 1D, the second plate portion 121 includes multiple connecting regions 129 yielded by the second protrusions 122. When the first side wall 117 is connected to the second side wall 128, the first protrusions 117a are connected to the connecting regions 129 of the second plate portion 121. The first protrusions 117a may be connected to the second plate portion 121 by applying resistance welding to the first protrusions 117a and the connecting regions 129 of the second plate portion 121 in cold working; and may be connected by diffusion bonding in hot working to enhance connectivity between the first casing 110 and the second casing 120 to achieve sufficient antiexpansion characteristics.

[0033] In this embodiment, since the first protrusions 117a and the second protrusions 122 are staggered from each other, there is no need for precise alignment between the first casing 110 and the second casing 120, and even if there is any offset between the first casing 110 and the second casing 120 during the manufacturing process, there is no effect on the connection between the first protrusion 117a and the connecting regions 129 of the second plate portion 121, and the process is convenient. In addition, the first protrusions 117a can be directly connected to the second plate portion 121, making it easy to maintain a connection strength of the first casing 110 and the second casing 120.

[0034] In addition, as shown in FIG. 1B, the second protrusions 122 rest against the first capillary structure 130, and help to fix a distance between the first plate portion 111 and the second plate portion 121, which may ensure flatness of the first capillary structure 130 and avoid collapse and deformation of the vapor chamber device 100 due to a change of internal pressure, and may effectively increase the service life of the vapor chamber device 100. In this embodiment, a difference value between a height H1 of the first protrusion 117a protruding from the first plate portion 111 and a height H2 of the second protrusion 122 protruding from the second plate portion 121 is a height H3 of a capillary layer.

[0035] As shown in FIG. 1B to FIG. 1D, in this embodiment, a number of the second protrusions 122 is greater than a number of the first protrusions 117a. Multiple steam passages 124 are formed between the second protrusions 122. The second protrusion 122 is used as a structure defining the steam passages, a guide structure for the liquid condensed by steam to flow down along the second protrusion 122, and a support structure to avoid collapse of the first casing 110 and the second casing 120. Thus, a greater number of the second protrusions 122 may provide a greater number of the steam passages 124, the guide structure, and the support structure.

[0036] In addition, in this embodiment, a size of the first protrusion 117a is greater than a size of the second protrusion 122. The first protrusion 117a is mainly used as a connection structure for connecting the second plate portion 121, so a larger size of the first protrusion 117a may provide a larger connecting area. Of course, the relationship between the size and number of the first protrusion 117a and the second protrusion 122 is not limited thereto.

[0037] Furthermore, since the first protrusion 117a in this embodiment is directly connected to the second plate portion 121, the first protrusion 117a may also be used as a structure defining a part of the steam passages, and may have a function of allowing the liquid condensed by steam to flow down along the first protrusion 117a. The first protrusion 117a and the second protrusion 122 may significantly shorten a path length of the liquid backflow and effectively reduce flow resistance.

[0038] In addition, as shown in FIG. 1B and FIG. 1D, in this embodiment, the second protrusion 122 is, for example, a cylinder, and shapes of the second protrusions 122 are consistent, but the shape of the second protrusion 122 is not limited thereto. In other embodiments, the second protrusion 122 may also be a rectangular column, a square column, an elliptical column, a polygonal column, a tapered column, an irregular column, or/and a combination thereof. The shape and distribution form of the second protrusion 122 are not limited thereto. Moreover, in this embodiment, the second protrusion 122 and the second plate portion 121 are integrally formed, and the second plate portion 121 and the second protrusions 122 are made, for example, by stamping, chemical etching, extruding, forging, or die-casting processes, but not limited thereto.

[0039] In addition, in this embodiment, as seen from a cross section of FIG. 1B, a cross section of the second protrusion 122 is a rectangle, but in other embodiments, the cross section of the second protrusion 122 may also be an inverted trapezoid, so the constructed steam passage 124 has a trapezoidal cross-sectional shape. In other embodiments, the second protrusions 122 may include multiple tapered columns, multiple trapezoidal columns, multiple cylinders, or multiple irregular columns. Thus, a cross-sectional shape of the second protrusion 122 may be triangular, arc-shaped, or other shapes. Likewise, the cross-sectional shape of the steam passage 124 may be triangular, arc-shaped, or other shapes.

[0040] It should be noted that in this embodiment, an internal space surrounded by the first casing 110 and the second casing 120 will be filled with an appropriate amount of working fluid g (marked in FIG. 1D, and the working fluid g in FIG. 1D is gas). The working fluid g is, for example, acetone compatible with an aluminum container, but the type of the working fluid g is not limited thereto. In other embodiments, the working fluid g may also be water or other types of working fluid, as long as it can be compatible with the material of the vapor chamber device. The working fluid g flows in the first casing 110 in the form of liquid, for example.

[0041] The outer surface 1114 (marked in FIG. 1B) of the first casing 110 of the vapor chamber device 100 contacts the heat source 10, and heat emitted by the heat source 10 is transferred to the first casing 110. A region of the vapor chamber device 100 corresponding to the heat source 10 is called an evaporation zone. In the evaporation zone, the working fluid g (liquid) absorbs heat and is vaporized into gas (steam). The working fluid g (gas) flows upward to the steam passage 124 of the second casing 120 and diffuses within the second casing 120, and then condenses into liquid in a condensation region of the vapor chamber (e.g., a region of the second casing 120 or the first casing 110 of the vapor chamber device 100 outside projection of the heat source 10), and discharges the heat from the vapor chamber device 100. When the working fluid g is condensed from gas to liquid, the working fluid g may flow down along side walls of the second protrusion 122 and the first protrusion 117a. The condensed working fluid g (liquid) flows back down to a region near the heat source 10 and evaporates, and a thermal cycle is completed.

[0042] In this embodiment, the steam passage 124 of the second casing 120 may be vacuumed to exclude noncondensable gases such as air.

[0043] It should be noted that, in this embodiment, the second protrusions 122 rest against the first capillary structure 130, and may support the second plate portion 121, effectively avoiding the collapse of the first casing 110, the second casing 120, and the steam passages 124 during vacuuming. In addition, the first protrusion 117a may be connected with the corresponding connecting region 129, so that when the pressure between the first plate portion 111 and the second plate portion 121 is greater than 1 atmosphere (i.e., the saturation pressure corresponding to an operating temperature of the vapor chamber is higher than the ambient pressure), the distance between the first plate portion 111 and the second plate portion 121 may be maintained fixed, and the vapor chamber device 100 may be prevented from expanding and deforming.

[0044] The vapor chamber device or the second casing thereof of other implementations will be introduced in the following. Components that are the same or similar to those in the previous embodiment are represented by the same or similar symbols and will not be repeated, and only the main differences are described.

[0045] FIG. 1E to FIG. 1G are schematic views of inner surfaces of second casings of various vapor chamber devices according to other embodiments of the disclosure. Referring to FIG. 1E first, the main difference between a second casing 120a in FIG. 1E and the second casing 120 in FIG. 1D lies in shapes of the second protrusion 122 and 122a. In this embodiment, a second protrusion 122a is a square column, but the shape of the second protrusion 122a is not limited thereto.

[0046] Referring to FIG. 1F, the main difference between a second casing 120b of FIG. 1F and the second casing 120 of FIG. 1D is that, in this embodiment, the second protrusions 122 include multiple first support columns 122b and multiple second support columns 123, the shape of the first support columns 122b is different from the shape of the second support columns 123, the first support columns 122b are disposed at positions corresponding to the heat source 10, and the second support columns 123 are located next the first support columns 122b and extend in an axial direction A1.

[0047] In this embodiment, a high-density first support columns 122b are disposed at positions of the second casing 120 corresponding to the heat source 10, and provide good structural strength. The second support columns 123 are disposed on both sides of the first support columns 122b and extend in the axial direction A1 to guide a flow direction of the working fluid g (gas). In addition, in this embodiment, the second support column 123 are partially yielded to the connecting region 129 for the connection of the first protrusion 117a (as shown in FIG. 1B).

[0048] Referring to FIG. 1G, the main difference between a second casing 120c of FIG. 1G and the second casing 120 of FIG. 1D is that, in this embodiment, the second protrusions 122b are disposed at positions corresponding to the heat source 10, and the other part of the second protrusions 123, 125, 127 is arranged radially around the part corresponding to the heat source 10. This design also allows for good guidance of the flow direction of the working fluid g (gas).

[0049] In the above embodiment, second protrusions 122, 122a, 122b, 123, 125, 127 of a part of the second casing 120, 120a, 120b, 120c are removed to partially form the connecting region 129, and the connecting region 129 is used to allow the connection of the first protrusion 117a and the second plate portion 121.

[0050] FIG. 2 is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure. Referring to FIG. 2, the main difference between a vapor chamber device 100d in FIG. 2 and the vapor chamber device 100 in FIG. 1B is that, in this embodiment, a size of the first protrusion 117d is the same as the size of the second protrusion 122.

[0051] Similarly, since the first protrusion 117d is directly connected to the second plate portion 121, the first protrusions 117d and the second protrusions 122 are staggered from each other, there is no need for precise alignment between the first casing 110 and the second casing 120, and the connecting process is convenient. The second protrusions 122 rest against the first capillary structure 130, effectively avoiding the collapse of the first casing 110, the second casing 120, and the steam passages 124 during vacuuming.

[0052] FIG. 3A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure. FIG. 3B is a schematic top view of a first casing of the vapor chamber device in FIG. 3A. It should be noted that a cross section in FIG. 3A is a cross section along a line B-B in FIG. 3B, i.e., in a width direction of the vapor chamber device, unlike a cross section in FIG. 1B in a length direction of the vapor chamber device. In addition, in FIG. 3B, a convex bar 112 is shown by thin lines, and a first protrusion 117e is shown by bold lines.

[0053] Referring to FIG. 3A and FIG. 3B, the main difference between a vapor chamber device 100e of FIG. 3A and the vapor chamber device 100 of FIG. 1B is that, in this embodiment, the first casing 110e includes a second capillary structure 113 protruding integrally from the inner surface 1112 of the first plate portion 111. The second capillary structure 113 includes multiple grooves 114 formed between multiple convex bars 112 to serve as fluid channels.

[0054] More specifically, the convex bars 112 protrude from the inner surface 1112 of the first plate portion, so that the groove 114 are defined between two adjacent convex bars 112. In this embodiment, the first plate portion 111 is integrally formed with the convex bars 112, and such a design may have a relatively simple structure. Since there is no thermal contact resistance between the first plate portion 111 and the convex bars 112 (i.e., between the first plate portion 111 and the groove 114), the heat transfer effect is better.

[0055] The working fluid g (FIG. 3B), for example, flows in the groove 114 of the second capillary structure 113 of the first casing 110e in the form of liquid. The second capillary structure 113 is designed with the grooves 114 to provide a lower flow resistance. In this embodiment, a width of the groove114 is, for example, between 50 microns and 200 microns, and a depth of the groove 114 is, for example, between 50 microns and 200 microns, but the width and the depth of the groove 114 are not limited thereto.

[0056] As shown in FIG. 3A, a height of the first protrusion 117e is greater than a height of the convex bar 112. The first capillary structure 130 passes through the first protrusion 117e, and is disposed between the second capillary structure 113 and the second protrusions 122 of the second casing 120. Since the first capillary structure 130 is disposed on the groove 114 of the second capillary structure 113, the upper part of the groove 114 of the second capillary structure 113 is covered by the first capillary structure 130, and a capillary-like structure is formed in a direction of the extension of the groove 114 (the direction of injection or injection into the drawing surface). This structure enables the working fluid g in the groove 114 to resist gravity, so that the vapor chamber device 100 may complete a thermal cycle well in a non-horizontal condition.

[0057] Therefore, in this embodiment, the open groove 114 of the second capillary structure 113 is covered with a mesh-like first capillary structure 130, which not only maintains the low flow resistance advantage of the groove 114, but also significantly enhances the capillary force and makes the vapor chamber device 100e suitable for non-horizontal placement.

[0058] FIG. 3C is a schematic view of an inner surface of a first casing of a vapor chamber device according to another embodiment of the disclosure. It should be noted that, in FIG. 3C, the convex bar 112 is shown by thin lines, and a first protrusion 117f is shown by bold lines. In addition, a second casing corresponding to a first casing 110f in FIG. 3C may be, for example, the second casing 120c in FIG. 1G. It can be seen from FIG. 3C and FIG. 1G that positions of the first protrusions 117f in FIG. 3C correspond to the positions of the connecting regions 129 in FIG. 1G; however, the second casing corresponding to the first casing 110f in FIG. 3C is not limited thereto.

[0059] Referring to FIG. 3C, in this embodiment, the first protrusions 117f and at least a part of the convex bars 112 are radially arranged together, so that at least a part of grooves 114, 115, 118 are arranged radially. In addition, grooves 119 of the first casing 110f corresponding to the heat source 10 are arranged in a checkerboard pattern. Of course, in an embodiment, it is possible to have only the convex bars 112 arranged radially, without being limited by the drawing.

[0060] Specifically, in this embodiment, the first casing 110f has a variety of grooves 114, 115, 118, 119 in different directions, which are arranged radially to reduce the flow resistance and allow the condensed working fluid g (liquid) to flow back quickly. The arrangement of the grooves 114, 115, 118 of the inner surface 1112 of the first casing 110f is not limited to the radial pattern, and may be any arrangement sufficient to guide the working fluid g (liquid).

[0061] It should be noted that, in an embodiment, the first protrusions may be evenly distributed in regions other than the evaporation zone. In another embodiment, the first protrusions may also be unevenly distributed in regions other than the evaporation zone. The shape and size of the first protrusions are not limited. In other embodiments, the first protrusions may also be partially located in the evaporation zone and is not limited by the drawing.

[0062] FIG. 4A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure. FIG. 4B is a schematic top view of a first casing of the vapor chamber device in FIG. 4A. Similarly, a cross section in FIG. 4A, like FIG. 3A, is in the width direction of the vapor chamber device.

[0063] Referring to FIG. 4A and FIG. 4B, the main difference between a vapor chamber device 100g of FIG. 4A and the vapor chamber device 100e of FIG. 3A is that, in this embodiment, the vapor chamber device 100g further includes a third capillary structure 140 filled in the grooves 114 in regions corresponding to the heat source 10.

[0064] The third capillary structure 140 includes metal powder, non-woven metal wool, or chemically or physically produced nanostructures. In this embodiment, the third capillary structure 140 is in the form of a sintered capillary structure, for example, where the metal powder is sintered in a localized region of the groove 114. Of course, in other embodiments, the form of the third capillary structure 140 is not limited thereto. The first capillary structure 130 may also be a metal foam layer with a large number of internal holes, and the third capillary structure 140 (metal powder, or chemically or physically produced nanostructure) may also be filled in the holes in the metal foam layer.

[0065] In this embodiment, the addition of metal powder or metal wool with stronger capillary force to the second capillary structure 113 near the heat source 10 increases the capillary force therein and enhances the drying resistance. In addition, because the third capillary structure 140 is only disposed at the position corresponding to the heat source 10 in the second capillary structure 113, a path through which the liquid flows back is not blocked.

[0066] It should be noted that, in this embodiment, since the third capillary structure 140 corresponding to the region of the heat source 10 has a stronger capillary force, and the groove 114 in the second capillary structure 113 covered by the first capillary structure 130 has both lower flow resistance and stronger capillary force, the proper combination of the three capillary structures results in a more rapid return of the working fluid to the evaporation zone close to the heat source 10, so that the evaporation zone of the vapor chamber device is less likely to dry out, and has better heat dissipation efficiency.

[0067] FIG. 5A is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure. FIG. 5B is a schematic top view of a first casing of the vapor chamber device in FIG. 5A. FIG. 5C is a schematic view of an inner surface of a second casing of the vapor chamber device of FIG. 5A.

[0068] Referring to FIG. 5A to FIG. 5C, the main difference between a vapor chamber device 100h of FIG. 5A and the vapor chamber device 100 of FIG. 1B is that, in this embodiment, one of the first side wall 117 and the second side wall 128 includes a ring-shaped convex bar 150, and the other one of the first side wall 117 and the second side wall 128 includes a ring-shaped groove 152. For example, the first side wall 117 includes the ring-shaped convex bar 150, and the second side wall 128 includes the ring-shaped groove 152. The ring-shaped convex bar 150 surrounds the first protrusion 117a, and the ring-shaped groove 152 surrounds the second protrusion 122. The ring-shaped convex bar 150 is embedded in the ring-shaped groove 152.

[0069] In this embodiment, the first casing 110 and the second casing 120 are metal, and the ring-shaped convex bar 150 and the ring-shaped groove 152 may be made in advance during the manufacturing process. A width of the ring-shaped convex bar 150 may be slightly larger than a width of the ring-shaped groove 152, and when the ring-shaped convex bar 150 is embedded in the ring-shaped groove 152, the ring-shaped convex bar 150 may be tightly squeezed into the ring-shaped groove 152, providing a seal by deformation through compression. This procedure is particularly suitable for the first casing 110 and the second casing 120 which are made of aluminum with excellent ductility.

[0070] In addition, as shown in FIG. 5A, in this embodiment, in order to enhance the sealing of the vapor chamber device 100, the first side wall 117 and the second side wall 128 have a sealing region 154 at edges. The sealing region 154 surrounds the ring-shaped convex bar 150 and the ring-shaped groove 152, and may also cover a region surrounding the ring-shaped convex bar 150 and the ring-shaped groove 152. That is, the edges of the vapor chamber device 100 further adopts pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding to achieve an effect of second vacuum sealing.

[0071] Certainly, the structure of the ring-shaped convex bar 150 embedded in the ring-shaped groove 152 and the design of the edge of the vapor chamber device 100 as the sealing region 154 of this embodiment may also be applied to the vapor chamber device 100 to 100g of other embodiments mentioned above, and is not limited to FIG. 5A.

[0072] In the vapor chamber devices of the above embodiments, the first protrusion of the first casing is connected to the connecting region of the second plate portion, so that the first casing and the second casing may be connected well, and large-area, low-cost vapor chambers may be produced. The vapor chamber device is suitable for connecting aluminum with cold working to produce a thin vapor chamber with strong heat dissipation performance, which may be applied to 5G base stations, natural convection heat dissipation on the surface of high power fanless computer cases, and temperature control of energy storage or automotive lithium battery modules for large area heat dissipation.

[0073] FIG. 6 is a schematic cross-sectional view of a vapor chamber device according to another embodiment of the disclosure. Referring to FIG. 6, the main difference between a vapor chamber device 100i in FIG. 6 and the vapor chamber device 100 in FIG. 1B is that, in this embodiment, the vapor chamber device 100i further includes multiple extended capillary layers 132 extending from the first capillary structure 130, and are integrated with the first capillary structure 130, and the extended capillary layers 132 surround the first protrusions 117a. The design of the extended capillary layer 132 facilitates the condensed liquid of the second casing 120 to flow back to the evaporation zone above the heat source 10 in the first capillary structure 130 on the first casing 110, thus forming a thermal cycle. Of course, the extended capillary layer 132 may also be applied to other implementations mentioned above, without being limited by FIG. 6.

[0074] In addition, the structure of the ring-shaped convex bar 150 embedded in the ring-shaped groove 152 and the design of the sealing region 154 in FIG. 5A may also be applied to the vapor chamber device 100i of this embodiment.

[0075] To sum up, the first side wall of the vapor chamber device of the disclosure is connected to the second side wall, and the first protrusions of the first casing are connected to the connecting regions of the second plate portion to increase the structural strength of the first casing and second casing and avoid deformation due to changes in internal pressure. In addition, since the first protrusions and the second protrusions are staggered from each other, there is no need for precise alignment between the first casing and the second casing, and even if there is any offset between the first casing and the second casing during the manufacturing process, there is no effect on the connection between the first protrusion and the connecting region of the second plate portion, and the process is convenient. Furthermore, the first capillary structure is disposed above the inner surface of the first plate portion, and the second protrusions of the second casing rest against the first capillary structure, which may avoid collapse and deformation due to the low pressure of the vacuum inside the vapor chamber device. Therefore, the vapor chamber device of the disclosure may have better structural strength and is easy to manufacture.

Claims

1. A vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) adapted to be thermally coupled to a heat source (10), the vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) comprising:

    a first casing (110, 110e, 110f, 110h) comprises a first plate portion (111), a plurality of first protrusions (117a, 117d, 117e, 117f) protruding from an inner surface (1112) of the first plate portion (111), and a first side wall (117) protruding from the inner surface (1112) and surrounding the first protrusions (117a, 117d, 117e, 117f), wherein the heat source (10) is adapted to contact an outer surface (1114) of the first plate portion (111);
    a first capillary structure (130) disposed above the inner surface (1112) of the first plate portion (111) and surrounding the first protrusions (117a, 117d, 117e, 117f); and
    a second casing (120, 120a, 120b, 120c, 120h) stacked on the first casing (110, 110e, 110f, 110h), the second casing (120, 120a, 120b, 120c, 120h) comprising a second plate portion (121), a plurality of second protrusions (122, 122a, 122b) protruding from the second plate portion (121), and a second side wall (128) protruding from the second plate portion (121) and surrounding the second protrusions (122, 122a, 122b), wherein the first side wall (117) is connected to the second side wall (128), a plurality of steam passages (124) are formed between the second protrusions (122, 122a, 122b), the second plate portion (121) comprises a plurality of connecting regions (129) yielded by the second protrusions (122, 122a, 122b), the first protrusions (117a, 117d, 117e, 117f) are connected to the connecting regions (129), and the second protrusions (122, 122a, 122b) rest against the first capillary structure (130).

2. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein a number of the second protrusions (122, 122a, 122b) is greater than a number of the first protrusions (117a, 117d, 117e, 117f), and a size of the first protrusion (117a, 117d, 117e, 117f) is greater than a size of the second protrusion (122, 122a, 122b).

3. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein a difference value between a height (H1, H2, H3) of the first protrusion (117a, 117d, 117e, 117f) protruding from the first plate portion (111) and a height (H1, H2, H3) of the second protrusion (122, 122a, 122b) protruding from the second plate portion (121) is a height (H1, H2, H3) of a capillary layer.

4. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein each of the first protrusions (117a, 117d, 117e, 117f) is columnar or strip-shaped, and the first protrusions (117a, 117d, 117e, 117f) are evenly distributed on the inner surface (1112).

5. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein the second protrusions (122, 122a, 122b) comprise a plurality of first support columns (122b) and a plurality of second support columns (123, 125, 127), a shape of the first support columns (122b) is different from a shape of the second support columns (123, 125, 127), the first support columns (122b) are disposed at positions corresponding to the heat source (10), and the second support columns (123, 125, 127) are located next to the first support columns (122b) and extend in an axial direction (A1).

6. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein a part of the second protrusions (122, 122a, 122b) is disposed at a position corresponding to the heat source (10), and the other part of the second protrusions (122, 122a, 122b) is arranged radially around the part.

7. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein the first capillary structure (130) is a mesh structure woven by a plurality of wires, a non-woven mesh structure, or a metal foam layer, and sintered metal powder, and the first capillary structure (130) comprises a plurality holes.

8. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein the first casing (110, 110e, 110f, 110h) comprises a second capillary structure (113) protruding integrally from the inner surface (1112) of the first plate portion (111), the second capillary structure (113) comprises a plurality of grooves (114, 115, 118, 119) formed between a plurality of convex bars (112) to serve as fluid channels, and the first capillary structure (130) is disposed between the second capillary structure (113) and the second protrusions (122, 122a, 122b) of the second casing (120, 120a, 120b, 120c, 120h).

9. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 8, wherein at least a part of the grooves (114, 115, 118, 119) are radially arranged.

10. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 9, wherein the first protrusions (117a, 117d, 117e, 1171) and at least a part of the convex bars (112) are radially arranged

together.

11. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 8 further comprising a third capillary structure (140) filled in the grooves (114, 115, 118, 119) in regions corresponding to the heat source (10), and the third capillary structure (140) comprises metal powder, non-woven metal wool, or nanostructures.

12. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to any one of claims 1, 8, and 11 further comprising a plurality of extended capillary layers (132) extending from the first capillary structure (130) and integrated with the first capillary structure (130), and the extended capillary layers (132) surround the first protrusions (117a, 117d, 117e, 117f).

13. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein one of the first side wall (117) and the second side wall (128) comprises a ring-shaped convex bar (150), the ring-shaped convex bar (150) surrounds corresponding first protrusions (117a, 117d, 117e, 1171) or second protrusions (122, 122a, 122b), and the other one of the first side wall (117) and the second side wall (128) comprises a ring-shaped groove (152) surrounding corresponding first protrusions (117a, 117d, 117e, 117f) or second protrusions (122, 122a, 122b), and the ring-shaped convex bar (150) is embedded in the ring-shaped groove (152).

14. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 13, wherein the first side wall (117) and the second side wall (128) have a sealing region (154) at edges, the sealing region (154) seals the edges of the first side wall (117) and the second side wall (128) by pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding, and the sealing region (154) surrounds or covers the ring-shaped convex bar (150) and the ring-shaped groove (152).

15. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to any one of claims 1, 8, and 11, wherein the first side wall (117) and the second side wall (128) have a sealing region (154) at edges, and the sealing region (154) seals the edges of the first side wall (117) and the second side wall (128) by pinching, diffusion bonding, brazing, soldering, laser welding, or arc welding.

16. The vapor chamber device (100, 100d, 100e, 100g, 100h, 100i) according to claim 1, wherein a material of the first casing (110, 110e, 11 0f, 110h) and the second casing (120, 120a, 120b, 120c, 120h) comprises aluminum or aluminum alloy.

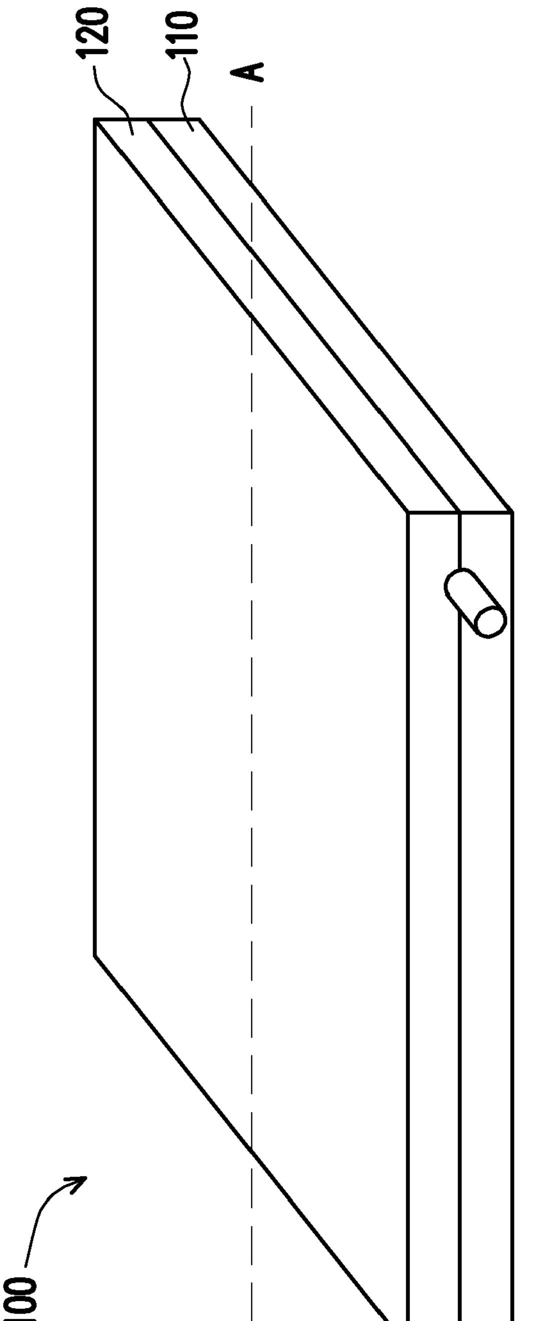
100
120
110
A
A

FIG. 1A

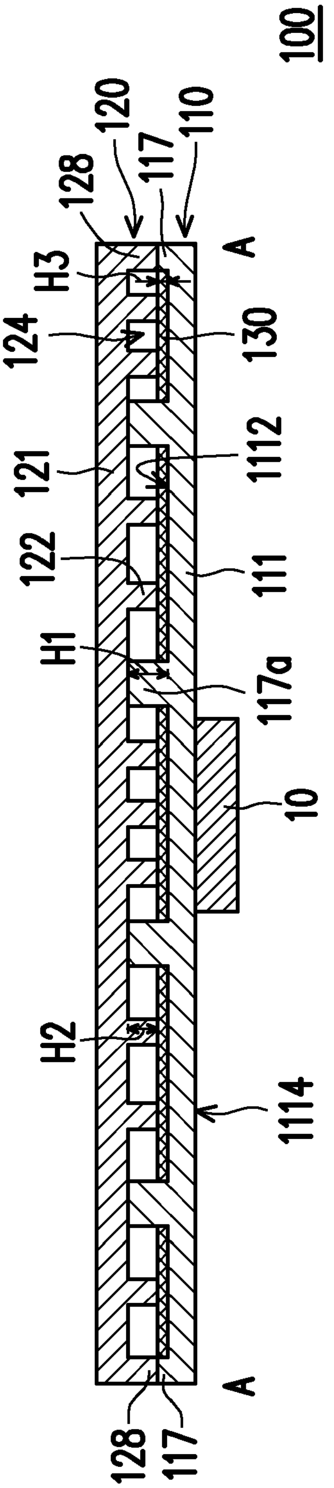
100
128
120
117
110
A
H3
124
130
121
1112
122
111
H1
117a
10
H2
1114
128
117
A

FIG. 1B

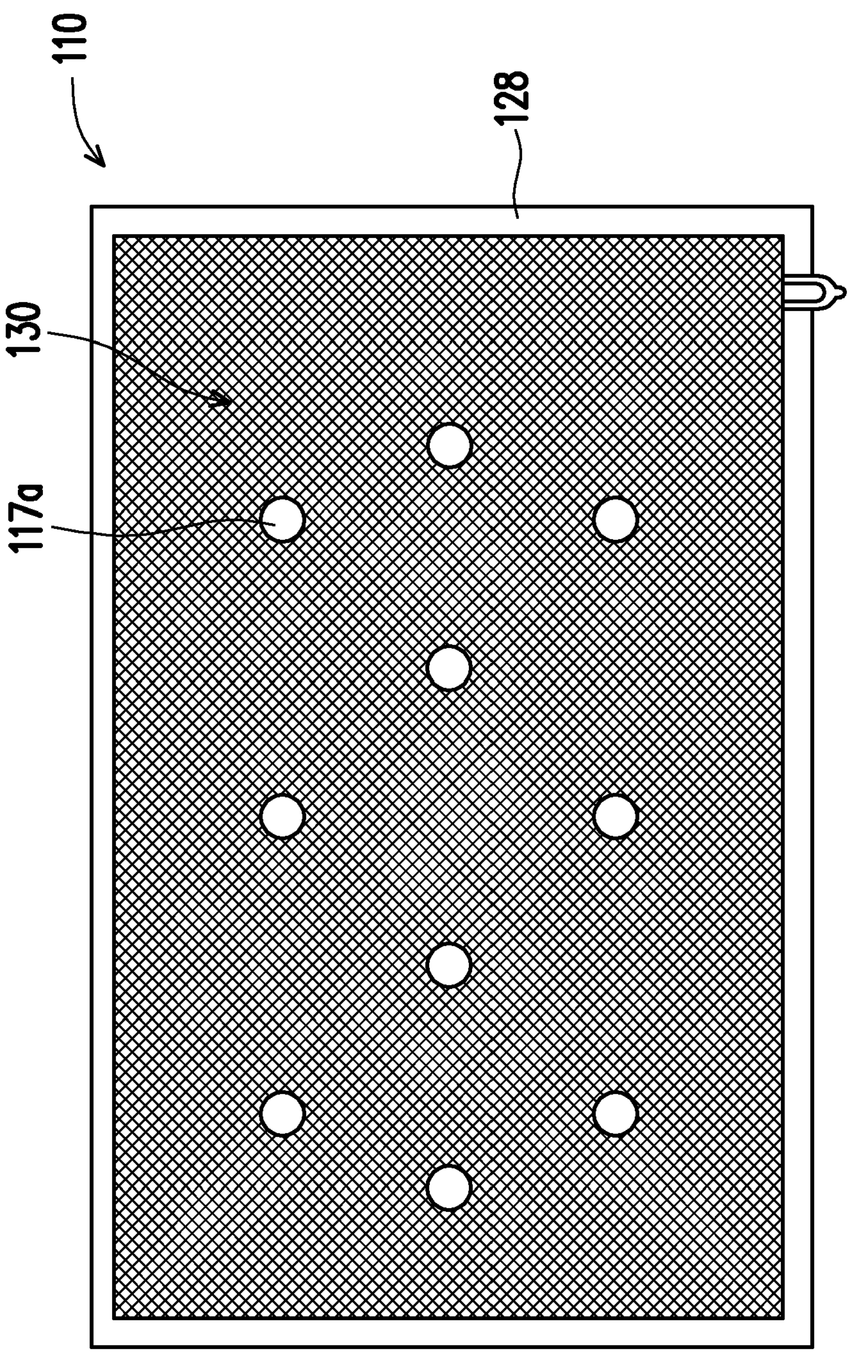

FIG. 1C

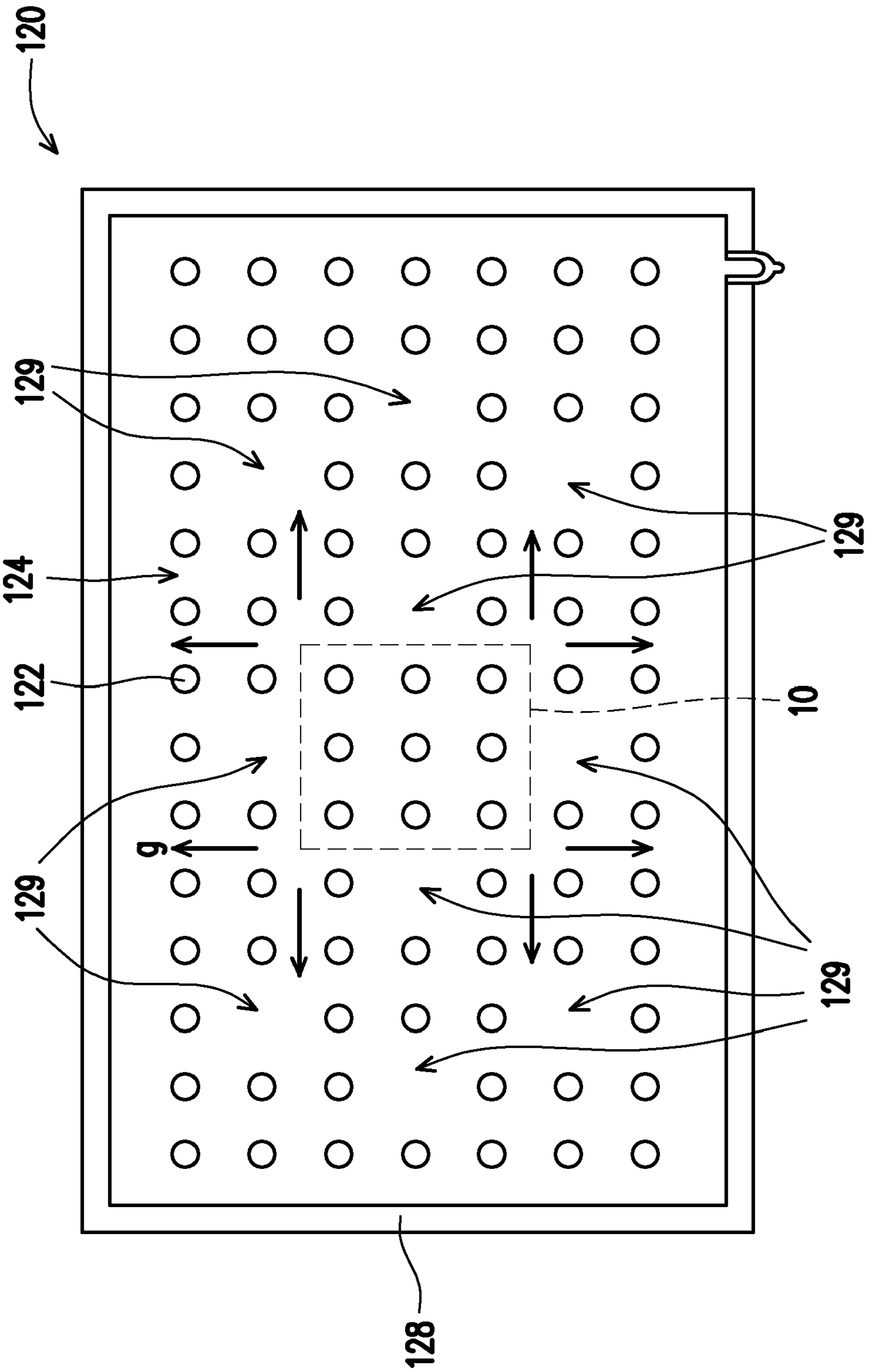

FIG. 1D

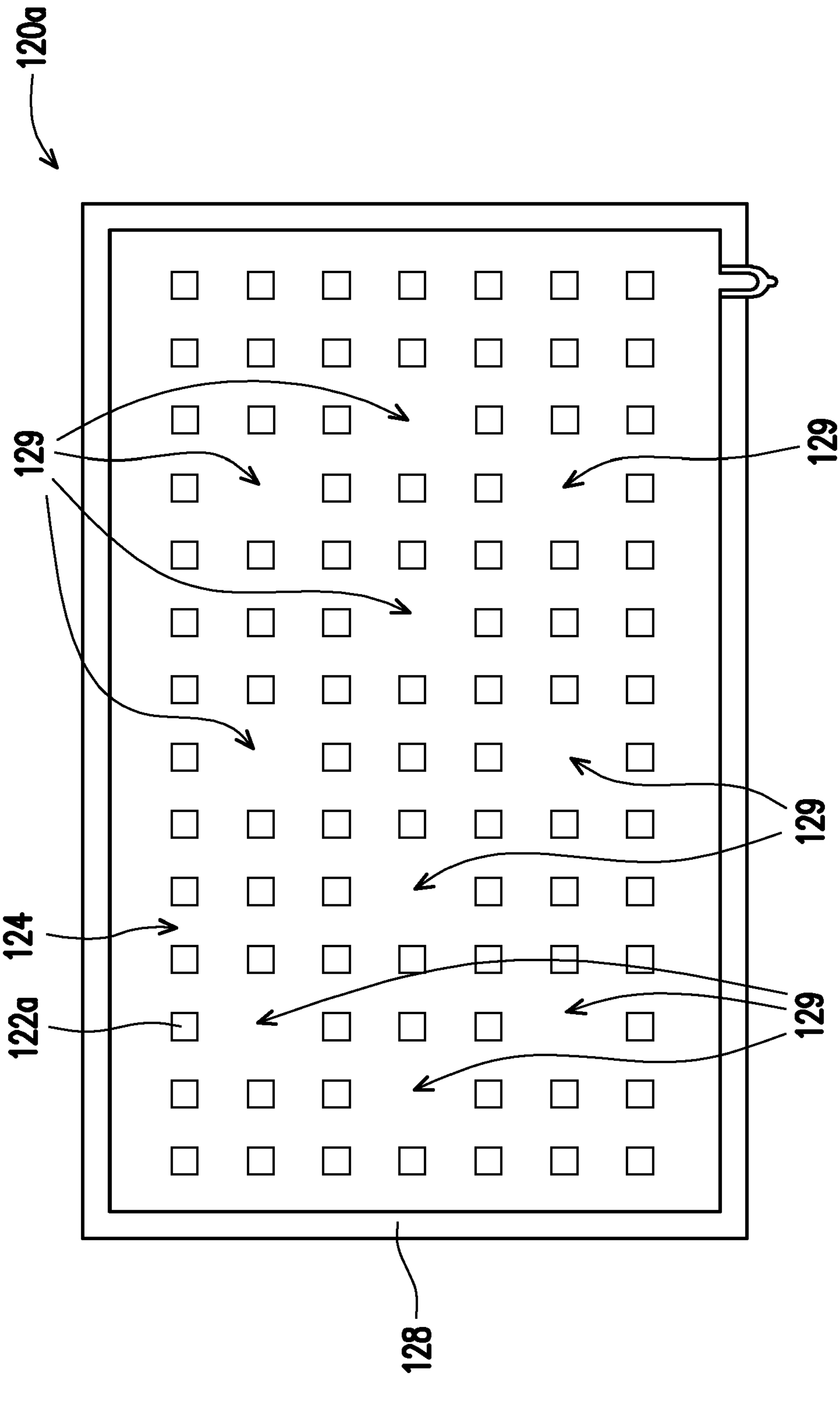

FIG. 1E

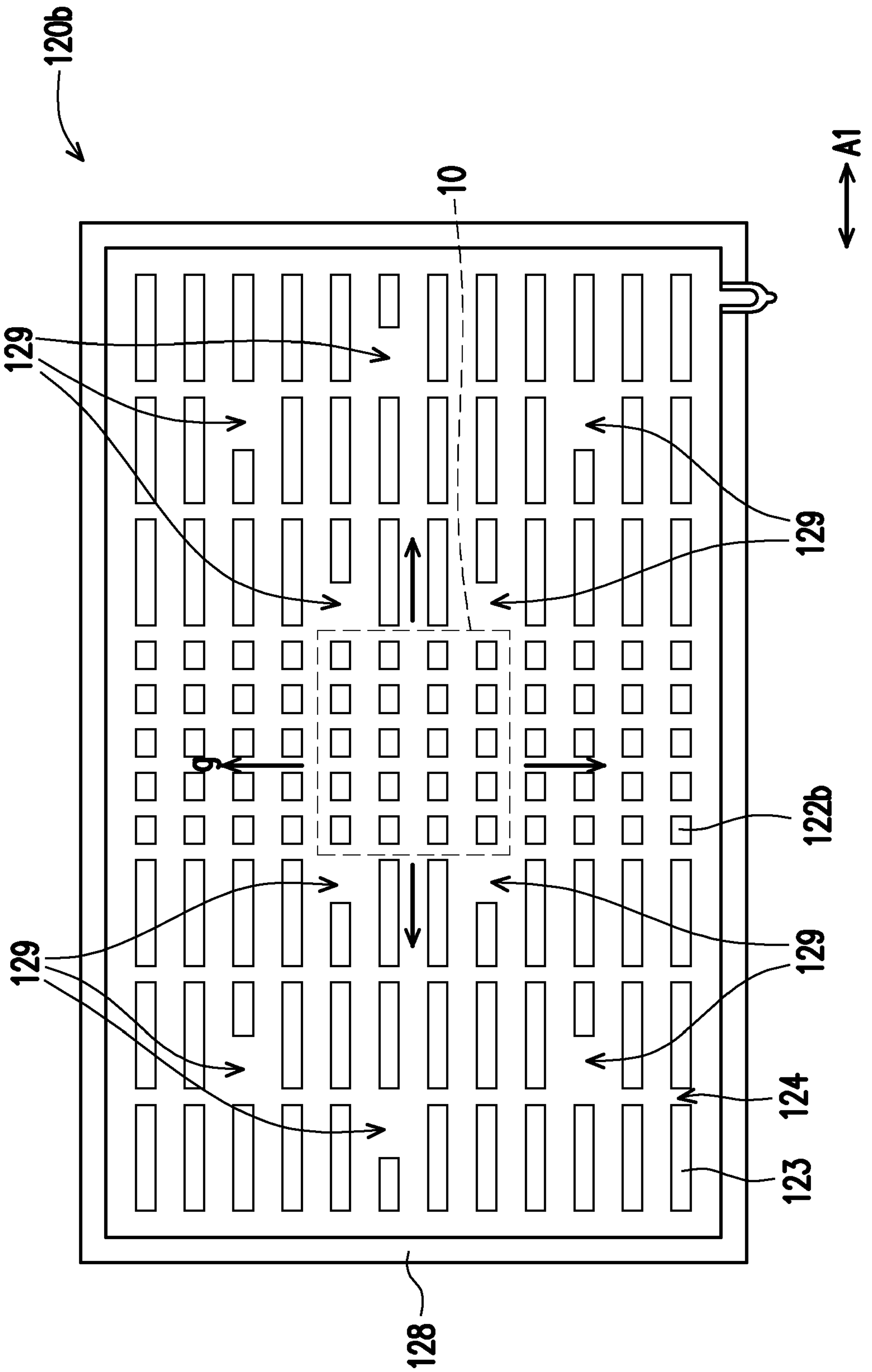

FIG. 1F

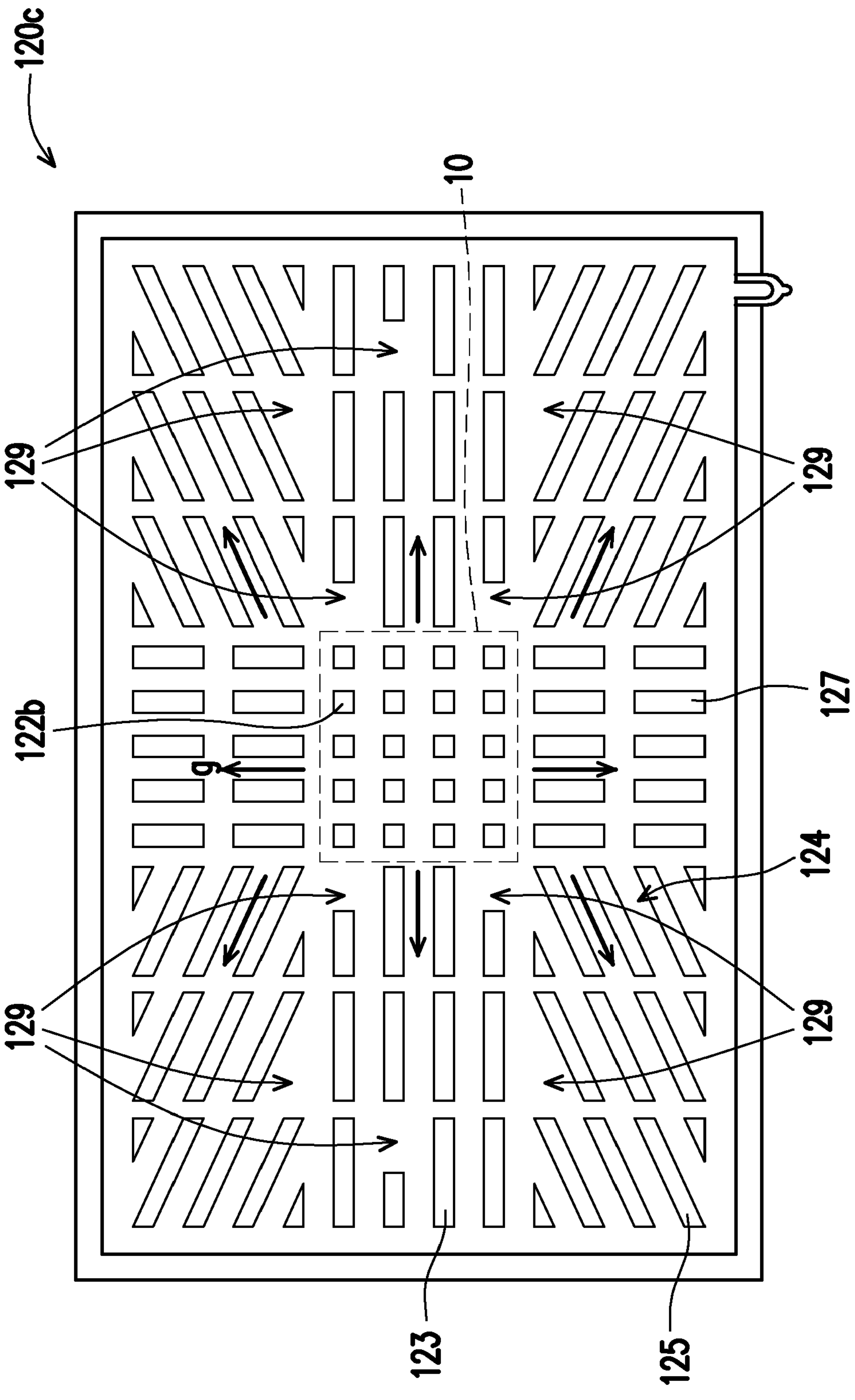

FIG. 1G

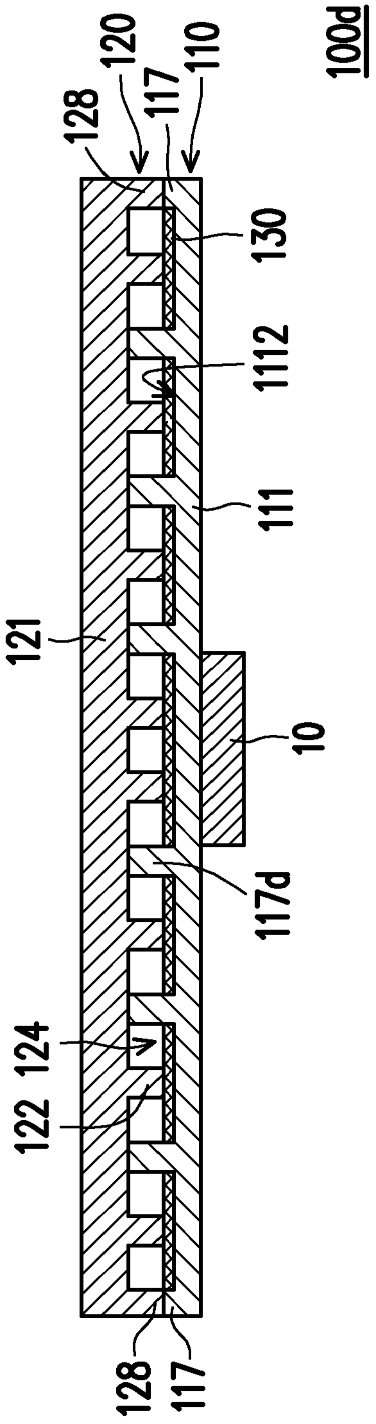

FIG. 2

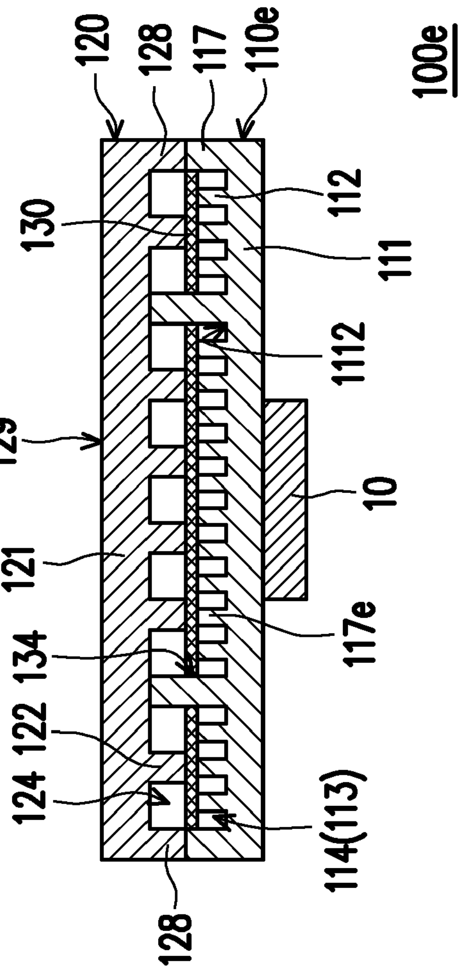
120
128
117
110e
100e
130
112
111
1112
129
10
121
117e
134
122
124
114(113)
128

FIG. 3A

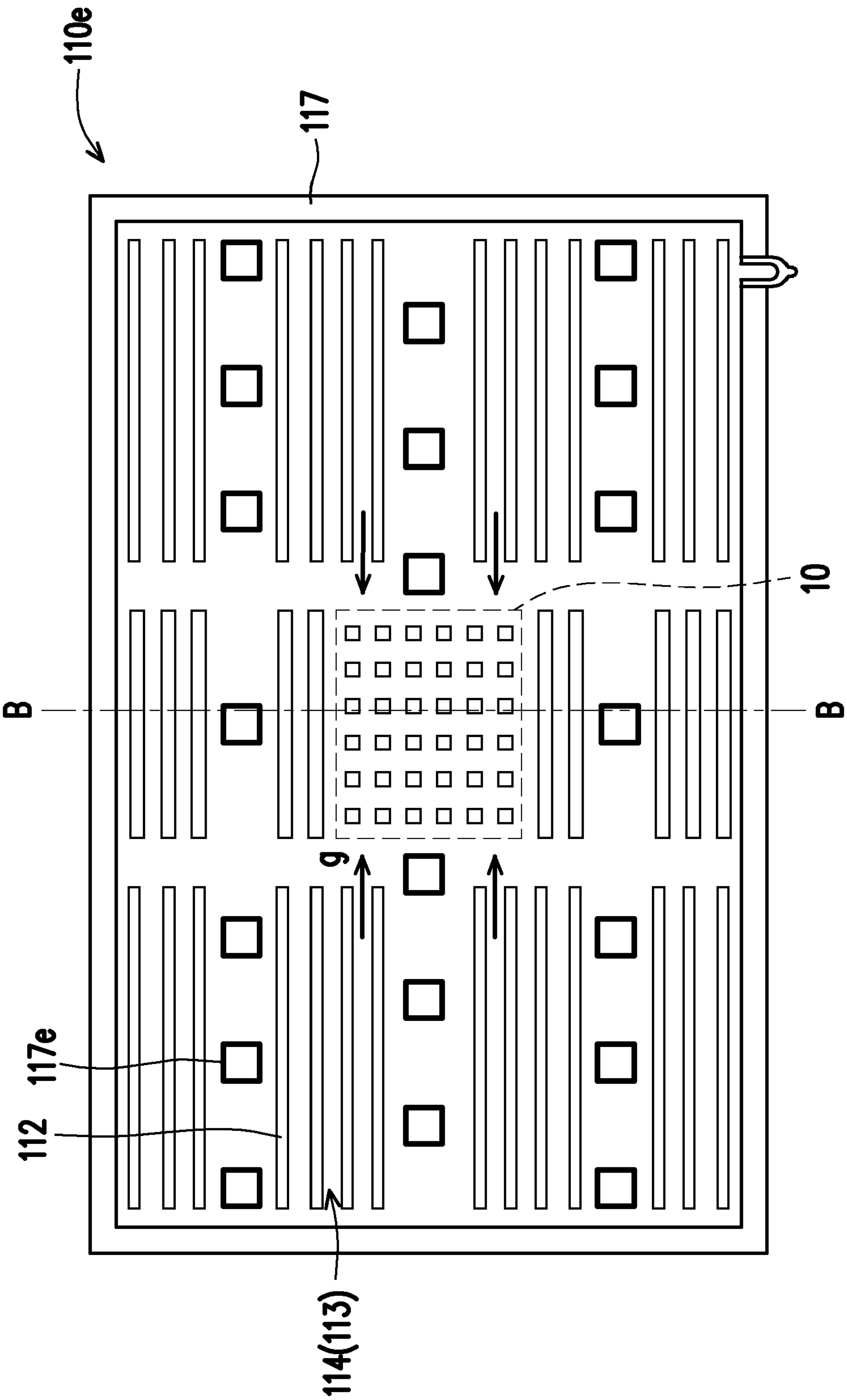

FIG. 3B

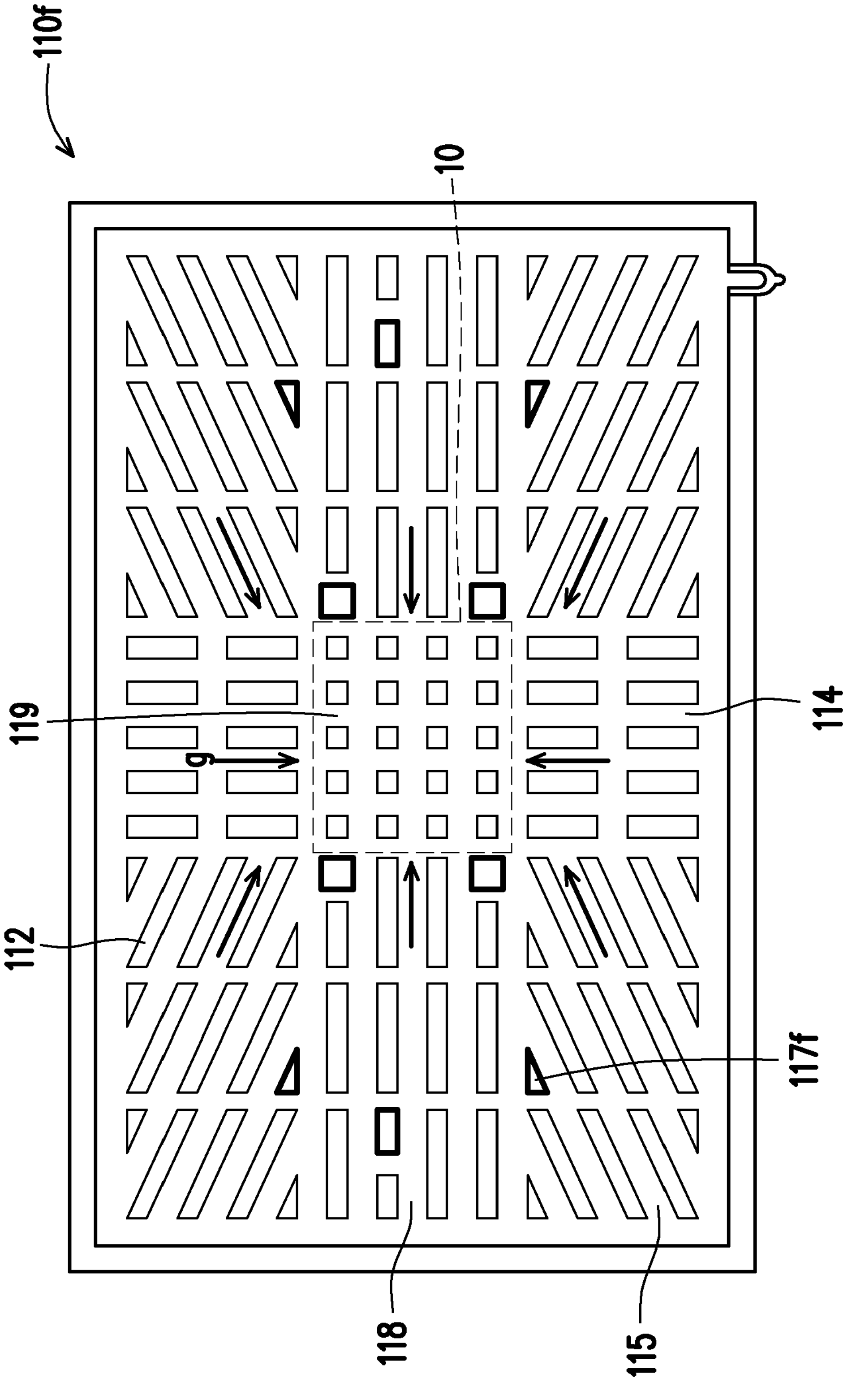

FIG. 3C

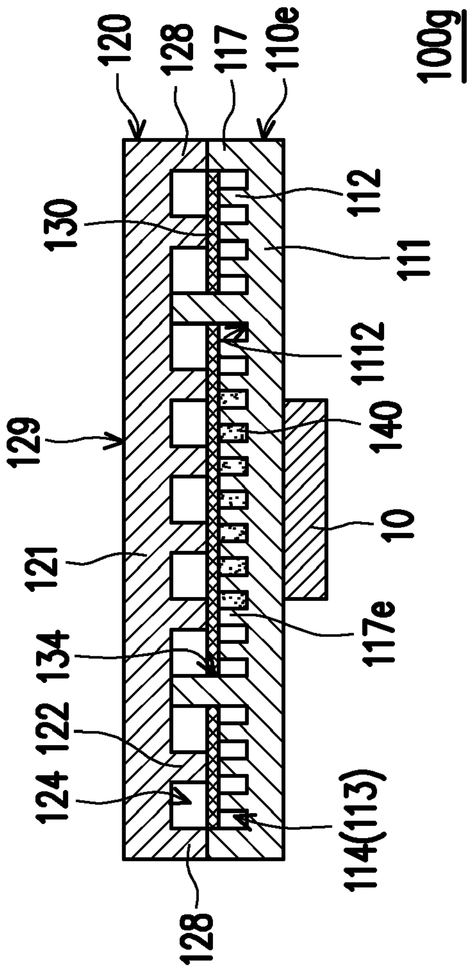
120
128
117
110e
100g
130
112
111
1112
129
140
121
10
117e
134
122
124
114(113)
128

FIG. 4A

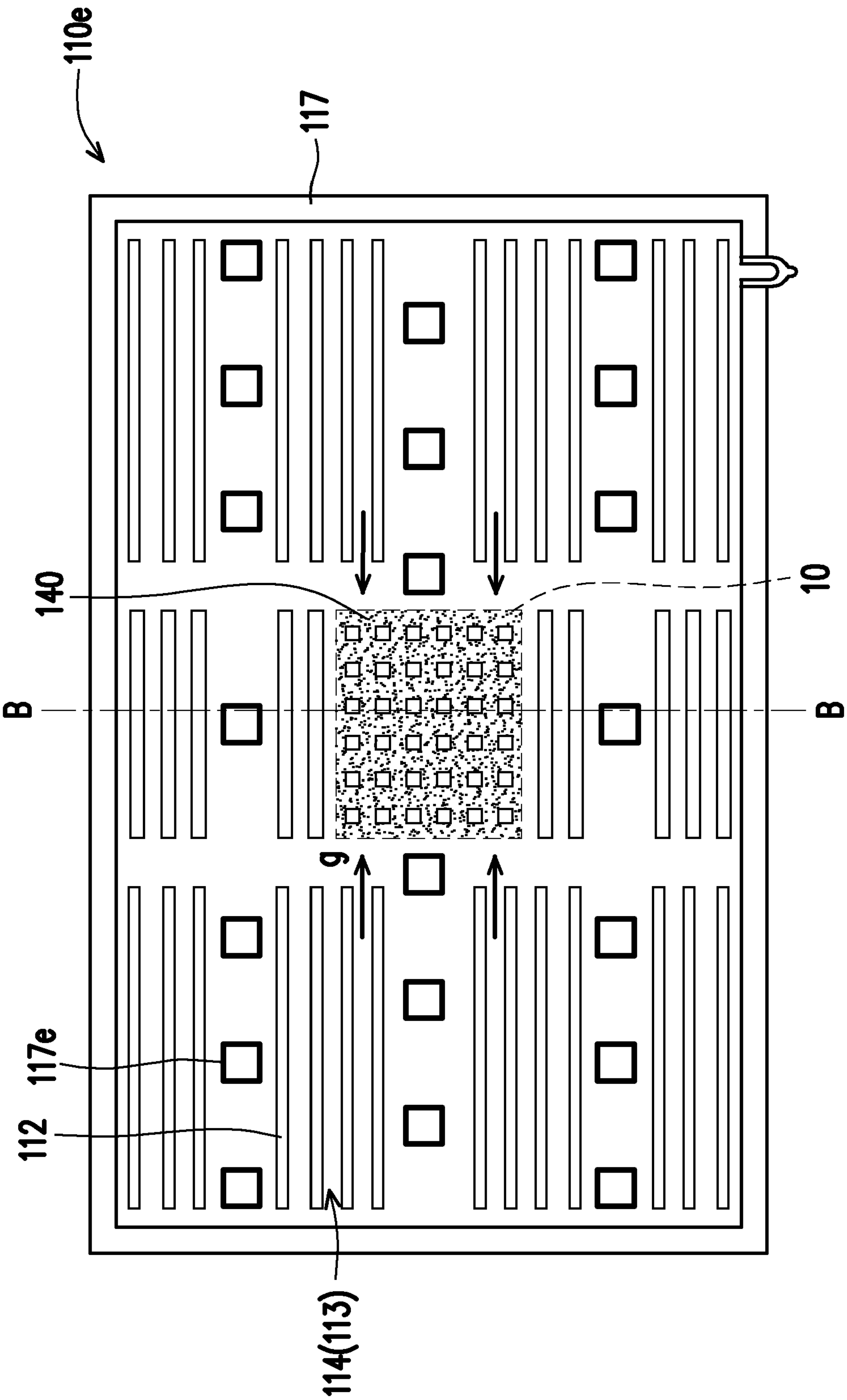

FIG. 4B

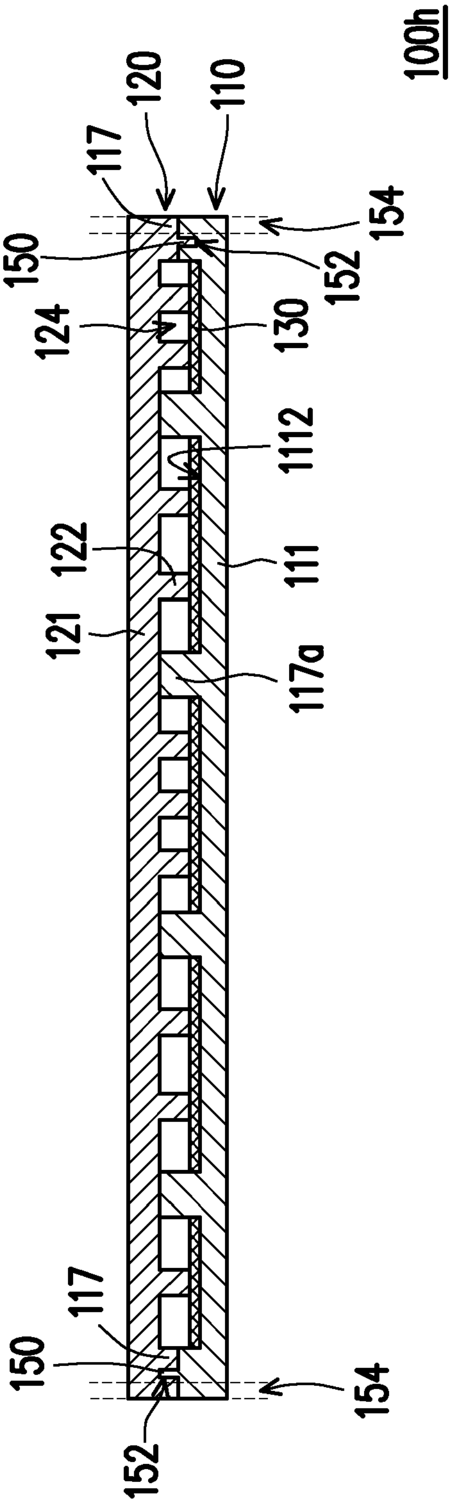
100h
120
110
117
154
150
152
124
130
1112
122
111
121
117a
117
150
154
152

FIG. 5A

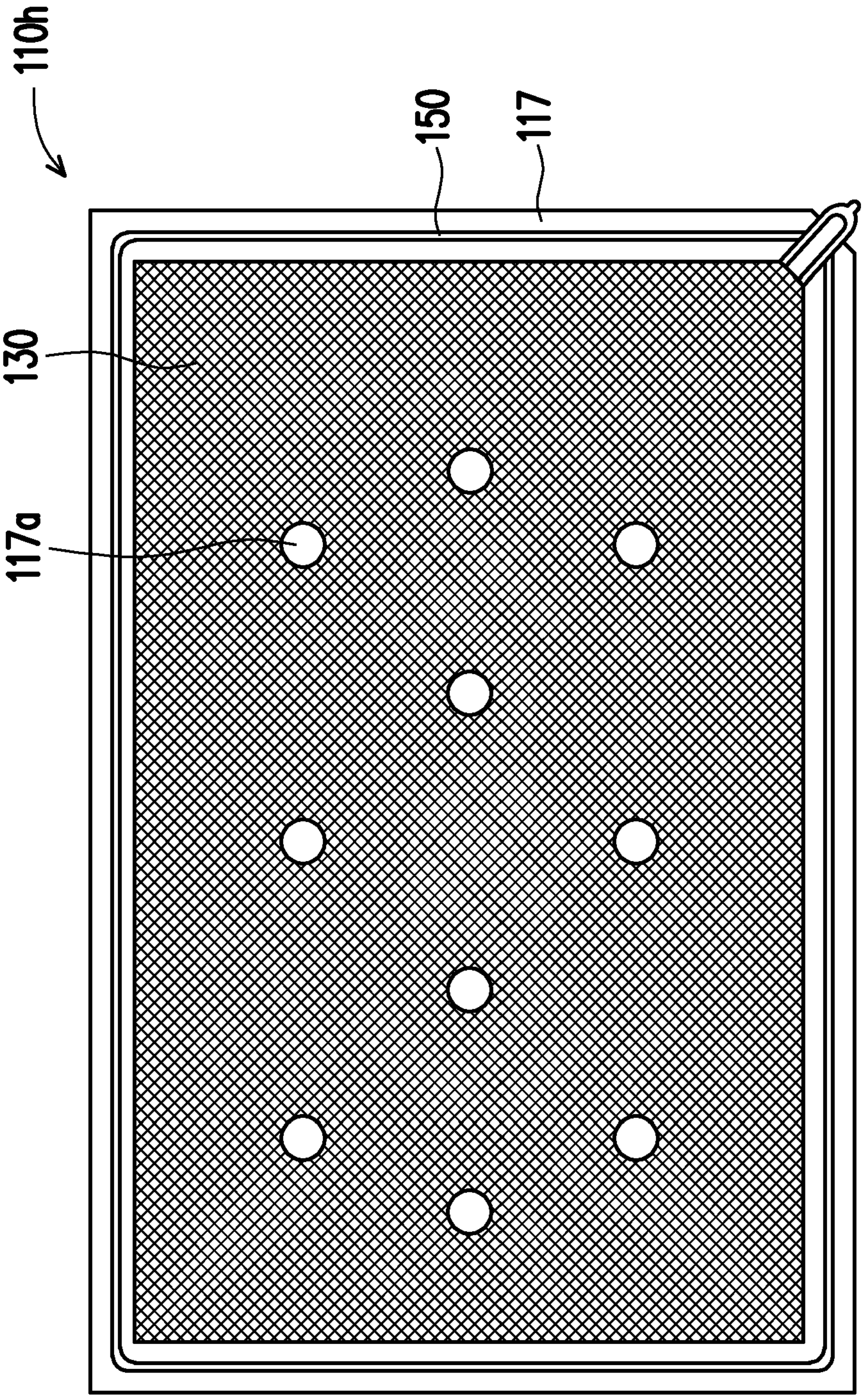

FIG. 5B

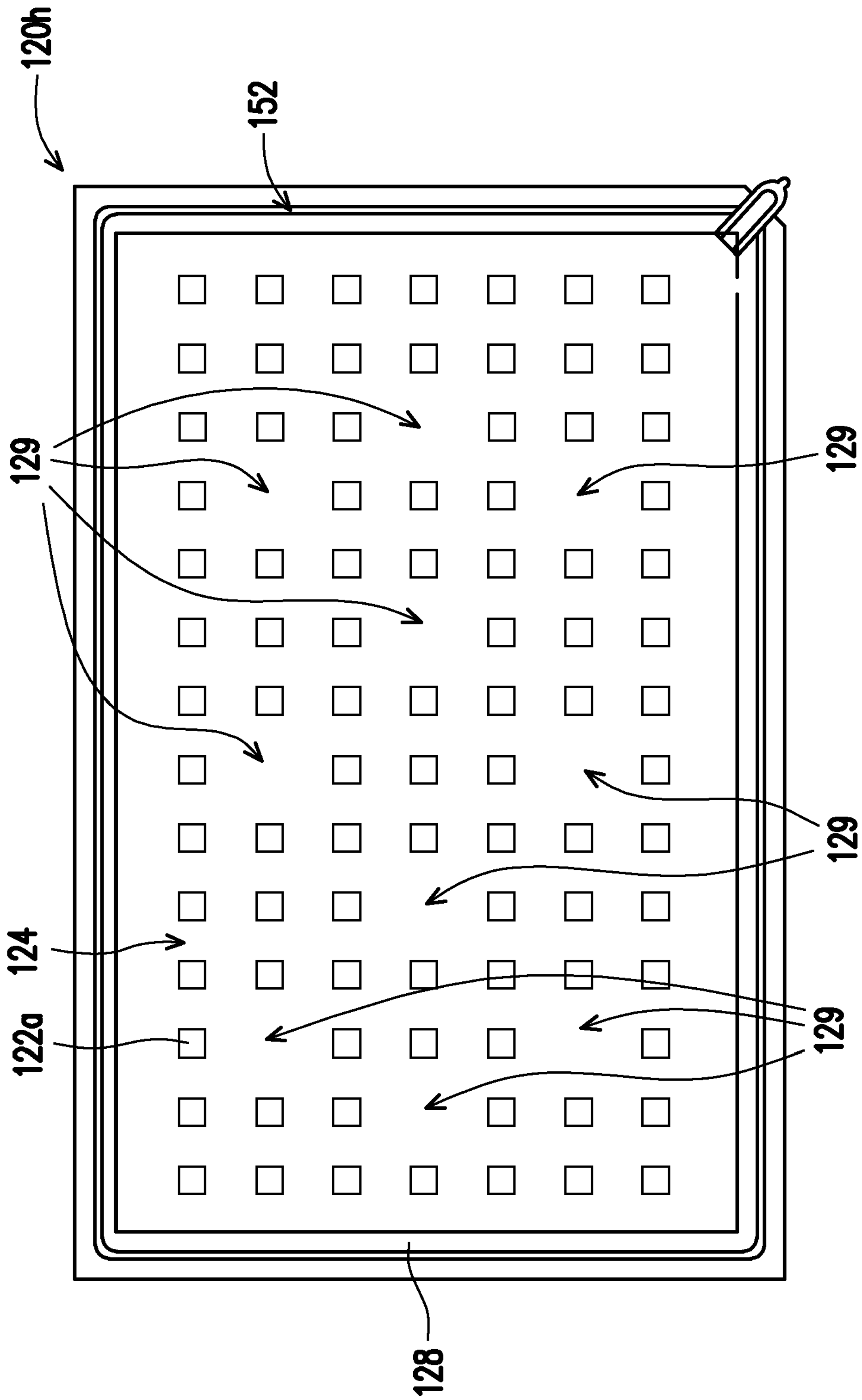

FIG. 5C

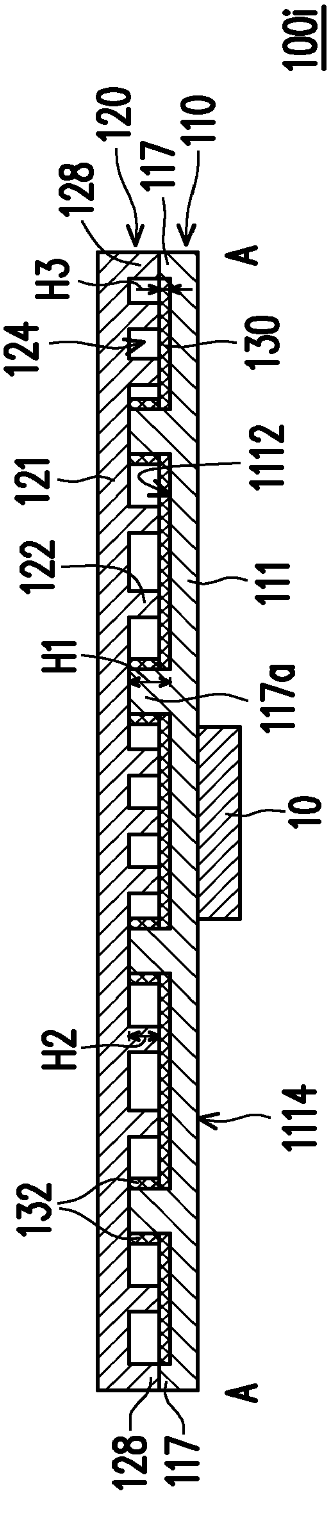
100i
120
110
128
117
A
H3
124
130
1112
121
122
111
H1
117a
10
H2
1114
132
128
117
A

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 6961

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F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 November 2023	Bain, David

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