US 20070240860A1

(19) United States

(12) Patent Application Publication

Meyer, IV et al.

(10) Pub. No.: US 2007/0240860 A1

(43) Pub. Date: Oct. 18, 2007

(54) SUPPORT STRUCTURE FOR A PLANAR COOLING DEVICE

(75) Inventors: **George A. Meyer IV**, San Jose, CA (US); **Ki-Bu Nam**, Seoul (KR); **Sung Sik Kwack**, Seoul (KR); **Jae Joon Choi**, Sungnam-City (KR)

Correspondence Address:
**DLA PIPER US LLP**
**2000 UNIVERSITY AVENUE**
**E. PALO ALTO, CA 94303-2248 (US)**

(73) Assignee: **CELSIA TECHNOLOGIES KOREA, INC.**

(21) Appl. No.: **11/410,772**

(22) Filed: **Apr. 24, 2006**

(30) **Foreign Application Priority Data**

Apr. 18, 2006 (KR) ........................... 10-2006-0034917

**Publication Classification**

(51) **Int. Cl.**
*F28D 15/04* (2006.01)

(52) **U.S. Cl.** ................................ **165/104.26**; 29/890.032

(57) **ABSTRACT**

A support structure for a compact planar cooling device is presented. The support structure allows the cooling device to be made with a simpler structure than most conventional cooling devices. The cooling device includes a planar casing, a wick layer, and the support structure. The support structure includes a flat plate with a portion cut out to form an opening and a spacer on the flat plate. The spacer is made by bending or folding the cut-out portion of the plate. The spacer enhances coolant circulation inside the cooling device by pushing the wick layer against the inner surface of the casing and maintaining a set distance between the support structure and the casing to allow unimpeded coolant movement. The cooling device can be made cost-effectively without compromising heat transfer efficiency.

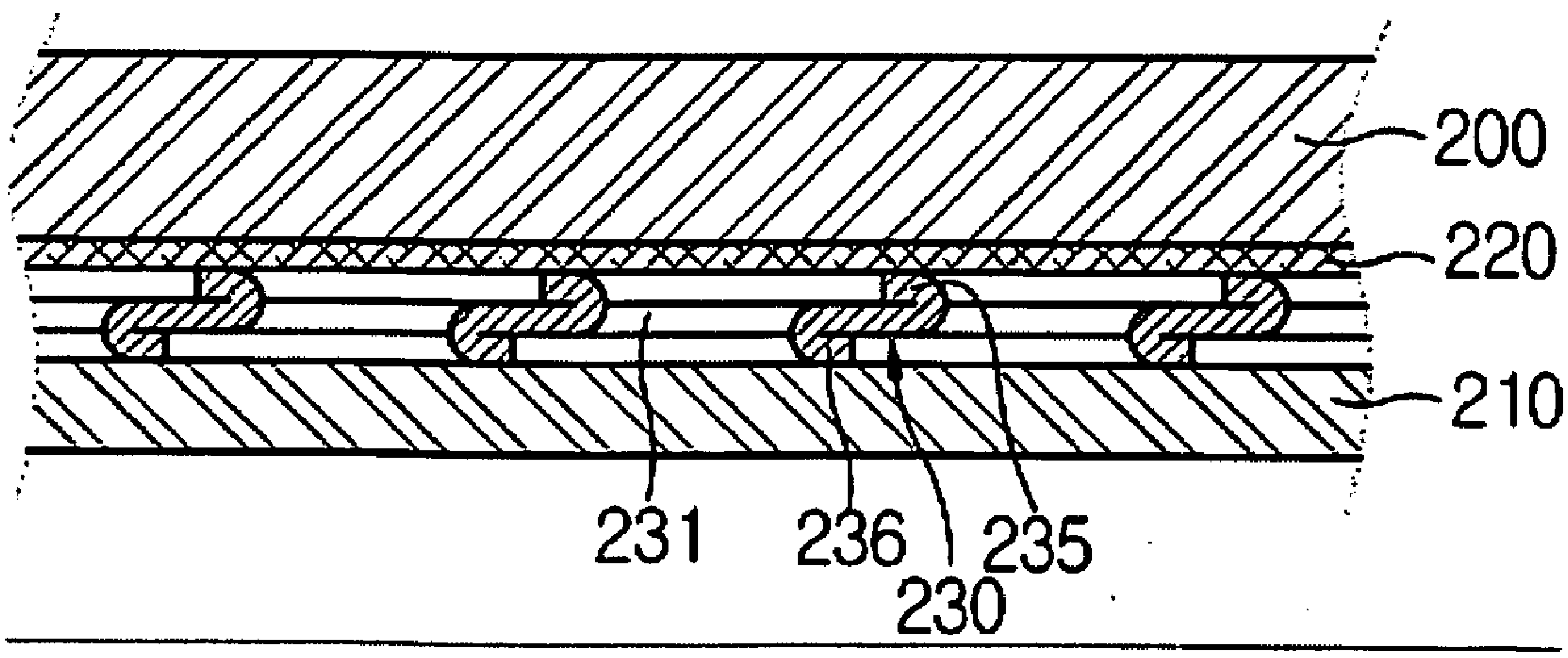


FIG. 1A

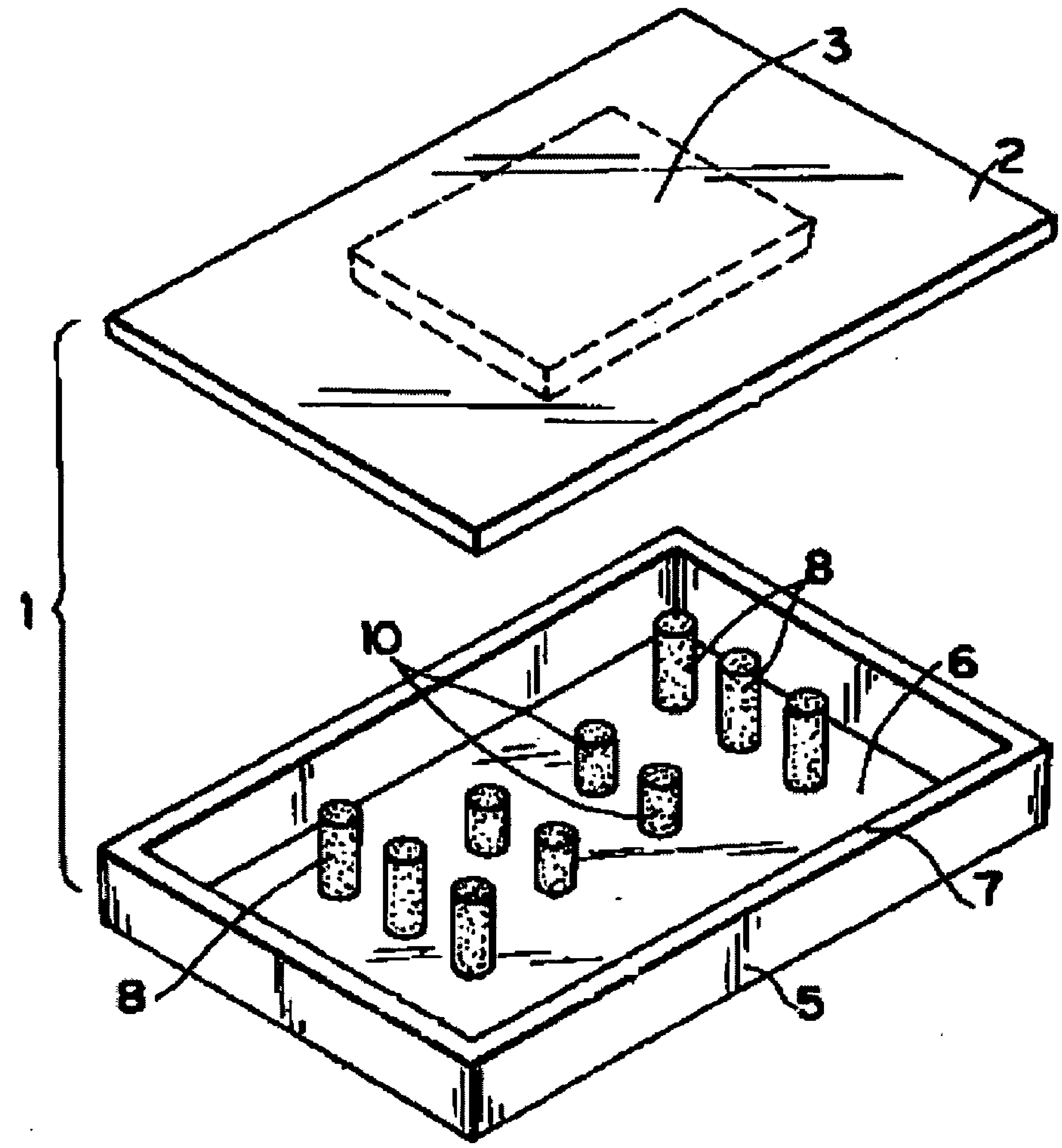
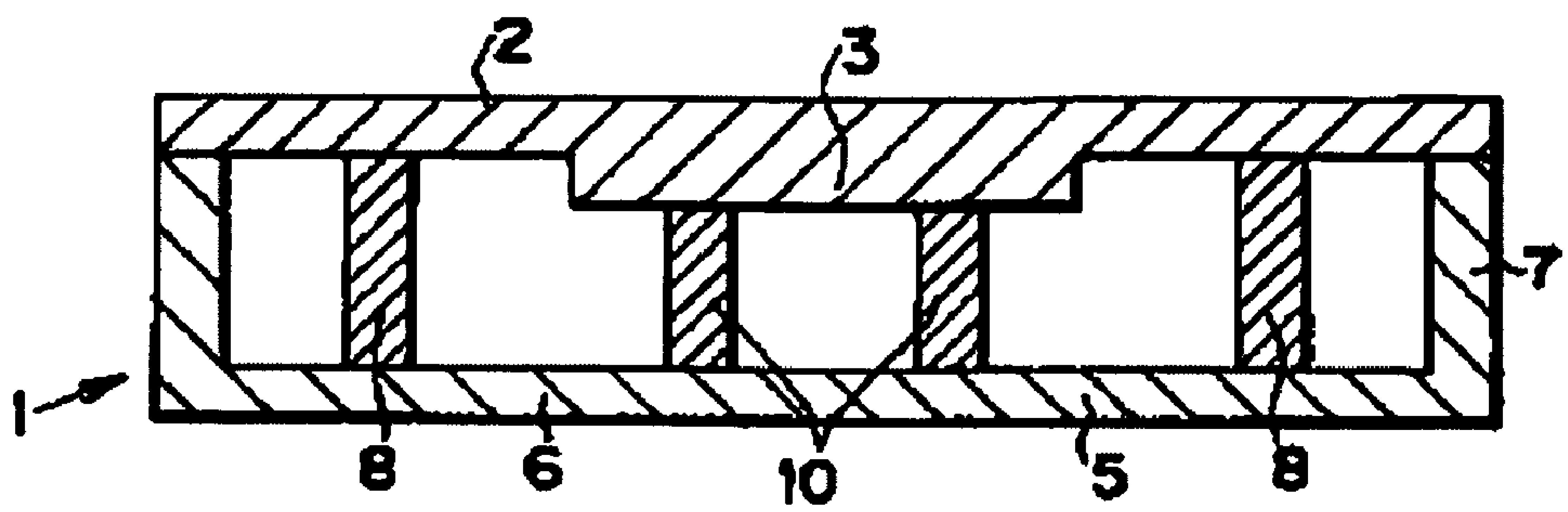



FIG. 1B



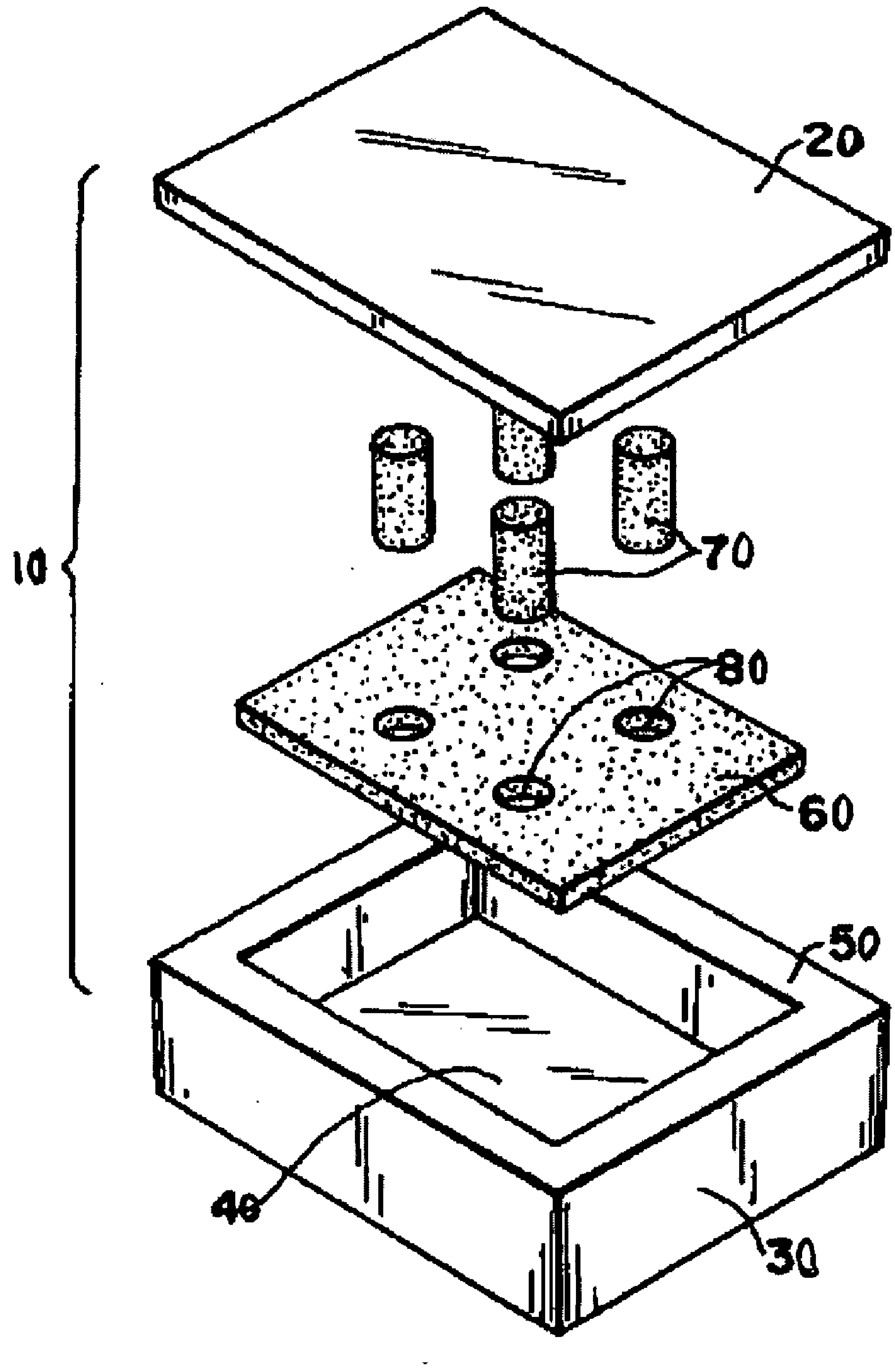



FIG. 2

FIG. 3

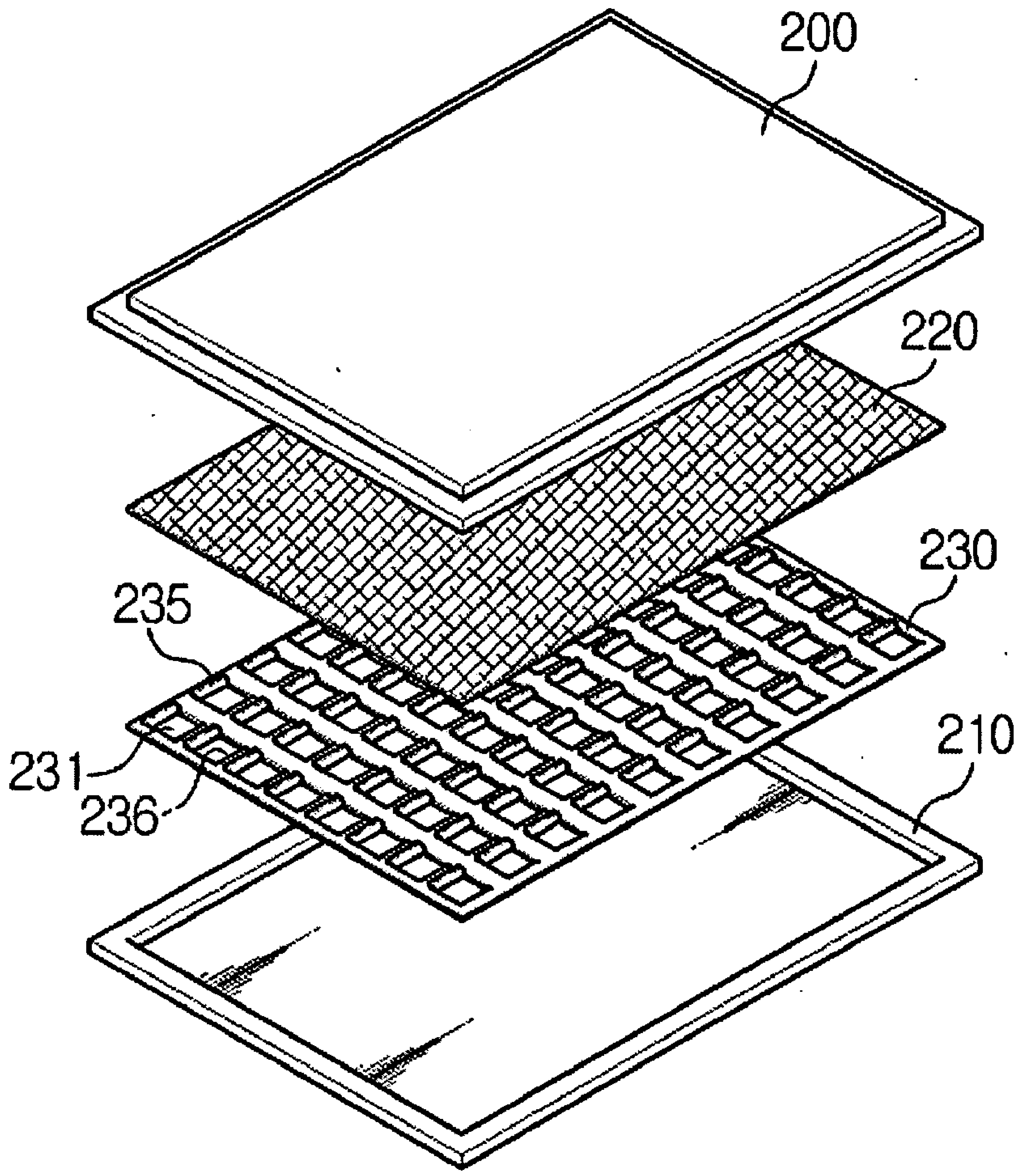



FIG. 4

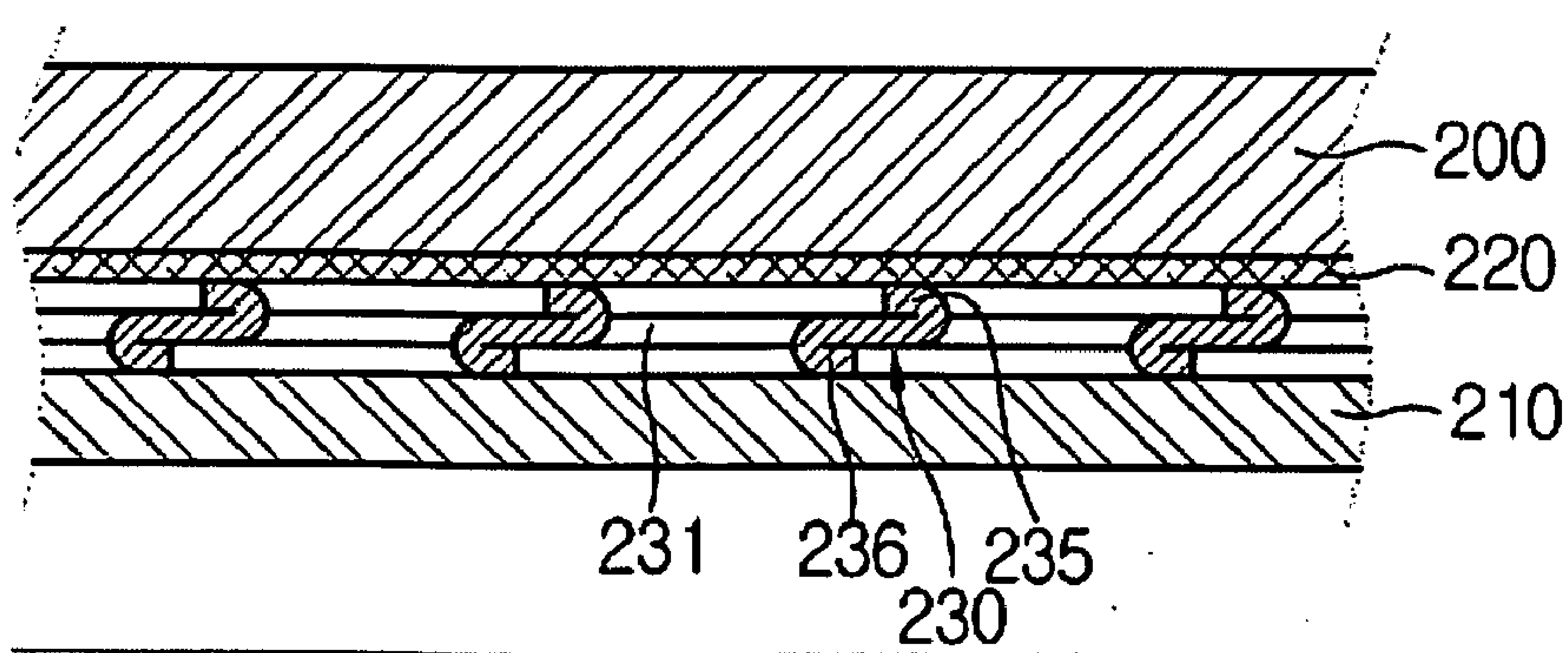
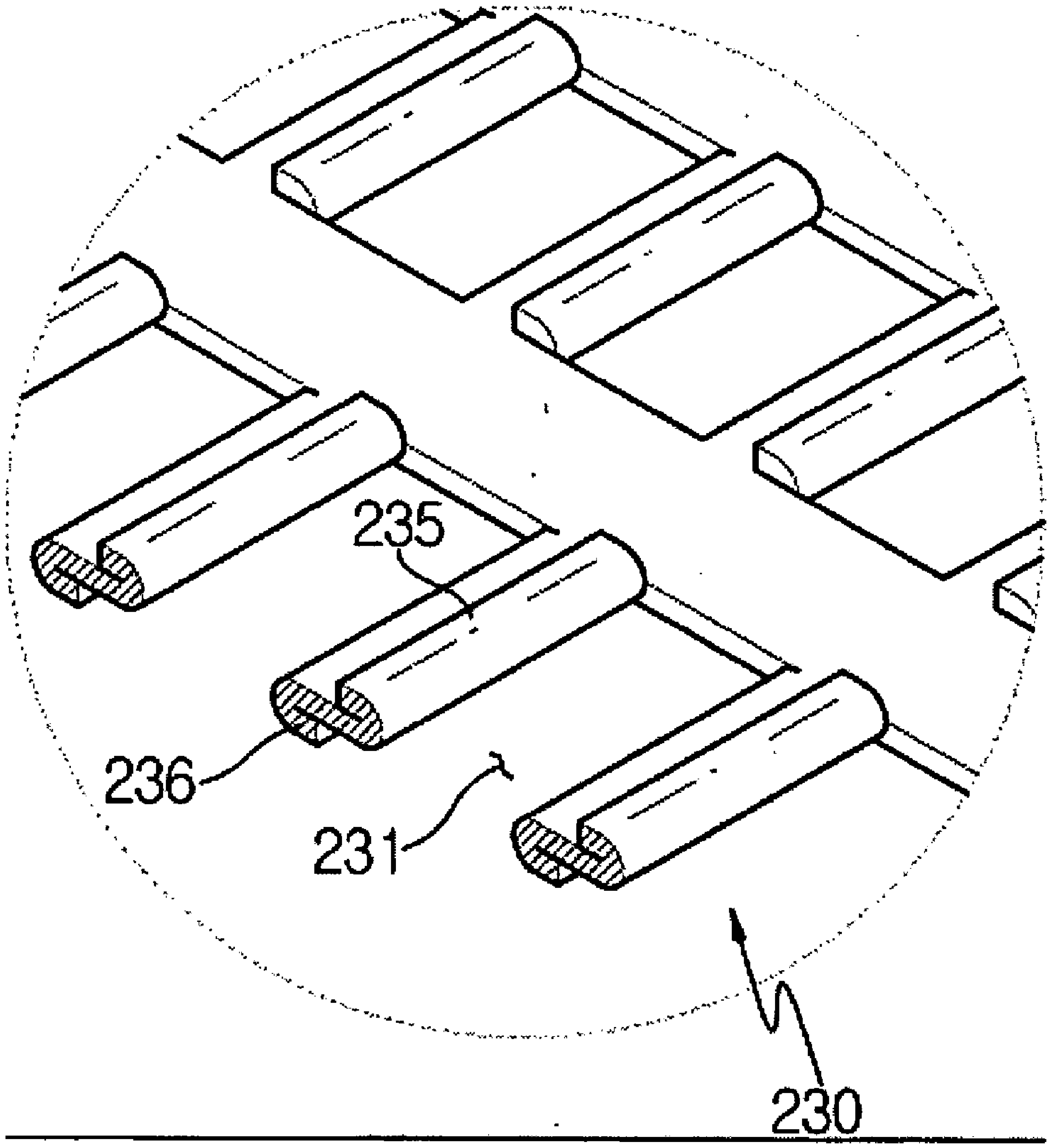


FIG. 5



# FIG. 6

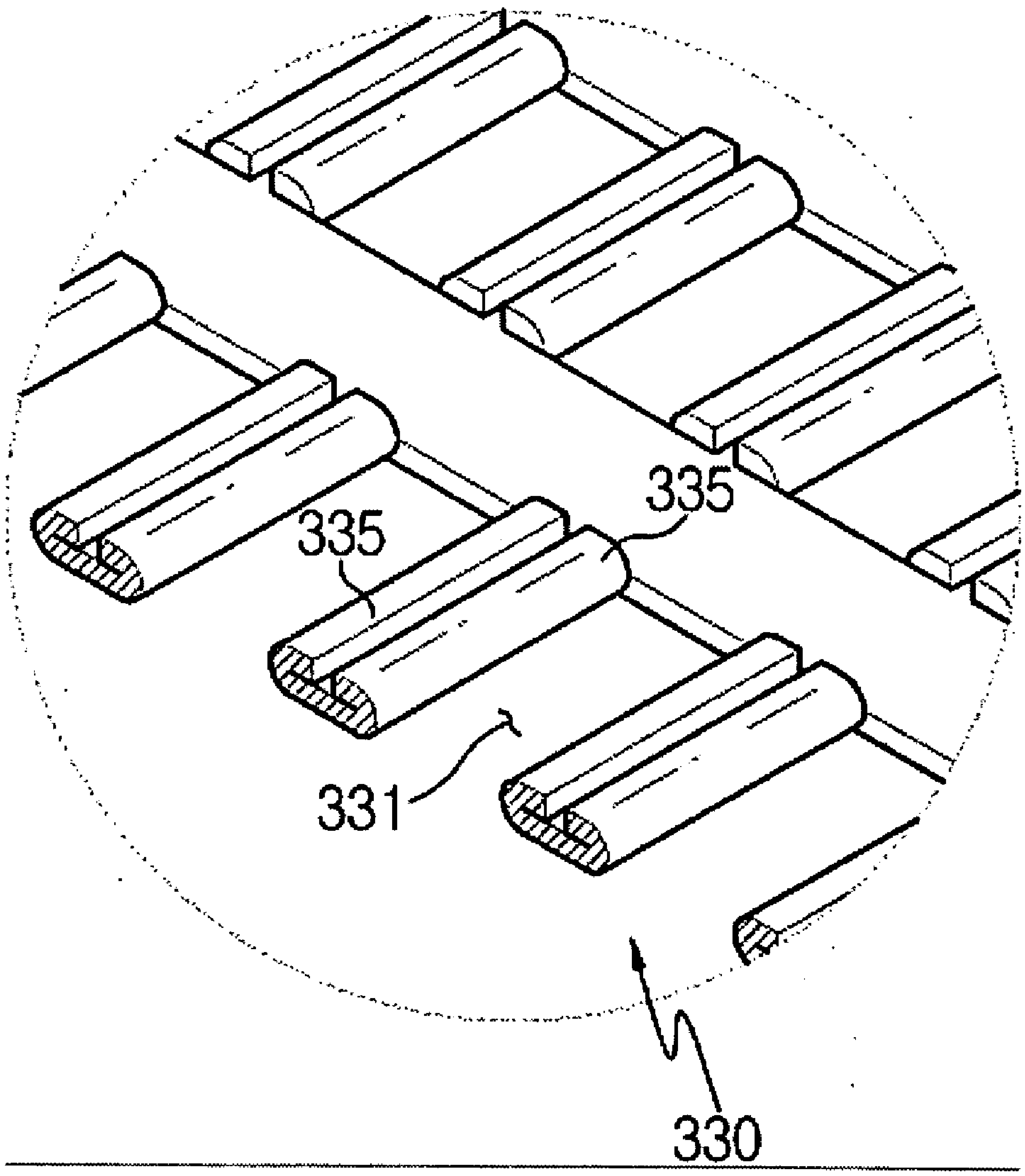
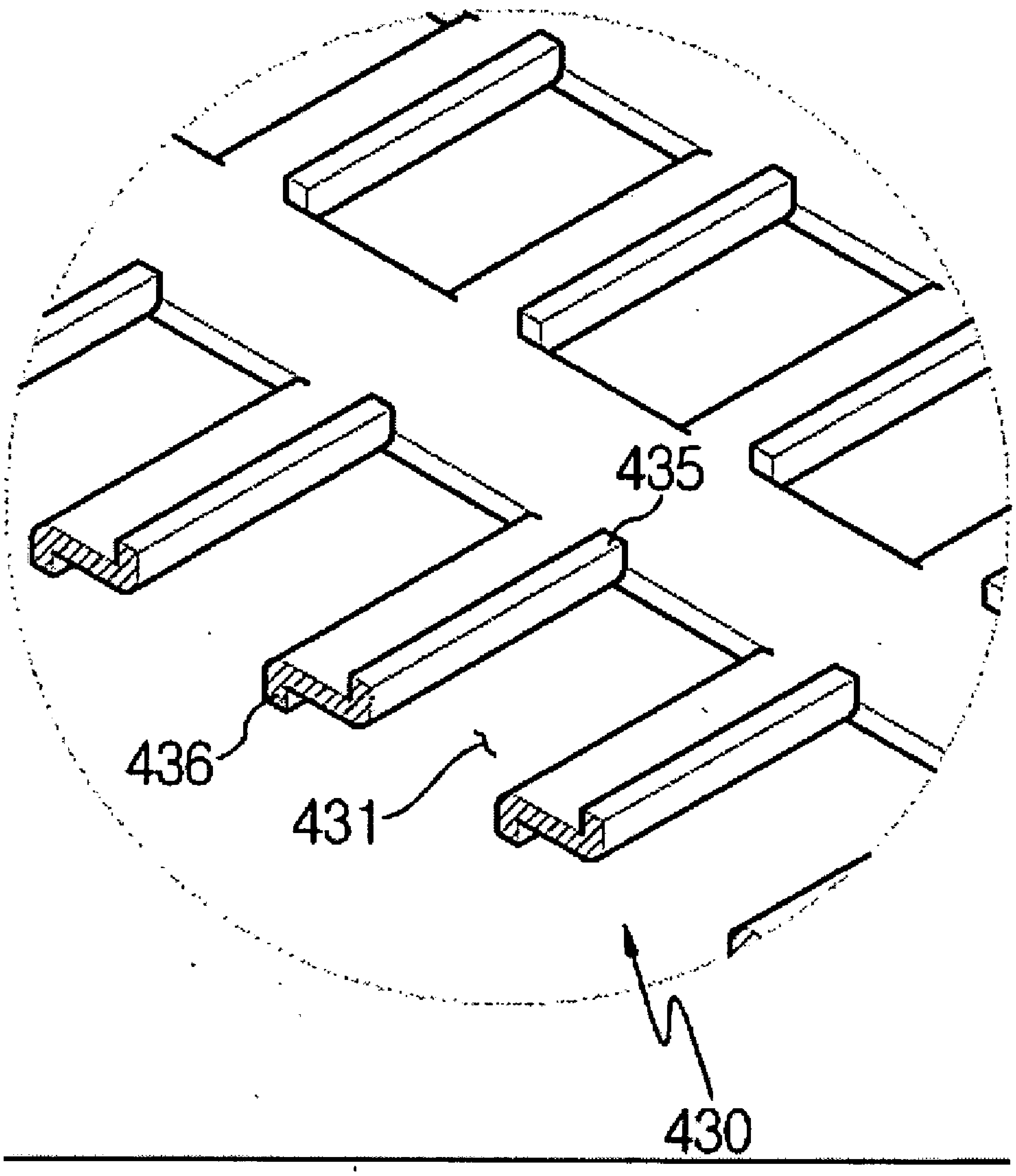


FIG. 7



# FIG. 8

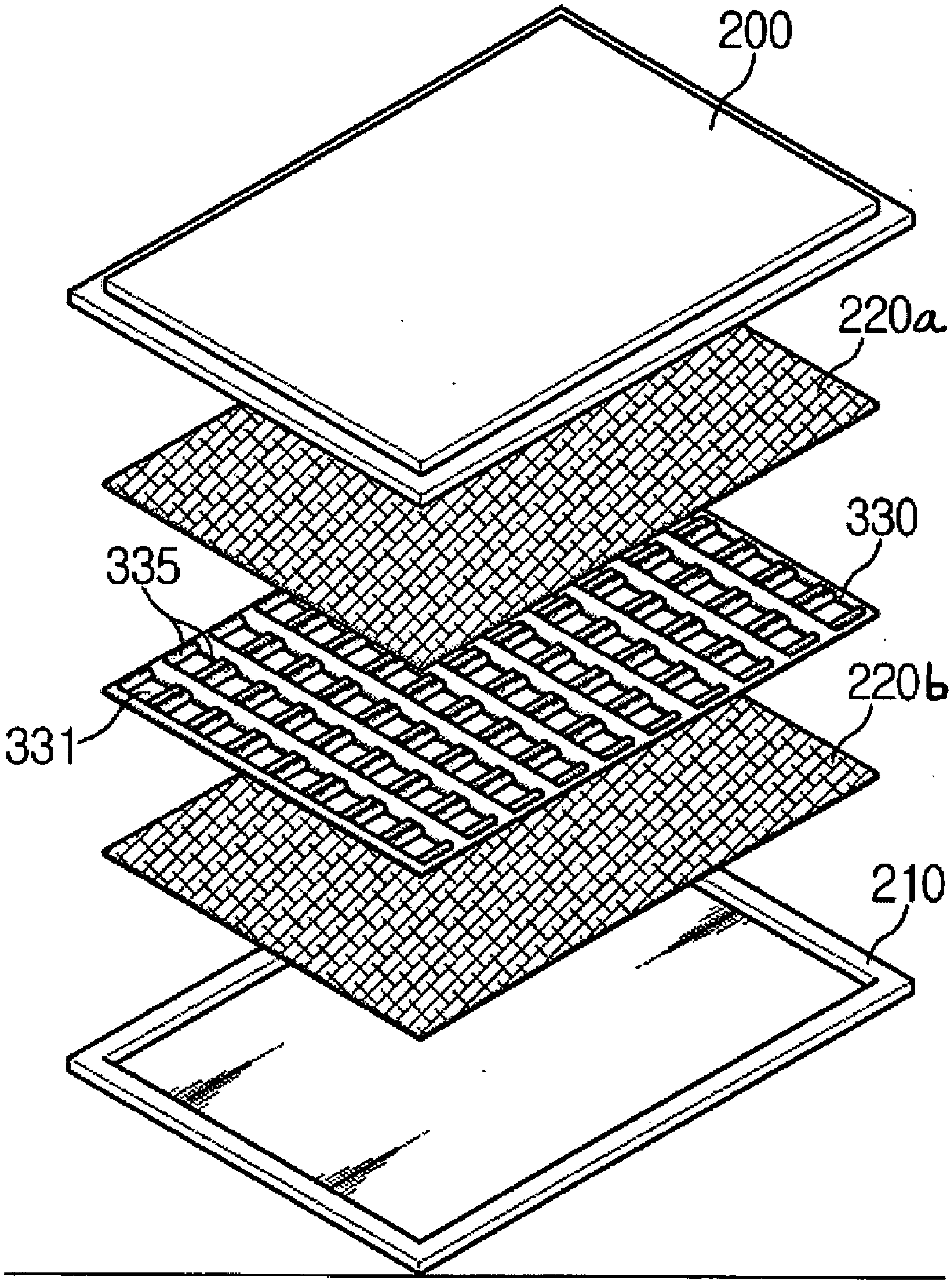


FIG. 9

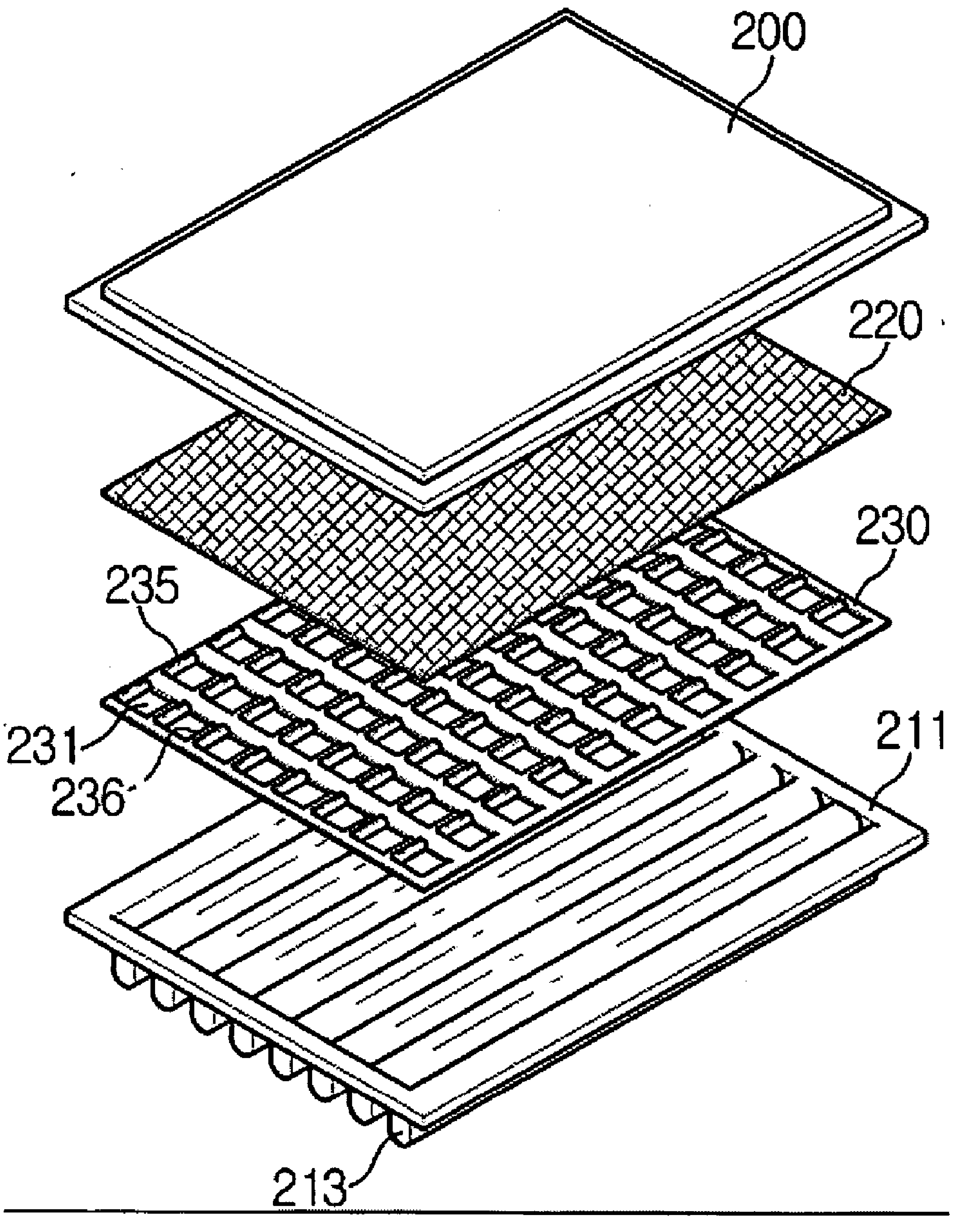


**FIG. 10**

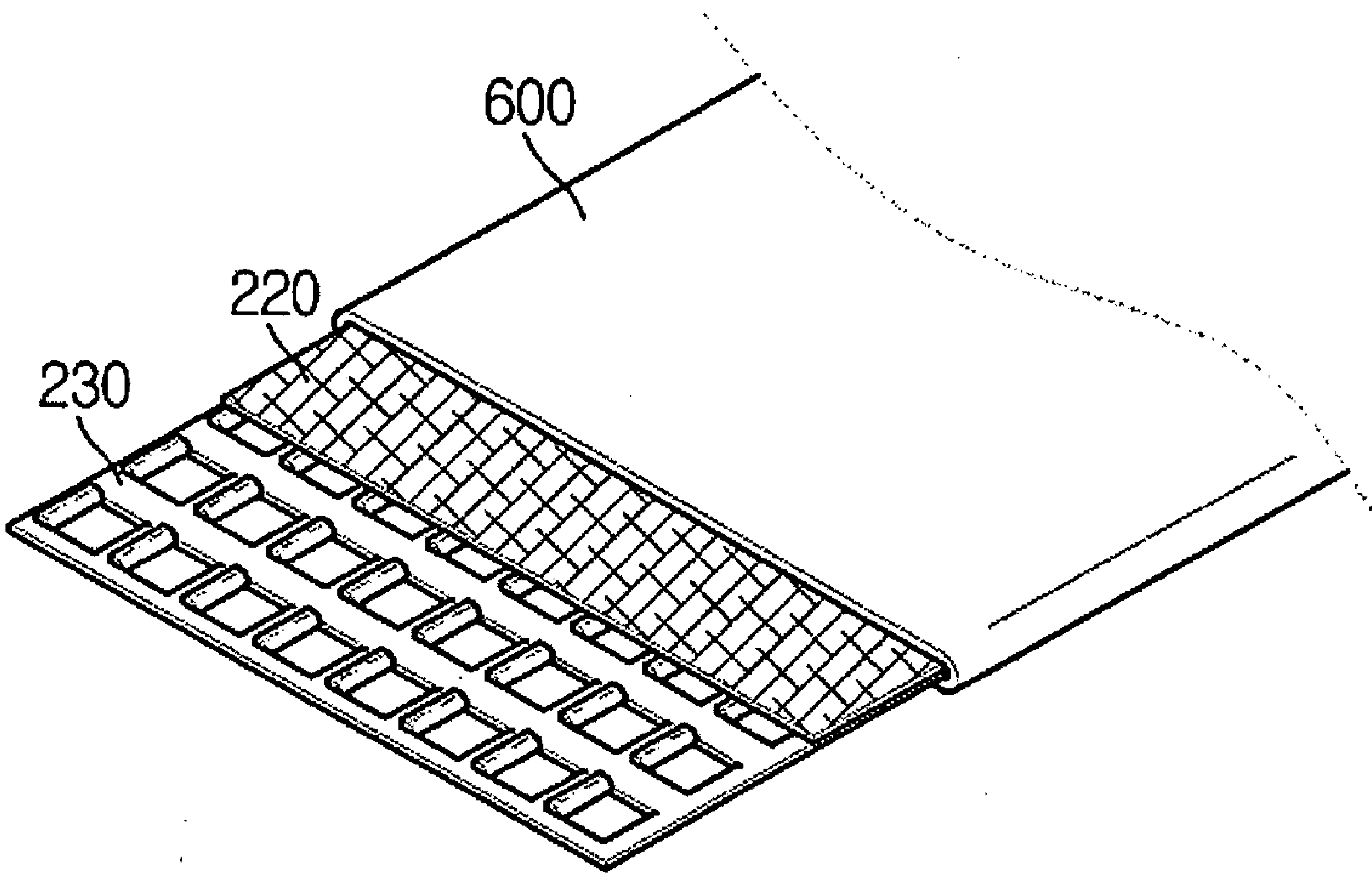


FIG. 11

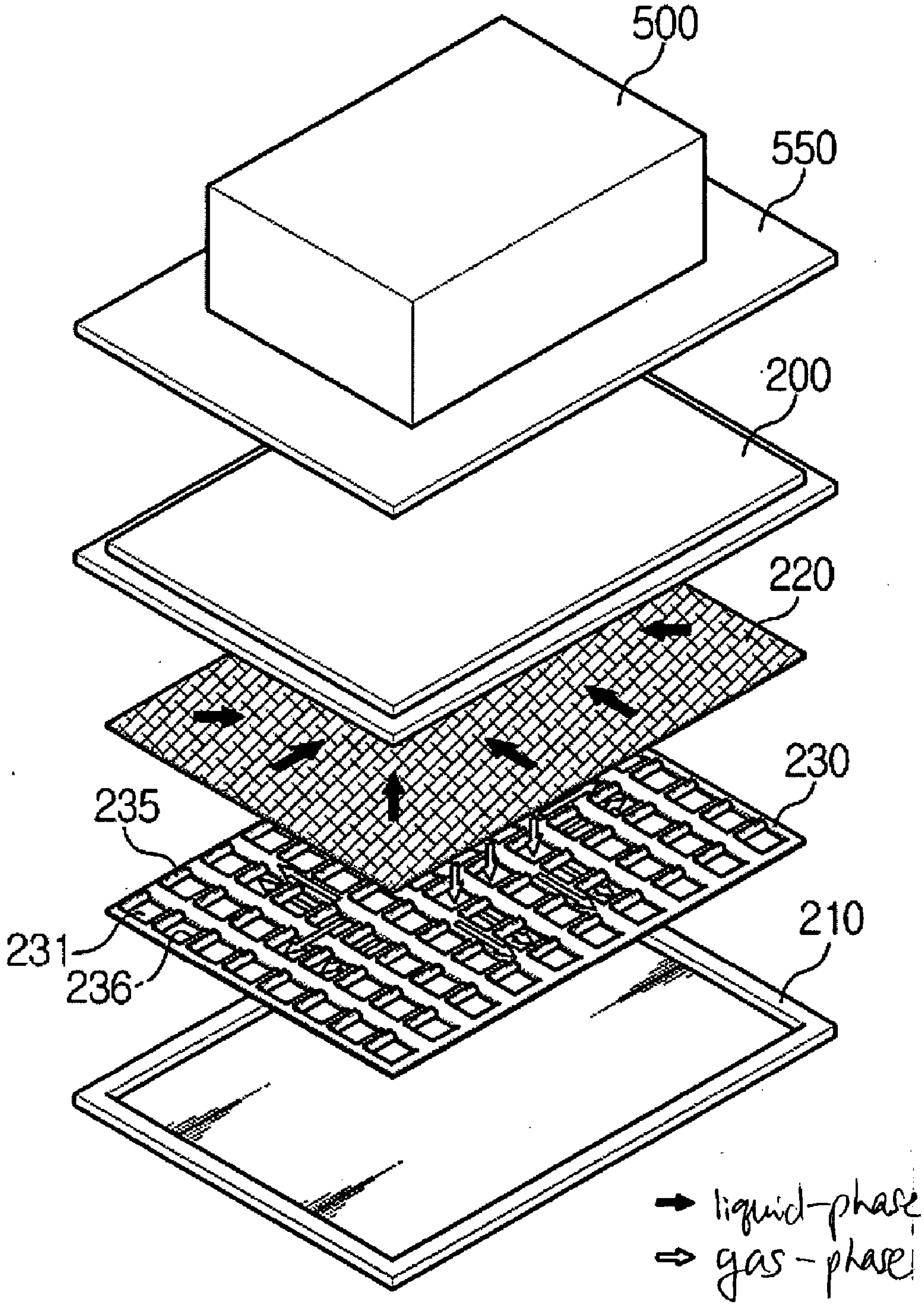
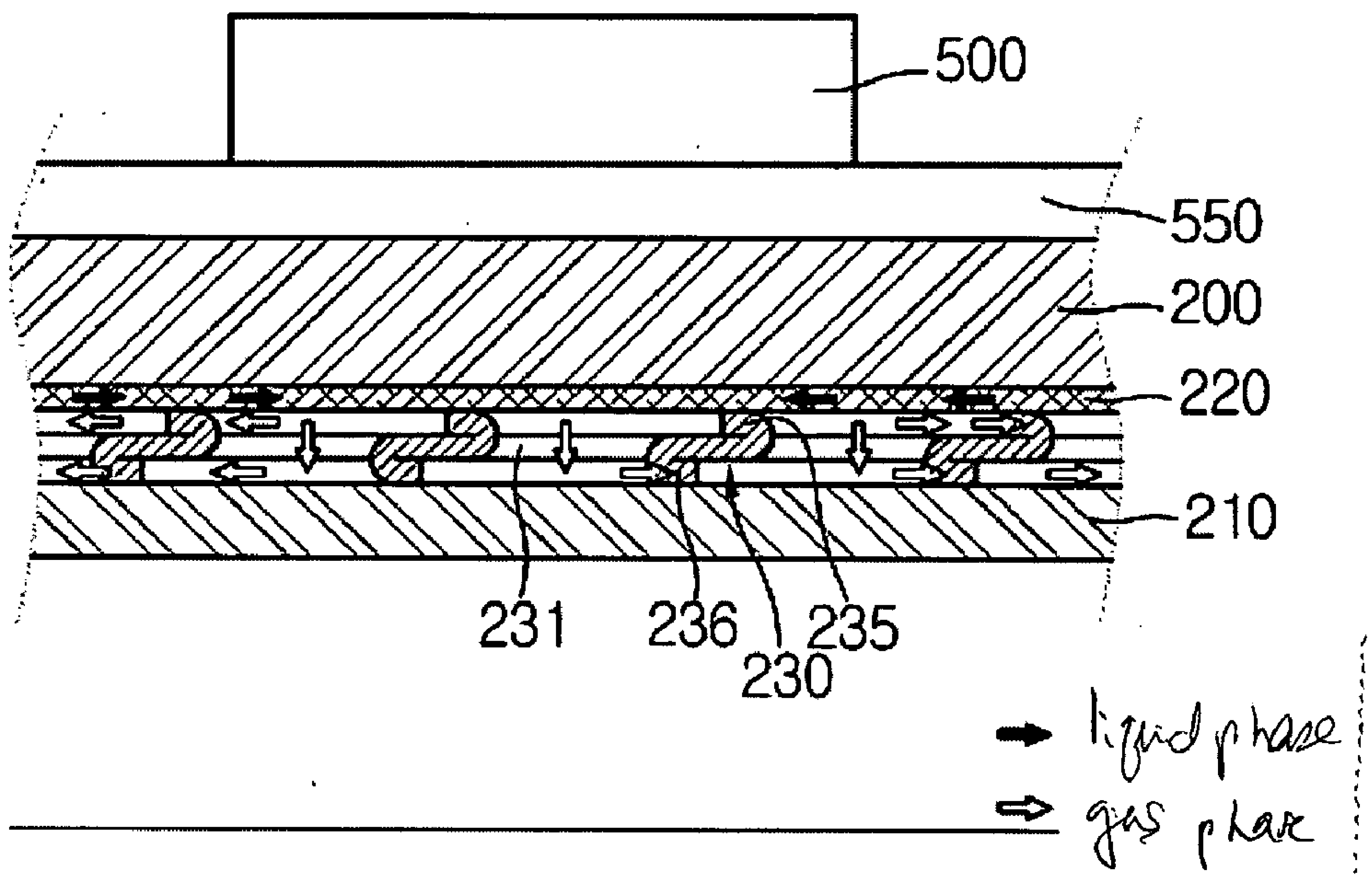


FIG. 12



# SUPPORT STRUCTURE FOR A PLANAR COOLING DEVICE

## CROSS REFERENCE TO RELATED APPLICATION(S)

**[0001]** This application claims priority from Korean Patent Application No. 10-2006-0034917 filed on Apr. 18, 2006, the content of which is incorporated by reference herein in its entirety.

## BACKGROUND OF THE INVENTION

**[0002]** 1. Field of the Invention

**[0003]** The invention relates generally to heat transfer devices and more specifically to cooling devices capable of being placed in small spaces.

**[0004]** 2. Background Information

**[0005]** Today, memory chips, central processing units, and embedded chips are used in numerous types of electronic devices. To ensure reliable operation of these devices, the devices have to be prevented from overheating. Keeping various electronic devices cool enough for optimal performance has become more challenging as the circuit density increases and many of these devices are made smaller and lighter. Furthermore, many consumer electronic devices today include additional heat sources such as optical display components. For example, laptops, personal digital assistants (PDA), and mobile phones may include liquid crystal display (LCD) panels using lamps or light emitting diodes (LEDs) as light sources. With electronic devices getting more compact yet including more heat sources, the traditional methods of dealing with heat dissipation, such as open packaging or cooling fans, do not provide an adequate solution to heat generation in these devices.

**[0006]** Recently, cooling devices that use evaporation and condensation, generally called "heat pipes," have become popular for dissipating heat in electronic devices. An advantage of heat pipes over cooling fans is that they can be made smaller, in line with the general size trend of consumer electronics.

**[0007]** FIGS. **1**A and **1**B are exploded perspective view and a cross-sectional view, respectively, of a conventional planar heat pipe **1**. As shown, the heat pipe **1** has an open box **5** and a lid **2** that are designed to be combined. The open box **5** includes a base **6** and sidewalls **7**. The lid **2** is a plate having a thick portion **3** near its center. As shown, the thick portion **3** is located such that it is placed inside the cooling device **1** when the open box **5** is combined with the lid **2**.

**[0008]** A plurality of support structures **8**, **10** are formed inside the heat pipe **1**. The support structure **8** is of such height that it extends between the base **6** and the part of the lid **2** that is not the thick portion **3**. The support structure **10** extends between the base **6** and the thick portion **3**. The outer layers of the support structures **8**, **10** are made with capillary wicks, thus enhancing the circulation of fluid (e.g., coolant) through capillary force.

**[0009]** If a heat source (e.g., CPU) is attached to the lid **2** of the heat pipe **1**, the fluid that was absorbed in the capillary wick layer of the support structures **8**, **10** evaporate by absorbing the heat. The gas-phase fluid moves toward the base **6** and condenses as heat is dissipated through the sidewalls **5**. The condensed fluid is absorbed back by the capillary wick layer of the support structures **8**, **10**, and the evaporation-condensation cycle repeats.

**[0010]** The heat pipe I shown in FIGS. **1**A and **1**B has numerous disadvantages. First, the design of the support structures **8**, **10** cause the cooling device **1** to be thicker than what is acceptable for many applications. The overall thickness cannot be decreased without compromising the cooling efficiency. Second, the heights of the support structures **8**, **10**, which span the distance between the base **6** and the lid **2**, have to be exact for the cooling device to function properly. A small manufacturing error that changes the height of one of the support structures **8**, **10** could prevent the cooling device **10** from being properly assembled, possibly adversely affecting its performance.

**[0011]** FIG. **2** is an exploded perspective view of another conventional heat pipe **10**. The heat pipe of FIG. **2** includes an upper member **20** and a lower member **30** that can be combined to form a coolant space. Similarly to the heat pipe **1** of FIGS. **1**A and **1**B, the lower member **30** has a base **40** and sidewalls **50**. However, unlike the cooling device **1**, the cooling device **10** has a capillary sheet **60** that fits in the space defined by the sidewalls **50**. The support structure **70** are also different from the support structures **8**, **10** of the heat pipe **1** because it is designed to fit with holes **80** on the capillary sheet **60**.

**[0012]** The heat pipe **10** is not without shortcomings. For example, each support structure **70** is manufactured separately and placed in the holes **80** before it is placed in the heat pipe **10**. These steps complicate the fabrication process. Furthermore, because the capillary sheet **60** and the support structures **70** contain ceramic or metal, the cost of fabrication becomes higher. Therefore, the heat pipe **10** does not lend itself to cost-effective fabrication of thin, light-weight apparatuses.

**[0013]** A need exists for a small, planar heat pipe having a relatively simple structure that can be made cost-effectively.

## SUMMARY OF THE INVENTION

**[0014]** In one aspect, the invention is a support structure for a cooling device. The support structure includes a flat plate with a portion cut out to form an opening and a spacer on the flat plate. The spacer is made by bending the cut-out portion of the flat plate. The support structure may be useful for a planar, thin cooling device.

**[0015]** In another aspect, the invention is a cooling device including a planar casing. A wick layer and the above support structure are positioned inside the casing.

**[0016]** In yet another aspect, the invention is a method of making a cooling device. The method entails forming a support structure by providing a flat plate, cutting a portion of the flat plate to create an opening, and forming a spacer on the flat plate. The spacer is formed by bending the cut portion of the flat plate.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0017]** FIG. **1**A and **1**B show a conventional planar heat pipe.

[0018] FIG. **2** shows another conventional planar heat pipe.

[0019] FIG. **3** is an exploded perspective view of the cooling device in accordance with a first embodiment of the invention.

[0020] FIG. **4** is a cross-sectional view of the cooling device of FIG. **3**.

[0021] FIG. **5** is a close-up view of a portion of the support structure in the cooling device of FIG. **3**.

[0022] FIG. **6** is a close-up view of a portion of an embodiment of the support structure usable with the cooling device of the invention.

[0023] FIG. **7** is a close-up view of a portion of another embodiment of the support structure usable with the cooling device of the invention.

[0024] FIG. **8** is an exploded perspective view of a second embodiment of the cooling device in accordance with the invention.

[0025] FIG. **9** is a third embodiment of the cooling device in accordance with the invention.

[0026] FIG. **10** is an open perspective view of a fourth embodiment of the cooling device in accordance with the invention.

[0027] FIG. **11** is an exploded perspective view of the cooling device attached to a heat source.

[0028] FIG. **12** is a cross-sectional view of the cooling device of FIG. **11** illustrating its operation.

## DETAILED DESCRIPTION OF THE INVENTION

[0029] The present invention provides a planar cooling device that is structurally simpler than the above-described conventional heat pipes. In the planar cooling device of the invention, a bent portion is incorporated into the support structure to maintain the coolant travel path at a desired size. The design allows for increased coolant travel space, allowing efficient coolant circulation and improved cooling. The cooling device of the invention may be made as thin as 0.5-5 mm.

[0030] An additional benefit of the structure of the invention is that the support structure imparts rigidity to the device, making the cooling device more reliable.

[0031] Due to its simplified structure, the invention can be produced more cost-effectively than the conventional heat pipes without compromising the cooling power.

[0032] As used herein, "planar" structure is a structure having a flat portion.

[0033] FIG. **3** is an exploded perspective view of the cooling device in accordance with a first embodiment of the invention, FIG. **4** is a cross-sectional view of the cooling device of FIG. **3**, and FIG. **5** is a close-up view of a portion of the support structure in the cooling device of FIG. **3**.

[0034] As shown in FIG. **3**, the cooling device of the invention includes a casing made of a first plate **200** and a second plate **210**. The first plate **200** and the second plate **210** may be combined to form an enclosed space between the two plates **200**, **210**. The two plates **200**, **210** may be sealed together to form the enclosed space so that a coolant fluid (e.g., water, methanol, ethanol) is contained in the enclosed space. The seal may be formed around the edges so as to not intrude upon the enclosed space. Either or both of the first and second plates **200**, **210** is designed so that it can be attached to a printed circuit board (PCB) or a chip. For example, the first plate **200** may have a flat surface that can easily be attached to a PCB or a chip, and an adhesive layer may be placed on the flat surface.

[0035] The first plate **200** and the second plate **210** are made of a material that has sufficient rigidity to protect the structures in the space between the two plates. The material may be, for example, aluminum, titanium, plastic, metallized plastic, graphite, copper, or any plastic combination capable of transferring heat effectively. Preferably, the first plate **200** and the second plate **210** are prepared from one large sheet of material. The first plate **200** and the second plate **210** may be laminated to facilitate their attachment to a heat source.

[0036] Between the first plate **200** and the second plate **210** is a capillary wick **220**. The capillary wick **220**, which is attached to the first plate **200**, is capable of absorbing the coolant fluid by capillary action. The capillary wick **220** is preferably made of a hydrophilic wick. A hydrophilic wick, which is well-known, contains a plurality of micro-fibers and each micro-fiber is capable of absorbing and retaining the coolant fluid. In some embodiments, the capillary wick **220** may be attached to the second plate **210**.

[0037] A support structure **230** is also located between the first plate **200** and the second plate **210**. In the particular embodiment of FIG. **3**, the support structure **230** is located between the wick layer **220** and the second plate **210**. The support structure **230** supports the capillary wick **220** and forms the coolant fluid travel path by maintaining a certain distance between itself and the second plate **210**. The support structure **230** has openings **231** through which the gaseous coolant can travel from one side of the support structure **230** to the other side (e.g., from the side closer to the first plate **200** to the side closer to the second plate **210**).

[0038] To form the openings **231**, the support structure **230**, which initially starts out as a solid plate, is cut to form one or more "flaps" that are partially attached to the main body of the solid plate. For example, an "H" may be cut into the solid plate so that two flaps are formed for each opening **231**. The flaps are then bent or folded to open up the openings **231**, and the bent/folded portion of the flap forms spacers **235** located near the openings **231**. The folded portion is bent by more than a 90°-angle such that the flap touches the flat plate.

[0039] The side of the cooling device that has the capillary wick **220** is the side that is closer to the heat source. The coolant fluid is absorbed by the capillary wick **220**. When the cooling device receives heat from the heat source, the coolant fluid in the capillary wick **220** evaporates by absorbing the latent heat. The gas passes through the openings **231** to the other side of the support structure **230**, where it cools down and condenses.

[0040] The spacers **235**, **236** may be formed so that some of them (spacers **235**) are bent toward the first plate **200** and others (spacers **236**) are bent toward the second plate **210**.

As illustrated in FIG. **4**, the spacers **235**"push" the capillary wick **220** toward the first plate **200**, eliminating any unevenness in the contact area between the capillary wick **220** and the first plate **200** and enhancing the efficiency of heat absorption and the effect of capillary force. The spacers **236** push against the second plate **210** to maintain a substantially uniform gap between the support structure **230** and the second plate **210**, thereby maintaining an unimpeded travel path for the coolant fluid. The support structure **230** is made of a material that is rigid enough that the spacers **236** prevent the coolant travel path from being deformed by pressure applied to the cooling device from the outside.

[**0041**] The support structure **230** may be made from a similar list of materials as the first and the second plates **200**, **210**, such as aluminum, titanium, plastic, metalized plastic, graphite, copper, any plastic combination.

[**0042**] FIG. **6** is a close-up view of a portion of a support structure **330** usable with the cooling device of the invention. Unlike in the embodiment of FIGS. **3**, **4**, and **5**, all the spacers **335** are bent in the same direction in this embodiment. The support structure **330** is particularly suited for use with a multi-wick embodiment of the cooling device such as the one illustrated below in FIG. **8**.

[**0043**] FIG. **7** is a close-up view of a portion of a support structure **430** usable with the cooling device of the invention. As shown, the spacers **435**, **436** are bent to form a substantially 90° angle in this embodiment, unlike in the embodiment of FIGS. **3**, **4**, and **5** where the cut-out flaps were "folded."

[**0044**] In yet another embodiment, it is possible to form one spacer per opening instead of two spacers per opening as in the above embodiments. In this case, the support structure **230** would be formed by cutting lines through a solid plate such that the lines form three sides of a rectangle, a "C" shape, or a "U" shape (instead of an "H" shape as in the above embodiments). The flap would then be bent/folded to create the opening and a spacer.

[**0045**] The spacers and the openings do not always have to be formed together. For example, the solid plate of the support structure may be cut with lines that form multiple rectangles so that the piece that is cut out is completely detached from the solid plate. The cut-out piece can then be formed into a desired shape and attached to a desired spot on the solid plate so that it can maintain a separation distance between the support structure and an adjacent layer.

[**0046**] The support structure **230/330/430** may be attached to one of the first and second plates **200**, **210** by any well-known attachment method, such as welding (tig welding, plasma welding, seam welding, high frequency welding, etc.) or soldering a surface of the support structure **230/330/430** to the plate. Attaching the support structure to one of the plates **200**, **210** improves heat exchange and enhances general reliability of the cooling device.

[**0047**] FIG. **8** is an exploded perspective view of a second embodiment of the cooling device in accordance with the invention. As shown, the cooling device of the multi-wick embodiment includes the first plate **200**, the second plate **210**, and the support structure **330**. In addition, the cooling device includes a first wick layer **220***a* and a second wick layer **220***b* positioned between the support structure **330** and one of the plates **200**, **210**, respectively. The support structure **330** is, therefore, located between the two wick layers **220***a*, **220***b*. Details of the support structure **330** were provided above in reference to FIG. **6**. The cooling device of FIG. **8** may be made with the support structure **230** or **430** as well. The multi-wick embodiment of the cooling device works particularly well when there are two heat sources, one near each of the two plates **200**, **210**. In the case where there are two heat sources, the parts of the cooling device that are closest to the two heat sources act as evaporation areas, and condensation occurs in the other parts of the cooling device.

[**0048**] FIG. **9** is a third embodiment of the cooling device in accordance with the invention. The finned-embodiment that is shown is substantially similar to the embodiment of FIG. **3** except that it has fins **213** on the lower plate **211** to increase the heat exchange surface. In this embodiment, the first plate **210** is designed so it can be positioned adjacent to a heat source. The coolant fluid evaporates on the side of the support structure **230** that is closer to the first plate **200**, then expands into the side that is closer to the second plate **210** through the openings **231**. Optionally, each of the fins **213** is designed with a hollow space **215** so that the coolant fluid can travel inside the fins **213** for a more effective heat dissipation. However, the fins **213** being designed to hold coolant fluid is not a requirement of the invention. The presence of the fins **213**, even without the hollow spaces **215**, aids heat dissipation by increasing the heat exchange surface.

[**0049**] FIG. **10** is an open perspective view of a fourth embodiment of the cooling device in accordance with the invention. Unlike the embodiment shown in FIG. **3**, the casing for this embodiment does not use a first plate and a second plate. Instead, the casing is formed with a planar tube **600**. The planar tube **600** may be prepared by obtaining a cylindrical pipe and pressing it down to a planar shape. Methods that may be used to press the pipe to form a planar tube are well known, and depends on the material from which the cylindrical pipe is made. The capillary wick **220** is attached to an inner surface of the planar tube **600**, and the support structure **230** is positioned inside the planar tube. Once the capillary wick **220** and the support structure **230** are placed in the tube **600**, the open ends of the tube **600** are sealed. Although FIG. **10** shows the support structure **230** as being used, support structures of other designs (e.g., support structures **330**, **430**) may be used with the tube embodiment. The tube embodiment is cost-effective because it is simple to manufacture.

[**0050**] The tube **600** may be made of the same material as the first and the second plates **200**, **210**, such as aluminum, titanium, plastic, copper, metalized plastic, graphite, plastic combinations, and other suitable metals with good heat conduction properties.

[**0051**] FIG. **11** is an exploded perspective view and FIG. **12** is a cross-sectional view illustrating the operation of the cooling device of the invention. In the example that is illustrated, a PCB **550** with a chip **500** (a heat source) is attached to the cooling device. The first plate **200** of the cooling device is adjacent to the PCB **550**, so that the heat that is generated from the chip **500** reaches the first plate **200** through the PCB **550**. The heat that reaches the first plate **200** evaporates at least some of the coolant fluid that was absorbed in the wick layer **220**. As some of the coolant fluid in the wick layer **220** evaporates, more liquid-phase coolant is pulled to fill the space by capillary force (see dark arrows). Due to the thinness of the cooling device, the weight of the water vapor is low enough that gravitational effects do not interfere with the liquid absorption by capillary force.

[0052] In the hot part of the cooling device, the coolant fluid absorbs latent heat to change its phase from liquid to gas, making the heat absorption that occurs at the interface between the cooling device and the PCB **550** highly efficient.

[0053] Some of the evaporated gas-phase coolant fluid expands in the space between the first plate **200** and the wick layer **220**. Some gas-phase coolant fluid crosses over to a cooler portion of the cooling device through the openings **231** in the support structure **230**, as shown by the light arrows. The coolant fluid that passes through the openings **231** expands in all directions to fill the space between the support structure **230** and the second plate **210**. As the coolant fluid expands in the cool portion of the cooling device and dissipates heat through the second plate **210**, condensation occurs. The condensed liquid is absorbed back by the wick layer **220** through capillary force and repeatedly goes through the evaporation-condensation cycle. The spacers **235** maintain the distance between the support structure **230** and the first plate **200**, while the spacers **236** maintain the distance between the support structure **230** and the second plate **210**. Thus, with the wick layer **220** and the space created by the support structure **230**, there is an open path through which the coolant fluid can circulate unimpeded between the hot and cool portions of the cooling device.

[0054] The cooling device of the invention simplifies manufacturing and therefore allows cooling devices to be made cost-effectively. The support structure **230**"pushes" the wick layer **220** close to the surface of the cooling device that is closest to the heat source, improving heat transfer. At the same time, the support structure **230** maintains a circulation space for the coolant fluid to aid heat dissipation. Furthermore, the support structure **230** makes the cooling device rigid, and therefore more reliable. Without the support structure, the cooling space could be deformed (e.g., the two plates collapse toward each other) easily upon impact, impeding the coolant circulation path and disturbing the flow of the coolant fluid. The simple design of the spacers **235**, **236** and the openings **231** allow the support structure to perform all these functions without raising the manufacturing cost.

[0055] Although the invention has been described with reference to the above example, it will be understood that modifications and variations are encompassed within the spirit and scope of the invention. For example, the shape and number of the spacers are not limited to the particular embodiments shown here. Any structure that may be formed from a solid plate to maintain a certain distance between the support structure and an adjacent plate would be within the spirit and scope of the invention. Accordingly, the invention is limited only by the following claims.

What is claimed is:

**1**. A support structure for a cooling device, the support structure comprising:

a flat plate with a portion cut out to form an opening; and

a spacer on the flat plate, wherein the spacer is made by bending the cut-out portion of the flat plate.

**2**. The support structure of claim 1, wherein the cut-out portion is bent while partially attached to the flat plate so that the spacer is attached to the flat plate.

**3**. The support structure of claim 1, wherein two cut-out portions are formed in forming the opening, and wherein the two-cutout portions are made into two spacers.

**4**. The support structure of claim 3, wherein the flat plate is cut out in the shape of an H so that the opening is a rectangular opening and the two spacers are formed along parallel sides of the rectangular opening.

**5**. The support structure of claim 3, wherein the two cut-out portions are bent in different directions so that the two spacers are formed on different surfaces of the flat plate.

**6**. The support structure of claim 3, wherein the two cut-out portions are bent in the same direction so that the two spacers are formed on the same surface of the flat plate.

**7**. The support structure of claim 1, wherein bending the cut-out portion of the flat plate comprises folding the cut-out portion onto a surface of the flat plate.

**8**. The support structure of claim 1, wherein bending the cut-out portion of the flat plate comprises bending the cut-out portion so that it forms a substantially 90°-angle with respect to the flat plate.

**9**. The support structure of claim 1 further comprising a plurality of cut-out portions that form a plurality of openings and a plurality of spacers.

**10**. The support structure of claim 1, wherein the flat plate is made of one of aluminum, titanium, plastic, metallized plastic, graphite, and copper.

**11**. A cooling device comprising:

a planar casing;

a wick layer positioned inside the casing; and

a support structure positioned inside the casing, wherein the support structure has:

a flat plate with a portion cut out to form an opening; and

a spacer on the flat plate, wherein the spacer is made by bending the cut-out portion of the flat plate.

**12**. The device of claim 11, wherein the planar casing comprises a first plate and a second plate attached together to form a space between them.

**13**. The device of claim 11, wherein the planar casing comprises a flattened tube.

**14**. The device of claim 11, wherein the planar casing has fins.

**15**. The device of claim 4, wherein the fins have a hollow space so that fluid in the planar casing travels in the hollow space.

**16**. The device of claim 11, wherein the wick layer is positioned between an inner surface of the planar casing and the support structure.

**17**. The device of claim 11, wherein the wick layer is attached to an inner surface of the planar casing.

**18**. The device of claim 11, wherein the wick layer is a first wick layer, further comprising a second wick layer positioned on the other side of the support structure from the first wick layer.

**19**. The device of claim 11, wherein the wick layer is a copper felt layer.

**20**. The device of claim 11, wherein the wick layer is a hydrophilic wick capable of absorbing fluid by capillary force.

**21**. The device of claim **111**, wherein the cut-out portion of the support structure is bent while partially attached to the flat plate so that the spacer is attached to the flat plate.

**22**. The device of claim 11, wherein there are two cut-out portions formed in forming the opening and the two cut-out portions are made into two spacers.

**23**. The device of claim 22, wherein the opening is a rectangular opening and the two spacers are formed along parallel sides of the rectangular opening.

**24**. The device of claim 22, wherein the two cut-out portions are bent in different directions so that the two spacers are formed on different surfaces of the flat plate.

**25**. The device of claim 22, wherein the two cut-out portions are bent in the same direction so that the two spacers are formed on the same surface of the flat plate.

**26**. The device of claim 11, wherein bending the cut-out portion of the flat plate comprises folding the cut-out portion onto a surface of the flat plate.

**27**. The device of claim 11, wherein bending the cut-out portion of the flat plate comprises bending the cut-out portion so that it forms a substantially 90°-angle with respect to the flat plate.

**28**. The device of claim 11, wherein the support structure has a plurality of cut-out portions that form a plurality of openings and a plurality of spacers.

**29**. A method of making a cooling device, the method comprising forming a support structure by:

providing a flat plate;

cutting a portion of the flat plate to create an opening; and

forming a spacer on the flat plate by bending the cut portion of the flat plate.

**30**. The method of claim 29 further comprising placing the support structure in a planar casing.

**31**. The method of claim 30 further comprising attaching the support structure to the planar casing by welding or soldering.

**32**. The method of claim 30 further comprising placing a wick layer inside the planar casing.

**33**. The method of claim 32, wherein the wick layer is a first wick layer, further comprising placing a second wick layer inside the planar casing such that the first and the second wick layers are on different sides of the support structure.

**34**. The method of claim 30 further comprising forming the planar casing by attaching a first plate and a second plate with a seal.

**35**. The method of claim 30 further comprising forming the planar casing by flattening a cylindrical tube.

**36**. The method of claim 30 further comprising forming fins on the planar casing.

**37**. The method of claim 30 further comprising forming hollow spaces inside the fins so that fluid in the planar casing can travel inside the fins.

**38**. The method of claim 29, wherein the forming of the spacer on the flat plate comprises bending the cut portion of the flat plate while a part of the cut portion is attached to the flat plate.

**39**. The method of claim 29, wherein forming of the spacer on the flat plate comprises forming a plurality of spacers for the opening.

**40**. The method of claim 39, wherein the plurality of spacers are formed on different sides of the support structure.

**41**. The method of claim 39, wherein the plurality of spacers are formed on the same side of the support structure.

**42**. The method of claim 29, wherein bending the cut portion comprises folding the cut portion against the flat plate.

**43**. The method of claim 29, wherein bending the cut portion comprise forming a substantially 90°-angle between the cut portion and the flat plate.

**44**. The method of claim 29 wherein the cutting of the portion of the flat plate comprises cutting an "H" pattern on the flat plate to form two flaps that are capable of being bent to form the opening.

**45**. The method of claim 29 wherein the cutting of the portion of the flat plate comprises cutting a "C" or a "U" pattern on the flat plate to produce a flap capable of being bent to form the opening.

* * * * *