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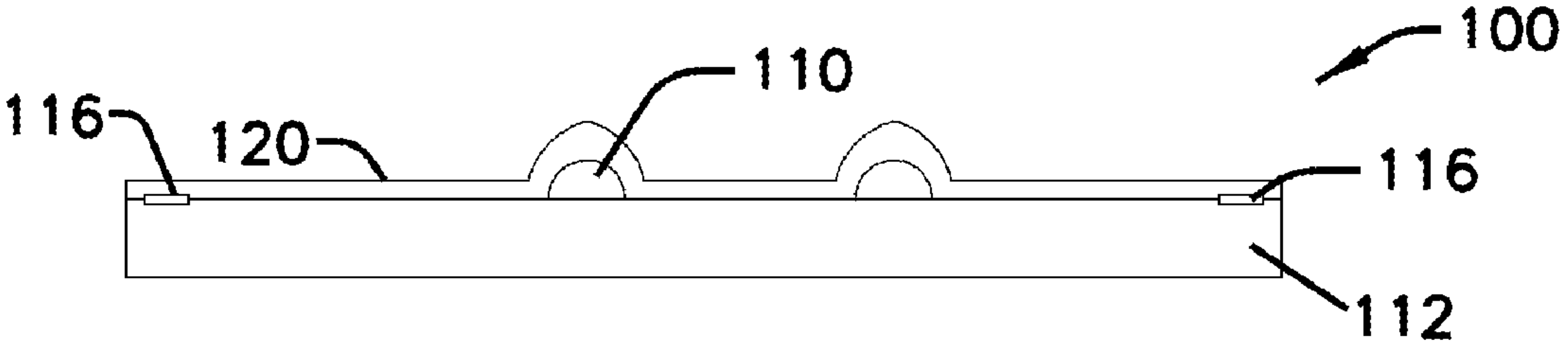
(54) Title: LED LIGHT SYSTEM

FIG. 1



(57) **Abrégé/Abstract:**
A light system includes a first substrate and a second substrate having the first substrate thereon. A light emitting diode (LED) is connected to the first substrate. An encapsulation layer covers the LED and at least a majority of the first substrate.

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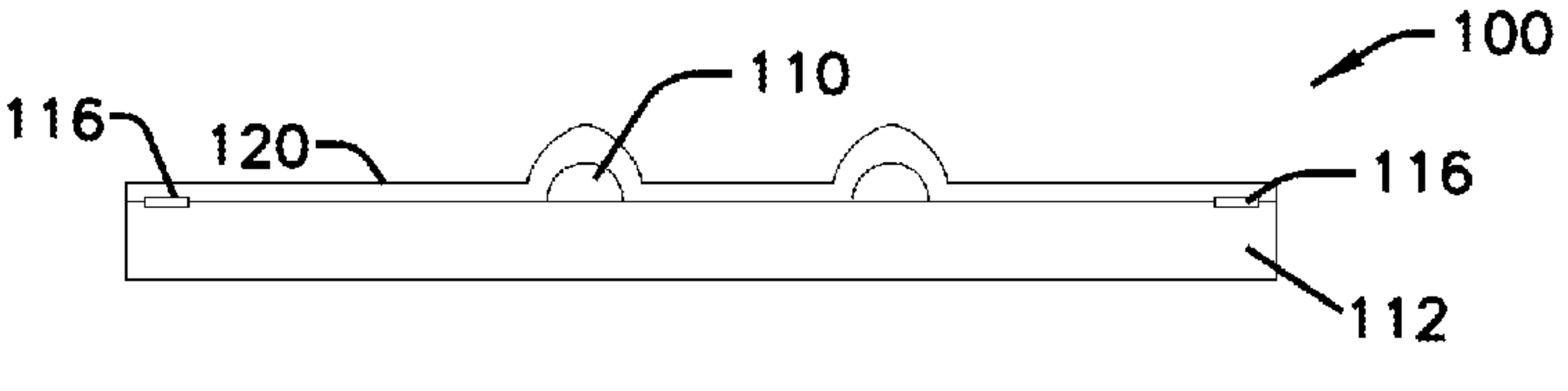
(54) Title: LED LIGHT SYSTEM

FIG. 1



(57) Abstract: A light system includes a first substrate and a second substrate having the first substrate thereon. A light emitting diode (LED) is connected to the first substrate. An encapsulation layer covers the LED and at least a majority of the first substrate.

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LED LIGHT SYSTEM

Cross-Reference to Related Application

[0001] This application is being filed on July 7, 2017 as a PCT International Patent Application and claims the benefit of U.S. Patent Application Serial No. 62/360,001, filed on July 8, 2016, the disclosure of which is incorporated herein by reference in its entirety.

Background

[0002] Lighting systems that use light emitting diodes (LED) as a light source are becoming increasingly popular in many lighting applications. Some applications for LED-based light fixtures include hazardous environments where electrical and thermal abnormalities must be avoided to prevent explosion or fire hazards.

[0003] Some known LED fixture designs have an optical chamber that includes an LED light source, secondary beam shaping refractive optics, a polycarbonate or glass cover, a gasket, and sealant/adhesive for attaching and sealing the light source to the fixture enclosure. Having many different layers adds complexity to the assembly process.

Summary

[0004] In accordance with certain aspects of the present disclosure, a light system includes a first substrate with a light emitting diode (LED) connected to a surface of the first substrate. An encapsulation layer directly contacts and covers the LED and at least a majority of the surface of the first substrate. In some examples, the first substrate is a printed circuit board (PCB) that is attached to a second substrate such as a heat sink substrate. The encapsulation layer is formed of an elastomeric material such as silicone, and the encapsulation may include optic characteristics molded therein.

[0005] In accordance with further aspects of the present disclosure, a method of making a light fixture includes providing an LED on a first substrate, and attaching the first substrate to a second substrate. An encapsulation layer is over molded to cover the LED and at least a majority of the first substrate. In some examples, the encapsulation layer is clamped to the first substrate with the gasket positioned between the encapsulation layer and the second substrate. The over molding process may include positioning a mold over the first and second substrates, and injecting an elastomeric material such as silicone into a cavity formed by the mold and the first and second substrates. The over molding process may further include forming optical characteristics in the encapsulation.

Brief Description of the Drawings

[0006] Figure 1 is a schematic side view illustrating an example of an LED system in accordance with aspects of the present disclosure.

[0007] Figure 2 is a side view illustrating an example LED light fixture in accordance with aspects of the present disclosure.

[0008] Figure 3 is a top view of the LED light fixture shown in Figure 2.

[0009] Figure 4 is a partial section view of a portion of an example LED system used in the LED light fixture shown in Figures 2 and 3, including a co-molded optic and gasket that are inseparably molded.

[0010] Figure 5 is a flow diagram illustrating an example of a process for making an LED system such as that shown in Figure 1.

[0011] Figure 6 illustrates an over mold suitable for use in the process shown in Figure 5.

Detailed Description

[0012] In the following Detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific examples in which the invention may be practiced. It is to be understood that other examples may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense.

[0013] Some known light fixtures that use light emitting diodes (LEDs) as a light source include an LED light source, a lens for providing secondary beam shaping refractive optics, polycarbonate or glass cover, a gasket, and sealant/adhesive. LED fixtures having several material layers can be problematic. For example, multiple layers – each with different refractive indexes – that light has to refract can result in higher refractive losses in the system. Further, manufacturing tolerances of these multiple layers can impact the light distribution pattern and also make assembly complicated. Still further, having different material layers around the periphery of the fixture for ingress protection and restrictive breathing purposes may increase fatigue on a sealing gasket, which overtime could weaken the restrictive breathing properties of the fixture.

[0014] In some examples disclosed herein, the secondary optics and/or poly carbonate/glass cover are replaced with an elastomeric encapsulation layer that includes optical characteristics. In some embodiments, a silicone-based optical layer is used. A desired optical pattern, such as a three-dimensional geometrical pattern, is molded into the encapsulation layer to achieve the desired optical distribution pattern. The encapsulation layer provides the desired surface contact to minimize an air gap between the surface of the LED and the inner surface of the encapsulation. For example, the encapsulation layer may include a free-form lens design molded into the encapsulation layer to produce a predetermined roadway light distribution pattern as defined by the Illuminating Engineering Society of North America (IESNA).

[0015] The provision of the optical encapsulating layer shields the optics from environmental elements such as water and dust, thus eliminating the need for a separate glass or plastic cover. In some examples, the encapsulation material including the molded optics is attached to the LED substrate using a silicone based adhesive. The encapsulation material, which may be a silicone-based material, and the adhesive satisfy the restrictive breathing and ingress protection requirements of the fixture. This can significantly reduce the number of components required for the fixture, eliminating the need for items such as bezel lenses, retainers, gaskets, and associated fasteners.

[0016] Figure 1 conceptually illustrates portions of an LED system 100 in accordance with aspects of the present disclosure. The LED system 100 includes one or more LEDs 110 on a substrate 112. In some examples, the substrate 112 is an LED substrate that may include a printed circuit board (PCB) assembly that provides the necessary electrical connections to the LEDs 110 and other electrical components of the system 10. The substrate 112 is typically connected to a heat sink device. In other examples, the substrate 112 is a heat sink substrate having the LEDs 110 and other components mounted directly thereto.

[0017] An encapsulation layer 120 covers at least a majority of the top surface of the substrate 112, including the LEDs 110. The encapsulation layer shown in Figure 1 covers the entire top surface of the substrate 112. In some examples, the encapsulation layer 120 is formed of an elastomeric material such as silicone or high impact resistant polymers such as polycarbonate based variants. The elastomeric encapsulation material may be a clear or diffused or tinted with a colored additive. Examples of suitable silicone substances include Loctite 5600 Silicone, Loctite Superflex RTV, and Loctite E-30CL 2-part epoxy from Henkel Corporation. The encapsulation layer 120 in some embodiments includes optic characteristics, such as total internal reflection (TIR) optics characteristics. For instance, the silicone encapsulating materials may be molded into optical shapes. Further, diffusing material may be added into the encapsulation material in some implementations, or the encapsulation 120 may be tinted to modify the light spectrum. Still further, the outer optic surface may be textured to diffuse the light and reduce glare. By including optical characteristics in the molded encapsulation 120, the need for an additional lens is eliminated in some implementations.

[0018] Thus, rather than only provide an optical layer over the LEDs 110, the encapsulation layer 120 directly contacts and covers the LEDs 110, as well as surfaces of the substrate 112 that do not have LEDs mounted thereon. In this manner, the encapsulation layer 120 provides a contiguous cover directly on the substrate 112 and LEDs 110, protecting the system 100 from elements such as impacts, corrosion, moisture, etc.

[0019] Figure 2 is a side view, and Figure 3 is a top view illustrating an example light fixture 101 incorporating another example of the LED system 100. The illustrated fixture 101 includes the LED system 100 attached to a heat sink assembly 200 that has a plurality of heat sink fins 202 extending therefrom. A driver compartment 210 houses a driver assembly, which includes a power supply for the fixture 101. The LEDs 110 are shown arranged generally in rows on the substrate 112, though any pattern of LEDs may be employed to achieve the desired light output.

[0020] Figure 4 is a close up, partial section view taken along line IV-IV of Figure 3, illustrating aspects of the LED system 100. The LED system 100 includes a pattern of LEDs 110 on a first substrate 112. In the embodiment shown in Figure 4, the first substrate 112 is an LED substrate that may include a printed circuit board (PCB) assembly that provides the necessary electrical connections to the LEDs 110 and other electrical components of the system 100. The LED substrate 112 is situated on a second substrate 114, which is a heat sink substrate in the illustrated example. The heat sink substrate 114 includes a center hub 118 that provides a routing for conductors such as wires 124 to extend from the LED substrate 112 to the driver compartment 210.

[0021] An encapsulation layer 120 covers the LED substrate 112 and the heat sink substrate 114. As noted above, the encapsulation layer 120 may be formed of silicone. A gasket 116 extends around a periphery of the heat sink substrate 114 and is positioned between the heat sink substrate 114 and the encapsulation layer 120. In the example shown in Figure 4, the encapsulation layer 120 is positioned directly on, and entirely covers the surface of the LED substrate 112, as well as the LEDs 110 mounted on the substrate 112. Thus, even portions of the top surface of the LED substrate 112 not having an LED 120 mounted thereon are covered by the encapsulation layer 120. The encapsulation layer thus acts as a protection layer against corrosion and humidity, protecting the entire upper surface of the LED system 100. In some examples the encapsulation layer 120 defines an air gap 122 between the LED 110 and an interior surface of the encapsulation layer 120, while in other examples there is no air gap between the LEDs 110 and the encapsulation layer 120.

[0022] In the example shown in Figure 4, the encapsulation layer further covers and seals the center hub 118, as well as the wires 124 and other components extending therethrough. In some embodiments, this eliminates the need for a separate seal for the center hub 118. The encapsulation layer 120 further covers connectors, wires, and other components supported by the LED substrate 112 and/or heat sink substrate 114. In this manner, “loose” components such as those not easily mounted to the substrates 112, 114 (antennas, sensors, wires, etc.) are embedded into the encapsulation layer 120 to fix these components in place and protect them from external elements.

[0023] In some implementations, one or both of the LED substrate 112 and the heat sink substrate 114 contain features such as grooves to facilitate the flow of the encapsulant, such as silicone, to help bind the encapsulation layer to the LED substrate 112 and/or the heat sink substrate 114. The LED system 100 shown in Figure 4 includes one or more locking tabs 130 extending from the encapsulation layer 120. A locking opening 132 is defined by the second substrate 114 and receives the locking tab 130 to secure the encapsulation layer 120 over the first and second substrates 112, 114. In some embodiments, the encapsulation layer 114, and more particularly the locking tab 130 has a durometer that is different than the durometer of the gasket 116. For example, the durometer of the locking tab 114 may be higher than that of the gasket 116, so that the locking tab 130 exhibits the desired strength to securely hold the encapsulation layer in place, while the softer gasket 116 may satisfactorily deform to perform its sealing function. In some implementations the durometer of the locking tab 130 is 1.5 to 2 times the durometer of the gasket 116 material. For example, the material of the encapsulation layer 120 has a durometer of about 60-90, while the material of the gasket 116 has a durometer of about 40-50.

[0024] The encapsulation 120 may be fabricated by different processes. For example, in some implementations, the encapsulation 120 is formed by a molding process wherein the encapsulation 120, including any optic characteristics, as well as the locking tab 130 are integrally formed using an injection molding process with a closed mold. Once the encapsulation 120 and locking tab 130 are formed, the locking tab 130 is pressed by force into the locking opening 132 formed in the heat sink substrate 114 and/or the LED substrate 112. The lower durometer gasket 116 in such embodiments is co-molded with the higher durometer material forming the encapsulation 120 and locking tab 130. Clamping hardware such as a clamp 140 and bolt 142 may be employed to ensure sufficient contact between the substrates 112, 114, the gasket 116 and the encapsulation 120.

[0025] In some embodiments discussed further below, the encapsulation layer 120 is overmolded directly onto the first substrate 112, eliminating the need for the gasket 116 and clamping hardware 140, 142. In other embodiments, the gasket 116 is formed separately from the encapsulation 120, and positioned around the periphery of the heat sink substrate 114 prior to clamping the encapsulation to the heat sink substrate 114.

[0026] In still further examples, the encapsulation 120 and locking tab 130 are formed using an over mold process. The LED substrate 112 and heat sink substrate 114 are pre-assembled and function as a bottom portion of a mold used to form the encapsulation 120, 116 and locking tab 130. The upper half of the mold, which includes any desired optical characteristics, seals against the preassembled components, forming a cavity into which the silicone or other material is injected to form the elastomeric components. The LED substrate 112 and/or heat sink substrate 114 may include features such as grooves or other openings to facilitate flow the encapsulation material and bond the substrates 112, 114 to one another.

[0027] Figure 5 is a flow diagram illustrating an example of a method 300 of making an LED light fixture. In block 310 of Figure 5, a first substrate (such as the LED substrate 112 shown in Figure 1) is provided to which an LED and other components and conductors are attached. The first substrate is placed adjacent a second substrate (such as the heat sink substrate 114) in block 312. In block 320, an encapsulation layer (such as the encapsulation 120) is molded and positioned to cover the LED and at least a majority of the first substrate. In the example shown in Figure 4, the gasket 116 may be co-molded with the encapsulation layer and positioned so as to surround around a periphery of the first substrate. In embodiments where the encapsulation is overmolded, the encapsulation layer is directly molded onto the first substrate, eliminating the need for a gasket since a seal is achieved through the bond between the encapsulation material and the substrate.

[0028] Figure 6 illustrates an example of an over mold 150 suitable for forming the encapsulation 120. The over mold 150 is placed over the preassembled first and second substrates 112, 114, and an encapsulation material 126, such as silicone, is injected into the mold formed by the over mold 150 and substrates 112, 114. The over mold 150 may include features that result in the formed encapsulation 120 having optical features configured to shape light from the LEDs 110 through refraction. In some embodiments, the over mold 150 is configured such that the encapsulation material flows over and encapsulates components in addition to the LEDs 120, such as wires 124 and other conductors and connectors extending through the central hub 118, achieving restricted breathing as desired. In some embodiments, this eliminates the need for separately sealing the central hub 118, such as by another potting compound.

[0029] The locking tabs 130 shown in Figure 4 are formed when the encapsulation materials flows into the locking openings 132 during the injection molding process. The mold 154 may be heated to achieve better fluidity of the encapsulation material, allowing 98-99% of the volume between the LED 110 and mold to be filled with the encapsulation material. In some embodiments, the clamping device 140, 142 is further provided to further connect the encapsulation material to the substrates 112, 114.

[0030] In the example shown in Figure 6, the over mold includes geometric and volumetric features 152 that control emissions from the LED 110 to refract and form desired distribution patterns. The mold 150 further is shaped to vary the thickness of the encapsulation layer 120 to generate desired secondary optics. For example, portions 154 of the encapsulation layer 120 positioned directly over and around corresponding LEDs 110 defines different thicknesses extending above the substrate 112. As shown in Figure 6, the mold 150 is formed such that the portion 154 of the encapsulation layer 120 has one thickness extending a first distance D_1 above the substrate 112, and another thickness extending a second distance D_2 above the substrate. Moreover, the encapsulation layer 120 defines a third thickness in areas encapsulating portions of the surface of the substrate 112 were there is no LED 110 on the substrate 112, such as area 156 shown in Figure 6. The thickness of the encapsulation 120 formed in the area 156 of the encapsulation 120 is defined by a third distance D_3 above the substrate, that is less than both distances D_1 and D_2. Thus, the encapsulation 120 defines various thicknesses, and in the example shown in Figure 6, the encapsulation 120 has greater thickness(es) in areas where an LED 110 is encapsulated. These different geometries are created so that incidence angles and path length of light within the material can be altered to achieve different light distribution patterns.

[0031] The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

What is claimed is:

1. A light system, comprising:
a first substrate;
a light emitting diode (LED) connected to a surface of the first substrate; and
an elastomeric encapsulation layer covering and directly contacting the LED and at least a majority of the surface of the first substrate.

2. The system of claim 1, further comprising a gasket extending around a periphery of the encapsulation layer and positioned between the first substrate and the encapsulation layer.

3. The system of claim 1, wherein the first substrate is one of a printed circuit board (PCB) and a heat sink substrate.

4. The system of claim 1, further comprising:
a second substrate having the first substrate thereon;
wherein the second substrate is a heat sink substrate.

5. The system of claim 1, wherein the encapsulation layer includes TIR optics.

6. The system of claim 1, further comprising:
a locking tab extending from the encapsulation layer; and
a locking opening defined by the second substrate receiving the locking tab, wherein the encapsulation layer has a first durometer and the locking tab has a second durometer that is at least 1.5 times higher than the first durometer.

7. The system of claim 1, wherein the encapsulation layer defines an air gap between the LED and an interior surface of the encapsulation layer.

8. The system of claim 1, wherein there is no lens over the LED.

9. The system of claim 2, wherein the gasket is integrally formed with the encapsulation layer.

10. The system of claim 1, wherein the encapsulation covers the entire surface of the first substrate.

11. The system of claim 1, wherein the encapsulation has a first thickness in a first area covering the LED and a second thickness in a second area covering a portion of the surface having no LED, wherein the first thickness is greater than the second thickness.

12. The system of claim 1, wherein the encapsulation has a first thickness in a first area covering the LED and a second thickness in a second area covering the LED, wherein the first thickness is greater than the second thickness.

13. A method of making a light fixture, comprising:
providing an LED on a first substrate;
over molding an encapsulation layer covering the LED and at least a majority of the first substrate.

14. The method of claim 13, further comprising attaching the first substrate to a second substrate.

15. The method of claim 13, wherein over molding the encapsulation layer includes:
positioning a mold over the first substrate; and
injecting silicone into a cavity formed by the mold and the first substrate.

FIG. 1

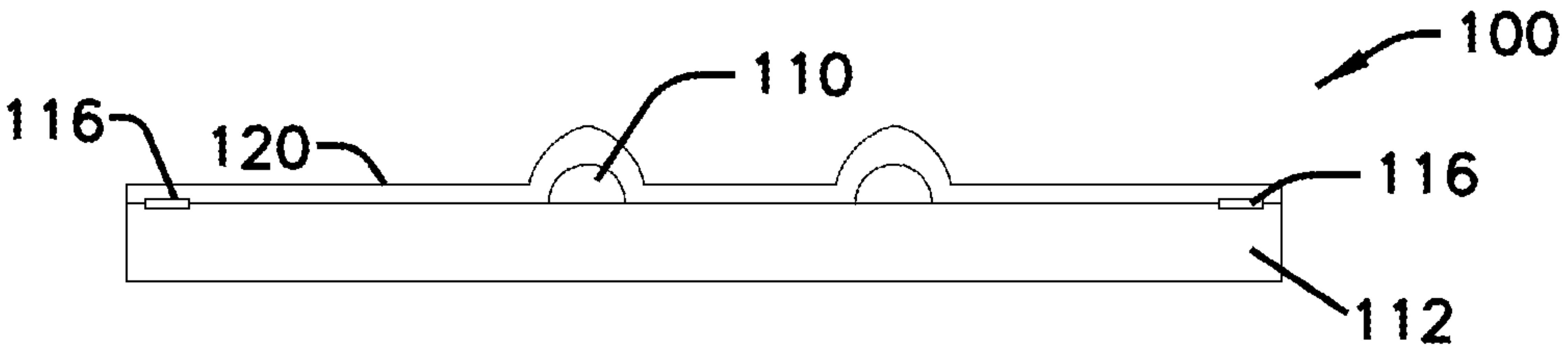

FIG. 2

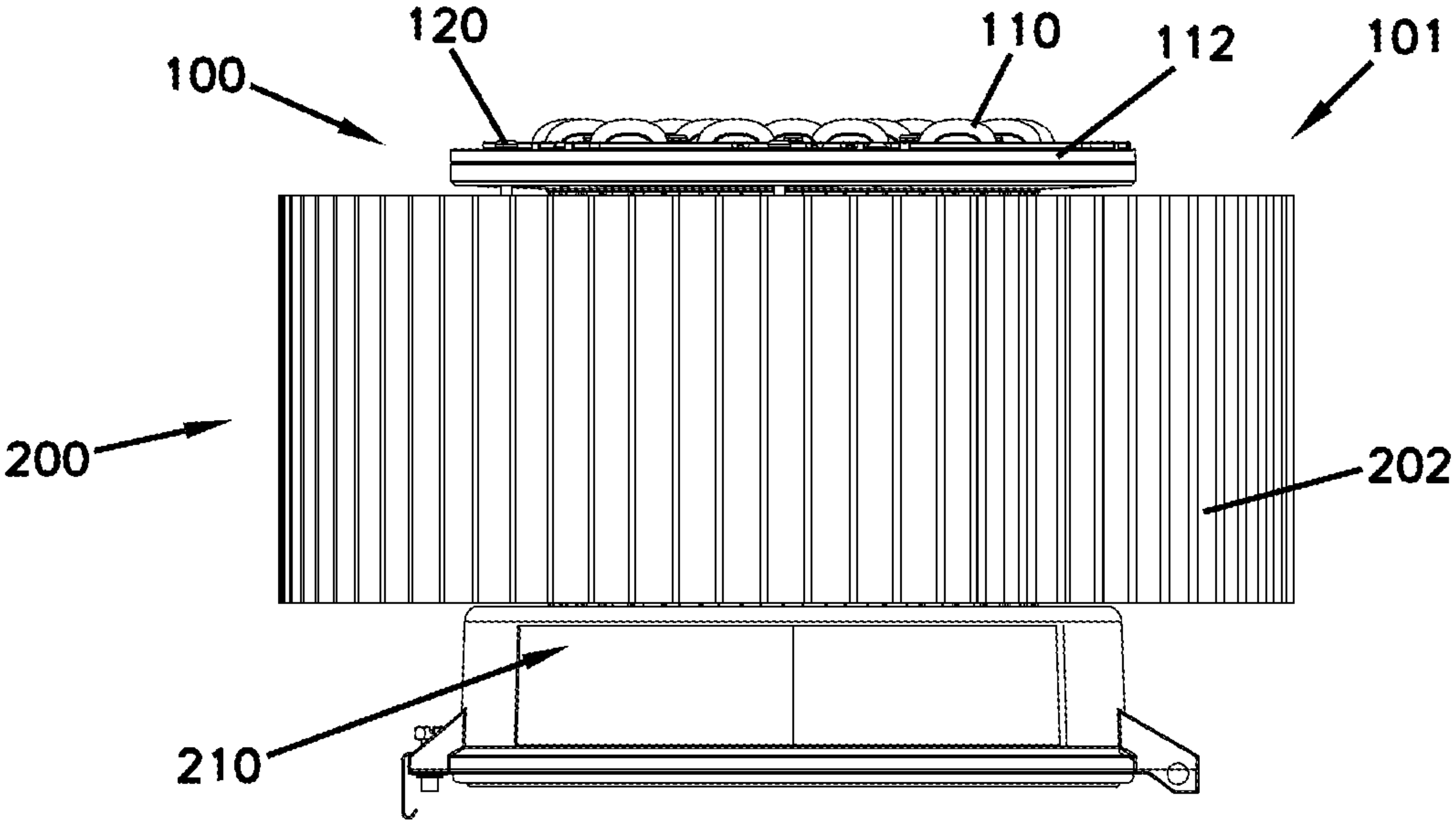

FIG. 3

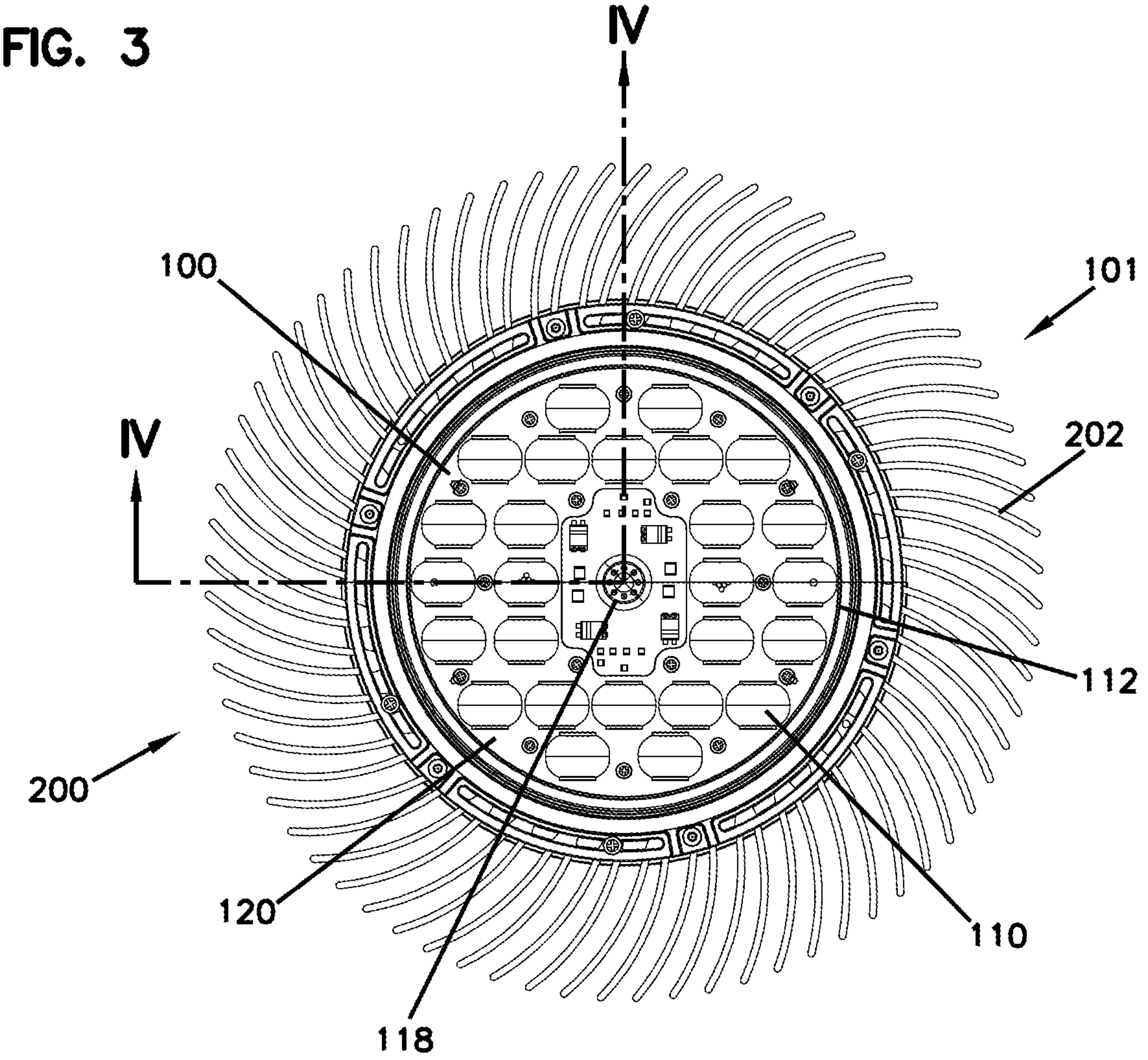
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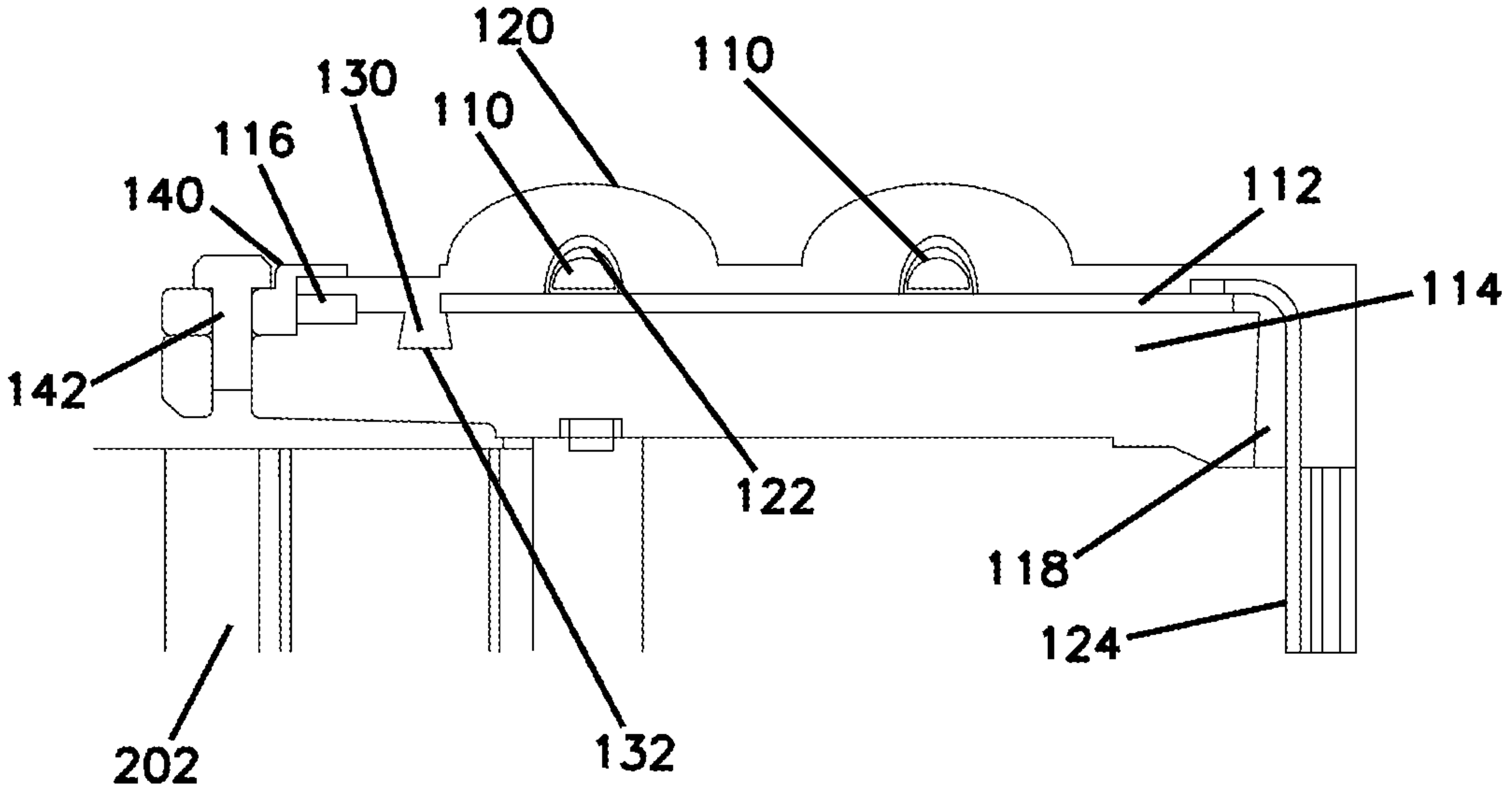
FIG. 4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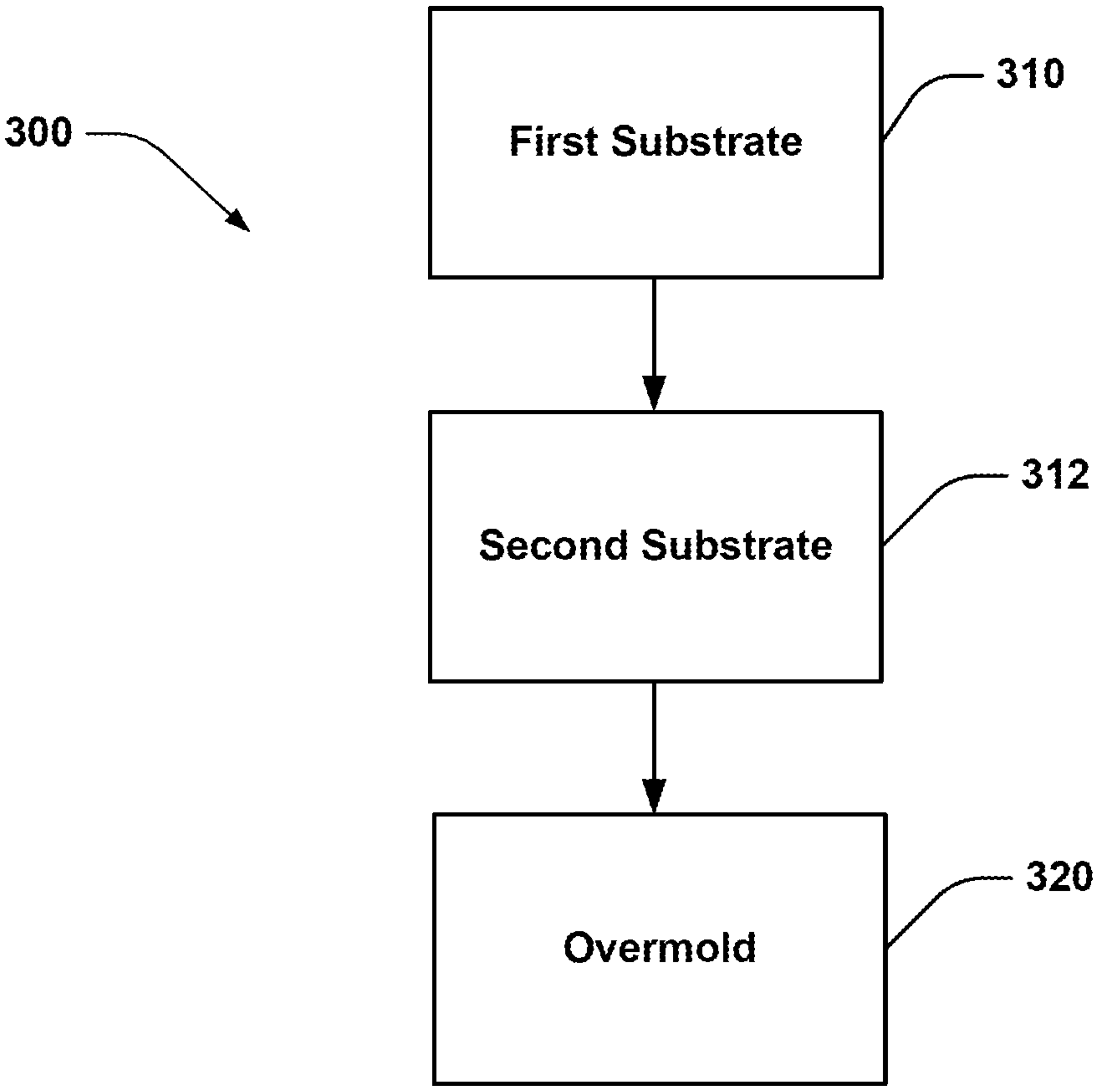

FIG. 6

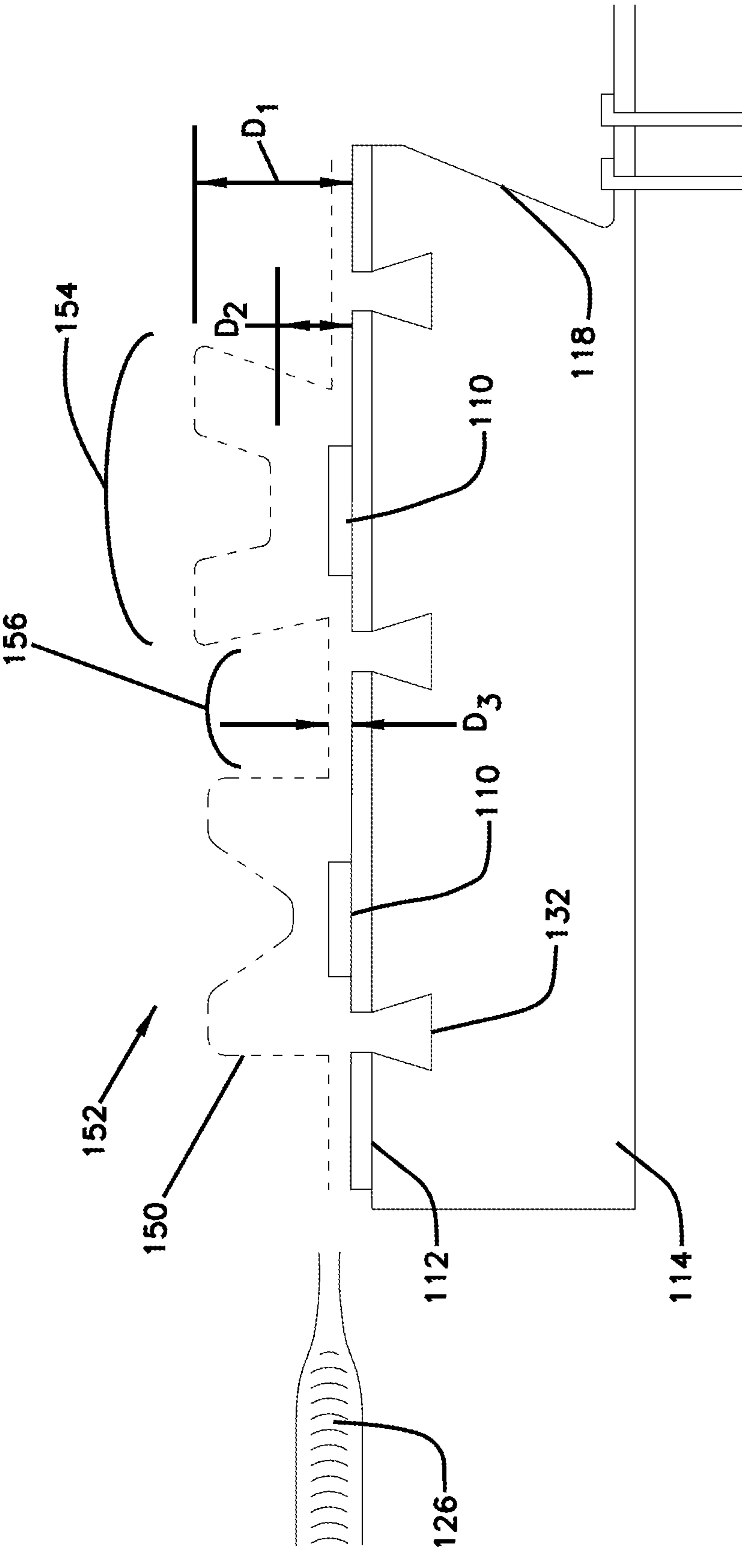

FIG. 1