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(54) Title: LAMP ASSEMBLY AND METHOD FOR MAKING

(57) Abstract: A lamp assembly, comprising a lens, a lamp housing in the form of an integral metal part, the lamp housing cooperating with the lens to at least partially define a lamp chamber that is generally fluidly isolated from an ambient atmosphere outside the lamp chamber, and at least one lamp provided in the lamp chamber and carried by the lamp housing. The lamp housing itself defines a heat sink exposed to the ambient atmosphere outside the lamp chamber such that heat from the at least one lamp is transmitted to the ambient atmosphere.

TITLE

LAMP ASSEMBLY AND METHOD FOR MAKING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to, and claims the benefit of priority from, United States Patent Application Serial No. 12/455568, filed 3 June 2009, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

This invention relates generally to a lamp assembly for dissipating the heat generated by one or more lamps provided in a generally fluidly sealed chamber of the lamp assembly.

BACKGROUND OF THE INVENTION

LED lamp applications, including those comprising high-powered LEDs, are being developed at an increasing rate. LEDs, unlike more conventional light sources such as tungsten, halogen or HID light sources, emit essentially no infrared radiation and are, therefore, "cold" on their optical output side. Nevertheless, LEDs do generate heat at their electrical junction, the so-called "back side," of the LED proper. This is particularly significant as the drive current increases in order to achieve greater LED optical output. Control of this thermal output, referred to as "junction temperature," is critical so as to ensure proper operating performance of the LED and avoid either premature degradation or failure.

With the "back side" of the LEDs being housed within the lamp housing, which housing is conventionally made primarily of plastic, the heat generated is "trapped" within the housing. This thermal output on the "back side" of LEDs must be removed in order to

prevent overheating and, relatedly, premature failure of the LED lamp. Accordingly, LEDs do require cooling via the introduction of heat sinks.

Conventionally, it is the practice to place such heat sinks within the housing of the LED lamp, where the LEDs themselves are housed. For instance, the head and tail-lamps for the CADILLAC CTS brand automobile utilize a single, high-power LED and a die-cast heat sink that dissipates heat within the housing of the lamp. Given that there is, for these particular applications, a sufficient amount of interior volume in which to dissipate this energy, such heat sinks serve their purpose. However, either for smaller volumes or applications generating additional thermal input, adequate dissipation of heat internally is complicated, thereby forcing the adoption of more elaborate thermal management solutions, such as exposing the heat sink to the outside of the housing or utilizing "heat pipes" (liquid filled thermal conductors) or cooling fans to circulate air within the lamp housing.

Still another solution, disclosed in United States Patent Application Pub. No. US 2007/0127252 A1 to Fallahi et al., published June 7, 2007, comprises an LED headlamp assembly for a motor vehicle having a plastic lens and a plastic lamp housing cooperating with the lens to define an inner chamber that is generally fluidly isolated from the atmosphere. A cast metal reflector is mounted to the lamp housing and has a polished reflective portion that reflects light forward through the lens. A separate heat sink portion of the reflector includes fins that extend through the lamp housing and are exposed to the atmosphere outside the lamp housing, such that heat from the inner chamber is transmitted from the fins to the atmosphere.

The foregoing thermal management solutions notwithstanding, it is desirable to have a lamp assembly, for automotive as well as other applications, that is able to effectively dissipate heat energy generated by LEDs or other light sources.

SUMMARY

The specification discloses a lamp assembly comprising a lens, a lamp housing in the form of an integral metal part, the lamp housing cooperating with the lens to at least partially define a lamp chamber that is generally fluidly isolated from an ambient atmosphere outside the lamp chamber, and at least one lamp provided in the lamp chamber and carried by the lamp housing. The lamp housing itself defines a heat sink exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere.

The heat sink defined by the lamp housing may further include radiating elements that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the radiating elements. In one embodiment of the invention, these radiating elements comprise fins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the fins. In another embodiment, these radiating elements comprise pins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the pins.

In another embodiment, the heat sink defined by the lamp housing further includes one or more ducts configured to promote passive convective cooling. These one

or more ducts may be formed integrally with the lamp housing or, alternatively, may be defined in a separate baffle that is secured to the lamp housing. Per one feature of the invention, each of the one or more ducts is formed using internal mold slides and lifters.

According to one feature of the invention, the at least one lamp includes a reflector portion positioned and configured to reflect light emitted by the at least one lamp forward through the lens. The reflector portion may include a polished surface.

Per another feature, the at least one lamp comprises an LED. The at least one LED may, per a further feature, be of the type connected to a circuit board including current paths connected to leads of the at least one LED and connectable to a source of electrical power operative to power the LED. According to this feature, the circuit board is connected to the lamp housing.

Per a further feature, the lamp housing is formed as a single, unitary – or monolithic -- metal piece.

The lamp housing may be formed, by way of non-limiting example, from one or more materials selected from the group of materials consisting of stainless steel, low alloy steel, tool steel, titanium, cobalt, copper, magnetic metal, hard-metal, refractory metal, ceramic, magnesium, aluminum, and magnesium/aluminum alloy.

The lamp housing may, according to another feature of the invention, be formed by the process of metal injection molding, including the sub-technique of thixoforming.

The lamp housing may, according to another feature of the invention, be combined with extension, or supplemental housings, which may optionally be made from dissimilar materials such as plastics and thermosets.

According to yet another feature, the lamp housing carries a plurality of lamps.

Per still another feature of the present invention, the lens is secured to the lamp housing by one or more bonding agents selected from the group consisting of butyl and silicone-based sealants. Alternatively, the lens may be secured to the lamp housing mechanically and sealed via the incorporation of a gasket or sealing device.

The specification also discloses a method for making a lamp assembly, the method including the steps of:

making a lamp housing as an integral metal part;

mounting at least one lamp in the lamp housing; and

mounting a lens on the lamp housing such that the lens cooperates with the lamp housing to at least partially define a lamp chamber that encloses the lamp, the lamp chamber being generally fluidly isolated from an ambient atmosphere outside the lamp chamber.

According to the foregoing method, the lamp housing defines a heat sink exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere.

Per one feature of the invention, the step of making the lamp housing further comprises making the lamp housing a single, unitary – or monolithic -- metal piece.

According to another feature, the step of making the lamp housing comprises making the lamp housing by the process of metal injection molding, including the sub-technique of thixoforming.

Per a still further feature, the step of mounting at least one lamp in the lamp housing includes providing a reflector portion in the lamp housing in a position to reflect light emitted by the at least one lamp forward through the lens. Alternatively, or in

addition, optical lenses, such as TIR ("Total Internal Refraction") lenses, may be employed.

Per yet another feature, the step of mounting at least one lamp in the lamp housing comprises mounting at least one LED in the housing.

According to a further feature of the invention, the at least one LED is connected to a circuit board including current paths connected to leads of the at least one LED and connectable to a source of electrical power operative to power the LED, the circuit board being mounted in the lamp housing.

The heat sink defined by the lamp housing may include radiating elements that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the radiating elements. In one embodiment of the invention, these radiating elements comprise fins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the fins.

In another embodiment, the heat sink defined by the lamp housing includes one or more ducts configured to promote passive convective cooling. In another embodiment, the heat sink defined by the lamp housing includes a one or more ducts configured to promote passive convective cooling. Per one feature of the invention, each of the one or more ducts is formed using internal mold slides and lifters.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a lamp assembly according to a first embodiment of the present invention;

FIG. 2A is a frontal perspective view of the lamp assembly according to the embodiment of **FIG. 1**;

FIG. 2B is a rear perspective view of the lamp assembly of **FIG. 2A**;

FIG. 2C is a bottom view of the lamp assembly of **FIG. 2A**;

FIG. 2D is a frontal view of the lamp assembly of **FIG. 2A**;

FIG. 2E is a top view of the lamp assembly of **FIG. 2A**;

FIG. 2F is a left-side view of the lamp assembly of **FIG. 2A**;

FIG. 2G is a right-side view of the lamp assembly of **FIG. 2A**;

FIG. 3 is an exploded perspective view of a lamp assembly according to a second embodiment of the present invention;

FIG. 4A is a frontal perspective view of the lamp assembly according to the embodiment of **FIG. 3**;

FIG. 4B is a rear perspective view of the lamp assembly of **FIG. 4A**;

FIG. 4C is a top view of the lamp assembly of **FIG. 4A**;

FIG. 4D is a frontal view of the lamp assembly of **FIG. 4A**;

FIG. 4E is a bottom view of the lamp assembly of **FIG. 4A**;

FIG. 4F is a left-side view of the lamp assembly of **FIG. 4A**;

FIG. 4G is a cross-sectional view of the lamp assembly of **FIG. 4A**;

FIG. 4H is a right-side view of the lamp assembly of **FIG. 4A**;

FIG. 5 is an exploded perspective view of a lamp assembly according to a third embodiment of the present invention;

FIG. 6A is a frontal perspective view of a lamp assembly according to the embodiment of **FIG. 5**;

FIG. 6B is a rear perspective view of the lamp assembly of **FIG. 6A**;

FIG. 6C is a top view of the lamp assembly of **FIG. 6A**;

FIG. 6D is a frontal view of the lamp assembly of **FIG. 6A**;

FIG. 6E is a bottom view of the lamp assembly of **FIG. 6A**;

FIG. 6F is a cross-sectional view of the lamp assembly of **FIG. 6A**;

FIG. 6G is a cross-sectional view of the lamp assembly of **FIG. 6A**;

FIG. 6H is a right-side view of the lamp assembly of **FIG. 6A**;

FIG. 6I is a left-side view of the lamp assembly of **FIG. 6A**;

FIG. 7 is an exploded perspective view of a lamp assembly according to a fourth embodiment of the present invention;

FIG. 8A is a frontal perspective view of a lamp assembly according to the embodiment of **FIG. 7**;

FIG. 8B is a rear perspective view of the lamp assembly of **FIG. 8A**;

FIG. 8C is a top view of the lamp assembly of **FIG. 8A**;

FIG. 8D is a frontal view of the lamp assembly of **FIG. 8A**;

FIG. 8E is a bottom view of the lamp assembly of **FIG. 8A**;

FIG. 8F is a left-side view of the lamp assembly of **FIG. 8A**;

FIG. 8G is a right-side view of the lamp assembly of **FIG. 8A**;

FIG. 8H is a cross-sectional view of the lamp assembly of **FIG. 8A**;

FIG. 9 is an exploded perspective view of a lamp assembly according to a fifth embodiment of the present invention;

FIG. 10A is a bottom perspective view of the lamp housing of the lamp assembly of the embodiment of **FIG. 9**;

FIG. 10B is a top perspective view of the lamp housing of the lamp assembly of the embodiment of **FIG. 10A**;

FIG. 11 is an exploded perspective view of a lamp assembly according to a sixth embodiment of the present invention;

FIG. 12A is a top perspective view of the lamp housing of the lamp assembly of the embodiment of **FIG. 11**; and

FIG. 12B is a bottom perspective view of the lamp housing of the lamp assembly of the embodiment of **FIG. 12A**.

DETAILED DESCRIPTION

As required, a detailed description of exemplary embodiments of the present invention are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which may be embodied in various and alternative forms. The accompanying drawings are not necessarily to

scale, and some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a providing a representative basis for teaching one skilled in the art to variously employ the present invention.

Referring now to the drawings, and more particularly to **FIGS. 1** through **2G** as exemplary of the invention as shown also in the embodiments of **FIGS. 3** through **4H**, **FIGS. 5** through **6I**, **FIGS. 7** through **8H**, **FIGS. 9** through **10B**, and **FIGS. 11** through **12B** the present invention may be seen to essentially comprise a lamp assembly **10** for dissipating heat generated by one or more lamps, the lamp assembly **10** comprising a lens **11**, a lamp housing **20** in the form of an integral metal part, and at least one lamp **30**. The lamp housing **20** cooperates with the lens **11** to at least partially define a lamp chamber that is generally fluidly isolated from an ambient atmosphere outside the lamp chamber, and it is in this lamp chamber that the at least one lamp **30** is disposed. Furthermore, the lamp housing **20** according to the present invention defines a heat sink exposed to the ambient atmosphere outside the lamp chamber, such that heat from the at least one lamp **30** is transmitted to the ambient atmosphere.

The inventive lamp assembly will be understood by those skilled in the art to have utility in numerous applications, including, without limitation, motor vehicles (including automobiles), and fixed indoor and outdoor (e.g., street lighting, parking garage lighting, etc.) lighting applications.

Unless specified otherwise, the several embodiments of the inventive apparatus as herein described, and shown variously in **FIGS. 1** through **2G**, **FIGS. 3** through **4H**,

FIGS. 5 through **6I**, **FIGS. 7** through **8H**, **FIGS. 9** through **10B**, and **FIGS. 11** through **12B**, are identical in all material respects.

A bonding agent may be disposed between the lens **11** and the lamp housing **20** in a position to adhere the lens to the lamp housing. The bonding agent may also include a sealant to seal the lens to the lamp housing. The bonding agent may include adhesives/sealants such as butyl and silicone based sealants, by way of non-limiting example. In other contemplated embodiments, the bonding agent may include other suitable adhesives and/or sealants known in the art.

It is also envisioned that the lens **11** may be mechanically connected to the lamp housing **20**, in which case sealing may be accomplished via a gasket or other sealing device interposed between the lens and lamp housing.

With continuing reference to **FIGS. 1** through **2G** as exemplary of the invention according to the several embodiments disclosed herein, the lamp housing **20** is an integral metal part formed from one or more materials such as, by way of non-limiting example, stainless steel, low alloy steel, tool steel, titanium, cobalt, copper, magnetic metal, hard-metal, refractory metal, ceramic, magnesium, aluminum, and/or magnesium/aluminum alloy. Preferably, though not necessarily, lamp housing **20** is formed as a single, unitary – or monolithic – metal part. Lamp housing **20** may, as described below, be formed by metal injection molding ("MIM"), including the sub-technique of thixoforming, or other conventional metal forming processes.

The lamp housing **11** may, optionally, be combined with extension or supplemental housings, made from dissimilar materials such as plastics and thermosets, which are joined to the housing **11**.

Referring to the particular embodiments of **FIGS. 3** through **4H**, **FIGS. 5** through **6I**, and **FIGS. 7** through **8H**, the at least one lamp **130, 230, 330** may comprise one or more reflector portions **131, 231, 331**. In conventional fashion, such one or more reflector portions **131, 231, 331** may be positioned and configured to reflect light emitted by the at least one lamp **130, 230** forward to the lens **111, 211**. The one or more reflector portions **131, 231, 331** may, to this end, include a polished surface. Rather than comprising separate elements, it is alternatively contemplated that the one or more reflector portions may be formed on or by a surface of the lamp housing itself, being disposed in a position to reflect light emitted by the lamp forward to the lens, such as shown by the reflector portions **31** in the embodiment of **FIGS. 1** through **2G** and the reflector portions **331** in the embodiment of **FIGS. 7** through **8H**. Of course, it is contemplated that a lamp assembly according to any of the embodiments described herein may or may not include one or more reflector portions, as desired.

Each at least one lamp **30, 130, 230, 330** comprises at least one light source, which may take the form of one or more LEDs **32, 132, 232**. The LEDs may be connected to one or more circuit boards **33, 133, 233**, each including current paths connected to leads of the one or more LEDs and connectable to a source of electrical power (not depicted) that is operative to power the one or more LEDs. The circuit board(s) **33, 133, 233** may be mounted in the lamp chamber of lamp housing **20, 120, 220**.

With particular reference to the embodiments of **FIGS. 1** through **2G** and **FIGS. 7** through **8H**, the at least one lamp **30, 330** may, optionally and according to user

preference, further include one or more of a light pipe **34**, **334**, reflector optics **336**, and/or total internal refraction optics **335**.

Still referring to **FIGS. 1** through **2G** as exemplary of the invention in the several embodiments thereof, the at least one lamp **30** is, as noted, carried by the lamp housing **20** such that the lamp housing **20** both defines the heat sink and carries the at least one lamp **30**. The heat sink is exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere.

With reference being had to the particular embodiments of **FIGS. 1** through **2G** and **FIGS. 3** through **4H**, the heat sink defined by lamp housing **20**, **120** may, as shown, further include radiating elements, such as the exemplary fins **22**, **122**, that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the one or more lamps **30**, **130** is transferred to the ambient atmosphere through the fins **22**, **122**. These radiating elements may comprise fins (such as shown in **FIGS. 1** through **2G**), pins **326** (such as shown in the embodiment of **FIGS. 7** through **8H**) etc., having any number of geometries and orientations as desired to ensure the sufficient dissipation of heat.

Turning now to the embodiments of **FIGS. 5** through **6I** and **FIGS. 7** through **8H**, the heat sink defined by lamp housing **220**, **320** may be seen to optionally comprise one or more ducts **223**, **323**. These ducts **223**, **323** are essentially channels which open at opposite ends to communicate with the ambient atmosphere outside of the lamp chamber, and which are shaped and positioned to promote passive convective cooling by using thermal load to generate a chimney effect; that is, convective cooling

via a convective flow generated through the thermal output of the LED and channeled via the defined thermal channel and/or ducts.

While the lamp housing *per se* of the invention defines a heat sink, it will be appreciated from the embodiment of **FIGS. 7** through **8H** that the heat sink defined by lamp housing may further optionally comprise any one or more of the foregoing additional radiating elements, such as fins **322** and/or pins **326**, and/or ducts **323** as also described heretofore.

In the embodiment of **FIGS. 5** through **6I**, the lamp housing **220** is formed to integrally include a plurality of such ducts **223**. As shown in the embodiment of **FIGS. 7** through **8H**, ducts **323** such as described above may alternatively be formed in a separate element **325** defining a baffle that is secured to the lamp housing **320**.

With reference now being had to **FIGS. 9** through **10B** and **FIGS. 11** through **12B** there are shown, respectively, embodiments of the inventive lamp assembly that are suited to employment as parking garage lights and street lights. Referring particularly to the exemplary parking garage light assembly **410** of **FIGS. 9** through **10B**, the same will be seen to comprise a lens **411**, lamp **430** (comprising, in the illustrated embodiment, a plurality of LEDs **432** secured to a circuit board **433**), and a lamp housing **420**. Lamp housing **420** is formed to define a plurality of U-shaped ducts **423** in an upper surface thereof, as depicted, each such duct communicating at an outlet end with the ambient atmosphere (as shown best in **FIGS. 9** and **10B**). An opposite, inlet end of each duct **423** (*see* reference numerals **423** in **FIG. 10A**) is defined through the lamp housing **420** so as to communicate ducts **423** with the lamp

chamber and so facilitate the dissipation of heat directly from the lamp chamber and out to the ambient atmosphere via ducts **423**. A separate cover element **427** is secured over the top of lamp housing **420** to substantially cover the ducts **423** but for, as shown, the opposite outlet and inlet ends thereof. As will best be seen in **FIG. 9**, ducts **423** may further comprise a plurality of small fins **422** extending inwardly from the walls of the ducts to increase the surface area for heat dissipation/transfer purposes. Turning next to the exemplary street light assembly **510** of **FIGS. 11** through **12B**, the same will be seen to likewise comprise a lens **511**, lamp **530** (comprising, in the illustrated embodiment, a plurality of LEDs **532** secured to a circuit board **533**), and a lamp housing **520**. Lamp housing **520** is formed to define a plurality of generally linear ducts **523** in an upper surface thereof, each such duct communicating at an outlet end with the ambient atmosphere, and at an opposite, inlet end with the lamp chamber defined in the housing **520** (*see* reference numerals **523** in **FIG. 12B**). A separate cover element **527** is secured over the top of lamp housing **520** to substantially cover the ducts **523**. As shown, cover element **527** includes a single opening **528** communicating with the outlet ends of the ducts **523** to facilitate the dissipation of heat energy therethrough and to the ambient atmosphere. As will best be seen in **FIG. 12A**, ducts **523** may each further comprise a plurality of small fins **522** extending inwardly from the walls of the ducts to increase the surface area for heat dissipation/transfer purposes.

Where the lamp housing **220** is formed by other than MIM, such as by die casting or investment casting, for instance, the duct portion or portions **223** may be formed using internal mold slides and lifters.

In practice, the lamp assemblies of the present invention can, per an exemplary but non-limiting method, be made by first fabricating a lamp housing (e.g., **20**, **120**, **220**) by MIM. This may, optionally, include making the lamp housing as a single, unitary -- or monolithic -- piece, and may also include the use of thixoforming, a sub-technique of MIM. A reflector portion (e.g., **131**, **231**), including, for instance, as described above, may be provided in the lamp housing in a position to reflect light emitted by the one or more lamps forward to the lens.

According to the embodiments described herein, the inventive lamp assembly is fashioned by the process of MIM, a conventional process employed to produce complex-shaped, three-dimensional precision metal parts without compromising strength. Generally speaking, the MIM process begins with the atomization of molten metal to form metal powders. The metal powder is subsequently mixed with thermoplastic binders to produce a homogeneous feedstock (approximately 60 volume % metal powder and 40 volume % binders). The feedstock is placed into an injection molder and molded at relatively low temperatures and pressures in conventional plastic injection molding machines to form a desired part. After injection molding, the binder is removed from the part by a process called "debinding." After debinding, the part is sintered at high temperatures, up to 2300 degrees F (1260°C), under a dry H_2 or inert gas atmosphere, to form a high-density metal part. In MIM, the complex shape of the molded part is retained throughout the process, so close tolerances can be achieved, and scrap is eliminated or significantly reduced as machining of the part after sintering is usually unnecessary.

For magnesium and aluminum-magnesium alloys, a sub-technique of MIM, called thixoforming, is used. In thixoforming, ground, shaven, pelletized and/or other forms of magnesium or magnesium alloys are heated into a uniform semi-solid, thixotropic state; the material is then injected into a mold that is quite similar in design, scope and capability to those employed for plastic injection molding. The resulting magnesium injection-molded component is then removed from the die and trimmed as required.

Use of the foregoing approaches enables the effective increase of the density of the heat dissipating features compared to traditional molding methods such as die casting, given the process capabilities of the MIM and thixoformed molding technologies. Thereby, a greater cooling feature density may be achieved in a significantly smaller volume, thereby yielding a smaller, lighter weight and likely lower cost component.

Once the lamp housing has been formed, a lamp may then be mounted on the lamp housing, which may include mounting an LED on the lamp housing. Where an LED is used, the LED may be mounted on the circuit board and the circuit board mounted on the lamp housing. A lens may then be mounted on the lamp housing and may be arranged such that the lens cooperates with the lamp housing to at least partially define a lamp chamber that encloses the lamp. The lens may be mounted such that the lens and lamp housing cooperate to generally fluidly isolate the lamp chamber from the ambient atmosphere.

The lamp housing may be formed to include radiating elements such as fins and/or pins, etc., and/or ducts, all as heretofore described.

By the foregoing, the inventor hereof has developed a lamp assembly, for automotive as well as other applications, that is at once economical to manufacture and able to effectively dissipate heat energy generated by LEDs or other light sources.

The foregoing description of the exemplary embodiments of the invention have been presented in order to explain the principals of the innovation and its practical application so as to enable one skilled in the art to utilize the innovation. It is not intended to be exhaustive of, or to limit the invention to, the precise forms disclosed, and although only exemplary embodiments of the present invention have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible to the present invention without materially departing from the novel teachings and advantages of the subject matter herein recited. Other substitutions, modifications, changes and omissions may be made in the exemplary embodiments without departing from the spirit of the present invention and, accordingly, all such modifications, changes, etc. are intended to be included within the scope of the invention as hereinafter claimed.

CLAIMS

The invention in which an exclusive property or privilege is claimed is defined as follows:

1. A lamp assembly, comprising:

a lens;

a lamp housing in the form of an integral metal part, the lamp housing cooperating with the lens to at least partially define a lamp chamber that is generally fluidly isolated from an ambient atmosphere outside the lamp chamber;

at least one lamp provided in the lamp chamber and carried by the lamp housing; and

wherein the lamp housing itself defines a heat sink exposed to the ambient atmosphere outside the lamp chamber such that heat from the at least one lamp is transmitted to the ambient atmosphere.

2. The lamp assembly as defined in claim 1, wherein further the heat sink defined by the lamp housing includes radiating elements that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the radiating elements.

3. The lamp assembly as defined in claim 2, wherein the radiating elements comprise fins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the fins.

4. The lamp assembly as defined in claim 2, wherein the radiating elements comprise pins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the pins.

5. The lamp assembly as defined in claim 1, wherein the at least one lamp includes a reflector portion positioned and configured to reflect light emitted by the at least one lamp forward through the lens.

6. The lamp assembly as defined in claim 1, wherein the at least one lamp comprises an LED.

7. The lamp assembly as defined in claim 6, wherein the at least one LED is connected to a circuit board including current paths connected to leads of the at least one LED and connectable to a source of electrical power operative to power the LED, the circuit board being connected to the lamp housing.

8. The lamp assembly as defined in claim 1, wherein the lamp housing is formed as a single, unitary metal piece.

9. The lamp assembly as defined in claim 1, wherein the lamp housing is formed by metal injection molding.

10. The lamp assembly as defined in claim 1, wherein the lamp housing is

formed by thixoforming.

11. The lamp assembly as defined in claim 1, wherein further the heat sink defined by the lamp housing includes one or more ducts configured to promote passive convective cooling.

12. The lamp assembly of claim 11, wherein the one or more ducts are defined in a separate baffle that is secured to the lamp housing.

13. The lamp assembly as defined in claim 1, wherein the lamp housing is formed from one or more materials selected from the group consisting of stainless steel, low alloy steel, tool steel, titanium, cobalt, copper, magnetic metal, hardmetal, refractory metal, ceramic, magnesium, aluminum, and magnesium/aluminum alloy.

14. A method for making a lamp assembly, the method including the steps of:

making a lamp housing as an integral metal part;

mounting at least one lamp in the lamp housing; and

mounting a lens on the lamp housing such that the lens cooperates with the lamp housing to at least partially define a lamp chamber that encloses the lamp, the lamp chamber being generally fluidly isolated from an ambient atmosphere outside the lamp chamber; and

wherein the lamp housing itself defines a heat sink exposed to the ambient atmosphere outside the lamp chamber such that heat from the at least one lamp is

transmitted to the ambient atmosphere.

15. The method of claim 14, wherein the step of making the lamp housing further comprises making the lamp housing a single, unitary metal piece.

16. The method of claim 14, wherein the step of making the lamp housing comprises making the lamp housing by metal injection molding.

17. The method of claim 14, wherein the step of making the lamp housing comprises making the lamp housing by thixoforming.

18. The method of claim 14, wherein the step of mounting at least one lamp in the lamp housing includes providing a reflector portion in the lamp housing in a position to reflect light emitted by the at least one lamp forward through the lens.

19. The method of claim 14, wherein the step of mounting at least one lamp in the lamp housing includes providing at least one of a light guide, light pipe or total internal refraction optical element to direct light emitted by the at least one lamp forward through the lens.

20. The method of claim 14, wherein the step of mounting at least one lamp in the lamp housing comprises mounting at least one LED in the lamp housing.

21. The method of claim 20, wherein the at least one LED is connected to a circuit board including current paths connected to leads of the at least one LED and connectable to a source of electrical power operative to power the LED, the circuit board being mounted in the lamp housing.

22. The method of claim 14, wherein further the heat sink defined by the lamp housing includes radiating elements that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the radiating elements.

23. The method of claim 22, wherein the radiating elements comprise fins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the fins.

24. The method of claim 22, wherein the radiating elements comprise pins that are exposed to the ambient atmosphere outside the lamp chamber such that heat from the lamp is transmitted to the ambient atmosphere through the pins.

25. The method of claim 14, wherein further the heat sink defined by the lamp housing includes one or more ducts configured to promote passive convective cooling.

26. The method of claim 25, wherein the plurality of ducts are defined in a separate baffle that is secured to the lamp housing.

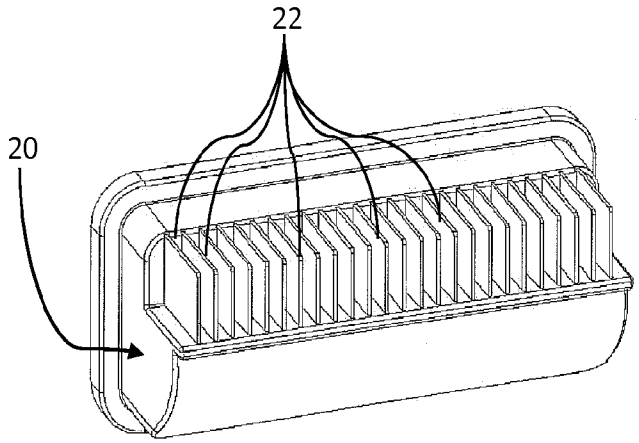


FIG. 2B

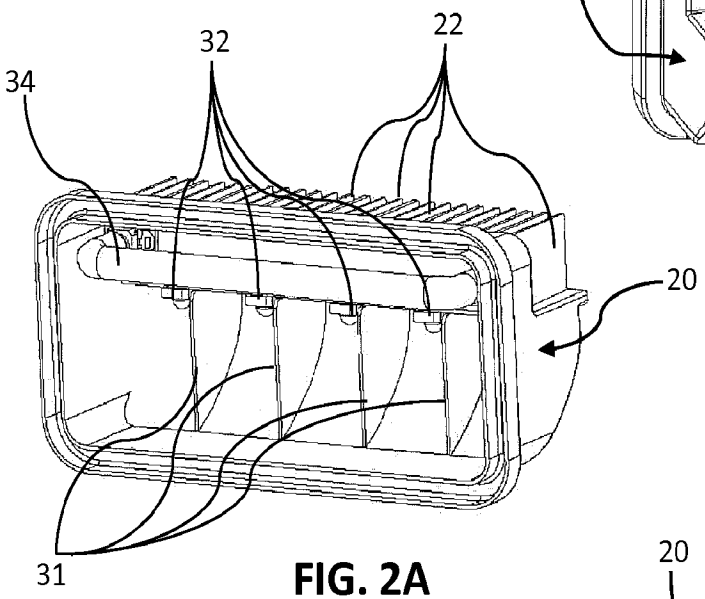


FIG. 2A

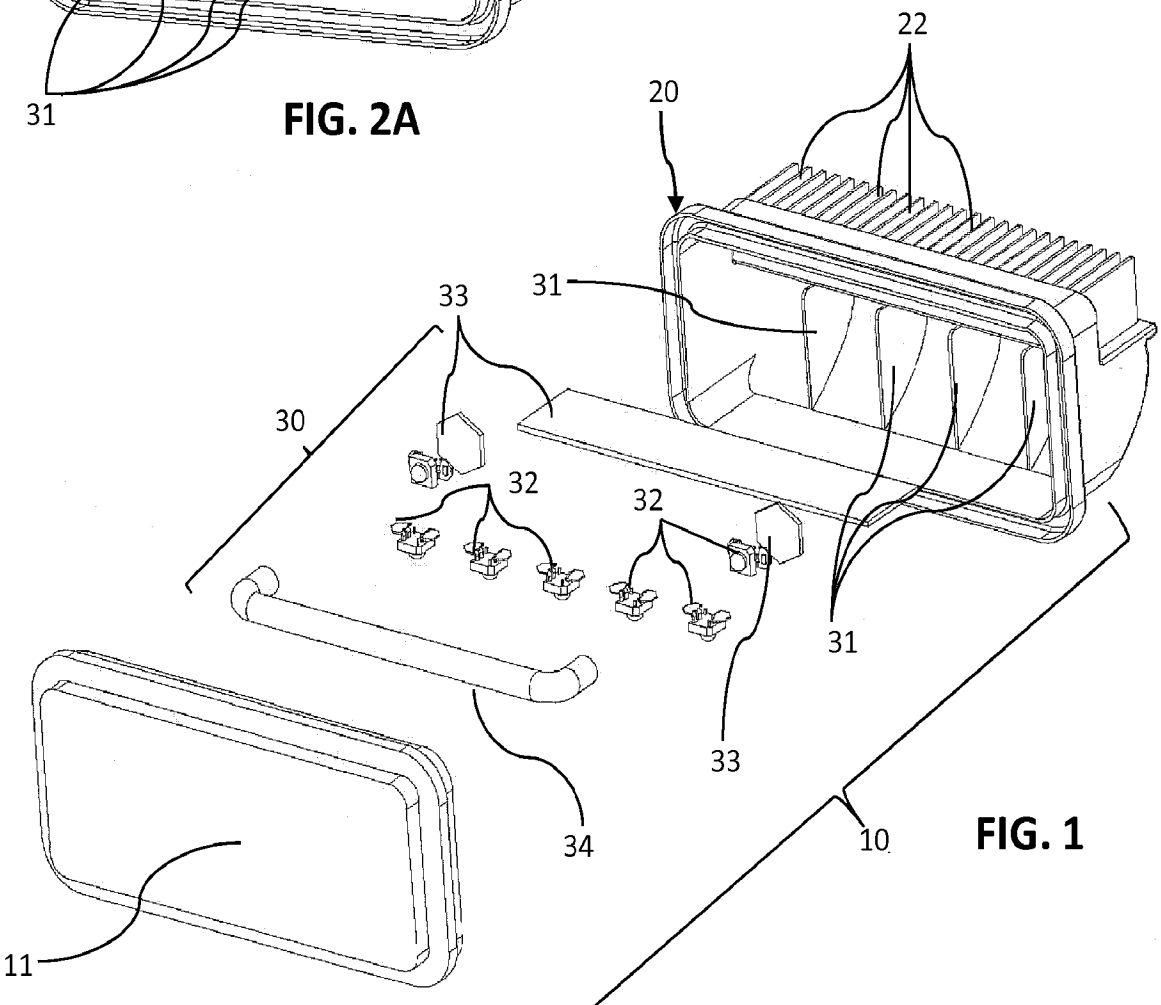


FIG. 1

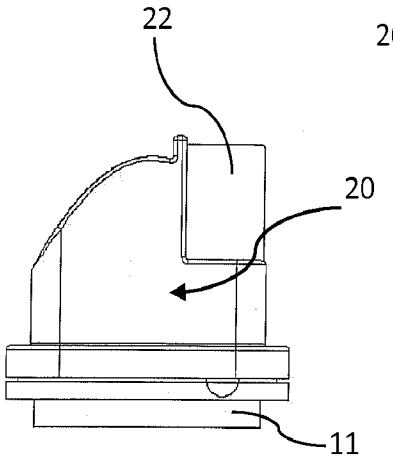


FIG. 2F

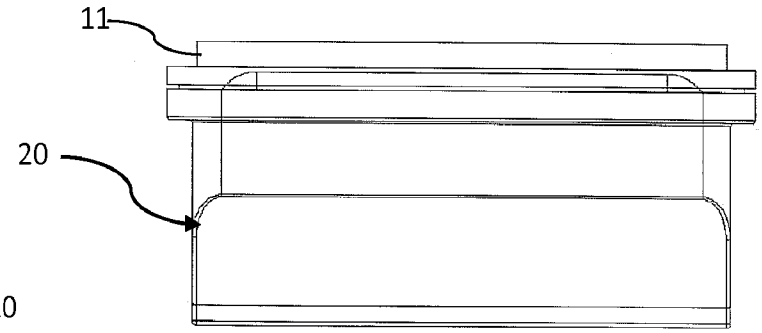


FIG. 2C

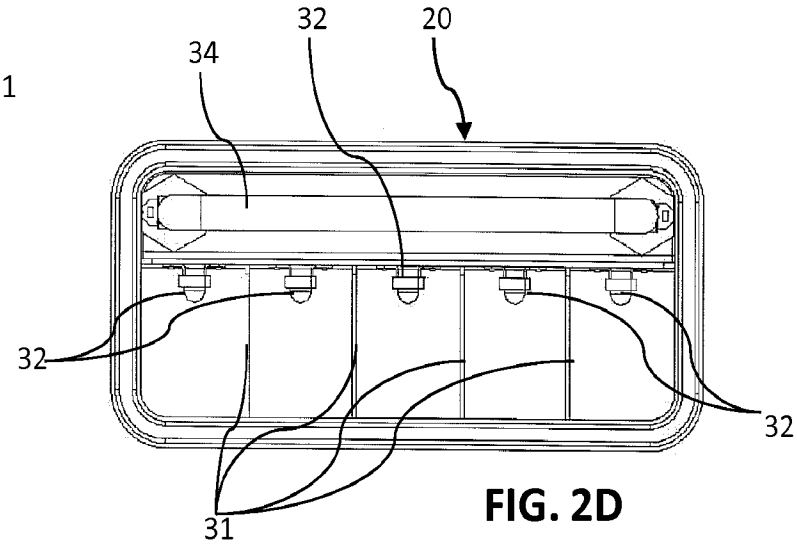


FIG. 2D

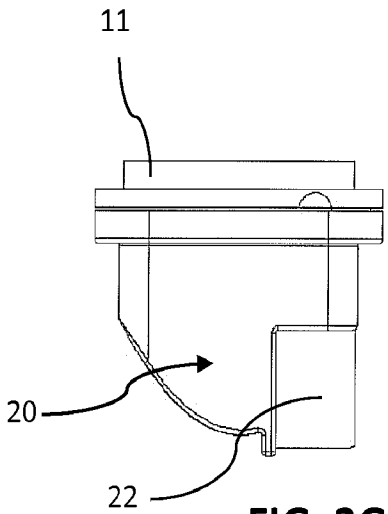


FIG. 2G

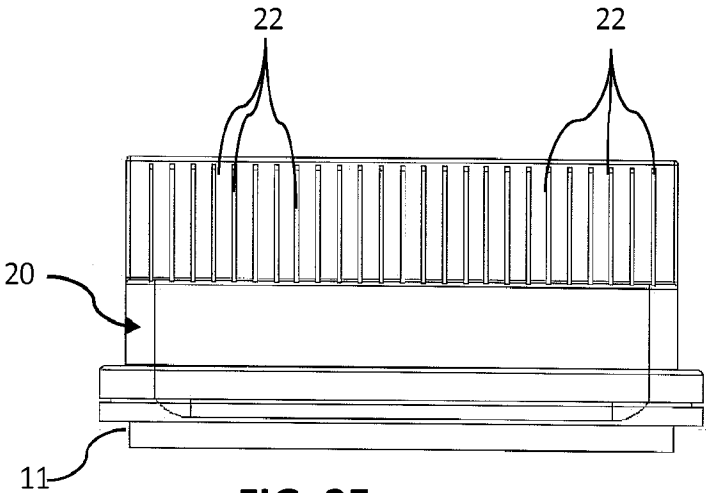


FIG. 2E

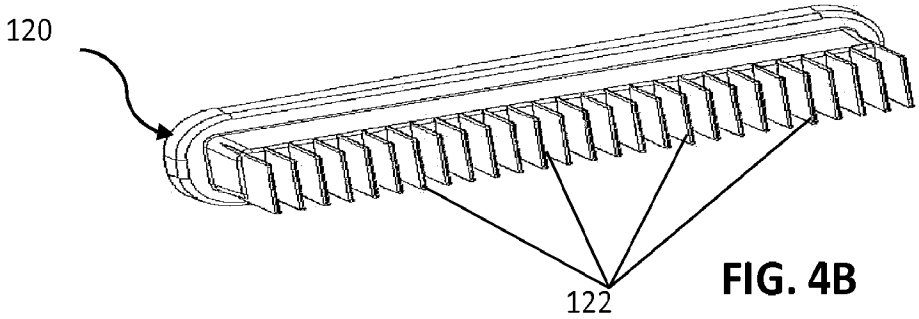


FIG. 4B

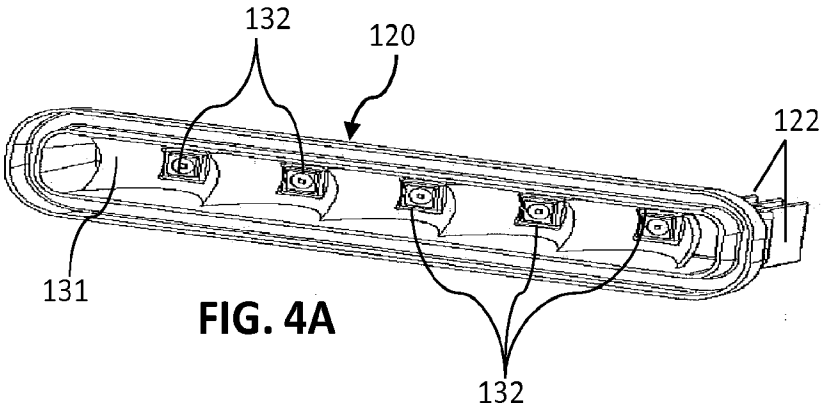


FIG. 4A

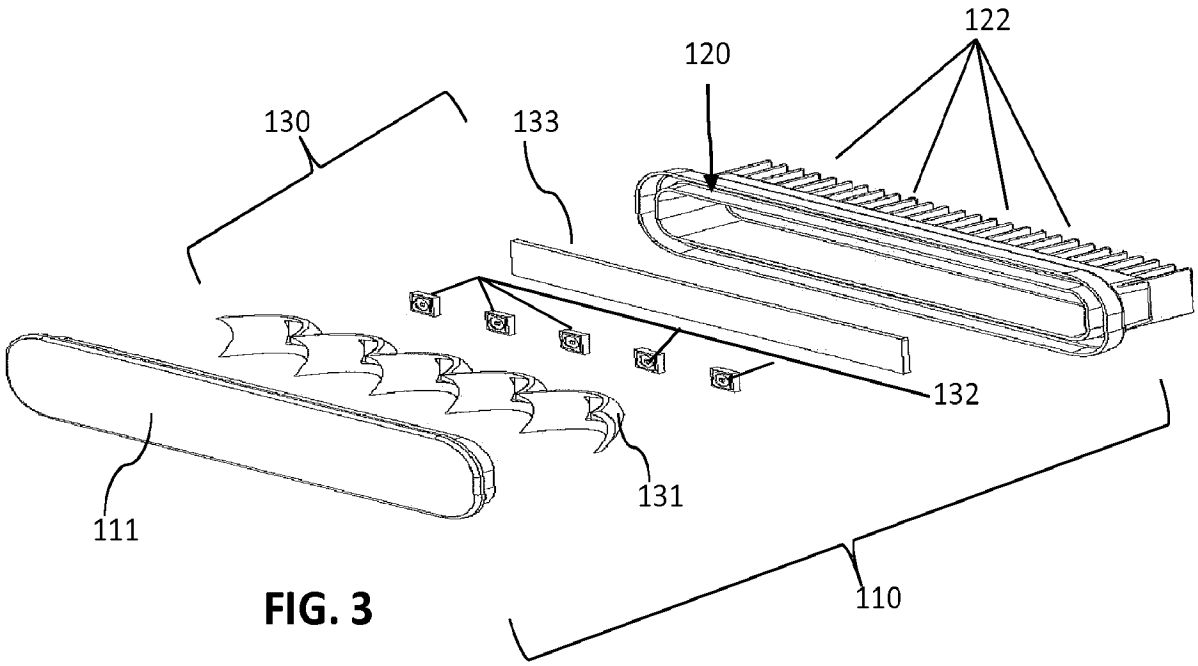


FIG. 3

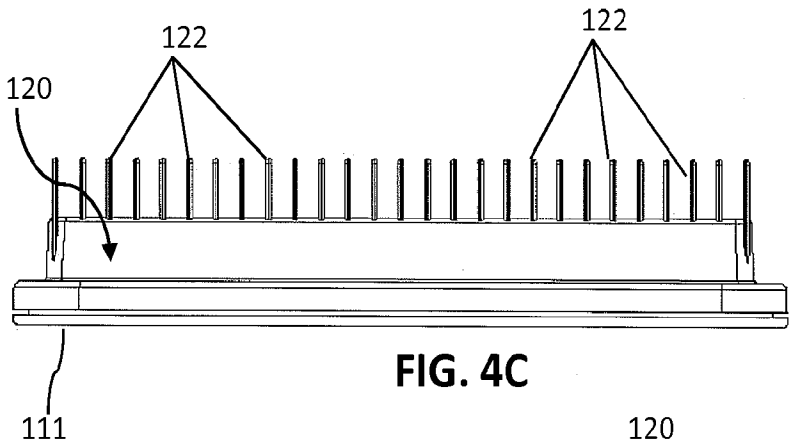


FIG. 4C

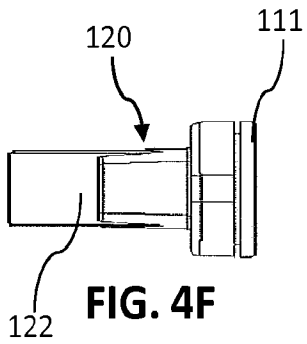


FIG. 4F

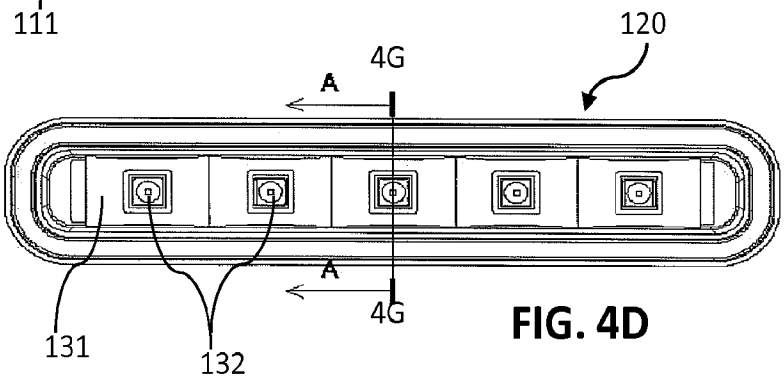


FIG. 4D

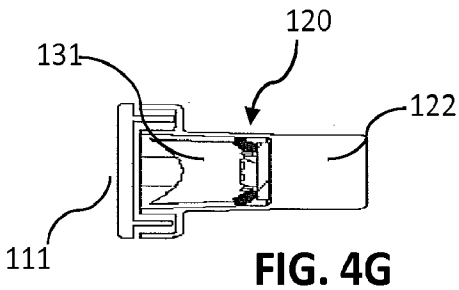


FIG. 4G

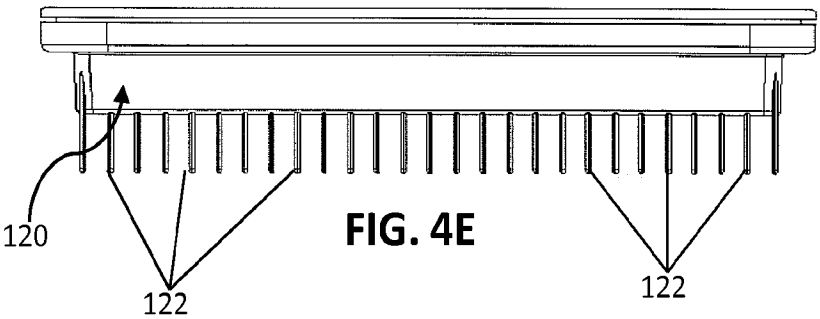


FIG. 4E

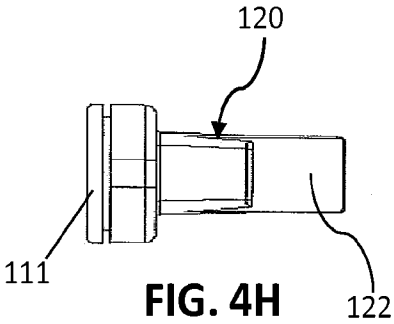


FIG. 4H

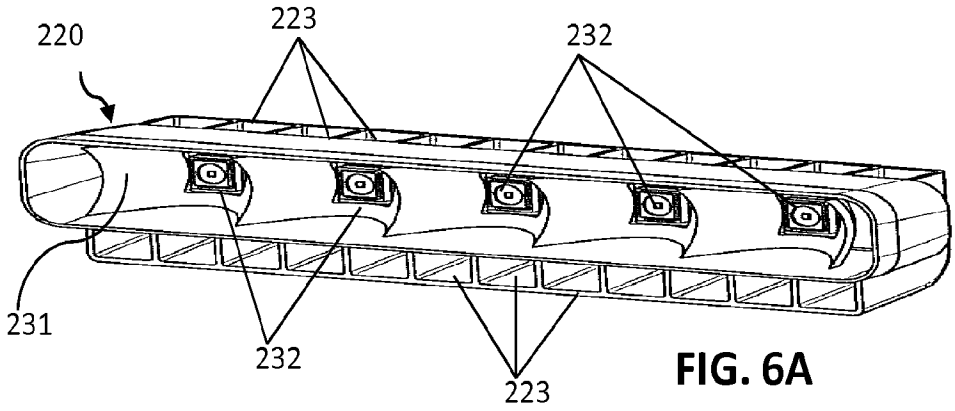


FIG. 6A

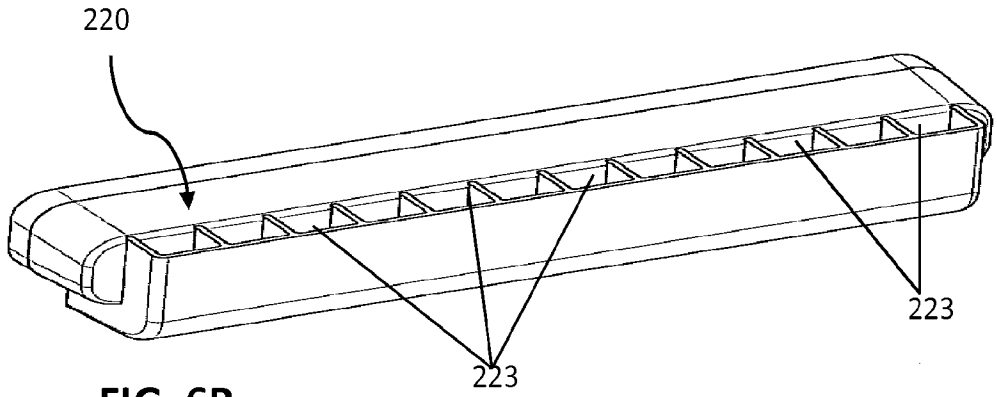


FIG. 6B

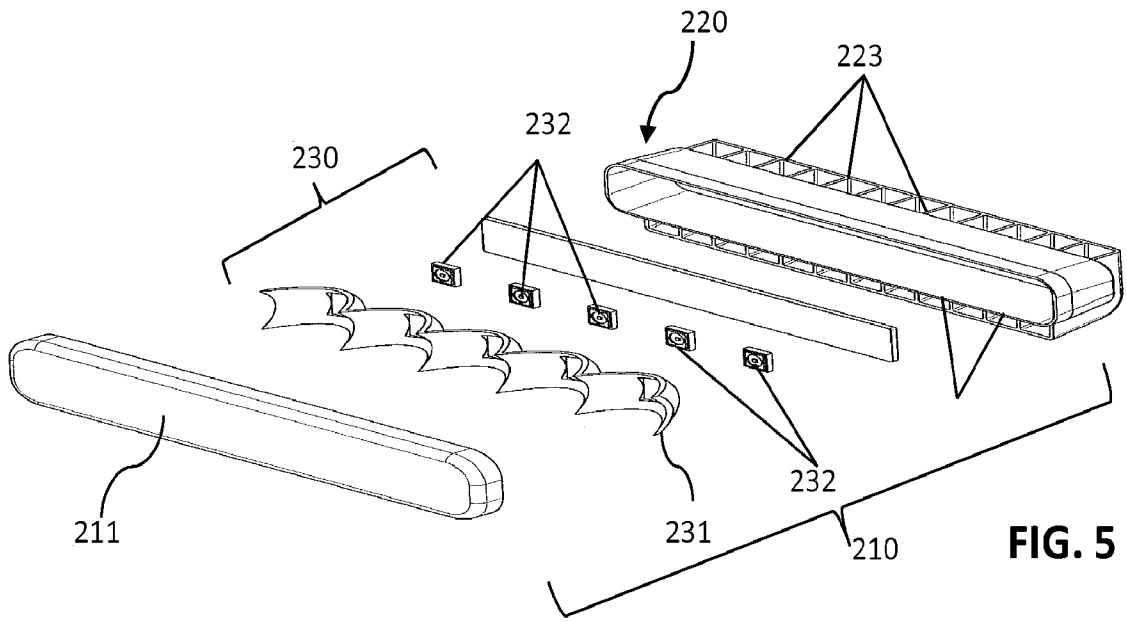


FIG. 5

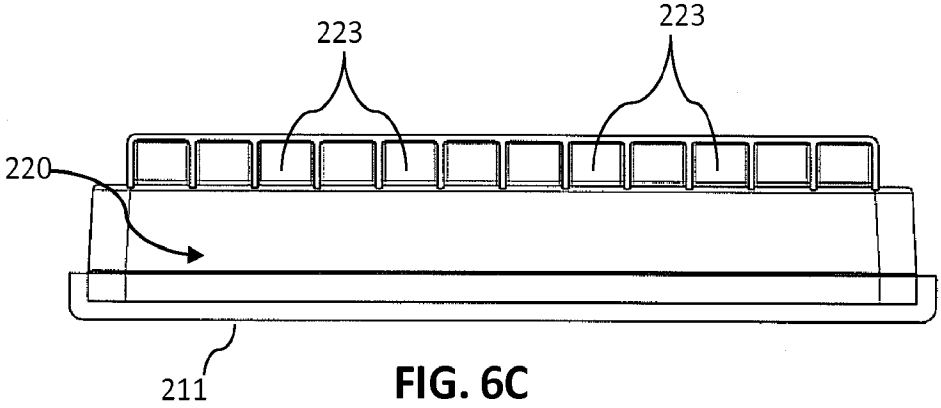


FIG. 6C

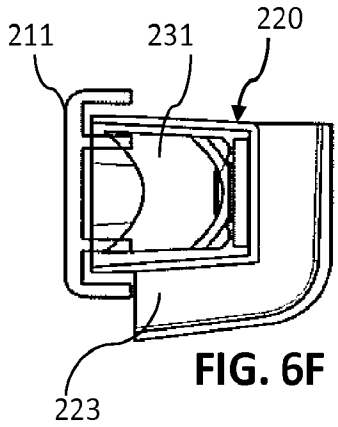


FIG. 6F

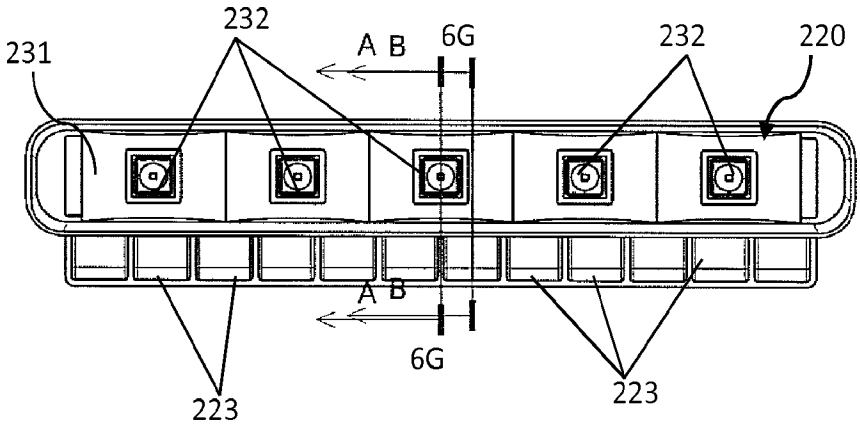


FIG. 6D

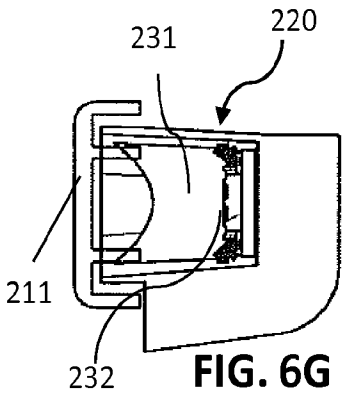


FIG. 6G

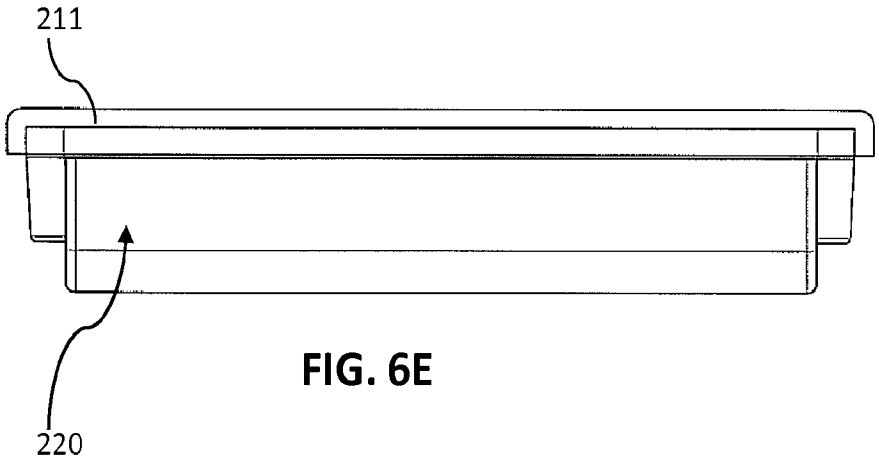


FIG. 6E

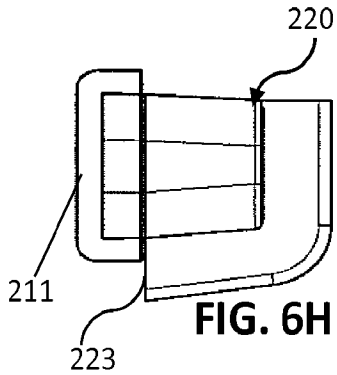


FIG. 6H

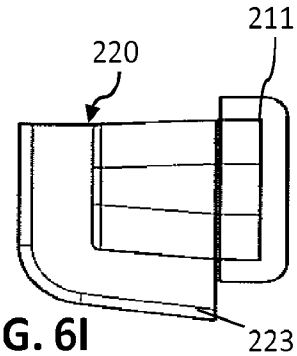
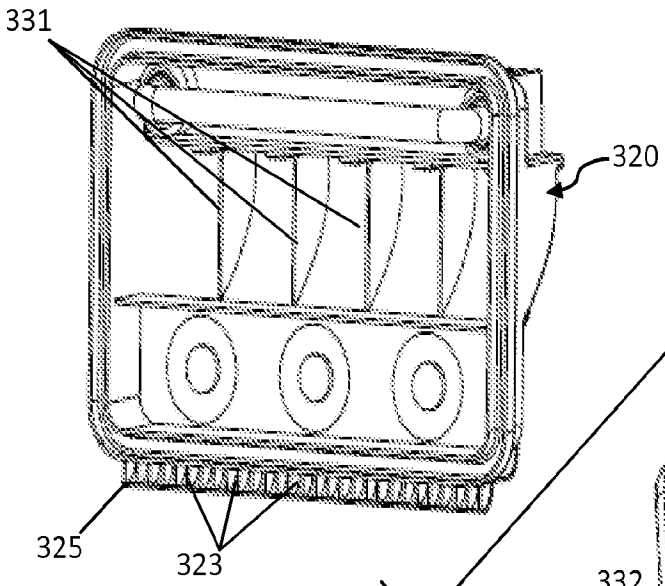


FIG. 6I

FIG. 8A



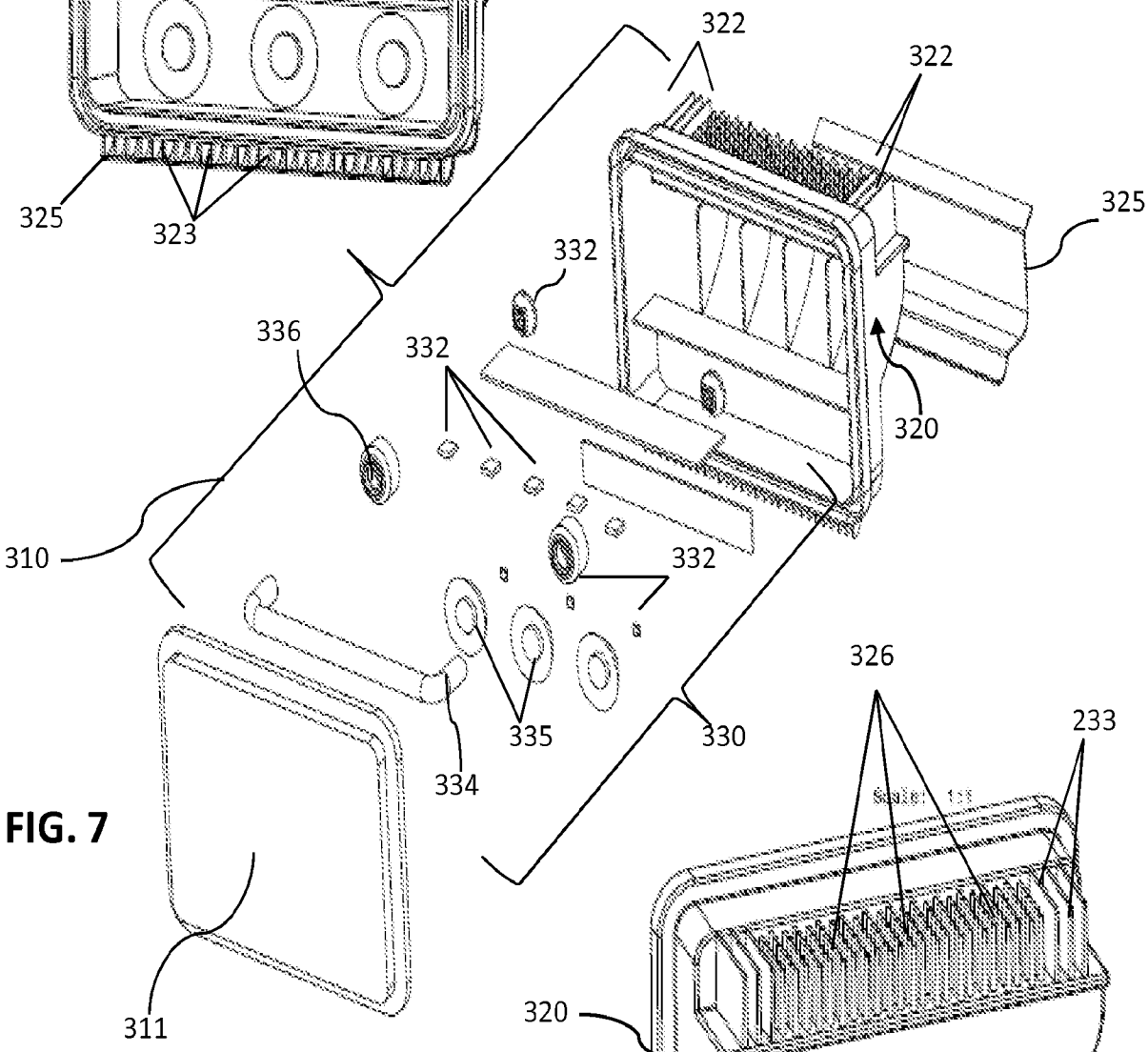


FIG. 7

FIG. 8B

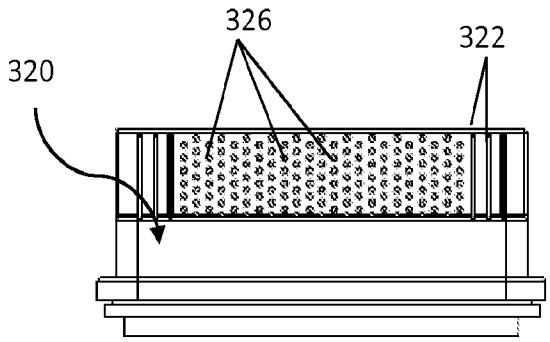


Fig. 8C

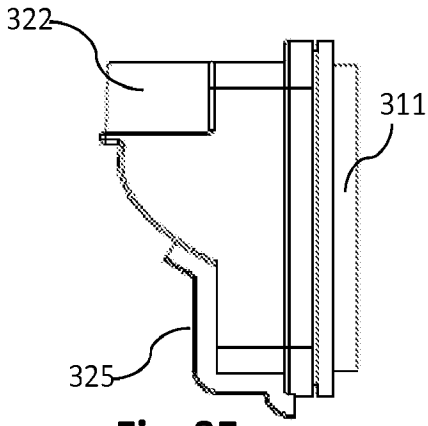


Fig. 8F

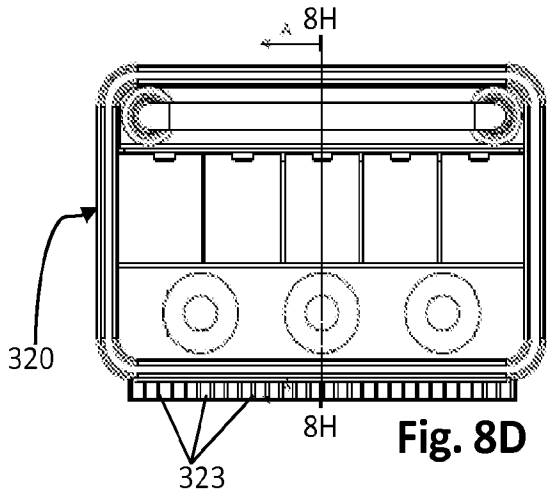


Fig. 8D

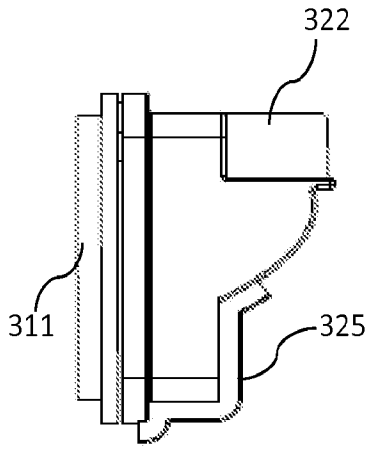


Fig. 8G

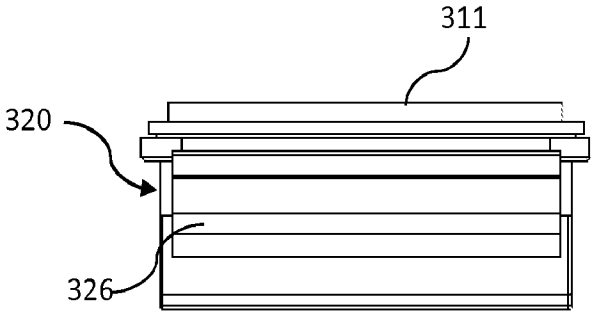


Fig. 8E

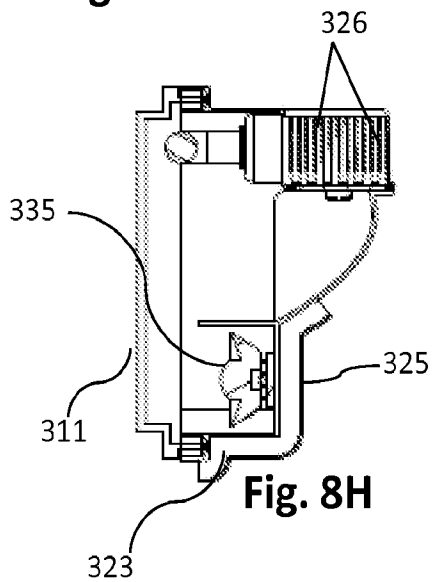


Fig. 8H

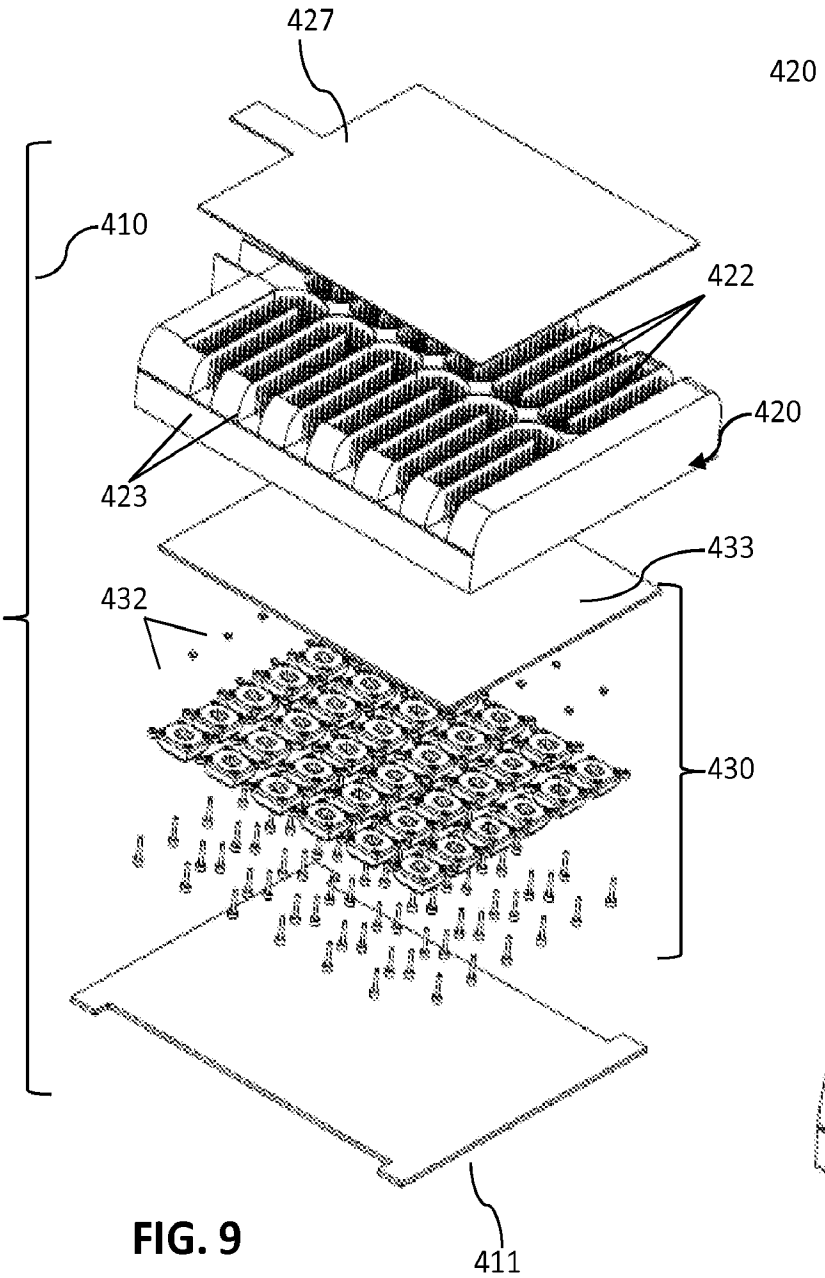


FIG. 9

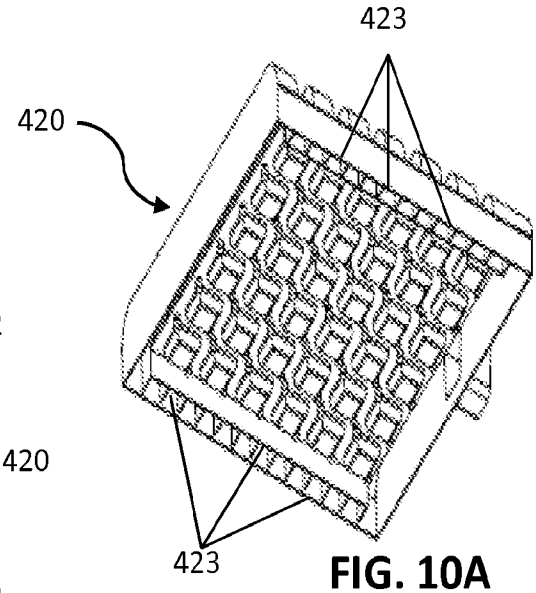


FIG. 10A

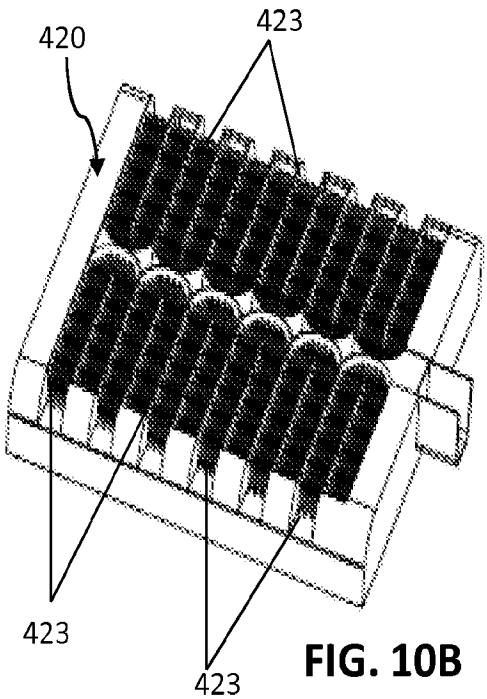


FIG. 10B

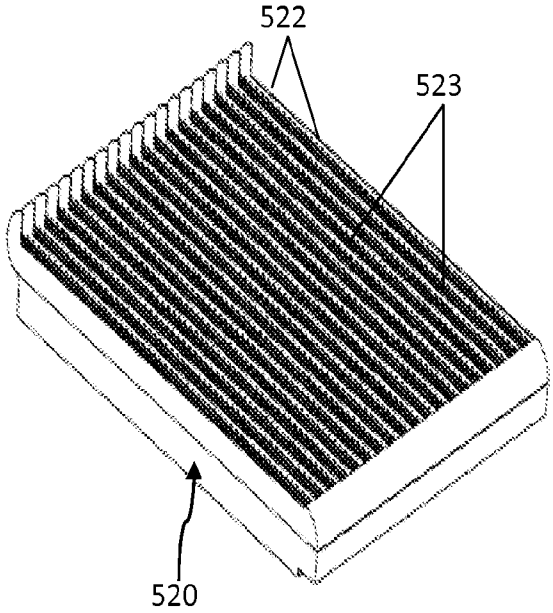


FIG. 12A

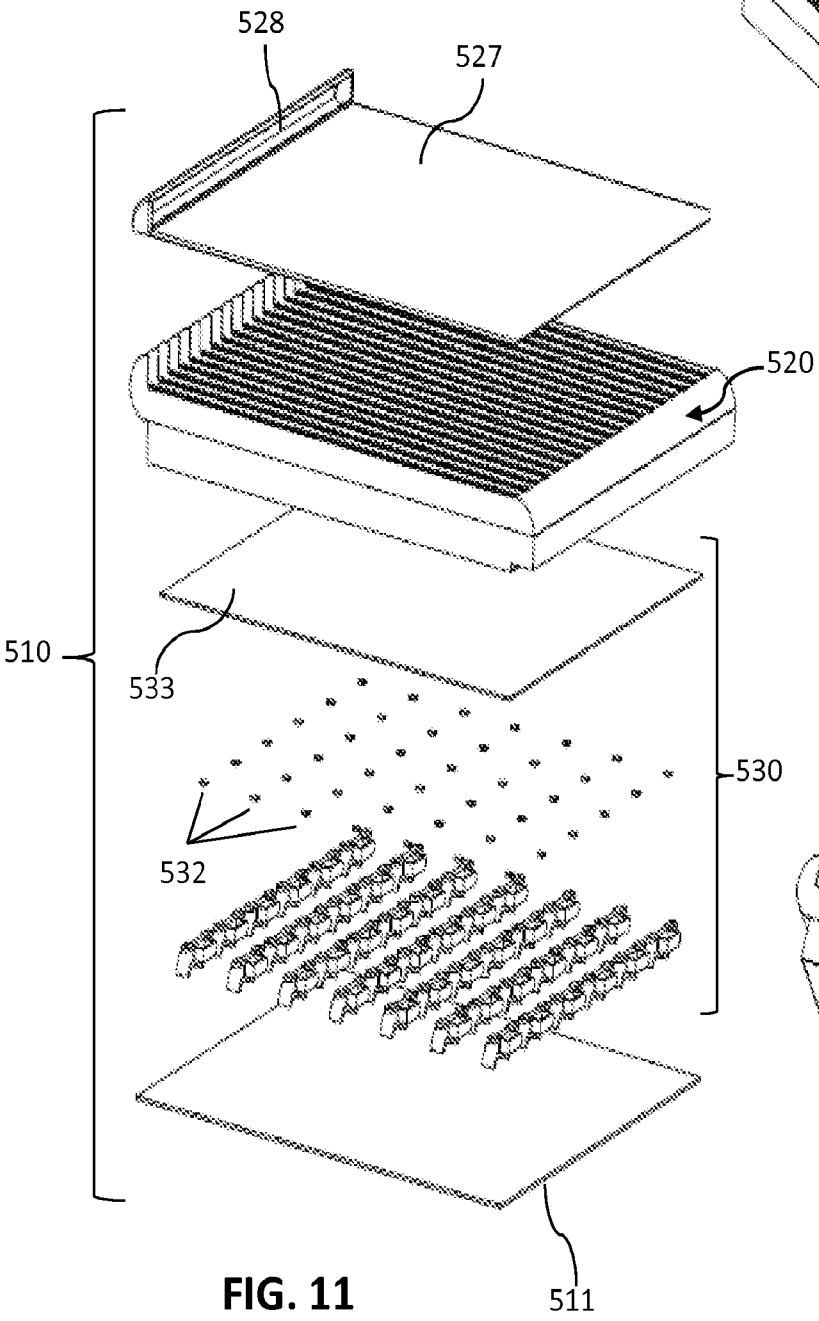


FIG. 11

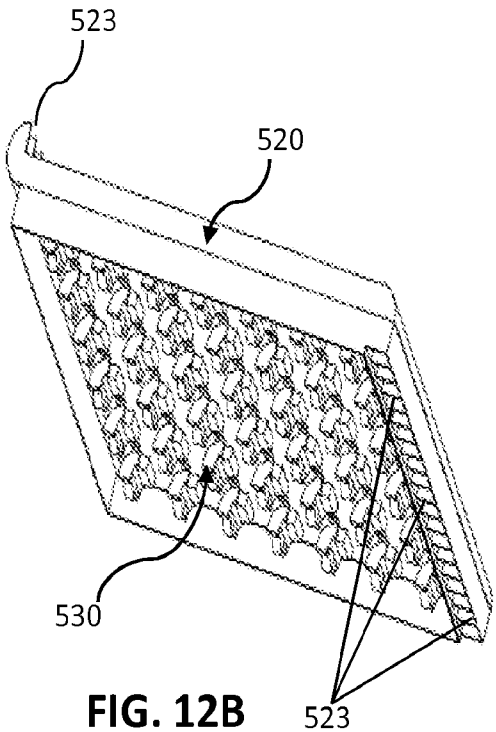


FIG. 12B