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Thomsen et al.

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(54) **FAN ASSEMBLY WITH ULTRA VIOLET DISINFECTION**

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F04D 25/08	(2006.01)
F04D 29/34	(2006.01)
F21V 33/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61L 9/20*** (2013.01); ***F04D 25/088*** (2013.01); ***F04D 29/34*** (2013.01); *A61L 2209/12* (2013.01); *A61L 2209/134* (2013.01); *A61L 2209/15* (2013.01); *F21V 33/0096* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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Primary Examiner — Jelitza M Perez

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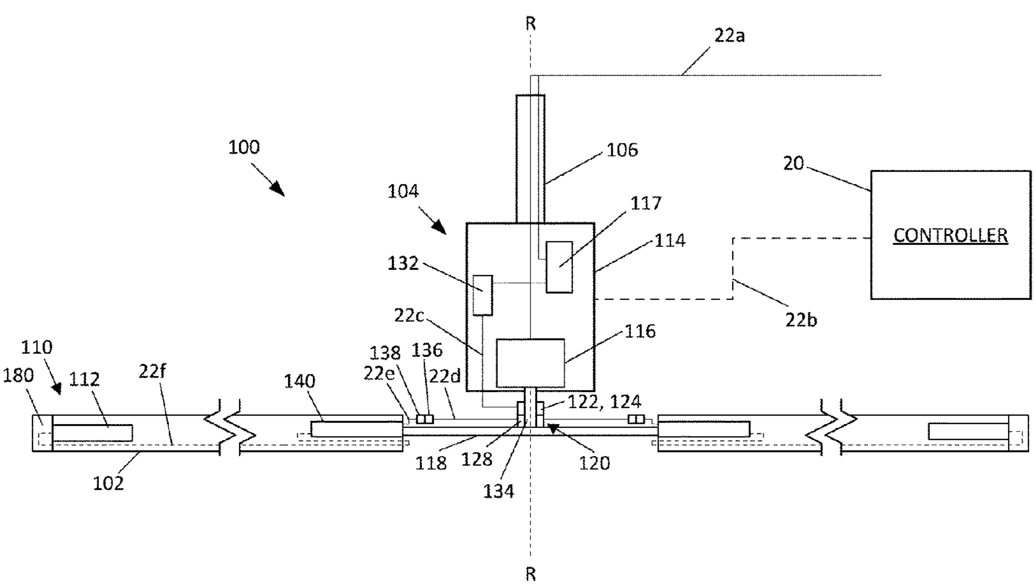
(57) **ABSTRACT**

A fan assembly includes an electric motor; a rotor driven by the electric motor to rotate about an axis of rotation, and a plurality of blades, for example airfoil shaped blades, attached to the rotor. At least one blade includes a lighting assembly having an ultraviolet light source mounted inside an internal cavity proximal to an end of a blade body of the at least one blade such that the outer shape of the blade is generally unchanged by the lighting assembly.

15 Claims, 22 Drawing Sheets



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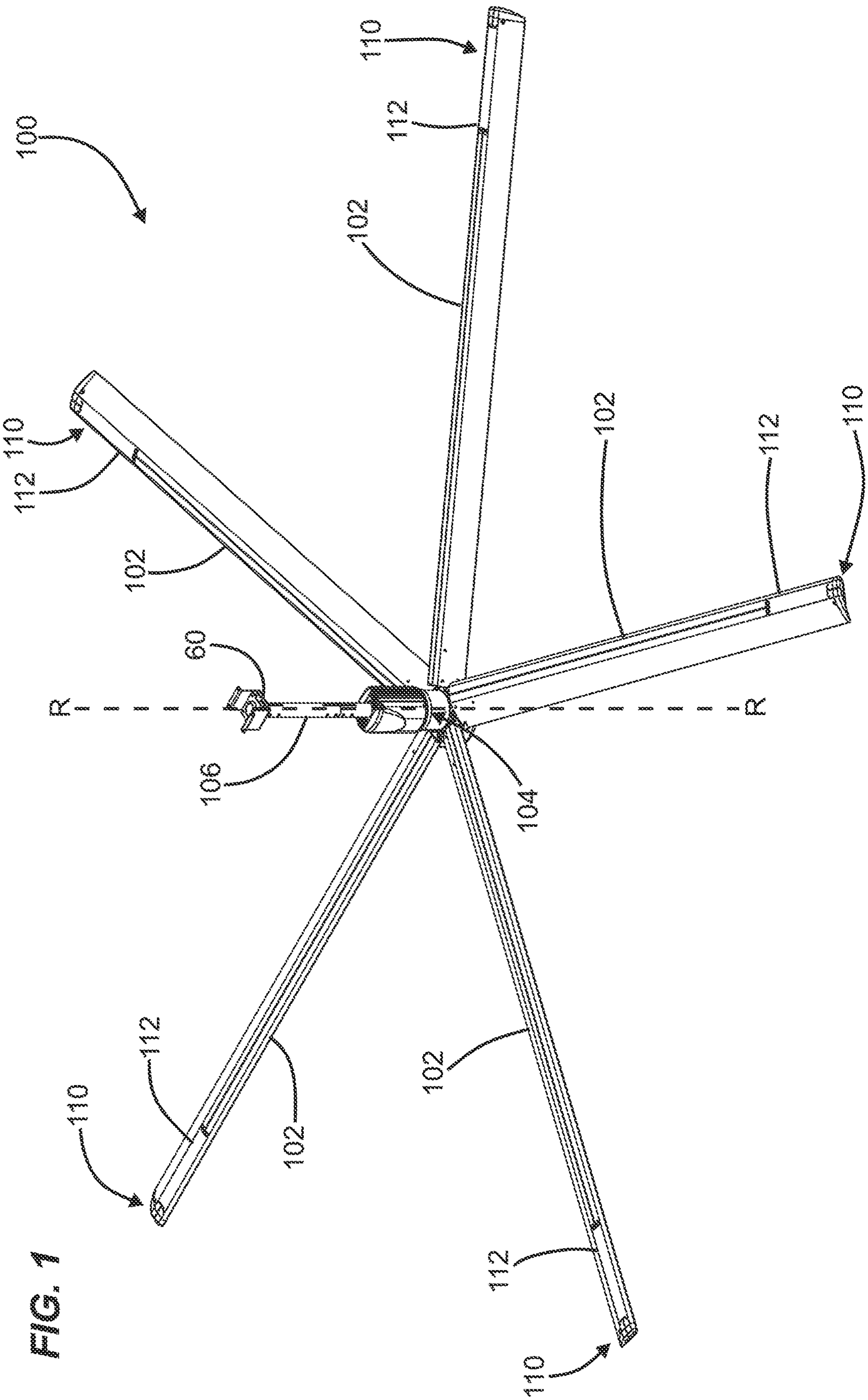
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FIG. 1

FIG. 2

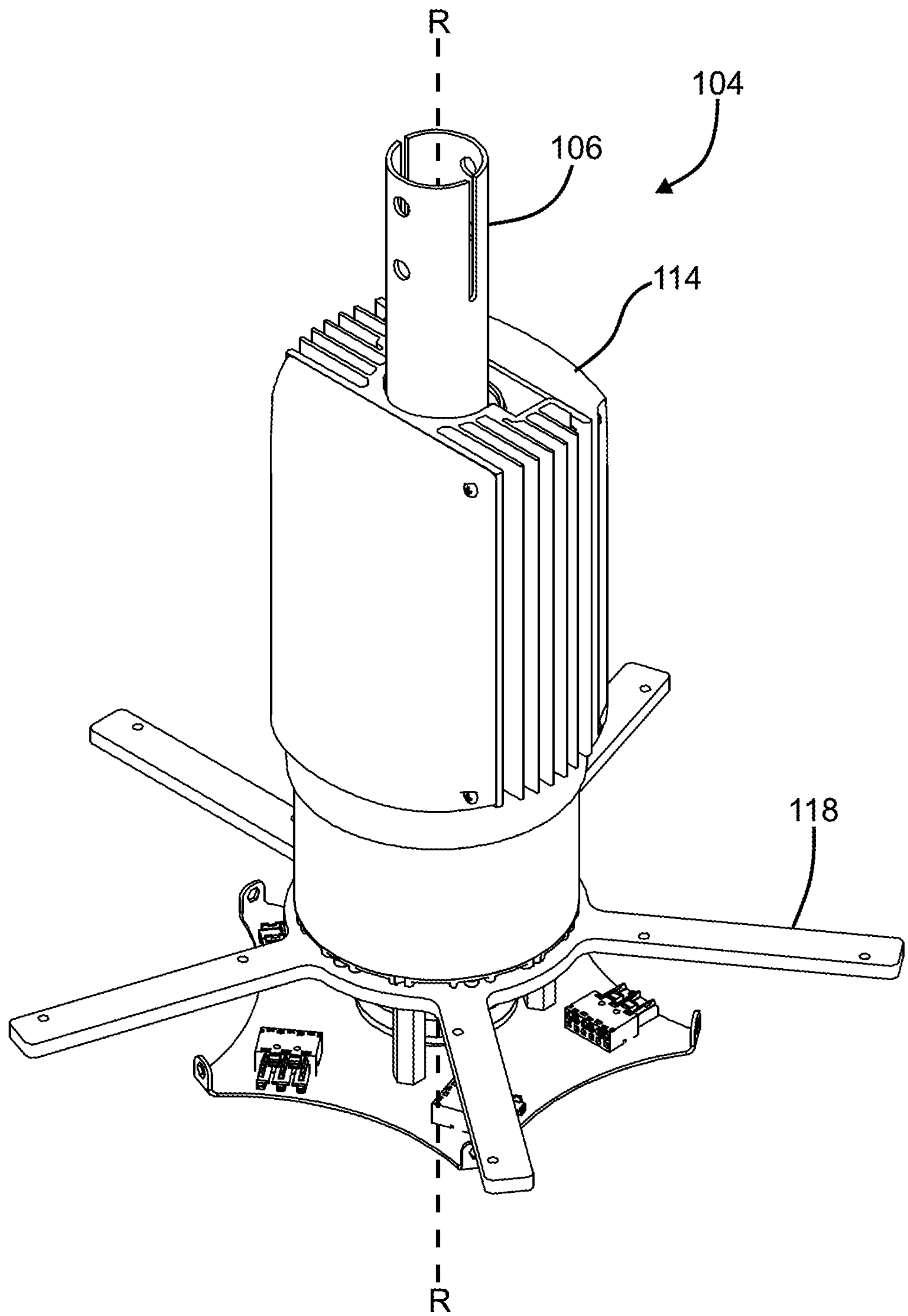
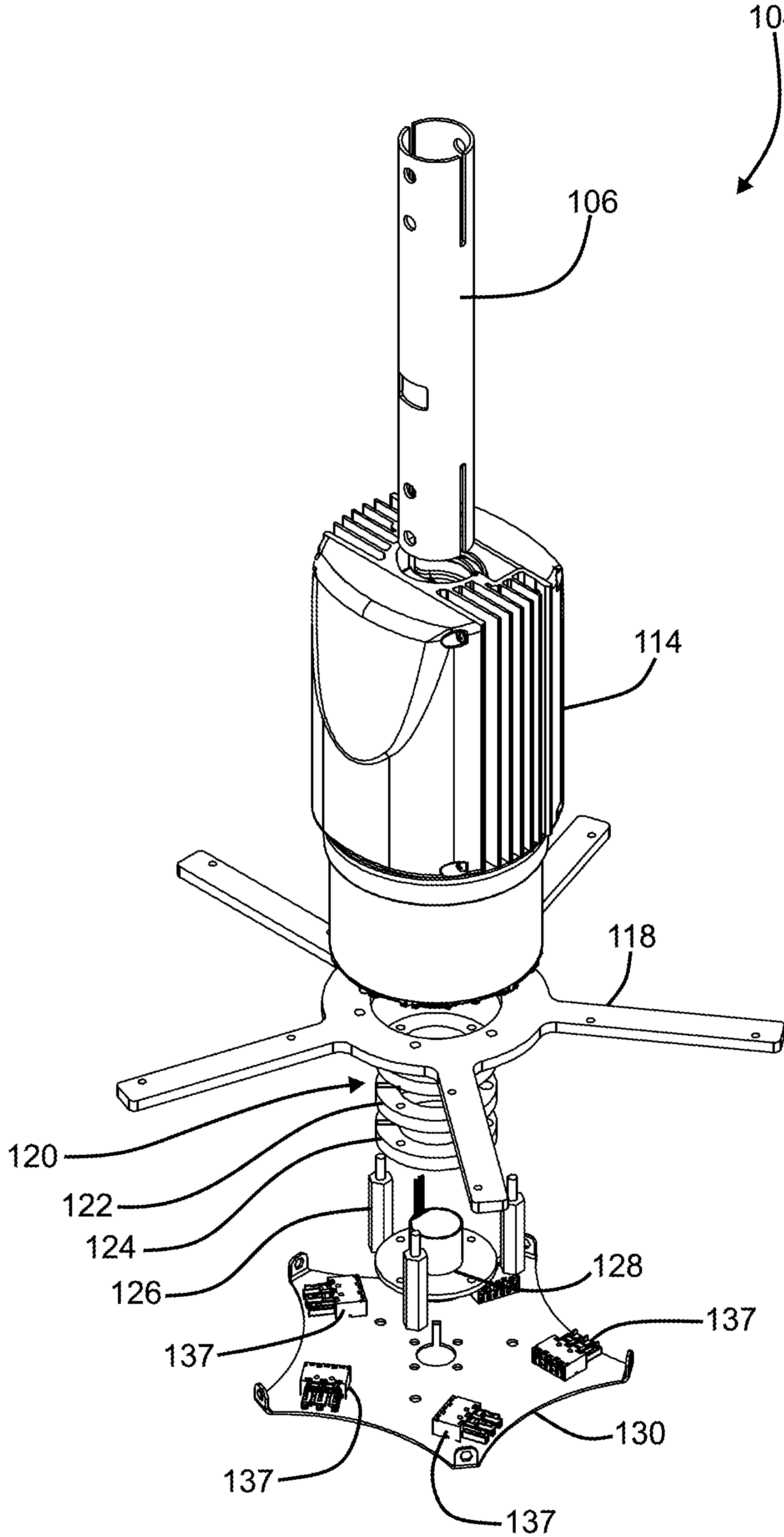


FIG. 3



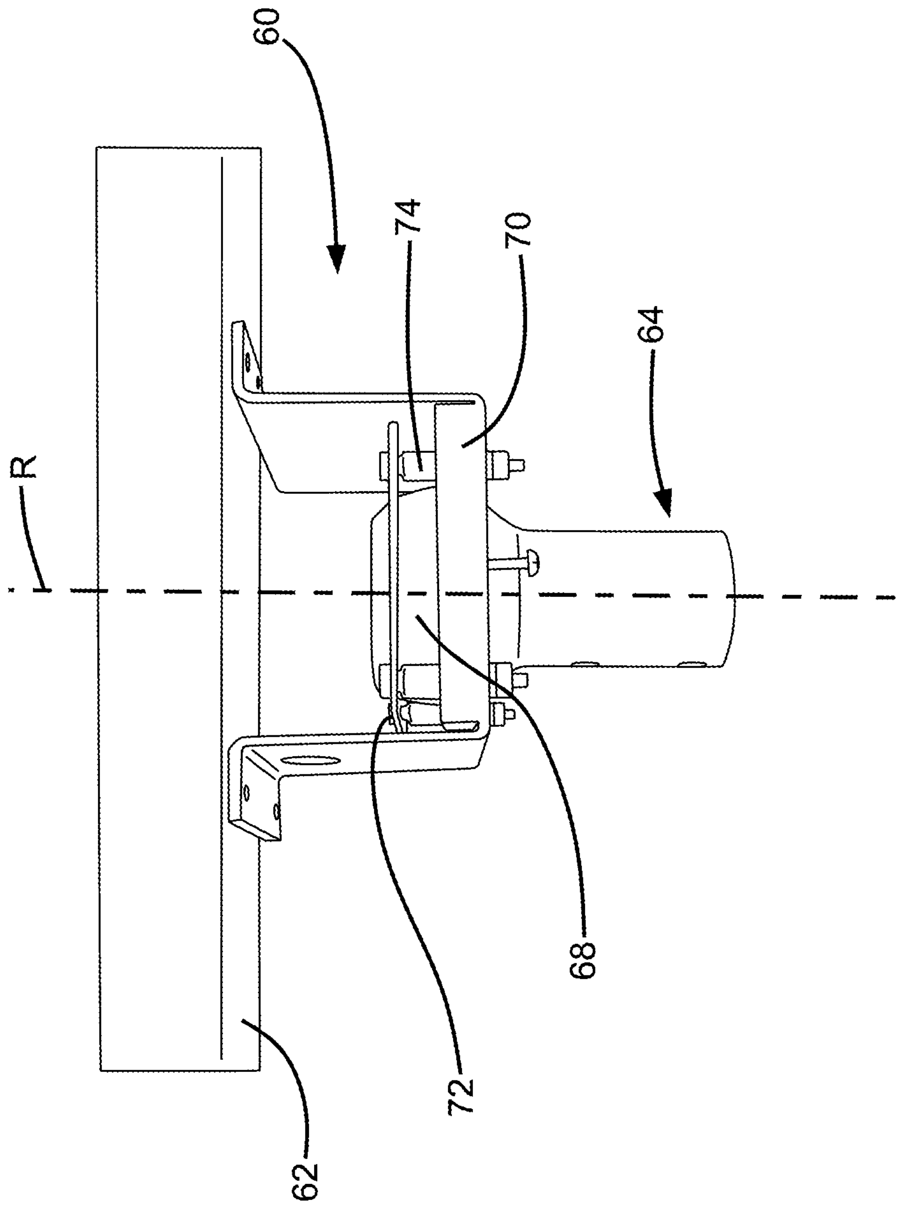
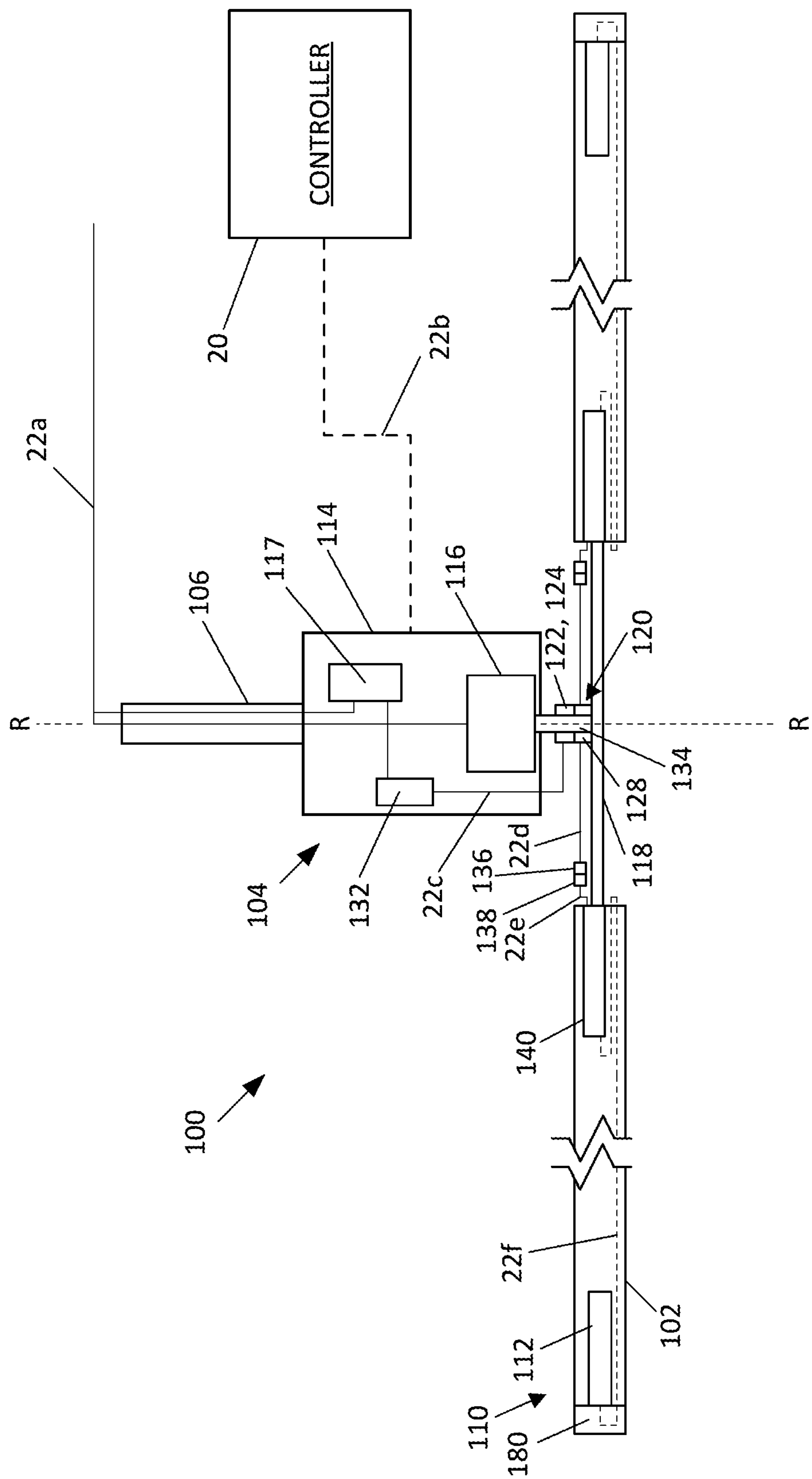


FIG. 3A

FIG. 4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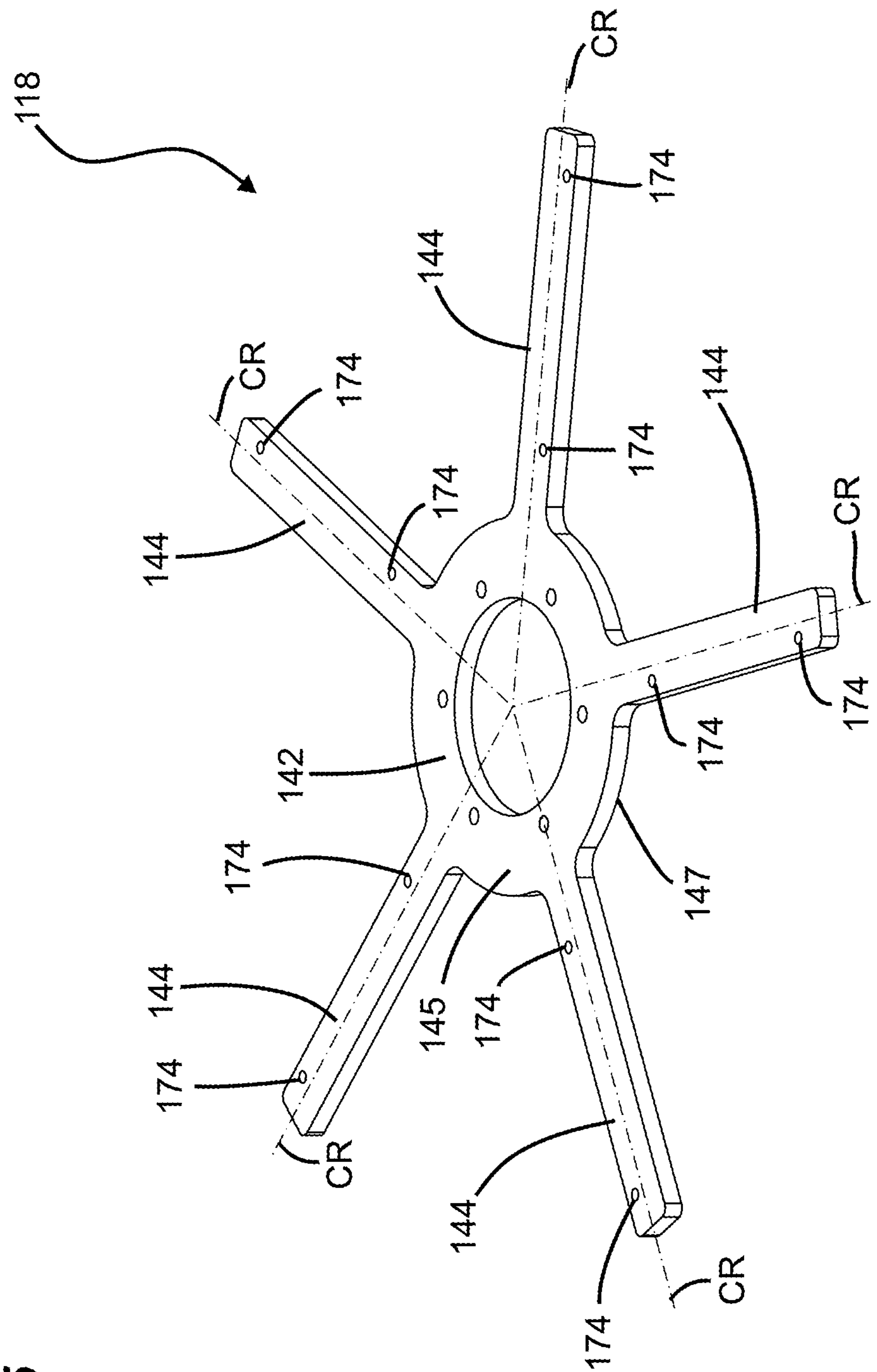
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FIG. 5

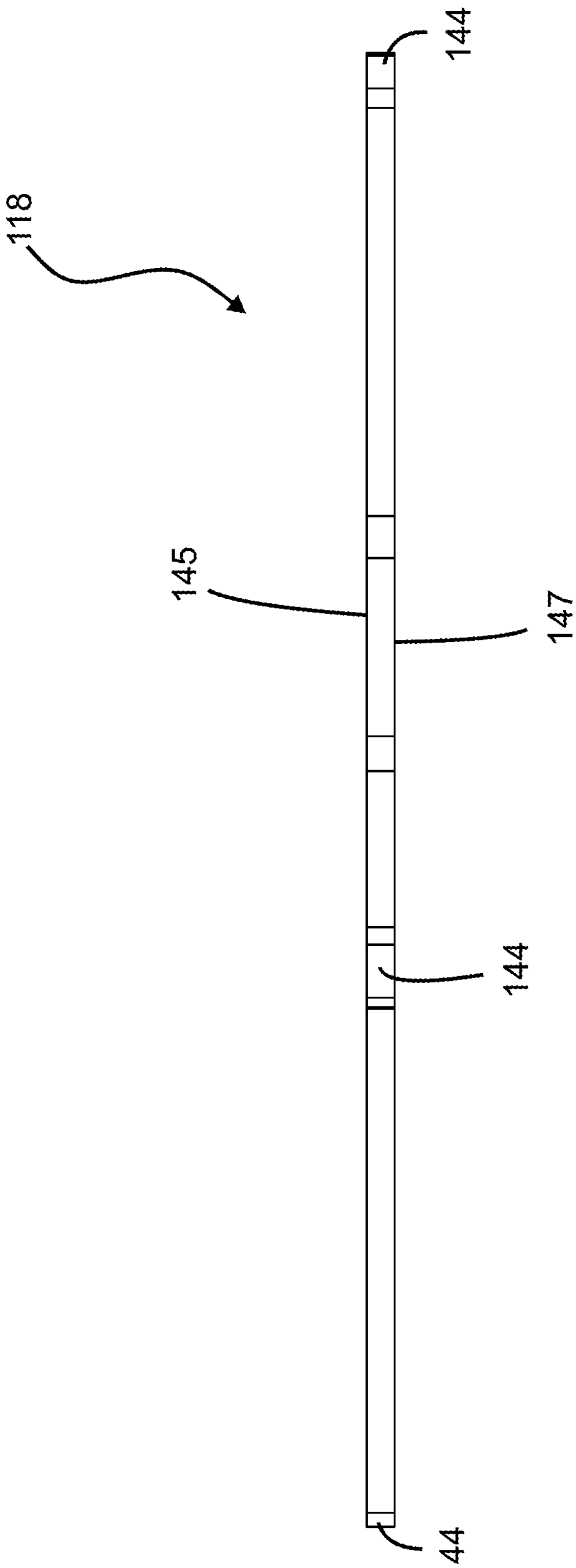


FIG. 5A

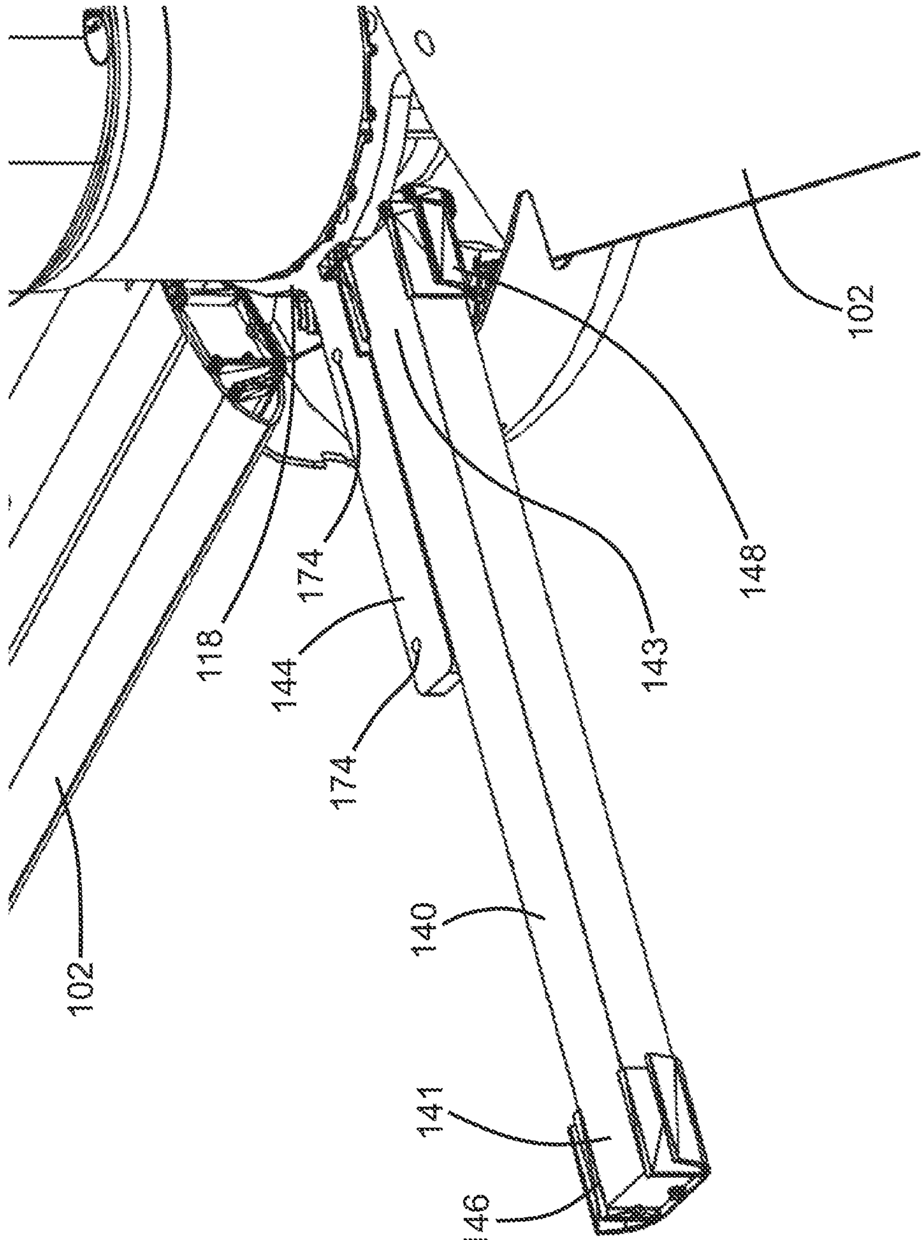


FIG. 6

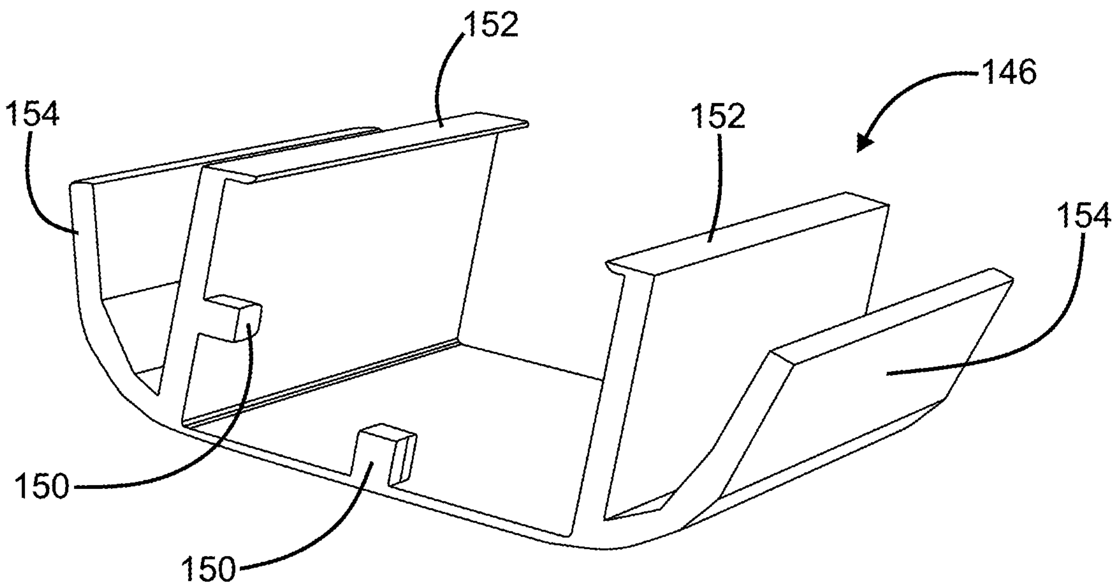


FIG. 7

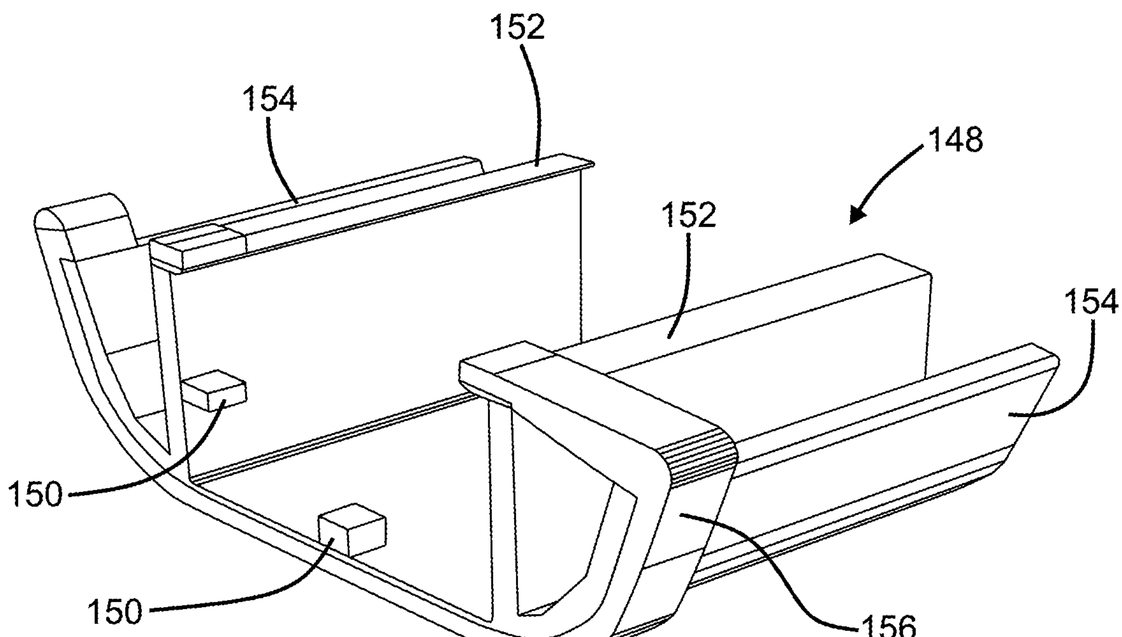


FIG. 8

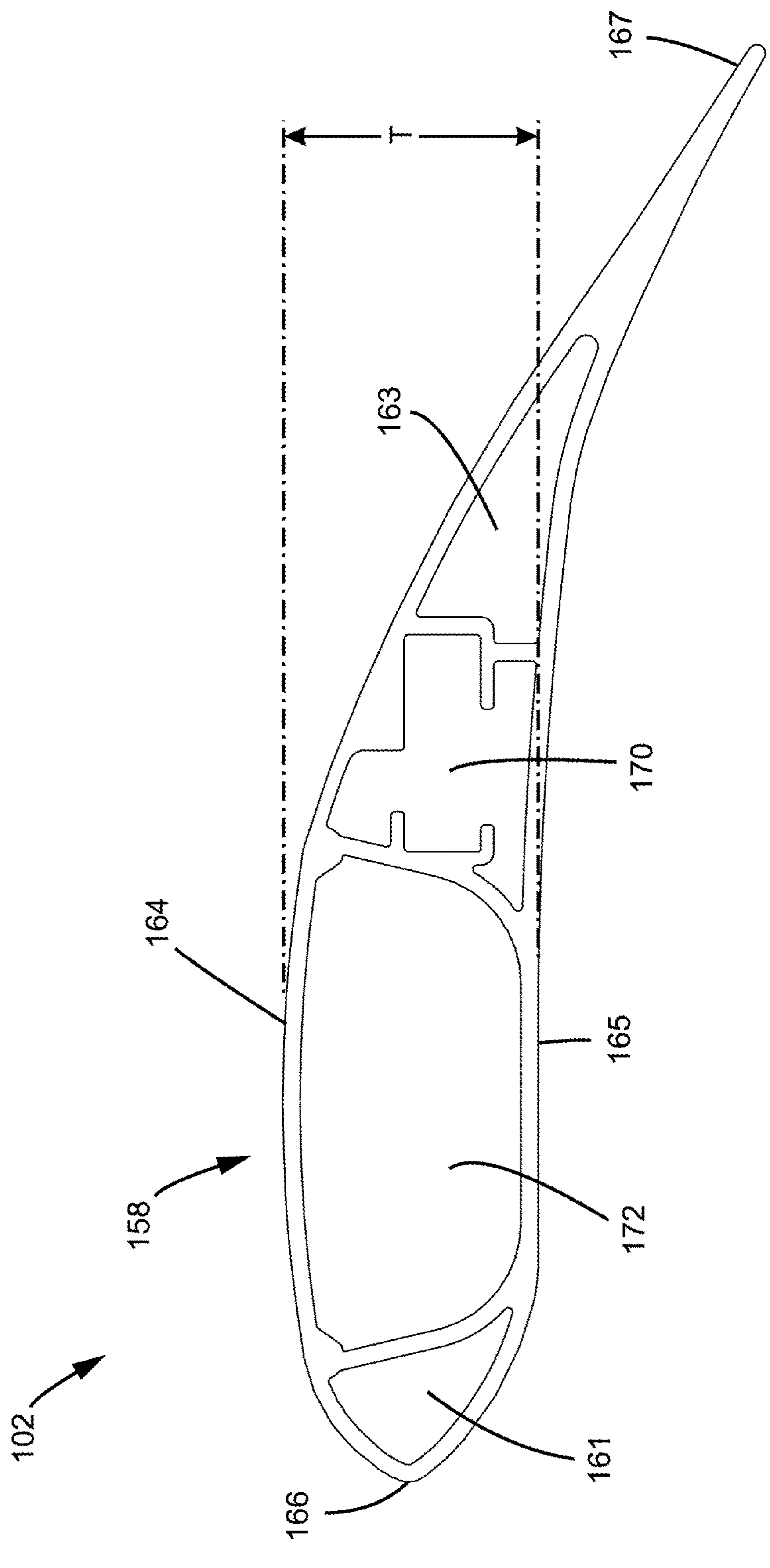


FIG. 9

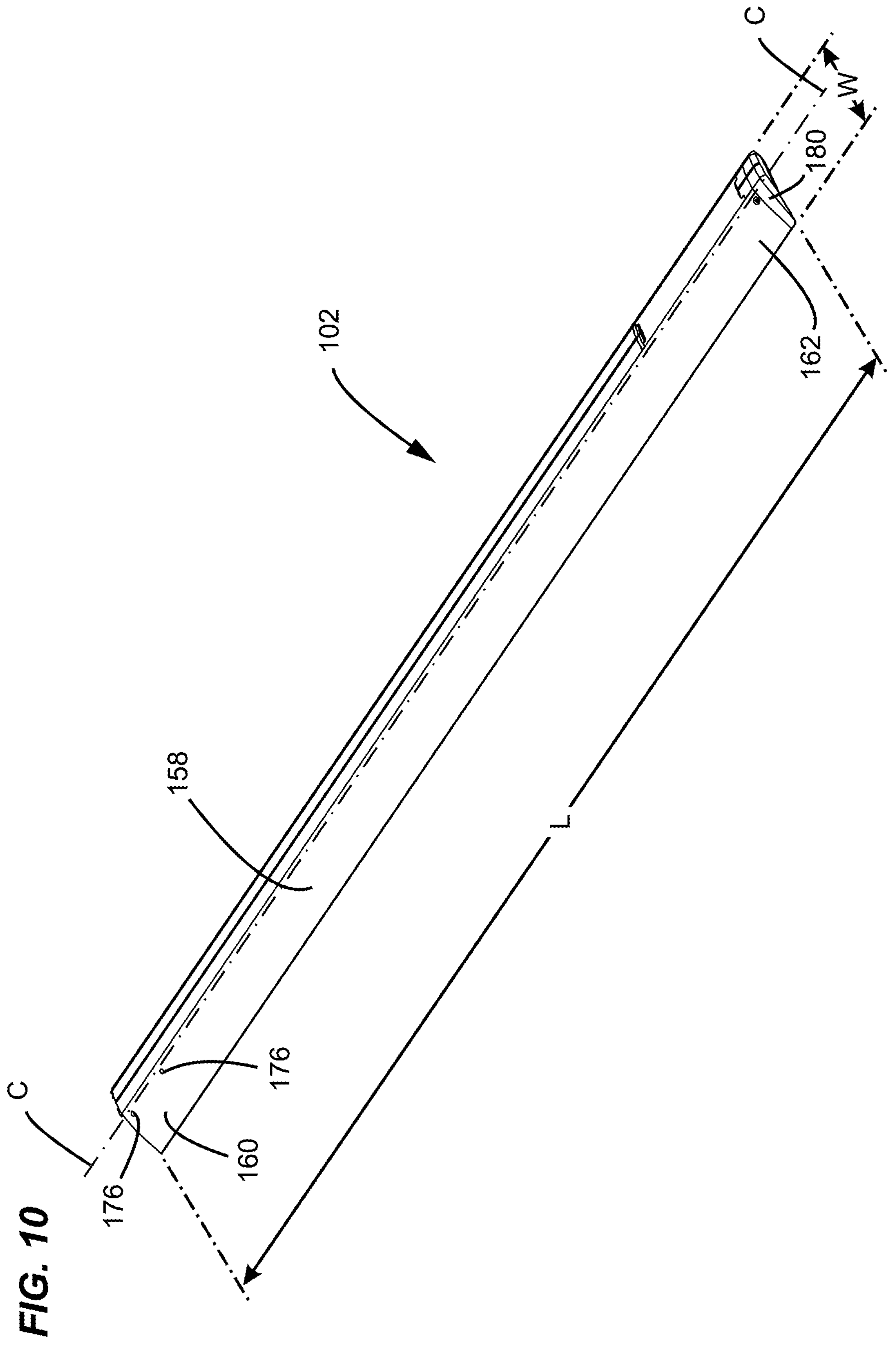


FIG. 10

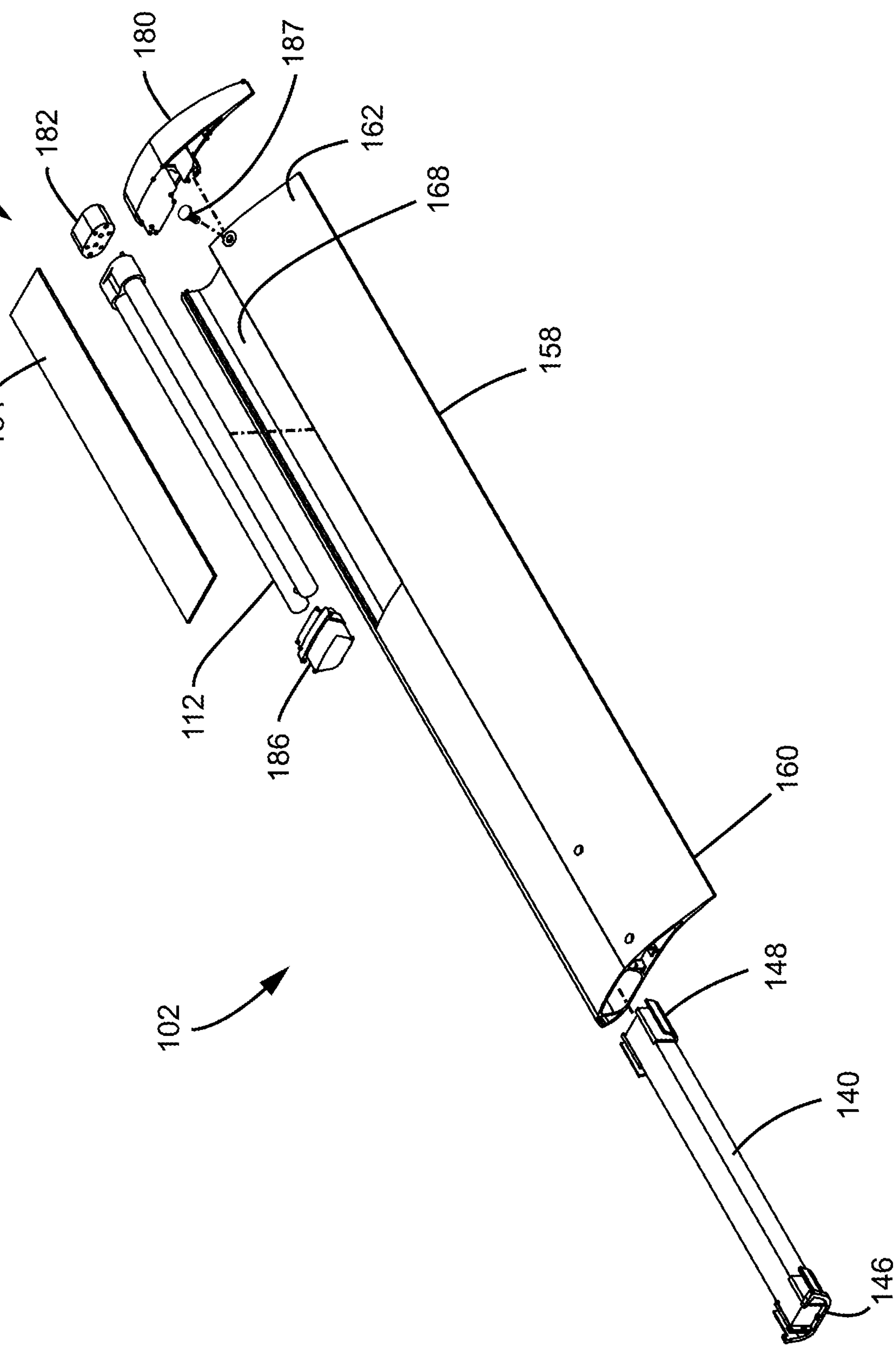


FIG. 11

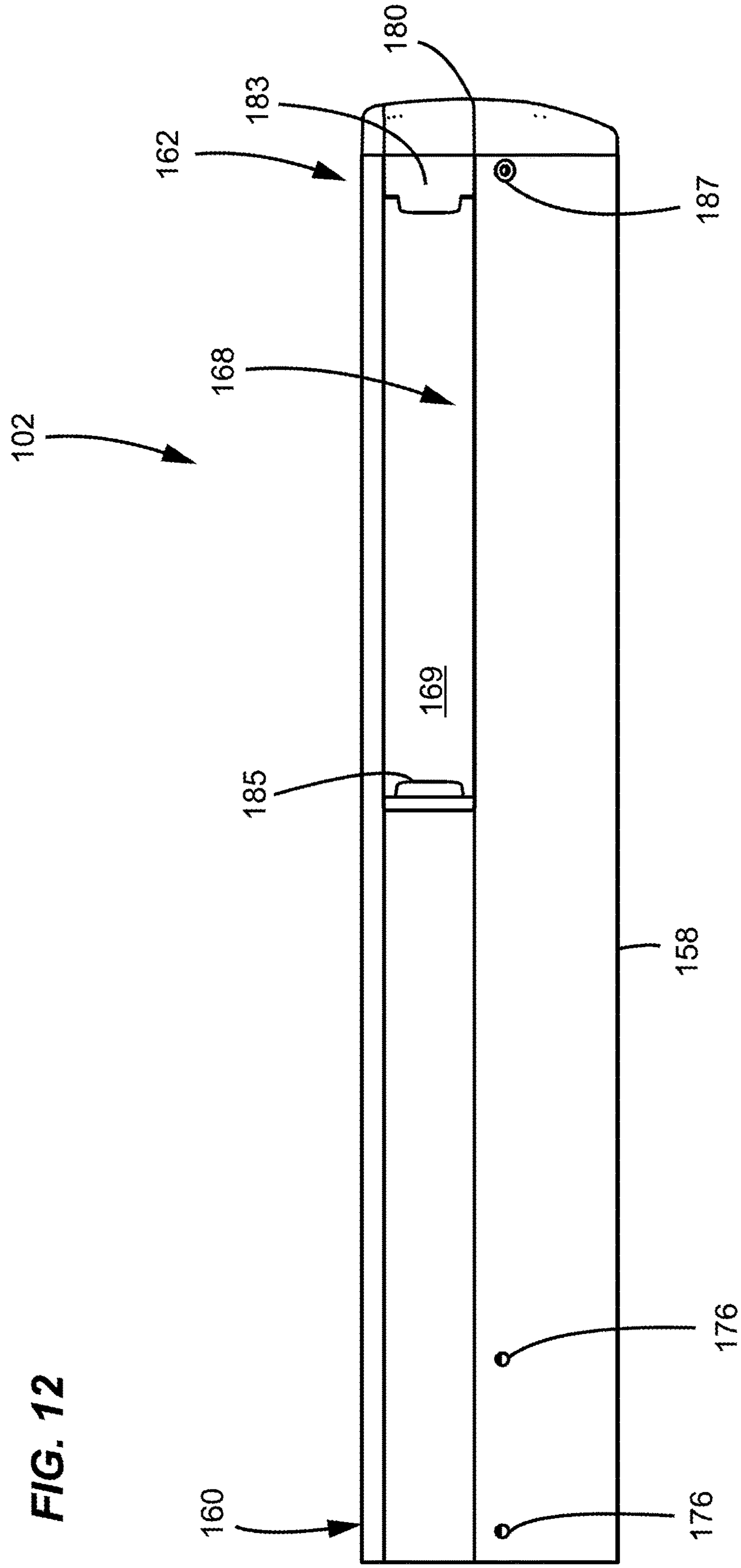


FIG. 12

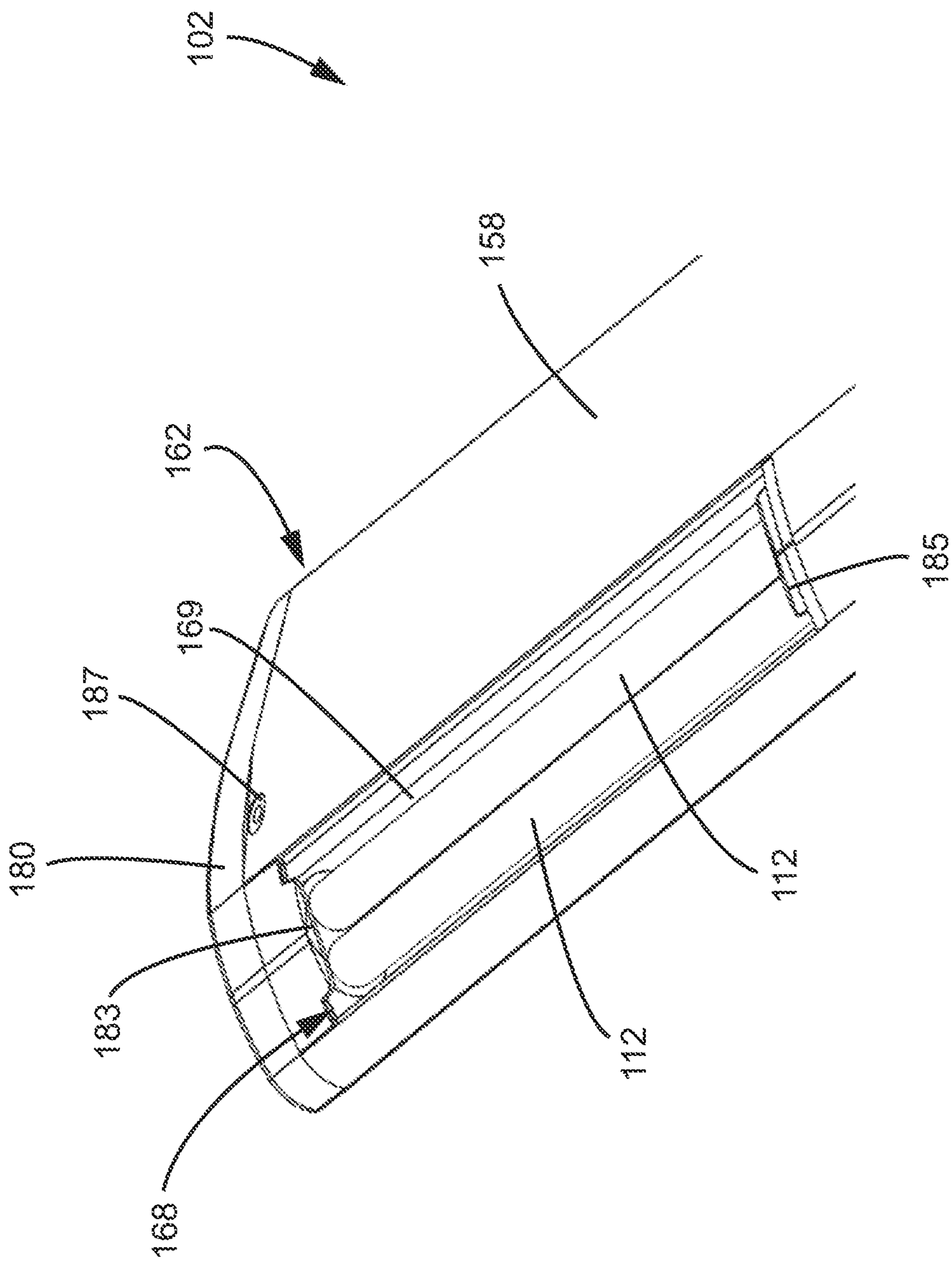


FIG. 13

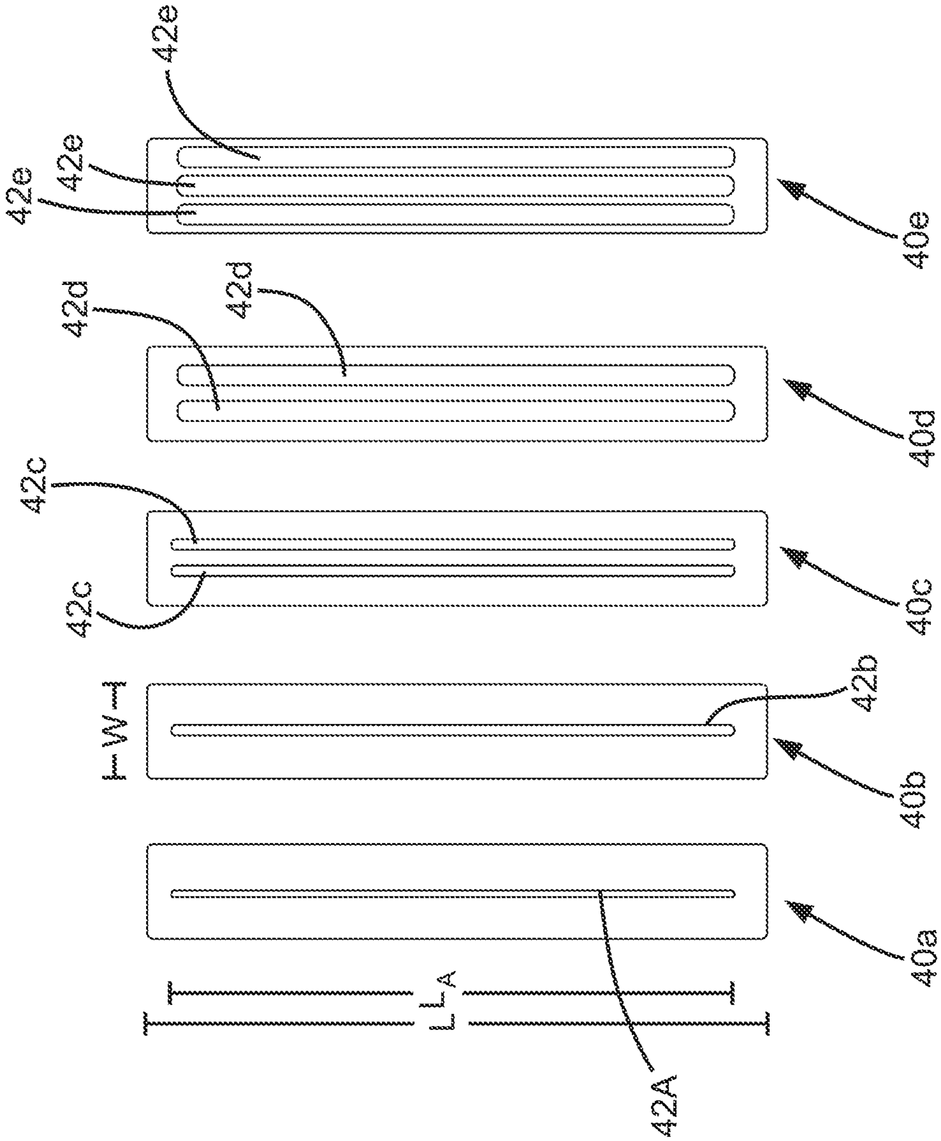


FIG. 13A

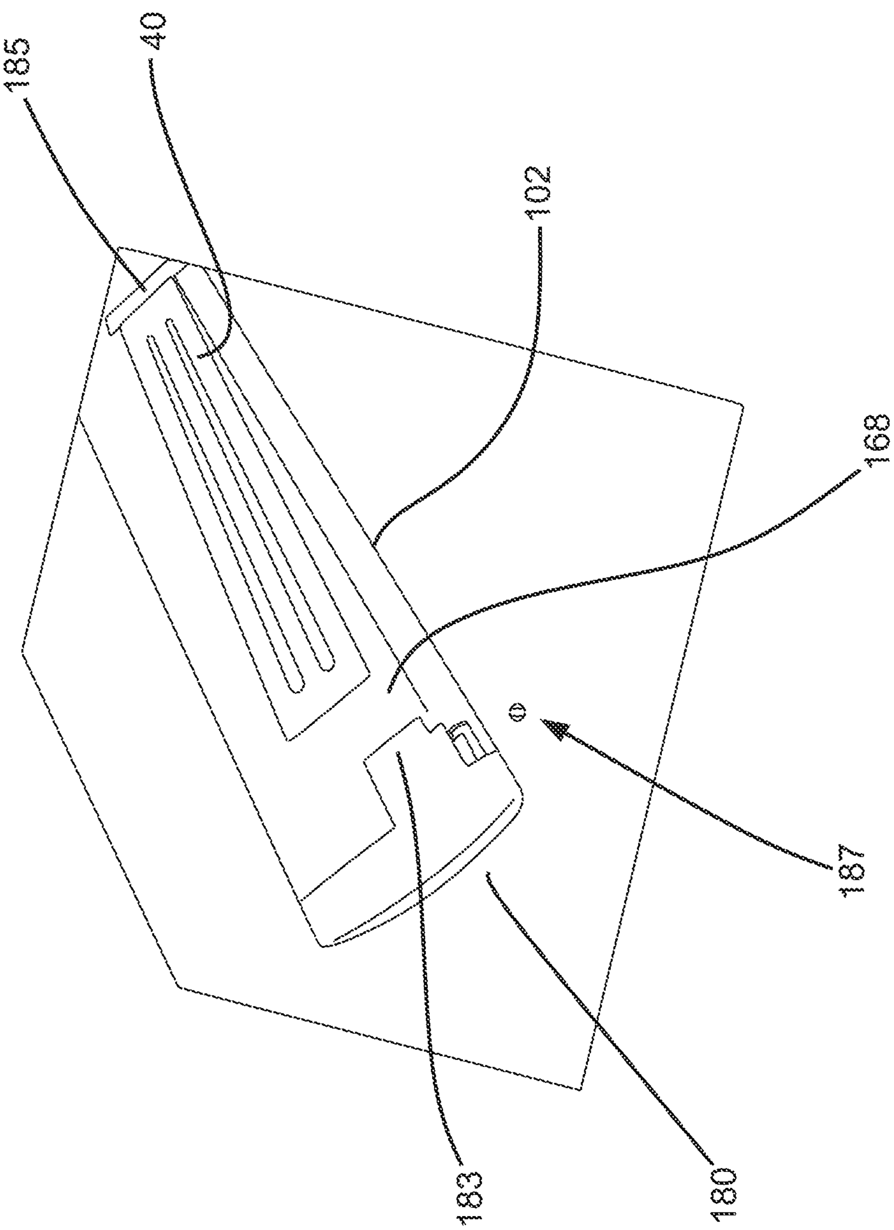


FIG. 13B

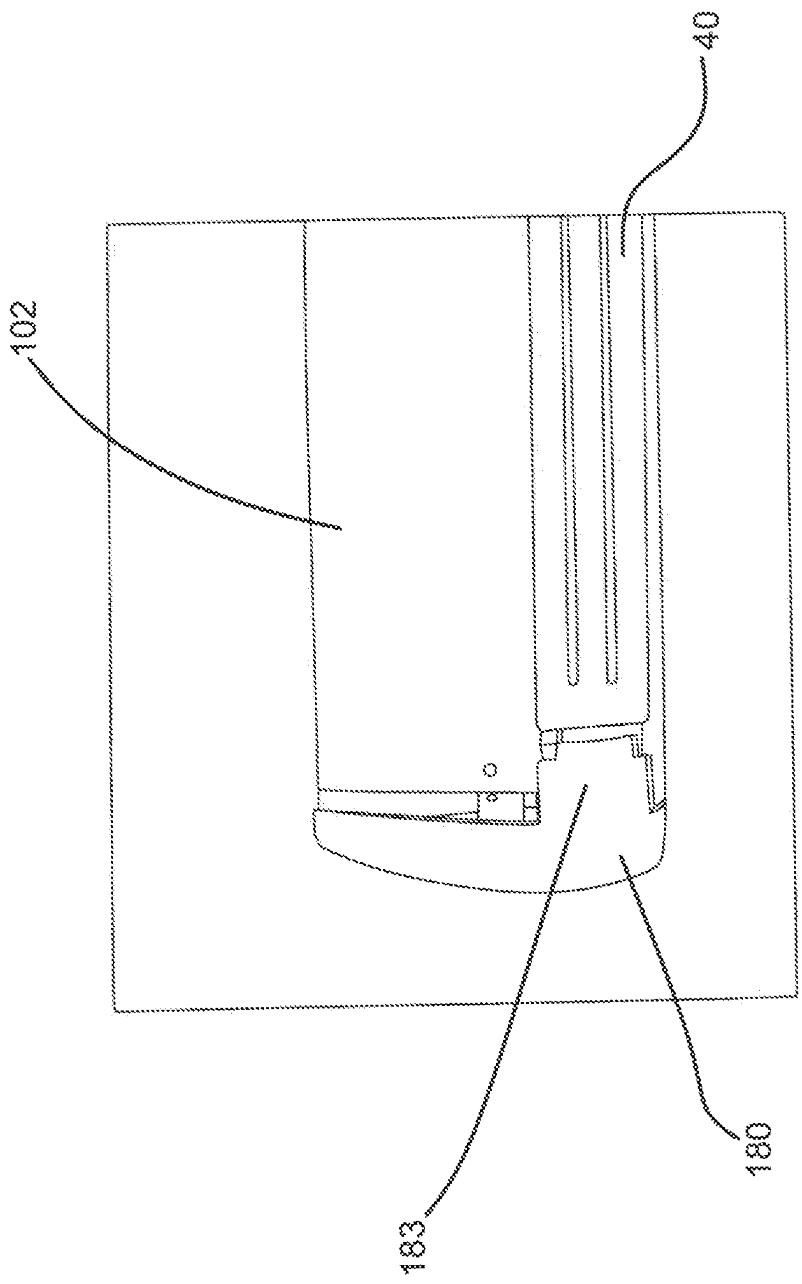


FIG. 13C

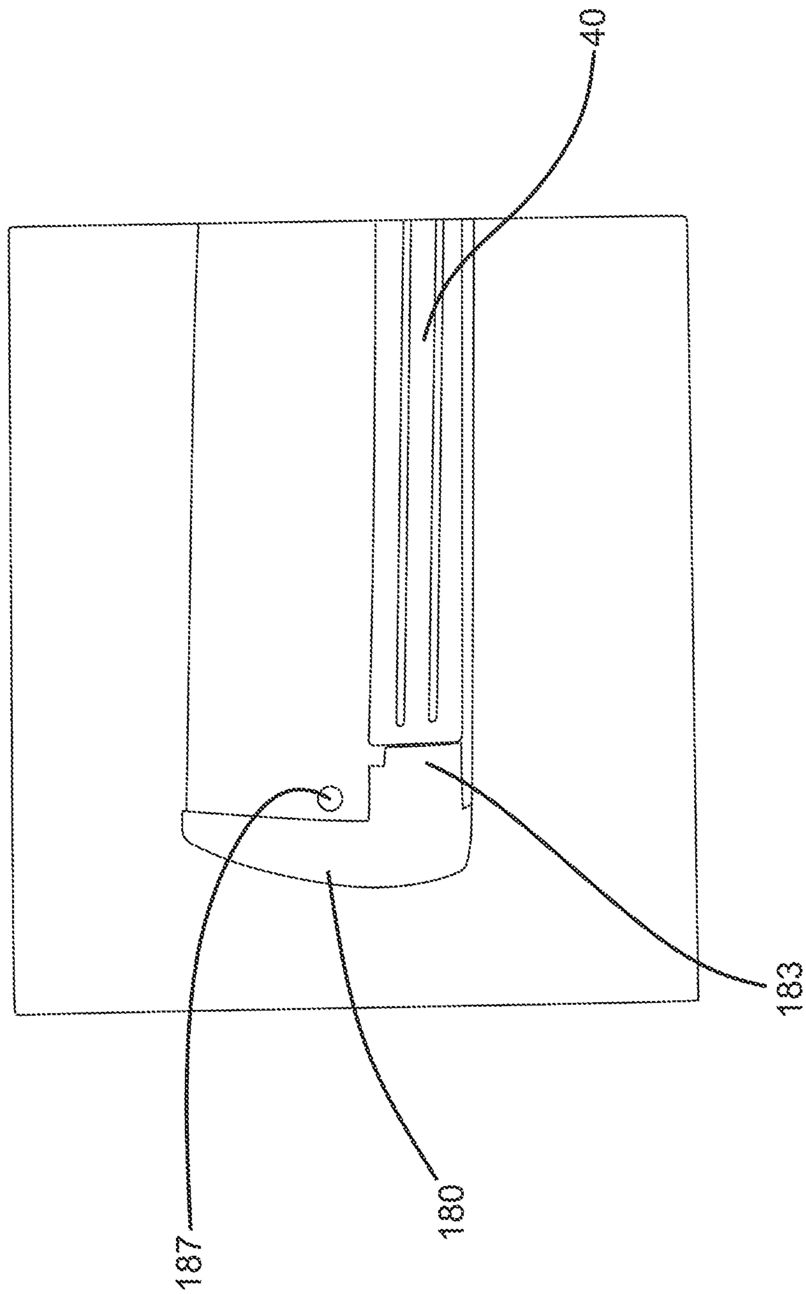


FIG. 13D

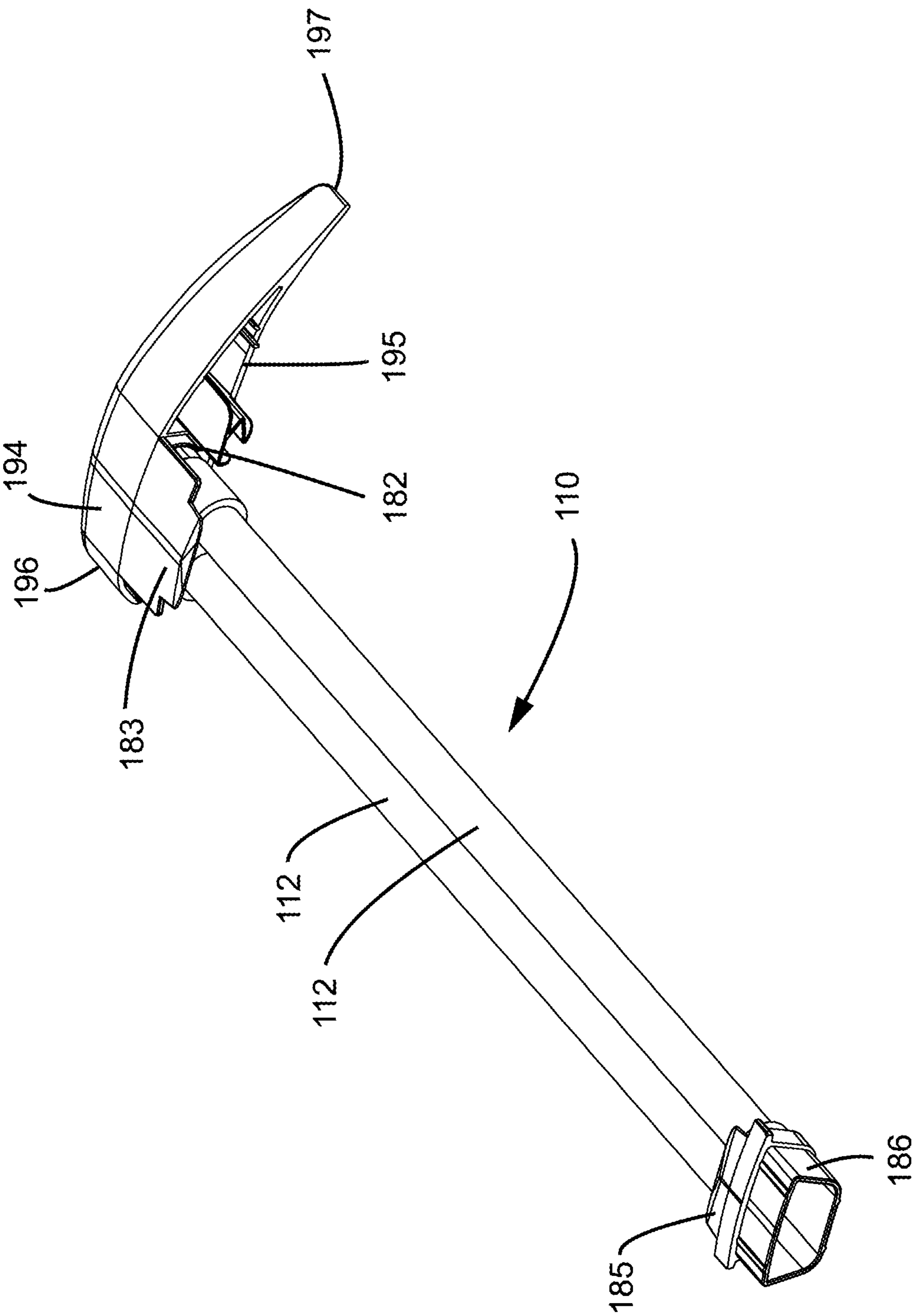


FIG. 14

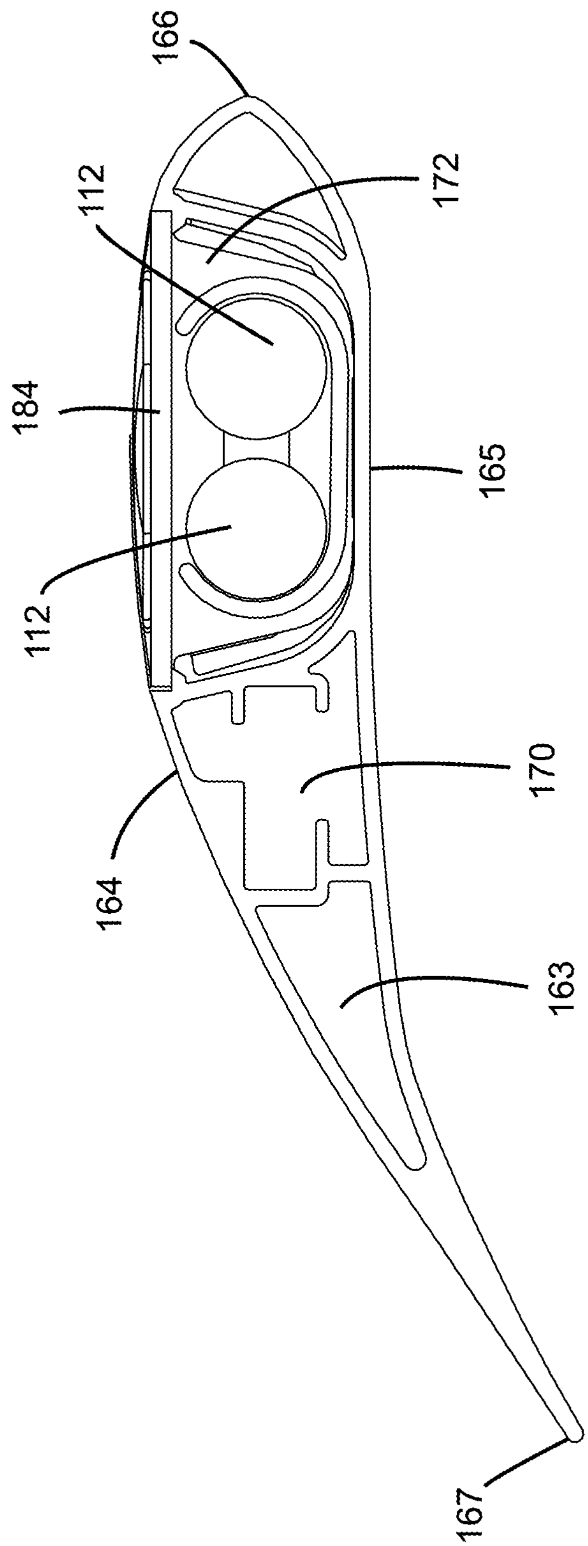
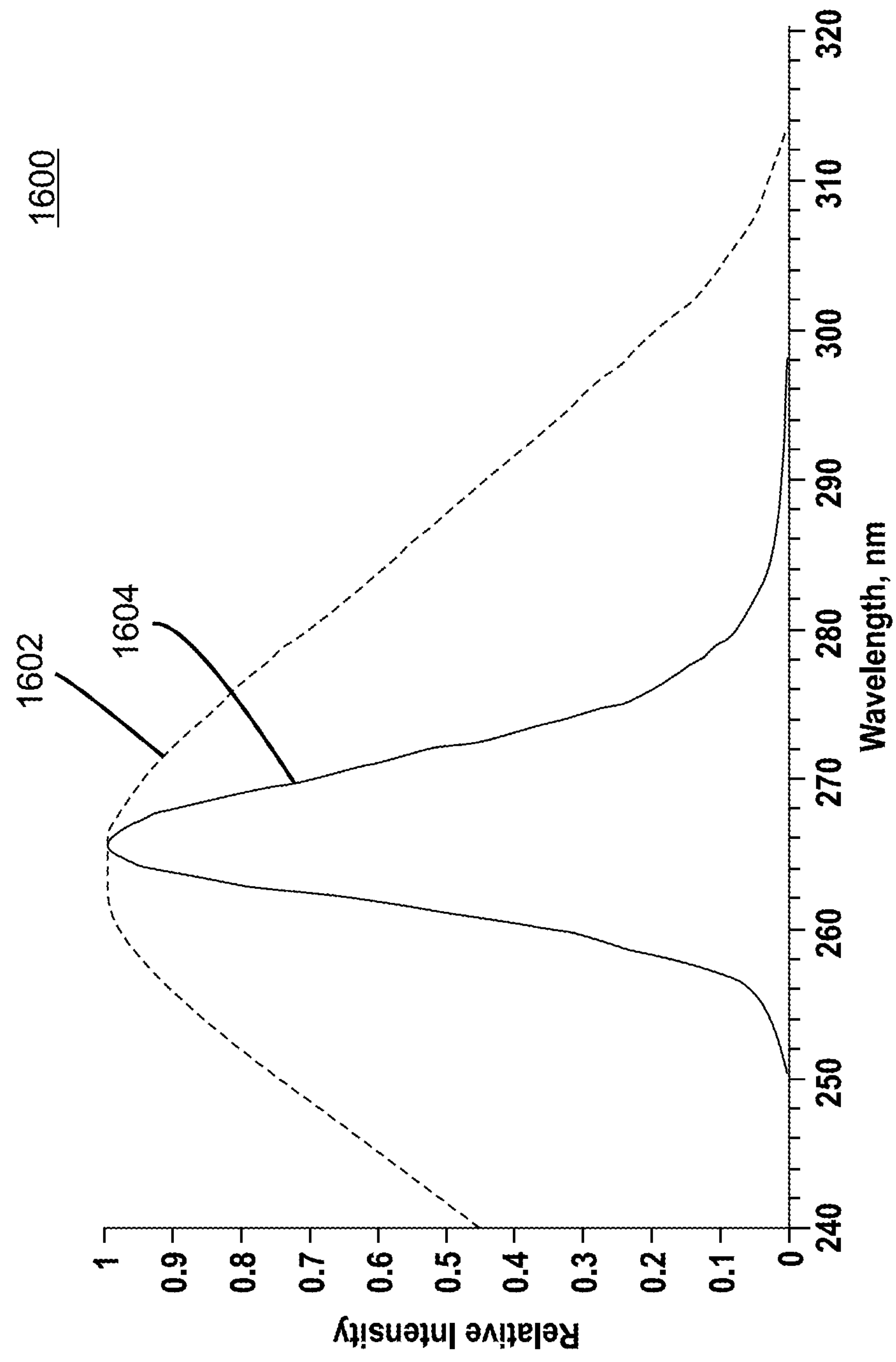


FIG. 15

FIG. 16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1604
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0.6
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0
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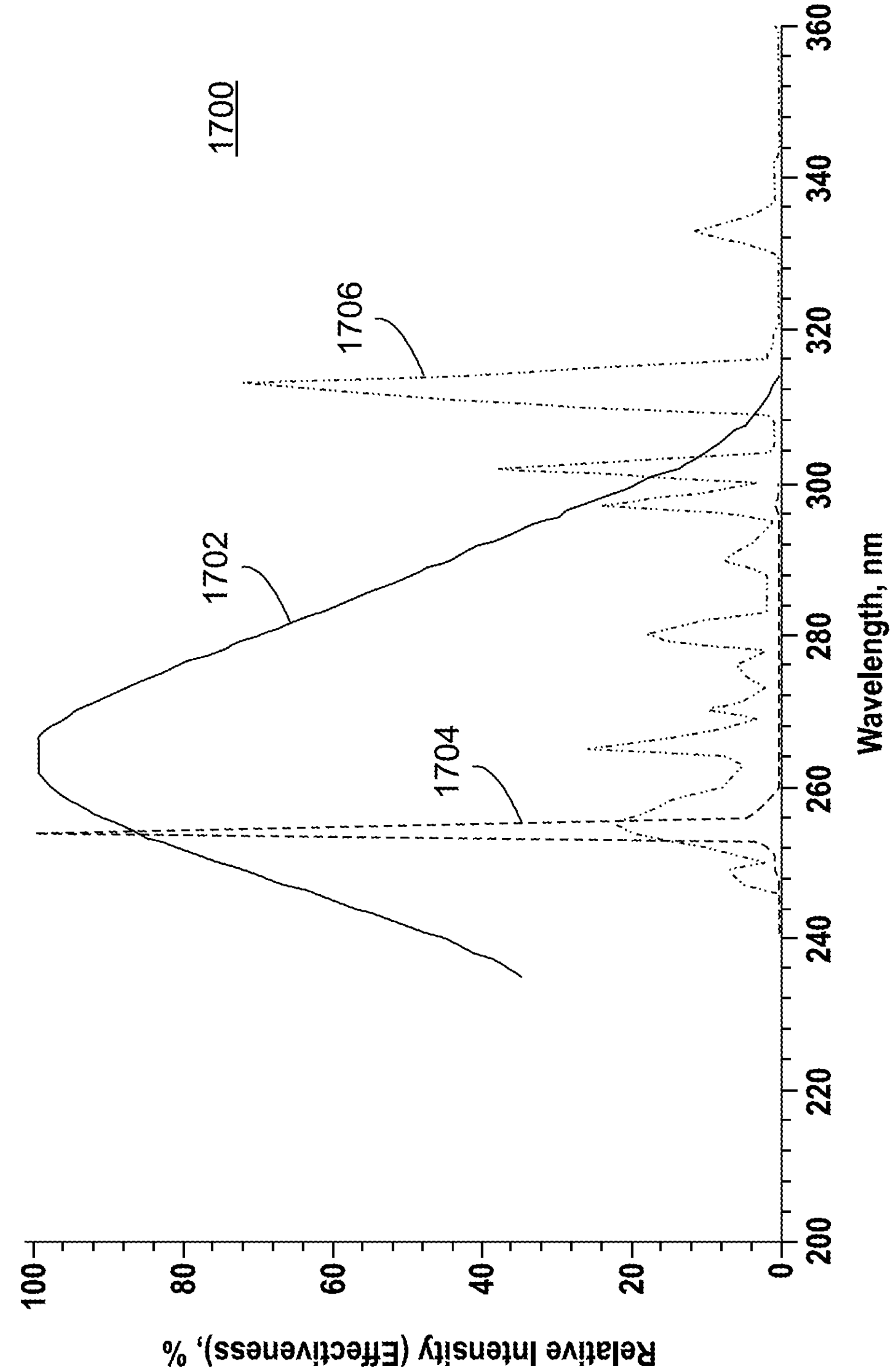
250
260
270
280
290
300
310
320
Wavelength, nm

FIG. 17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Wavelength, nm
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300
320
340
360

FAN ASSEMBLY WITH ULTRA VIOLET DISINFECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Danish Patent Application No. PA202070721 filed on Oct. 30, 2020, Danish Patent Application No. PA202170311 filed on Jun. 18, 2021, Danish Patent Application No. PA202170334 filed on Jun. 28, 2021, Danish Patent Application No. PA202170343 filed on Jun. 30, 2021, and Danish Patent Application No. PA202170497 filed on Oct. 7, 2021, the disclosures of which are incorporated herein by reference in their entireties.

BACKGROUND

A fan is a machine that is used to create airflow to ventilate a space such as a room in a building. A fan typically includes a rotating assembly that includes blades attached to a hub or rotor, and which act on the air. The rotating assembly is typically powered by an electric motor. Typical applications include climate control and personal thermal comfort, vehicle engine cooling systems, machinery cooling systems, ventilation, fume extraction, and the like.

One particular type of fan is a high-volume low speed fan (HVLS), which includes a large blade area that rotates at a slow speed. In this manner, relatively large volumes of air can be moved without creating a draft, due to the low speed of rotation. HVLS fans are typically used inside large indoor spaces, where a number of persons are working or otherwise spend time together, to provide an environment with fresh and clean air without creating drafts.

It is a general problem to stop the spread of contagious diseases in large indoor spaces. In some instances, the air is treated or is otherwise disinfected prior to being introduced into large indoor spaces such as by using various disinfectant solutions.

SUMMARY

In general terms, the present disclosure relates to a blade for use in a fan assembly that disinfects air acting on the blade, and a fan assembly incorporating such a blade. In one possible configuration, the fan is a high volume low speed (HVLS) fan. Various aspects are described in this disclosure, which include, but are not limited to, the following aspects.

In one aspect, a fan assembly comprises an electric motor; a rotor driven by the electric motor to rotate about an axis of rotation; a plurality of blades attached to the rotor, each blade having a blade body extending between first and second ends, the blade body being mounted to the rotor at the first end, the blade body having a profile defined by a top surface and a bottom surface arranged between a leading edge and a trailing edge, the profile of the blade body imparting motion on air when rotated by the rotor about the axis of rotation, and the blade body further having an internal cavity extending between the first and second ends; and a lighting assembly housed inside at least one blade of the plurality of blades, the lighting assembly including: an ultraviolet light source mounted inside the internal cavity proximal to the second end of the blade body; and an electrical ballast configured to supply an electrical current to the ultraviolet light source, the electrical ballast being mounted inside the internal cavity proximal to the first end of the blade body.

Another aspect relates to a blade assembly for a fan. The blade assembly comprises a blade body extending between first and second ends, the blade body configured for mounting to a rotor at the first end, the blade body having a profile defined by a top surface and a bottom surface arranged between a leading edge and a trailing edge, and the blade body further having an internal cavity extending between the first and second ends; and a lighting assembly housed inside the blade body, the lighting assembly including: an ultraviolet light source mounted inside the internal cavity proximal to the second end of the blade body.

Another aspect relates to a receptacle assembly for removable attachment to an end of a blade body. The receptacle assembly comprises a socket configured to receive at least one ultraviolet light source, the socket configured for connection to an electrical ballast for supplying an electrical current to the at least one ultraviolet light source; and one or more mechanical fasteners for removably attaching the receptacle assembly to the end of the blade body.

Another aspect relates to a blade for use in a fan, where said blade has a profile which when travelling through air will impart motion to the air, and where said blade has a front side surface and a back side surface, said front side surface and back side surface arranged between a leading edge and a trailing edge, where the leading edge and the trailing edge are arranged along a longitudinal axis, such that the blade in a cross-section orthogonal to the longitudinal axis has a cross-section and that integral inside said cross-section at least for a distance in the blade along the longitudinal axis, is provided one or more UV light sources, where said UV light sources are arranged to emit light away from said back side surface.

In some examples, the one or more UV light sources are arranged in a reflector, and where a transparent or translucent cover is positioned covering the UV light sources, such that said transparent or translucent cover is integral and/or flush with said back side. In some examples, the one or more UV light sources extend 10% to 100% of the length of the blade in the direction of the longitudinal axis. In some examples, the one or more UV light sources extends 20% to 100% of the width between said leading edge and trailing edge.

In some examples, the one or more UV light sources are UV-C light sources, and have wave lengths in an interval between about 100 nanometers and about 300 nanometers. In some further examples, the UV-C wavelength is between about 253 nanometers and about 300 nanometers. In some further examples, the irradiance from the UV-C light sources is limited to below 100 W/cm2. In some further examples, the irradiance from the UV-C light sources is about 1 W/cm2. In some examples, the UV light source is a thin film applied to the back surface of the blade, where optionally the light sources are LED.

In some examples, two or more light sources are arranged in parallel, and where a control unit provided either in or outside the blade controls the light sources such that one, two or more light sources may be active at a desired time.

In some examples, the length of the blade along the longitudinal axis is between 50 cm and 350 cm and/or the width orthogonal to the longitudinal axis is between 5 cm and 40 cm, and/or the thickness of the blade at the blades thickest point in a direction orthogonal to a plane defined by the longitudinal axis and the width direction is between 1 cm and 12 cm.

In some examples, an aperture shield is provided covering the UVC light source, where said aperture shield is integral with the back side surface of the blade, and where the aperture shield is provided with one or more apertures, allowing the light to emit from the back side surface of the blade.

In another aspect, a high-volume low speed fan is provided with at least one blade, where said at least one blade is arranged in a rotor, such that a motor may rotate the rotor and the blade with a determined speed through the ambient air, whereby the back side of the blade passes a specified area per time unit and wherein a control unit is provided comprising predetermined data correlating the blades speed through the air with the emitted light intensity, such that the air passing the back side of the blade is exposing the air to a germicidal effective light dose.

In some examples, the high-volume low speed fan includes three, five, or eight blades. In some examples, the high volume low speed fan has a shaft extending from the fan, and where said shaft in a free distal end is provided with a ball, and where a mounting bracket suitable to mount the fan to a surface is provided, said bracket comprises a first plate member provided with an aperture larger than the diameter of the shaft, but smaller than the diameter of the ball, as well as flanges suitable to be mounted to said surface, and a second plate member provided with an aperture smaller than the diameter of the ball and with apertures, and where the ball is positioned between the two plates such that the first plate and the second plate engages the ball and where said plates may be urged together fixating the ball and thereby also the shaft.

Another aspect relates to a blade construction for a blade for a fan, wherein said blade construction incorporates a light source emitting light away from said blade, and where said blade extends longitudinally in a radial direction with respect to an axis of rotation for said fan, such that the blade construction has a root end suitable to be attached to a rotor unit, and a distal end furthest away from said root end, where the blade has an aerodynamic cross-section in a cross-section orthogonal to the longitudinal direction and where said cross-section consists of: (a) a first longitudinal chamber suitable to accommodate an electrical wire; (b) a second longitudinal chamber, which second longitudinal chamber is suitable to accommodate: (i) near the root end a transformer unit; (ii) near the distal end said light source; (c) a third longitudinal chamber suitable to accommodate: (i) near the root end a mounting bracket, allowing the blade to be mounted to the ventilators' rotor unit; (ii) near the distal end an endcap, said endcap having a cross-section corresponding to the cross-section of the blade, and where the endcap has a closed side and an opposing side having means for being attached to the blade, said means projecting in-to said third longitudinal chamber; and (d) a fourth longitudinal chamber allowing the blade to obtain the aerodynamic shape.

In some examples, the second longitudinal chamber near the distal end of the blade forms an open top cavity, allowing the light source to emit light out of the cavity, and where light source holding means are provided furthest away from said distal end in the cavity for fixing the light source in the cavity, and where electrical socket connection means are provided near the distal end for providing electrical current to the light source, where said electrical socket connection means may be fixable in said end cap.

In some examples, the second longitudinal chamber near the distal end of the blade forms an open top cavity, allowing the light source to emit light out of the cavity, and wherein a light source holding tray is provided, said tray fitting inside the open top cavity, wherein said tray comprises means for fixing and holding a light source and for providing electrical current to said light source. In some examples, the outer dimensions of the tray are designed to be insertable into the open top cavity, and wherein the means for fixing and holding a light source and for providing electrical current to said light source is different for different trays, such that different size or type of light sources may be installed in different trays. In some examples, a plurality of blade constructions is attached to a rotor of a high volume low speed fan for circulating the blades about an axis of rotation.

Another aspect relates to a blade for a fan wherein said blade incorporates a light source emitting light away from said blade, and wherein said blade extends longitudinally in a radial direction relative to a center of rotation for said fan, wherein the light source is covered by an aperture shield, wherein said aperture shield has one or more slits thereby causing a reduction in emitted light, such that the amount of emitted light is controlled.

In some examples, the aperture shield is mounted over the light source and is substantially flush with the outer surface of the blade. In some examples, the one or more slits are arranged parallel to the blades longitudinal direction, and wherein the slits extend in this direction between 100% and 10% of the light source length in the same direction. In some examples, one, two, three or more parallel slits are arranged in each aperture shield. In some examples, the aperture shield is manufactured from aluminum, plastics, composites, or other suitable non-translucent or semi-translucent material.

In some examples, a recess is provided along the periphery of an aperture in which the light source is arranged, said recess having a depth from the surface of the blade to a receiving surface corresponding to the thickness of the aperture shield, and where the aperture shield is accommodated inside said recess, such that the surface of the aperture shield is substantially flush with the blades surface adjacent the aperture. In some examples, the aperture shield may be fixed to the blade by one or more of the following techniques: (a) an adhesive may be used between the recess and the aperture shield; (b) the aperture shield may be fixed by mechanical fasteners such as threaded screws or rivets; (c) the recess may be provided with overhanging tabs in either end, such that the aperture shield may be inserted underneath said tabs, and thereby retained by the receiving surface and the tabs; (d) the recess is open-ended towards the distal end, such that the aperture shield may be placed in the recess, and an end cap member inserted in the distal end of the blade, locking the aperture shield in place.

In some examples, the light source is a UVC light source. In some examples, the aperture shield is made from a translucent material selected from ordinary silicon based glass, or a polymer.

In another aspect, a fan system comprises: a flat starfish rotor having a central part and extending from said central part a plurality of arms suitable for mounting blades; a plurality of blades to be mounted, one on each arm, each blade having an aerodynamic cross-section; a hub fastened to a surface, said hub including a drive unit, such as an electric motor and optionally associated gearing, and connected to said starfish rotor for rotating said starfish rotor relative to the hub; wherein the starfish rotor with arms is a monolithic flat element having an even thickness between a first and a second outer surfaces.

In some examples, the starfish rotor is provided with threaded holes on the arms suitable for mounting of the blades. In some examples, the starfish rotor is designed for rotation around an axis of rotation orthogonal to the upper and lower surfaces, and where the arms of the starfish rotor extend radially away from said axis of rotation. In some examples, the threaded holes on the starfish rotor are placed asymmetrically on the arms, and apertures are provided in a similar configuration as the holes on the arms, in the blades suitable to be mounted on the arms.

In another aspect, a method of assembling a fan system according to any of claims **1** to **3**, where the fan system includes a fastening bracket for attaching the fan system to a surface, and an electrical motor comprising a rotor and a stator as well as a motor management system in communication with a control unit, where an axle is extending from the rotor, such that the starfish element may be mounted on said axle, and where blades are arranged on the arms of the starfish element, wherein in a first step the electrical motor is connected to the motor management system, and if the control unit is hardwired, the wiring installation is completed; in a next step, the starfish element is attached to the axle extending from the rotor; in a further step an optional housing is arranged around the electrical motor and motor management system, wherein after the housing or a bracket fitted to the stator is connected to a mounting bracket, suitable to fastened the fan system to a surface, typically a downward facing side of a ceiling; thereafter the blades are arranged and fastened to the starfish element, at which time the electrical motor is connected to a suitable source of electricity and the motor management system and the electrical motor tested for proper operation.

DESCRIPTION OF THE FIGURES

The following drawing figures, which form a part of this application, are illustrative of the described technology and are not meant to limit the scope of the disclosure in any manner.

FIG. **1** is an isometric view of an example of a fan assembly including a plurality of blades, with at least one of the plurality of blades including a lighting assembly.

FIG. **2** is an isometric view of a hub of the fan assembly of FIG. **1**.

FIG. **3** is an exploded view of the hub of FIG. **2**.

FIG. **3**A illustrates an example of a bracket assembly that can be used to attach the fan assembly of FIG. **1** to a structure.

FIG. **4** schematically illustrates an example of the fan assembly of FIG. **1**.

FIG. **5** is an isometric view of a rotor of the motor assembly of FIG. **2**.

FIG. **5**A is a profile view of the rotor of FIG. **5**.

FIG. **6** is a partial isometric view of an electrical ballast of the ultraviolet lighting assembly positioned next to the rotor of FIG. **5**.

FIG. **7** is an isometric view of a first bracket for holding the electrical ballast inside an internal cavity of a blade of the fan assembly of FIG. **1**.

FIG. **8** is an isometric view of a second bracket for holding the electrical ballast inside the internal cavity of a blade of the fan assembly of FIG. **1**.

FIG. **9** is a view of a first end of a blade body of the fan assembly of FIG. **1**.

FIG. **10** is an isometric view of a blade of the fan assembly of FIG. **1**.

FIG. **11** is an exploded view of the blade of FIG. **10**.

FIG. **12** is a top view of the blade of FIG. **10**, with a window and light sources removed from the blade.

FIG. **13** is a partial isometric view of the blade of FIG. **10**, with the light sources installed in the blade.

FIG. **13**A illustrates examples of aperture shields that can be installed over the light sources shown in FIG. **13**.

FIGS. **13**B-**13**D show installation of an aperture shield on the blade of FIG. **10**.

FIG. **14** is an isometric view of the blade of FIG. **10**, with the blade body removed from the lighting assembly.

FIG. **15** is a view of a second end of the blade body of the fan assembly of FIG. **1**.

FIG. **16** illustrates a chart showing germicidal effectiveness for ultraviolet light sources that include UV LEDs.

FIG. **17** illustrates a chart showing germicidal effectiveness for ultraviolet light sources that include low and medium pressure UV light bulbs and/or lamps.

DETAILED DESCRIPTION

FIG. **1** is an isometric view of an example of a fan assembly **100** that moves air by rotating a plurality of blades **102** around a hub **104**. The fan assembly **100** includes a down rod **106** and a bracket assembly **60** for attaching the fan assembly **100** to a surface such as a ceiling. In one embodiment, the fan assembly is a high volume low speed (HVLS) fan.

Each of the plurality of blades **102** is shaped to have a profile that imparts motion on the air when rotating about an axis of rotation R. At least one of the plurality of blades **102** includes a lighting assembly **110** that is housed inside the blade and that disinfects the air above the blade. As will be described in more detail, the lighting assembly **110** is integrated into the blade such that it does not interfere or cause turbulence on the airflow generated by the blade.

The fan assembly **100** can include between three and eight blades. In the example shown in FIG. **1**, the fan assembly **100** includes five blades, and each blade includes a lighting assembly **110**. In alternative examples, some but not all of the blades include a lighting assembly **110**. Any number of blades and combinations of lighting assemblies are contemplated herein.

The lighting assembly **110** housed inside each blade **102** includes one or more light sources **112**. The light sources **112** emit light from a top surface of each blade **102** toward the ceiling where the fan assembly **100** is attached. Thus, the ultraviolet light is not directed below the fan assembly **100** where a number of persons may be located. The ultraviolet light can disinfect the airflow that is circulated by rotation of the blades **102** about the axis of rotation R, while reducing exposure to the ultraviolet light for persons located below the fan assembly **100**, such as when working inside a large indoor space.

Additionally, the light sources **112** are integrated inside an internal cavity of the blades **102** such that the aerodynamic properties of the blades **102** are not altered. In examples where the fan assembly **100** is an HVLS fan, the blades **102** travel through the air at a slow rotational speed to effectively impart motion on the air (e.g., create airflow). By integrating the light sources **112** inside the internal cavity of the blades **102**, the blades **102** can move the air with minimal turbulence on the airflow generated by the blades.

FIGS. **2** and **3** are respective isometric and exploded views of the hub **104**. The down rod **106** can attach a motor housing **114** to the ceiling. The motor housing **114** houses an electric motor **116** (see FIG. **4**), which drives a rotor **118** to rotate about the axis of rotation R.

As shown in FIG. **3**, the hub **104** includes a slip ring assembly **120** which is an electromechanical device that allows the transmission of power and electrical signals from stationary components **122**, **124** to a rotating component

128. In this example, the slip ring assembly **120** is used to transfer electrical current to the lighting assemblies **110** housed inside the blades **102** while allowing the blades **102** to rotate about the axis of rotation R.

As further shown in FIG. **3**, the hub **104** can also include bolts **126** for attaching the rotor **118** to a bottom bracket **130** that rotates along with the rotor **118**. Also, the rotating component **128** of the slip ring assembly **120** attaches to the bottom bracket **130** such that the rotating component **128** rotates about the axis of rotation R.

FIG. **3**A illustrates an example of a bracket assembly **60** that can be used to attach the fan assembly **100** to a structure **62**. In the example shown in FIG. **3**A, the structure **62** is a beam. In further examples, the structure **62** can be a ceiling or other type of fixed surface.

The structure **62** may have an angle relative to horizontal (e.g., the ground or floor). The bracket assembly **60** is able to position the down rod **106** (see FIGS. **1-3**) vertically. This allows the down rod **106** to be positioned parallel to the axis of rotation R such that the blades **102** can move through the air in a horizontal plane parallel to the ground or floor.

The hub **104** is attached to a first end of the down rod **106**, and a second end **64** of the down rod **106** has a bulbous portion **68**. The diameter of the bulbous portion **68** is larger than an aperture provided in a lower flange **70** of the bracket assembly **60**. In this example, the first end of the down rod **106** is first inserted through the aperture provided in the lower flange **70**, and the bulbous portion **68** will not pass through the aperture. The rounded shape of the bulbous portion **68** allows the down rod **106** to be orientated parallel to the axis of the rotation R, while the bracket assembly **60** has an orientation dictated by the structure **62** onto which it is mounted.

A fixation plate **72** is provided above the lower flange **70**. The fixation plate **72** is provided with a second aperture, such that the bulbous portion **68** extends slightly beyond the fixation plate **72** when the fixation plate **72** is attached over the bulbous portion **68**. The bulbous portion **68** is sandwiched between the lower flange **70** and the fixation plate **72** to secure the down rod **106** to the bracket assembly **60** while allowing the down rod **106** to be orientated relative to the bracket assembly **60**. Bolts **74** may be arranged around the periphery of the bulbous portion **68**, such that when tightening the bolts **74**, the fixation plate **72** and the lower flange **70** will be urged towards each other, thereby fixating the bulbous portion **68**.

FIG. **4** schematically illustrates an example of the fan assembly **100**. As shown in FIG. **4**, the electric motor **116** is housed inside the motor housing **114**. The electric motor **116** receives electrical power via wiring **22***a*. The electric motor **116** includes a motor shaft **134** for transferring rotational motion generated from the electrical power to the rotor **118** which is connected to the blades **102** for rotating the blades **102** about the axis of rotation R.

The hub **104** receives control signals from a controller **20** that is operatively connected to the hub **104** via a link **22***b*. The controller **20** is operable by a user to regulate the rotational speed generated by the electric motor **116** for rotating the rotor **118** and blades **102** about the axis of rotation R. For example, the controller **20** is operable to increase and decrease the rotation speed of the blades **102** driven by the electric motor **116**.

The stationary components **122**, **124** of the slip ring assembly **120** receive electrical current via wiring **22***c* from a power relay **132** housed inside the motor housing **114**. A drive **117** is connected to the controller **20** and electric motor **116**. The controller **20** controls the drive **117**, and the drive **117** controls the electric motor **116**. Also, the drive **117** can trigger the power relay **132**. The power relay **132** receives the electrical current either directly or through the drive **117**.

The controller **20** is operable by a user to regulate the output of the light sources **112** housed inside each blade **102**. For example, each blade **102** can include two or more light sources **112**, and the controller **20** is operable to individually turn on/off the ultraviolet light sources such that one, two, or more ultraviolet light sources can be active at a time to increase or decrease the output from the light sources **112**.

For example, when no personnel are present in the room below the fan assembly **100**, the intensity of the ultraviolet light emitted from the lighting assemblies **110** and the rotational speed of the blades **102** can be increased in order to more thoroughly disinfect the air in the room. In contrast, when the room is occupied with personnel, the intensity of the ultraviolet light emitted from the lighting assemblies **110** and the rotational speed of the blades **102** can be decreased to increase worker comfort and productivity, while also disinfecting the air.

The stationary components **122**, **124** of the slip ring assembly **120** transfer electrical current from the power relay **132** to the rotating component **128** (see FIG. **3**), which is attached to the bottom bracket **130** such that it rotates along with the rotor **118** and blades **102** about the axis of rotation R. The rotating component **128** includes wiring **22***d* that is terminated by an electrical connector **136**, which is mateable with a corresponding electrical connector **138**. FIG. **3** shows an example in which electrical adapters **137** are attached to the bottom bracket **130**, and can be used to facilitate the connection between the electrical connectors **136**, **138**.

A wiring **22***e* of an electrical ballast **140** is terminated by the electrical connector **138**. In the example shown in FIG. **4**, the electrical ballast **140** is housed inside an internal cavity of the blade **102**. The electrical ballast **140** limits the amount of electrical current received by the light sources **112**, which could otherwise rise to a destructive level. An electrical ballast **140** can be included in each blade **102** that includes light sources **112**.

The electrical ballast **140** supplies the electrical current via wiring **22***f* to a receptacle assembly **180** which is removably attached to an end of the blade **102**. The wiring **22***f* runs inside the internal cavity of the blade **102** from the electrical ballast **140** to the receptacle assembly **180**.

The receptacle assembly **180** includes a socket **182** (see FIG. **11**) for the light sources **112** housed inside the blade **102**. The receptacle assembly **180**, which is shown in more detail in FIGS. **10-14**, is shaped to conform with the profile of the blade **102**.

FIG. **5** is an isometric view of the rotor **118**. The rotor **118** includes a base **142** and arms **144** that extend from the base **142** in a radial direction orthogonal to the axis of rotation R. Each arm **144** has a central radial axis CR that is radial with respect to the axis of rotation R. The base **142** connects to the motor shaft **134** of the electric motor **116**, and each arm **144** attaches to a blade **102** of the fan assembly **100** to transfer the rotational motion generated by the electric motor **116** to the blades **102** for rotating the blades about the axis of rotation R.

In the example shown in FIG. **5**, the rotor **118** includes five arms for attaching five blades to the rotor. In other examples, the rotor **118** can include fewer than five arms or more than five arms for attaching fewer than five blades or more than five blades to the rotor.

FIG. **5**A is a profile view of the rotor **118**. Referring now to FIGS. **5** and **5**A, the rotor **118** (including the base **142** and the arms **144**) has a monolithic and flat construction. For example, the rotor **118** includes an upper surface **145** and a lower surface **147**, and the rotor **118** has a uniform thickness between the upper and lower surfaces **145**, **147**. This can simplify manufacture of the rotor **118** because the rotor **118** can cut from a uniformly thick steel plate with a minimal amount of metal working. Also, the monolithic and flat construction of the rotor **118** can improve the weight balance of the assembly of the blades **102** and the rotor **118** which can reduce the load on the motor shaft **134** of the electric motor **116**, and thereby reduce wear on the electric motor **116** and improve the durability of the fan assembly **100**.

Additionally, milling is not performed on the arms **144** and no twisting or bending of the arms **144** is provided to achieve a proper angling of the blades **102**. This can reduce the risk of mechanical failure of the rotor **118** because twisting or bending of the arms in order to provide proper angling of the blades **102** can mechanically weaken the rotor.

Since the rotor **118** does not include twisted or bent arms, the blades **102** are constructed to have a profile that is designed provide an optimum angle for moving air around the blades. The safety of the fan assembly **100** is improved by minimizing the risk of mechanical failure of the arms **144** of the rotor **118** by providing the blade **102** itself with a profile having an optimal angle for moving air instead of twisting the arms **144** of the rotor **118** at a desired angle.

As shown in FIG. **5**, the arms **144** of the rotor **118** each include apertures **174** that align with corresponding apertures **176** on the blade **102** (see FIG. **10**) such that a fastener such as a screw or bolt can be used to attach each blade **102** to an arm **144** of the rotor **118**. The apertures **174** are offset or asymmetrical with respect to the central radial axis CR of each arm. This ensures that the blade **102** is mounted to the rotor **118** in only one orientation. This can avoid erroneously mounting the blades **102** upside down, and thus ensure correct assembly of the blades **102** to the rotor **118**. It is estimated that this can reduce manufacturing errors caused by improper mounting of the blades **102** to the rotor **118** by about 40%.

FIG. **6** is a partial isometric view of an electrical ballast **140** positioned relative to the rotor **118** and with the blade **102** removed. FIG. **7** is an isometric view of a first bracket **146** for holding the electrical ballast **140** inside an internal cavity of a blade **102**, and FIG. **8** is an isometric view of a second bracket **148** for holding the electrical ballast **140** inside the internal cavity of the blade **102**. FIG. **9** is a view of a first end **160** of a blade **102**.

Referring now to FIGS. **6-9**, each arm **144** of the rotor **118** is insertable into an internal cavity **170** of each blade **102**. When inserted inside the internal cavity **170**, the central radial axis CR of each arm **144** aligns with a central axis C of the blade **102** (see FIG. **10**). This can improve the force distribution on the rotor **118**, and further improve the durability of the rotor **118**, and can also reduce wear on the electric motor **116**. In one aspect, the internal cavity **170** is provided with internal structures, such as flanges or wall members, defining a complementary cross-sectional shape to that of the arms **144** of the rotor. In the example shown, the internal cavity **170** and the arms **144** of the rotor define rectangular cross-sectional shapes.

As described above, when inserted inside the internal cavity **170**, the apertures **174** of the arms **144** align with apertures **176** on the blades **102**. Fasteners such as screws or bolts are threaded through the apertures **174**, **176** to secure the blades **102** to the rotor **118**.

The first bracket **146** can be fitted around a first end **141** of the electrical ballast **140**. The first bracket **146** includes tabs **150** that prevent the first end **141** of the electrical ballast **140** from sliding relative to the first bracket **146** in a radial direction away from the axis of rotation R. The first bracket **146** further includes ridges **152** that prevent the electrical ballast **140** from moving relative to the first bracket **146** in a direction parallel to the axis of rotation R.

The second bracket **148** can be fitted around a second end **143** of the electrical ballast **140**. The second bracket **148** includes tabs **150** that prevent the second end **143** of the electrical ballast **140** from sliding relative to the second bracket **148** in a radial direction toward the axis of rotation R. The second bracket **148** includes ridges **152** that prevent the electrical ballast **140** from moving relative to the second bracket **148** in a direction parallel to the axis of rotation R.

As shown in FIGS. **6-8**, the first and second brackets **146**, **148** each include winged portions **154** which are configured to deform to allow the electrical ballast **140** (with the first and second brackets **146**, **148** attached thereto) to be inserted into an internal cavity **172** of each blade **102**. The electrical ballast **140** is held inside the internal cavity **172** substantially parallel to the arms **144** of the rotor **118** that are inserted inside the internal cavity **170**.

The first and second brackets **146**, **148** can be made from a flexible plastic or rubber material that can fit around the first and second ends **141**, **143** of the electrical ballast **140**. The winged portions **154** expand inside the internal cavity **172** to hold the electrical ballast **140** in place within the blade **102** near the hub **104** of the fan assembly **100**. The second bracket **148** includes a stop **156** that prevents the electrical ballast **140** from sliding inside the internal cavity **172** in a radial direction away from the axis of rotation R.

In one aspect, the ridges **152** and winged portions **154**, which can be characterized as sidewalls, define a gap or interstitial space therebetween that advantageously provides a passageway for the wiring ***22f*** to be routed from the rear of the electrical ballast **140** back towards the first end **160** of the blade along the length of the electrical ballast **140**.

FIG. **10** is an isometric view of a blade **102**, and FIG. **11** is an exploded view of the blade **102**. Referring now to FIGS. **9-11**, the blade **102** is an assembly that includes a blade body **158** that extends between the first end **160** and a second end **162**. As described above, the blade body **158** is mounted to the rotor **118** of the fan assembly **100** at the first end **160**, and the receptacle assembly **180** mounts to the second end **162** of the blade body **158**.

As shown in FIG. **9**, the blade body **158** has a profile defined by a top surface **164** and a bottom surface **165** arranged between a leading edge **166** and a trailing edge **167**. In one aspect, the blade body **158** can be characterized as having an airfoil shape. In some examples, the blade body **158** is an extruded component, for example an extruded aluminum component. The profile of the blade body **158** imparts motion on air when the blade **102** is rotated by the rotor **118** about the axis of rotation RR. The internal cavities **170**, **172** can extend the entirety of the length of the blade body **158** between the first and second ends **160**, **162**.

The blade body **158** can further include internal cavities **161**, **163** that can also extend the entirety of the length of the blade body **158** between the first and second ends **160**, **162**. The blade body **158** is substantially hollow which can reduce the weight of the blade **102**, and thereby reduce the rotational inertia of the blade **102**. This can improve the efficiency of the fan assembly **100** by requiring less power from the electric motor **116** to rotate the blades **102**. Where the blade body **158** is an extruded component, the internal cavities **161**, **163**, **170**, **172** can be formed during the extrusion process.

As shown in FIG. **10**, the blade **102** has a length L. In some examples, the length L is about 1.5 feet to about 11.5 feet. In examples where the fan assembly **100** is a HVLS fan, the length L is 3.5 feet or greater. The length L allows for large areas to be treated by the ultraviolet light emitted from the light sources **112** as the blade **102** rotates through the air.

As shown in FIG. **10**, the blade **102** has a width W. In some examples, the width W is about 2 inches to about 16 inches. As shown in FIG. **9**, the blade **102** has a thickness T, which is defined at the thickest point between the top surface **164** and the bottom surface **165**. In some examples, the thickness T of the blade **102** is about 0.4 inches to about 4.8 inches.

As shown in FIG. **11**, the lighting assembly **110** includes the electrical ballast **140** (with the first and second brackets **146**, **148** attached thereto) inserted into the internal cavity **172** proximal to the first end **160** of the blade body **158**. The lighting assembly **110** further includes the light sources **112** mounted inside an open channel section **168** of the internal cavity **172** proximal to the second end **162** of the blade body **158**. In one example, the open channel section **168** can be formed by removing a portion of the top surface **164** from the blade body **158** to expose the interior of the blade body **158**. In one example, the blade body **158** is first formed by an extruding step and the open channel section **168** is formed in a subsequent step by a cutting or machining such that a portion of the top surface **164** is removed. Other manufacturing steps are possible. For example, the blade body **158** having an open channel section could be formed by molding, casting, or an additive manufacturing process.

The electrical ballast **140** supplies electrical current to the light sources **112** via the wiring **22*f*** connected to the socket **182** of the receptacle assembly **180** (see also FIG. **4**). In the example shown, the wiring **22*f*** extends from the electrical ballast **140** out of the internal cavity **172** and back through the length of the blade body **158** via the internal cavity **161** where the wiring **22*f*** then connects to the receptacle assembly **180**, described below.

The lighting assembly **110** further includes a window **184** which is positioned over the light sources **112** which are held inside the open channel section **168**. The window **184** is transparent to allow the light sources **112** to project ultraviolet light from the top surface **164** of the blade body **158** toward the ceiling where the fan assembly **100** is attached while being held inside the internal cavity **172** of the blade body **158**.

FIG. **12** is a top view of the blade **102** with the window **184** and light sources **112** removed from the blade **102**. FIG. **13** is a partial isometric view of the blade **102** with the light sources **112** installed in the blade **102**. FIG. **14** is an isometric view of the lighting assembly **110** with the blade body **158** removed therefrom. FIG. **15** is a view of the second end **162** of the blade body **158**, with the receptacle assembly **180** removed therefrom.

Referring now to FIGS. **11-15**, the window **184** is held between a first tab **183** of the receptacle assembly **180** and a second tab **185** of a holder **186** inserted inside the internal cavity **172** of the blade body **158**. The light sources **112** can be removed for replacement by detaching the receptacle assembly **180** from the second end **162** of the blade body **158**, and removing the window **184**. For example, the receptacle assembly **180** is removably attached to the second end **162** of the blade body **158** by a fastener **187** such as a screw that is inserted into an aperture at the second end **162** of the blade body **158**. When the fastener **187** is removed, the receptacle assembly **180** can be pulled out from the blade body **158**, and thereby freeing the window **184** held between the first and second tabs **183**, **185**.

As shown in FIG. **15**, the window **184** is flush with the leading edge **166** of the blade body **158**. Additionally, the window **184** can also be flush with at least a portion of the top surface **164** or the trailing edge **167**. This can reduce interference of the aerodynamic properties of the blade **102**, and thereby reduce turbulence on the motion imparted on the air by the blade **102**. This can be particularly advantageous for HVLS fans that have long blades (e.g., longer than 7 feet) because even though the blades travel through the air at low speed, each blade should impart motion on the air with minimal disturbance to avoid the creation of a draft.

In certain examples, the window **184** is made from quartz glass. In other examples, the window **184** can be made of other types of transparent or translucent materials that also allow the ultraviolet light from the light sources **112** to travel through the window **184**.

FIG. **13**A illustrates examples of aperture shields **40*a*-40*e*** that can be installed over the open channel section **168** of a blade **102** to control the amount of emitted light from the light sources **112** incorporated into the blade **102**. The aperture shields can replace the window **184**.

The aperture shields **40** can provide a simple and yet effective solution for adjusting the amount of light emitted from the one or more light sources **112** housed inside the blades **102** of the fan assembly **100**. By providing an aperture shield limiting the amount of ultraviolet light emitting from the one or more light sources **112**, it is possible to use the aperture shields **40** to provide predetermined or optimal doses of ultraviolet light for emission into the ambient environment above the blade **102** to exterminate viruses or microorganisms in the air.

The light sources **112** embedded inside each blade **102** can be covered by an aperture shield **40** (which can replace the window **184**). Each aperture shield has one or more apertures **42** that can control the amount of light that exits the blade. The size, shape, and number of the apertures **42** on the aperture shield **40** can vary to adjust the intensity or amount of ultraviolet light that is allowed to enter the ambient environment. The aperture shield **40** provides a physical limitation on the amount of light that can escape from inside the blade **102**. Consequently, it is possible to design the blades **102** in a standardized fashion for use in a number of environments with standard ultraviolet light sources by simply exchanging one type of aperture shield for another type of aperture shield. Thus, the light emission may be varied for a standardized blade.

For example, standardized blades can be used in a small room by installing the aperture shields **40** that have apertures **42** that are narrow (to limit the amount of light that is allowed to pass through the aperture shield), and the same standardized blades can be used in a larger room where it may be desirable to install the aperture shields **40** that have apertures **42** that are larger (to allow more ultraviolet light to pass through) for disinfecting the larger room.

The aperture shields **40** can be mounted over the light sources **112** such that they are substantially flush with the outer surface of the blade. The flush mounting serves to maintain the aerodynamic properties of the blade such that the aperture shields have minimal influence on the surface characteristics of the blade and as such the intended agitation/movement of the air is not disturbed. In some examples, the aperture shields **40** can be flush with the top surface **164** of the blade body **158**, and the aperture shields **40** provided with one or more apertures **42** allow the ultraviolet light to emit from the top surface **164** of the blade body **158**.

The aperture shields can be useful in examples where the light sources **112** emit too concentrated a dose of ultraviolet light. By positioning the aperture shield having one or more apertures in front of the light sources **112**, the emission of ultraviolet light can be limited. Moreover, the one or more apertures may be sized and/or shaped such that a desired dose of ultraviolet light is allowed to be emitted from the top surface **164**. It is therefore possible to use the same light sources **112** for all applications of the fan assembly **100**. As the electronic circuitry, socket, and the like have to be adapted depending on the light source used on the blade, the aperture shield can provide an advantage that allows a user of the fan assembly **100** to alter and/or control the dose of ultraviolet light by a simple mechanical aperture shield.

As shown in FIG. **13**A, the one or more apertures **42** are elongated in a longitudinal direction. In some examples, the one or more apertures **42** are slits that extend in a direction parallel to the length of the light sources **112**. In some examples, the one or more apertures have a length LA of about 10% and 100% the length of the light sources **112**. Also, the one or more apertures **42** can extend in a direction parallel to the central axis C of the blade **102**.

In accordance with the illustrative examples shown in FIG. **13**A, one, two, three, or more apertures **42** can be arranged in a parallel fashion on each aperture shield **40**. The aperture shields **40** are designed such that substantially any type of aperture shield may be configured for desired light emission reductions by covering the light sources **112**.

Additionally, the apertures **42** may be replaced by other shapes of apertures such as circular, oval, triangular, or any other shaped aperture to provide a reduction in the ultraviolet light emission. Any number of these types of apertures may be provided on an aperture shield.

The aperture shields **40** are preferably made from a non-translucent or semi-translucent material to diminish the emitted ultraviolet light intensity. As an illustrative example, the aperture shields **40** can be manufactured from aluminum, plastics, composites, or other suitable non-translucent or semitranslucent materials. Furthermore, materials such as, for example, aluminum may provide further advantages in that they can dissipate heat from the light sources **112** into the surrounding blade construction and ambient air.

In further embodiments, the aperture shields **40** can be made from a translucent material selected from ordinary silicon based glass, or a polymer. This material can block harmful ultraviolet rays such that only light in a safe lighting spectra is emitted through the material of the aperture shield, and ultraviolet rays can pass only through the apertures **42**. In this manner, more light from the light sources **112** may be emitted through the aperture shields **40**, while the amount ultraviolet light emission from the light sources **112** remains controlled.

In a further example embodiment, a recess is provided along the periphery of the open channel section **168** in which the light sources **112** are arranged. The recess has a depth from the top surface **164** of the blade **102** that corresponds to a thickness of the aperture shield **40**, allowing the aperture shield **40** to be accommodated inside the recess, such that the exterior surface of the aperture shield **40** is substantially flush with the top surface **164** of the blade **102**.

The aperture shields **40** can be fixed to the blades **102** by any of the following mechanisms or a combination of mechanisms: (1) an adhesive may be used between the recess along the periphery of the open channel section **168** and the aperture shield; (b) the aperture shield may be fixed by mechanical fasteners such as threaded screws, bolts, or rivets; (c) the recess along the periphery of the open channel section **168** may be provided with overhanging tabs in either end (e.g., first and second tabs **183**, **185**), such that the aperture shield may be inserted underneath the tabs, and thereby retained by the tabs over the open channel section **168**; (d) the recess along the periphery of the open channel section **168** is open-ended towards the distal end, such that the aperture shield can slide into the recess, and an end cap member is inserted at the distal end of the blade, locking the aperture shield in place.

Where it is desirable to be able to replace the aperture shields **40** on the blades **102**, the aperture shields can be fixed to the blades **102** by mechanical fasteners or overhanging tabs or sliding solutions. Whereas when it is desirable to more permanently fix the aperture shields **40** to the blades **102**, adhesives or more permanent fastening methods may be used.

FIGS. **13**B-**13**D show installation of an aperture shield **40** on a blade **102**. As shown in FIG. **13**B, the receptacle assembly **180** is loosened and partially removed from the blade body **158** by removing the fastener **187**. At the second end **162** of the blade body **158** is provided the open channel section **168** in which one or more light sources **112** are accommodated. By removing the receptacle assembly **180**, the aperture shield **40** is released and may be removed, replaced, or installed. The aperture shield **40** is retained in place by the first tab **183** of the receptacle assembly **180** and the second tab **185** of the holder **186** installed on the blade body **158**. By inserting the aperture shield **40** underneath the second tab **185** and thereafter attaching the receptacle assembly **180** to the second end **162** of the blade body **158**, the first tab **183** on the receptacle assembly **180** will likewise overlap the aperture shield **40** and in this manner retain the aperture shield **40** in its correct position above the open channel section **168**.

In FIG. **13**C, the receptacle assembly **180** is shown in a position relative to the second end **162** of the blade body **158** such that the first tab **183** overlaps the aperture shield **40**, which is positioned over the open channel section **168**. FIG. **13**D shows the receptacle assembly **180** attached to the second end **162** of the blade body **158** by the fastener **187**. In this figure, the first tab **183** overlaps an end of the aperture shield **40** thereby fixing the aperture shield **40** in place above the open channel section **168** where the light sources **112** are housed.

Referring back to FIG. **13**A, the different types of aperture shields **40***a* **40***e* can be installed on the blade **102** to provide different reductions in light intensity. The different types of aperture shields each have the same size, and may therefore be interchanged with one another in the open channel section **168** of the blade. As an illustrative example, each aperture shield **40** can have a length L of about 15 inches, and a width W of about 2 inches.

The aperture shield **40***a* has a narrow aperture **42***a* that can provide a reduction of about 95% compared to when no aperture shield is provided in front of the light sources **112**. The aperture shield **40***b* has a slightly wider aperture **42***b* that can provide a reduction of about 90%. The aperture shield **40***c* has two narrow apertures **42***c* that can provide a reduction of about 80%, the aperture shield **40***d* has two wider apertures **42***d* that can provide a reduction of about 60%, and the aperture shield **40***e* has three apertures **42***e* that can provide a reduction of about 40%. The design of the aperture shields **40***a*-**40***e* may vary and the apertures **42** may be replaced by differently shaped apertures or any other geometrical design to provide different sized openings to reduce the emitted ultraviolet light to a desired level in the ambient environment.

In addition to the foregoing, the blades **102** impart motion on the air by being angled with respect to the axis of rotation R which causes the air to move. The air is moved by the blades **102** into a zone in which the light sources **112** emit ultraviolet light to disinfect the light. The controller **20** can correlate the rotational speed of the blades **102** with the intensity of the ultraviolet light emitted from the light sources **112**, such that the air passing over the top surface **164** of the blade **102** is exposed to an effective dose of ultraviolet light.

The open channel section **168** can also include a reflector **169** that partially surrounds the light sources **112**. The reflector **169** can concentrate the ultraviolet light emitted from the light sources **112** toward the zone where the air is moved by the blades **102** to improve the germicidal effectiveness of the fan assembly **100**.

In the example shown in FIGS. **11-15**, the one or more light sources **112** include ultraviolet (UV) light bulbs or lamps. In this example, the one or more light sources **112** include a single light bulb that is U-shaped. In other examples, the one or more light sources **112** can include two UV light bulbs that extend parallel with one another. Accordingly, the one or more light sources **112** can include a single UV light bulb, two UV light bulbs, or more. In one example, each blade **102** is provided with a light source **112** that is a compact UV-C lamp, such as a Philips Lighting branded TUV PL-L model lamp. In such an example, the lamp can be configured with two parallel bulbs to emit short wave UV radiation with a peak wavelength at 253.7 nm. In one example, the lamp has a power input of about 60 to 67 watts. Other sizes, configurations, and types of lamps may be used without departing from the concepts herein.

As described above, the controller **20** can be used to regulate the output of the light sources **112** by individually turning on/off the light sources **112**. Advantageously, this allows one, two, or more of the one or more light sources **112** to be active at a time to increase or decrease the output from the one or more light sources **112**, as may be needed.

In further alternative examples, the one or more light sources **112** can include UV light-emitting diodes (LEDs). In a further example, when the one or more light sources **112** include UV LEDs, the one or more light sources **112** can be integrated into a film applied to the top surface **164** of the blade body **158**. The UV LEDs when integrated into the film can cover a larger surface area on the top surface **164** of the blade body **158** to create an effective dose of ultraviolet light to kill bacteria, viruses, and other pathogens. The film can have a thickness less than 2-3 mm in which the UV LEDs are embedded. The film can be adhered to the top surface **164** using an adhesive or can be printed directly onto the top surface **164** of the blade.

When the light sources **112** include UV LEDs, the UV LEDs can be attached to the top surface **164** of the blade body **158** as a film covering substantially the entirety of the top surface **164** in order to be able to provide sufficient doses of ultraviolet light. Also, the UV LEDs can provide a wide spectrum of intensity due to the possibility of igniting sections of the UV LEDs or all of the UV LEDs according to programmed parameters in the controller **20**.

In further examples, the light sources **112** can extend about 10% to about 100% of the length of the blade body **158** defined between the first and second ends **160**, **162**. In another example, the light sources **112** can extend about 20% to about 100% of the width of the blade body **158** defined between the leading edge **166** and the trailing edge **167**.

As shown in FIGS. **10-14**, the receptacle assembly **180** defines an exterior surface that matches the profile of the blade body **158**. For example, as shown in FIG. **14**, the receptacle assembly **180** includes a top surface **194** and a bottom surface **195** arranged between a leading edge **196** and a trailing edge **197** that substantially match the top surface **164**, bottom surface **165**, leading edge **166**, and trailing edge **167** of the blade body **158** such that the receptacle assembly **180** does not interfere with the aerodynamic properties of the blade **102**.

The ultraviolet light emitted from the light sources **112** destroys the ability of the DNA in bacteria, viruses, and other pathogens to replicate by causing damage to nucleic acid by forming covalent bonds between certain adjacent bases in the DNA structure. The formation of such bonds prevents the DNA from being unzipped for replications and consequently the microorganism is unable to reproduce. Furthermore, should the organism try to replicate, the microorganism will die due to the destruction of the DNA.

The one or more light sources **112** emit ultraviolet light within a certain range of wavelengths to destroy bacteria, viruses, and other pathogens. In some examples, the one or more light sources **112** emit light having wavelengths in the range from about 100 nm to about 300 nm. In some examples, the one or more light sources **112** emit light in the UV-C spectrum (e.g., in the range from about 200 nm to about 280 nm). In some examples, the one or more light sources **112** emit light having wavelengths in the range from about 253 nm to about 280 nm. In some examples, the one or more light sources **112** emit light having wavelengths in the range from about 253 nm to about 254 nm, and in particular having a wavelength of about 253.7 nm.

The dose of ultraviolet light delivered by the one or more light sources **112** to the bacteria, viruses, and other pathogens present in the air depends on the intensity of the light sources **112**, the time of exposure to the ultraviolet light emitted from the one or more light sources **112**, and a distance to the ultraviolet light emitted from the one or more light sources **112**. These factors can influence the germicidal effectiveness of the fan assembly **100**.

By avoiding that the light sources **112** emit light directly into a habitable zone below the fan assembly **100**, it is possible to use relatively strong intensities for the light sources **112** without surpassing a threshold for damaging UV exposure. In some examples, the irradiance from the light sources **112** is below 100 W/cm^2. The high wattage is used when LED lights are used as UV light sources whereas for traditional low and high pressure UV lights, the wattage may be in a much lower range of approximately 1.0-0.1 W/cm^2.

FIG. **16** illustrates a chart **1600** showing germicidal effectiveness for a light source that includes UV LEDs. In FIG. **16**, the wavelength of the ultraviolet light is on the X-axis and the intensity is on the Y-axis. As indicated by the dashed line **1602**, the germicidal effectiveness is maximized at about 256 nm to about 268 nm. As indicated by the curve **1604**, the germicidal effectiveness of the light source that includes UV LEDs is maximized at about 266 nm. It can be desirable to select a wavelength, which is effective to kill bacteria, viruses, and other pathogens while at the same mitigating any unintended side effects. In some examples, an optimal wavelength of about 253 nm-254 nm is selected for the light source.

FIG. **17** illustrates a chart **1700** of germicidal effectiveness for the light sources that include low and medium pressure UV lamps. In FIG. **17**, the wavelength of the ultraviolet light is on the X-axis and the intensity is on the Y-axis. As indicated by the curve **1702**, the germicidal effectiveness is maximized at about 256 nm to about 268 nm (see also the dashed line **1602** in FIG. **16**). As indicated by dashed lune **1704**, a low pressure UV lamp is more suitable for generating the wavelength and intensity for reaching maximum germicidal effectiveness than a medium pressure UV lamp represented by dashed line **1706**. Also, while the dashed lune **1704** indicates that the low pressure UV lamp is not as effective as the UV LEDs represented by the curve **1604** in FIG. **16**, the low pressure UV lamp is more energy efficient than the UV LEDs.

The various embodiments described above are provided by way of illustration only and should not be construed to be limiting in any way. Various modifications can be made to the embodiments described above without departing from the true spirit and scope of the disclosure.

What is claimed is:

1. A fan assembly comprising:

an electric motor;

a rotor driven by the electric motor to rotate about an axis of rotation;

a plurality of blades attached to the rotor, each blade having a blade body extending between first and second ends, the blade body being mounted to the rotor at the first end, the blade body having an airfoil-shaped profile defined by a top surface and a bottom surface arranged between a leading edge and a trailing edge, the profile of the blade body imparting motion on air when rotated by the rotor about the axis of rotation, and the blade body further having an internal cavity extending between the first and second ends; and

a lighting assembly housed inside at least one blade of the plurality of blades, the lighting assembly including:

an ultraviolet light source mounted inside the internal cavity proximal to the second end of the blade body; and

an electrical ballast configured to supply an electrical current to the ultraviolet light source, the electrical ballast being mounted inside the internal cavity proximal to the first end of the blade body.

2. The fan assembly of claim **1**, further comprising:

a slip ring configured to transfer electrical current from the electric motor to the electrical ballast while allowing the electrical ballast to rotate about the axis of rotation.

3. The fan assembly of claim **1**, wherein the lighting assembly includes a window positioned over the ultraviolet light source.

4. The fan assembly of claim **1**, wherein the lighting assembly includes an aperture shield positioned over the ultraviolet light source.

5. The fan assembly of claim **1**, wherein the lighting assembly includes a reflector mounted inside the internal cavity to at least partially surround the ultraviolet light source.

6. The fan assembly of claim **1**, wherein the lighting assembly includes two or more ultraviolet light sources, and a controller configured to control the two or more ultraviolet light sources such that one, two, or more ultraviolet light sources are active at a time.

7. The fan assembly of claim **1**, wherein the plurality of blades includes between three and eight blades attached to the rotor.

8. The fan assembly of claim **7**, wherein each of the plurality of blades includes a lighting assembly.

9. The fan assembly of claim **8**, wherein the fan assembly is a high-volume low speed fan.

10. A blade assembly for a fan, the blade assembly comprising:

a blade body extending between first and second ends, the blade body configured for mounting to a rotor at the first end, the blade body having an airfoil-shaped profile defined by a top surface and a bottom surface arranged between a leading edge and a trailing edge, and the blade body further having an internal cavity extending between the first and second ends; and

a lighting assembly at least partially housed inside the blade body, the lighting assembly including:

an ultraviolet light source mounted at least partially inside the internal cavity proximal to the second end of the blade body;

an electrical ballast configured to supply an electrical current to the ultraviolet light source, the electrical ballast being mounted inside the internal cavity proximal to the first end of the blade body;

a receptacle assembly attached to the second end of the blade body, the receptacle assembly including:

a socket configured to receive one end of the ultraviolet light source; and

one or more fasteners for removably attaching the receptacle assembly to the second end of the blade body; and

a window positioned over the ultraviolet light source, the window being continuous with the leading edge of the blade body, wherein the window is removably attached to the blade body between a first tab on the receptacle assembly and a second tab on the blade body.

11. The blade assembly of claim **10**, further comprising:

brackets for fixing the electrical ballast inside the internal cavity.

12. The blade assembly of claim **10**, wherein the socket is connected to the electrical ballast for supplying the electrical current to the ultraviolet light source.

13. The blade assembly of claim **10**, wherein the lighting assembly includes two or more ultraviolet light sources, each ultraviolet light source being independently controllable.

14. A receptacle assembly for removable attachment to an end of a blade body, the receptacle assembly comprising:

a socket configured to receive at least one ultraviolet light source, the socket configured for connection to an electrical ballast for supplying an electrical current to the at least one ultraviolet light source; and

one or more mechanical fasteners for removably attaching the receptacle assembly to the end of the blade body; and

a tab configured to secure a window over the ultraviolet light source.

15. The receptacle assembly of claim **14**, wherein the receptacle assembly defines an exterior surface that matches a profile of the blade body including a top surface and a bottom surface arranged between a leading edge and a trailing edge.

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