(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 May 2020 (14.05.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/097304 A1

(51) International Patent Classification:
G02B 6/00 (2006.01) *A47L 9/30* (2006.01)
G03B 21/00 (2006.01) *A47L 11/00* (2006.01)
G03B 21/20 (2006.01) *F21K 9/61* (2016.01)
G03B 21/14 (2006.01) *F21V 7/00* (2006.01)

(21) International Application Number:
PCT/US2019/060228

(22) International Filing Date:
07 November 2019 (07.11.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/756,752 07 November 2018 (07.11.2018) US

(71) Applicant: **SHARKNINJA OPERATING LLC** [US/US]; 89 A Street, Suite 100, Needham, Massachusetts 02494 (US).

(72) Inventors: **SUTTER, Catriona C.A.**; 2R, 182 St. Paul Street, Brookline, Massachusetts 02446 (US). **LIGGETT, Melinda L.**; 56 Oliver Street, Unit 2, Watertown, Massachusetts 02472 (US). **KAMADA, Isaku Douglas**; 99 Chestnut Hill Ave., Apt 308, Brighton, Massachusetts 02135 (US). **PEARCE, Emily**; 8 Waterhouse Street, Apt. 3, Somerville, Massachusetts 02144 (US).

(74) Agent: **CARROLL, Kevin J.** et al.; Grossman Tucker Perreault & Pfleger, PLLC, 55 South Commercial Street, Manchester, New Hampshire 03101 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

(54) Title: ILLUMINATOR OPTIC FOR ROBOTIC CLEANER

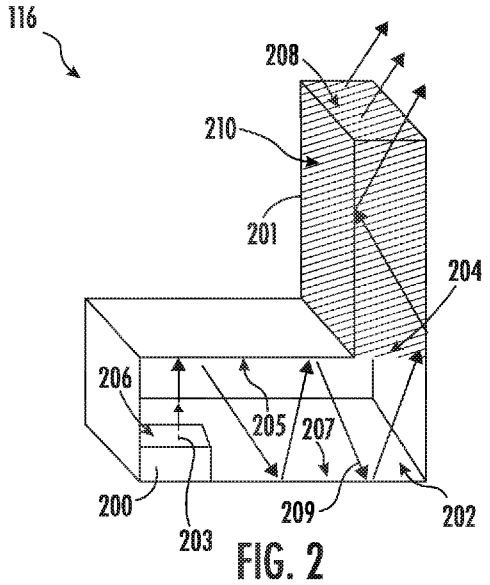


FIG. 2

(57) Abstract: A robotic cleaner may include a body and an illuminator assembly. At least a portion of the illuminator assembly may be disposed within the body. The illuminator assembly may include an illuminator optic configured to emit light from an illumination surface and an illumination guide configured to direct light into the illuminator optic. The illumination guide may have a cavity. The cavity may include a reflecting surface and a directing surface, the reflecting surface being positioned opposite the directing surface.

[Continued on next page]

WO 2020/097304 A1

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

ILLUMINATOR OPTIC FOR ROBOTIC CLEANER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application Serial No. 62/756,752, filed on November 7, 2018, entitled Illuminator Optic for Robotic Cleaner, which is fully incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to robotic cleaners and more particularly to a robotic vacuum cleaner.

BACKGROUND INFORMATION

[0003] Robotic cleaners have become an increasingly popular appliance for automated cleaning applications. For example, robotic vacuum cleaners may be used to vacuum surfaces with little or no user interaction. Robotic vacuum cleaners may include a suction system as well as various cleaning implements and agitators such as rotating brush rolls and side brushes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0005] FIG. 1 shows a top view of a schematic example of a robotic cleaner, consistent with embodiments of the present disclosure.

[0006] FIG. 2 shows a cross-sectional perspective view of a schematic example of an illuminator assembly, consistent with embodiments of the present disclosure.

[0007] FIG. 3 shows a perspective view of an annular illumination assembly, consistent with embodiments of the present disclosure.

[0008] FIG. 4 shows an enlarged view of a portion of the annular illuminator assembly of FIG. 3, consistent with embodiments of the present disclosure.

[0009] FIG. 5 shows a cross-sectional view of a portion of a robotic cleaner having the illuminator optic of FIG. 3 installed therein, consistent with embodiments of the present disclosure.

[0010] FIG. 6 shows a top view of a printed circuit board, consistent with embodiments of the present disclosure.

[0011] FIG. 7 shows a perspective view of a portion of an illuminator assembly, consistent with embodiments of the present disclosure.

[0012] FIG. 8 shows a schematic cross-sectional view of an example of an illumination assembly coupled to a printed circuit board (PCB), consistent with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0013] The present disclosure is generally directed to a robotic cleaner having an illuminator assembly. The robotic cleaner includes a body. The body includes an illuminator assembly. The illuminator assembly includes an illuminator optic that is visible to a user of the robotic cleaner. The illuminator optic can generally be described as a light guide configured to diffuse light passing therethrough such that an illumination surface of the illuminator optic appears luminescent. As such, the illuminator optic includes a light diffusing material such that light received within the illuminator optic is diffused when traveling therethrough.

[0014] One or more light sources may be disposed on a printed circuit board disposed within the body of the robotic cleaner. The light sources are horizontally offset from a light receiving surface of the illuminator optic, wherein the light sources are disposed between the printed circuit board and the illuminator optic. An emission axis of the one or more light sources extends generally parallel to the illuminator optic. As such, the emitted light is reflected at least once before being incident on the light receiving surface of the illuminator optic. Reflection of the light prior to its incidence on the light receiving surface of the illuminator optic, may result in the light having a more consistent appearance (e.g., a more consistent intensity) when compared to light being emitted directly into the illuminator optic.

[0015] FIG. 1 shows a schematic example of a robotic cleaner 100 (e.g., a robotic vacuum cleaner) having a body 102, at least one wheel 104 (shown in hidden lines) coupled to the body 102, at least one drive motor 106 (shown in hidden lines) configured to cause a corresponding wheel 104 to rotate, urging the body 102 across a surface to be cleaned 110 (e.g., a floor), and a dust cup 108 (shown in hidden lines) configured to receive debris from the surface to be cleaned 110. One or more inputs 112 may be disposed on a top surface 114 of the body 102 of the robotic cleaner 100. The inputs 112 may be configured to cause the robotic cleaner 100 to engage in various behaviors (e.g., start/stop cleaning, return to a docking station, and/or any other behavior).

[0016] As also shown, the robotic cleaner 100 can include an illuminator assembly 116. At least a portion of the illuminator assembly 116 can be disposed within the body 102. The illuminator assembly 116 can be configured to be illuminated according to a predetermined

pattern and/or color based, at least in part, on a status of the robotic cleaner 100. For example, the illuminator assembly 116 can indicate whether the robotic cleaner 100 is in a standby state, a cleaning state, a fault state, and/or any other state.

[0017] The illuminator assembly 116 can have any shape. For example, the illuminator assembly 116 may be square shaped, rectangle shaped, annular shaped, octagonal shaped, triangle shaped, and/or any other shape. In some instances, the illuminator assembly 116 may extend around a non-illuminated volume (e.g., an annular shaped illuminator assembly 116 may extend around a non-illuminated circular volume).

[0018] FIG. 2 shows a schematic cross-sectional view of the illuminator assembly 116. As shown, the illuminator assembly 116 includes an illuminator optic 201 configured to emit light from an illumination surface 208, an optical cavity 202, and an optical emitter 200 (e.g., a light emitting diode) disposed within the optical cavity 202. The optical cavity 202 is optically coupled to the illuminator optic 201 such that light emitted by the optical emitter 200 is incident on a light receiving surface 204 of the illuminator optic 201. As shown, the optical emitter 200 is horizontally offset from the illuminator optic 201 (e.g., the light receiving surface 204 of the illuminator optic 201) and has an emission axis 203 that extends generally parallel to one or more side surfaces 210 of the illuminator optic 201.

[0019] A light emitting surface 206 of the optical emitter 200 can be oriented such that it faces in a direction of the illumination surface 208 of the illuminator optic 201 (e.g., the light emitting surface 206 is substantially parallel to the illumination surface 208). As such, when the optical emitter 200 is horizontally offset from the light receiving surface 204 of the illuminator optic 201, light emitted by the optical emitter 200 is reflected off at least one surface of the optical cavity 202 before being incident on the light receiving surface 204. This may result in a more uniform intensity of light being emitted from the illumination surface 208 of the illuminator optic 201.

[0020] Light may be incident on the light receiving surface 204 at an angle such that, after passing into the illuminator optic 201, the light is incident on the one or more side surfaces 210 of the illuminator optic 201. As such, the light may be reflected off one or more of the side surfaces 210 before passing through the illumination surface 208. In other words, the illuminator optic 201 can be configured to encourage light to be internally reflected within the illuminator optic 201. An example light path is generally illustrated by arrows 209 in FIG. 2.

[0021] While the illuminator optic 201 is shown as not extending within the optical cavity 202, other configurations are possible. For example, the illuminator optic 201 can extend at least partially within the optical cavity 202 such that at least two light receiving surfaces 204 can receive light emitted by the optical emitter 200. In some instances, the illuminator optic 201 can extend from a top surface 205 of the optical cavity 202 into the optical cavity 202 and to a bottom surface 207 of the optical cavity 202.

[0022] FIG. 3 shows a perspective view of an annular illuminator assembly 301, which may be an example of the illuminator assembly 116 of FIG. 1. The illuminator assembly 301 can include an annular illuminator optic 300 that extends around an illumination guide 302, the illumination guide 302 being configured to direct light into the illuminator optic 300. The illumination guide 302 defines at least one cavity 304 configured to receive an optical emitter 305 (e.g., a light emitting diode). The cavity 304 is configured such that at least a portion of light emitted from the optical emitter 305 is reflected within the cavity 304 before being incident on a light receiving surface 306 of the illuminator optic 300. For example, the illumination guide 302 can be configured such that the emitted light is directed toward the illuminator optic 300 along a light path 303.

[0023] For example, the optical emitter 305 can be configured to emit light towards a top surface 308 of the cavity 304 such that at least a portion of the emitted light is incident on and reflected from the top surface 308. In other words, the optical emitter 305 can be configured to emit light in a direction of an illumination surface 310 of the illuminator optic 300. The cavity 304 can be configured to direct the emitted light towards a respective one or more channels 312. The channels 312 optically couple the cavity 304 to the receiving surface 306 of the illuminator optic 300.

[0024] FIG. 4 shows an enlarged view of the illuminator assembly 301 taken at detail view IV-IV of FIG. 3. As shown, the cavity 304 can include a reflecting surface 400 configured to direct light emitted by the optical emitter 305 towards the channels 312. At least a portion of the reflecting surface 400 can extend in a direction of the illuminator optic 300. As shown, at least a portion of the top surface 308 may define at least a portion of the reflecting surface 400.

[0025] The reflecting surface 400 can include at least one arcuate portion. In some instances, the reflecting surface 400 can have a convex shape in a first plane and a concave shape in a second plane. For example, and as shown, the reflecting surface 400 can have a convex shape in a horizontal plane (e.g., a plane generally parallel to a surface to be cleaned)

and a concave shape in a vertical plane (e.g., a plane generally perpendicular to the surface to be cleaned).

[0026] The cavity 304 can also include a directing surface 402 configured to direct light emitted by the optical emitter 305 into a respective channel 312. As shown, the directing surface 402 extends in a direction of the reflecting surface 400. The directing surface 402 can have a generally triangular shape with one or more planar sides configured to direct light into a respective channel 312.

[0027] The directing surface 402 is positioned opposite the reflecting surface 400 such that at least a portion of the light incident on the reflecting surface 400 is directed generally towards the directing surface 402. As such, the reflecting surface 400 and the directing surface 402 can generally be described as cooperating to direct light along respective channels 312 and into the light receiving surface 306 of the illuminator optic 300. At least a portion of the light incident on the light receiving surface 306 may pass into the illuminator optic 300. In some instances, at least a portion of the light incident on the light receiving surface 306 may be reflected from the light receiving surface 306. The reflected light may continue to travel along the respective channel 312. As light reflects along the channel 312, a portion of the light may enter the illuminator optic 300 at different locations along the light receiving surface 306.

[0028] Reflection of light emitted by the optical emitter 305 at least once before entering the illuminator optic 300 may result in the light emitted from the illumination surface 310 having a more uniform appearance (e.g., intensity) when compared to light emitted directly into the illuminator optic 300. As such, in some instances, the cavity 304 and/or the channels 312 can be configured to increase the number of reflections of the emitted light prior to the light entering the illuminator optic 300. For example, reflection of the emitted light may prevent the emitted light from directly entering the illuminator optic 300. Directly emitting light into the illuminator optic 300 may create a bright spot on the illumination surface 310. In other words, the directing surface 402 can be positioned such that light emitted from the optical emitter 305 prevents light from being transmitted directly from the optical emitter 305 and into the illuminator optic 300, which may reduce or prevent the appearance of bright spots on the illumination surface 310. In some instances, for example, a portion (e.g., at least 80%, 90%, or 95%) of the illumination surface 310 illuminated by a respective optical emitter 305 may have a substantially uniform intensity (e.g., the illumination intensity varies by less

than 5%, 10%, or 15%) over the portion of the illumination surface 310 that is illuminated by the optical emitter 305.

[0029] FIG. 5 shows a cross-sectional view of a portion of a robotic cleaner 500, which may be an example of the robotic cleaner 100 of FIG. 1. The robotic cleaner 500 includes the illuminator assembly 301 of FIG. 3. As shown, the optical emitter 305 is coupled to a printed circuit board (PCB) 502 disposed within a body 501 of the robotic cleaner 500 such that the optical emitter 305 is disposed between the PCB 502 and the illumination guide 302 (e.g., such that at least one optical emitter 305 is received within a respective cavity 304). The PCB 502 can define at least a portion of the cavity 304 such that light emitted from the optical emitter 305 is reflected from the top surface 308 of the cavity 304 towards the PCB 502 such that it can be reflected from the PCB 502. Light reflected from the PCB 502 may be incident on the top surface 308 of the cavity 304 or the light receiving surface 306 of the illuminator optic 300.

[0030] As shown, the light receiving surface 306 can extend substantially parallel (e.g., within plus or minus 1°, 2°, 3°, 4°, or 5° of parallel) to an emission axis 504 of the optical emitter 305. Alternatively, the emission axis 504 may extend transverse to (e.g., substantially perpendicular to) the light receiving surface 306 (e.g., as shown in FIG. 2). In some instances, the illuminator optic 300 can extend within the cavity 304 such that two or more light receiving surfaces 306 are capable of receiving light. For example, one or more of the light emitting surfaces 306 can extend substantially parallel (e.g., within plus or minus 1°, 2°, 3°, 4°, or 5° of parallel) to the emission axis 504 of the optical emitter 305 and one or more of the light emitting surfaces 306 can extend transverse to the emission axis 504 of the optical emitter 305.

[0031] Emitted light can generally follow a light path 506 that extends from the optical emitter 305 through the cavity 304 and into the illuminator optic 300. The illuminator optic 300 can be configured to encourage the internal reflection of light traveling therein (or passing therethrough). For example, the illuminator optic 300 can have one or more sidewalls 508 having a surface polish that encourages reflection. By way of further example, in some instances, one or more outer surfaces of the illuminator optic 300 can have a reflective material (e.g., a paint) applied thereto and/or at least a portion of the robotic cleaner 500 and/or the illumination guide 302 can be reflective (e.g., have a reflective paint applied thereto and/or be made of a reflective material).

[0032] The illuminator optic 300 can also be configured to diffuse the light extending (or passing) therethrough. In some instances, for example, the illuminator optic 300, the illumination guide 302, and/or the optical emitter 305 can be configured such that a portion (e.g., at least 80%, 90%, or 95%) of the illumination surface 310 illuminated by a respective optical emitter 305 may have a substantially uniform intensity (e.g., the illumination intensity varies by less than 5%, 10%, or 15%) over the portion of the illumination surface 310 that is illuminated by the optical emitter 305.

[0033] The illuminator optic 300 can be made of, for example, polycarbonate, glass, acrylic, and/or any other suitable light transmissive material. In some instances, the illumination surface 310 can be textured (e.g., etched) such that the illumination surface 310 encourages diffusion of light passing therethrough.

[0034] FIG. 6 shows a top view of a PCB 600, which may be an example of the PCB 502 of FIG. 5. As shown, the PCB 600 includes one or more light emitting diodes (LEDs) 602, which may be an example of the optical emitters 305 of FIG. 3. The LEDs 602 have an emission axis that extends transverse to (e.g., substantially perpendicular to) a top surface 606 the PCB 600 such that light is emitted in a direction away from the PCB 600.

[0035] The LEDs 602 are arranged such that an illumination guide (e.g., the illumination guide 302 of FIG. 3) can be positioned above the LEDs 602 such that the illumination guide directs light emitted by the LEDs 602 into an illuminator optic (e.g., the illuminator optic 300 of FIG. 3).

[0036] As shown, the PCB 600 can include a reflective portion 604 that extends at least partially around each of the LEDs 602. The reflective portion 604 can be configured to direct light incident on the reflective portion 604 in a direction away from the PCB 600. As such, reflection within the cavities defined by the illumination guide are encouraged.

[0037] The reflective portion 604 may be applied to the top surface 606 of the PCB 600 using, for example, a silk-screening process. In some instances, the reflective portion 604 may be an adhesive label coupled to the top surface 606, a paint applied to the top surface 606, and/or any other reflective material.

[0038] Each of the LEDs 602 may be individually (or selectively) addressable. As such, the LEDs 602 can be configured to illuminate according to a pattern. By illuminating each of the LEDs 602 individually according to a pattern the illumination surface of the illuminator optic can be illuminated according to different patterns. For example, one or more segments/predetermined portions of the illuminating surface can be illuminated to form a

static or moving pattern by individually illuminating respective ones of the LEDs 602 according to a pattern. As such, the illuminator optic can be used to communicate a status of a robotic cleaner (e.g., the robotic cleaner 100 of FIG. 1) to a user of the robotic cleaner using the illuminated patterns. Additionally, or alternatively, one or more of the LEDs 602 can be bi-colored LEDs (e.g., the LEDs 602 can be red/blue bi-colored LEDs). As such, in some instances, a status of the robotic cleaner can be communicated using a color of the light emitted from the illumination surface of the illuminator optic. For example, different colors and/or patterns can be used to indicate a status of the robotic cleaner. In some instances, a sound sequence may be used to communicate a status of the robotic cleaner. For example, a sound sequence may be associated with a respective light pattern (e.g., comprising one or more colors and/or illumination patterns).

[0039] FIG. 7 shows a perspective view of a portion of an illuminator assembly 701, which may be an example of the illuminator assembly 301 of FIG. 3. The illuminator assembly 701 includes an illuminator optic 700 and an illumination guide 702. The illuminator optic 700 may have a polished exterior surface 704 which is configured to cause light to internally reflect in a direction of the illumination guide 702. For example, the exterior surface 704 may have a substantially mirror-like finish. The illumination guide 702 can be made of a light reflective material (e.g., a white material) configured to cause light to internally reflect within the illuminator optic 700 in a direction of the exterior surface 704. As such, the exterior surface 704 of the illuminator optic 700 and the illumination guide 702 may generally be described as being configured to cause internal reflection of light within the illuminator optic 700.

[0040] FIG. 8 shows a schematic example of an illuminator assembly 800, which may be an example of the illuminator assembly 116 of FIG. 1, coupled to a printed circuit board (PCB) 802. As shown, the PCB 802 includes a plurality of light emitting diodes (LEDs) 804 coupled thereto. Each of the LEDs 804 are disposed within a respective cavity 806 defined within an illumination guide 808 such that at least a portion of the light emitted by the LEDs 804 is reflected from a respective reflection surface 810 within the cavity 806. As shown, each reflection surface 810 is angled relative to an emission axis of corresponding LEDs 804 such that light incident on the reflection surface 810 is directed towards a light receiving surface 812 of an illuminator optic 814. At least a portion of the light incident on the light receiving surface 812 of the illuminator optic 814 may enter the illuminator optic 814 and be emitted from the illuminator optic 814 at an illumination surface 816.

[0041] An example of a robotic cleaner, consistent with the present disclosure, may include a body and an illuminator assembly. At least a portion of the illuminator assembly may be disposed within the body. The illuminator assembly may include an illuminator optic configured to emit light from an illumination surface and an illumination guide configured to direct light into the illuminator optic. The illumination guide may have a cavity. The cavity may include a reflecting surface and a directing surface, the reflecting surface being positioned opposite the directing surface.

[0042] In some instances, the robotic cleaner may further include a printed circuit board (PCB) that may have one or more optical emitters coupled thereto and the PCB may be disposed within the body such that the one or more optical emitters are received within a respective cavity of the illumination guide. In some instances, the PCB may include a reflective portion configured to extend at least partially around at least one of the one or more optical emitters. In some instances, the robotic cleaner may further include one or more optical emitters that may be horizontally offset from the illuminator optic. In some instances, at least a portion of light emitted from a respective one of the one or more optical emitters may be reflected from a top surface of a respective cavity. In some instances, a light receiving surface of the illuminator optic may extend substantially parallel to an emission axis of an optical emitter configured to emit light into the cavity. In some instances, the illuminator optic may be annular. In some instances, the illuminator optic may be configured to encourage internal reflection of light passing therethrough. In some instances, the illuminator optic may be configured to diffuse light passing therethrough.

[0043] Another example of a robotic cleaner, consistent with the present disclosure, may include a body, at least one wheel coupled to the body, at least one drive motor configured to cause a corresponding wheel to rotate, an illuminator assembly, wherein at least a portion of the illuminator assembly may be disposed within the body, and a printed circuit board (PCB) having one or more light emitting diodes (LEDs) coupled thereto. The illuminator assembly may include an illuminator optic configured to emit light from an illumination surface and an illumination guide configured to direct light into the illuminator optic. The PCB may be disposed within the body such that the one or more LEDs are received within a respective cavity defined within the illumination guide, wherein an emission axis of a respective one of the one or more LEDs extends substantially parallel to a light receiving surface of the illuminator optic.

[0044] In some instances, the PCB may include a reflective portion configured to extend at least partially around at least one of the one or more LEDs. In some instances, at least a portion of light emitted from a respective one of the one or more LEDs may be reflected from a top surface of a respective cavity. In some instances, each cavity may include a reflecting surface and a directing surface, the reflecting surface and the directing surface being configured to cooperate to direct light emitted by a respective LED to the light receiving surface of the illuminator optic. In some instances, the illuminator optic may be annular. In some instances, the illuminator optic may be configured to encourage internal reflection of light passing therethrough. In some instances, the illuminator optic may be configured to diffuse light passing therethrough.

[0045] An example of an illuminator assembly, consistent with the present disclosure, may include an illuminator optic configured to emit light from an illumination surface and an illumination guide configured to direct light into the illuminator optic. The illumination guide may have a cavity configured to receive an optical emitter. The cavity may include a reflecting surface and a directing surface, the reflecting surface and the directing surface being configured to cooperate to direct light emitted by the optical emitter to a light receiving surface of the illuminator optic.

[0046] In some instances, a light receiving surface of the illuminator optic may extend substantially parallel to an emission axis of the optical emitter. In some instances, the illuminator optic may be annular. In some instances, the illuminator optic may be configured to encourage internal reflection of light passing therethrough.

[0047] While the present disclosure has generally described the illuminator assembly has being used with a robotic cleaner, the illuminator assembly can be used with any device where communication using a color and/or light pattern may be desirable. For example, the illuminator assembly may be used with an upright vacuum cleaner, a docking station for a robotic cleaner, appliances (e.g., washer/dryers, kitchen stoves/ovens, and/or any other appliance), audio/video equipment (e.g., televisions, stereos, smart speakers, and/or any other audio/video equipment), and/or any other device.

[0048] While the principles of the invention have been described herein, it is to be understood by those skilled in the art that this description is made only by way of example and not as a limitation as to the scope of the invention. Other embodiments are contemplated within the scope of the present invention in addition to the exemplary embodiments shown and described herein. Modifications and substitutions by one of ordinary skill in the art are

considered to be within the scope of the present invention, which is not to be limited except by the following claims.

CLAIMS

What is claimed is:

1. A robotic cleaner comprising:

a body; and

an illuminator assembly, at least a portion of the illuminator assembly being disposed within the body, the illuminator assembly comprising:

an illuminator optic configured to emit light from an illumination surface; and

an illumination guide configured to direct light into the illuminator optic, the illumination guide having a cavity, the cavity including a reflecting surface and a directing surface, the reflecting surface being positioned opposite the directing surface.

2. The robotic cleaner of claim 1 further comprising a printed circuit board (PCB) having one or more optical emitters coupled thereto, the PCB being disposed within the body such that the one or more optical emitters are received within a respective cavity of the illumination guide.

3. The robotic cleaner of claim 2, wherein the PCB includes a reflective portion configured to extend at least partially around at least one of the one or more optical emitters.

4. The robotic cleaner of claim 1 further comprising one or more optical emitters horizontally offset from the illuminator optic.

5. The robotic cleaner of claim 4, wherein at least a portion of light emitted from a respective one of the one or more optical emitters is reflected from a top surface of a respective cavity.

6. The robotic cleaner of claim 1, wherein a light receiving surface of the illuminator optic extends substantially parallel to an emission axis of an optical emitter configured to emit light into the cavity.

7. The robotic cleaner of claim 1, wherein the illuminator optic is annular.

8. The robotic cleaner of claim 1, wherein the illuminator optic is configured to encourage internal reflection of light passing therethrough.

9. The robotic cleaner of claim 1, wherein the illuminator optic is configured to diffuse light passing therethrough.

10. A robotic cleaner comprising:

a body;

at least one wheel coupled to the body;

at least one drive motor configured to cause a corresponding wheel to rotate;

an illuminator assembly, at least a portion of the illuminator assembly being disposed within the body, the illuminator assembly comprising:

an illuminator optic configured to emit light from an illumination surface; and

an illumination guide configured to direct light into the illuminator optic; and

a printed circuit board (PCB) having one or more light emitting diodes (LEDs) coupled thereto, the PCB being disposed within the body such that the one or more LEDs are received within a respective cavity defined within the illumination guide, wherein an emission axis of a respective one of the one or more LEDs extends substantially parallel to a light receiving surface of the illuminator optic.

11. The robotic cleaner of claim 10, wherein the PCB includes a reflective portion configured to extend at least partially around at least one of the one or more LEDs.

12. The robotic cleaner of claim 10, wherein at least a portion of light emitted from a respective one of the one or more LEDs is reflected from a top surface of a respective cavity.

13. The robotic cleaner of claim 10, wherein each cavity includes a reflecting surface and a directing surface, the reflecting surface and the directing surface being configured to cooperate to direct light emitted by a respective LED to the light receiving surface of the illuminator optic.

14. The robotic cleaner of claim 10, wherein the illuminator optic is annular.

15. The robotic cleaner of claim 10, wherein the illuminator optic is configured to encourage internal reflection of light passing therethrough.

16. The robotic cleaner of claim 10, wherein the illuminator optic is configured to diffuse light passing therethrough.

17. An illuminator assembly comprising:

an illuminator optic configured to emit light from an illumination surface; and

an illumination guide configured to direct light into the illuminator optic, the illumination guide having a cavity configured to receive an optical emitter, the cavity including a reflecting surface and a directing surface, the reflecting surface and the directing surface being configured to cooperate to direct light emitted by the optical emitter to a light receiving surface of the illuminator optic.

18. The illuminator assembly of claim 17, wherein a light receiving surface of the illuminator optic extends substantially parallel to an emission axis of the optical emitter.

19. The illuminator assembly of claim 17, wherein the illuminator optic is annular.

20. The illuminator assembly of claim 17, wherein the illuminator optic is configured to encourage internal reflection of light passing therethrough.

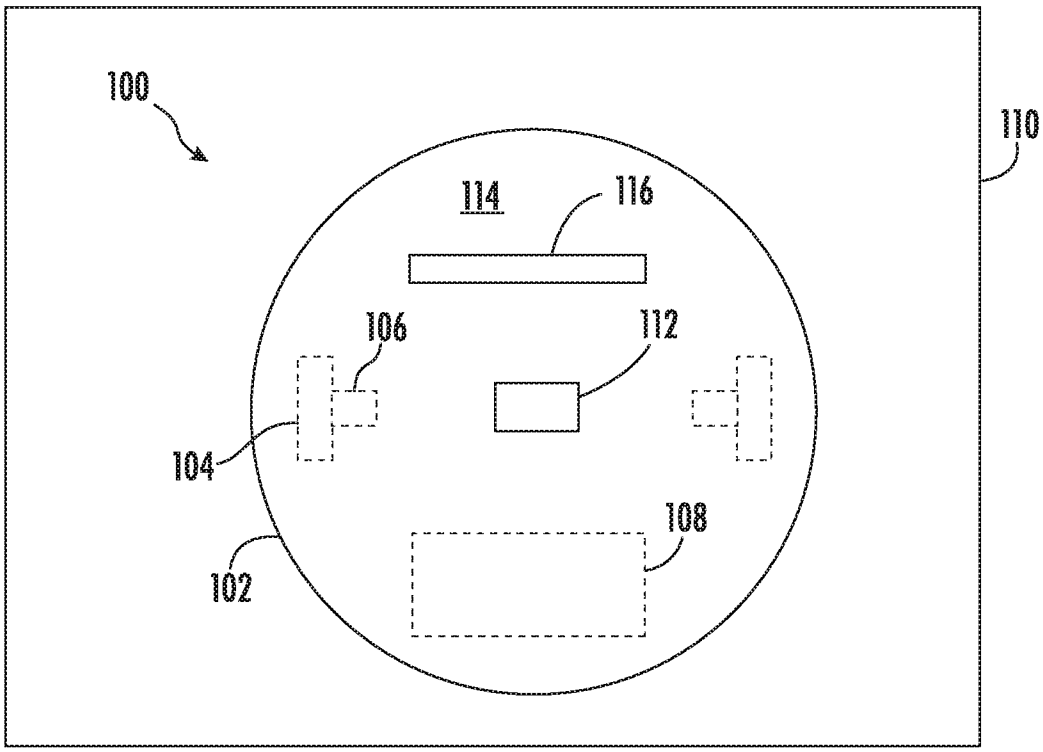

100
110
114
116
106
112
104
108
102

FIG. 1

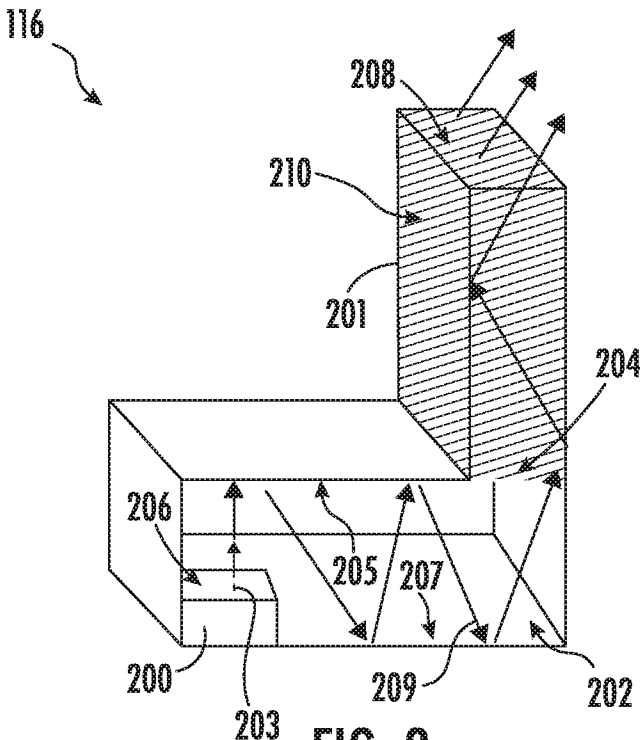

116
208
210
201
204
206
205
207
200
209
202
203

FIG. 2

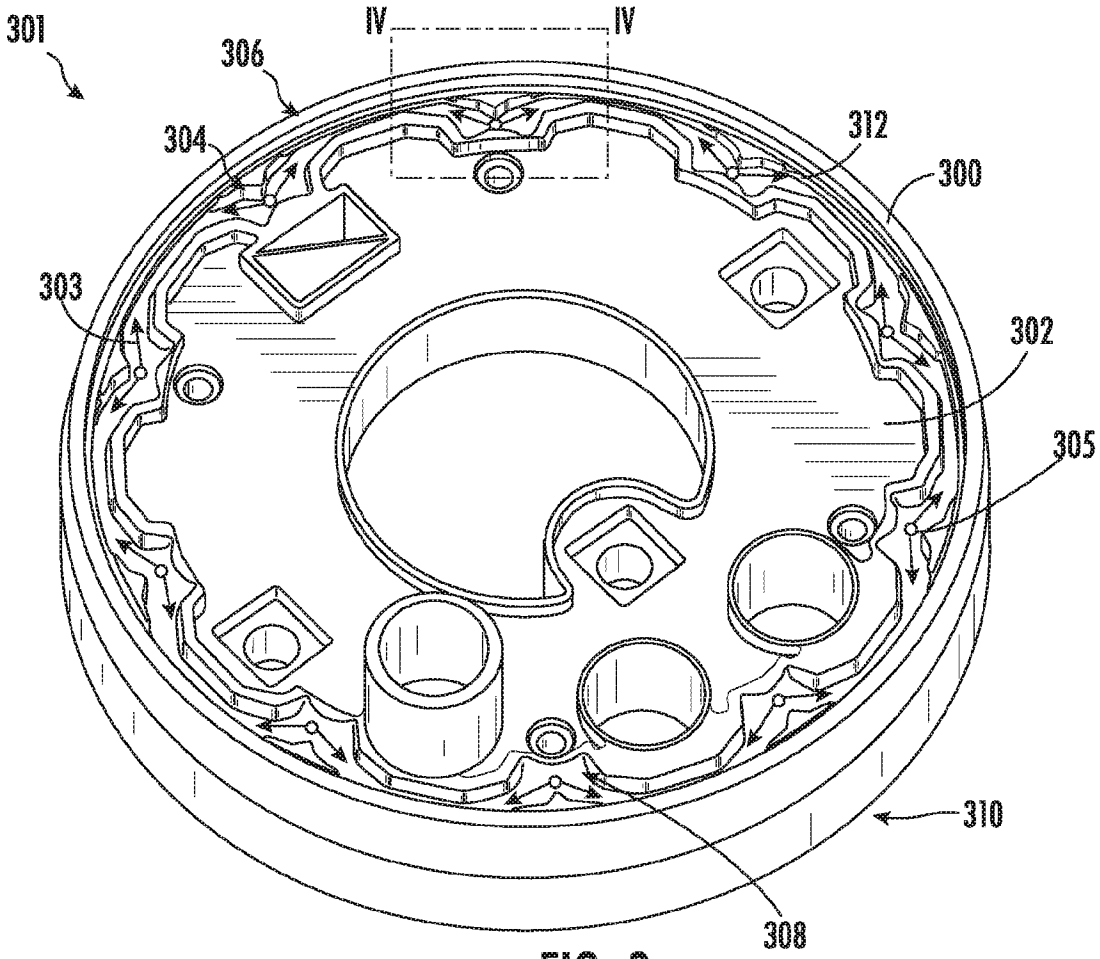

301
306
IV
IV
304
312
300
303
302
305
310
308

FIG. 3

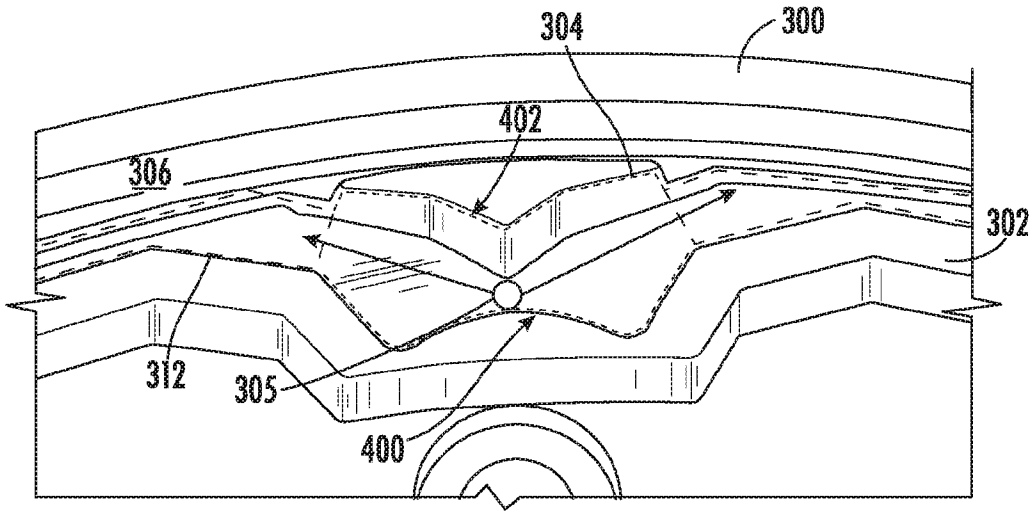

304
300
402
306
302
312
305
400

FIG. 4

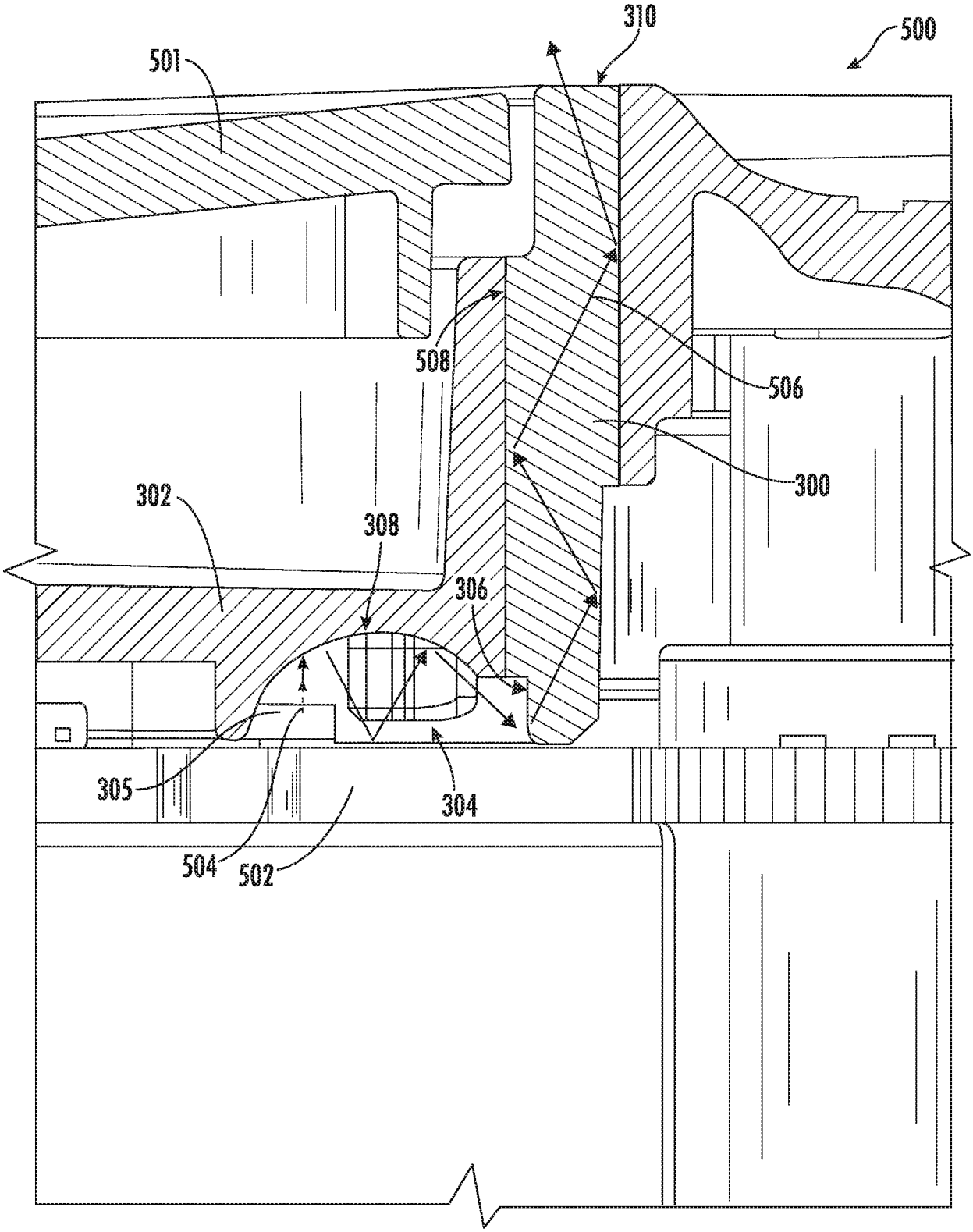


FIG. 5

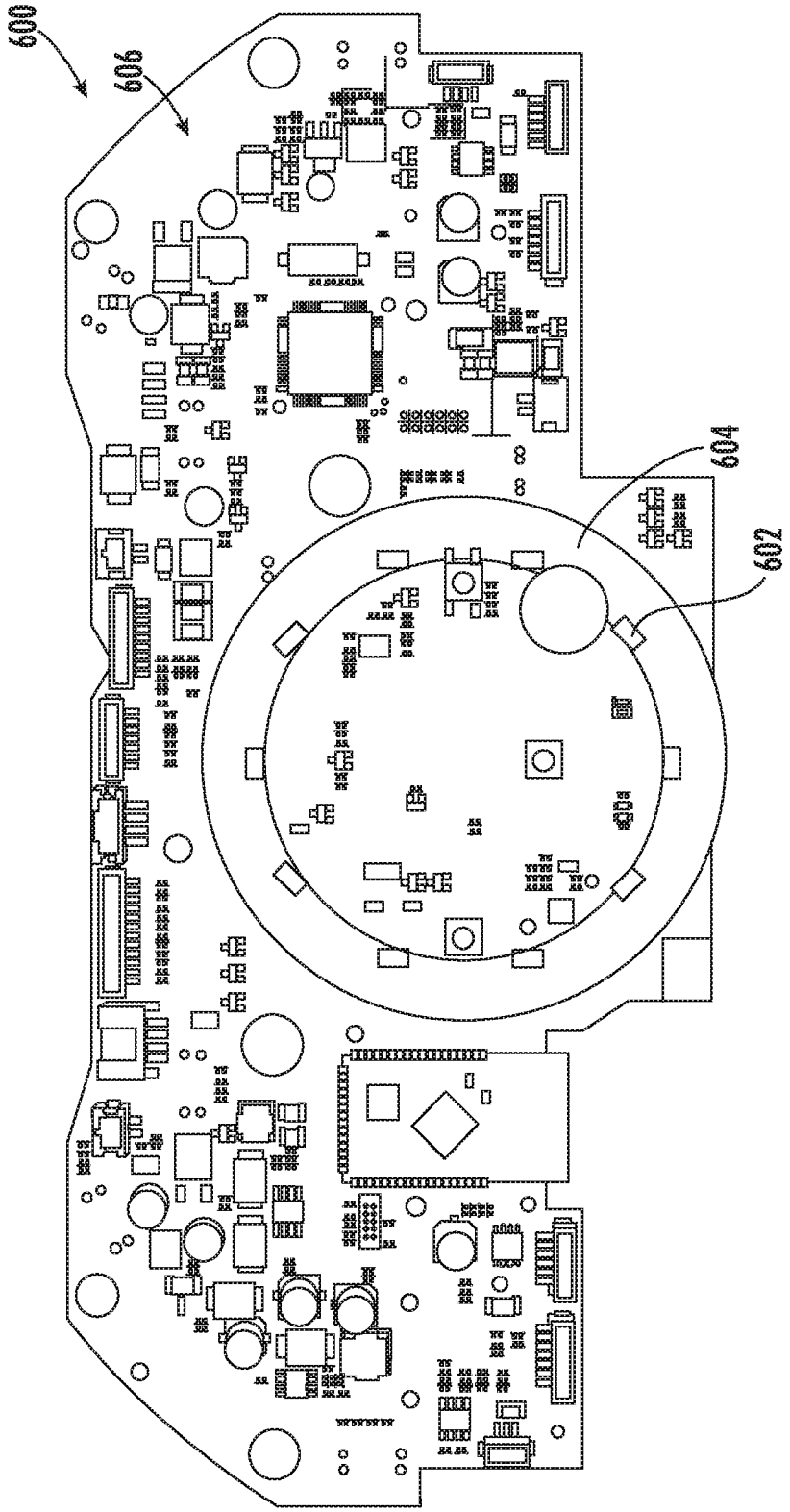


FIG. 6

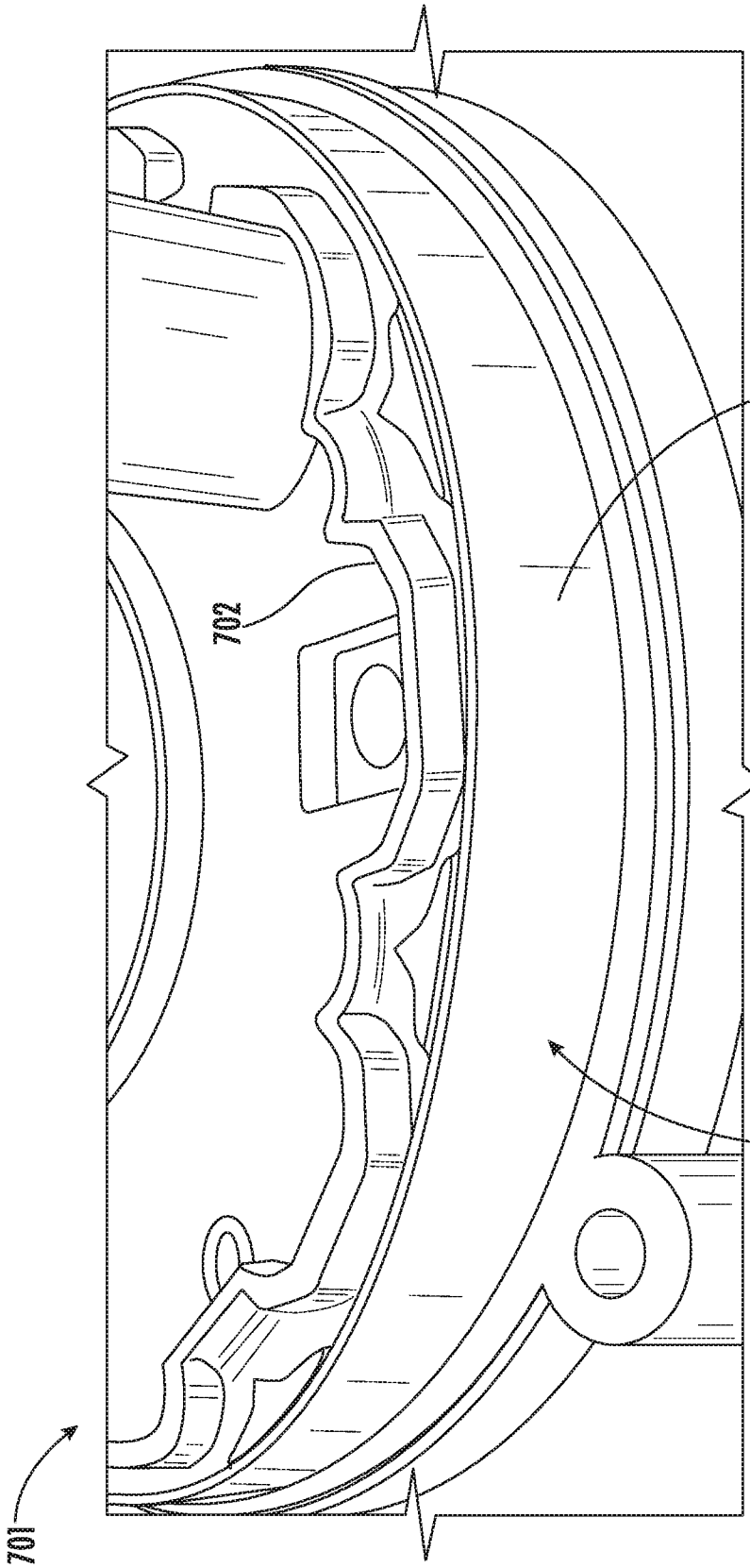


FIG. 7

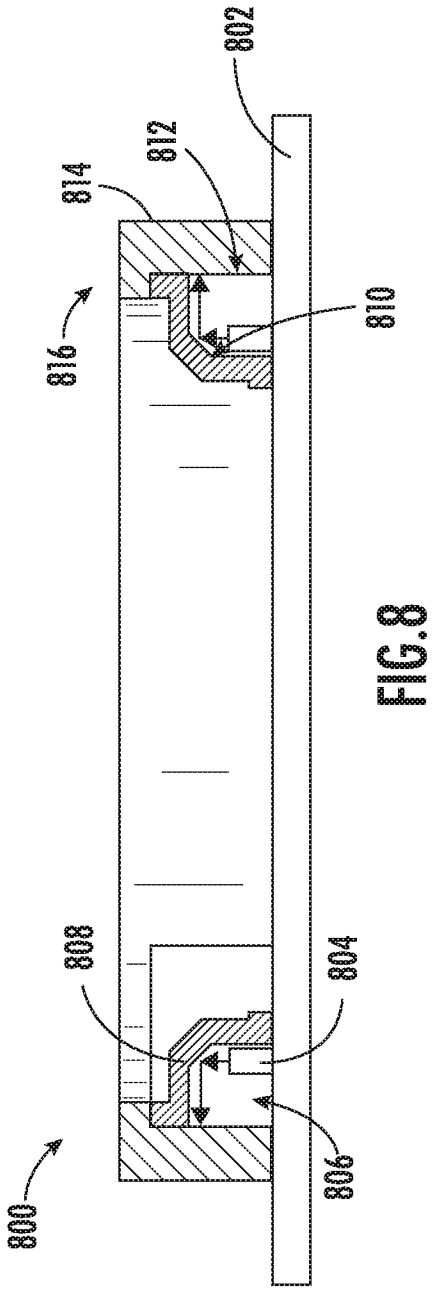


FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US19/60228

A. CLASSIFICATION OF SUBJECT MATTER

IPC - G02B 6/00; G03B 21/00, 21/20, 21/14; A47L 9/30, 11/00; F21K 9/61; F21V 7/00 (2020.01)

CPC - G02B 6/00, 6/008, 6/0075, 6/0001, 27/0056; G03B 21/00, 21/20, 21/14, 21/2013, 21/145, 21/2006, 21/2033; A47L 9/30, 11/00; F21K 9/61; F21V 7/00, 7/0025, 7/0091

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2018/0050634 A1 (IROBOT CORPORATION) 22 February 2018; figures 2a, 4c, 5b, 5c, paragraphs [0079], [0086], [0110], [0115], [0117], [0119], [0120], [0123], [0124]	1-4, 6, 8-10, 11, 15-18, 20 --- 5, 7, 12-14, 19
Y	US 2016/0291235 A1 (LUMENS CO. LTD.) 06 October 2016; figures 1-3, paragraphs [0075], [0077]	5, 12, 13
Y	US 2011/0157899 A1 (KO, C) 30 June 2011; figure 3, paragraphs [0016], [0022]	7, 14, 19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 January 2020 (07.01.2020)	29 JAN 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300