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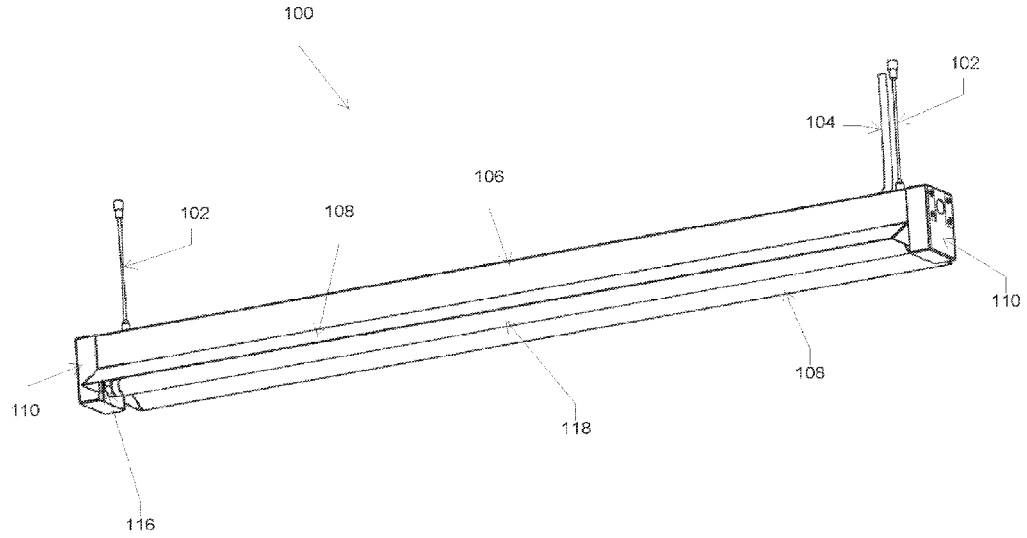


FIG. 1

(57) **Abstract:** A luminaire includes a frame, opposing sockets coupled to the frame, a bulb removably coupled to the opposing sockets, and a panel coupled to the frame. Each of the opposing sockets projects distally from, the frame. The bulb that, is removably coupled to the opposing sockets emits ultraviolet radiation. The panel that is coupled to the frame blocks ultraviolet radiation emitted by the bulb.

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[Continued on next page]

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GERMICIDAL LUMINAIRE

FIELD

[0001] Embodiments described herein relate to a germicidal luminaire.

SUMMARY

[0002] The present disclosure relates, in one aspect, to a luminaire including a frame, opposing sockets coupled to the frame, a bulb removably coupled to the opposing sockets, and a panel coupled to the frame. The opposing sockets project distally from the frame. The bulb is configured to emit ultraviolet radiation. The panel is configured to block ultraviolet radiation emitted by the bulb.

[0003] In some embodiments, at least a portion of the panel absorbs a majority of radiation that strikes the portion of the panel.

[0004] In some embodiments, at least a portion of the panel is covered with carbon nanotubes.

[0005] In some embodiments, at least a portion of the panel is a carbon black color.

[0006] In some embodiments, a face of the panel is angled relative to the bulb.

[0007] In some embodiments, the panel extends parallel to a central axis of the bulb in a longitudinal direction of the bulb.

[0008] In some embodiments, a plane extending colinear with the central axis of the bulb intersects the panel at an angle that is between 90 degrees and 170 degrees.

[0009] In some embodiments, the angle is between 130 degrees and 160 degrees.

[0010] In some embodiments, the angle is 145 degrees.

[0011] In some embodiments, the panel is a first panel, and the luminaire further includes a second panel disposed opposite the bulb from the first panel.

[0012] In some embodiments, the first panel and the second panel are integrally formed together as a unitary part.

[0013] In some embodiments, mounting hardware is coupled to the frame. The mounting hardware extends away from the frame. The frame is disposed between the mounting hardware and the bulb.

[0014] In some embodiments, end caps are coupled to the frame. Mounting hardware is coupled to the endcaps. The mounting hardware extends away from the frame. The bulb is disposed between the mounting hardware and the frame.

[0015] In some embodiments, an enclosure is disposed about a majority of the bulb. The enclosure includes the panel.

[0016] In some embodiments, the panel extends outwardly from the enclosure away from the bulb.

[0017] In some embodiments, the panel is a first panel. The enclosure further includes a second panel extending into the enclosure toward the bulb.

[0018] In some embodiments, a plan extending colinear with a central axis of the bulb intersects the first panel at a first angle that is between 10 degrees and 50 degrees.

[0019] In some embodiments, the first angle is between 20 degrees and 40 degrees.

[0020] In some embodiments, the first angle is 30 degrees.

[0021] In some embodiments, the plane forms a second angle of between 10 degrees and 30 degrees relative to the second panel.

[0022] In some embodiments, the second angle is 20 degrees.

[0023] In some embodiments, the panel reflects less than half as much radiation as the frame.

[0024] Other aspects of the embodiments will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. 1 illustrates a perspective view of a luminaire, according to embodiments described herein.

[0026] FIG. 2 illustrates a front elevation view of the luminaire of FIG. 1.

[0027] FIG. 3 illustrates a bottom plan view of the luminaire of FIG. 1.

[0028] FIG. 4 illustrates a top plan view of the luminaire of FIG. 1.

[0029] FIG. 5 illustrates a side elevation view of the luminaire of FIG. 1.

[0030] FIG. 6 illustrates a cross-sectional side elevation view of the luminaire of FIG. 1.

[0031] FIG. 7 illustrates a cross-sectional front elevation view of the luminaire of FIG. 1.

[0032] FIG. 8 illustrates an exploded front elevation view of the luminaire of FIG. 1.

[0033] FIG. 9 illustrates an exploded perspective view of the luminaire of FIG. 1.

[0034] FIG. 10 illustrates a perspective view of a luminaire, according to embodiments described herein.

[0035] FIG. 10B illustrates a perspective view of the luminaire of FIG. 10 with an alternative panel.

[0036] FIG. 11 illustrates a front elevation view of the luminaire of FIG. 10.

[0037] FIG. 12 illustrates a bottom plan view of the luminaire of FIG. 10.

[0038] FIG. 13 illustrates a top plan view of the luminaire of FIG. 10.

[0039] FIG. 13B illustrates a top plan view of the luminaire of FIG. 10B.

[0040] FIG. 14 illustrates a side elevation view of the luminaire of FIG. 10.

[0041] FIG. 15 illustrates a cross-sectional side elevation view of the luminaire of FIG. 10.

[0042] FIG. 16 illustrates a cross-sectional front elevation view of the luminaire of FIG. 10.

[0043] FIG. 17 illustrates an exploded front elevation view of the luminaire of FIG. 10.

[0044] FIG. 18 illustrates an exploded perspective view of the luminaire of FIG. 10.

[0045] FIG. 18B illustrates an exploded perspective view of the luminaire of FIG. 10B.

[0046] FIG. 19 illustrates a perspective view of a luminaire, according to embodiments described herein.

[0047] FIG. 20 illustrates a front elevation view of the luminaire of FIG. 19.

[0048] FIG. 21 illustrates a bottom plan view of the luminaire of FIG. 19.

[0049] FIG. 22 illustrates a top plan view of the luminaire of FIG. 19.

[0050] FIG. 23 illustrates a side elevation view of the luminaire of FIG. 19.

[0051] FIG. 24 illustrates a cross-sectional side elevation view of the luminaire of FIG. 19.

[0052] FIG. 25 illustrates a cross-sectional top plan view of the luminaire of FIG. 19.

[0053] FIG. 26 illustrates an exploded top plan view of the luminaire of FIG. 19.

[0054] FIG. 27 illustrates an exploded perspective view of the luminaire of FIG. 19.

DETAILED DESCRIPTION

[0055] Air purification and room disinfection has become more important in light of recent events. Germicidal luminaires can be used for a variety of applications including surface disinfection and air disinfection. For surface disinfection, a germicidal luminaire projects ultraviolet radiation onto a surface to be disinfected. For air disinfection, a germicidal luminaire may create a germicidal zone in a room such as, for instance, an upper portion of the room. Standard building climate control systems move airborne pathogens from the lower portion of a room to the upper portion of the room. The air, therefore, naturally flows past the germicidal zone. Pathogen inactivation occurs through the cumulative exposure to the ultraviolet radiation

over time. Each exposure cycle inactivates pathogens until the concentration in the room is effectively diluted.

[0056] The present disclosure illustrates three embodiments of germicidal luminaires 100, 200, 300. Of course, this disclosure may contemplate other additional luminaires. Features from one embodiment may be included or omitted in another embodiment to create yet another embodiment, for instance.

[0057] With reference to FIG. 1, an embodiment of a luminaire 100 is shown. The luminaire 100 is configured to be hung from a support surface disposed directly above the luminaire 100 by hardware 102, making the luminaire 100 a pendant luminaire in this embodiment. The hardware 102 is illustrated as a wire having fasteners at each end, but other forms of the hardware 102 are contemplated herein.

[0058] The luminaire 100 is further illustrated as being powered by mains power in a building. As such, the luminaire 100 is illustrated with a power supply cable 104 that is configured to extend to, for instance, the support surface above the luminaire 100. Of course, other forms of power delivery are also contemplated herein including, for instance, a battery powered luminaire.

[0059] The illustrated embodiment of the luminaire 100 further includes a frame 106, at least one panel 108 coupled to the frame 106, and endcaps 110 coupled to the frame 106. These components make up the general housing of the luminaire 100.

[0060] As shown in FIGS. 1, 6, and 7, the frame 106 is illustrated as being a hollow rectangular prism. Other embodiments of the luminaire 100 may include a frame 106 having a different shape. As shown particularly in FIG. 7, the hardware 102 is shown coupled directly to an upper wall of the frame 106. The power supply cable 104 is also illustrated as extending through the upper wall of the frame 106 and into a cavity 112 formed by the frame 106. In some embodiments, the cavity 112 may contain one or more electrical components of the luminaire 100, such as a ballast 114. Additional or alternative electrical components, such as a controller, may be disposed in the cavity 112.

[0061] With continued reference to FIG. 7, the luminaire 100 further includes a pair of sockets 116 coupled to a lower wall of the frame 106. In the illustrated embodiment, the sockets 116 are coupled to the frame 106 in a position that is opposite the frame 106 from the hardware 102. In some embodiments, the sockets 116 are tombstone sockets that removably receive the bulb 118. In some embodiments, the sockets 116 are of a construction that allows a user to remove and replace the bulb 118 by twisting the bulb 118 along its central longitudinal axis L1 and then moving the bulb into and out of engagement with the sockets 116 in a direction perpendicular to the central longitudinal axis L1.

[0062] As shown in FIGS. 1, 5, and 7, the endcaps 110 are coupled to the frame 106. These endcaps 110 in the illustrated embodiment are for decorative purposes as well as structural purposes. The endcaps 110 serve to close the cavity 112 on each end of the frame 106. In the illustrated embodiment, the endcaps 110 are removably coupled to the frame 106, but other embodiments may include permanently affixed endcaps 110. In the illustrated embodiment, the endcaps 110 are not coupled directly to the sockets 116, but rather only cover at least a portion of the sockets 116 for aesthetic purposes and for purposes of protecting the sockets 116 from accidental damage due to dropping the luminaire 100, for instance.

[0063] As discussed briefly above, the luminaire 100 further includes at least one bulb 118. In the illustrated embodiment, the bulb 118 is a fluorescent bulb, although other embodiments may include different types of bulbs including, for instance, light-emitting diode (LED) bulbs. The bulb 118 is configured to emit ultraviolet radiation having a wavelength of 254 nanometers (nm). This wavelength is associated with germicidal properties. In some embodiments, a majority of the radiation emitted by the bulb 118 has a wavelength of 254 nm. Radiation having this wavelength may also be harmful to humans and other animals upon direct and/or prolonged exposure. To address this concern, the illustrated embodiment of the luminaire 100 is configured to be operated only when the corresponding room is unoccupied. In some embodiments, one or more occupancy sensors, timers, some combination thereof, or the like are utilized. Of course, other embodiments may include a bulb configured to emit radiation in additional or alternative wavelengths that also possess germicidal properties.

[0064] As shown in FIGS. 1 and 5, the illustrated embodiment of the luminaire 100 includes two panels 108. The two panels 108 fan outwardly away from the frame 106. Shown best in FIG. 9, the two panels 108 in the illustrated embodiment are formed as a single unitary part. The panels 108 may be cast together, or they may be stamped and/or bent from a single sheet of metal, for instance. A center section 120, having each of the panels 108 on either side, is coupled to the frame 106. In the illustrated embodiment, the center section 120 is positioned between the frame 106 and the bulb 118. The panels 108 and, optionally, also the center section 120 are covered with or made from a reflection reducing material. In some embodiments, the reflection reducing material is a layer of dark paint applied to the panels 108 and/or center section 120. In some embodiments, the dark paint includes a carbon black paint. In some embodiments, the panels 108 and/or center section 120 are covered in carbon nanotubes, which are exceptional at absorbing light and, therefore, reducing reflection. In some embodiments, all the surfaces of the panels 108 and/or center section 120 are covered with or made from the reflection reducing material. Other embodiments, however, may include only portions of the panels 108 and/or the center section 120 covered with or made from the reflection reducing material. For instance, some embodiments may not include a coating on a side of the center section 120 that faces the frame 106. Regardless of the configuration, the panels 108 are positioned and configured to direct the radiation from the bulb 118 to a desired destination. In this embodiment, the down pendant luminaire 100 is configured to emit the radiation downwardly in a room onto one or more surfaces in the room.

[0065] As shown in FIG. 6, the panels 108 are positioned relative to the bulb 118 to achieve the desired emission destination. In the illustrated embodiment, a plane P1 bisects the bulb 118 and extends colinearly with the central longitudinal axis L1 of the bulb 118. This plane P1 also intersects with the panel 108 and forms an angle A1 therewith. In some embodiments, this angle A1 between the plane P1 and the panel 108 is between 90 and 170 degrees. In some embodiments, the angle A1 is between 130 and 160 degrees. In some embodiments, the angle A1 is 145 degrees.

[0066] Turning now to FIG. 10, the present disclosure also contemplates another embodiment of a luminaire 200. This second embodiment of a luminaire 200 shares many components with the luminaire 100 discussed above. This commonality between luminaires 100,

200 may save a manufacturer costs in production and may also provide for more flexible and/or timely purchase order fulfillment. Of course, the luminaires 100, 200 need not be similar as described herein, since the described embodiments are only examples. For the second embodiment of a luminaire 200 described herein, only differences from the luminaire 100 described above will be explored below. Similar components will be numbered with a value of one hundred higher than the corresponding components from the luminaire 100 above, and, as such, may not be explicitly described below in the interest of brevity.

[0067] As shown in FIG. 10, the luminaire 200 is arranged as an up pendant luminaire 200. This luminaire 200 is configured to emit the radiation upwardly in a room so as to perform air disinfection above a predetermined height in the room such as, for instance, seven feet (or 2.1 meters). In some embodiments, this up pendant luminaire 200 allows for occupancy of the room during operation, unlike the down pendant luminaire 100 described above.

[0068] In the illustrated embodiment, the hardware 202 is coupled to each of the endcaps 210 instead of the frame 206. In this manner, the frame 206 may be in a configuration that is flipped relative to the embodiment described above. Also, the power supply cable 204 may extend through one of the endcaps 210 as shown in FIG. 10.

[0069] The panels 208 and center section 220 are coupled to the frame 206 in manner similar to that described above. This embodiment of the luminaire 200 also utilizes the reflection reducing material/coating. In this embodiment, such material and/or coating is helpful in providing control of the emission destination for an occupied room. Dosage of the radiation emitted by the bulb 218 must be carefully limited so as to be safe for use in an occupied room. In addition to the reflection reducing material and/or coating, the luminaire 200 may further be controlled to emit radiation for limited periods of time to avoid excessive radiation emission.

[0070] In the illustrated embodiment, the luminaire 200 further includes an additional panel 222 that blocks at least some of the radiation emitted by the bulb 218. As shown in FIG. 10, the additional panel 222 spans across the luminaire 200 and is coupled to each of the endcaps 210. Although not required in all embodiments, the hardware 202 and the power supply cable 204 also pass through this additional panel 222.

[0071] As shown in FIGS. 10 and 13, the additional panel 222 includes at least one strengthening rib or contour 224. These strengthening ribs 224 assist in maintaining the rigidity of the additional panel 222. Otherwise, the panel 222 might bow due to the span between endcaps 210. The strengthening ribs 224 span the additional panel 222 in a direction parallel with the length of the panel 222 in the illustrated embodiment. In the embodiment shown in FIGS. 10B, 13B, and 18B, the alternative additional panel 222b includes strengthening ribs 224b that span transversely relative to the length of the panel 222b. In some embodiments, however, additional rigidity is provided in the form of a thicker or different material for the panel 222, additional material for the panel 222, or some other supporting structure connected to the panel 222, and the ribs 224 may not be required in such embodiments.

[0072] As shown in FIGS. 10 and 15, the additional panel 222 may include side sections 226 that project toward the frame 206. These side sections 226 may provide further rigidity to the additional panel 222. The side sections 226 are illustrated as depending downwardly from the main portion of the additional panel 222. The embodiment in FIGS. 10B and 18B also includes side sections 226b that project away from the frame 206. These side sections 226b are illustrated as depending upwardly from the main portion of the additional panel 222b. Other embodiments may omit these side sections 226, 226b.

[0073] Some embodiments may include the additional panel 222, 222b having reflection reducing material and/or coating. Other embodiments, however, may include both the center section 220 and the additional panel 222, 222b having reflective properties to project more radiation away from the luminaire 200. In any instance, the additional panel 222, 222b prevents radiation emission directly above the luminaire 200. This feature may avoid damage to the hardware 202 and/or power supply cable 204, as well as damage to the ceiling in the room. Further, this feature may reduce the likelihood of the emitted radiation reflecting off of a surface on the ceiling and toward the occupied portion of the room.

[0074] As shown in FIG. 15, the panels 208 are positioned relative to the bulb 218 to achieve the desired emission destination. In the illustrated embodiment, a plane P2 bisects the bulb 218 and extends colinearly with the central longitudinal axis L2 of the bulb 218. This plane P2 also intersects with the panel 208 and forms an angle A2 therewith. In some embodiments, this angle

A2 between the plane P2 and the panel 208 is between 90 and 170 degrees. In some embodiments, the angle A2 is between 130 and 160 degrees. In some embodiments, the angle A2 is 145 degrees.

[0075] With reference to FIG. 19, the present disclosure further contemplates yet another embodiment of a luminaire 300. This third embodiment of a luminaire 300 shares many components with the luminaire 100 discussed above. This commonality between luminaires 100, 300 may save a manufacturer costs in production and may also provide for more flexible and/or timely purchase order fulfillment. Of course, the luminaires 100, 300 need not be similar as described herein, since the described embodiments are only examples. For the third embodiment of a luminaire 300 described herein, only differences from the luminaire 100 described above will be explored below. Similar components will be numbered with a value of two hundred higher than the corresponding components from the luminaire 100 above, and, as such, may not be explicitly described below in the interest of brevity.

[0076] As shown in FIG. 19, the luminaire 300 is shown as an up wall fixture. This luminaire 300 is configured to emit the radiation upwardly in a room so as to perform air disinfection above a predetermined height in the room such as, for instance, seven feet (or 2.1 meters). In some embodiments, this up wall luminaire 300 allows for occupancy of the room during operation, unlike the down pendant luminaire 100 described above.

[0077] In the illustrated embodiment, the hardware 302 is coupled to the frame 306, but the hardware 302 is in the form of a wall-mount plate. As shown in FIG. 22, the wall-mount plate 302 may couple directly to an electrical box 328 to be received in a wall of a room. In this manner, the frame 306 may be in a configuration that is rotated 90 degrees relative to the embodiment of the luminaire 100 described above.

[0078] With reference to FIGS. 24, 26, and 27, the luminaire 300 further includes an enclosure 330 coupled to the frame 306. In the illustrated embodiment, the enclosure 330 is made of three enclosure sections 332a, 332b, 332c that are coupled to each other. In some embodiments, the enclosure sections 332a, 332b, 332c are removably coupled to each other and/or removably coupled to the frame 306 for easy service of the bulb 318. In other embodiments, at least some of the enclosure sections 332a, 332b, 332c may be permanently

coupled to each other, or at least some of the enclosure sections 332a, 332b, 332c may be permanently coupled to the frame 306.

[0079] With particular reference to FIGS. 24 and 27, each of the enclosure sections 332a, 332b, 332c are put together to form the walls of the enclosure 330. In the illustrated embodiment, the first enclosure section 332a is an L-shaped section that forms a wall between the frame 306 and the bulb 318 as well as a bottom wall on a downward facing side of the bulb 318. The first enclosure section 332a further includes a plurality of tabs 334 that are received through a front wall of the frame 306. The second enclosure section 332b is a C-shaped section that forms a bottom wall on the downward facing side of the bulb 318, thereby at least partially overlapping with the first enclosure section 332a. The second enclosure section 332b also forms a front wall that is away from the wall on which the luminaire 300 is mounted, which places the bulb 318 between this front wall and the frame 306. An opening 336 that is shown in FIG. 24 is formed at least partially by this front wall of the second enclosure section 332b. The second enclosure section 332b further forms a top wall. The bottom wall and the top wall of the second enclosure section 332b are mounted to the endcaps 310. The third enclosure section 332c is roughly a U-shaped section that forms a top wall, thereby at least partially overlapping with the second enclosure section 332b. The third enclosure section 332c further includes a plurality of tabs 338 that are received through a top wall of the frame 306. The third enclosure section 332c also includes a downwardly extending front wall that cooperates with the front wall of the second enclosure section 332b to form the opening 336. The third enclosure section 332c also includes an additional panel 322 to at least partially direct the radiation emitted by the bulb 318.

[0080] The panel 308 is coupled to the front wall of the second enclosure section 332b and extends over the opening 336 to block at least some of the radiation that passes through the opening 336. In this manner, the radiation emitted by the bulb 318 is only permitted to move upwardly and away from the luminaire 300. As stated above, the panel 308 may be painted, coated, or may include a radiation absorbing or radiation blocking material as discussed above. Further, the additional panel 322 of the third enclosure section 332c may be painted, coated, or may include a radiation absorbing or radiation blocking material. In some embodiments, the additional panel 322 of the third enclosure section 332c may instead be reflective to direct radiation toward the opening 336. Similarly, the other surfaces of the enclosure sections 332a,

332b, 332c may be painted, coated, or may include a radiation absorbing or radiation blocking material. Alternatively, these other surfaces of the enclosure sections 332a, 332b, 332c may instead be reflective to direct radiation toward the opening 336.

[0081] With continued reference to FIG. 24, the panel 308 is positioned relative to the bulb 318 to achieve a desired emission destination. In the illustrated embodiment, a plane P3 bisects the bulb 318 and extends colinearly with the central longitudinal axis L3 of the bulb 318. This plane P3 also intersects with the panel 308 and forms an angle A3 therewith. In some embodiments, this angle A3 between the plane P3 and the panel 308 is between 10 and 50 degrees. In some embodiments, the angle A3 is between 20 and 40 degrees. In some embodiments, the angle A3 is 30 degrees.

[0082] Although the additional panel 322 does not extend far enough to intersect with the plane P3 as illustrated in FIG. 24, an angle A4 can be measured between the face of the additional panel 322 and the plane P3. In some embodiments, this angle A4 is between 10 and 30 degrees. In some embodiments, this angle A4 is 20 degrees.

CLAIMS

What is claimed is:

1. A luminaire comprising:

a frame;

opposing sockets coupled to the frame and projecting distally therefrom;

a bulb removably coupled to the opposing sockets, the bulb configured to emit ultraviolet radiation; and

a panel coupled to the frame, the panel configured to block ultraviolet radiation emitted by the bulb.

2. The luminaire of claim 1, wherein at least a portion of the panel is configured to absorb a majority of radiation that strikes the portion of the panel.

3. The luminaire of claim 2, wherein at least a portion of the panel is covered with carbon nanotubes.

4. The luminaire of claim 2, wherein at least a portion of the panel is a carbon black color.

5. The luminaire of claim 1, wherein a face of the panel is angled relative to the bulb.

6. The luminaire of claim 5, wherein the panel extends parallel to a central axis of the bulb in a longitudinal direction of the bulb.

7. The luminaire of claim 6, wherein a plane extending colinear with the central axis of the bulb intersects the panel at an angle that is between 90 degrees and 170 degrees.

8. The luminaire of claim 7, wherein the angle is between 130 degrees and 160 degrees.

9. The luminaire of claim 8, wherein the angle is 145 degrees.

10. The luminaire of claim 1, wherein

the panel is a first panel, and

the luminaire further comprises a second panel disposed opposite the bulb from the first panel.

11. The luminaire of claim 10, wherein the first panel and the second panel are integrally formed together as a unitary part.

12. The luminaire of claim 1, further comprising mounting hardware coupled to the frame, the mounting hardware extending away from the frame and the frame disposed between the mounting hardware and the bulb.

13. The luminaire of claim 1, further comprising

end caps coupled to the frame, and

mounting hardware coupled to the endcaps, the mounting hardware extending away from the frame and the bulb disposed between the mounting hardware and the frame.

14. The luminaire of claim 1, further comprising an enclosure disposed about a majority of the bulb, the enclosure including the panel.

15. The luminaire of claim 14, wherein the panel extends outwardly from the enclosure away from the bulb.

16. The luminaire of claim 15, wherein

the panel is a first panel, and

the enclosure further includes a second panel extending into the enclosure toward the bulb.

17. The luminaire of claim 16, wherein a plane extending colinear with a central axis of the bulb intersects the first panel at a first angle that is between 10 degrees and 50 degrees.

18. The luminaire of claim 17, wherein the first angle is between 20 degrees and 40 degrees.

19. The luminaire of claim 18, wherein the first angle is 30 degrees.

20. The luminaire of claim 17, wherein the plane forms a second angle of between 10 degrees and 30 degrees relative to the second panel.

21. The luminaire of claim 20, wherein the second angle is 20 degrees.

22. The luminaire of claim 1, wherein the panel reflects less than half as much radiation as the frame.

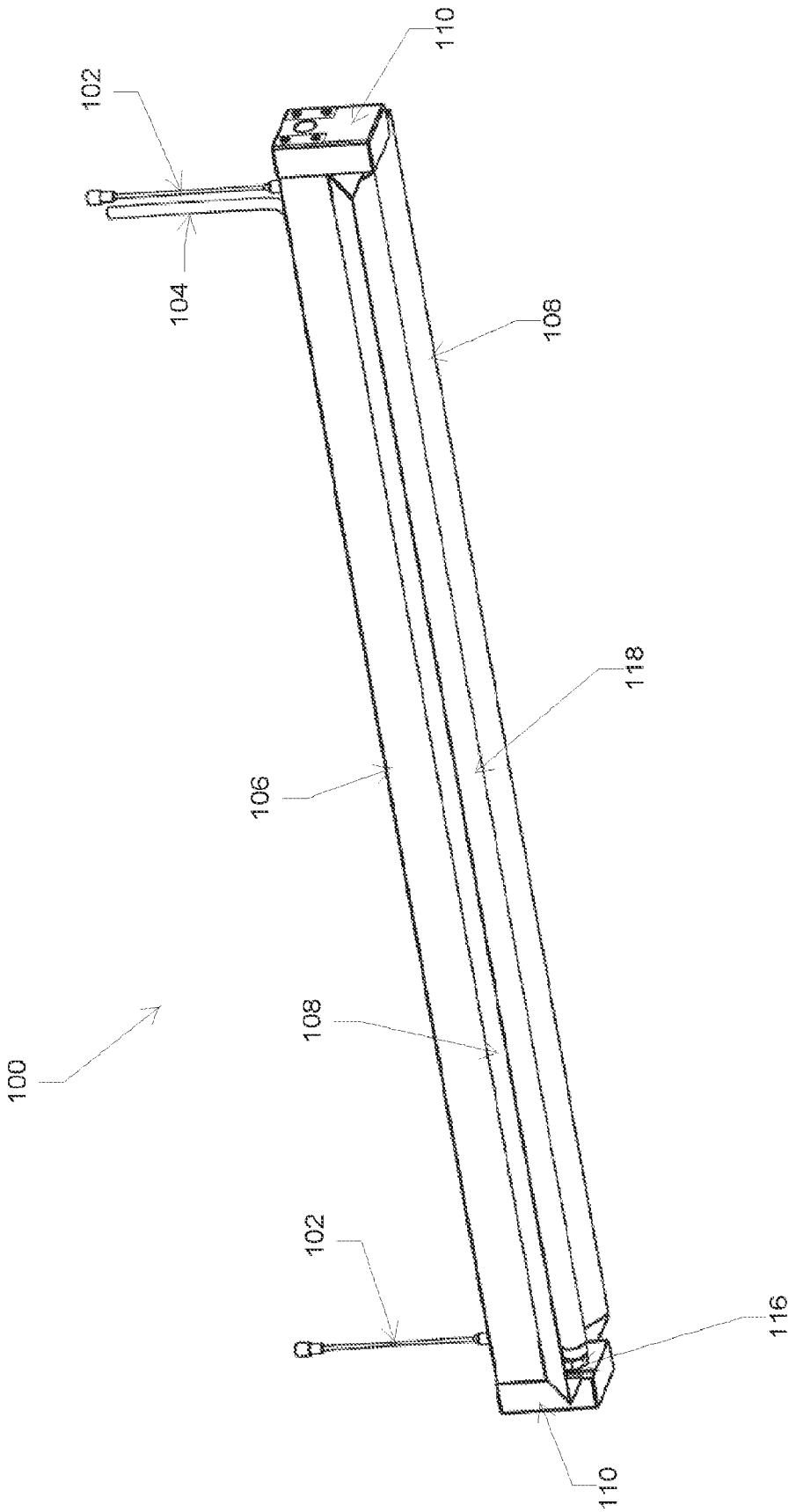


FIG. 1

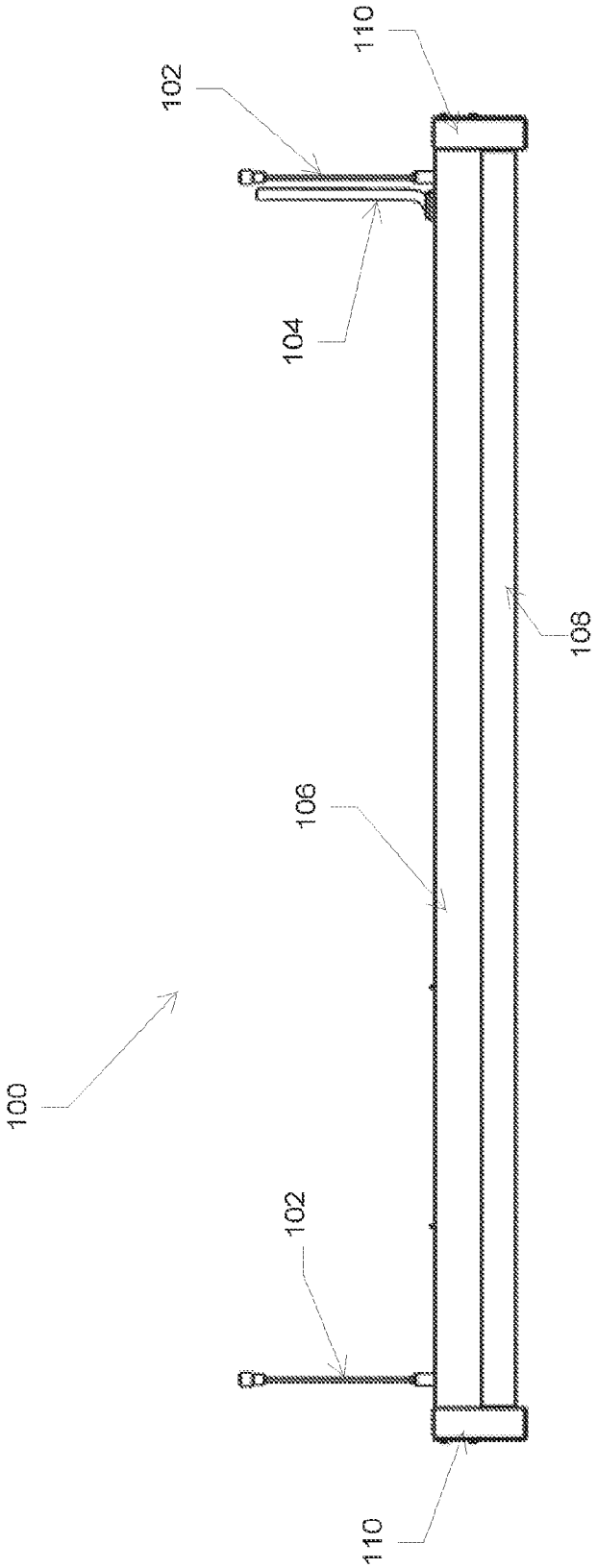


FIG. 2

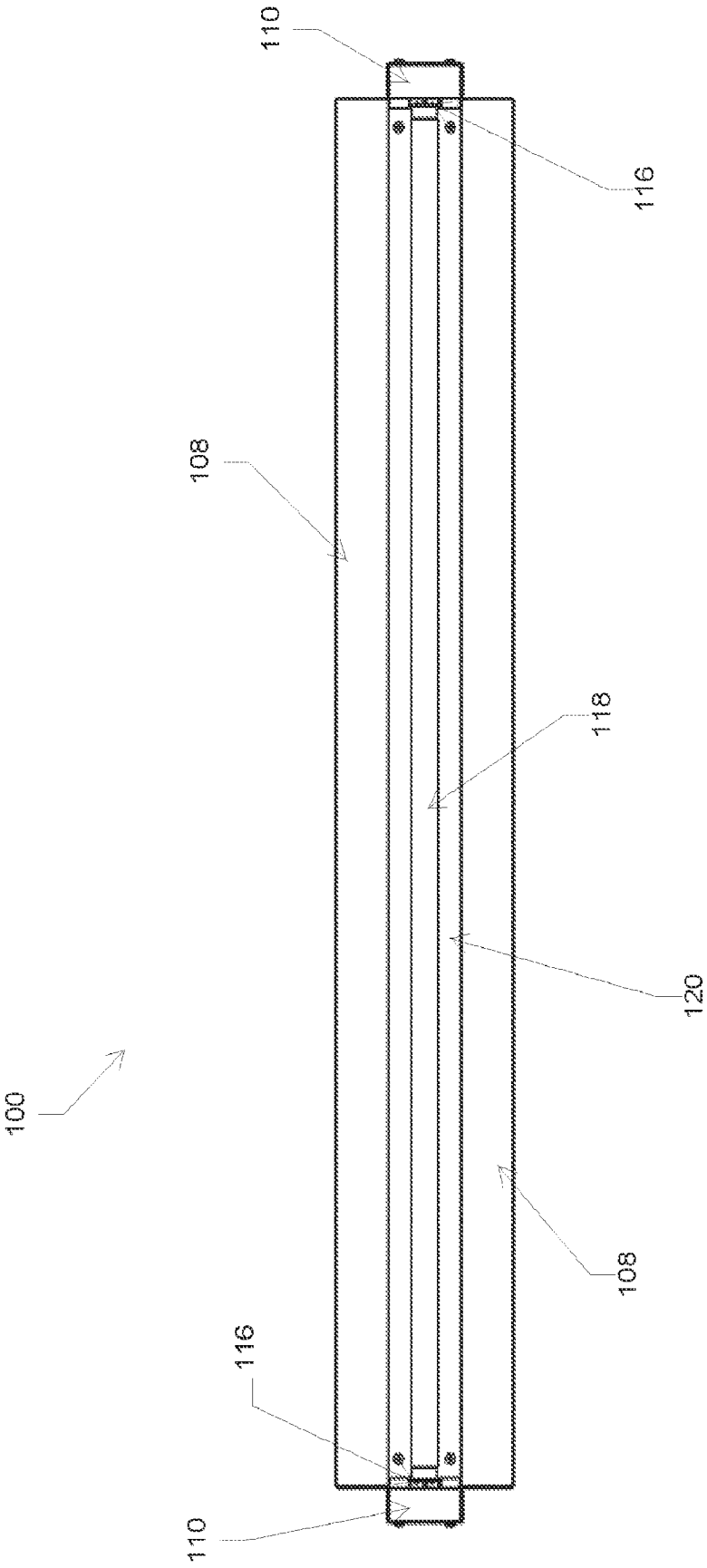


FIG. 3

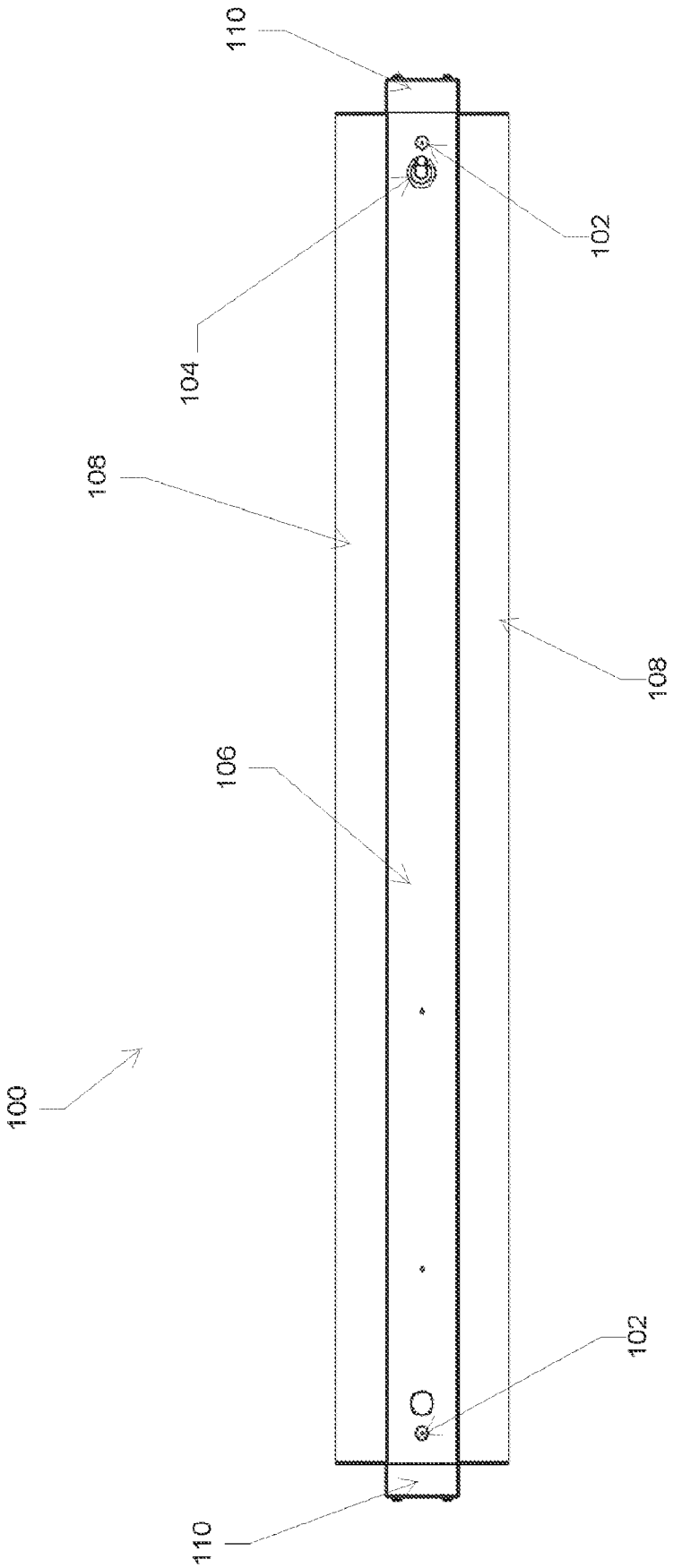


FIG. 4

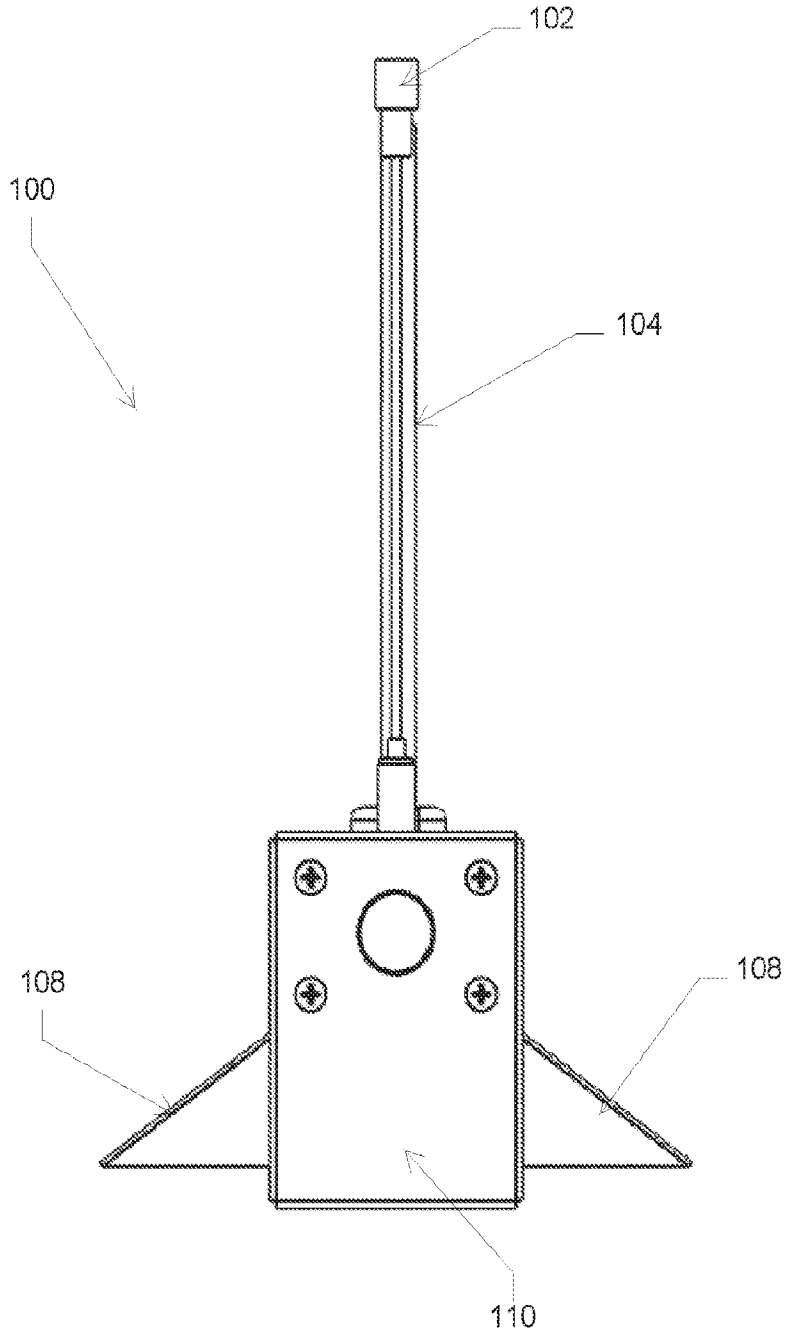


FIG. 5

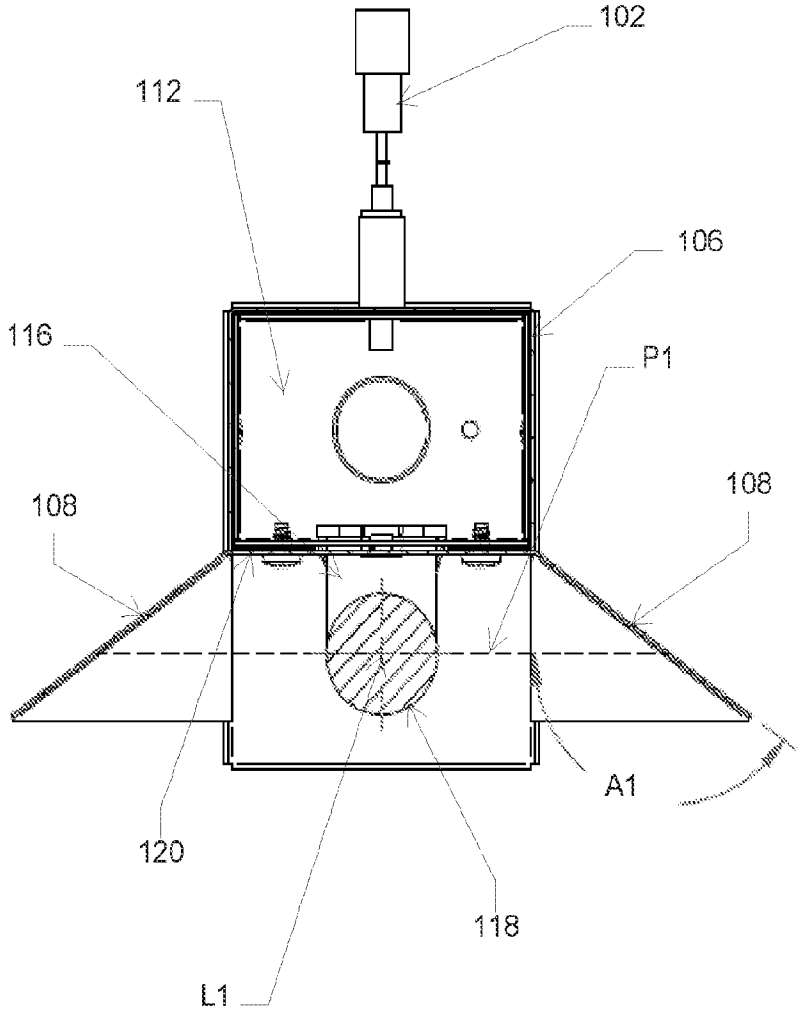


FIG. 6

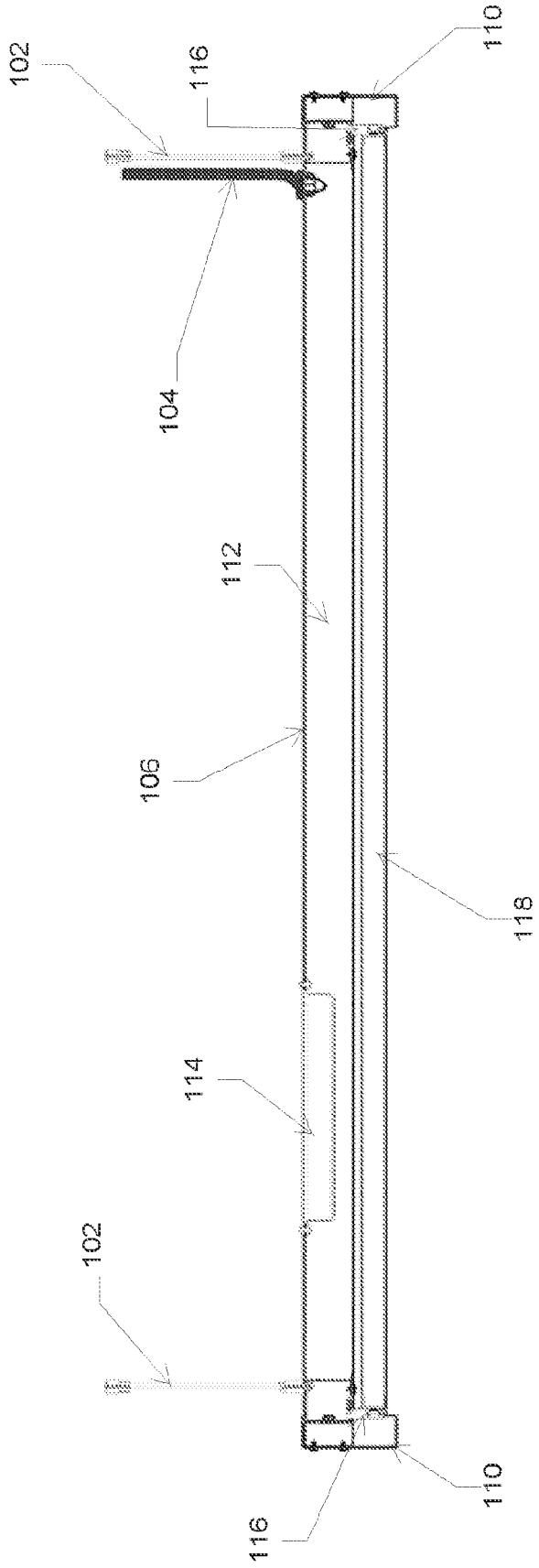


FIG. 7

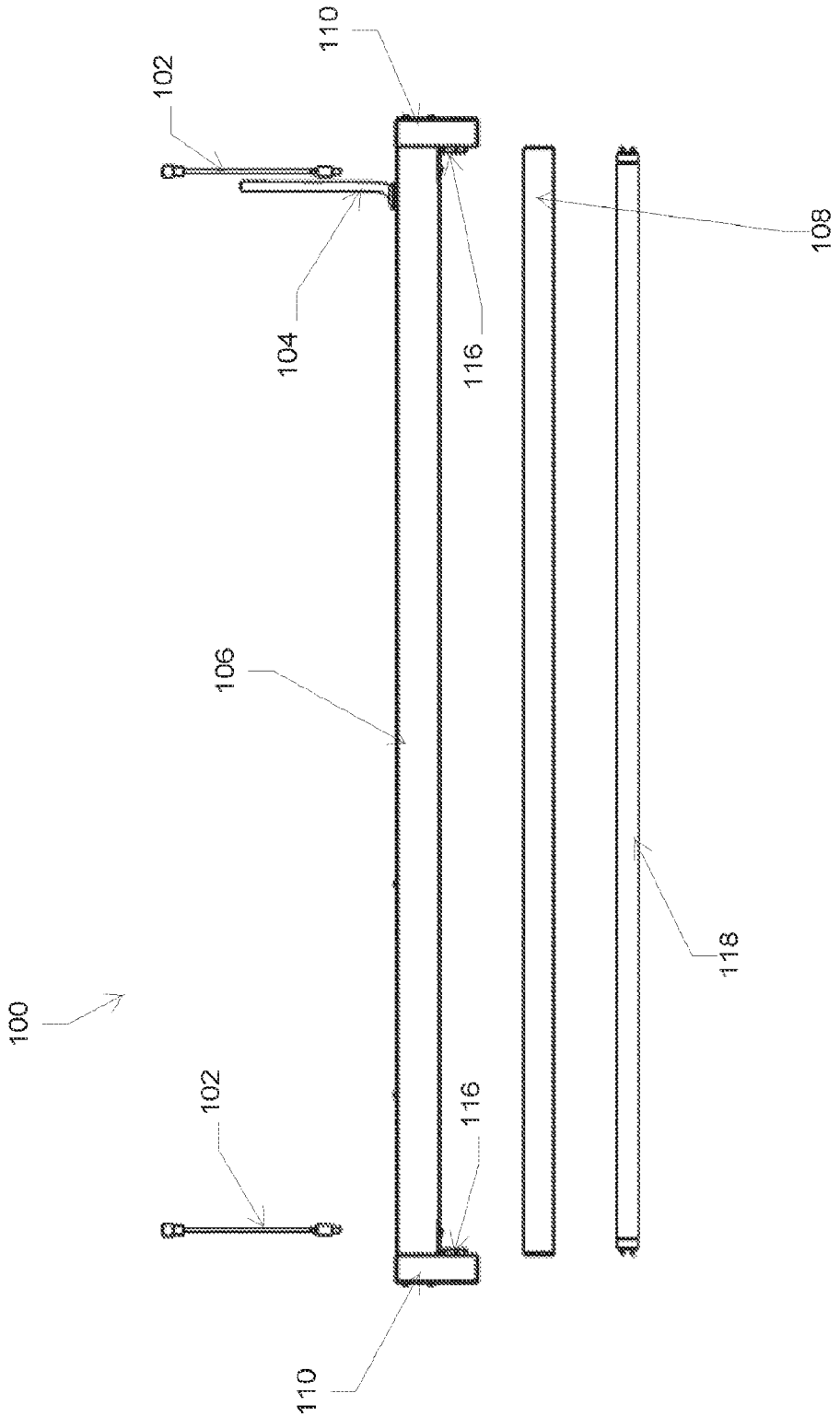


FIG. 8

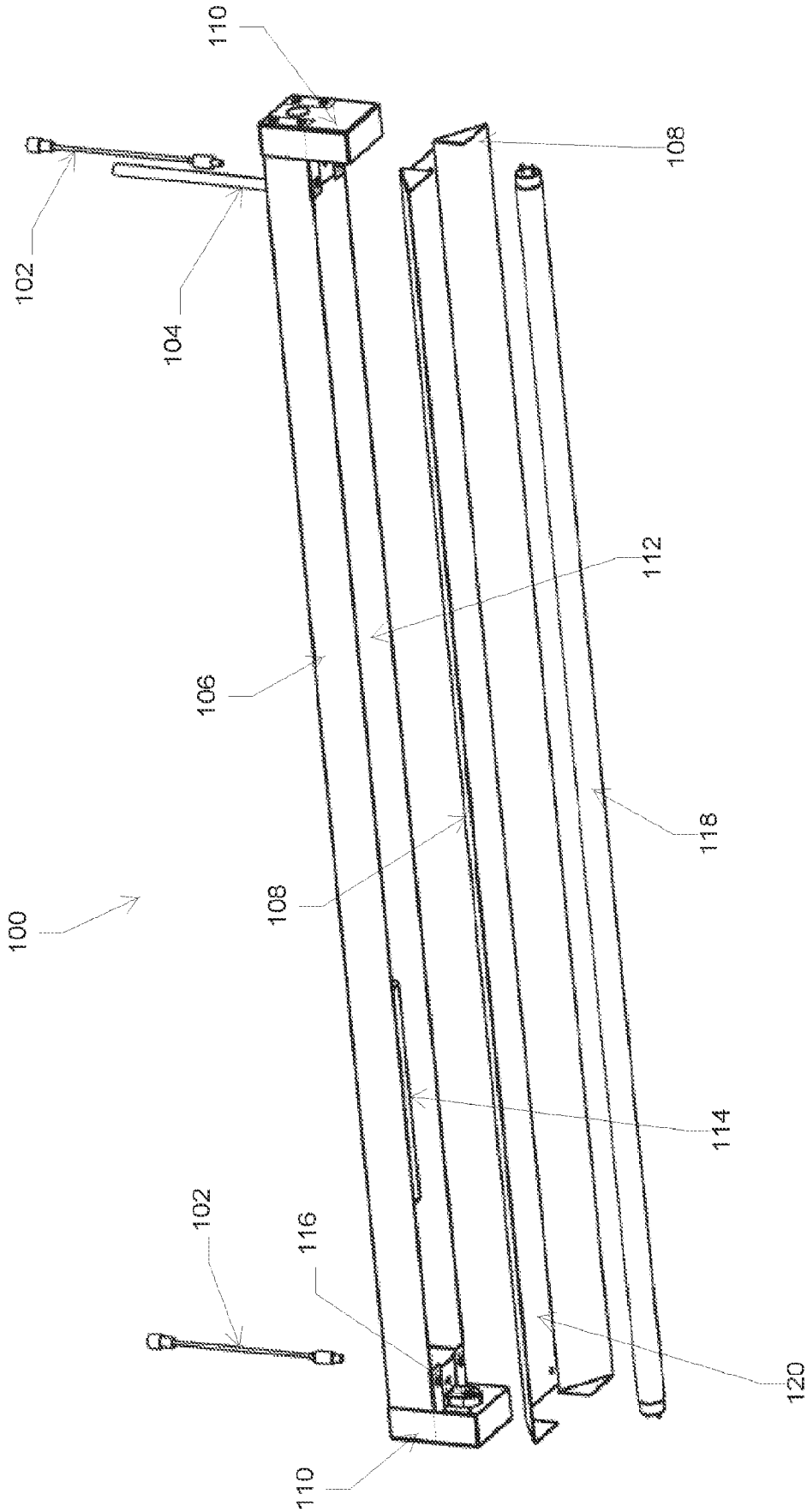


FIG. 9

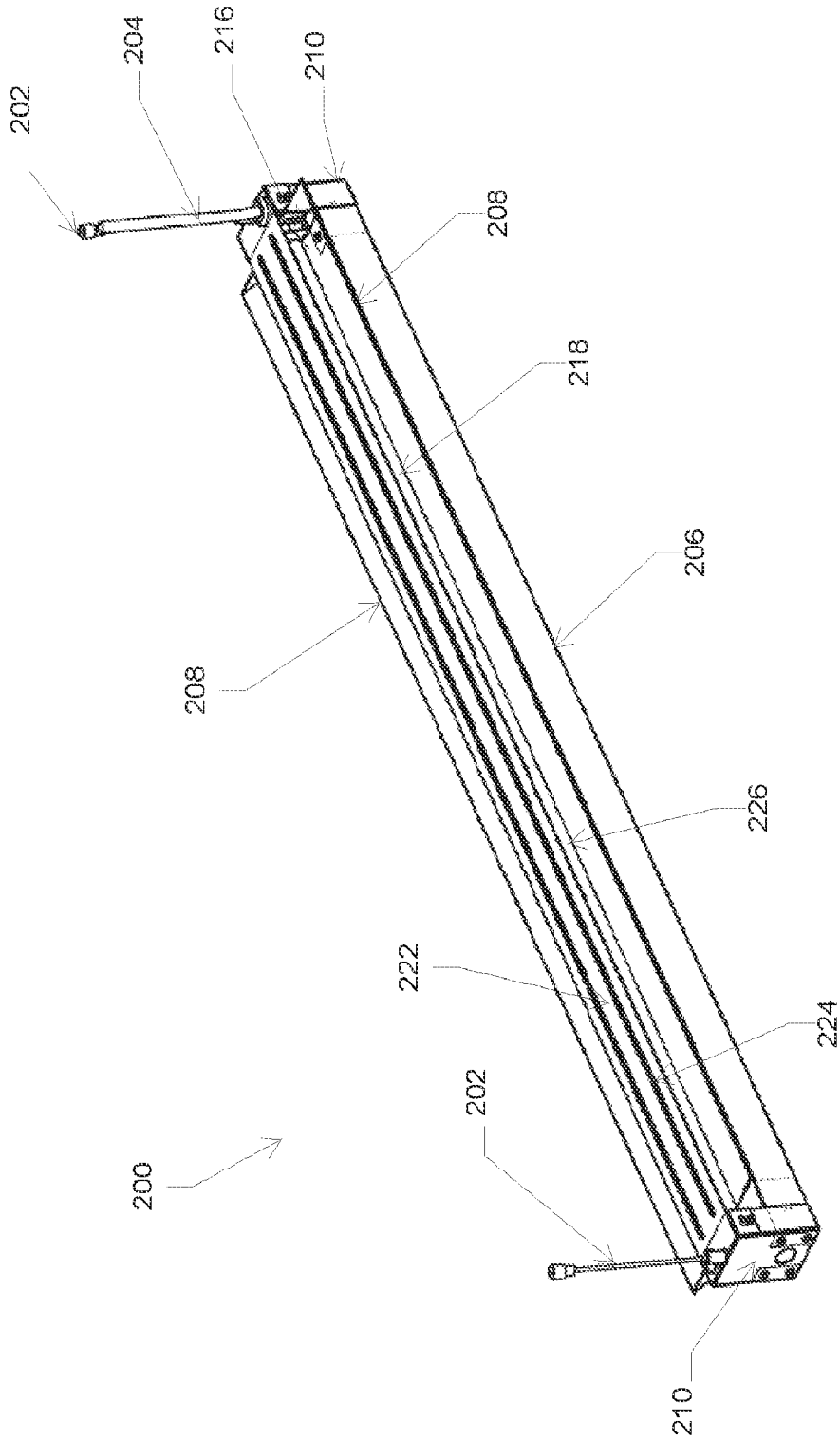


FIG. 10

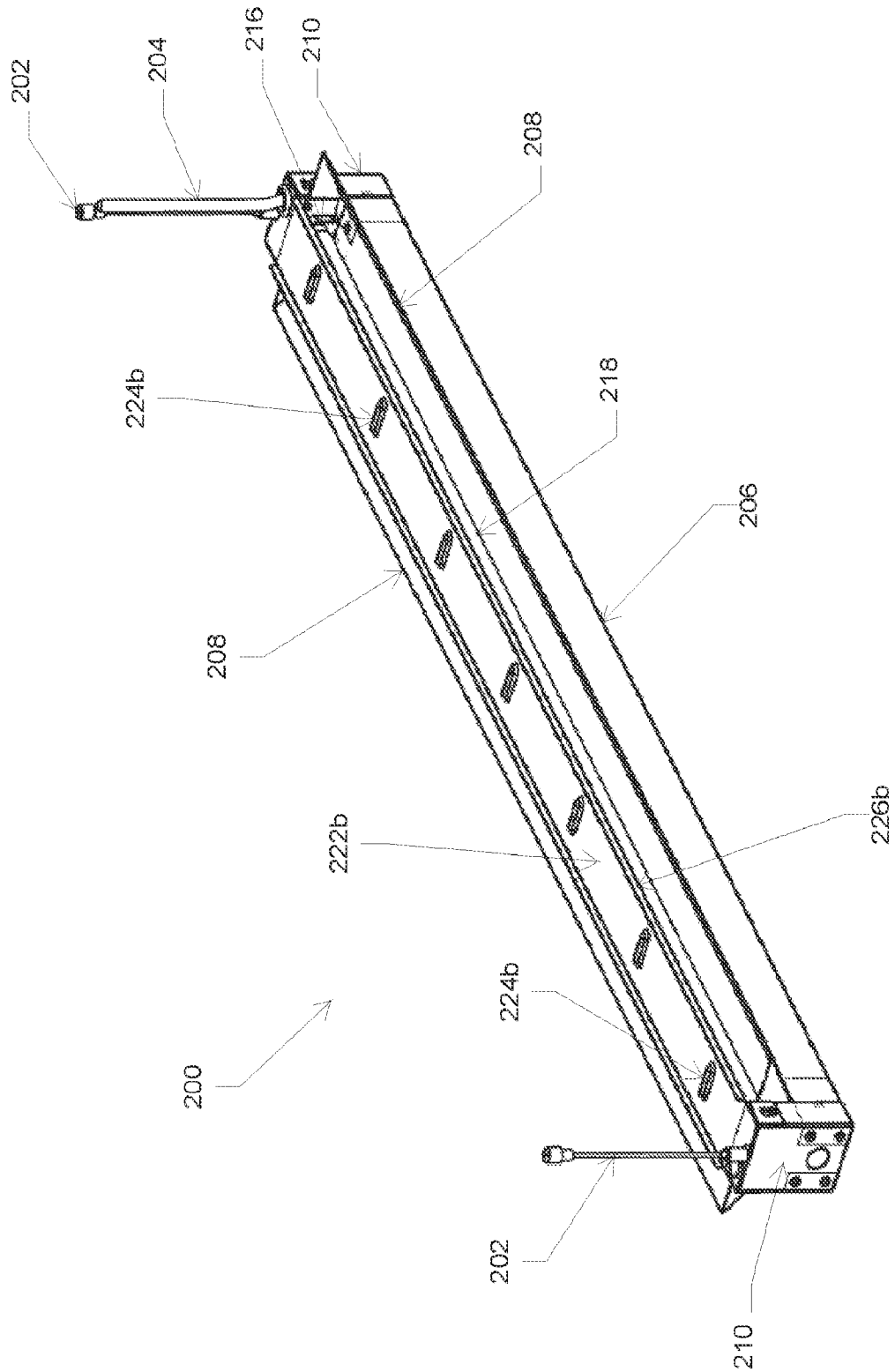


FIG. 10B

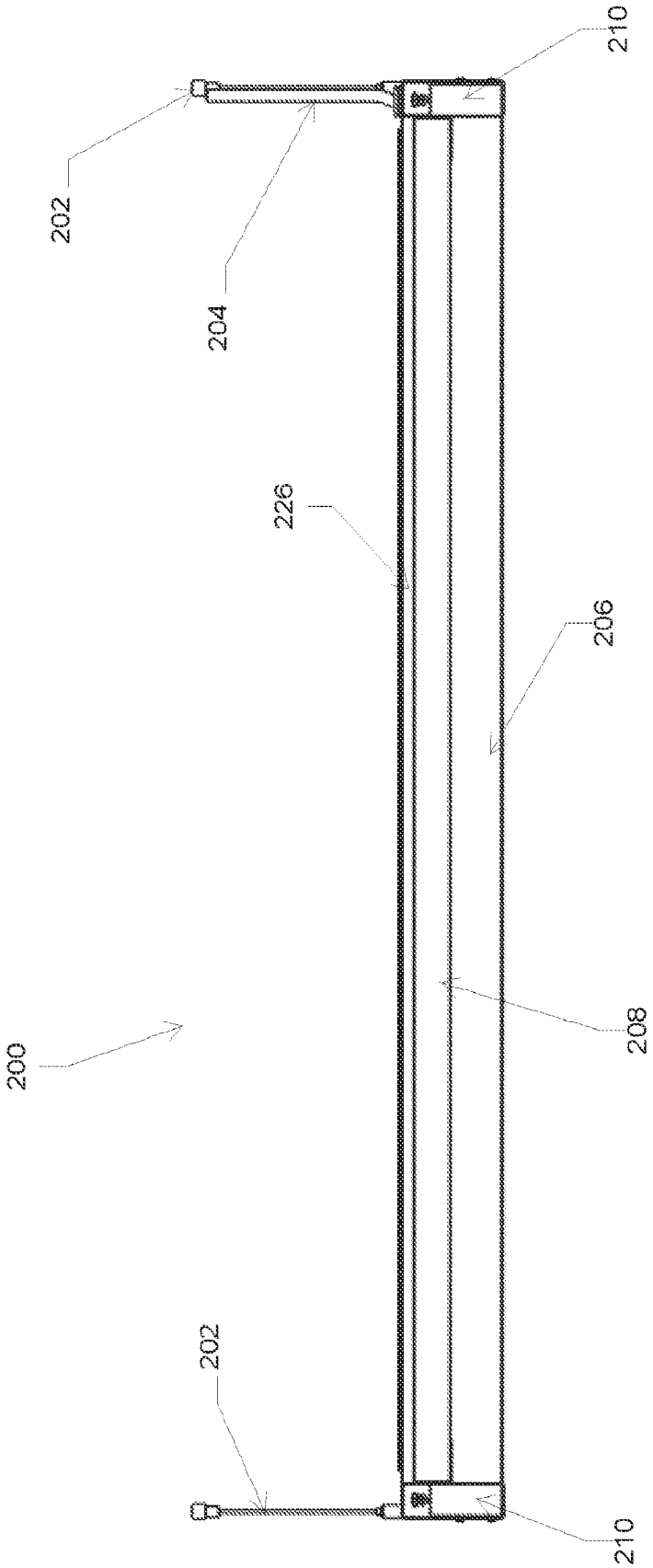


FIG. 11

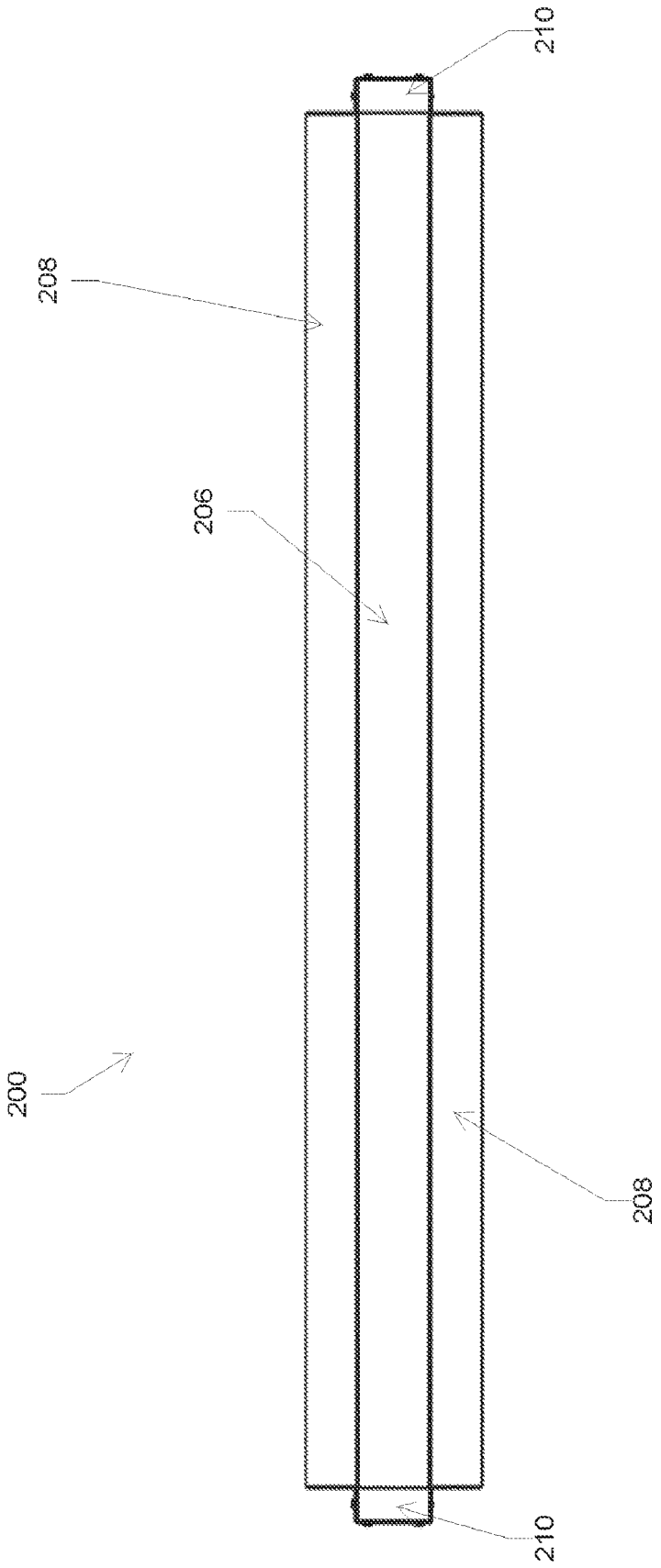


FIG. 12

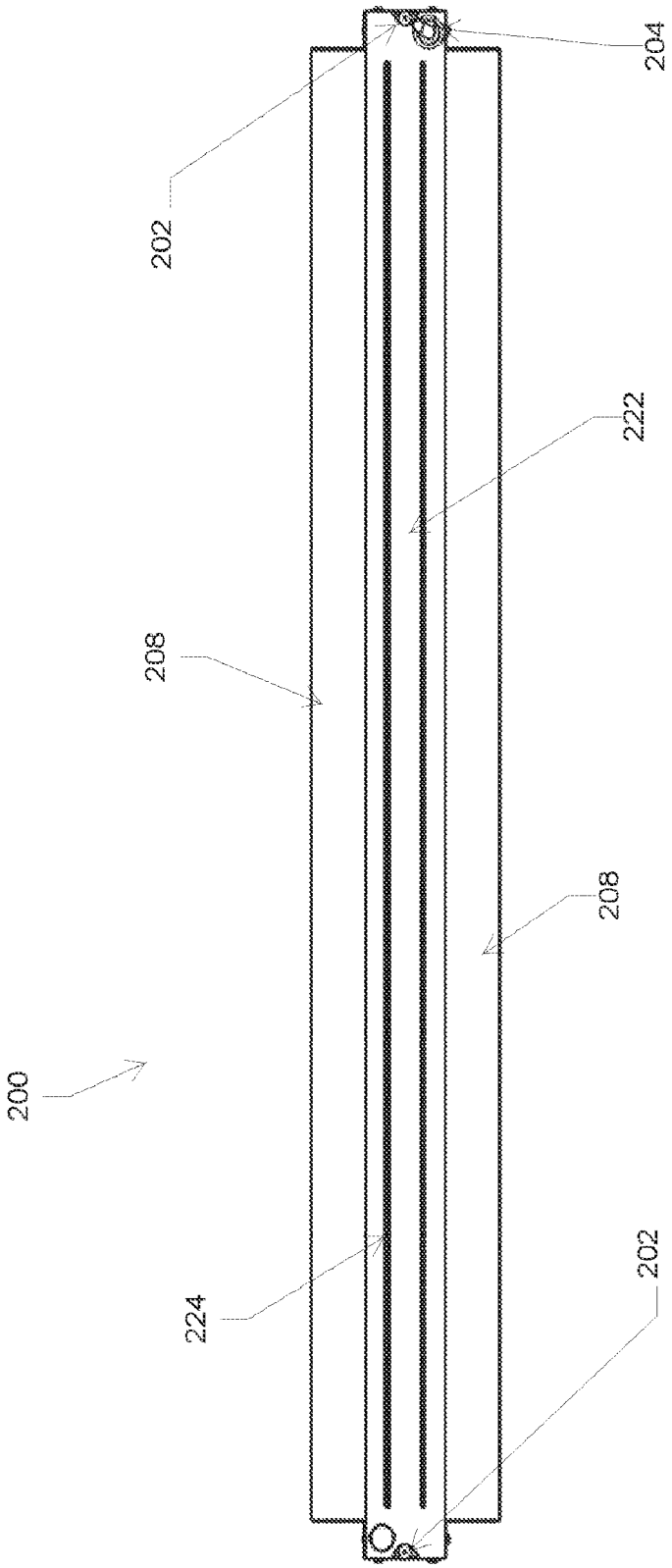


FIG. 13

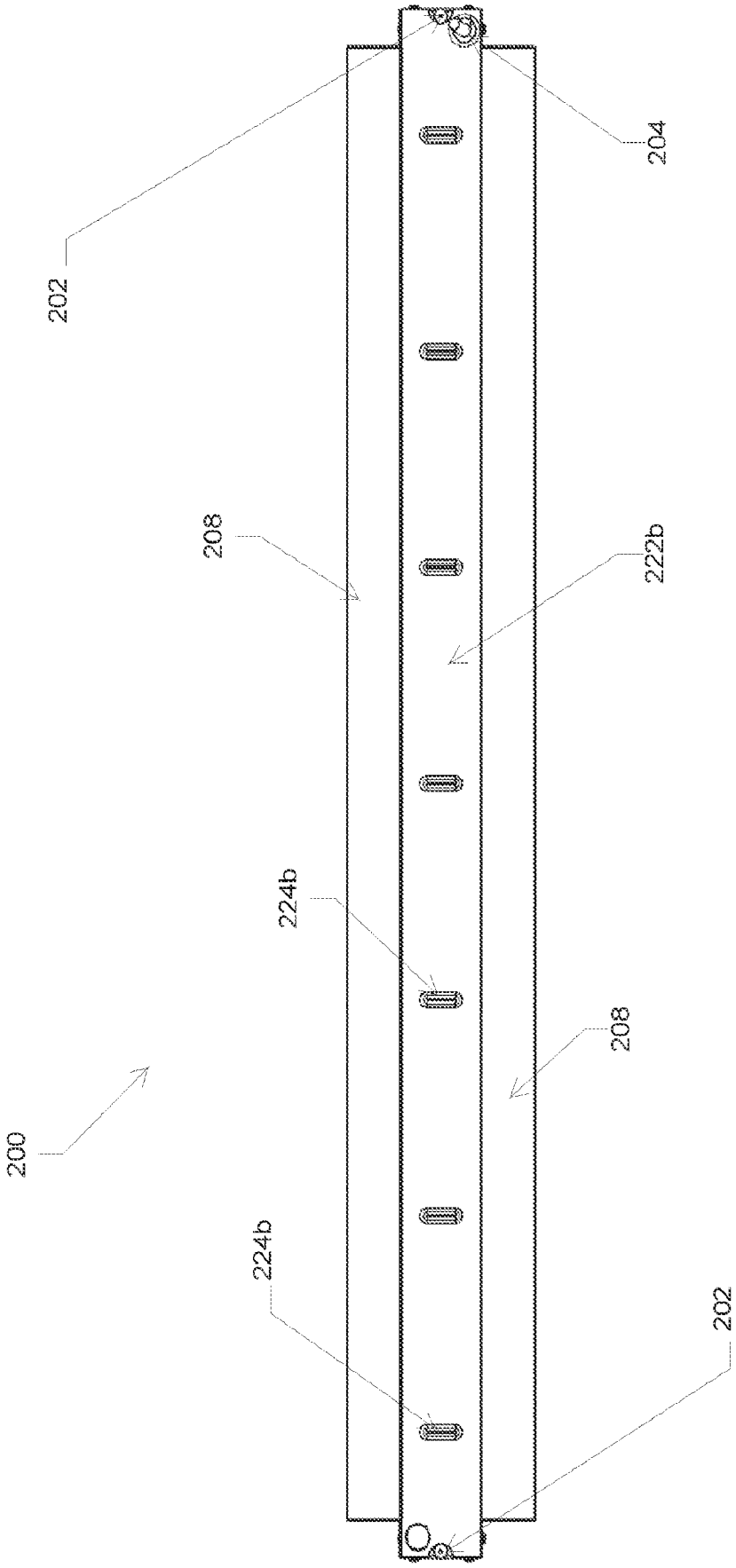


FIG. 13B

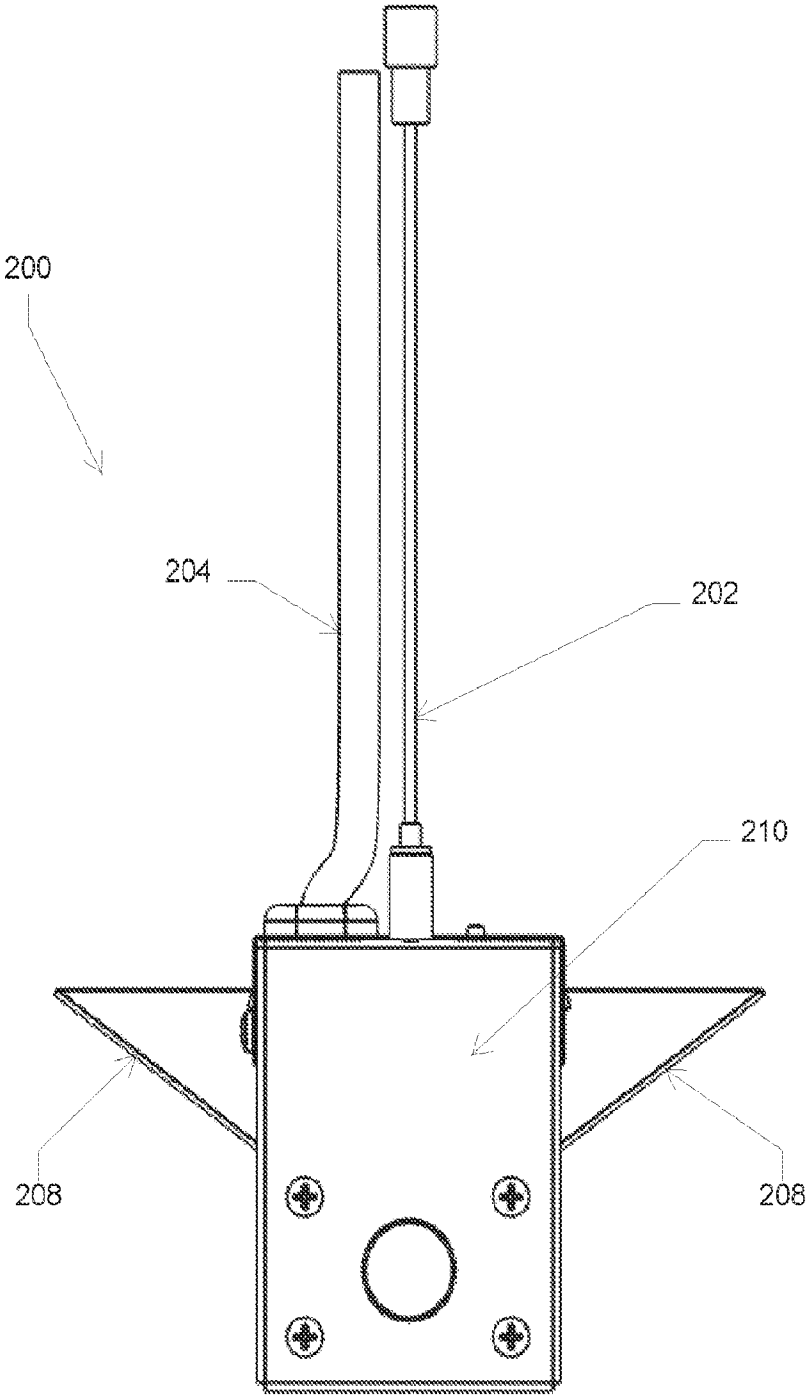


FIG. 14

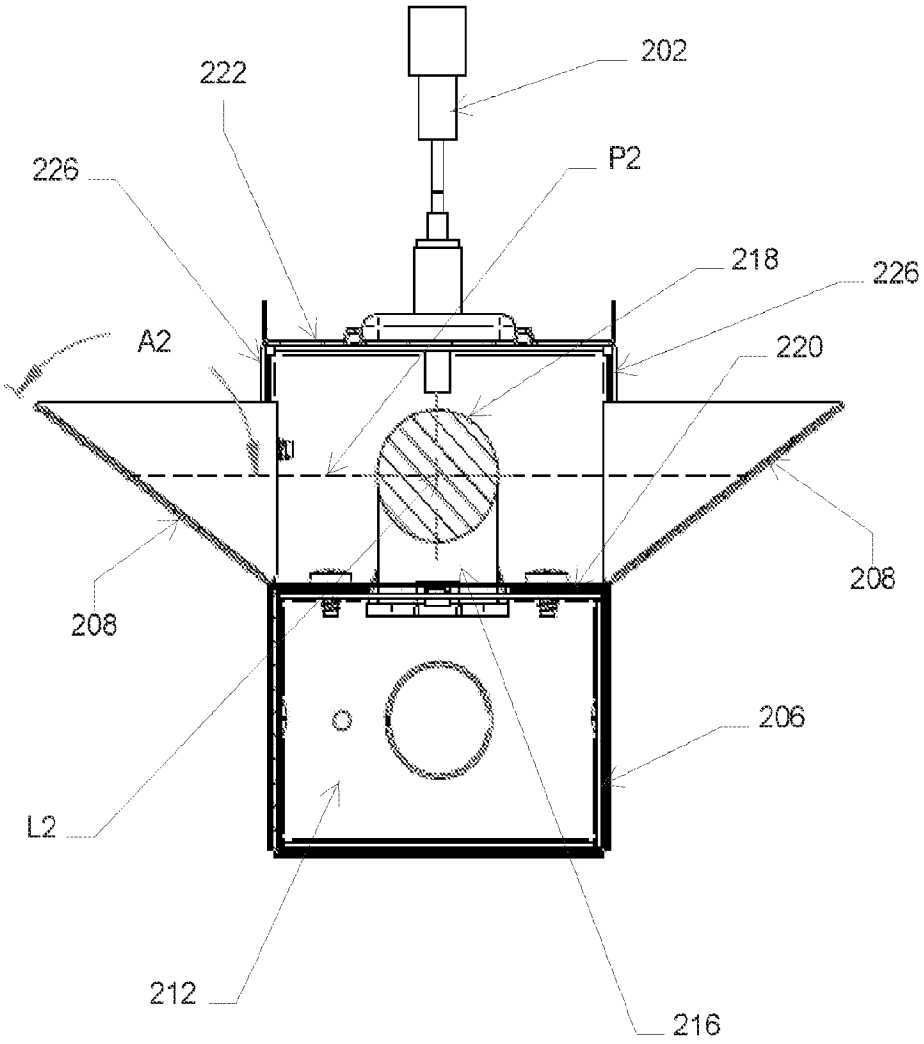


FIG. 15

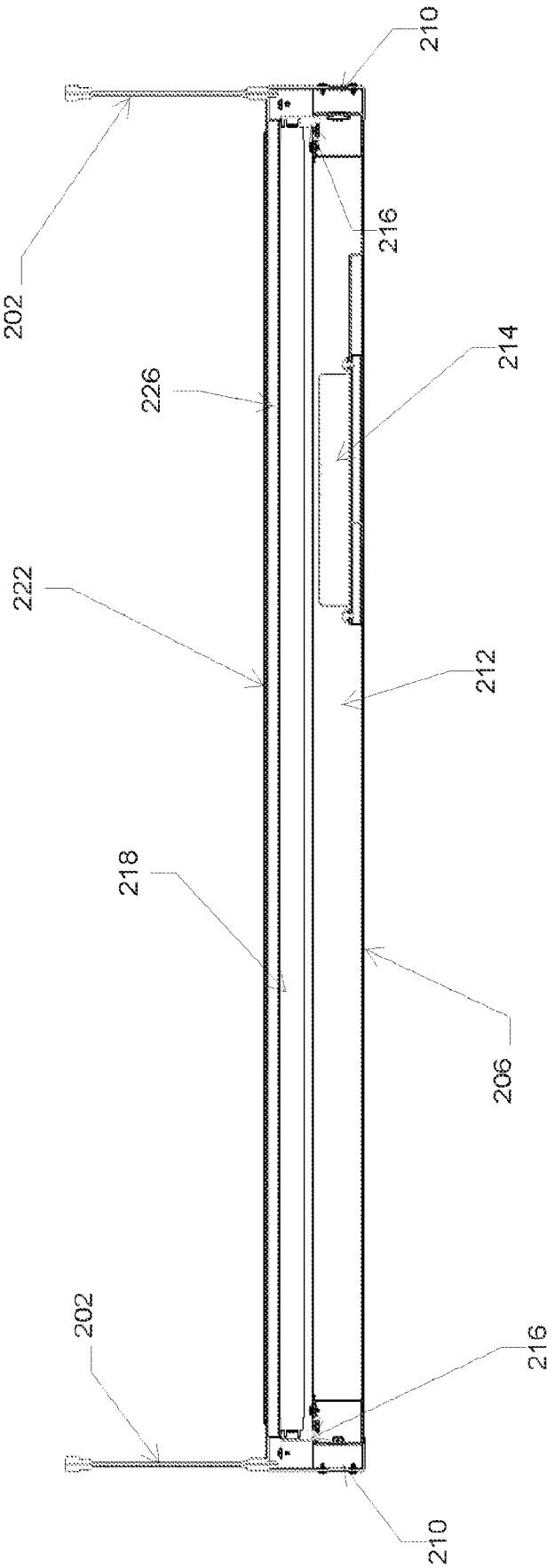


FIG. 16

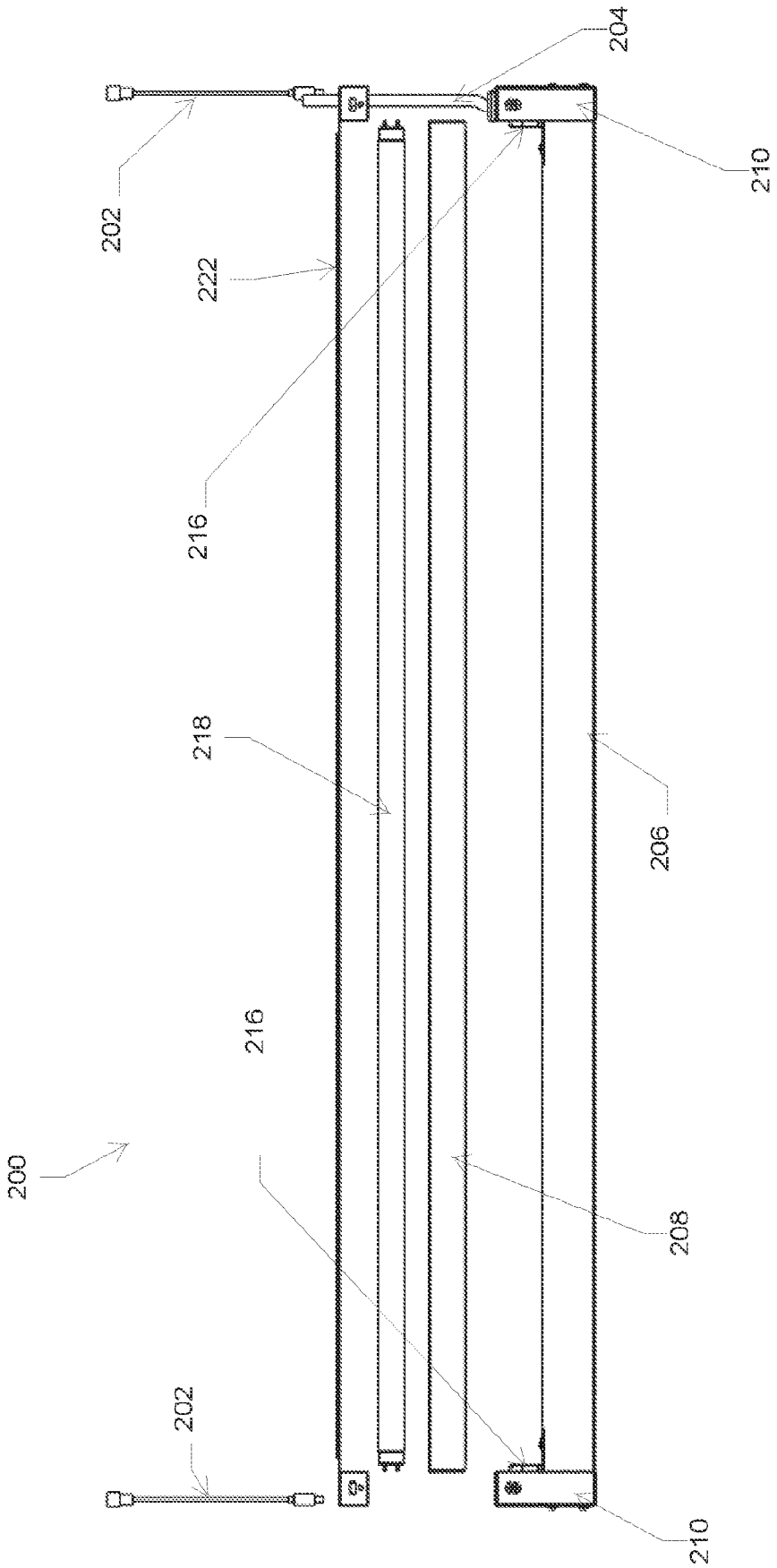


FIG. 17

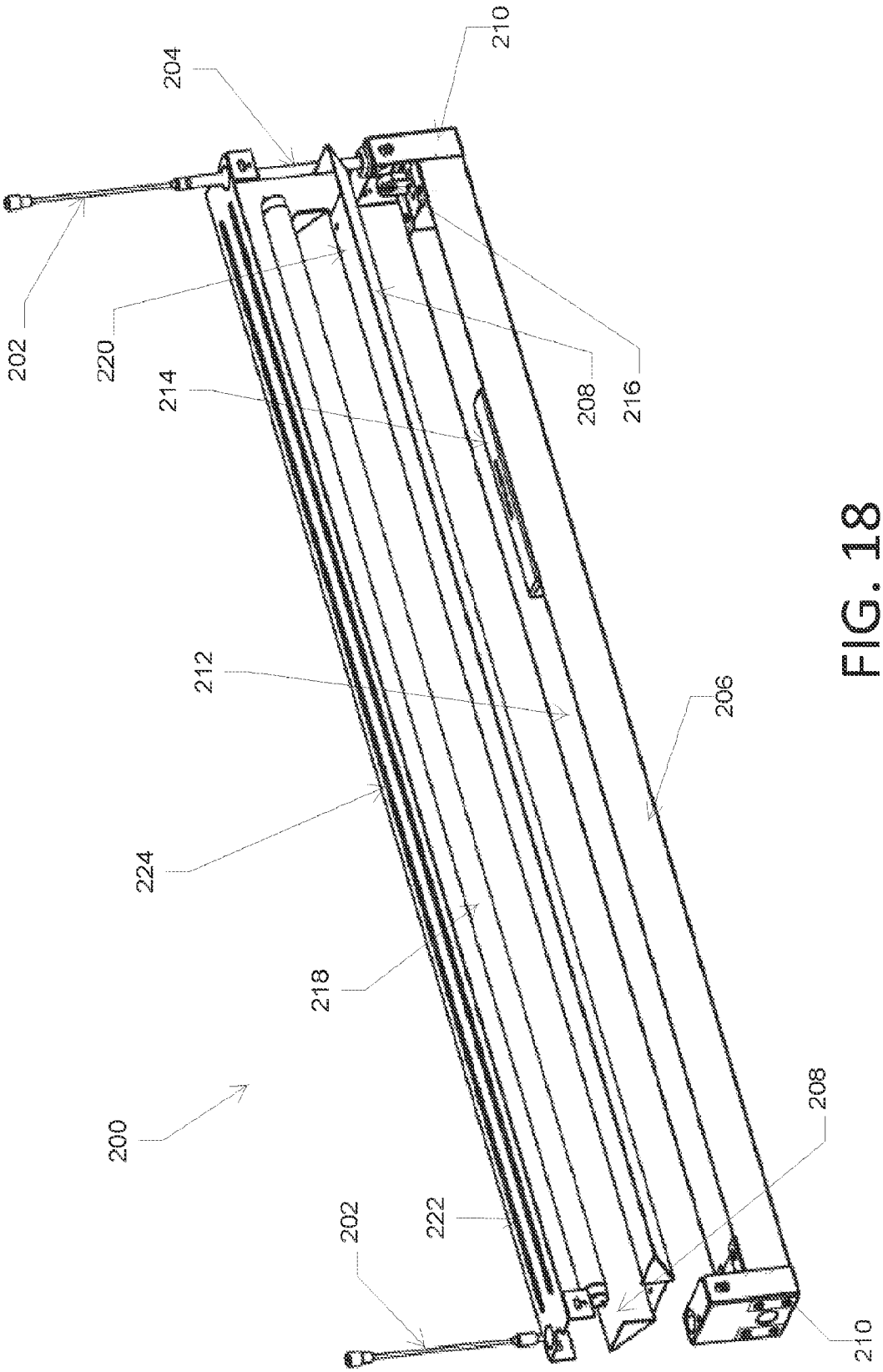


FIG. 18

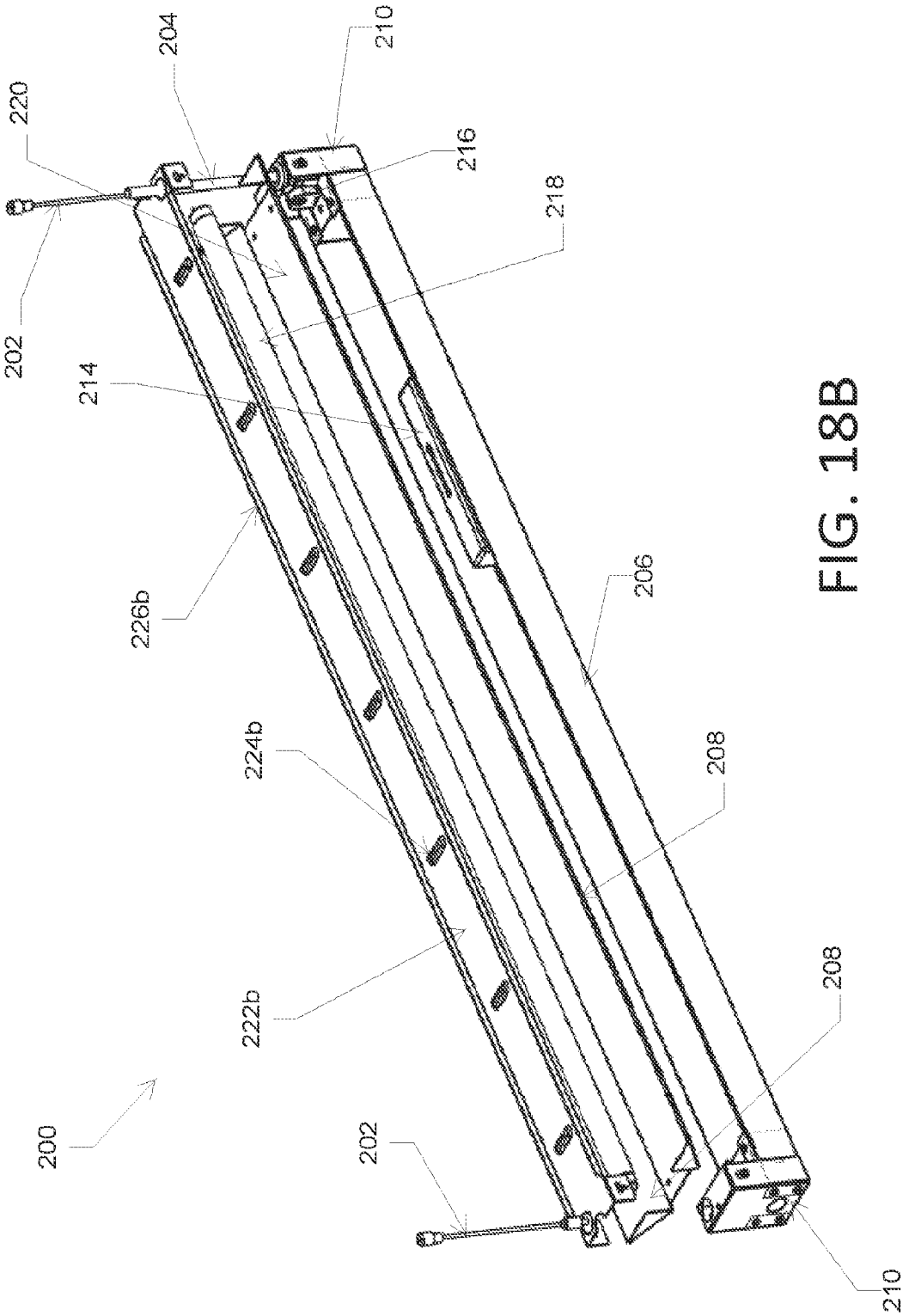


FIG. 18B

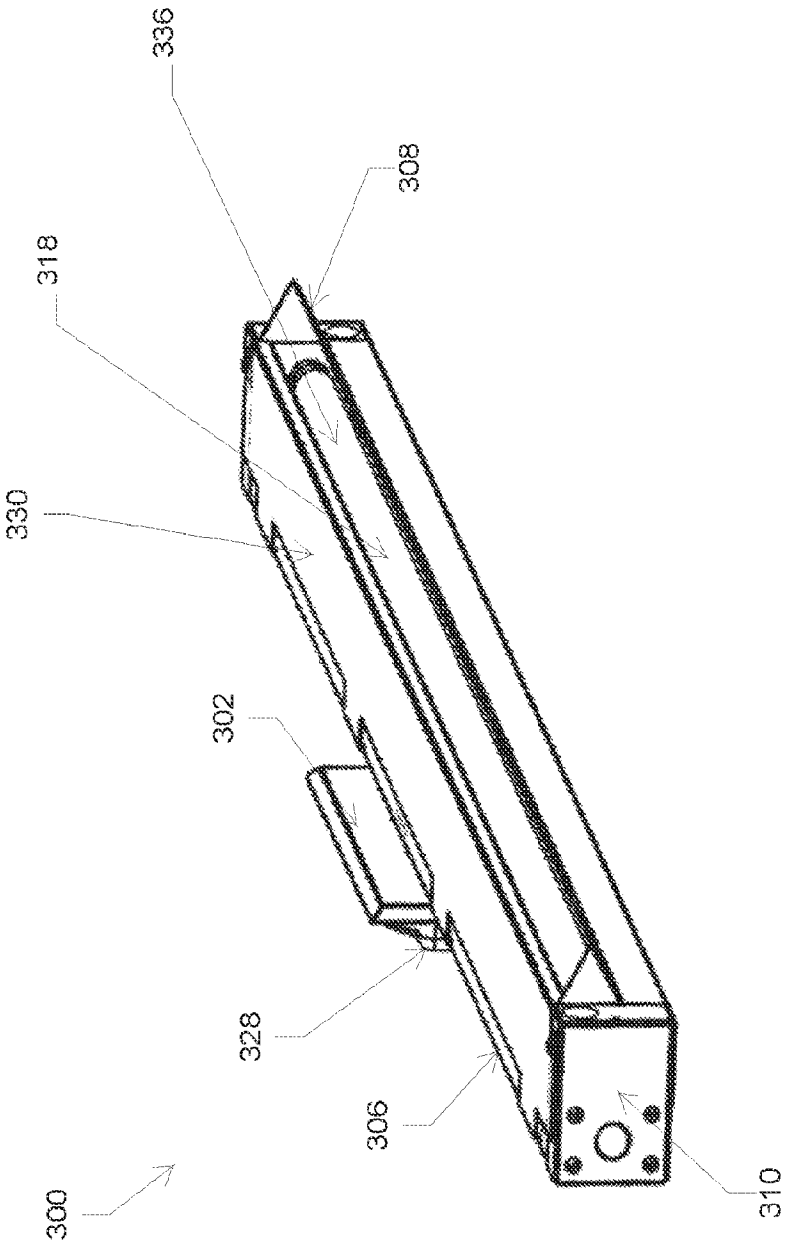


FIG. 19

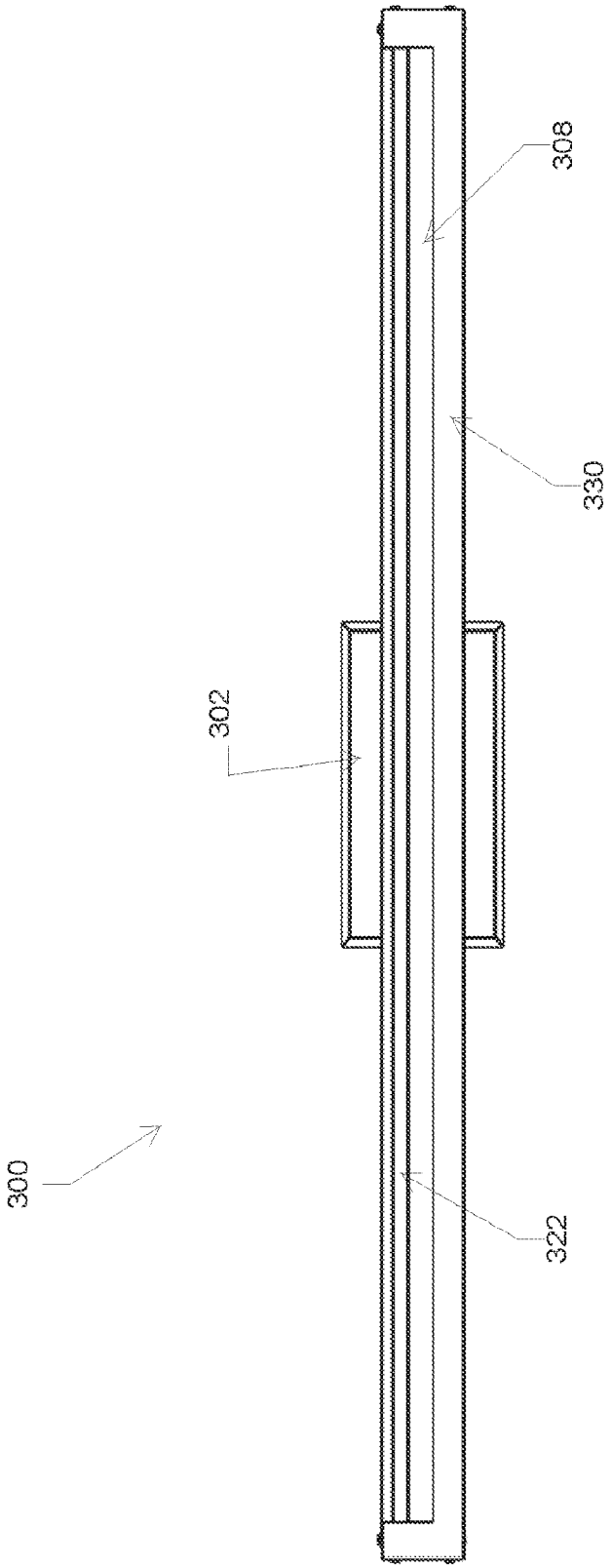


FIG. 20

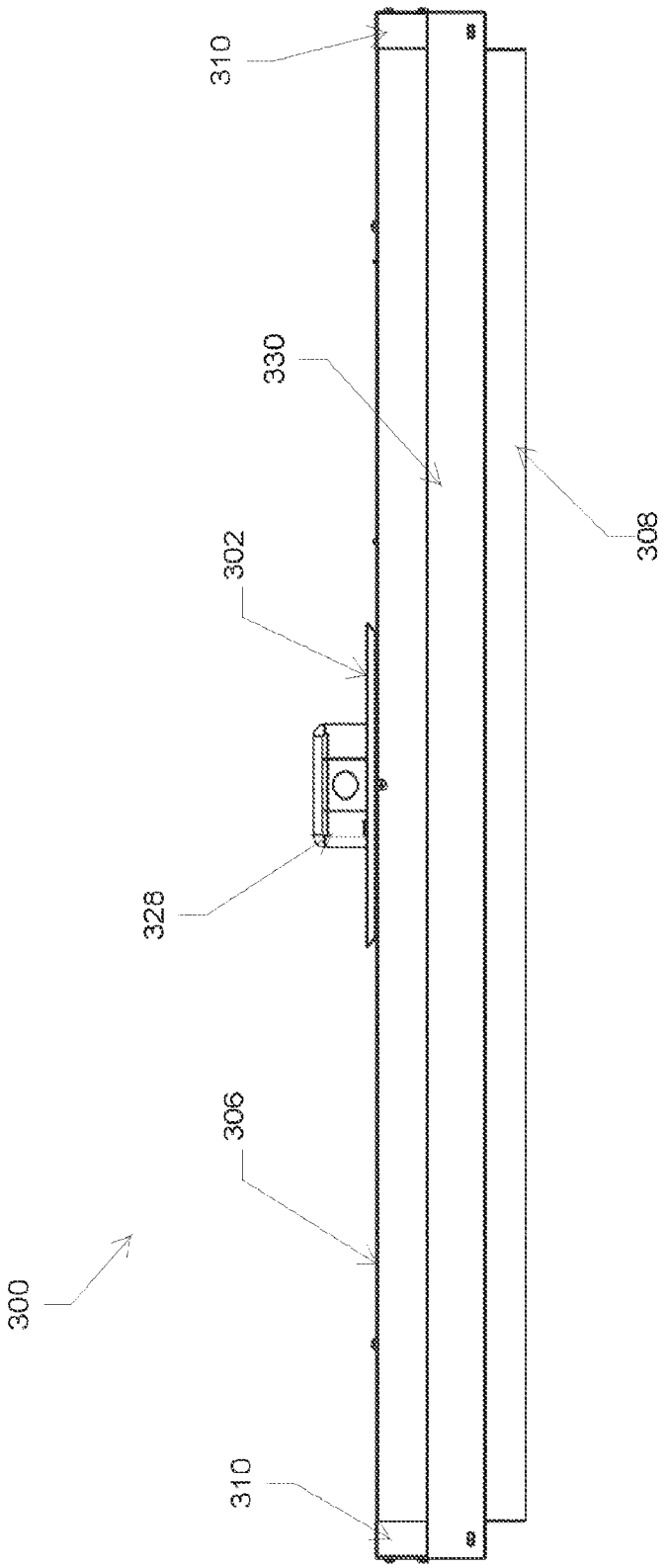


FIG. 21

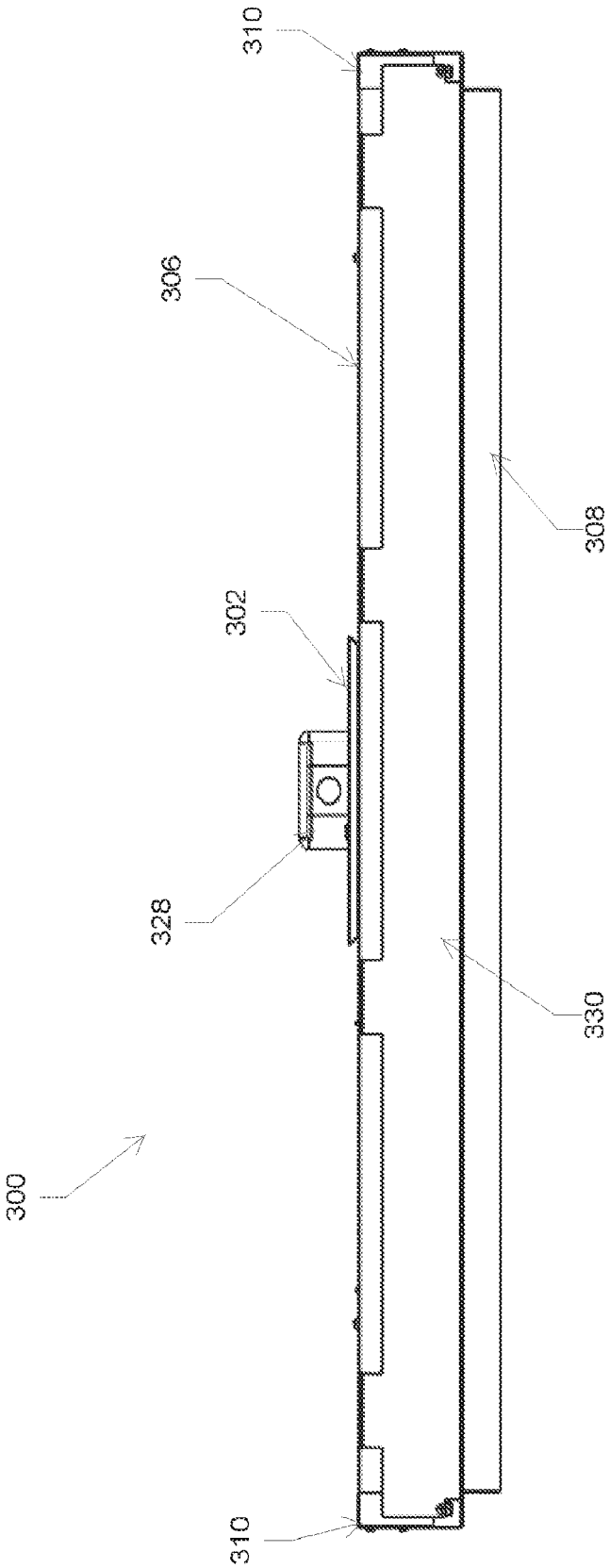


FIG. 22

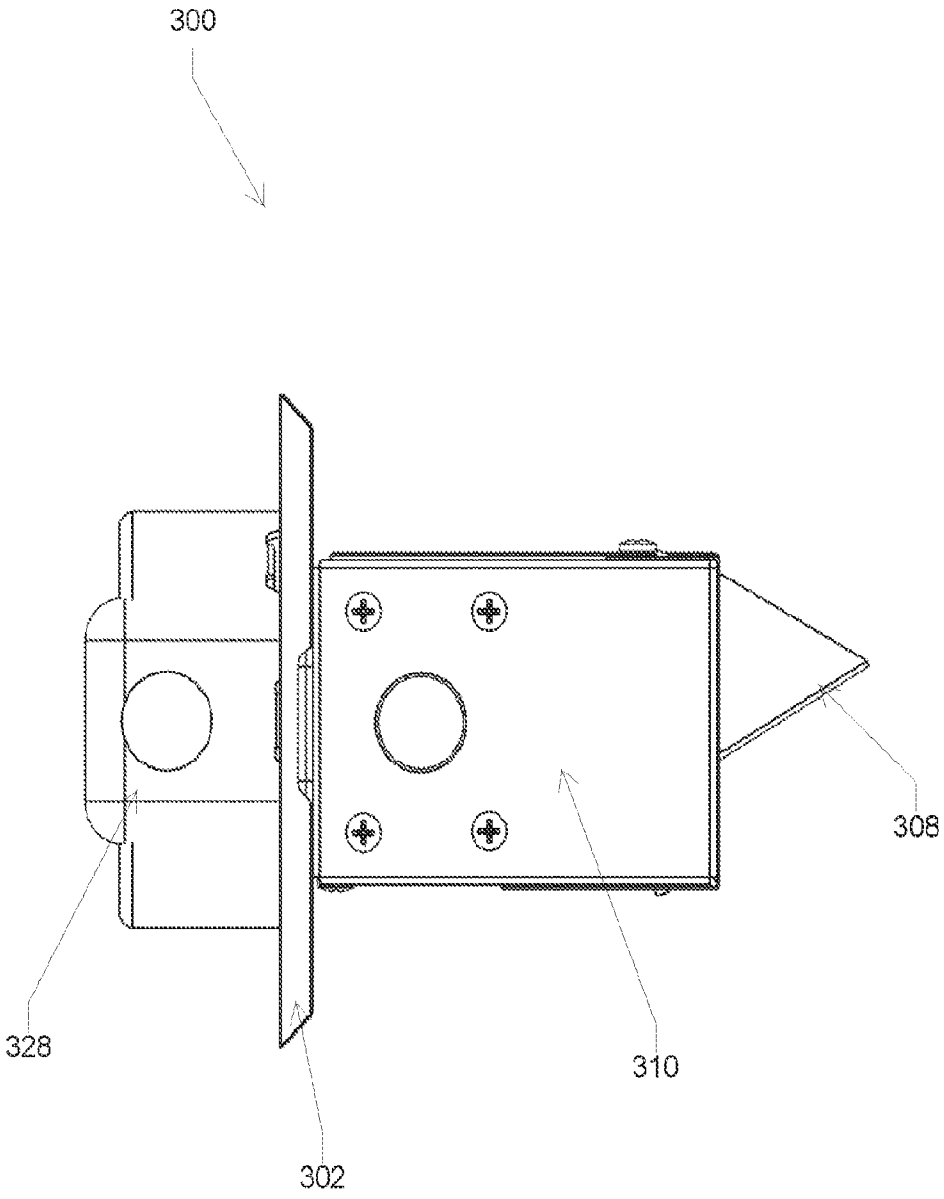


FIG. 23

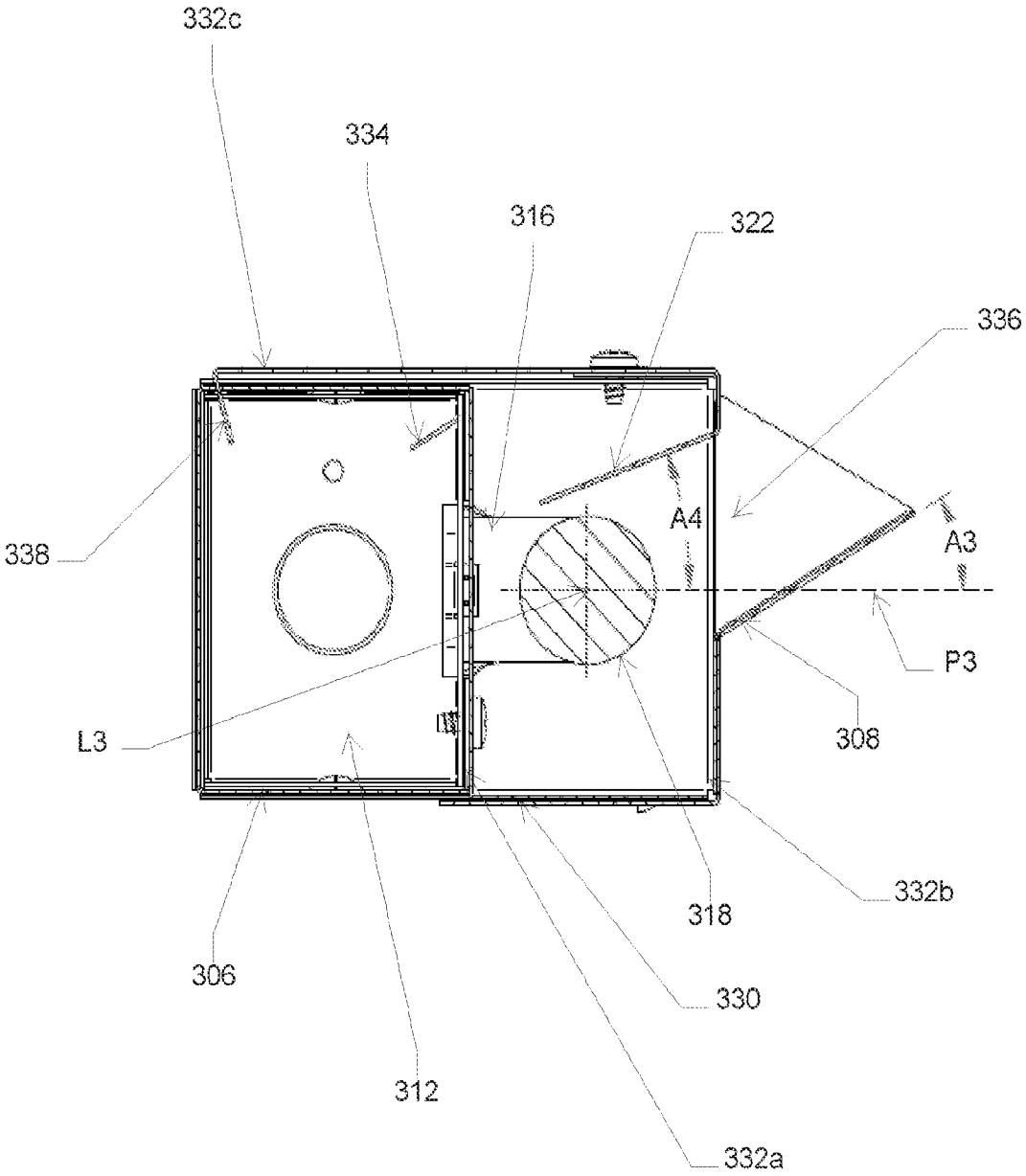

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FIG. 24

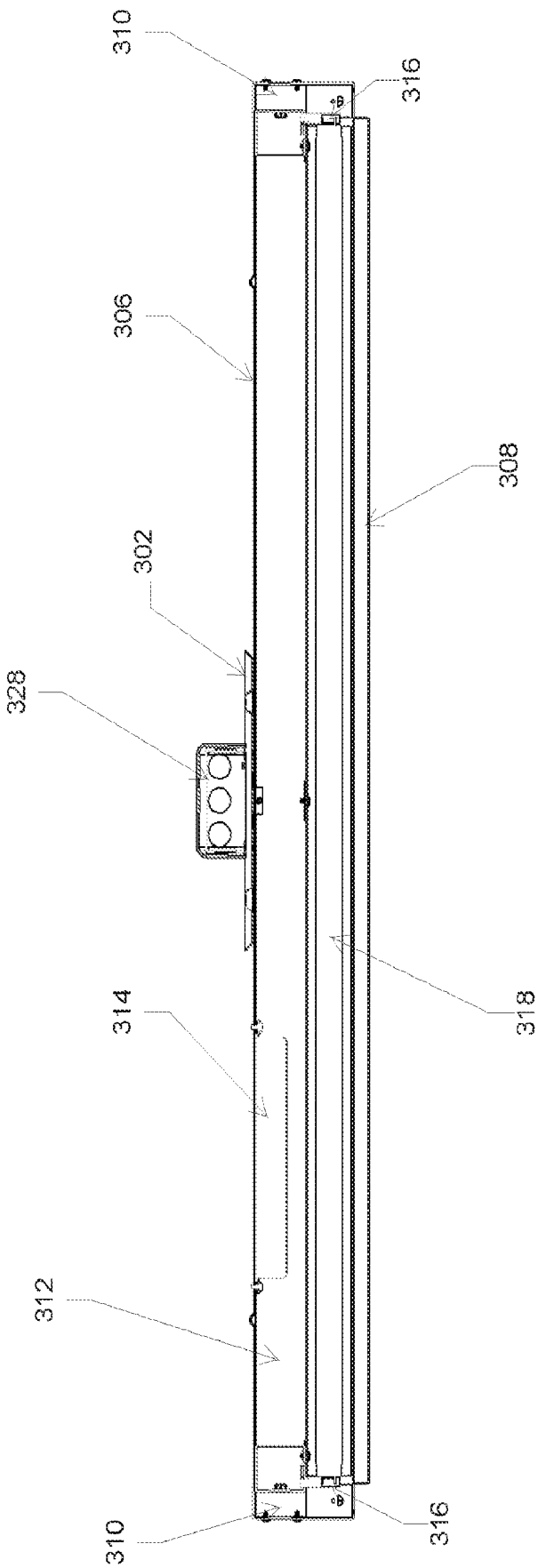


FIG. 25

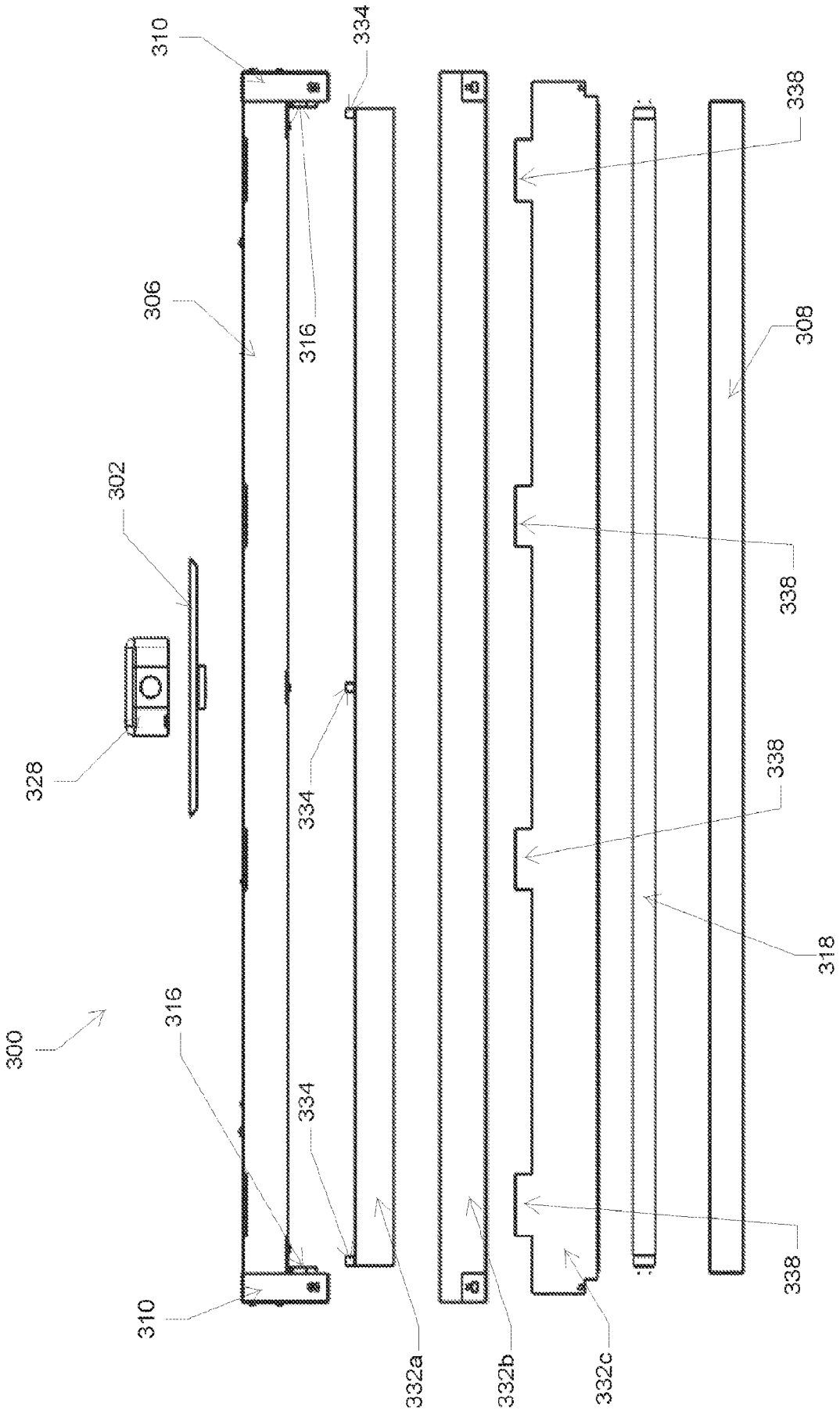

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FIG. 26

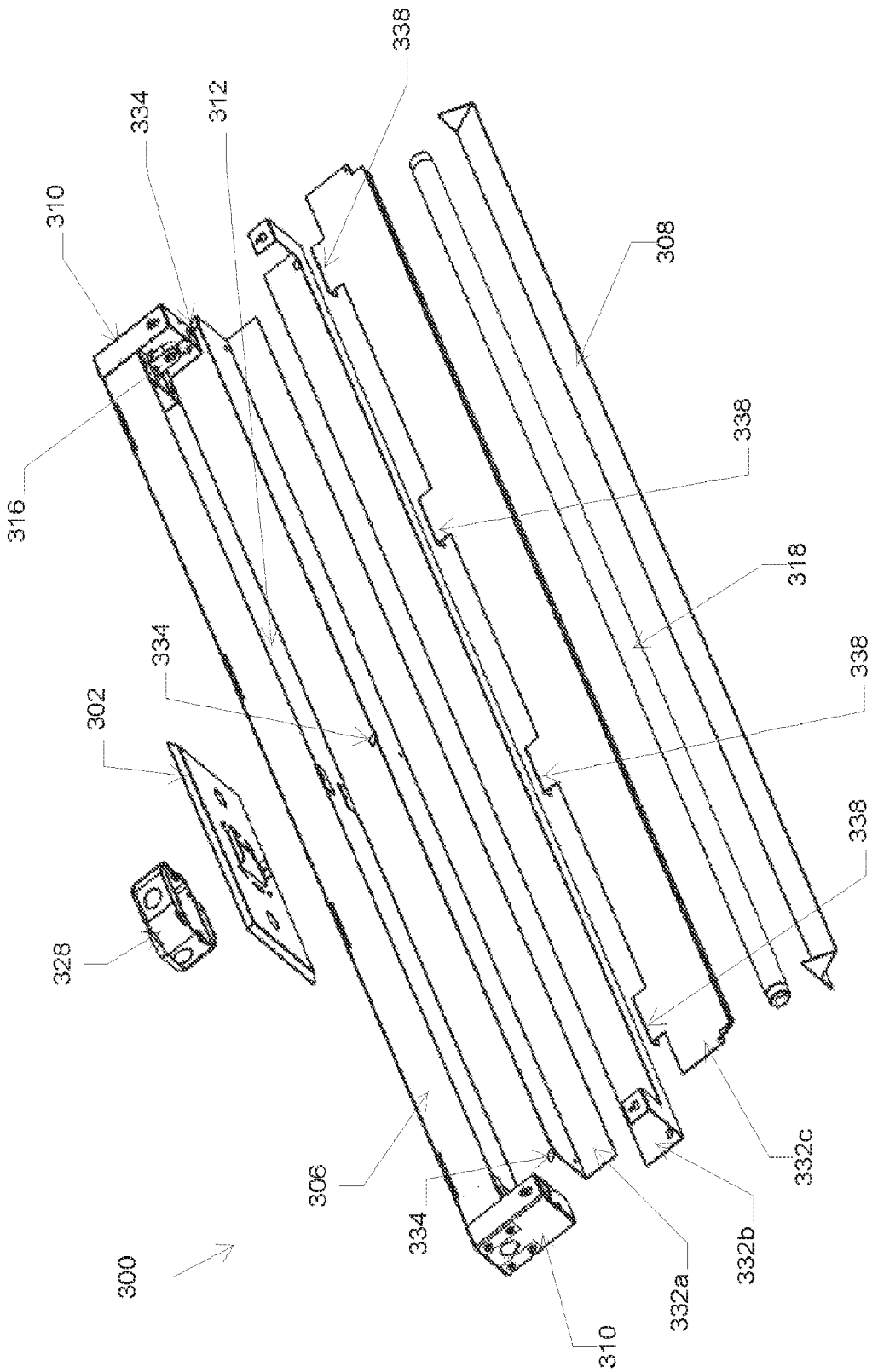

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FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/59475

A. CLASSIFICATION OF SUBJECT MATTER
IPC - A61L 9/20, A61L 2/10 (2022.01)
CPC - A61L 9/20, A61L 2/10, A61N 5/0624, F21V 7/005, F21Y 2103/00

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 2016/0175475 A1 (Elevated Health System, LLC), 23 June 2016 (23.06.2016), entire document, especially Fig. 1-9; para [0028]-[0035].	1, 5-22 ---------- 2-4
Y	US 2013/0115131 A1 (Hegg et al.), 9 May 2013 (09.05.2013), entire document, especially Fig. 1-4; para [0026].	2-4
A	US 2014/0084185 A1 (Palmer et al.), 27 May 2014 (27.05.2014), entire document.	1-22
A	US 6,457,846 B2 (Cook et al.), 1 October 2002 (01.10.2002), entire document.	1-22

☐ 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
5 January 2022	FEB 03 2022
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 Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300