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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 January 2021 (14.01.2021)

WIPO | PCT

(10) International Publication Number
WO 2021/007014 A1

(51) International Patent Classification:
H02G 3/32 (2006.01) *F16L 3/13* (2006.01)
H02G 3/04 (2006.01)

(21) International Application Number:
PCT/US2020/038587

(22) International Filing Date:
19 June 2020 (19.06.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/871,993 09 July 2019 (09.07.2019) US

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(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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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, 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))*

(54) Title: SHROUD FOR CABLE HANGERS

(57) Abstract: The present disclosure is directed to a shroud for a cable hanger which may isolate the metal interfaces between cable hangers and their supporting structures. The present disclosure is also directed to an interference mechanism of the shroud which may minimize or eliminate accidental escape of the hanger from a supporting structure.

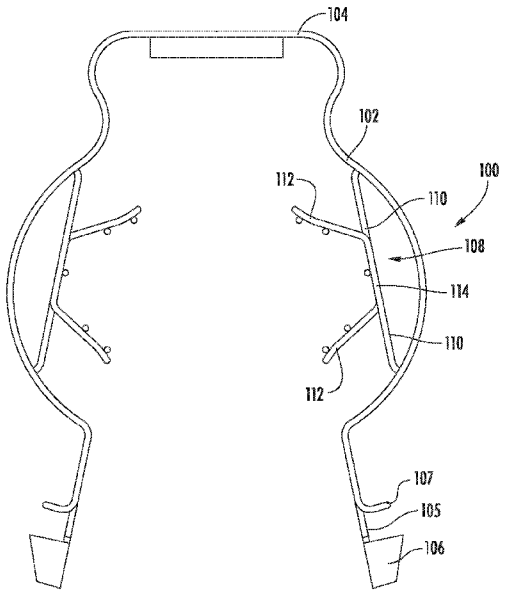

FIG. 1

WO 2021/007014 A1

SHROUD FOR CABLE HANGERS

Related Application

[0001] This application claims priority from and the benefit of U.S. Provisional Patent Application No. 62/871,993, filed July 9, 2019, the disclosure of which is hereby incorporated herein by reference in its entirety.

Field of the Invention

[0002] The invention relates generally to devices for supporting cables and, in particular, to shrouds for covering hangers used for securing cables to support structures.

Background of the Invention

[0003] Cable hangers are commonly used to secure cables to structural members of antenna towers and/or along tunnel walls. Generally, each cable is attached to a structural member by cable hangers mounted at periodically-spaced attachment points.

[0004] One popular cable hanger is discussed in U.S. Patent No. 8,191,836 to Korczak, the disclosure of which is hereby incorporated herein in its entirety. Hangers disclosed therein have generally a U- or C-shaped profile with rounded arms. A locking projection extends from the free end of each arm, and the "root" of the hanger that spans the fixed ends of the arms has a large aperture. The hanger can hold a cable between the arms; gripping of the cable is enhanced by short fingers that extend inwardly from the arms to engage the cable. Hangers can be "stacked" onto each other by inserting the locking projections of one hanger into the large aperture of the next hanger. One variety of cable hanger of this type is the SNAP-STAK®

hanger, available from CommScope, Inc. (Joliet, Illinois). The SNAP-STAK® hanger is offered in multiple sizes that correspond to the outer diameters of different cables.

[0005] Passive intermodulation (PIM) is a form of signal interference which degrades the performance of electrical systems, especially communications systems. PIM may be generated, for example, by poor contacts in the signal path. In general, however, any nonlinearity introduced into the signal path can contribute to PIM. For example, components external to the signal path but present within the electrical fields generated by the signal transmission may be coupled with the signal path and introduce undesirable nonlinearities leading to PIM generation.

[0006] Areas near cellular antennas (i.e., within 1λ, or one wavelength) can be (relatively) high radio frequency (RF) energy environments. Conductive items in these areas, such as hangers and other hardware, can generate undesirable PIM. Typical examples of potential PIM-generating conditions include the combination of metal-on-metal (e.g., steel-on-steel) contact between two or more components, plus low contact pressure and/or relative movement between the steel components at the joint.

[0007] In particular, PIM is exacerbated in metal joints which have low or inconsistent clamping pressure, such as when the joints experience relative motion. In some environments, cable hangers are subjected to harsh external forces, including wind, rain, and snow. Such forces cause the hangers to experience time-varying loads which may rock the hangers back and forth, which may even lead to hanger failure. In addition to generating PIM within metal-on-metal joints of the hangers, the rocking motion of the cables themselves may lead to variable contact pressure within the cables' connectors, directly injecting PIM into the signal path.

[0008] As such, it may be desirable to provide solutions for hanging cables with reduced (or eliminated) likelihood of PIM generation.

Summary

[0009] As a first aspect, embodiments of the invention are directed to a shroud for a cable hanger which generally secures a cable to a supporting structure. In one embodiment, the shroud comprises a body, and the body has an outward surface and an inward surface. The outward surface includes an outward receiving surface, and the inward surface includes an interference

feature, which comprises a projection. The inward surface optionally includes an inward receiving surface.

[0010] As a second aspect, embodiments of the invention are directed to a cable hanger. The cable hanger comprises a base panel. The cable hanger also comprises a first arm and a second arm, each of which has a proximal end and a distal end (the proximal end being attached to the base panel). The distal ends of each of the first and second arms comprise first locking projections and second locking projections, respectively, which are configured to be inserted into an aperture of a structure. The first locking projections comprise a first contact surface, and the second locking projections comprise a second contact surface. A first shroud is disposed along the first contact surface of the hanger, and a second shroud is disposed along the second contact surface of the hanger. Further embodiments of the invention are directed to methods for the production, assembly, and use of cable hangers described herein.

[0011] As a third aspect, embodiments of the invention are directed to a method for producing a cable hanger shroud comprising the step of configuring a shroud to electrically isolate the cable hanger from a structure. The cable hanger is generally configured to attach to an aperture of the structure where the cable hanger and the aperture are substantially metallic. Further embodiments of the invention are directed to methods for the production, assembly, and use of cable hangers described herein.

Brief Description of the Figures

[0012] **FIG. 1** is a side view of an exemplary cable hanger.

[0013] **FIG. 2** is a side view of an exemplary cable hanger installation.

[0014] **FIG. 3** is a front perspective view of one embodiment of a shroud attached to a cable hanger of **FIG. 1**.

[0015] **FIG. 4** is a front perspective view of the shroud of **FIG. 3**.

[0016] **FIG. 5** is a front view of the shroud of **FIG. 3**.

[0017] **FIG. 6** is a rear perspective view of the shroud of **FIG. 3**.

[0018] **FIG. 7** is a partial rear perspective view of the shroud of **FIG. 3** attached to a cable hanger of **FIG. 1**.

[0019] **FIG. 8** shows schematic side and section views of one embodiment of a first shroud of **FIG. 3** interacting with a second shroud of **FIG. 3**. The shrouds are shown in a detached condition prior to passing through an aperture in a structure.

[0020] **FIG. 9** shows schematic side and section views of the first and second shrouds of **FIG. 8**. The shrouds are shown in an engaged condition while passing through an aperture in a structure.

[0021] **FIG. 10** shows schematic side and section views of the first and second shrouds of **FIG. 8**. The shrouds are shown in a detached condition while engaging an aperture in a structure.

[0022] **FIG. 11** is a schematic side view of the first and second shrouds of **FIG. 8**. The shrouds are shown interfering with each other as the hanger deforms in reaction to an applied load while engaging with an aperture in a structure.

[0023] **FIG. 12** is a schematic side view of the shrouds of **FIG. 11**. The shrouds are shown interfering with each other as the hanger deforms under an oppositely applied load.

[0024] **FIG. 13** is a schematic side view of a first shroud interacting with a second shroud according to additional embodiments of the invention, wherein the shrouds are shown in a detached condition.

[0025] **FIG. 14** is a front perspective view of another embodiment of a shroud of the present invention.

[0026] **FIG. 15** is a schematic side view of the first and second shrouds of **FIG. 14** interacting, wherein the shrouds are shown inserting into each other while passing through an aperture in a structure.

[0027] **FIG. 16** is a schematic side view of the shrouds of **FIG. 15**. The shrouds are shown interfering with each other while engaging with an aperture in a structure.

[0028] **FIG. 17** is a schematic side view of the shrouds of **FIG. 15**. The shrouds are shown interfering with each other while engaging with an aperture in a structure.

[0029] **FIG. 18** shows side and enlarged views of an alternative embodiment of a shroud attached to a cable hanger.

[0030] **FIG. 19** shows side and enlarged views of an additional embodiment of a shroud attached to a cable hanger.

[0031] **FIG. 20** shows side and enlarged views of a further embodiment of a shroud attached to a cable hanger.

Detailed Description

[0032] The present invention is described with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments that are pictured and described herein; rather, these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art. It will also be appreciated that the embodiments disclosed herein can be combined in any way and/or combination to provide many additional embodiments.

[0033] Unless otherwise defined, all technical and scientific terms that are used in this disclosure have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The terminology used in the below description is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used in this disclosure, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that when an element (e.g., a device, circuit, etc.) is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0034] Referring now to the figures, a cable hanger, designated broadly at **100**, is shown in **FIG. 1**. The hanger **100** includes curved arms **102** that extend from a generally flat base **104**.

Locking projections **106** extend from the free ends (i.e., the distal ends) of the arms **102**. Locking tabs **107** may also extend from the arms **102** at positions typically spaced apart from and proximal to the locking projections **106**. In some embodiments, the hanger **100** also contains a gripping mechanism **108**. The gripping mechanism **108** employs two adjacent cantilevered tabs **110** extending from the interior surface of the arm **102**. The cantilevered tabs **110** may terminate in grip pads **112** and may optionally be joined together by a joint **114**. When cables are inserted into the hanger **100**, the gripping mechanism **108** accepts the cables within the cantilevered tabs **110** and grip pads **112** to secure and center the cables within the hanger **100**. Various embodiments of the gripping mechanism **108** may be provided, as discussed in U.S. Patent No. 9,866,004 to Vaccaro, the disclosure of which is hereby incorporated herein in its entirety.

[0035] As can be seen in **FIG. 2**, a cable hanger installation **200** is formed when the locking projections **106** are inserted through an optionally reinforced hole or aperture **204** to mate the hanger **100** to a structure **202** (e.g., a tower structure). The base **104** of the hanger **100** may optionally include a second reinforced hole **204** that can receive the locking projections **106** of another hanger **100** to mount a second cable or group of cables. The locking tabs **107** and the locking projections **106** cooperatively form a receiving surface **105** which contacts, grips, cradles, and/or captures the reinforced hole **204**, thereby forming one embodiment of a contact surface on the distal end of the arms **102**. Once attached, the arms **102** together generally define a circle within which a cable can be grasped, as may be aided by a gripping mechanism **108**.

[0036] Those skilled in this art will appreciate that the cable hangers **100** discussed above are typically formed of a metallic material, such as steel, and may be formed as a unitary member (often from a flat blank stamped from sheet steel and bent into a desired shape). Also, it will be apparent to those of skill in this art that the cable hangers **100** can be arranged in a "stacked" relationship by inserting the locking projections **106** of one cable hanger **100** into a mounting hole **204** in the base **104** of a second cable hanger **100** in the manner described above with respect to the solitary cable hanger **100** in **FIG. 2**. The second cable hanger **100** may be identical to or different from the first cable hanger **100** as needed for hanging the cable in question. Thus, as used herein, the structure **202** may refer to either a different structure (e.g., a tower) or another hanger **100**.

[0037] The foregoing demonstrates one type of metal-on-metal joint in an exemplary cable hanger installation **200**: the receiving surface **105**, bounded by the locking tabs **107** and the locking projections **106**, forms the contact surface between the hanger **100** and the structure **202**. The metal-on-metal contact is susceptible to generating PIM, especially when exposed to high energy RF fields.

[0038] In one embodiment of the present invention, a shroud may be placed over the contact surfaces of the hanger **100** to minimize and/or eliminate metal-on-metal contact with the structure **202**. For instance, **FIG. 3** depicts a shroud **300** placed over a contact surface of a hanger **100**. The shroud **300** has a body; the outward surface **302** of the body is visible in **FIG. 3**. The locking tabs **107** are enclosed in locking tab covers **307**, while the locking projections **106** are covered by the locking projection covers **306**. As seen in **FIG. 4**, the locking tabs **107** are received by an inward receiving surface **309**. The locking projections **106** may optionally reside within indexing slots **310**. The indexing slots **310** may serve to align the shroud **300** into the proper orientation and location for attachment to the hanger **100**. A locking feature, such as a snap feature **308**, may mate with the hanger **100** to secure the shroud **300** to the hanger **100**, as shown in **FIG. 3**.

[0039] The receiving surface **105** of the hanger **100** is typically covered by the receiving surface **305** of the shroud **300**, completing coverage of the contact surfaces on the distal end of one arm **102** of the hanger **100**. The formation of the shroud receiving surface **305** in one embodiment is more directly pictured in **FIG. 5**. The lower surfaces of the locking tab covers **307** form the upper boundary of the shroud receiving surface **305** while the upper surfaces of the locking projection covers **306** form the lower boundary. Similarly, the locking tab covers **307** enclose an inward receiving surface **309** on the inward surface **303**. The lower boundary of the shroud receiving surface **305**, formed by the locking tab covers **307**, is adjacent to the upper boundary of the shroud receiving surface **305**. In one embodiment, the receiving surface which receives the locking tabs **107** from the hanger **100** (i.e., the inward receiving surface **309**) and the receiving surface which covers the distal contact surfaces of the arm **102** (i.e., the outward receiving surface **305**) share a boundary formed by the locking tab covers **307**. In one embodiment, a similar shroud **300** may be placed on the second arm **102** of the hanger **100**; if the hanger **100** were inserted into a hole **204**, as in **FIG. 2**, the pair of shrouds **300** would isolate the

hanger **100** from the structure, the shroud **300** itself providing the mating surface with the structure **202**. As the shrouds **300** are typically formed with a nonmetallic material (such as a ceramic or polymeric material), at least within the shroud receiving surface **305**, the shrouds **300** may minimize or even eliminate metal-on-metal contact within the installation **200** and provide electrical isolation therebetween, thereby reducing or eliminating the possibility of the generation of PIM.

[0040] Generally, the material selected for the outward receiving surface **305** will be nonmetallic, although it is contemplated that some portions of the shroud **300** might comprise metallic materials (e.g., as a filler to increase abrasion resistance or for reinforcement or spring-like functionality in localized portions, such as within the body or within the locking feature **308**). In some embodiments, however, the shroud **300** will be substantially or completely formed from a nonmetallic material, such as a dielectric material. Exemplary materials for the shroud **300** include ceramics and polymeric materials, including those optionally reinforced or filled (e.g., with fibers, beads, or particles) or unfilled. In some embodiments, the shroud **300** is formed of polymeric materials such as acetal, polyethylene, polypropylene, PVC, or the like. For instance, rubber or rubberized polymers may be used to increase the security and/or grip strength of the connection between the hanger **100** and the structure **202** or to damp and/or provide isolation from structural vibrations. Where a particular dielectric effect is desired, the thickness of the shroud may be adjusted to achieve the effect (e.g., insulative or capacitive).

[0041] Although some embodiments generally conform to the geometry of the underlying hanger **100**, other embodiments may depart from the geometry of the hanger **100**. For instance, the locking tab covers **307** may form bifurcated inward receiving surfaces **309** on the inward surface **303**, which individually cover the locking tabs **107** of the hanger **100** (as shown in **FIG. 6**) while having a portion of the shroud body disposed therebetween. In some embodiments, the locking tab covers **307** may form an inward receiving surface **309** running the width of the shroud **300** along its inward surface **303**. Alternatively, or additionally, the locking projection covers **306** may form a contiguous shelf running along at least some portion of the shroud **300** instead of the discrete and localized covers **306**. Likewise, any means of locking feature **308** may be employed, whether a snap, hook, clip, or the like; it is contemplated that

chemical adhesives, including thermoplastic or thermoset adhesives, may substitute for or supplement a mechanical locking feature **308**.

[0042] In some embodiments, the shroud **300** may be manufactured directly onto the hanger **100**. For instance, the hanger **100** may be dipped into a thermoplastic or thermoset polymer in a molten state, after which the polymer hardens and forms a shroud **300** intimately bonded and conforming to the hanger **100**. Similarly, the shroud **300** may be formed by spraying a material onto the hanger **100**, or by casting or molding a material around the hanger **100**. In some embodiments, the shroud **300** may cover only a portion or the entirety of the hanger **100**. In other embodiments, the shroud **300** may be manufactured separately (e.g., by injection molding or additive manufacturing) and subsequently attached to the hanger **100**. For instance, a shroud **300** may be manufactured in a single step with a single material, or may optionally have various materials molded to or otherwise deposited on other portions (e.g., applying a rubberized material to the outward receiving surface **305** while forming the locking projection covers **306** or locking feature **308** to contain a more rigid material or combination of materials).

[0043] In some embodiments, the shroud **300** may improve the grip between the hanger **100** and the structure **202** in an installation **200**, advantageously improving the stability of the cable mounting. The security of the connection between the hanger **100** and the structure **202** in an installation **200** may also be improved by a mechanical interference mechanism. In one embodiment, the interference mechanism employs at least one projection on the shroud **300**. **FIG. 6** shows the inward surface **303** of a shroud **300**. In the pictured embodiment, the shroud **300** contains two projections extending from the inward surface **303** of the shroud **300**: a first projection **312** and a second projection **314**. The second projection **314** contains a cavity **315**. **FIG. 7** demonstrates how the projections **312** and **314** may extend into the area between the arms **102** of the hanger **100** when the shroud **300** is installed.

[0044] In one configuration, two substantially identical shrouds **300** are arranged in a substantially opposing orientation as shown in **FIG. 8**, as they would typically be if they were attached to opposing arms **102** of a hanger **100**. Each shroud **300** has a first projection **312** and a second projection **314**, within which lies a cavity **315**. In general, the cavity **315** may be sized so that the projection **312** of one shroud **300** may suitably slide into the cavity **315** of the other

shroud **300**. The length of the projections **312** and **314** may be measured normal to the inward surface **303**. The width of the projections **312** and **314** (and the cavity **315**) may be measured parallel to the receiving surface **305** (generally into the page as shown in the schematic side view of **FIG. 8**). The height of the projections **312** and **314** (and the depth of the cavity **315**) may be measured in a direction perpendicular to the length and the width. If the length, width, and height of the first projection **312** are smaller than the depth, width, and height, respectively, of the cavity **315** of the second projection **314**, then the projection **312** of the first shroud **300** will typically fit within the cavity **315** of the second shroud **300**.

[0045] When two shrouds **300** are installed on a hanger **100**, the projections **312** and **314** on each may interact as the arms **102** of the hanger **100** are pinched or squeezed together for installation. For example, in **FIG. 8**, the projections **312** and the cavities **315** are aligned substantially or entirely in the direction or along the path that the arms **102** of the hanger **100** travel during installation, and, if the dimensions are appropriately selected, the projections **312** will typically insert into the opposite projections **314**—as shown in **FIG. 9**—as projections **312** are received into the cavities **315**. For clarity, only one projection **312** and one cavity **315** are shown in the schematic side view. The collapse of the shrouds **300** together generally permits the locking projections **106**, optionally partially or completely enclosed in locking projection covers **306** as shown, to fit through an aperture **204** of a structure **202**. Once the locking projections **106** are inserted through the aperture **204**, the arms **102** may be released, permitting the locking projections **107** to engage with the structure **202** via the rim of the aperture **204**, as shown in **FIG. 10**.

[0046] After installation, the hanger **100** may deflect or shift under operational and/or environmental loads (e.g., wind). The interaction of the projections **312** and **314** may be configured to vary depending on the load condition. For instance, in contrast to the substantially symmetric force applied to both arms **102** during installation, various environmental loads (e.g., from rain, snow, wind, cable inertia, wildlife, etc.) will be applied asymmetrically during operation, and the hanger **100** will experience torque and the arms **102** will not deform or pinch together in a symmetric fashion. For example, **FIG. 11** depicts a cable hanger experiencing a transverse load **902** (e.g., from wind) applied near and substantially parallel to the base panel **104** of the hanger **100**. Because the hanger **100** is restrained within the hanger assembly **200** by the

asymmetric reaction forces **908** and **906** exerted by the structure **202** on the hanger **100**, a net moment **904** is induced within the cable hanger **100**, deforming the hanger **100**. In some cases, the deformation may cause one arm **102** to rotate and be forced away from the structure **202** while the other arm **102** also rotates and is forced toward the structure **202**. In this manner, the projections **312** and **314** may fall out of alignment, depending on the load condition.

[0047] While the foregoing offers one example of a scenario in which the projections **312** and **314** fall out of alignment, the misalignment of the shrouds **300** may arise any time the hanger **100** experiences asymmetric loading and the arms **102** deform in an asymmetric fashion. **FIGS. 11** and **12** depict exemplary scenarios in which the projections **312** are not in alignment with the cavities **315**. When misaligned, the projections **312** and the cavities **315** do not insert together; the projections **312** are not received in the cavities **315**. Instead, they interfere with the opposing shroud **300**, typically abutting along an interference surface **316**. In a hanger installation **200**, as shown in **FIG. 2**, the interference of the shrouds **300** would advantageously prevent or impede the collapse of the arms **102** together, increasing the security of the connection of the hanger **100** within the reinforced hole **204** by preventing the locking projections **106** from escaping the aperture or hole **204**.

[0048] The above-described mechanism is but one example of how the interference mechanism may adaptively permit the installation of the hanger **100** onto a structure **202** (i.e., when arms **102** are intentionally pinched or squeezed) while preventing or impeding the accidental removal or escape of the hanger **100** from the structure **202** when it is not desired (i.e., when natural or artificial loads are experienced in operation). The nature of the interaction between the projections **312** and **314** of two opposing shrouds **300** may change depending on the geometry of the projections **312** and **314**. For instance, a projection is but one type of interference feature. A cavity may be an interference feature on its own. For example, the length of a second projection **314** may be very short. Alternatively, the second projection **314** may be substantially or entirely coincident with the inward surface **303** (i.e., having a length of zero units). **FIG. 13** depicts an embodiment of a shroud **400** in which a rim of the cavity **415** is on the inward surface **403**. Thus, as the shrouds **400** move together, the projection **412** may align and insert into the cavity **415** or may abut the inward surface **403**, and the inward surface

403 may form an interference surface **416** (such as to maintain the locking projection covers **406** and the locking tab covers **407** in a particular position).

[0049] In alternative embodiments, multiple interference features may comprise one or more projections, as in the embodiment of a shroud **500** shown in **FIG. 14**. The interference feature **512** may comprise two or more projections. When substantially identical shrouds **500** are opposed, they may adaptively align and misalign in the above-described manner, permitting the opposing interference features **512** and **514** to insert together and collapse, as in **FIG. 15** (such as to allow the locking projection covers **506** to fit within an aperture **204**), or misalign and interfere along an interference surface **516**, as in **FIGS. 16** and **17** (such as to prevent or impede the edge of the aperture **204** from escaping from between the locking projection covers **506** and the locking tab covers **507**).

[0050] While **FIGS. 3**–**17** generally depict receiving surfaces, e.g, receiving surfaces **305** and **309**, as forming an enclosure or channel for receiving an aperture **204** (of the structure **202**) or the locking tabs **107**, some embodiments may contain at least one open or partially open receiving surface. For example, **FIG. 18** depicts one embodiment of a shroud **600** adapted for a cable hanger **100'** which has locking projections **106'** but no locking tabs **107**. Thus, the shroud **600** is not adapted to engage with any locking tabs **107**: the shroud **600** has one outward receiving surface **605** for engaging with an aperture **204**. The outward receiving surface **605** is open, formed by a projection or shelf which may also include the locking projection cover **606**. Instead of enclosing the locking projections **106'**, the cover **606** may only abut the contact surface of the locking projections **106'**. When engaging with an aperture **204**, the aperture **204** will generally contact the outward receiving surface **605**, which cradles or otherwise captures the aperture **204** between the locking projection cover **606** and the outward surface **602**.

[0051] In an alternative embodiment, as shown in **FIG. 19**, a shroud **700** has an open inward receiving surface **709** which receives the locking tab **107** of a hanger **100**. The inward receiving surface **709** forms a ledge or flange which may also include the locking tab cover **707**. Instead of enclosing the locking tabs **107**, the cover **707** may only abut the locking tabs **107** and terminate along the outward surface **702**. When engaging with an aperture **204**, the aperture **204** will generally contact the outward receiving surface **705** (which may take the form of a channel,

as depicted), which cradles the aperture **204** between the locking projection cover **706** and the locking tab cover **707**. In an alternative embodiment, as shown in **FIG. 20**, the open inward receiving surface **809** of a shroud **800** has a lip or flange which forms an open channel which may receive and partially enclose the locking tab **107** within the locking tab cover **807**. Additionally, or alternatively, the locking projection cover **806** may have a similar lip or flange. The lips and/or flanges may, for example, engage with the locking projections **106** or the locking tabs **107** to index the shroud **800** on the hanger **100**. Any lips and/or flanges may also provide mistake-proofing functionality to aid installation of the shroud **800** onto the hanger **100**, such as by limiting the shroud **800** to fit onto the hanger **100** in only one orientation, or even to aid installation of the hanger **100** onto a structure **202** by providing a positive insertion depth stop or interfacing with other orientating features on the structure **202** or on a cable jacket. In other embodiments, the shrouds **800** are configured for universal fit in a number of orientations to permit quick and interchangeable installation.

[0052] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

That Which is Claimed is:

1. A shroud for a cable hanger, comprising a body, the body having an outward surface and an inward surface;

wherein the outward surface includes an outward receiving surface; and

wherein the inward surface includes a first interference feature, the first interference feature comprising a projection.

2. The shroud of Claim 1, wherein the inward surface includes an inward receiving surface.

3. The shroud of any of the preceding claims;

wherein the outward receiving surface has an upper boundary;

wherein the inward receiving surface has a lower boundary; and

wherein the upper boundary of the outward receiving surface is adjacent to the lower boundary of the inward receiving surface.

4. The shroud of any of the preceding claims, wherein the inward receiving surface contains a first inward receiving surface portion and a second inward receiving surface portion.

5. The shroud of any of the preceding claims, wherein the body comprises a locking feature, the locking feature being configured to mate with a cable hanger.

6. The shroud of Claim 5, wherein the locking feature comprises at least one feature selected from a hook, a snap, or a clip.

7. The shroud of any of the preceding claims, wherein the inward surface comprises a second interference feature.

8. The shroud of Claim 7,

wherein the first interference feature includes a projection, the projection having a length extending away from the inward surface, a width parallel to the inward receiving surface and perpendicular to the length, and a height perpendicular to the width of the projection and the length;

wherein the second interference feature includes a cavity, the cavity having a depth extending into the inward surface, a width parallel to the inward receiving surface and perpendicular to the depth, and a height perpendicular to the width of the cavity and the depth;

wherein the width of the cavity is greater than the width of the projection; and

wherein the height of the cavity is greater than the height of the projection.

9. The shroud of any of the preceding claims, wherein the outward receiving surface comprises a dielectric material.

10. The shroud of any of the preceding claims, wherein the shroud is configured to decrease passive intermodulation.

11. The shroud of any of the preceding claims, wherein the outward receiving surface comprises an indexing slot.

12. The shroud of any of the preceding claims, wherein the shroud is manufactured directly onto the cable hanger.

13. A cable hanger, comprising:

a base panel;

a first arm having a proximal end and a distal end, the proximal end being attached to the base panel, the distal end comprising first locking projections configured to be inserted into an aperture of a structure, the first locking projections comprising a first contact surface;

a second arm having a proximal end and a distal end, the proximal end being attached to the base panel, the distal end comprising second locking projections configured to be inserted into the aperture of the structure, the second locking projections comprising a second contact surface;

a first shroud disposed along the first contact surface; and

a second shroud disposed along the second contact surface.

14. The cable hanger of Claim 13, wherein the first shroud comprises an interface between the first contact surface and the structure, and wherein the second shroud comprises an interface between the second contact surface and the structure.

15. The cable hanger of Claim 13 or 14, wherein the first shroud electrically isolates the first contact surface from the structure, and wherein the second shroud electrically isolates the second contact surface from the structure.

16. The cable hanger of any of Claims 13–15,

wherein the first shroud comprises a first inward surface and a first outward surface, the first inward surface having a first interference feature disposed thereon, the first inward surface being adjacent to the first contact surface, the first outward surface being configured to mate with the aperture of the structure; and

wherein the second shroud comprises a second inward surface and a second outward surface, the second inward surface having a second interference feature disposed thereon, the second inward surface being adjacent to the second contact surface, the second outward surface being configured to mate with the aperture of the structure.

17. The cable hanger of Claim 16,

wherein the first interference feature and the second interference feature are configured to assume a first aligned position when a load applied to the first shroud is approximately symmetric to a load applied to the second shroud, and

wherein the first interference feature and the second interference feature are configured to assume a second misaligned position when a load applied to the first shroud is asymmetric to a load applied to the second shroud.

18. The cable hanger of Claim 17,

wherein the first interference feature is configured to insert into the second interference feature in the first aligned position; and

wherein the first interference feature is configured to interfere with the second interference feature in the second misaligned position.

19. The cable hanger of Claim 16, 17, or 18,

wherein the first interference feature includes a projection, the projection having a length extending away from the inward surface, a width parallel to the inward receiving surface and perpendicular to the length, and a height perpendicular to the width of the projection and the length;

wherein the second interference feature includes a cavity, the cavity having a depth extending into the inward surface, a width parallel to the inward receiving surface and perpendicular to the depth, and a height perpendicular to the width of the cavity and the depth;

wherein the width of the cavity is greater than the width of the projection; and

wherein the height of the cavity is greater than the height of the projection.

20. The cable hanger of any of Claims 16–19, wherein the first interference feature includes a projection and the second interference feature includes a projection.

21. The cable hanger of any of Claims 13–20, wherein the first shroud is configured to be substantially identical to the second shroud.

22. The cable hanger of any of Claims 13–21, wherein the first shroud comprises at least two interference features and the second shroud comprises at least two interference features.

23. The cable hanger of any of Claims 13–22, wherein the first shroud abuts the first locking projections and the second shroud abuts the second locking projections.

24. The cable hanger of any of Claims 13–23, wherein the first shroud encloses the first locking projections and the second shroud encloses the second locking projections.

25. The cable hanger of any of Claims 13–24, wherein the first shroud abuts the first locking tabs and the second shroud abuts the second locking tabs.

26. The cable hanger of any of Claims 13–25, wherein the first shroud encloses the first locking tabs and the second shroud encloses the second locking tabs.

27. The cable hanger of any of Claims 13–26, wherein at least one of the first shroud and the second shroud is chemically adhered to the cable hanger.

28. The cable hanger of any of Claims 13–27, wherein at least one of the first shroud and the second shroud is mechanically secured to the cable hanger.

29. The cable hanger of any of Claims 13–28, wherein at least one of the first shroud and the second shroud comprises a dielectric material.

30. The cable hanger of any of Claims 13–29, wherein at least one of the first shroud and the second shroud is composed of a dielectric material.

31. The cable hanger of any of Claims 13–30, wherein at least one of the first shroud and the second shroud is manufactured directly onto the cable hanger.

32. The cable hanger of any of Claims 13–31, wherein at least one of the first shroud and the second shroud is manufactured by coating the hanger with a material which subsequently hardens.

33. A method for hanging a cable comprising the step of attaching the cable hanger of any of Claims 13–32 to a structure.

34. A method for hanging a cable comprising the step of pinching the arms of the cable hanger of any of Claims 17–32 together while the first shroud and the second shroud are in the first aligned position.

35. A method for assembling a cable hanger comprising the step of attaching a shroud of any of Claims 1–12 to a cable hanger.

36. The method of Claim 35, wherein the shroud is formed upon attachment to the hanger, the shroud being formed by coating a material onto the hanger.

37. A method for producing the cable hanger of any of Claims 13–32 comprising a step selected from:

attaching at least one of the first shroud and the second shroud onto a cable hanger;

molding at least one of the first shroud and the second shroud onto a cable hanger; and

dipping a cable hanger into a material which subsequently hardens to form at least one of the first shroud and the second shroud.

38. The method of Claim 36 or 37, wherein the material comprises a polymer.

39. A method for decreasing passive intermodulation in an electrical circuit comprising the step of hanging an electrical cable in a cable hanger, the cable hanger comprising the shroud of any of Claims 1–12.

40. A method for producing a cable hanger shroud, comprising the step of:

configuring a shroud to electrically isolate the cable hanger from a structure, the cable hanger being configured to attach to an aperture of the structure, the cable hanger and the aperture being substantially metallic.

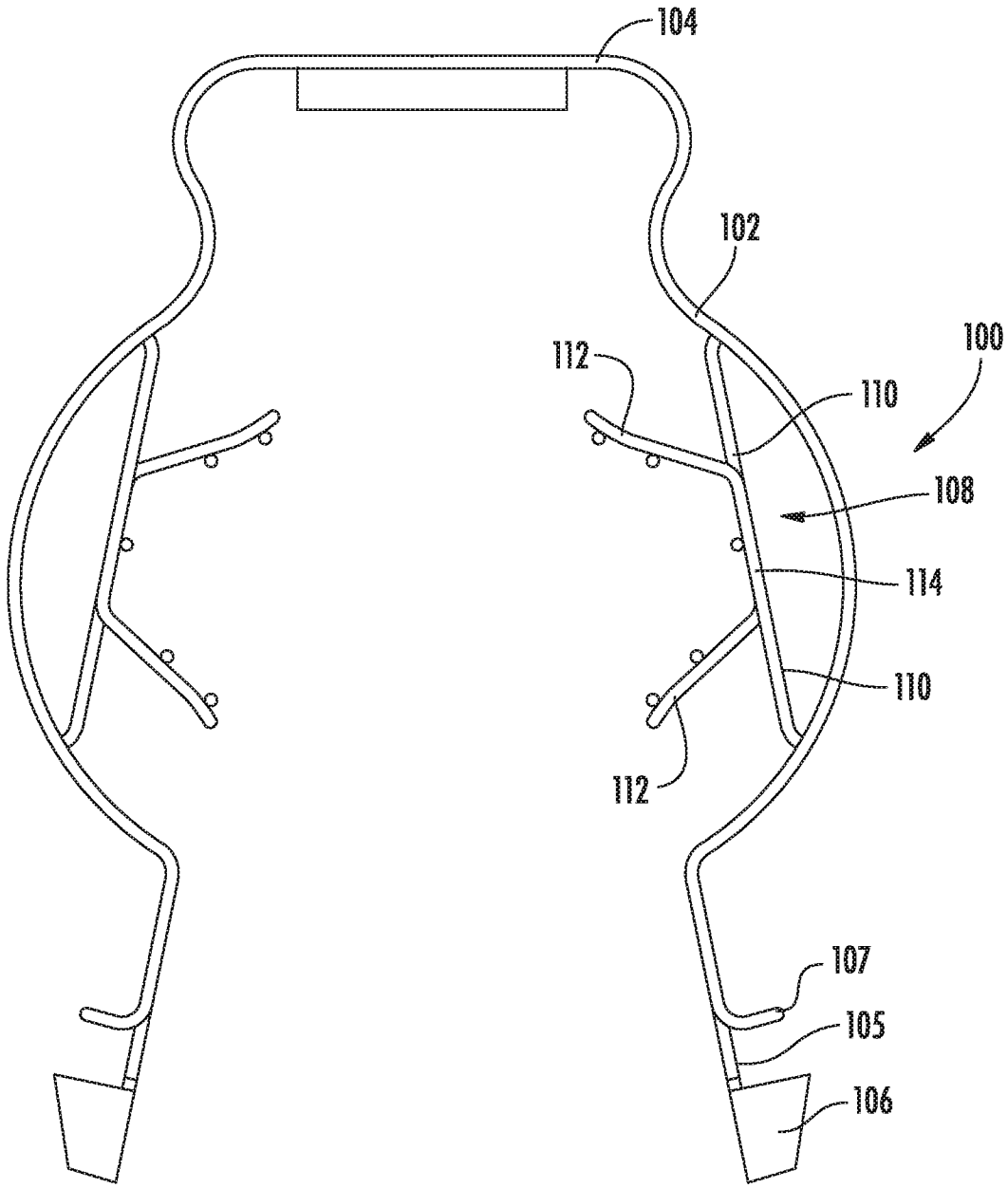

FIG. 1

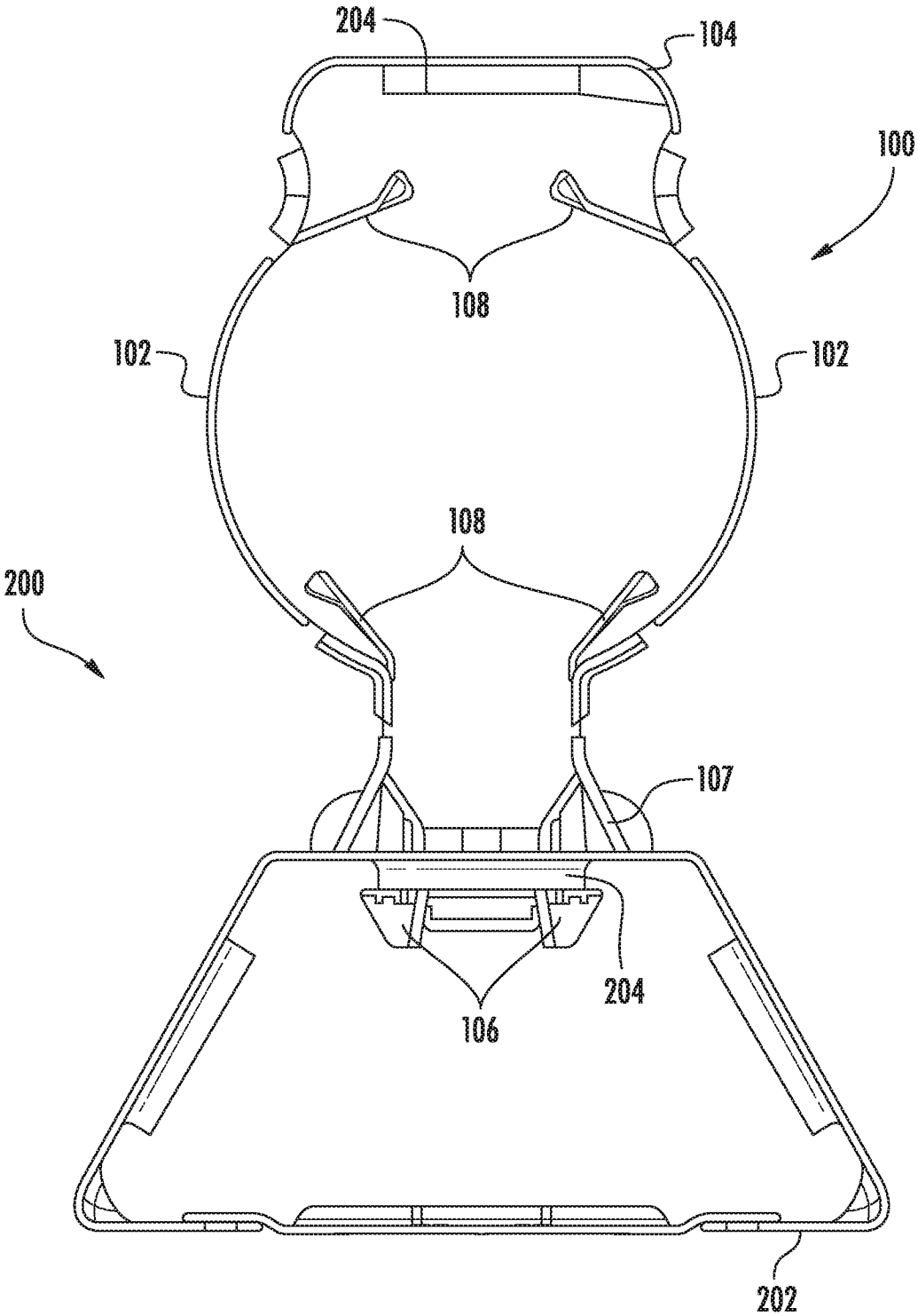

FIG. 2

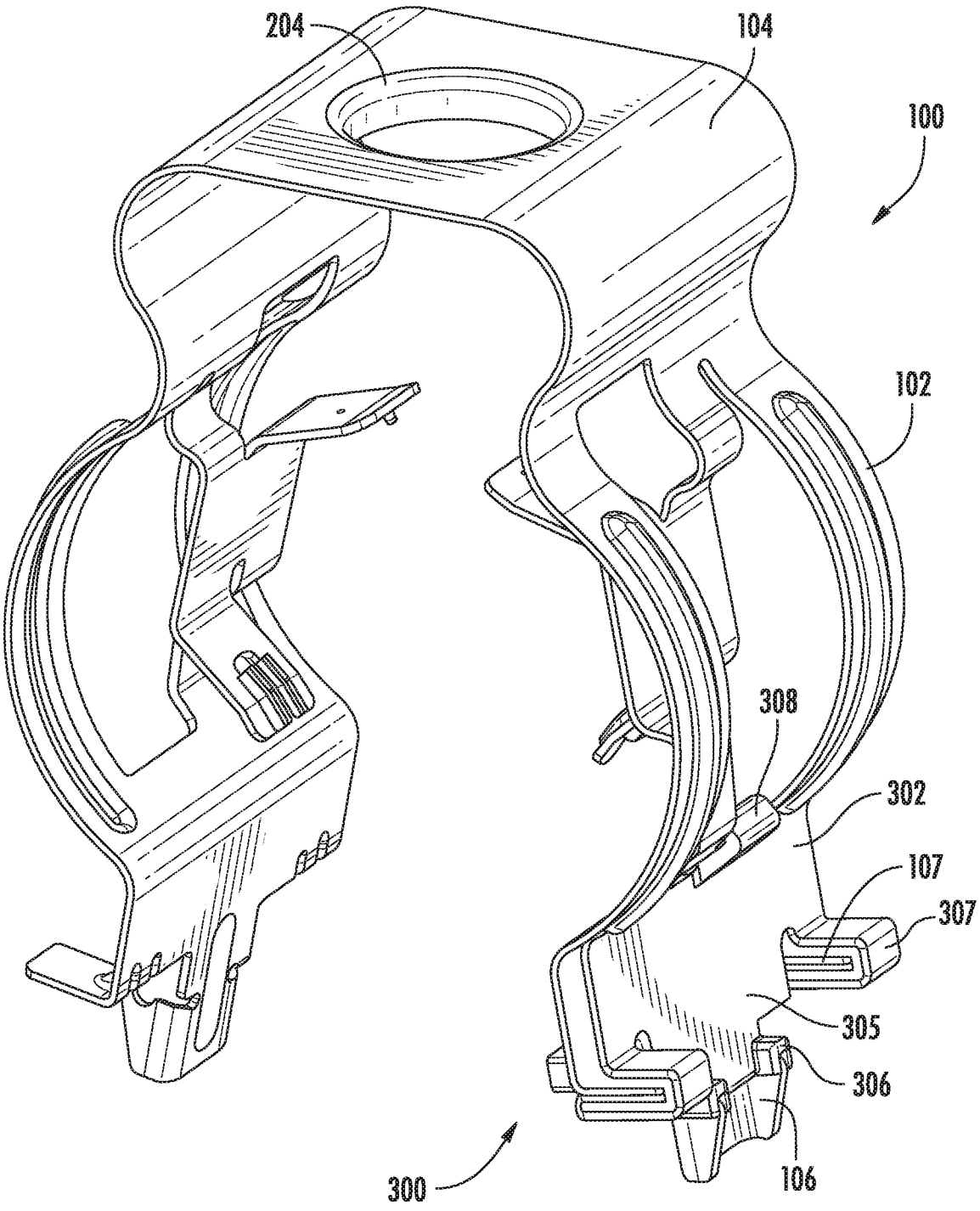

FIG. 3

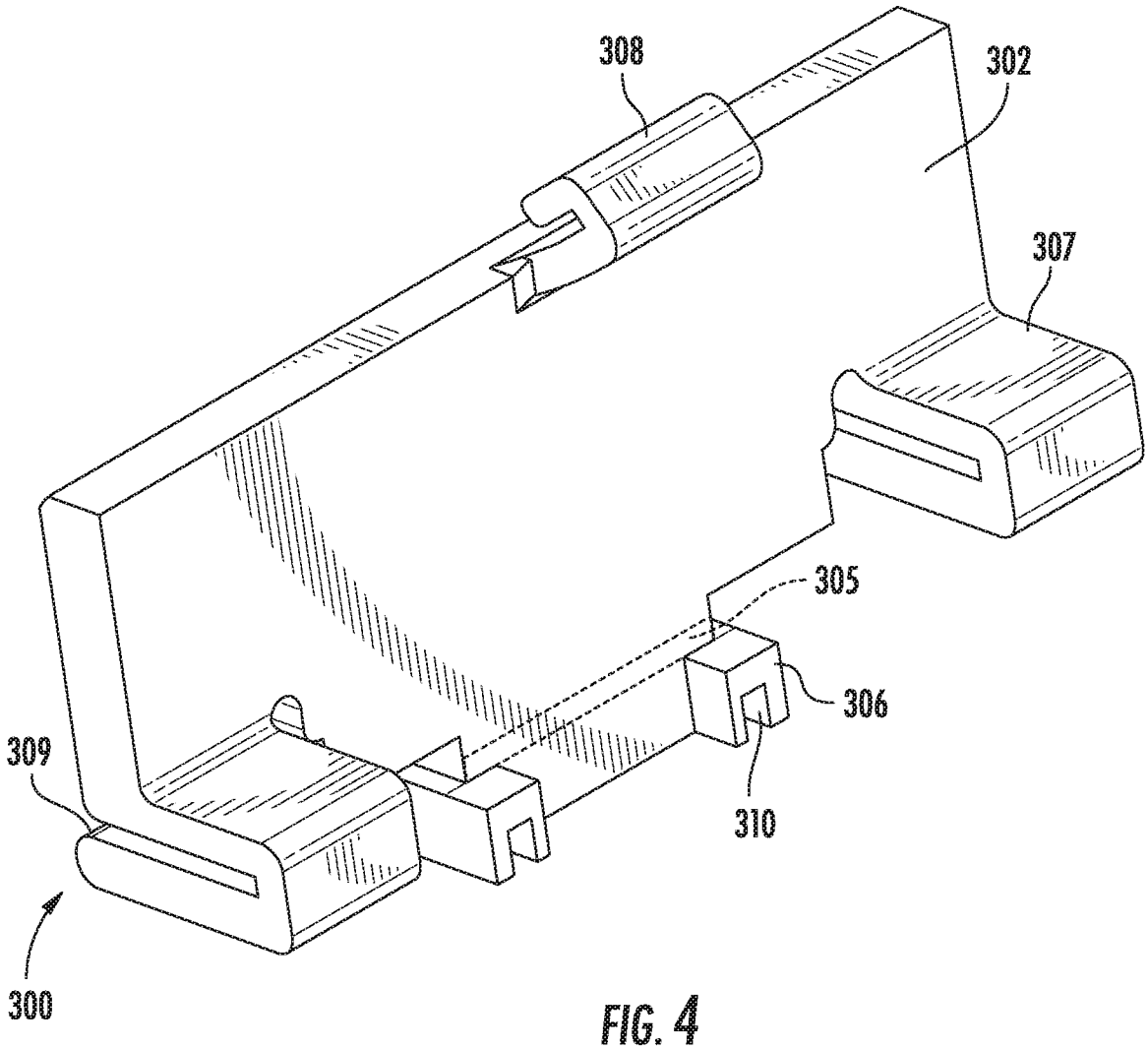

FIG. 4

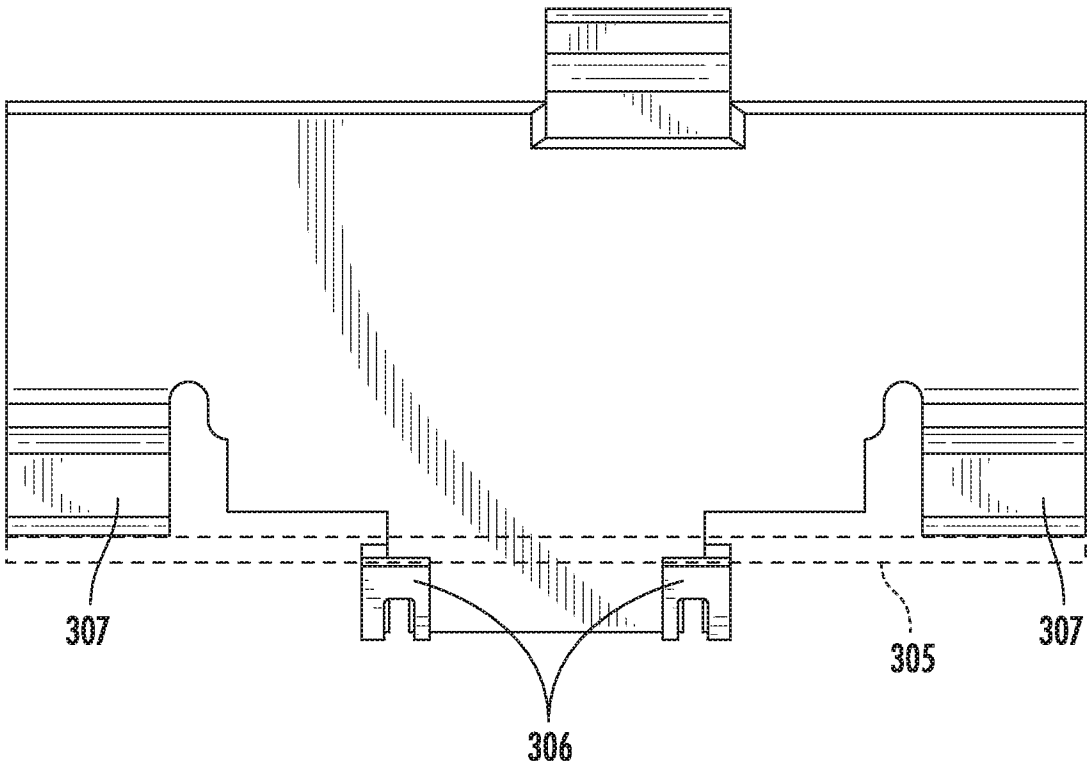

FIG. 5

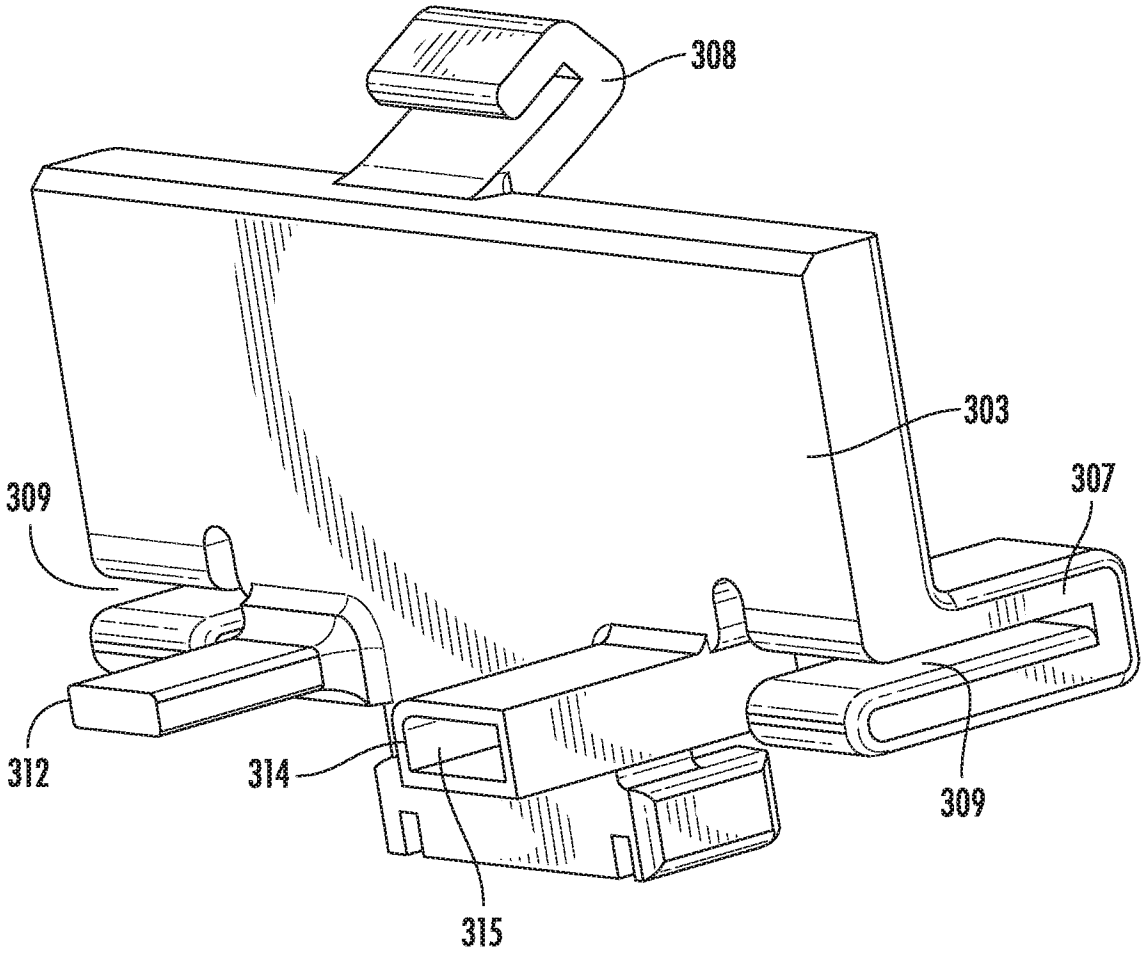

FIG. 6

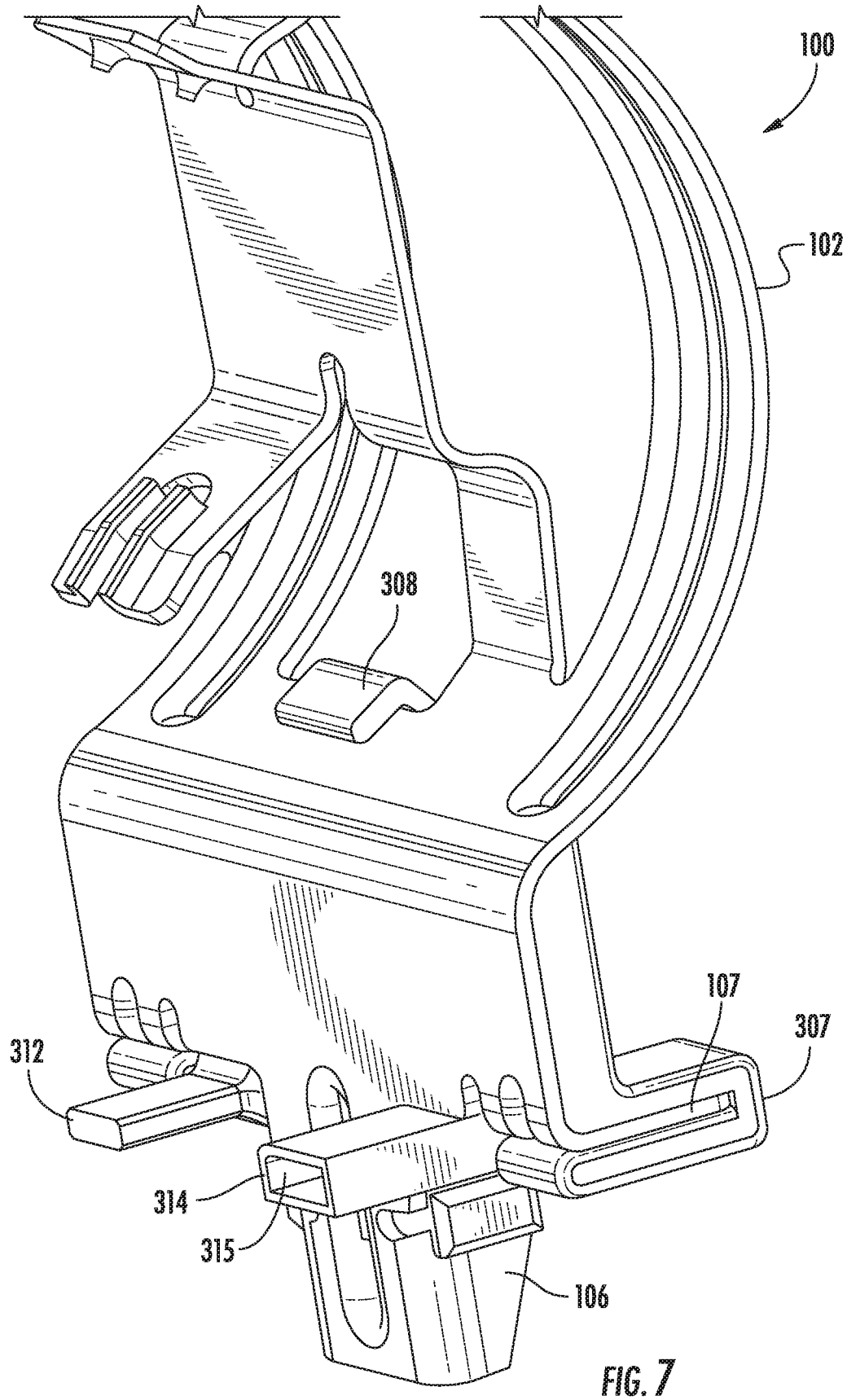

FIG. 7

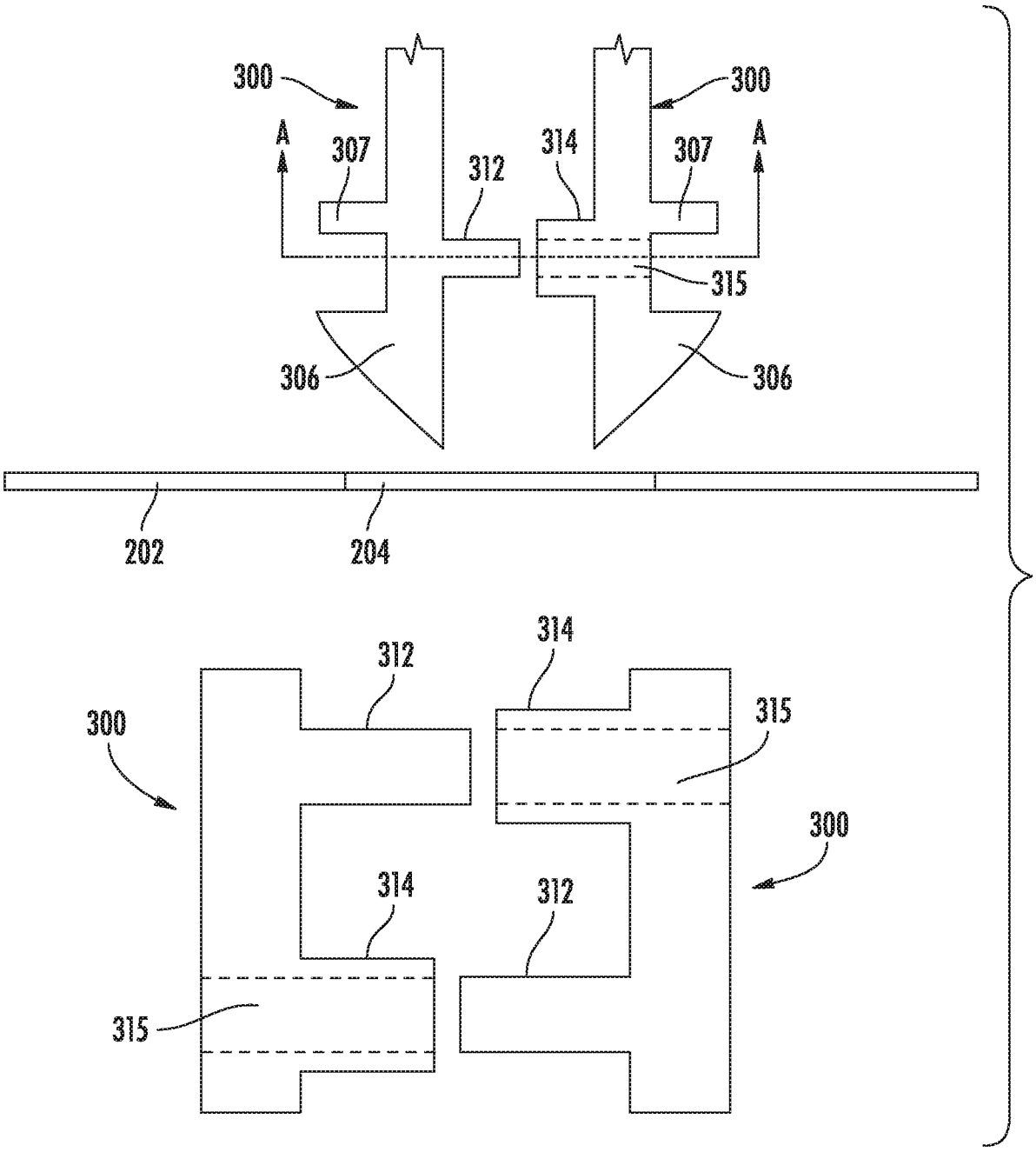
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FIG. 8

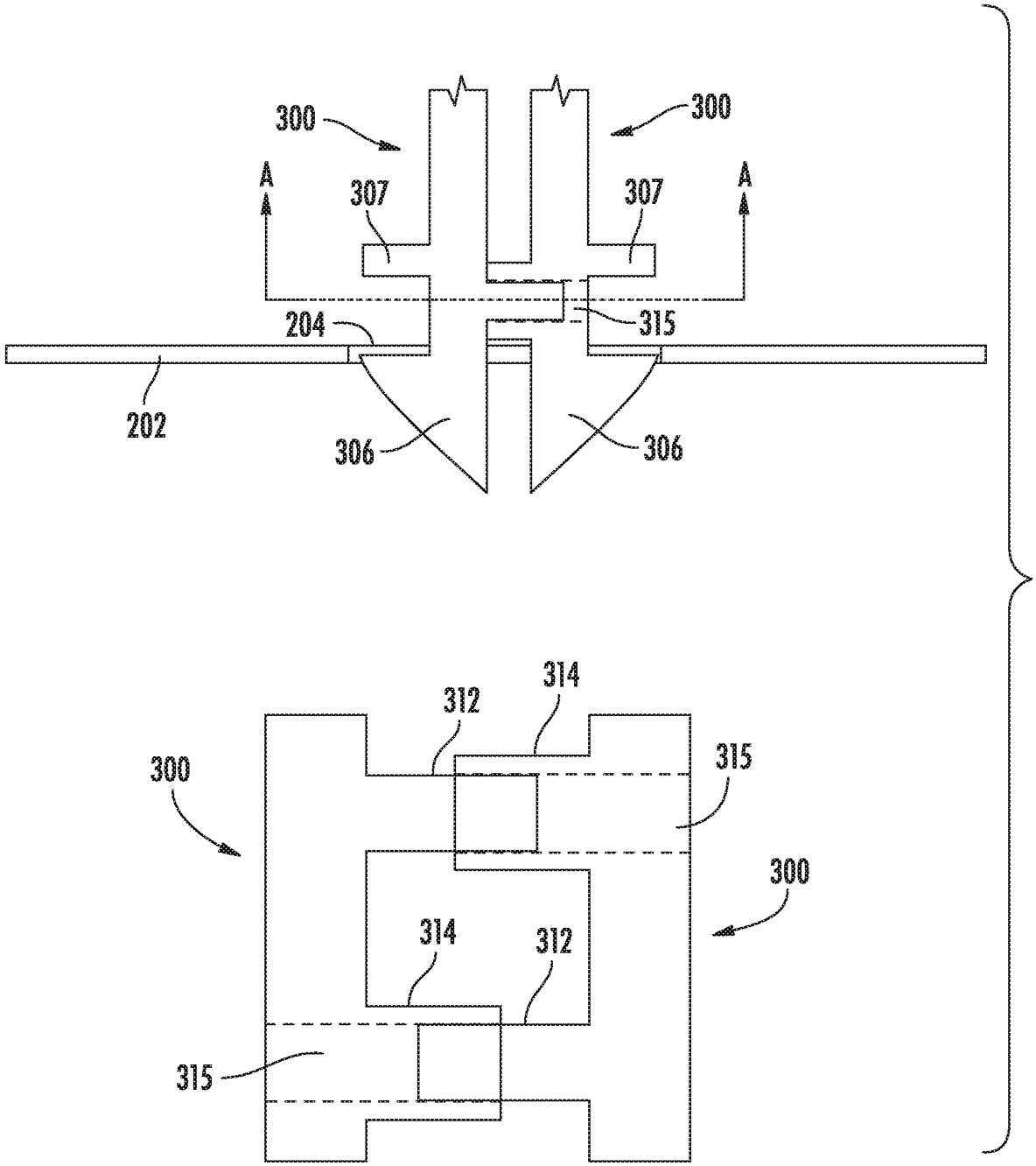
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FIG. 9

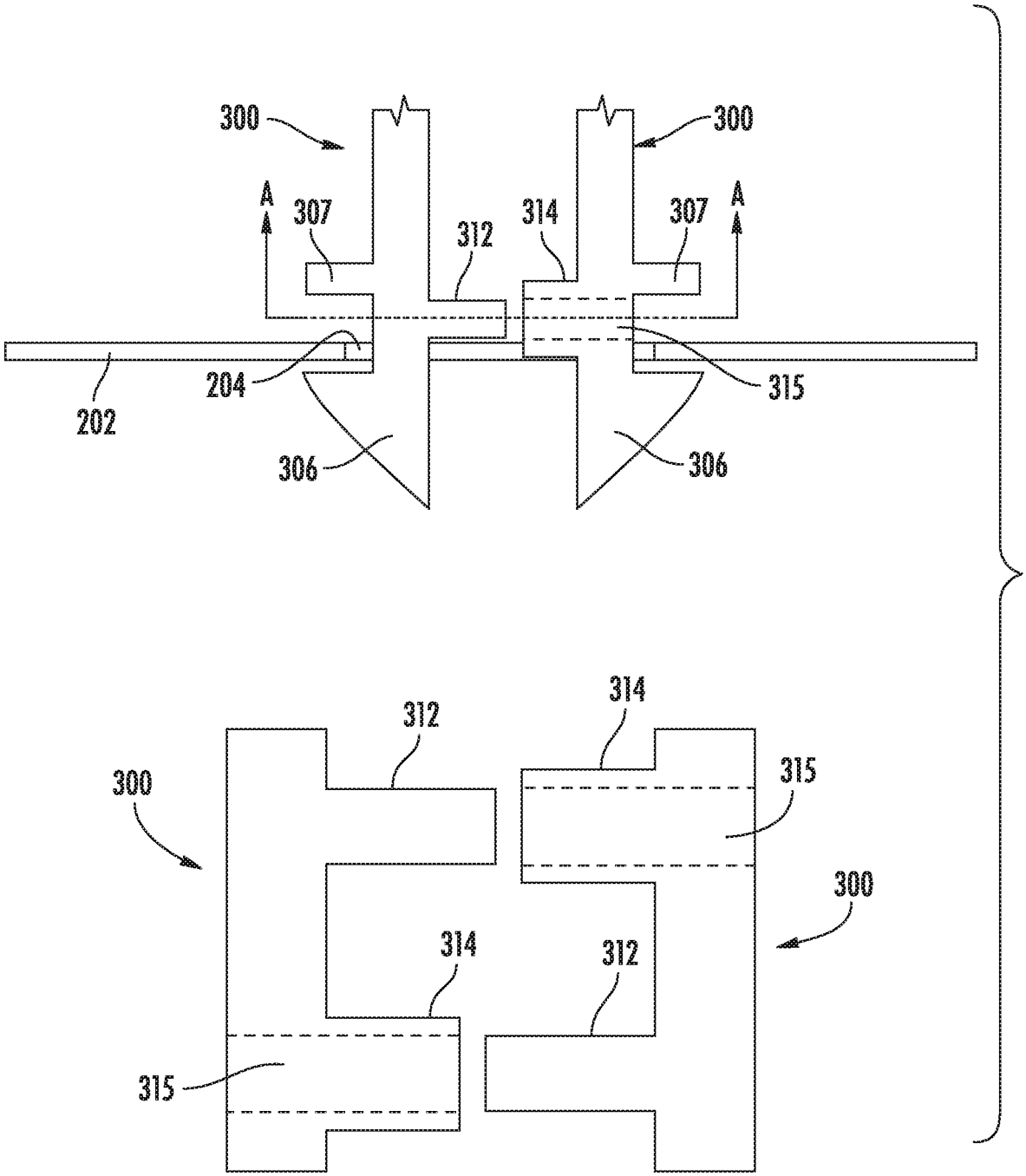
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FIG. 10

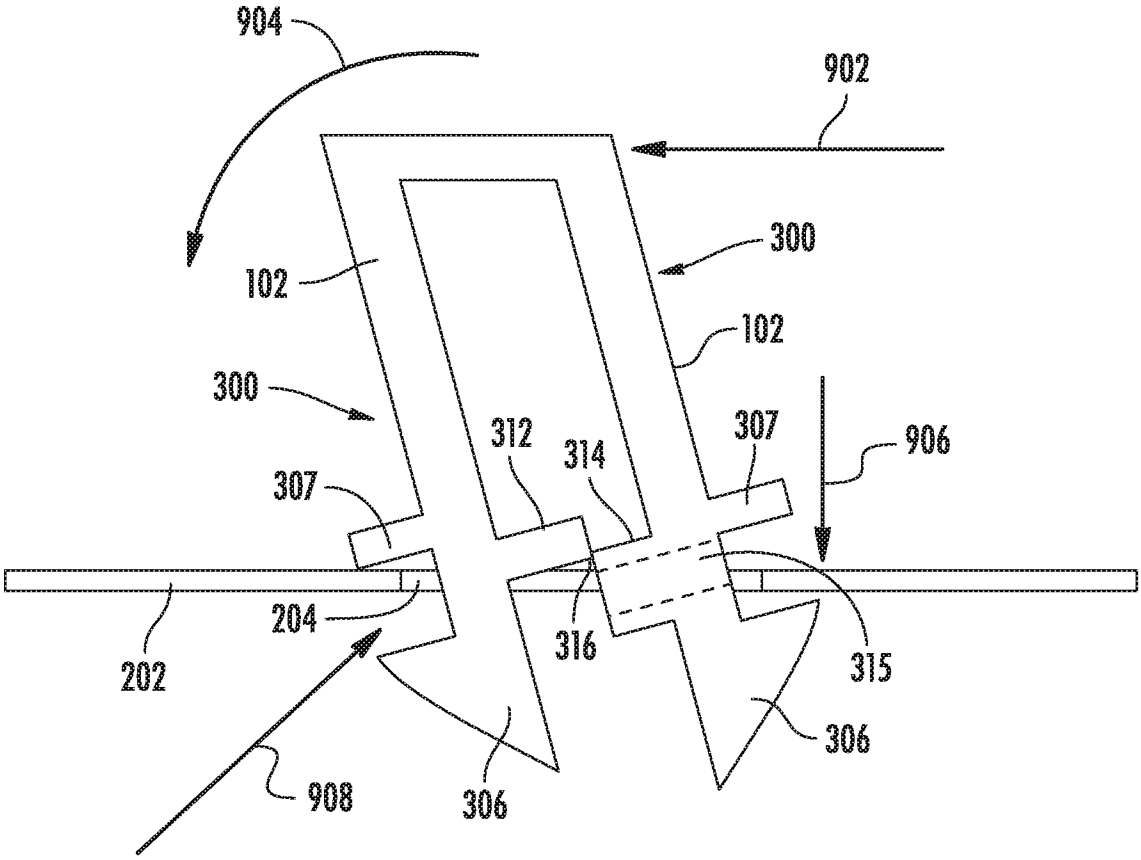
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FIG. 11

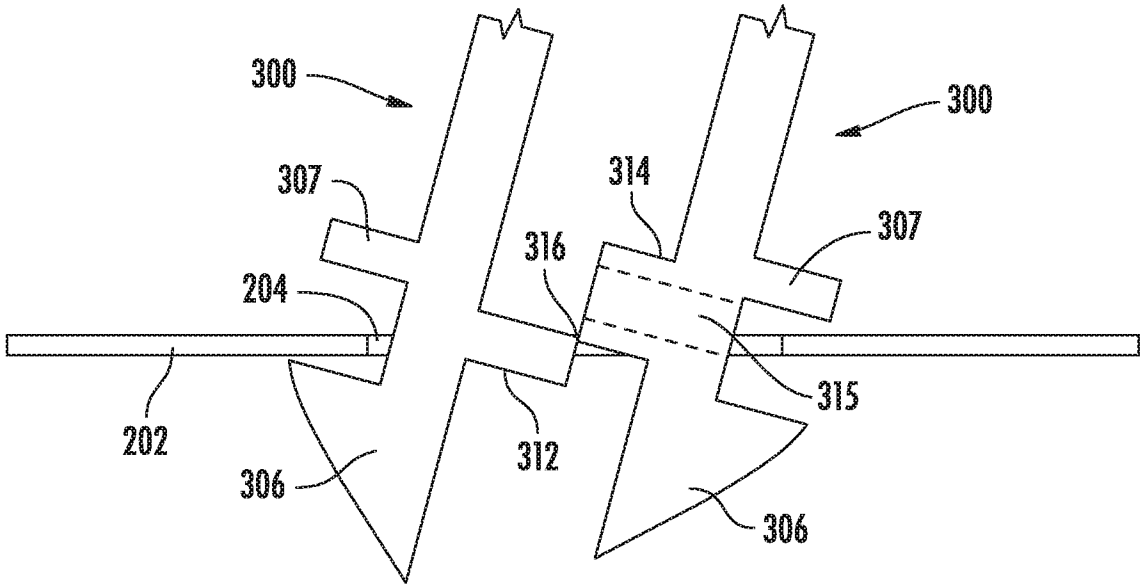

FIG. 12

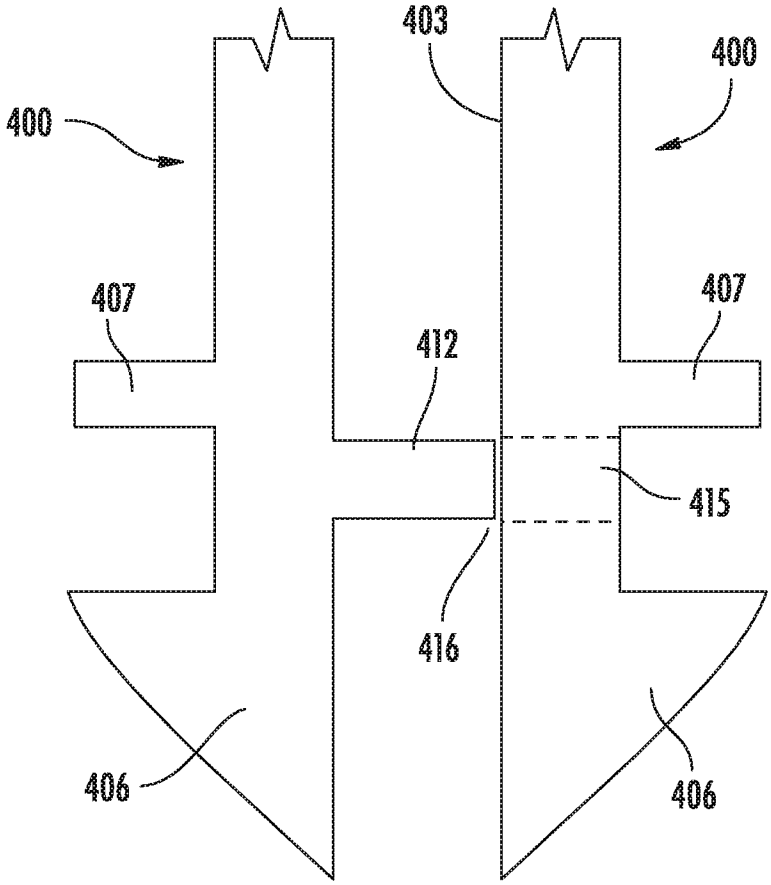

FIG. 13

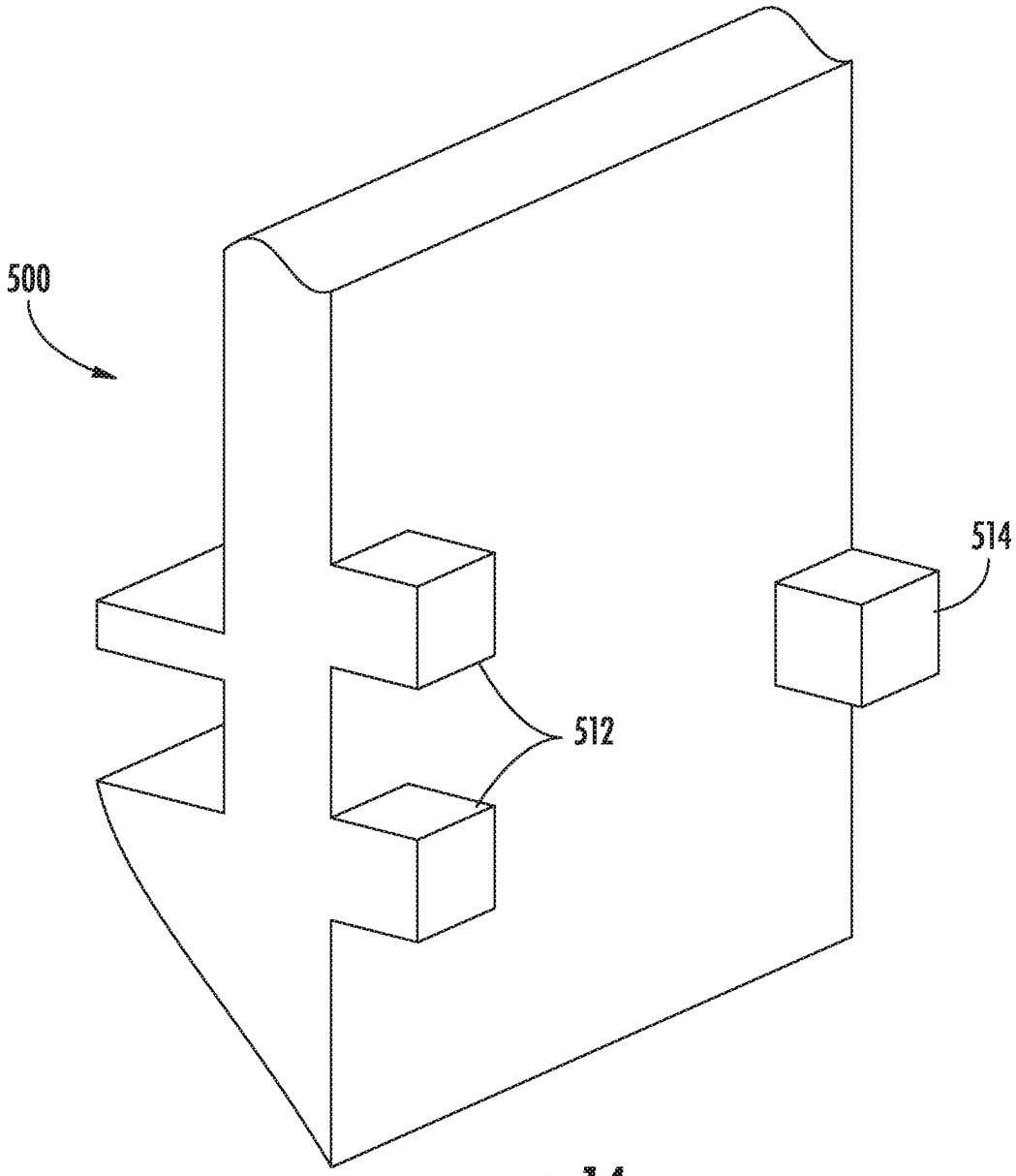

FIG. 14

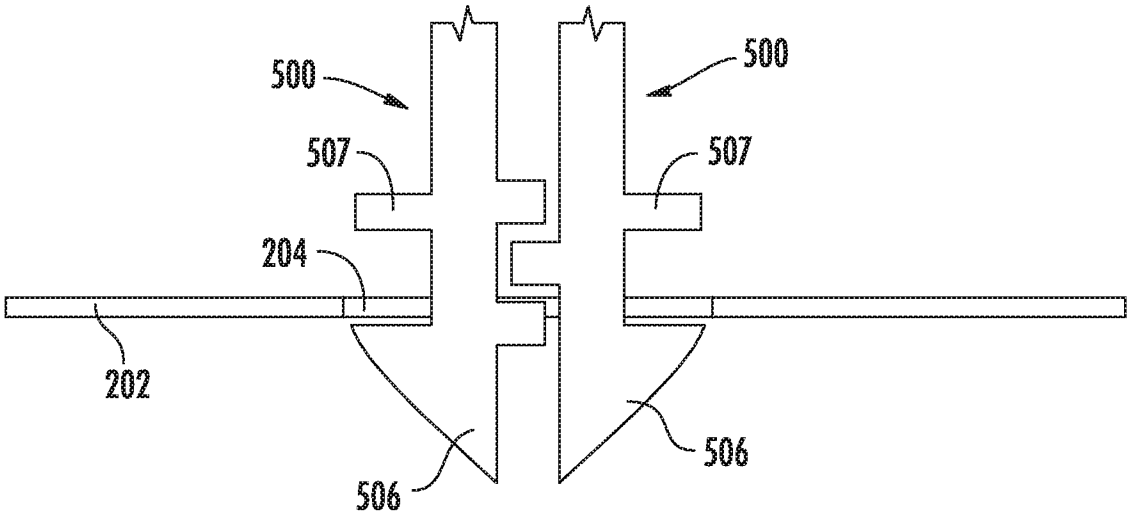

FIG. 15

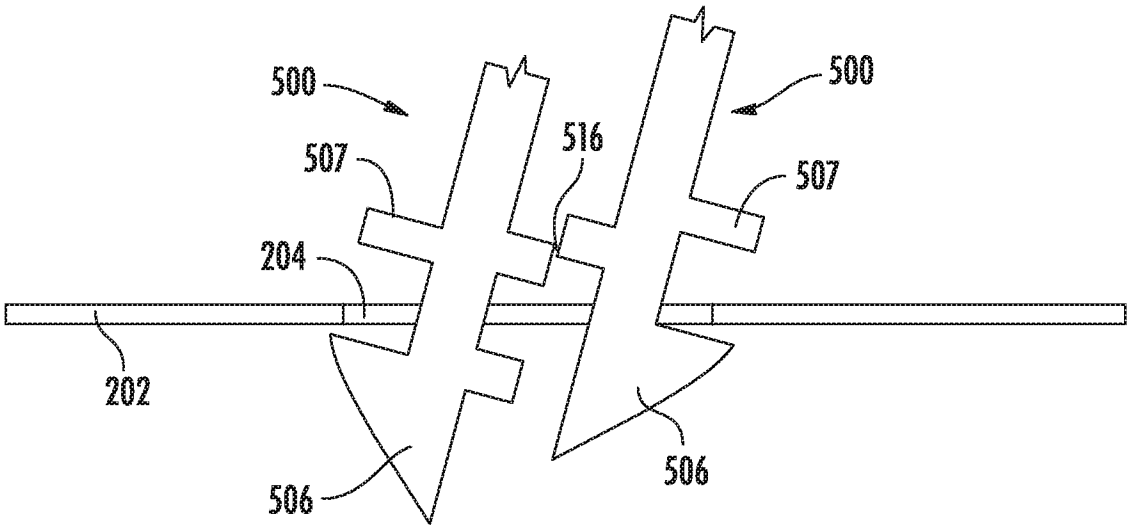

FIG. 16

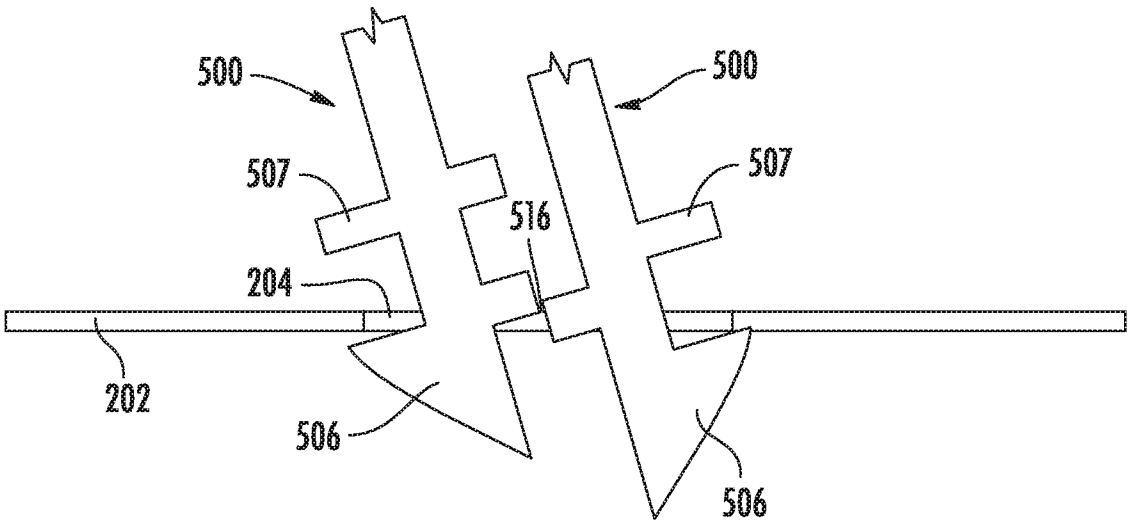

FIG. 17

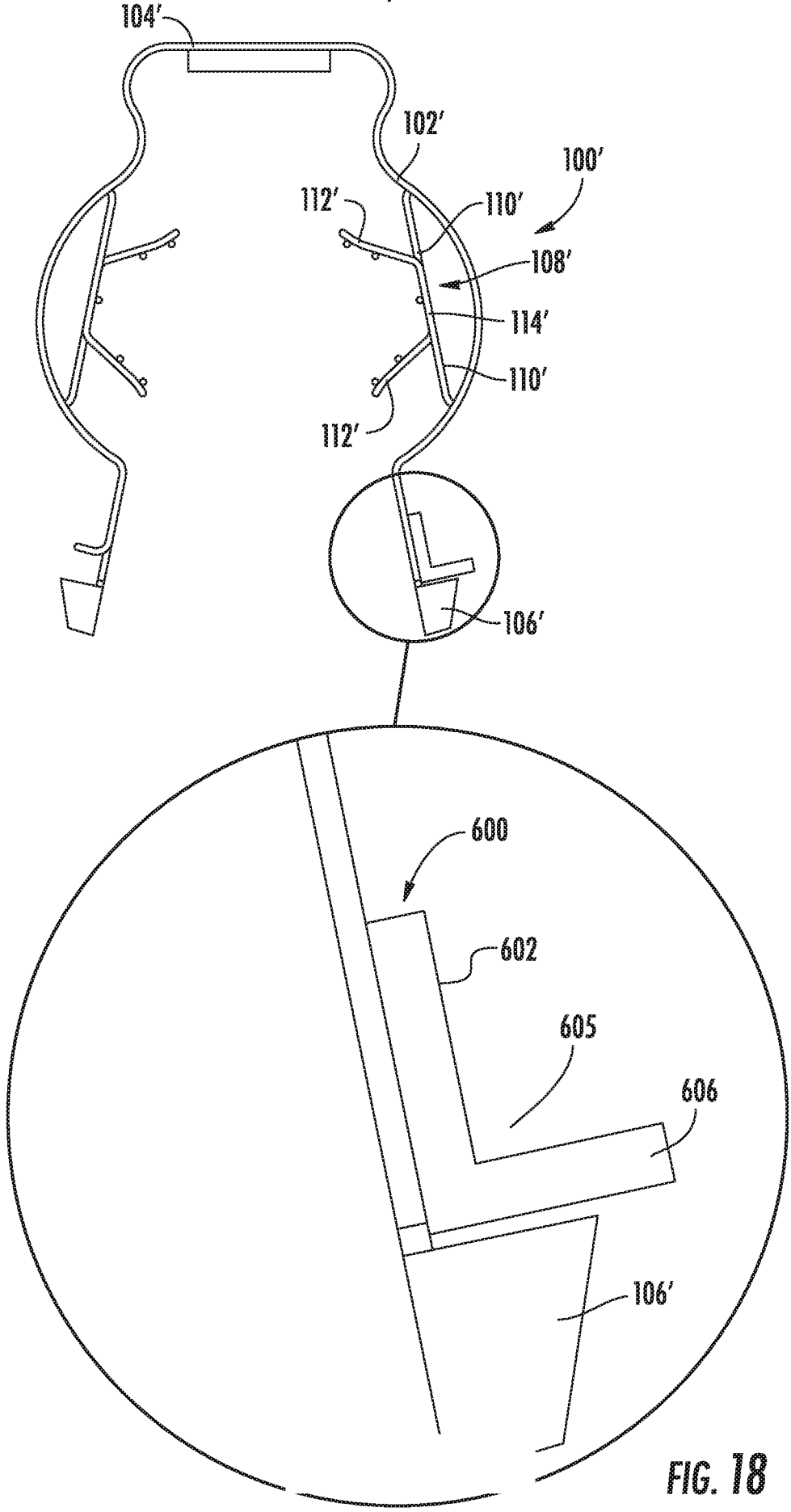

FIG. 18

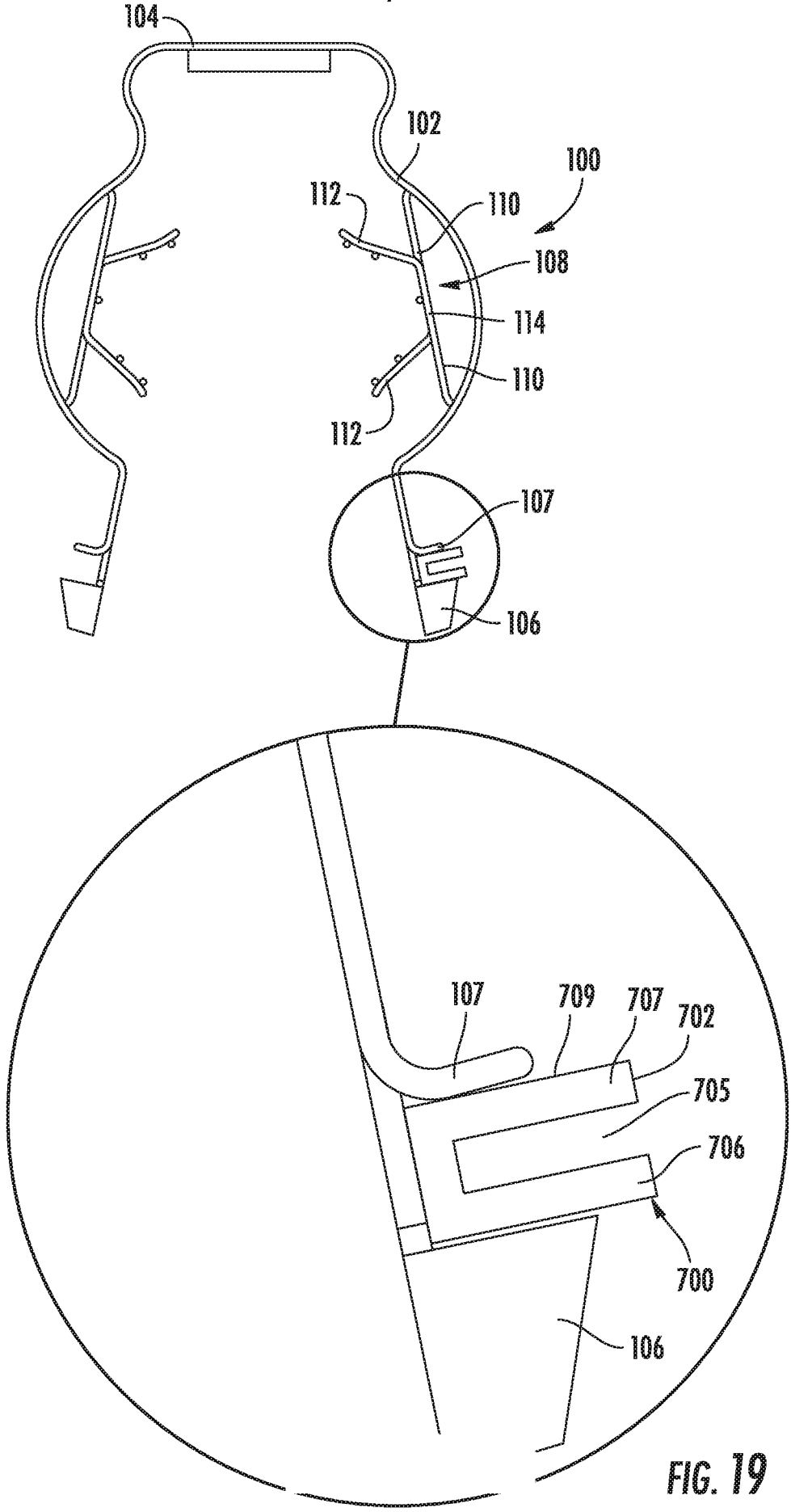
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FIG. 19

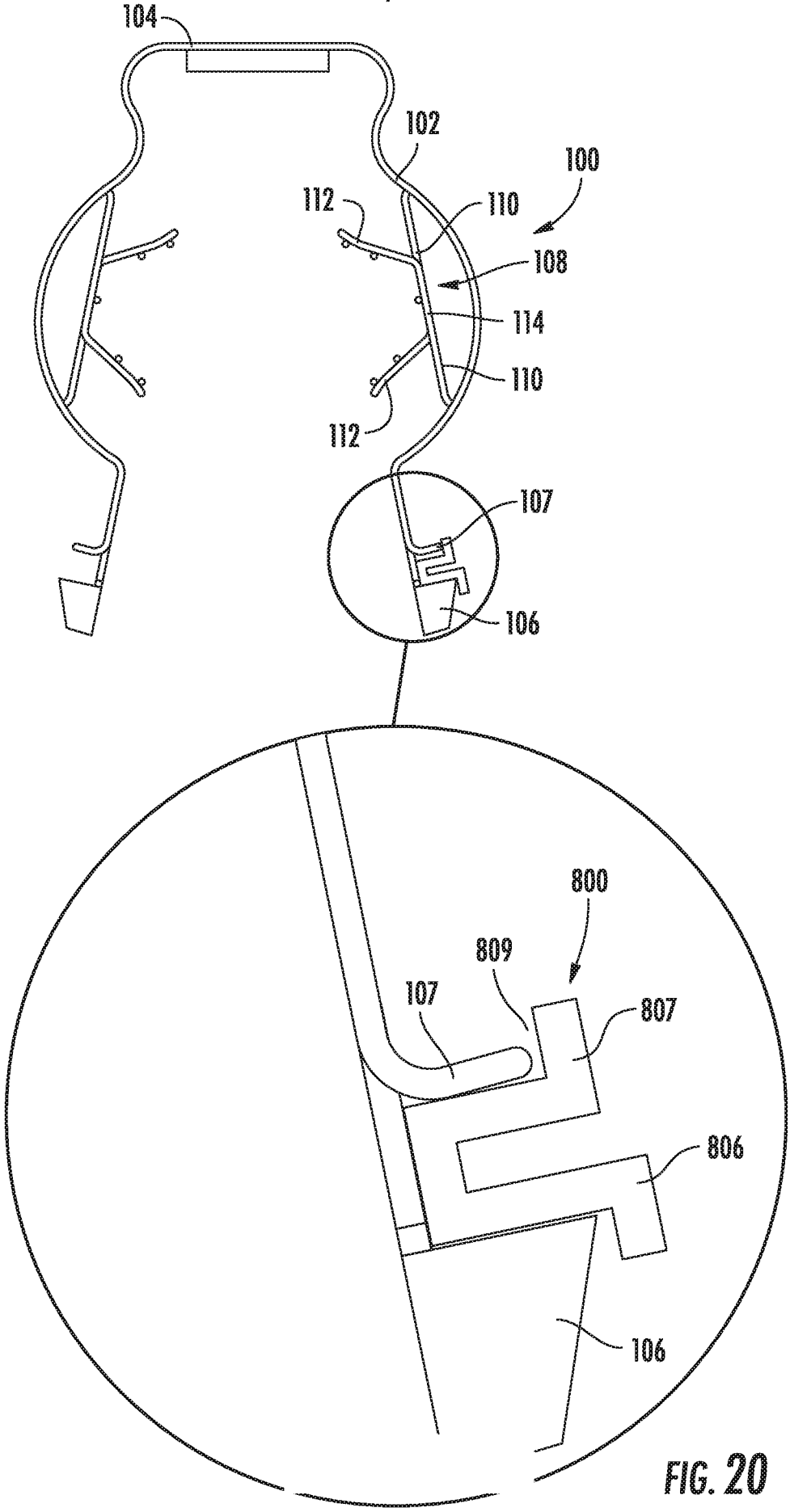
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FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/038587

A. CLASSIFICATION OF SUBJECT MATTER

H02G 3/32(2006.01)i, H02G 3/04(2006.01)i, F16L 3/13(2006.01)i

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)
H02G 3/32; B29C 67/00; F16B 29/00; F16L 3/04; F16L 3/08; F16L 3/12; H01B 17/58; H02G 3/00; H02G 3/22; H02G 3/04; F16L 3/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: shroud, cable, hanger, projection, locking, metal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0086704 A1 (A. RAYMOND ET CIE) 27 March 2014 See paragraphs [0114]-[0115] and figures 21-22.	1-3,13-15,40
Y	US 6161804 A (JAMIE M. PASKE et al.) 19 December 2000 See column 6, line 50 - column 7, line 7, claim 1, 14 and figure 3a.	1-3,13-15,40
A	JP 2010-288367 A (SUMITOMO WIRING SYST LTD.) 24 December 2010 See paragraphs [0017]-[0031] and figure 2.	1-3,13-15,40
A	WO 2017-149271 A1 (LINIAN SUPPLY CO., LTD.) 08 September 2017 See claim 1 and figure 1.	1-3,13-15,40
A	US 8011621 B2 (RICHARD KORCZAK) 06 September 2011 See claim 1 and figure 9.	1-3,13-15,40

☐ 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 October 2020 (07.10.2020)	**07 October 2020 (07.10.2020)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea
Facsimile No. +82-42-481-8578

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/038587

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 6, 8 , 17-18 , 36
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 6, 8 , 17-18 , 36 are considered to be unclear in that they refer to one of the claims which do not comply with PCT Rule 6.4(a).

3. ☒ Claims Nos.: 4-5, 7, 9-12, 16, 19-35, 37-39
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2020/038587

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014-0086704 A1	27/03/2014	CN 103717378 A	09/04/2014
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