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(54) **Title:** CAM FOR ELECTRICAL CONNECTOR ASSEMBLY

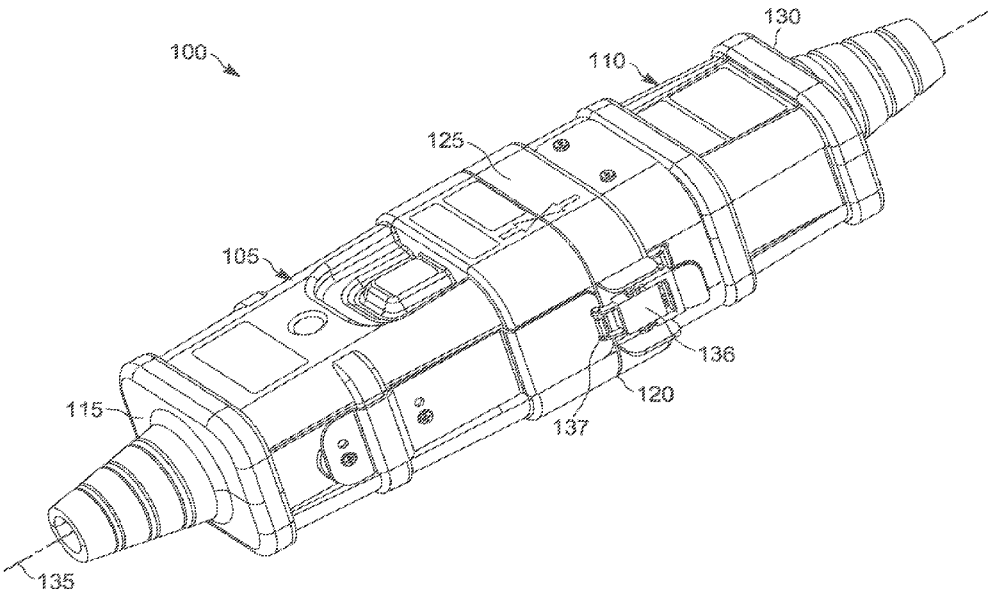

FIG. 1

(57) **Abstract:** An electrical connector assembly includes a first electrical connector and a second electrical connector. The first electrical connector includes a locking feature. The second electrical connector includes a motor, a locking member that engages the locking feature, a cam driven by the motor, and a ledge. The cam includes a first cam portion and a second cam portion. The cam rotates between a locked position where the first cam portion contacts the locking member and prevents movement of the locking member and an unlocked position where the first cam portion is spaced from the locking member and allows movement of the locking member. The ledge includes a first ledge portion and a second ledge portion angularly displaced from the first ledge portion. The second cam portion contacts the second ledge portion in the locked position. The first cam portion contacts the first ledge portion in the unlocked position.

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Cam for Electrical Connector Assembly

Related Applications:

[0001] This application is based on U.S. Provisional Application Serial No. 63/514,231, filed July 18, 2023, the disclosure of which is incorporated herein by reference in its entirety and to which priority is claimed.

Field:

[0002] The present disclosure relates to an electrical contact device. More particularly, the present disclosure relates to an electrical contact device with a locking mechanism.

Background:

[0003] Many types of electrical connectors exist to provide electrical connection between two or more wires or cables. These electrical connectors generally include a male connector that is receivable within a female connector to form an electrical connection. In many forms, the male and female connector can be easily connected and disconnected from one another so that a user may selectively determine whether there is an electrical connection between the wires or cables. For example, the male connector may be one or more prongs that are dimensioned to securely fit within one or more receptables. The prongs may snuggly fit within the receptables (e.g., with a friction fit) to maintain an electrical connection if the wires or cables shift, but a force provided by the user may easily overcome any frictional engagement to separate the male and female connectors.

[0004] In certain operating environments, it may be important that the male and female connectors remain connected to prevent accidental disengagement. For example, the cables joined by the male and female connectors may carry a high voltage and/or current. Disconnecting the male connector from the female connector while electrical power is supplied to the cables can be dangerous because arcing can occur. This risk of arcing

may still be present in time periods soon after electrical power is no longer supplied because residual current and/or voltage may still be present in the cables. The male and female connectors need to prevent disengagement while electrical power is supplied and while residual current and/or voltage remains that could result in a dangerous condition.

Summary:

[0005] Various examples of the present disclosure can overcome various of the aforementioned and other disadvantages associated with known electrical connectors and offer new advantages as well.

[0006] According to one aspect of various examples of the present disclosure there is provided an interlock for securing electrical connectors together and a cam having a support surface for moving the interlock, wherein a center of the support surface is aligned with a movement direction of the interlock.

[0007] According to another aspect of various examples of the present disclosure, there is provided a cam that has a support surface which is movable between a locked position and an unlocked position, and wherein the support surface receives a perpendicular force in the locked position.

[0008] According to one aspect of various examples of the present disclosure there is provided a housing having a first stop surface, a second stop surface, and a cam rotatable between the first stop surface and the second stop surface.

[0009] According to another aspect of various examples of the present disclosure, there is provided a cam driven by a motor between a predetermined first position and a predetermined second position.

[0010] According to another aspect of various examples of the present disclosure, there is provided an electrical connector assembly that includes a first electrical connector and a second electrical connector. The first electrical connector includes at least one locking feature. The second electrical connector includes a motor, at least one locking member, at least one cam, and a ledge. The at least one locking member movably engageable with the at least one locking feature. The at least one cam is driven by the motor and including a first cam portion and a second cam portion, wherein the at least one cam is rotatable between a locked position where the first cam portion contacts the

at least one locking member and prevents movement of the at least one locking member and an unlocked position where the first cam portion is spaced apart from the at least one locking member and allows movement of the at least one locking member. The ledge includes a first ledge portion and a second ledge portion angularly displaced from the first ledge portion. The second cam portion contacts the second ledge portion in the locked position. The first cam portion contacts the first ledge portion in the unlocked position.

[0011] According to another aspect of various examples of the present disclosure, there is provided a first electrical connector of an electrical connector assembly. The first electrical connector includes a housing, a cam disposed within the housing and driven to rotate by a motor, and a first locking member disposed at least partially within the housing. The cam includes a shaft having a first projection and a second projection spaced apart from the first projection. The first locking member releasably secures the first electrical connector to a second electrical connector. The first locking member can receive a force to move the first locking member from a secured position to an unsecured position. The cam can move between a locked position where the first projection contacts the first locking member and an unlocked position where the first projection is spaced apart from the first locking member. The force can be applied in a direction substantially perpendicular to the first projection in the locked position.

[0012] According to another aspect of various examples of the present disclosure, there is provided a first electrical connector of an electrical connector assembly. The first electrical connector includes a housing having a first stop surface and a second stop surface, a cam disposed within the housing and driven to rotate by a motor, and a first locking member disposed at least partially within the housing. The cam includes a shaft having a first projection and a second projection spaced apart from the first projection. The first locking member can releasably secure the first electrical connector to a second electrical connector. The cam can move between a locked position where movement of the first locking member is limited and an unlocked position where the first locking member is movable. The locked position is a first predetermined location where the second projection contacts the second stop surface and the unlocked position is a second predetermined location where the first projection contacts the first stop surface.

[0013] According to another aspect of various examples of the present disclosure, there is provided a method of connecting a first electrical connector to a second electrical connector. The method includes rotating a cam from a locked position to an unlocked position; moving a locking member from a secured position to an unsecured position; coupling the second latch to the first latch; and returning the cam to the locked position, wherein movement of the cam from the unlocked position to the locked position moves the locking member from the unsecured position to the secured position.

[0014] The disclosure herein should become evident to a person of ordinary skill in the art given the following enabling description and drawings. The drawings are for illustration purposes only and are not drawn to scale unless otherwise indicated. The drawings are not intended to limit the scope of the disclosure. The following enabling disclosure is directed to one of ordinary skill in the art and presupposes that those aspects within the ability of the ordinarily skilled artisan are understood and appreciated.

Brief Description of the Drawings:

[0015] Various aspects and advantageous features of the present disclosure will become more apparent to those of ordinary skill when described in the detailed description of preferred examples and reference to the accompany drawings.

[0016] FIG. 1 is a perspective view of an electrical connector assembly having a male connector and a female connector in a connected position.

[0017] FIG. 2 is a perspective view of an electrical connector assembly with the male connector and the female connector in a disconnected position.

[0018] FIG. 3 is a perspective view of the female connector of the electrical connector assembly of FIG. 2.

[0019] FIG. 4 is a perspective view of the female connector of FIG. 3 with an outer casing removed.

[0020] FIG. 5 is a side view of the female connector of FIG. 4.

[0021] FIG. 6 is a perspective view of a first cam and a first latch.

[0022] FIG. 7 is a side view of the first cam and first latch of FIG. 6.

[0023] FIG. 8 is a perspective view of the first latch of FIG. 6.

[0024] FIG. 9 is a perspective view of a second cam and a second latch.

[0025] FIG. 10 is an end view of the second cam and second latch or FIG. 9.

[0026] FIG. 11 is a front view of the second latch of FIG. 9.

[0027] FIG. 12 is a perspective view of the cam.

[0028] FIG. 13 is a front view of the cam of FIG. 12.

[0029] FIG. 14 is a rear view of the cam of FIG. 12.

[0030] FIG. 15 is a cross-sectional view of the female connector of FIG. 4 viewed along section 15--15 and illustrating a first cam and a second cam in a first position.

[0031] FIG. 16 is a cross-sectional view of the female connector of FIG. 4 viewed along section 16--16 and illustrating the first cam in the first position.

[0032] FIG. 17 is a cross-sectional view of the female connector of FIG. 4 viewed along section 17--17 and illustrating the first cam in the first position.

[0033] FIG. 18 is a cross-sectional view of the female connector of FIG. 4 viewed along section 18--18 and illustrating the second cam in the first position.

[0034] FIG. 19 is a cross-sectional view of the female connector of FIG. 4 viewed along section 19--19 and illustrating the second cam in the first position.

[0035] FIG. 20 is a cross-sectional view of the female connector of FIG. 4 viewed along section 16--16 and illustrating the first cam in the second position.

[0036] FIG. 21 is a cross-sectional view of the female connector of FIG. 4 viewed along section 18--18 and illustrating the second cam in the second position.

[0037] FIG. 22 is a cross-sectional view of the female connector of FIG. 4 viewed along section 15--15 and illustrating a first cam and a second cam in the second position and a first latch and a second latch in a second position.

[0038] FIG. 23 is a cross-sectional view of the female connector of FIG. 4 viewed along section 15--15 illustrating a plunger in a depressed position.

[0039] FIG. 24 is a perspective view of the male connector and the female connector in a connected position with the outer casing of the female cover removed.

[0040] FIG. 25 is a cross-sectional view of the female connector of FIG. 24 viewed along section 25--25 and illustrating a first cam and a second cam in a first position.

Detailed Description:

[0041] As shown in FIGS. 1 and 2, an electrical connector assembly 100 includes a female connector 105 that can selectively receive a male connector 110. The female connector 105 may include a first end 115 and a second end 120 opposite to the first end 115. The male connector 110 may include a first end 125 and a second end 130 opposite to the first end 115. Each of the female and male connectors 105, 110 may be connected to a wire or cable that can carry electrical power. For example, a cable may extend from the first end 115 of the female connector 110 and from the second end 130 of the male connector 110. Selectively connecting the male connector 110 to the female connector 105 may close an electrical circuit and permit electrical power to flow between the cables and power a device.

[0042] The female and male connectors 105, 110 may be movable (e.g., translatable) relative to one another along a connector axis 135. For example, the first end 125 of the male connector 110 may be positioned facing the second end 120 of the female connector 105 so that the first end 125 is receivable within the second end 120 as the male connector 110 is moved along the connector axis 135. As described in more detail below, at least one of the female connector 105 and the male connector 110 may include a clasp 136 that secures the female and male connectors 105, 110 together while electrical power is present to prevent improper disconnection of the female and male connectors 105, 110.

[0043] In some forms, the clasp 136 may be a member pivotably coupled to the male connector 105. The claps 136 may include a first end that is engageable by a user and a second end opposite to the first end. The second end may selectively engage a hook 137 that is coupled to the female connector 105. The clasp 136 may include a locked position (e.g., as shown in FIGS. 1 and 2) and an unlocked position (not shown). In the locked position, the second end of the clasp 136 may be proximate to the surface of the male connector 110 and may be applying tension to the second end. Particularly, the second end may be received within the hook 137 and the applied tension draws the female connector 105 toward the male connector 110. In the unlocked position, the first end moves away (e.g., pivots) from the surface of the female connector 105 and releases tension in the clasp 136. This may permit the second end to move relative to the hook

137 and may therefore allow the female and male connectors 105, 110 to separate from one another.

[0044] As shown in FIG. 3, the female connector 105 may include a body 140 that includes the first and second ends 115, 120. A casing 145 may be disposed around the body 140. In the illustrated example, the casing 145 may be formed from an electrically insulative material (e.g., rubber). The casing 145 may be formed from a material that promotes gripping in a user's hand (e.g., having a relatively high coefficient of friction) to assist the user in securely grasping the body 140. However, other examples may omit the casing 145.

[0045] In some forms, a support 150 is positioned on either side of the body 140 (only one support 150 shown). The supports 150 may be constructed from a different material than the body 140 (e.g., a metallic material), although in other examples the supports 150 may be constructed from the same material as the body 140. The illustrated supports 150 are formed separately from the body 140 and are connected to the body 140 during assembly. Fasteners 155 are shown as connecting the supports 150 to the body 140, although other fastening methods may be used (e.g., adhesives, magnets, etc.).

[0046] The supports 150 may add rigidity to the body 140 and help support the more flexible material that makes up the casing 145. Some forms of the supports 150 may include at least one hook 160. The illustrated hook 160 is formed at an end of the support 150 (e.g., proximate to the second end 120 of the female connector 105). In other forms, the hook 160 may be formed at a different location along the length of the support 150.

[0047] FIGS. 4 and 5 illustrate the female connector 105 with the casing 145 removed for illustrative purposes so that a connection portion 165 is shown. The connection portion 165 may include a first section 170 and a second section 175. The illustrated first section 170 may include a substantially rectangular cross section and may be larger than the second section 175, which may include an elliptical cross section. The second section 175 may be disposed proximate to an upper end of the first section 170 so that a center of the second section 175 is not aligned with a center of the first section 170 (see e.g., FIG. 5). Although in other examples, the centers of the first and section sections 170, 175 may be aligned.

[0048] In some forms, the female connector 105 may include a first interlock 180 and a second interlock 185 spaced apart from the first interlock 180. The illustrated connection portion 165 includes the first interlock 180 on the first section 170 and the second interlock 185 on the second section 175, although any configuration may be used (e.g., both interlocks 180, 185 on the same section). As described in more detail below, each interlock 180, 185 is movable between a respective first and second position to permit coupling and uncoupling of the male connector 110 to the female connector 105.

[0049] As shown in FIGS. 6 to 8, the first interlock 180 may include a lever 190, a first cam 195, and a first motor 200 for driving the first cam 195. As described in more detail below, the cam 195 may be movable between a first position and a second position to permit or prevent movement (e.g., pivotable movement) of the lever 190.

[0050] In some forms, the lever 190 includes a body 205 that has a first end and a second end. A button 210 may be formed at the first end and a coupler 215 may be formed at the second end. The button 210 may include a substantially planar surface to provide a surface for a user to engage. The surface of the button 210 may be inclined to assist a user in engaging the button (e.g., in which direction to rotate the lever 190). The coupler 215 may include an undercut region 220 and may be formed as a hook that can selectively engage and lock onto another element.

[0051] In some forms, a pivot point 225 may be formed between the first and second ends of the body 205 and may extend substantially perpendicularly with respect to a direction between the first and second ends. A shaft 230 extends through the pivot point 225 and permits pivoting movement of the body 205 when the button 210 is engaged.

[0052] In certain forms, the button 210 and the coupler 215 may be formed on opposite surfaces of the body 205. For example, FIG. 7 illustrates the button 210 formed on an upper surface of the body 205 and the coupler 215 formed on a lower surface of the body 205. As described in more detail below, this configuration permits the coupler 215 to be raised as the button 210 is depressed. In other forms, the button 210 and the coupler 215 may be formed on the same surface of the body 205.

[0053] With continued reference to FIG. 7, an undercut 232 may be formed proximate to the button 210 at the first end of the body 205. The undercut 232 may be formed beneath a portion of the button 210 (e.g., the non-inclined portion of the button 210).

[0054] As shown in FIGS. 9 to 11, the second interlock 185 may include a button 235, a second cam 240, and a second motor 245 for driving the second cam 240. As described in more detail below, the second cam 240 may be movable between a first position and a second position to permit or prevent movement (e.g., pivotable movement) of the button 235.

[0055] As shown in FIGS. 10 and 11, the button 235 may include a lower flange 250 and an upper locking portion 255. The lower flange 250 may have a larger width than the upper locking portion 255, although this may be reversed, or the widths may be the same. The lower portion 250 and the upper locking portion 255 may be cylindrical in shape, although either one may have a different shape (e.g., a rectangular prism, elliptical, etc.). The upper locking portion 255 may be formed substantially perpendicularly with respect to the lower portion 250 so that an outer surface of the upper locking portion 255 is not sloped relative to the lower portion 250.

[0056] In some forms, the lower flange 250 may be positioned proximate to the second cam 240 and the upper locking portion 255 may extend away from the lower flange 250 in a direction away from the cam 240. In other examples, the orientation of the button 235 may be reversed so that the upper locking portion 255 is positioned proximate to the cam 240.

[0057] With continued reference to FIGS. 10 and 11, a biasing member 260 may be coupled to the button 235. The illustrated biasing member 260 is a helical compression spring, although other forms of biasing members may be used. In some forms, the biasing member 260 may be coupled to the button 235 proximate to the lower flange 250. The bias of the biasing member 260 may be directed away from the upper locking portion 255 and toward the cam 240. As described in more detail below, the cam 240 as positioned in FIGS. 9 and 10 can overcome the spring force in the biasing member 260 so that the button 235 moves against the bias.

[0058] In certain forms, the biasing member 260 is positioned so that it extends on either side of the lower flange 250. This positioning of the biasing member 260 may reduce wear on the biasing member 260.

[0059] FIGS. 12 to 14 illustrate one example of a cam. The first and second cams 195, 240 are substantially identical and include substantially the same elements. As

such, description of only one of the cams 195, 240 may be applied to both the first and second cams 195, 240.

[0060] As shown in FIG. 12, the cams 195, 240 include an elongated shaft 265 that extends along a rotation axis 270. The illustrated shaft 265 may be substantially cylindrical in shape, although the shaft 265 may include any other shape.

[0061] A first end 275 of the shaft 265 may include a cavity 280 that extends at least partially into the shaft 265. In some forms, walls of the cavity 280 may have a different shape than the outer surface of the shaft 265. For example, the illustrated cavity 280 may include a substantially D-shaped opening 285, although the cavity 280 may have a different shape (e.g., circular, elliptical, triangular, rectangular, etc.) in other forms.

[0062] In certain forms, the D-shaped opening 285 may be smaller than outer wall of the cavity 280. For example, the D-shaped opening 285 may be recessed from the first end 275. An opening of the cavity 285 may be substantially circular in shape and may be separate from the D-shaped opening.

[0063] A second end 290 may be opposite the first end 275 along the rotation axis 270. A first projection 295 may extend from the second end 290 in a direction substantially perpendicular to the rotation axis 270. In some forms, the first projection 295 may be integrally formed with the shaft 195, 240, although in other examples, the first projection 295 may be separately formed and connected to the shaft 195, 240 (e.g., via welding, molding, adhesive, etc.).

[0064] In some forms, the first projection 295 may include a curved surface 300 and a planar surface 305. As shown in FIG. 13, the curved surface 300 may include substantially the same radius of curvature as the shaft 265 and may directly contact the shaft 265. The curved surface 300 may extend away from the shaft 265 toward the planar surface 305. A length of the planar surface 305 may extend along the rotation axis 270 from the second end 290 at least partially toward the first end 275. The length of the first projection 295 may be at least as long length of the planar surface 305.

[0065] In some forms, the cam 195, 240 may include a second projection 310 disposed between the first and second ends 275, 290 and spaced apart from the first projection 295. The illustrated example shows the second projection 310 disposed closer

to the first end 275, although the second projection 310 may be disposed at any portion along the length of the shaft 265.

[0066] As shown in FIGS. 13 and 14, some forms of the second projection 310 may be similarly shaped to the first projection 295. For example, the second projection 310 may include a curved surface 315 and a planar surface 320.

[0067] In certain forms, the radius of curvature of the curved surface 315 of the second projection 310 may be larger than the radius of curvature of the curved surface 300 of the first projection 295. The curved surface 315 of the second projection 310 may not uniformly mate with the outer surface of the shaft 265.

[0068] The planar surface 315 of the second projection 310 may be substantially parallel with respect to the planar surface 305 of the first projection 295. In some forms, the planar surface 315 may have a smaller area than the planar surface 305. For example, the planar surface 315 may have a smaller length and/or a smaller width. The planar surface 305 (e.g., and therefore the second projection 310) may extend along the rotation axis 270 a lesser amount than the first projection 295.

[0069] In some forms, the first projection 295 and the second projection 310 may each extend in substantially opposite directions from one another. For example, the first and second projections 295, 310 may each extend along a direction substantially perpendicular with respect to the rotation axis 270 so that the planar surface 305 faces an opposite direction as the planar surface 320. In other words, the first and second projections 295, 310 may be oriented approximately 180 degrees apart.

[0070] In certain forms, the curved surface 300 of the first projection 295 and the curved surface 315 of the second projection 310 may be on the same side of the cam 195, 240. For example, the curved surfaces 300, 315 are on the same side of the shaft 265 when the cam 195, 240 is viewed along the rotation axis 270 (see e.g., FIGS. 13 and 14).

[0071] Returning to FIGS. 6 and 9, the first motor 200 and the second motor 245 are coupled to the respective first cam 195 and the second cam 240. The first motor 200 and the second motor 245 may be substantially like one another such that the description of either motor 200, 245 may be equally applicable to the other motor 200, 245.

[0072] Each motor 200, 245 may be connected to the first end 275 of the respective cam 195, 240. Specifically, a motor shaft 325 (see e.g., FIG. 15) may be received within the respective cavity 280. More specifically, the motor shaft 325 may include a substantially D-shape that is receivable within the D-shaped opening 285. The asymmetrical shape of the motor shaft 325 and the D-shaped opening 285 may permit only a single connection orientation and/or may limit slippage between the respective motor 200, 245 and cam 195, 235 when moving.

[0073] In some forms, the first motor 200 and the second motor 245 may move together. For example, a controller may control the movement of the first motor 200 and the second motor 245 so that they move in unison. In other examples, the first motor 200 and the second motor 245 may be controlled separately by the controller or each motor 200, 245 may be controlled by a separate controller.

[0074] In some forms, the first motor 200 and the second motor 245 are DC motors. For example, each motor 200, 245 may be a small geared DC motor. In other examples, other types of motors (e.g., servo motors) may be used.

[0075] As shown in FIG. 15, the female connector 105 may be assembled so that the first interlock 180 and the second interlock 185 are spaced apart from one another but substantially aligned. For example, the rotation axis 275 of each cam 195, 240 may be co-linear with one another. Although in other examples, the rotation axes 275 may be parallel with respect to one another, the rotation axes 275 may intersect one another.

[0076] In some forms, the female connector 105 may include an upper housing 330 containing the first and second interlocks 180, 185, and a lower housing 335 containing a plunger 340. Both the upper housing 330 and the lower housing 335 may extend between the first section 170 and the second section 175.

[0077] The plunger 340 may be an elongated member with a first end 345 and a second end 350 opposite to the first end 345. The first end 345 may be at least partially received within the lower housing 335 and the second end 350 may extend away so that it is at least partially outside of the lower housing 335.

[0078] In some forms, the plunger 340 may include a groove 355 disposed between the first and second ends 345, 350. The groove 355 may be similarly shaped to the coupler 215 so that the groove 355 can receive the coupler 215.

[0079] In some forms, a biasing member 360 is disposed within the lower housing 335 and is connected to the first end 345 of the plunger 340. The biasing member 360 may be a compression spring, although any type of biasing member may be used. As shown in FIG. 15, the biasing member 360 may be in a neutral position (e.g., uncompressed), in a not fully compressed position, or under tension. In other words, the biasing member 360 may not be fully compressed in the position illustrated in FIG. 15.

[0080] FIGS. 15 to 19 illustrate a first locked position of the female connector 105. The first locked position forms a state where the female connector 105 is separate from the male connector 110 and unable to connect to the male connector 110. In the first locked position, the first and second interlocks 180, 185 are positioned so that they block connection with the male connector 110.

[0081] Specifically, the first motor 200 drives the first cam 195 to rotate so that the first projection 295 pivots toward the lever 190. For example, the first cam 195 may be driven so that in the locked position, the planar surface 305 faces the undercut 232. In the illustrated example, the planar surface 305 may be in contact with the undercut 232 in the locked position, although in other examples, the planar surface 305 may be near the undercut 232.

[0082] As shown in FIGS. 16 and 17, the first cam 195 may be positioned so that in the locked position, the planar surface 305 contacts a center of the undercut 232. For example, the planar surface 305 may contact the undercut 232 in a center along a length and/or a width direction.

[0083] As shown in FIG. 16, the upper housing 330 may include a first stop 365 (e.g., a cantilevered stop) that extends from a lower portion of the upper housing 330 away from the lower housing 335. The first stop 365 may be disposed so that, in the locked position, the second projection 310 contacts the first stop 365.

[0084] The second motor 245 similarly drives the second cam 240 to rotate so that the projection 295 pivots toward the button 235. For example, the second cam 240 may be driven so that in the locked position, the planar surface 305 faces the lower flange 250. In the illustrated example, the planar surface 305 may be in contact with the lower flange 250 in the locked position, although in other examples, the planar surface 305 may be near the lower flange 250.

[0085] As shown in FIGS. 10, 18, and 19, the second cam 240 may be positioned so that in the locked position, the planar surface 305 contacts a center of the lower flange 250. For example, the planar surface 305 may be in contact with the lower flange 250 in a center along a length and/or width direction.

[0086] As shown in FIG. 18, the upper housing 330 may include a second stop 370 (e.g., a cantilevered stop) that extends from a lower portion of the upper housing 330 away from the lower housing 335. The second stop 370 may be disposed so that, in the locked position, the second projection 310 contacts the second stop 370.

[0087] Rotating the first and second cams 195, 240 to the locked position secures the first and second interlocks 180, 185 in the first locked position. For example, the contact between the planar surface 305 of the second cam 240 and lower flange 250 may limit downward movement of the button 235. The planar surface 305 may support the button 235 against the spring bias of the biasing member 260. As shown in FIG. 15, the upper locking portion 255 of the button 235 may extend through the upper housing 330 so that it is at least partially exposed. In this position, the upper locking portion 255 may act as a stop to block the male connector 110 from being slide over the second section 175 toward the first section 170.

[0088] Additionally, the contact between the planar surface 305 of the first cam 195 and the undercut 232 may limit rotation of the lever 190 about the shaft 230. The planar surface 305 may support the button 210 via the undercut 232 in a first position where the button 210 extends through the upper housing 330 so that it is at least partially exposed. In this position, the coupler 215 may extend through the upper housing 330 and into the lower housing 335. Specifically, the groove 355 of the plunger 340 may be aligned with the coupler 215 so that the coupler 215 is received within the groove 355. The undercut region 220 may hook around an edge of the lower housing 335 and pass into the groove 355 to secure the plunger 340 in place. In this position, the second end 350 of the plunger 340 is positioned near a free end of the second section 175. The plunger 340 may further block the insertion of the male connector 110 onto the second section 175 of the female connector 105.

[0089] In some forms, positioning the planar surfaces 305 in a center of the respective undercut 232 and lower flange 250 limits any moment created when a force is applied to

the button 210 and/or to the top surface of the upper locking portion 255. For example, a user may apply a force (e.g., inadvertently) to the upper surface of the button 210 and/or the upper locking portion 255. This force may be applied along an axis that substantially intersects with a center of the respective planar surface 305. Additionally, the area of each planar surface 305 may be sufficiently large enough to account for minor deviations in locations of force application. Accordingly, an axis through which the force is applied may pass perpendicularly to the respective planar surface 305 and the distance between the axis and the center of the respective planar surface 305 may be substantially small. The small moment may therefore limit the likelihood that the respective cam 195, 240 fails because of an applied force. Limiting failure of the cams 195, 240 (and therefore maintaining the lever 190 and the button 235 in the locked position) assists in limiting improper engagement of the male connector 110 to the female connector 105.

[0090] In certain forms, the lever 190 may be biased toward its locked position (e.g., where the button 210 extends from the upper housing 330). For example, a spring (not shown) may be positioned around the shaft 230 to maintain the lever 190 in this position (e.g., FIG. 15). This may assist in maintaining a connection between the coupler 215 and another element even while the cam 195 is not in the locked position. Providing a force to the button 210 (e.g., with a user's finger) may be sufficient to overcome the spring bias and move the lever 190.

[0091] In some forms, the stops 365, 370 may assist in ensuring that the cams 195, 240 are properly oriented. As described above, the first and second motors 200, 245 may be DC motors. These types of motors may be movable in different directions (e.g., forward and reverse) but may not be controllable to a specific position. In other words, DC motors 365, 370 may not be controllable to the locked position illustrated in FIGS. 15 to 19. The respective stops 365, 370 may act as a rotational stop to uniformly control the rotation of each cam 195, 240. In other words, contact between the respective second projection 310 and stop 365, 370 limits further rotational movement and prevents the motor 365, 370 from over rotating.

[0092] In certain forms, each cam shaft 265 may be at least partially supported by a respective one of the stops 365, 370. For example, each cam shaft 265 may rest on top of the respective stop 365, 370 so that each shaft 265 is supported between the first end

275 and the second end 290. In the event a force is applied to either cam 195, 240 via the planar surface 305, the respective stop 365, 370 provides support and limits a bending moment that could cause failure.

[0093] In certain forms, the shape of the button 235 may further assist in preventing improper connection between the male connector 110 and the female connector 105. As described above, the upper locking portion 255 of the button 235 may be substantially cylindrical in shape such that walls of the upper locking portion 255 are not substantially sloped or curved. This shape assists in limiting inadvertent slippage of the male connector 110 over the upper locking portion 255 because the absence of a curved surface limits the ability of the male connector 110 to slide over the upper locking portion 255. Even if the male connector 110 was able to move past the upper locking portion 255 (e.g., because of a second cam 240 failure), the plunger 340 would provide a secondary blocking mechanism to limit further translation of the male connector 110 toward the first portion 170 of the female connector 105.

[0094] As shown in FIGS. 20 to 21, the motors 200, 245 may drive the respective cams 195, 240 to rotate out of the locked position and to the unlocked position. The illustrated unlocked position may be approximately 90 degrees from the locked position, although any position may be used. In the unlocked position, the cams 195, 240 move so that the respective planar surface 305 no longer contacts the undercut 232 or the lower flange 250. Each planar surface 305 may face a side of the female connector 105 so that the respective curved surface 300, 315 faces toward the undercut 232 and the lower flange 250.

[0095] The upper housing 330 may include a third stop 375 proximate to the first cam 195 and a fourth stop 380 proximate to the second cam 240. The third stop 375 may include a surface oriented approximately 90 degrees from the surface of the first stop 365, and the fourth stop 380 may include a surface oriented approximately 90 degrees from the surface of the second stop 370. The surfaces of the third and fourth stops 375, 380 may also face the lever 190 and the button 235 respectively.

[0096] As described above, the motors 200, 240 may be DC motors and may not be controllable to rotate to stop at a specific position. The third and fourth stops 375, 380 may function similarly to the first and second stops 365, 370 by limiting rotational

movement of the cams 195, 240 past a predetermined point to consistently define an unlocked position.

[0097] In the illustrated unlocked position, the lever 190 and the button 235 may be free to move. For example, the lever 190 may pivot in a counterclockwise direction (e.g., as viewed in FIG. 22) so that the undercut 232 moves toward the shaft 265. As this occurs, the coupler 215 may pivot in the counterclockwise direction so that it moves out of the lower housing 335 and into the upper housing 330. Specifically, the undercut region 220 moves out of engagement with the groove 355.

[0098] In some forms, the biasing member 360 may be in a neutral position in the first locked position (see e.g., FIG. 15). When the first the first cam 195 is pivoted to the unlocked position and a force is applied to the button 210 so that the coupler 215 pivots out of the groove 355, the plunger 340 may remain in the locked position (see e.g., FIG. 22). For example, the biasing member 360 may not be substantially under tension when the coupler 215 is received within the groove 355. When the first cam 195 is pivoted, there may be substantially no spring force applied to the plunger 340 such that the plunger 340 is not immediately pulled at least partially into the lower housing 335. However, the plunger 340 may be movable when an outside force is applied because it is not constrained by the lever 190. As described later, movement of the plunger 340 into the lower housing 335 may compress the biasing member 360 and produce a spring force directed toward the second section 175.

[0099] In other forms, the biasing member 360 may be in tension in the first locked position (see e.g., FIG. 15). When the first cam 195 is pivoted to the unlocked position and a force is applied to the button 210 so that the coupler 215 pivots out of the groove 355, a spring force of the biasing member 360 may return the biasing member toward a neutral position (e.g., the length of the biasing member 360 may contract as tension in the biasing member is reduced). The spring force may draw the biasing member 360, and therefore the plunger 340 toward the retracted position in FIG. 23. In this position, the plunger 340 may be substantially or entirely within the lower housing 335 and not blocking the insertion of the male connector 110.

[0100] In addition, the button 235 may move into the upper housing 330 toward the shaft 265. As described above, the biasing member 260 may be connected to the button

235 so that it is in tension when the second cam 240 rotates to the locking position. When the second cam 240 is rotated toward the unlocked position, the position of the first projection 295 no longer counteracts the spring bias of the biasing member 260. The biasing member 260 may move toward a neutral position, which may pull the button 235 (e.g., the upper locking portion 255) into the upper housing 330. As illustrated in FIG. 23, the top of the upper locking portion 255 may be substantially flush with the outer surface of the second portion 175. In this position, the upper locking portion 255 may not provide an obstruction for a male connector 110 to be inserted onto the second portion 175.

[0101] As shown in FIGS. 24 and 25, the male connector 110 may be connected to the female connector 105 by moving the male connector 110 onto the second portion 175 of the female connector 105 in the direction of the first portion 170. This may establish an electrical connection between cables connected to female connector 105 and the male connector 110 respectively.

[0102] As shown in FIG. 25, the male connector 110 may include a body 385 having a cavity 390 shaped and sized to receive the second portion 175 of the female connector 105. While the second cam 240 is in the unlocked position and the upper locking portion 255 does not extend substantially above the surface of the second portion 175, the male connector 110 may move along the second portion 175 toward the first portion 170 in a substantially unobstructed way.

[0103] The male connector 110 may include an opening 395. When the male connector 110 is fully inserted onto the female connector 105, the button 235 may be aligned with the opening 395. In the illustrated example, the dimensions of the opening 395 may be greater than the dimension of the button 235 (e.g., the upper locking portion 255). In other examples, the dimension of the opening 395 may be approximately the same as the dimension of the button 235.

[0104] In some forms, the male connector 110 may include a groove 400 that has a similar shape to the groove 355 of the plunger 340. As described in more detail below, the lever 190 (e.g., the coupler 215) may be received within the groove 400 to secure the male connector 110 to the female connector 105.

[0105] In some forms, the plunger 340 may remain in the extended position (e.g., at least partially extending from the lower housing 335). As the male connector 110 is

moved onto the second portion 175 toward the first portion 170, the male connector 110 applies a force to the first end 350 of the plunger 340. This force may exceed the spring force of the biasing member 360 and cause the biasing member 360 to compress, which allows the plunger 340 to move into the lower housing 335. The plunger 340 may remain in this retracted position while the male connector 110 remains in contact with the first end 350. In other examples, the plunger 340 may be in the retracted position prior to the male connector 110 contacting the first end 350.

[0106] As the male connector 110 moves toward the first portion 170 of the female connector 105, the groove 355 may be moved out of alignment with the coupler 215 and the groove 400 may be moved toward alignment with the coupler 215. When the male connector 110 is fully inserted, the groove 400 may be positioned at approximately the same position as the groove 355 was in the first locked position (see e.g., FIG. 15).

[0107] Once the male connector 110 is fully inserted, the first and second motors 200, 245 may drive the respective cams 195, 240 to rotate toward the locked position. This rotation causes the first projection 295 of each cam 195, 240 to move away from the third and fourth stops 370, 380 respectively, and causes the second projection 310 of each cam 195, 240 to move toward the first and second stops 365, 370 respectively.

[0108] As the first cam 195 is driven to rotate toward the locked position, the curved surface 300 rotates toward the undercut region 220 and the planar surface 305 eventually contacts the undercut region 220. Contact between the first cam 195 and the undercut region 220 drives the lever 190 to pivot. Specifically, the button 210 may move so that it extends out of the upper housing 330 and the coupler 215 moves so that it extends into the lower housing 335. The button 210 may be assessable for a user to engage and the coupler 215 may extend into the groove 400. As the coupler 215 enters the groove 400, the undercut region 220 may engage an edge of the groove 400 and the lower housing 335 to limit disassembly of the male connector 110 from the female connector 105 (e.g., by moving the male connector 110 away from the first portion 170).

[0109] As the second cam 240 is driven toward the locked position, the curved surface rotates toward the lower flange 250 and the planar surface 305 eventually contacts the lower flange 250. Contact between the second cam 240 and the lower flange 250 drives

the button 235 to move against the spring bias of the biasing member 260 so the button 235 extends at least partially out of the upper housing 330.

[0110] In some forms, the button 235 may be aligned with the opening 395 so that the upper locking portion 255 is at least partially received within the opening 395. As shown in FIG. 25, the top of the upper locking portion 255 may be substantially flush with the outer surface of the male connector 110. In the locked position, the upper locking portion 255 may limit the ability of the male connector 110 to be removed from the female connector 105. In certain forms, the substantially cylindrical shape of the upper locking portion 255 may assist in limiting forceful disengagement of the male connector 110. As described above, the angled shape (e.g., as opposed to a rounded shape) of the upper locking portion 255 limits the ability of the male connector 110 to slip over the button 235 and disconnect despite the second cam 240 being in the locked position.

[0111] The second locked position may be defined when the male connector 110 is connected to the female connector 105 and both cams 195, 240 have returned to the locked position, thereby securing the two connectors 105, 110 together. In this position, an electrical connection may be formed between the female and male connectors 105, 110 so that electrical current may pass between the two. The first and second interlocks 180, 185 may prevent the connectors 105, 110 from being disassembled while current is flowing.

[0112] In some forms, the controller may control the first and/or second motor 200, 245 to rotate based on the presence of absence of the male connector 110. For example, the female and male connectors 105, 110 may be disconnected and the controller may detect when electrical current is applied to the female connector after it is connected to the male connector 110 is connected. The cams 195, 240 may be initially in the unlocked position (see e.g., FIG. 22). At this point, the controller may direct the motors 200, 245 to drive the cams 195, 240 to the locked position (see e.g., FIG. 25). When the cams 195, 240 contact the respective stops 365, 370, the respective motors 200, 245 are stalled. Current may surge through each of the motors 200, 245 when they are stalled. The controller can sense a surge in the motors 200, 245 and can stop the flow of current to the motors 200, 245. Cutting off power to the motors 200, 245 after contact with the respective stops 365, 370 may assist in limiting damage to the motors 200, 245 (e.g.,

from overheating). The controller may keep the cams 195, 240 in the locked position until current is removed and it is safe to disconnect the female and male connectors 195, 240.

[0113] One of ordinary skill will appreciate that the exact dimensions and materials are not critical to the disclosure and all suitable variations should be deemed to be within the scope of the disclosure if deemed suitable for carrying out the objects of the disclosure.

[0114] One of ordinary skill in the art will also readily appreciate that it is well within the ability of the ordinarily skilled artisan to modify one or more of the constituent parts for carrying out the various examples of the disclosure. Once armed with the present specification, routine experimentation is all that is needed to determine adjustments and modifications that will carry out the present disclosure.

[0115] The above examples are for illustrative purposes and are not intended to limit the scope of the disclosure or the adaptation of the features described herein. Those skilled in the art will also appreciate that various adaptations and modifications of the above-described preferred examples can be configured without departing from the scope and spirit of the disclosure. Therefore, it is to be understood that, within the scope of the appended claims, the disclosure may be practiced other than as specifically described.

CLAIMS

What is claimed is:

1. An electrical connector assembly comprising:

a first electrical connector including at least one locking feature;

a second electrical connector including;

a motor,

at least one locking member movably engageable with the at least one locking feature,

at least one cam driven by the motor and including a first cam portion and a second cam portion, wherein the at least one cam is rotatable between a locked position where the first cam portion contacts the at least one locking member and prevents movement of the at least one locking member and an unlocked position where the first cam portion is spaced apart from the at least one locking member and allows movement of the at least one locking member, and

a ledge including a first ledge portion and a second ledge portion angularly displaced from the first ledge portion, wherein the second cam portion contacts the second ledge portion in the locked position, and wherein the first cam portion contacts the first ledge portion in the unlocked position.

2. The electrical connector assembly of claim 1, wherein a center of the at least one locking member is movable about a locking axis, and wherein a center of the first cam portion is positioned along the locking axis while in the locked position.

3. The electrical connector assembly of claim 1, wherein the at least one locking member includes a squared shape in cross section.

4. The electrical connector assembly of claim 1, wherein the at least one locking member is biased toward the unlocked position, and wherein the movement of the at least one cam toward the locked position is configured to overcome the bias.

5. The electrical connector assembly of claim 1, further comprising a sensor for sensing a voltage level, wherein the motor drives the at least one cam to the locked position when the sensor senses a voltage level above a predetermined threshold, and

wherein the motor drives the at least one cam to the unlocked position when the sensor senses a voltage below the predetermined threshold.

6. The electrical connector assembly of claim 1, wherein:

the at least one locking member includes a first locking member and a second locking member spaced apart from the first locking member;

the at least one cam includes a first cam and a second cam, wherein the first cam is associated with the first locking member and the second cam is associated with the second locking member;

the first cam includes a first support surface configured to be substantially perpendicular to a first force applied to the first locking member while the first cam is in the locked position; and

the second cam includes a second support surface configured to be substantially perpendicular to a second force applied to the second locking member while the second cam is in the locked position.

7. A first electrical connector of an electrical connector assembly, the first electrical connector comprising:

a housing;

a cam disposed within the housing and driven to rotate by a motor, the cam including a shaft having a first projection and a second projection spaced apart from the first projection;

a first locking member disposed at least partially within the housing and configured to releasably secure the first electrical connector to a second electrical connector, the first locking member is configured to receive a force to move the first locking member from a secured position to an unsecured position;

wherein the cam is configured to move between a locked position where the first projection contacts the first locking member and an unlocked position where the first projection is spaced apart from the first locking member; and

wherein the force is configured to be applied in a direction substantially perpendicular to the first projection in the locked position.

8. The first electrical connector of claim 7, wherein the first locking member is a lever that includes a first end with a button, a second end with an undercut, and a pivot

point disposed between the first end and second end, wherein the button is configured to receive the force and the undercut is configured to selectively engage the second electrical connector.

9. The first electrical connector of claim 8, wherein the button includes a first planar surface and the first projection includes a second planar surface, and wherein the second planar surface is oriented substantially parallel to the first planar surface when the cam is in the locked position.

10. The first electrical connector of claim 7, wherein the first locking member is a button that includes an upper locking portion and a lower flange, and wherein a biasing member is connected to the lower flange and configured to bias the first locking member into the housing.

11. The first electrical connector of claim 10, wherein the upper locking portion is substantially cylindrical in shape and extends substantially perpendicular from the lower flange.

12. The first electrical connector of claim 7, wherein the housing includes a first stop surface and a second stop surface spaced apart from the first stop surface, wherein the first projection contacts the first stop surface in the unlocked position and the second projection contacts the second stop surface in the locked position.

13. The first electrical connector of claim 7, wherein the first projection is disposed about 180 degrees from the second projection along the shaft, and wherein the first stop surface is disposed about 90 degrees from the second stop surface.

14. A first electrical connector of an electrical connector assembly, the first electrical connector comprising:

a housing having a first stop surface and a second stop surface;

a cam disposed within the housing and driven to rotate by a motor, the cam including a shaft having a first projection and a second projection spaced apart from the first projection;

a first locking member disposed at least partially within the housing and configured to releasably secure the first electrical connector to a second electrical connector;

wherein the cam is configured to move between a locked position where movement of the first locking member is limited and an unlocked position where the first locking member is movable; and

wherein the locked position is a first predetermined location where the second projection contacts the second stop surface and the unlocked position is a second predetermined location where the first projection contacts the first stop surface.

15. The first electrical connector of claim 14, wherein the first locking member is a lever that includes a first end with a button, a second end with an undercut, and a pivot point disposed between the first end and second end, wherein the button is configured to receive the force and the undercut is configured to selectively engage the second electrical connector.

16. The first electrical connector of claim 15, wherein the button includes a first planar surface and the first projection includes a second planar surface, and wherein the second planar surface is oriented substantially parallel to the first planar surface when the cam is in the locked position.

17. The first electrical connector of claim 14, wherein the first locking member is a button that includes an upper locking portion and a lower flange, and wherein a biasing member is connected to the lower flange and configured to bias the first locking member into the housing.

18. The first electrical connector of claim 17, wherein the upper locking portion is substantially cylindrical in shape and extends substantially perpendicular from the lower flange.

19. The first electrical connector of claim 14, wherein the first projection is disposed about 180 degrees from the second projection along the shaft, and wherein the first stop surface is disposed about 90 degrees from the second stop surface.

20. The first electrical connector of claim 14, wherein the second stop surface at least partially supports the shaft in the locked position and the unlocked position.

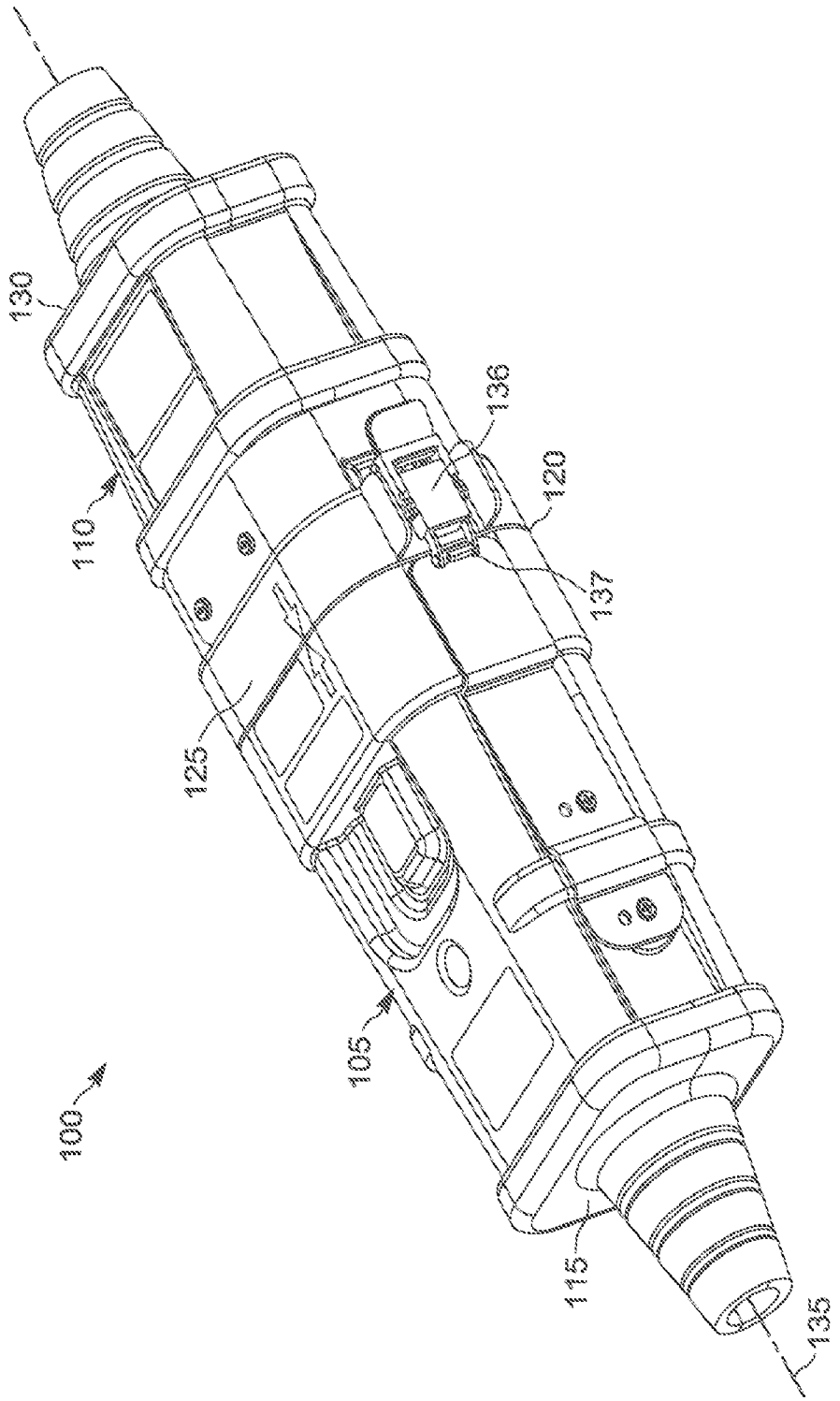

FIG. 1

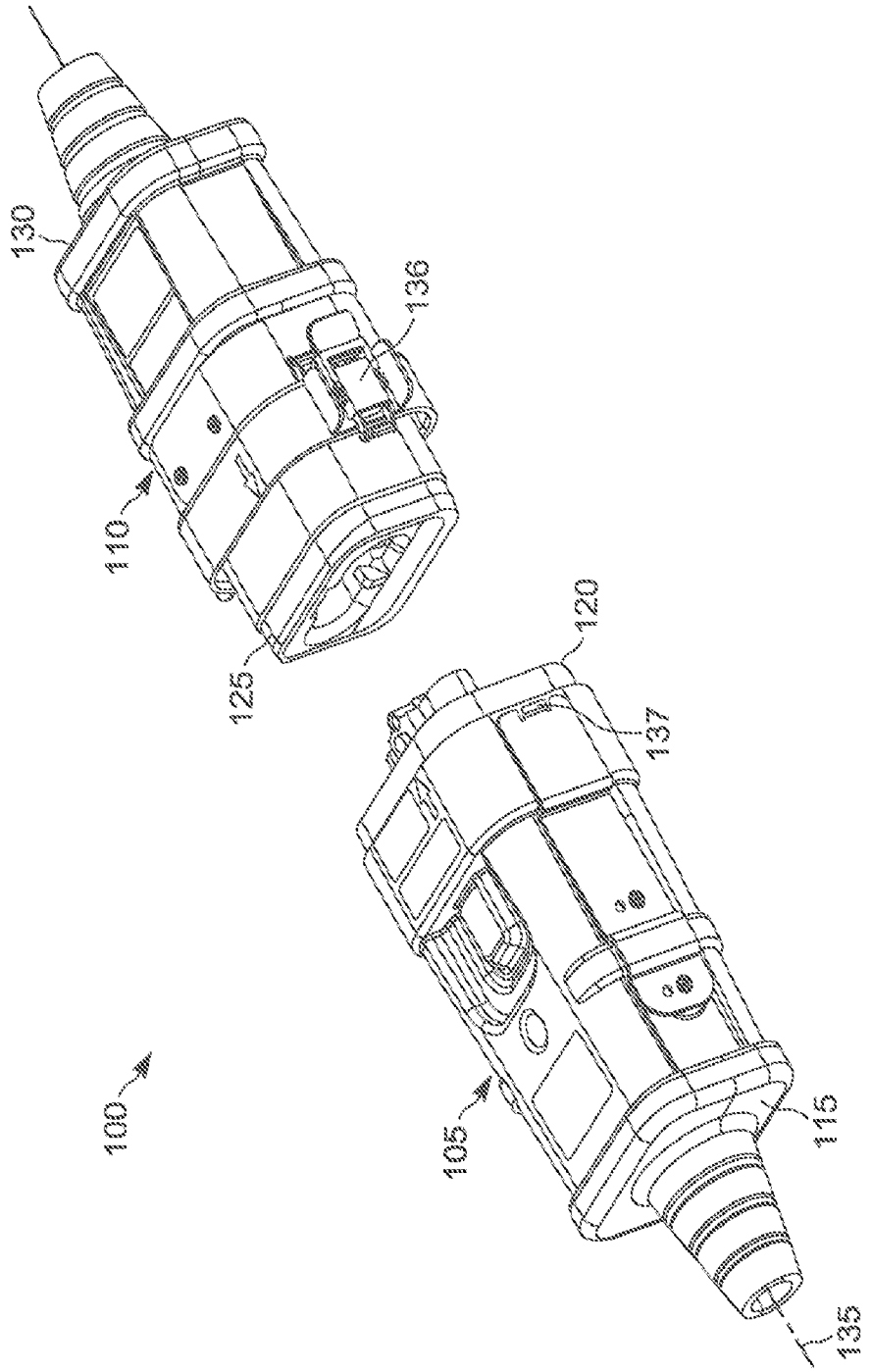

FIG. 2

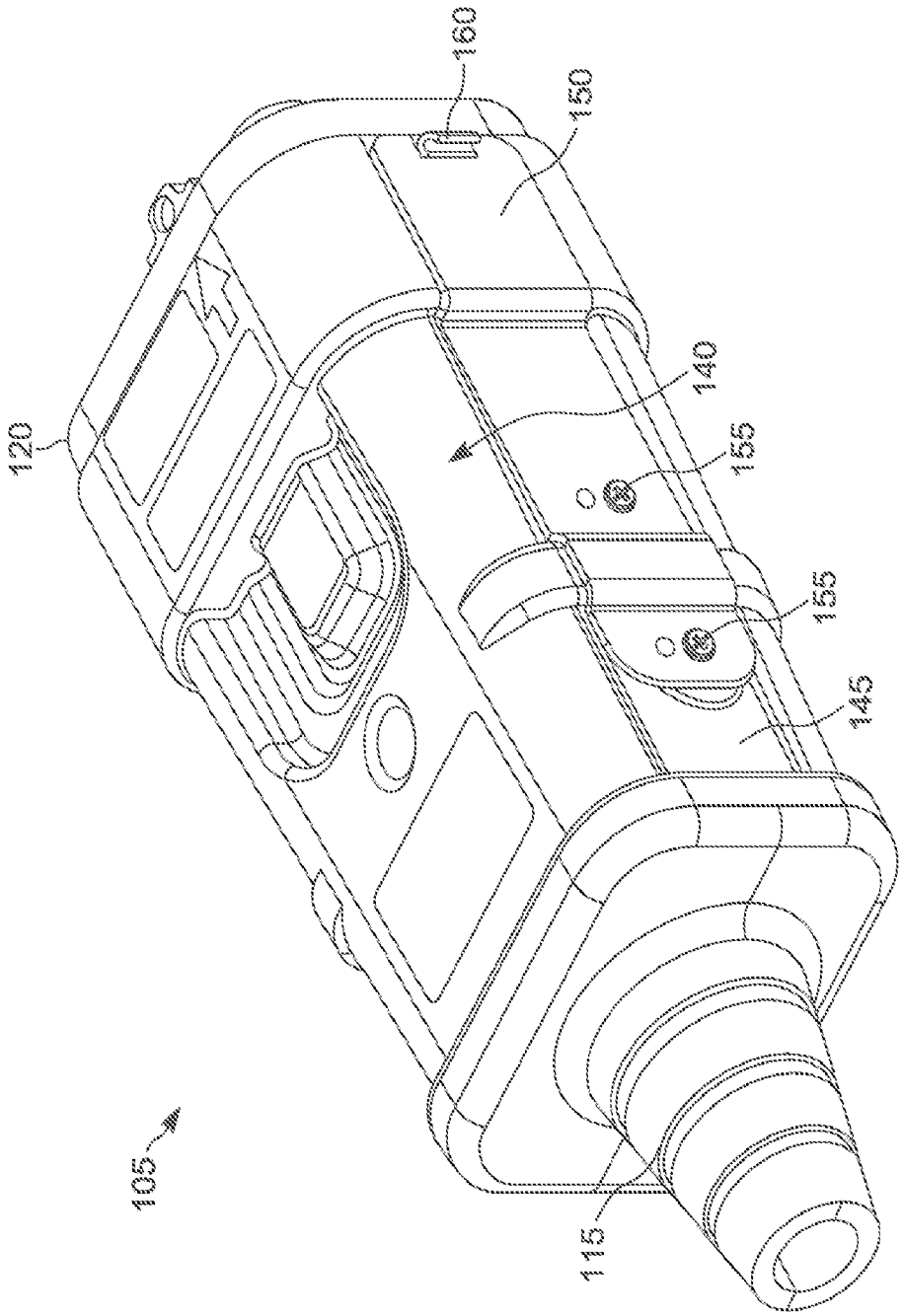

FIG. 3

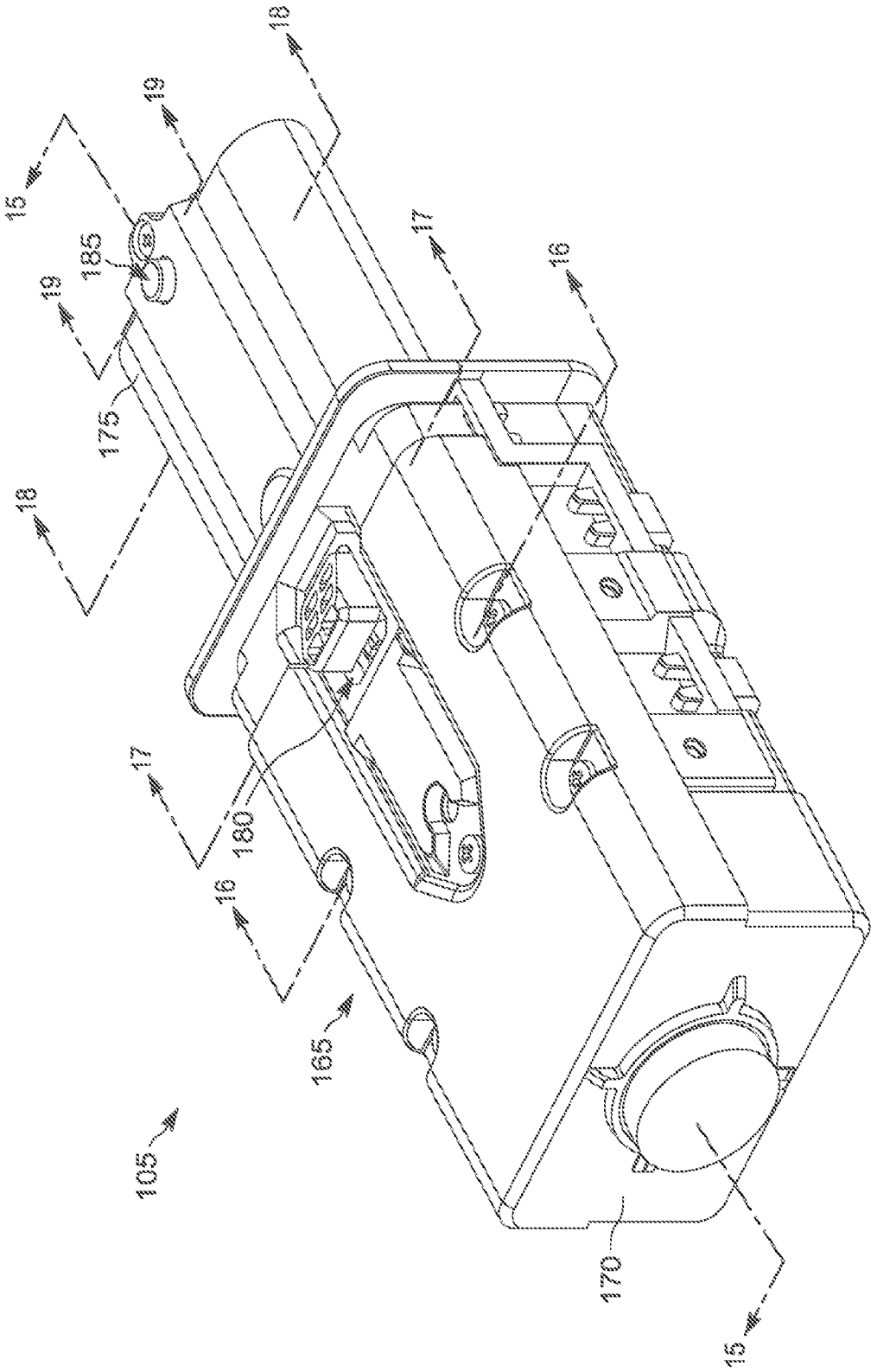

FIG. 4

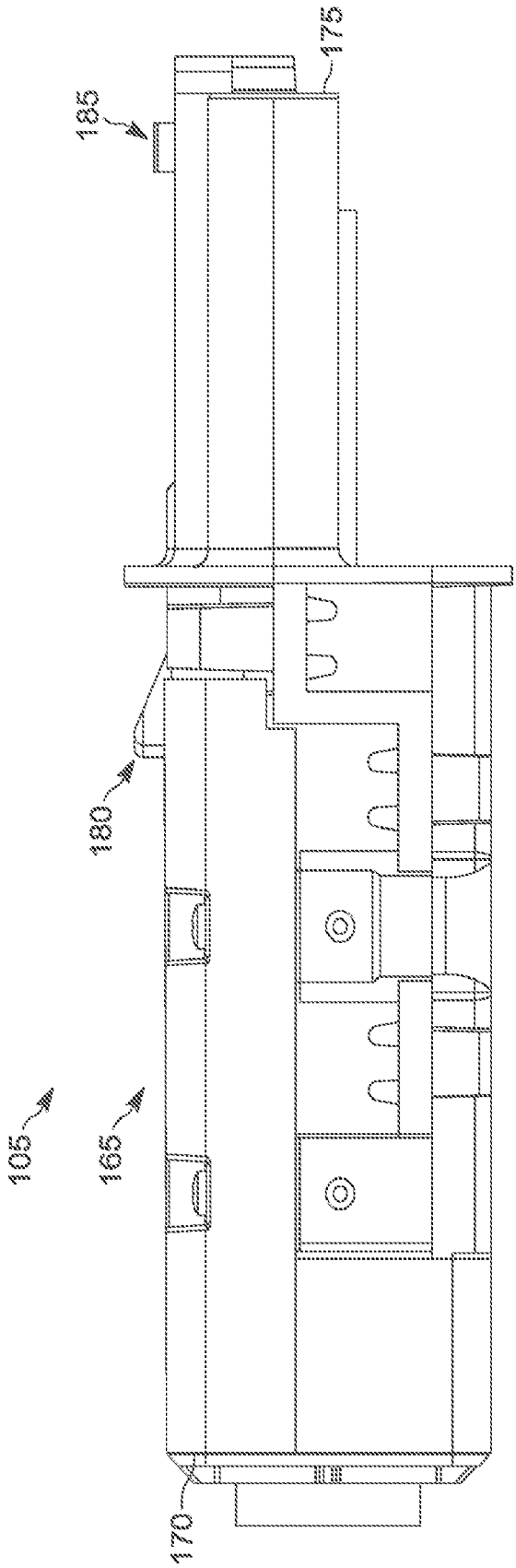

FIG. 5

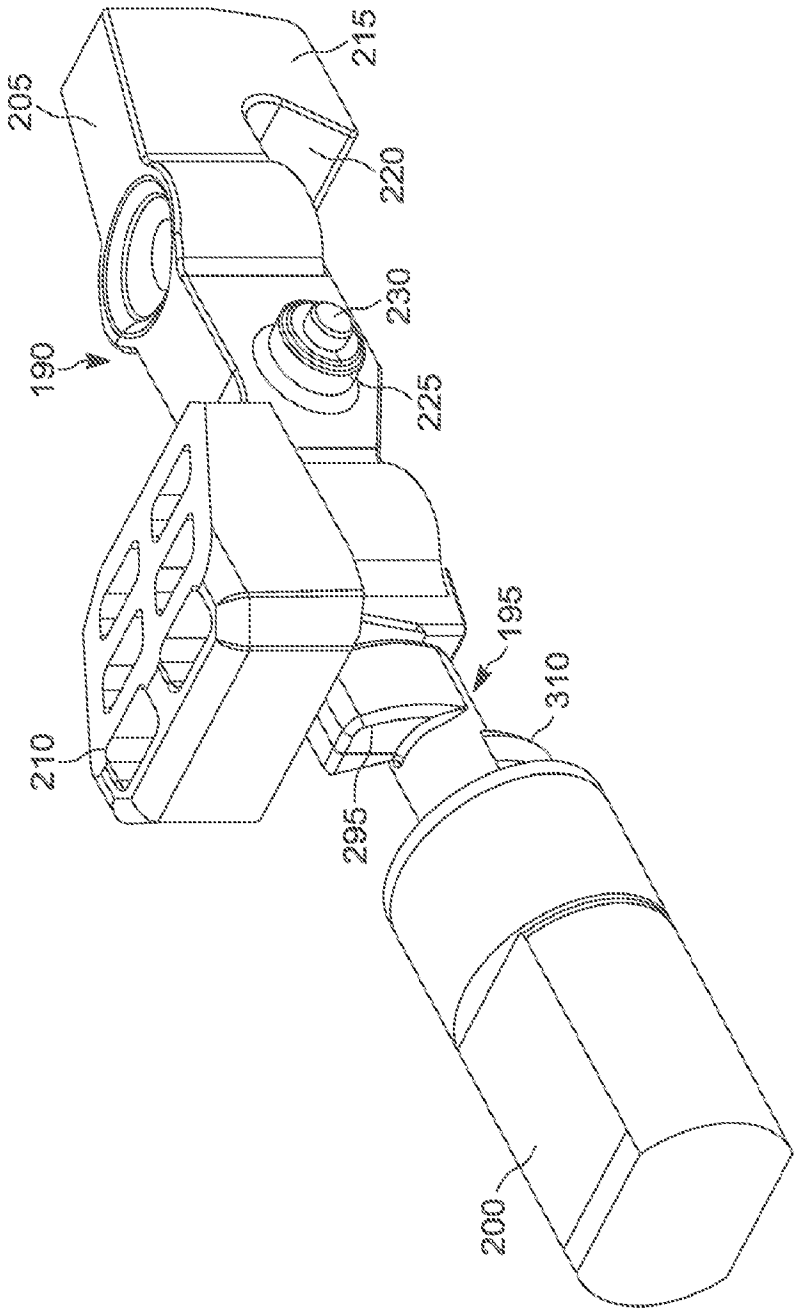

FIG. 6

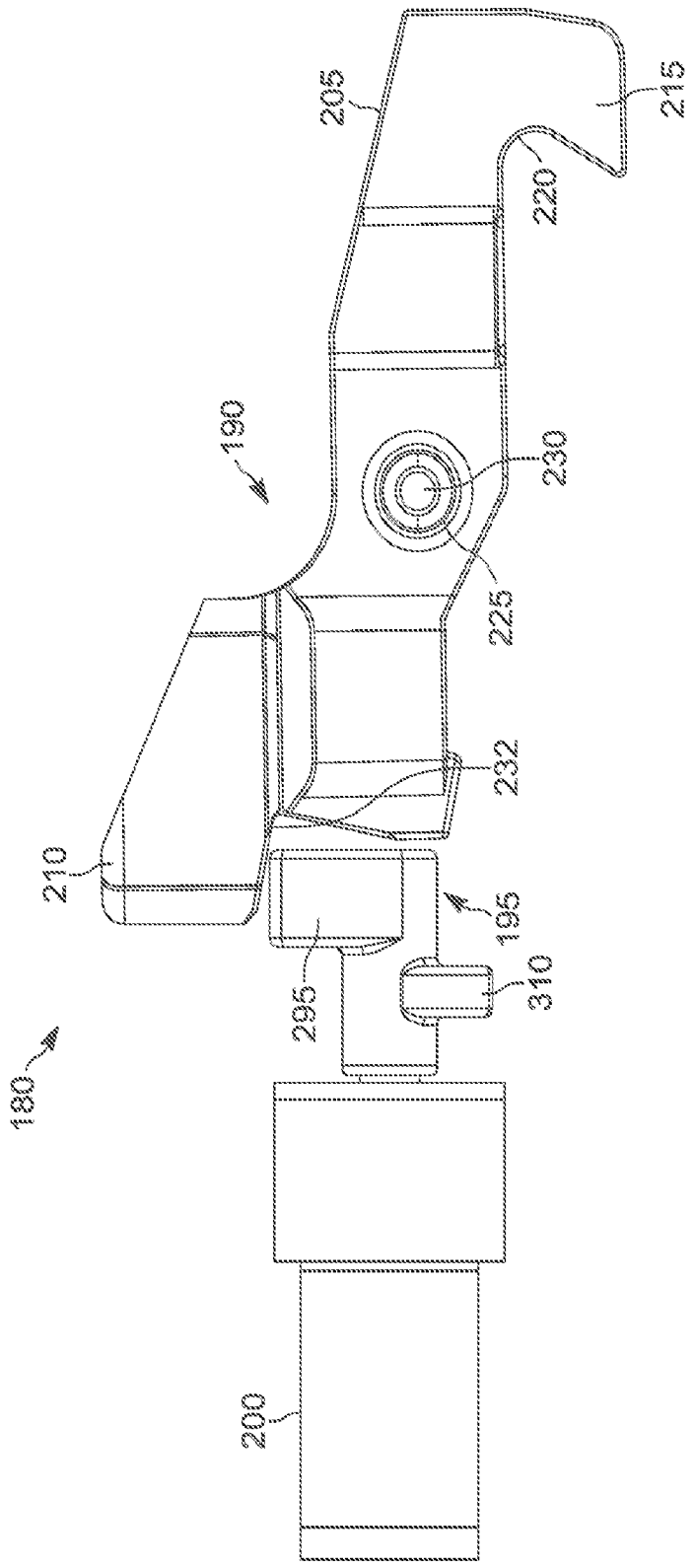

FIG. 7

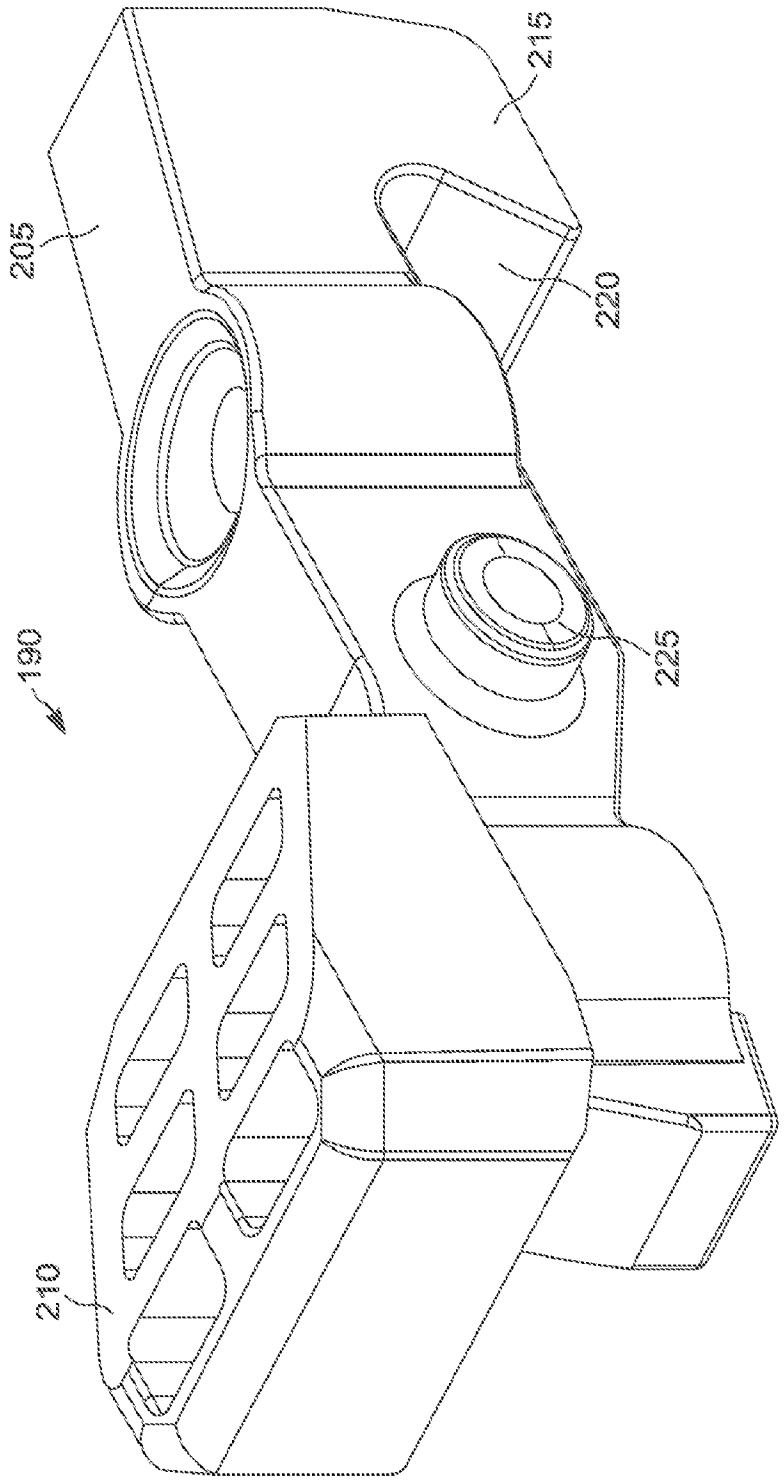

FIG. 8

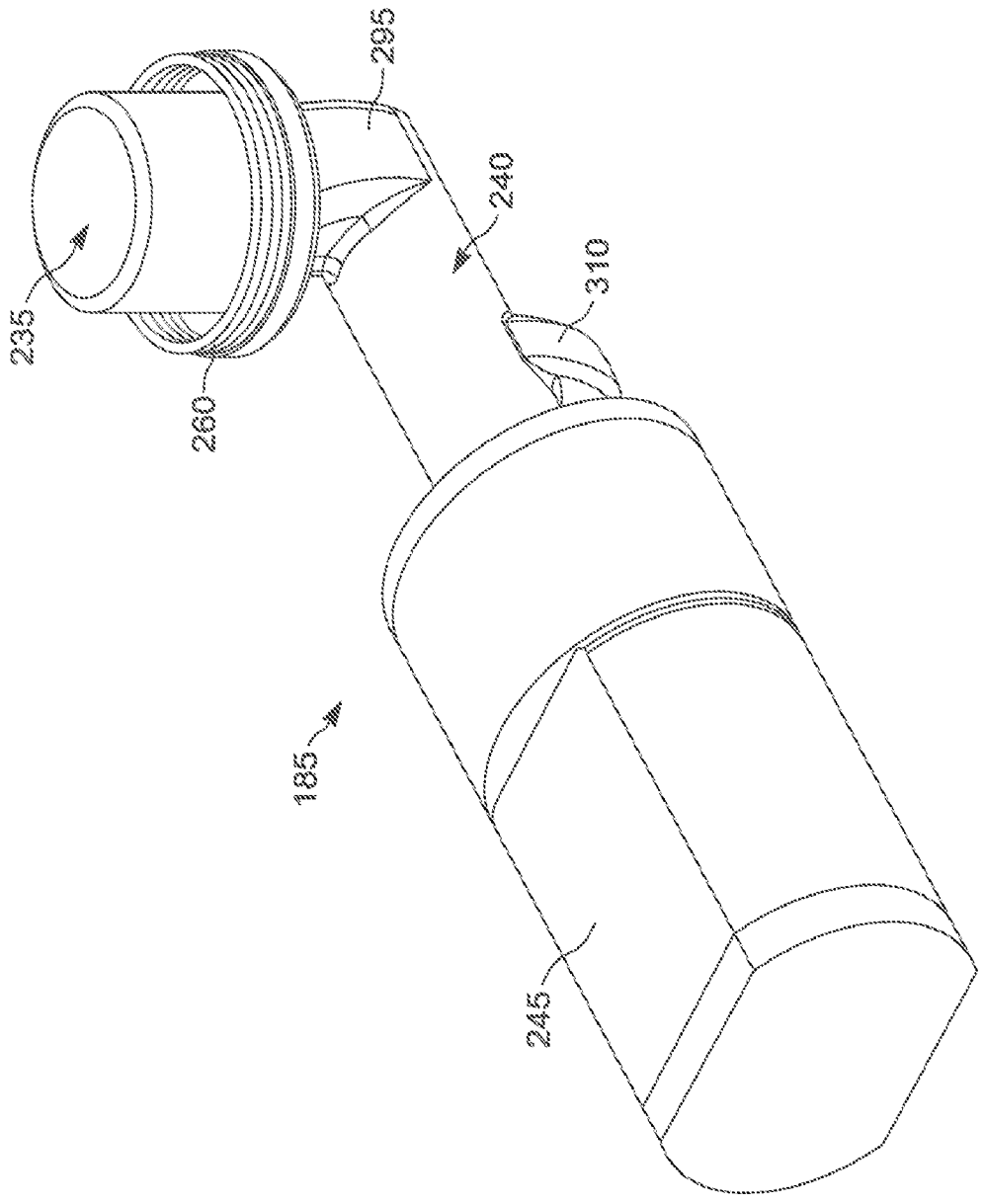

FIG. 9

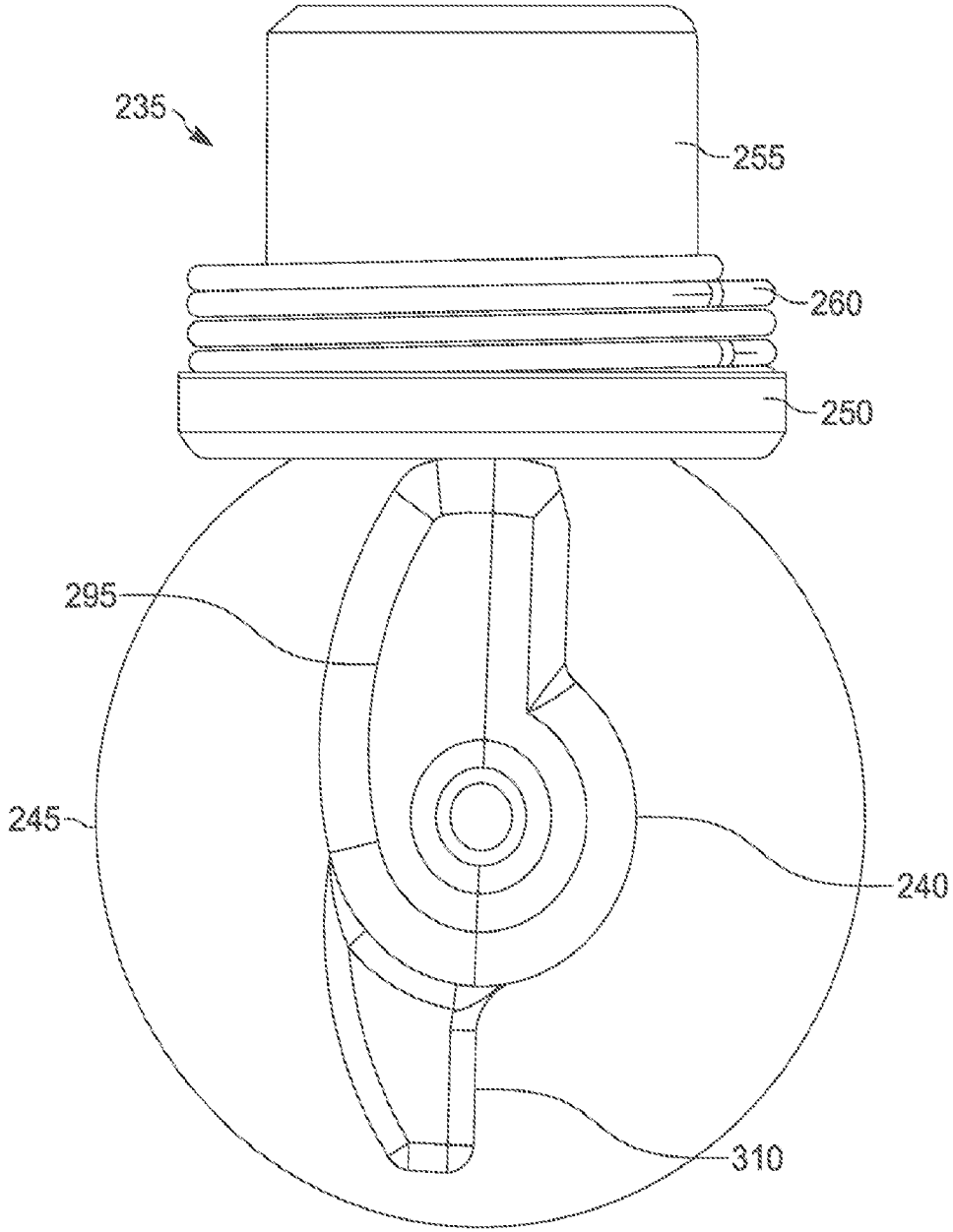

FIG. 10

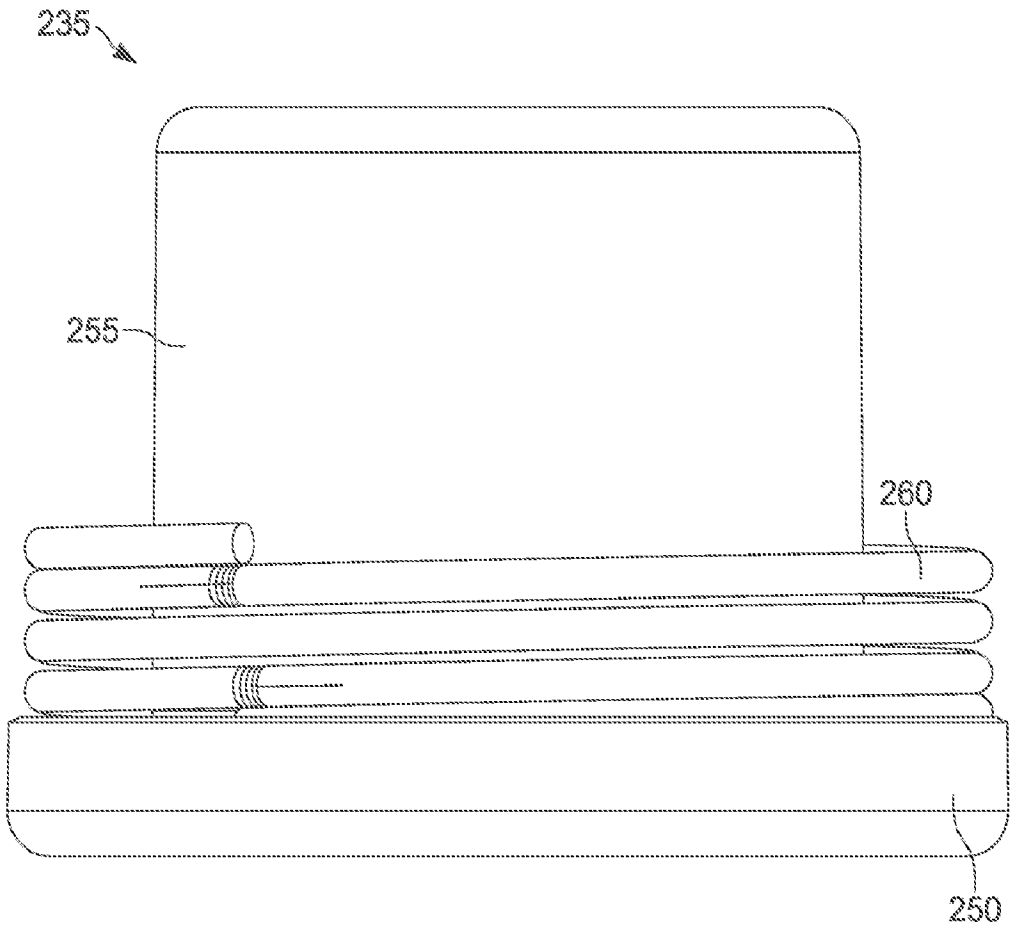

FIG. 11

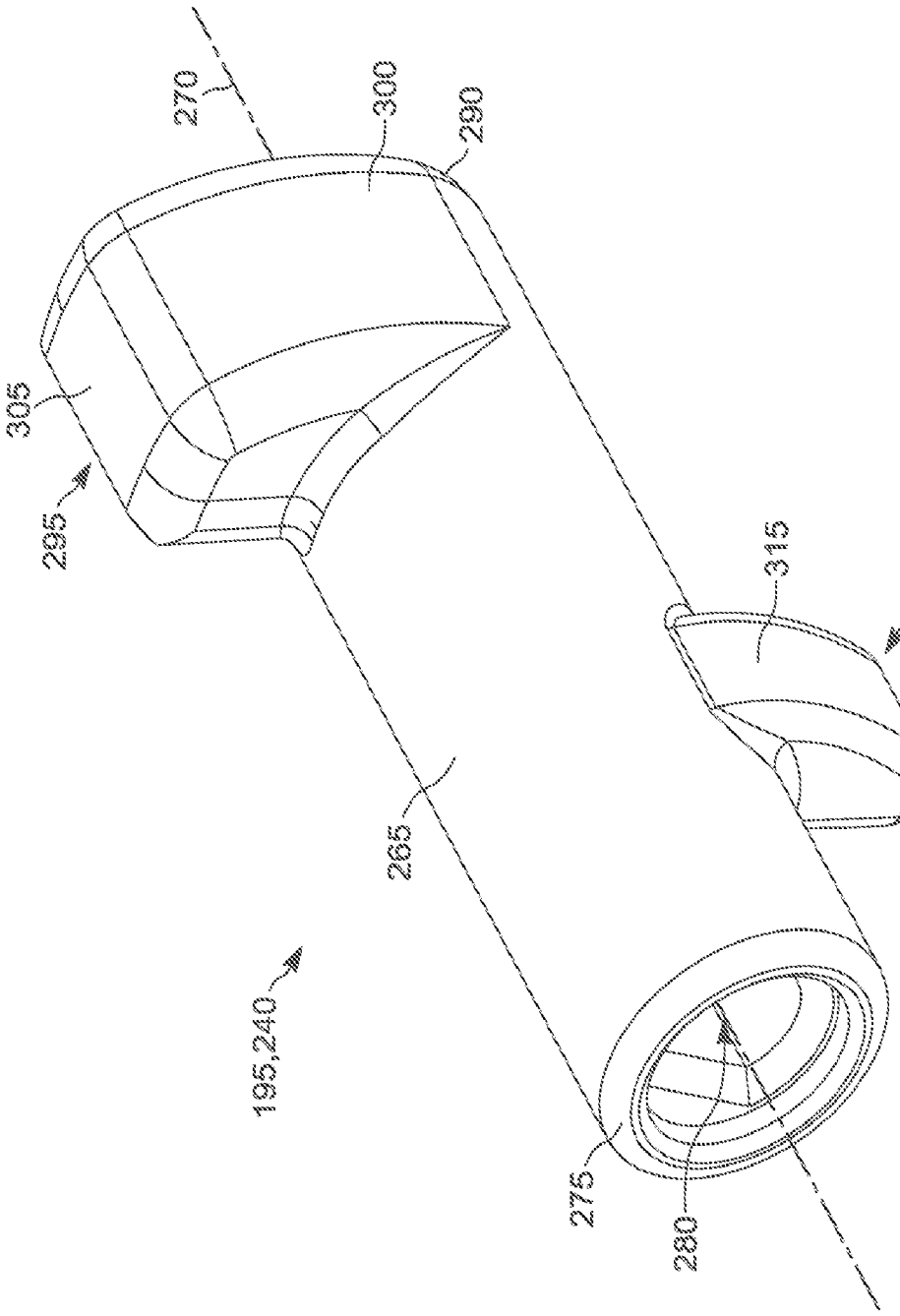

FIG. 12

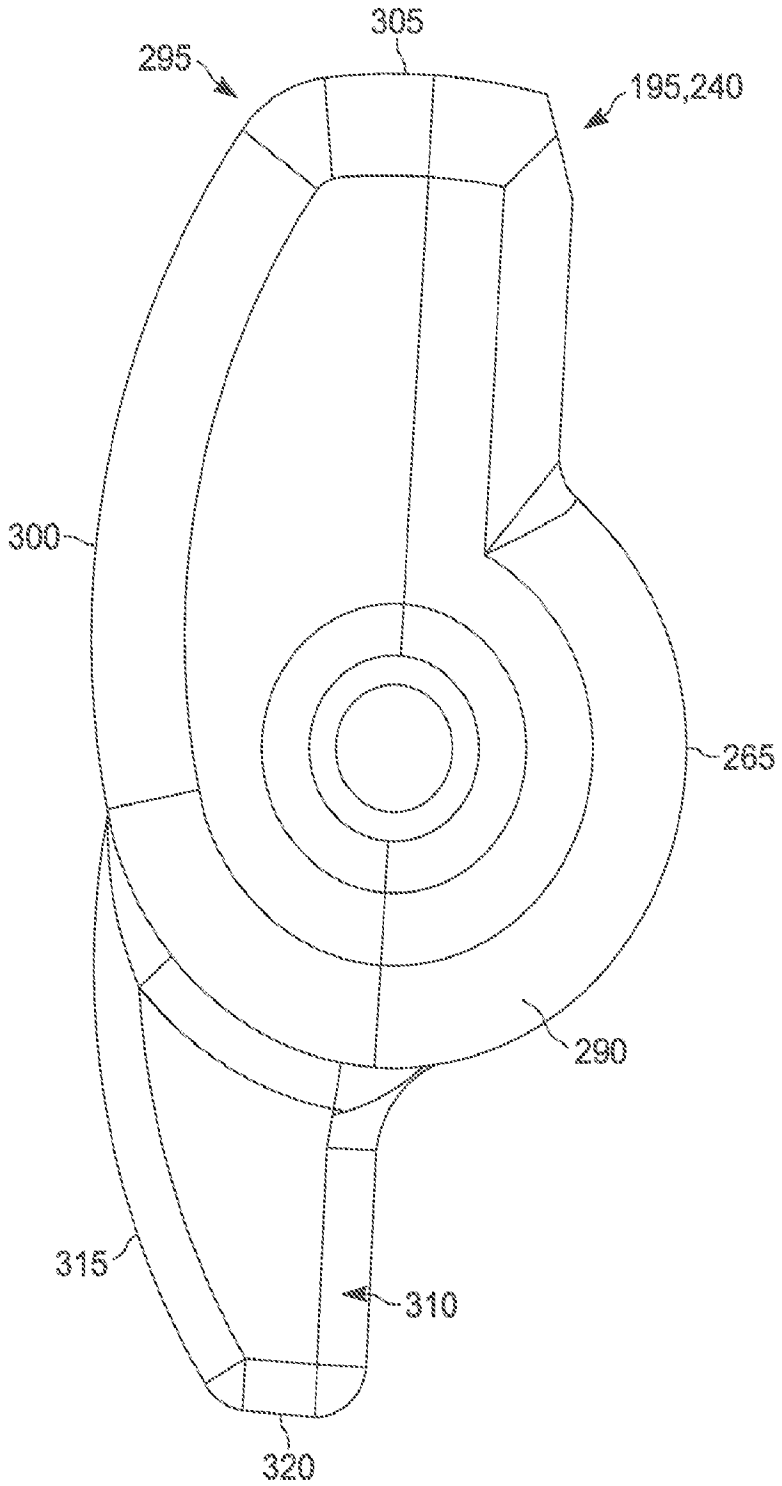

FIG. 13

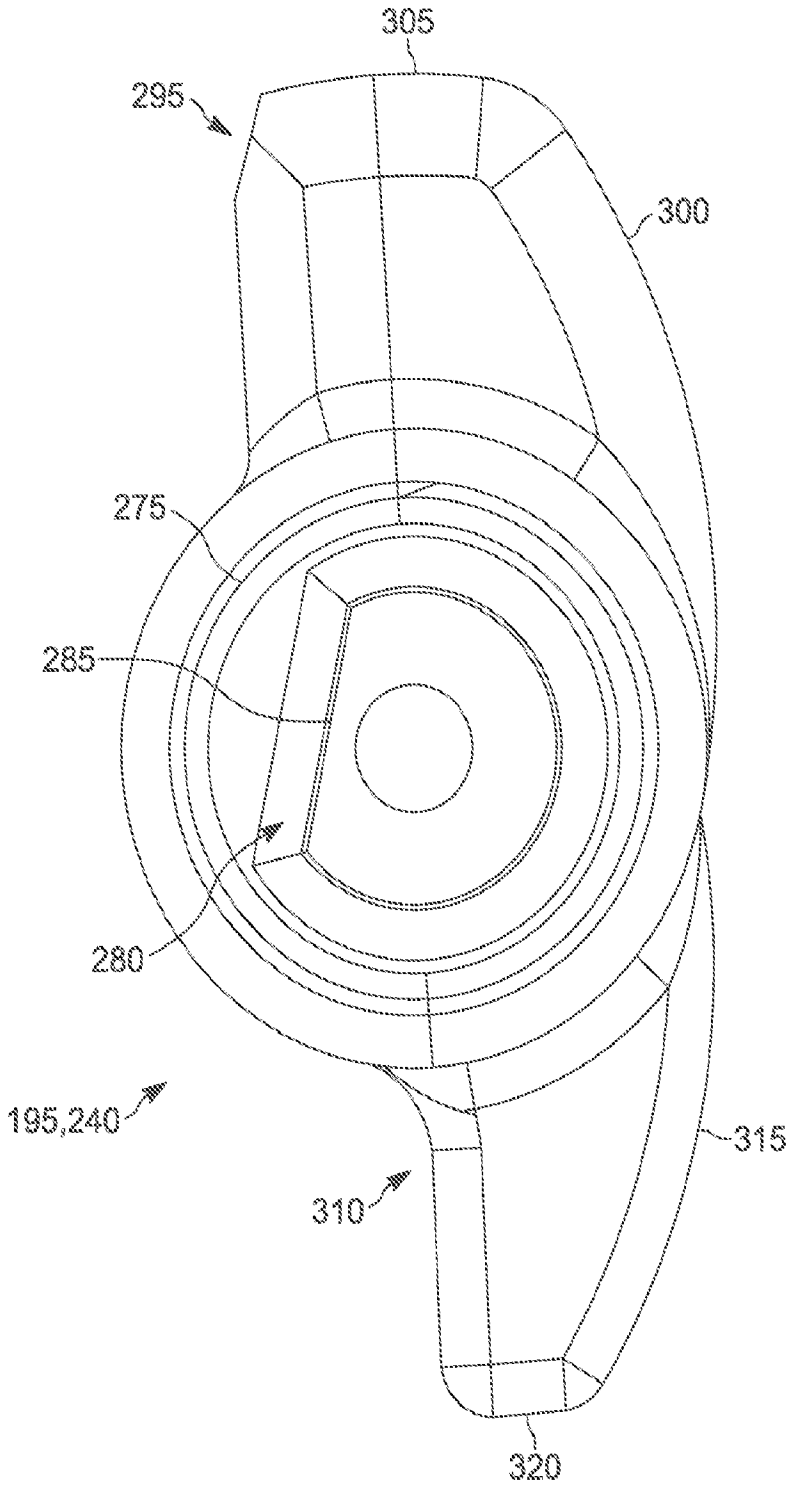

FIG. 14

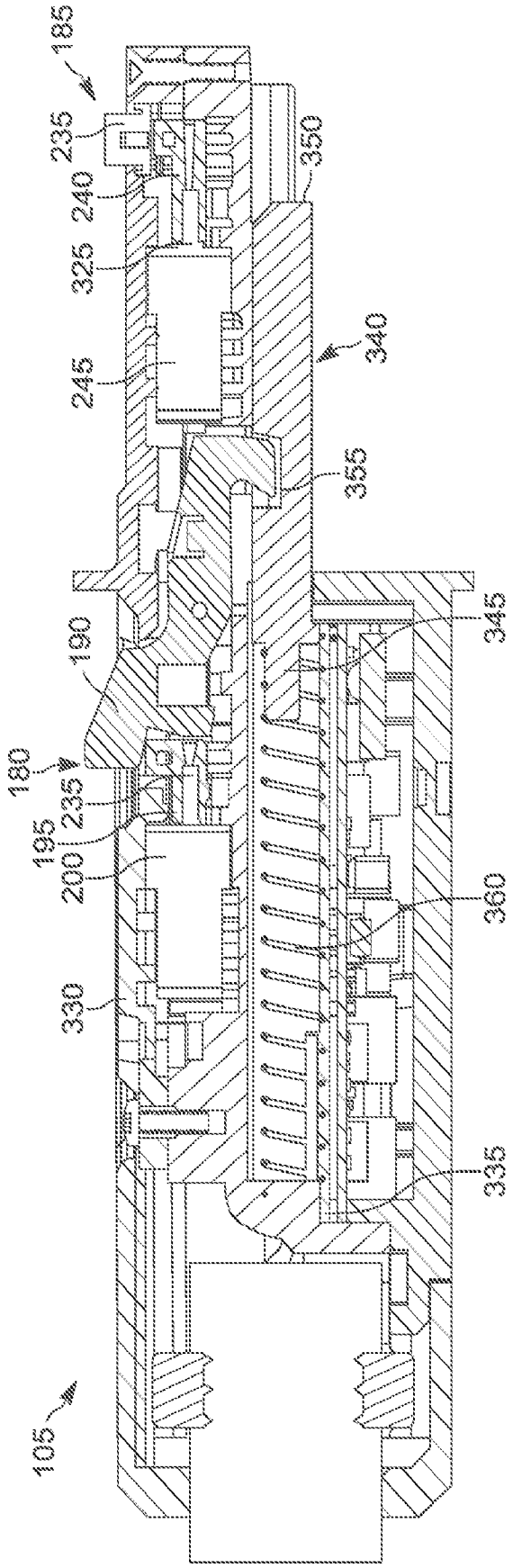
185
235
240
325
245
350
340
355
345
190
180
235
195
200
360
330
335
105

FIG. 15

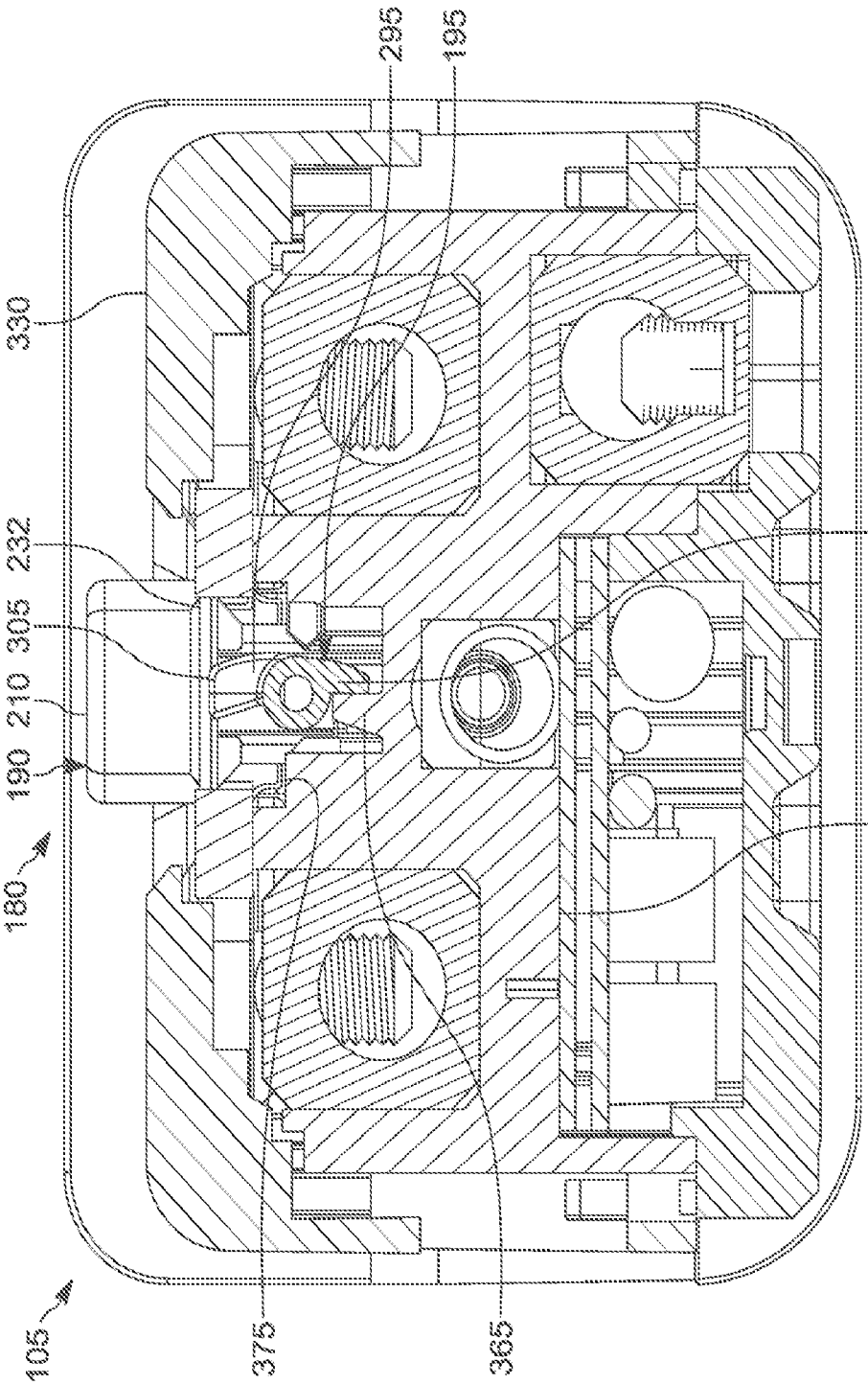

FIG. 16

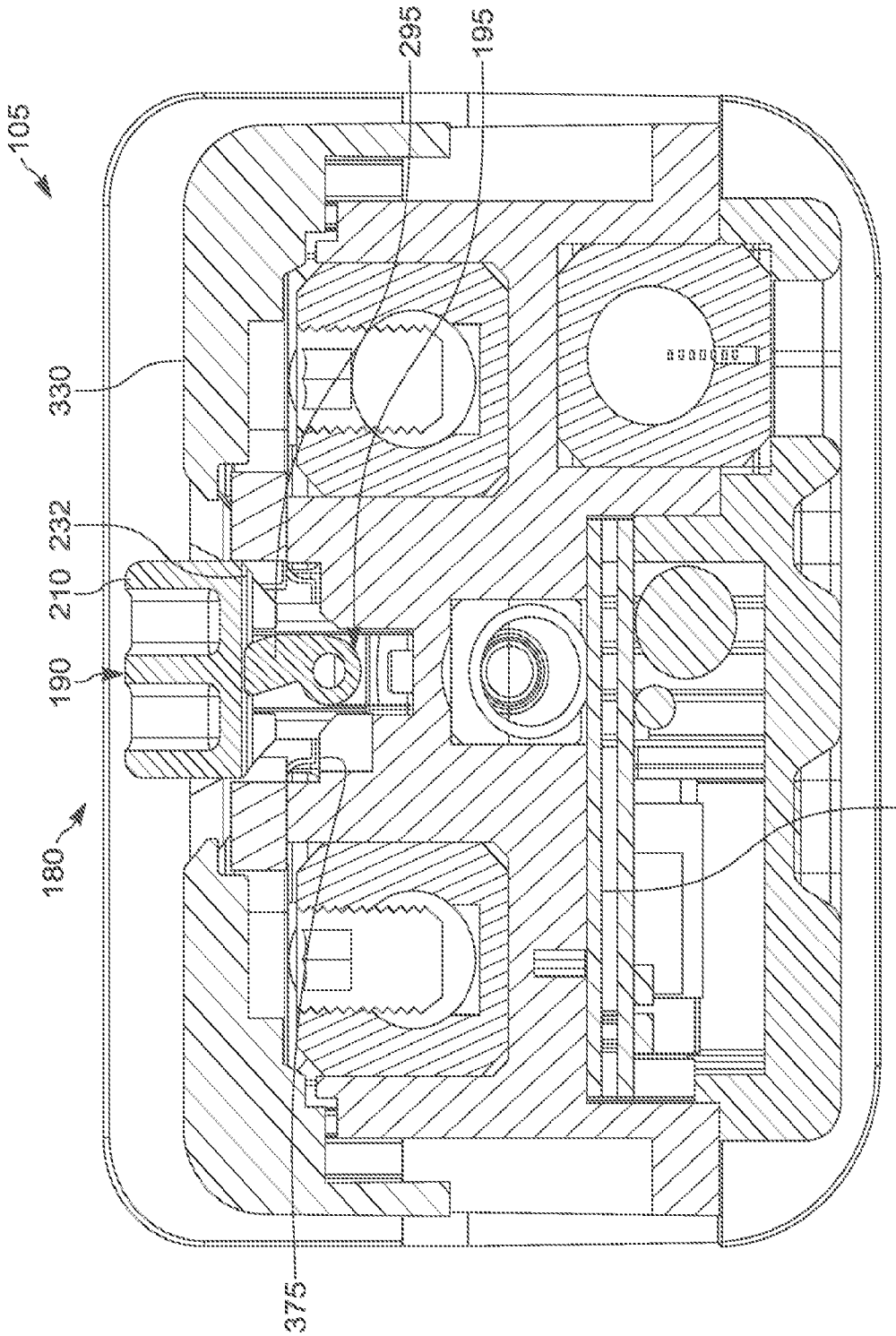

FIG. 17

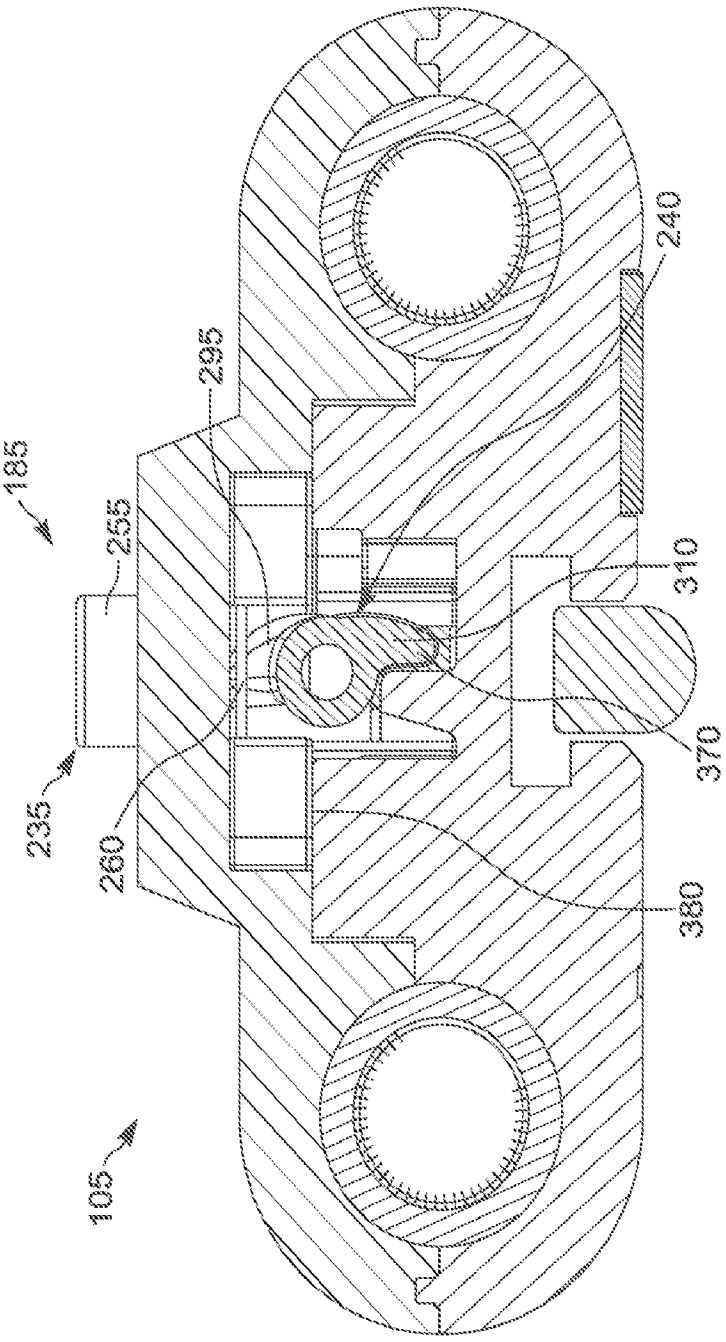

FIG. 18

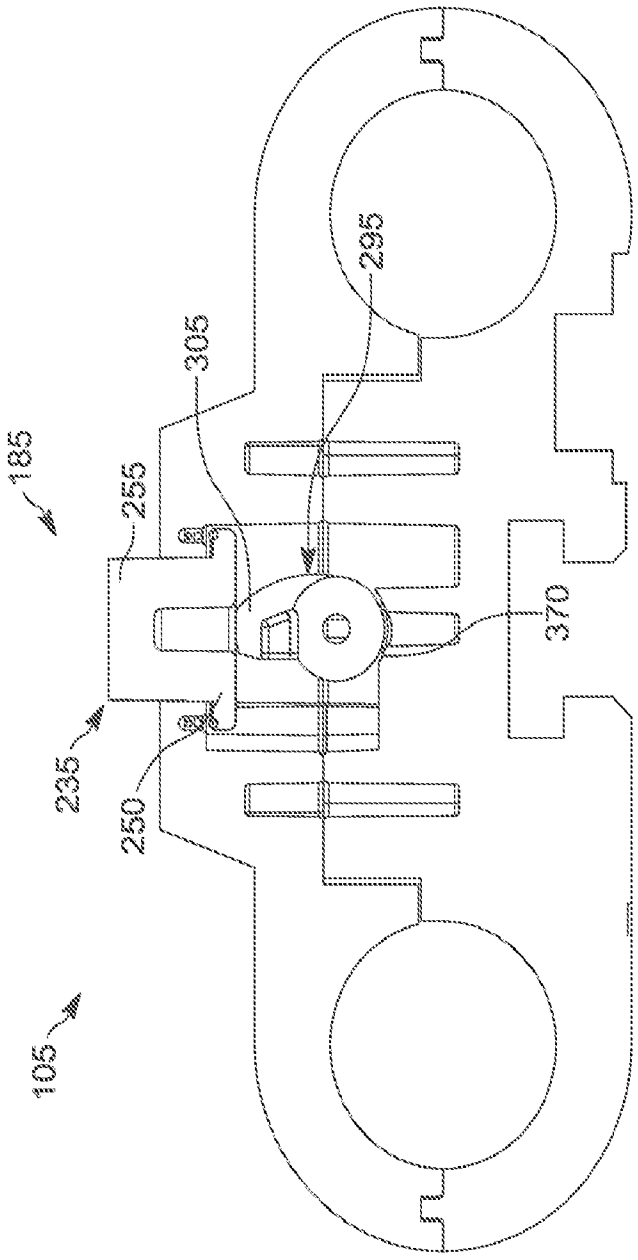

FIG. 19

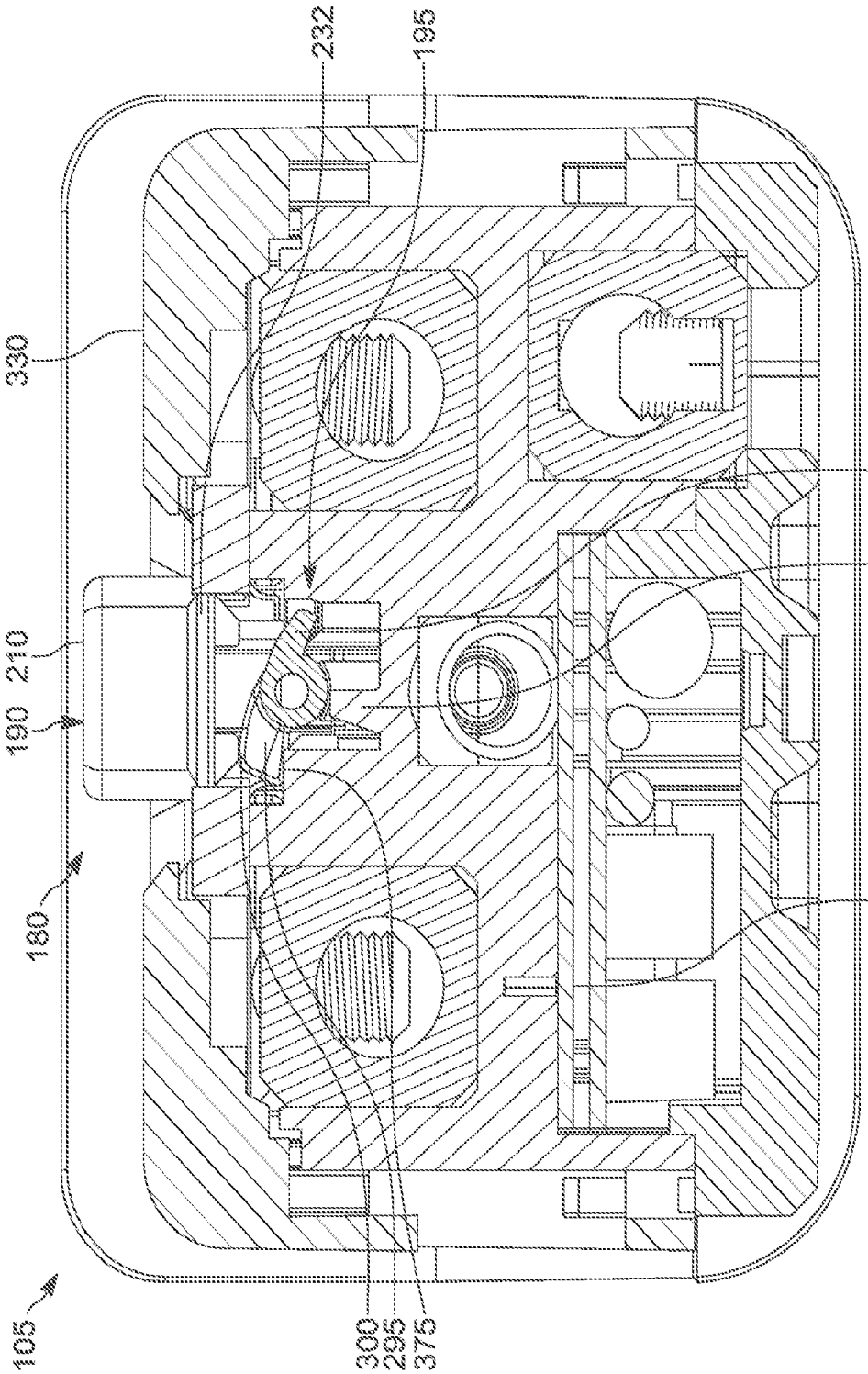

FIG. 20

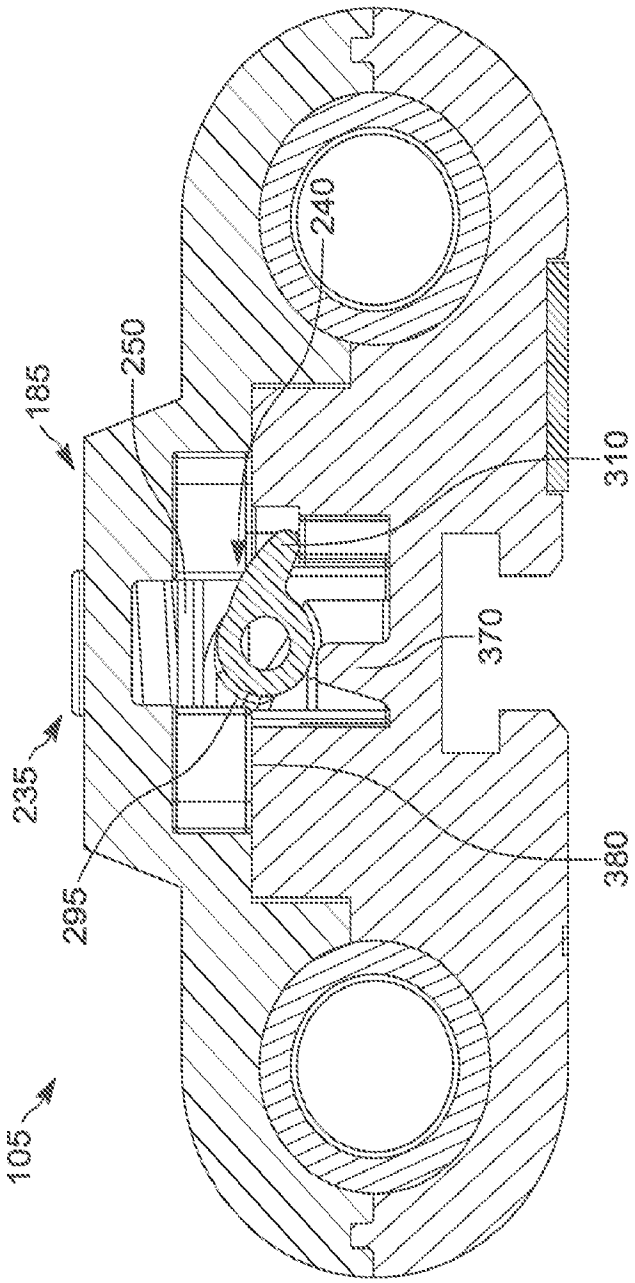

FIG. 21

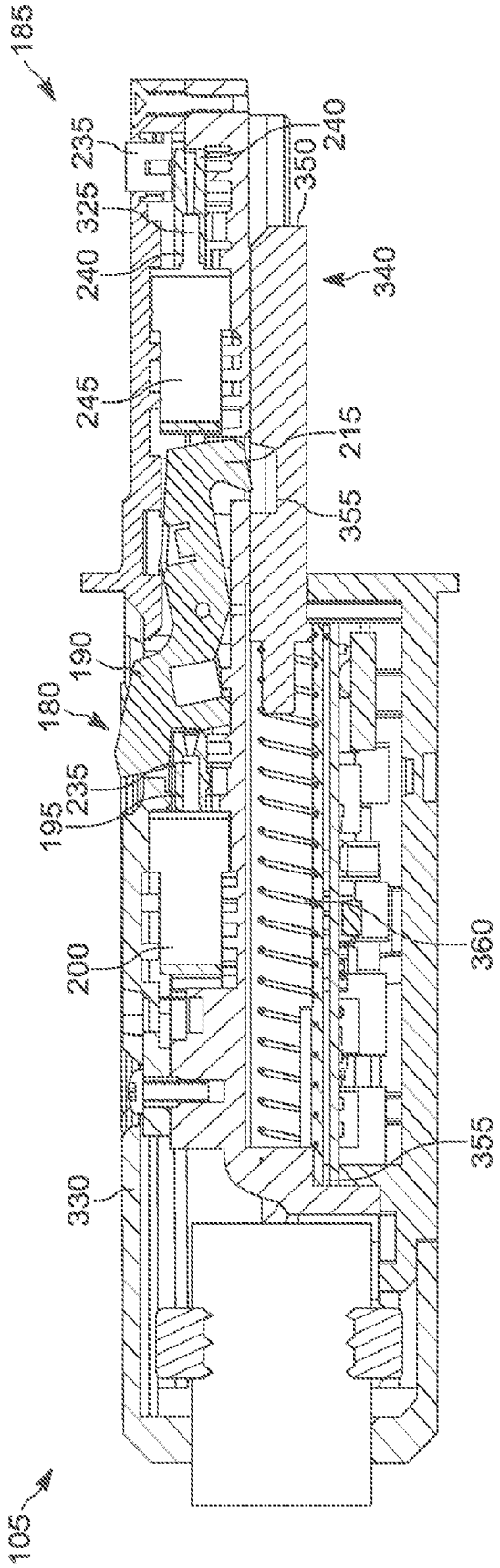
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FIG. 22

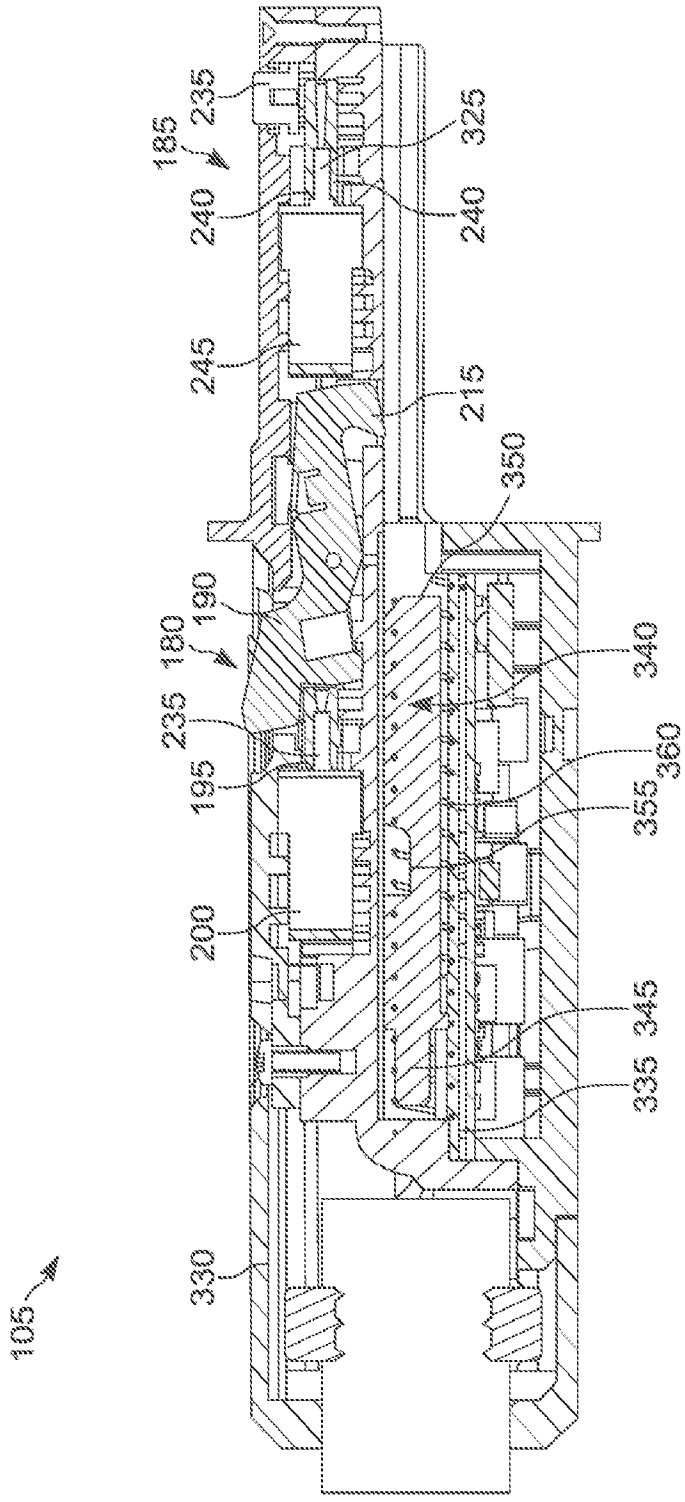
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FIG. 23

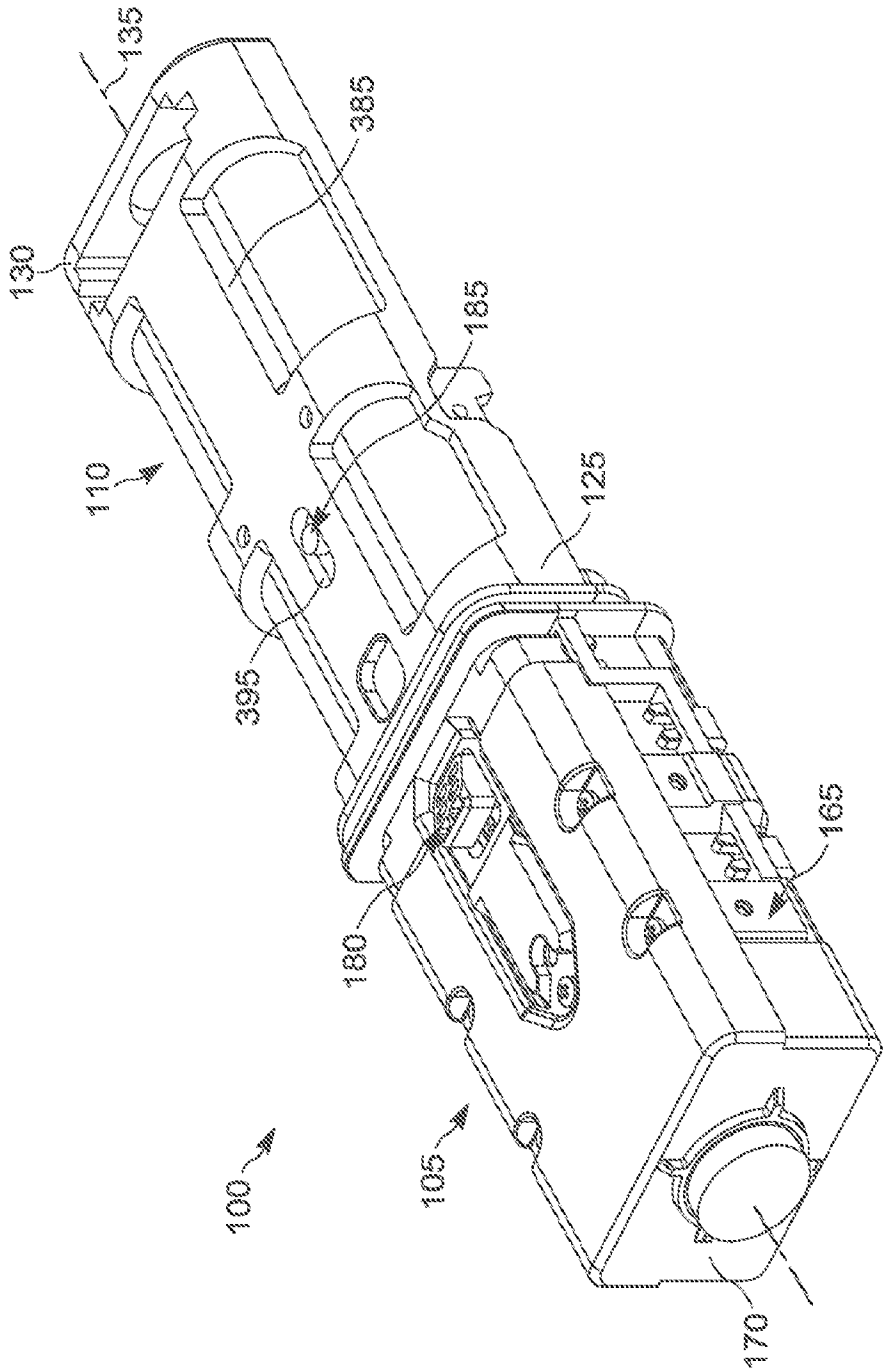

FIG. 24

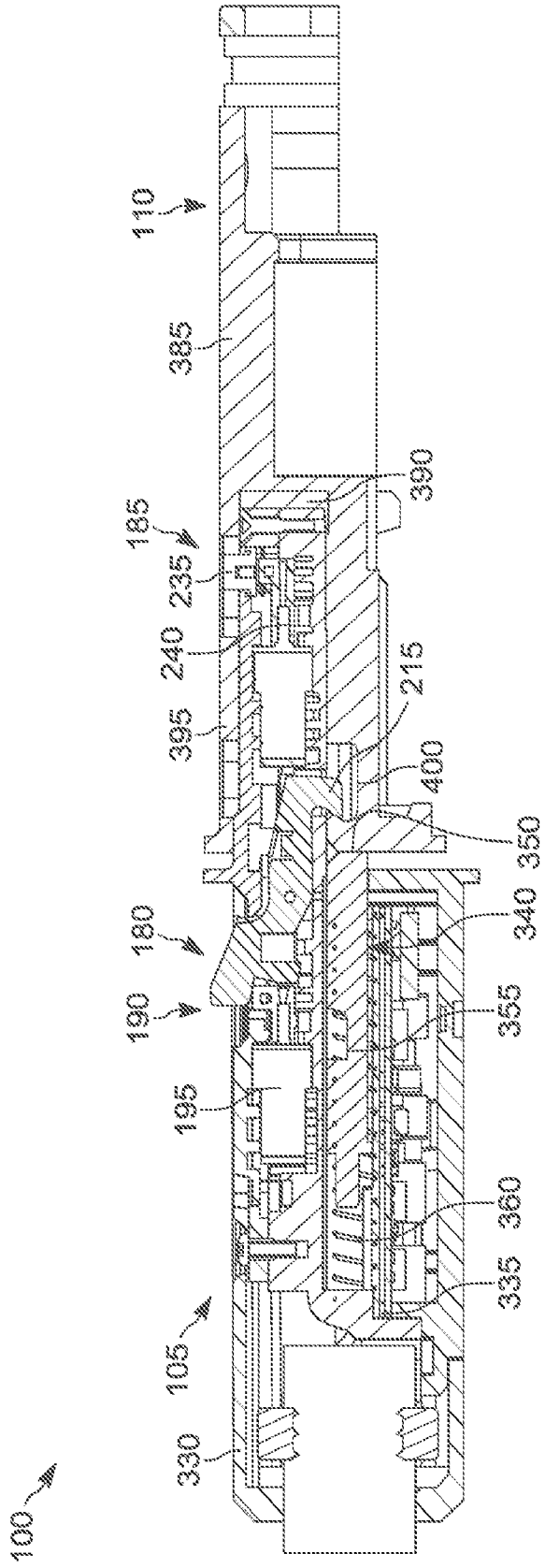
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FIG. 25