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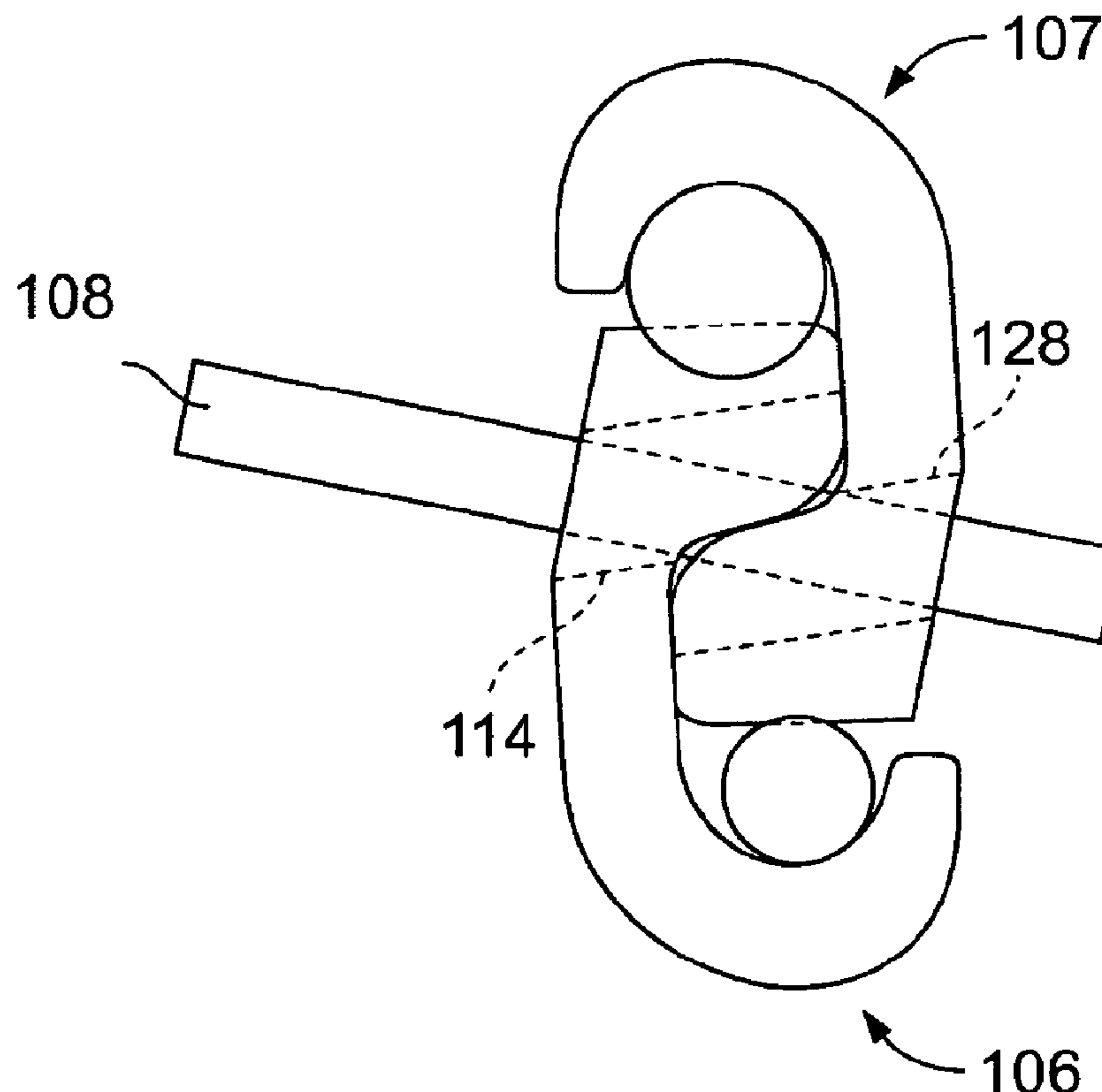
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(54) Title: COMBINATION WEDGE TAP CONNECTOR HAVING A VISUAL ALIGNMENT INDICATOR



(57) Abrégé/Abstract:

An electrical connector assembly includes a first conductive member having a first hook portion extending from a first base wedge portion and adapted to engage a first conductor, and a second conductive member having a second hook portion extending from a second wedge portion and adapted to engage a second conductor. The first wedge portion and the second wedge portion are adapted to nest with one another and be secured to one another. Each of the first and second conductive members includes a visual alignment indicator to define a final mating relation between the first and second conductive members once fully mated.

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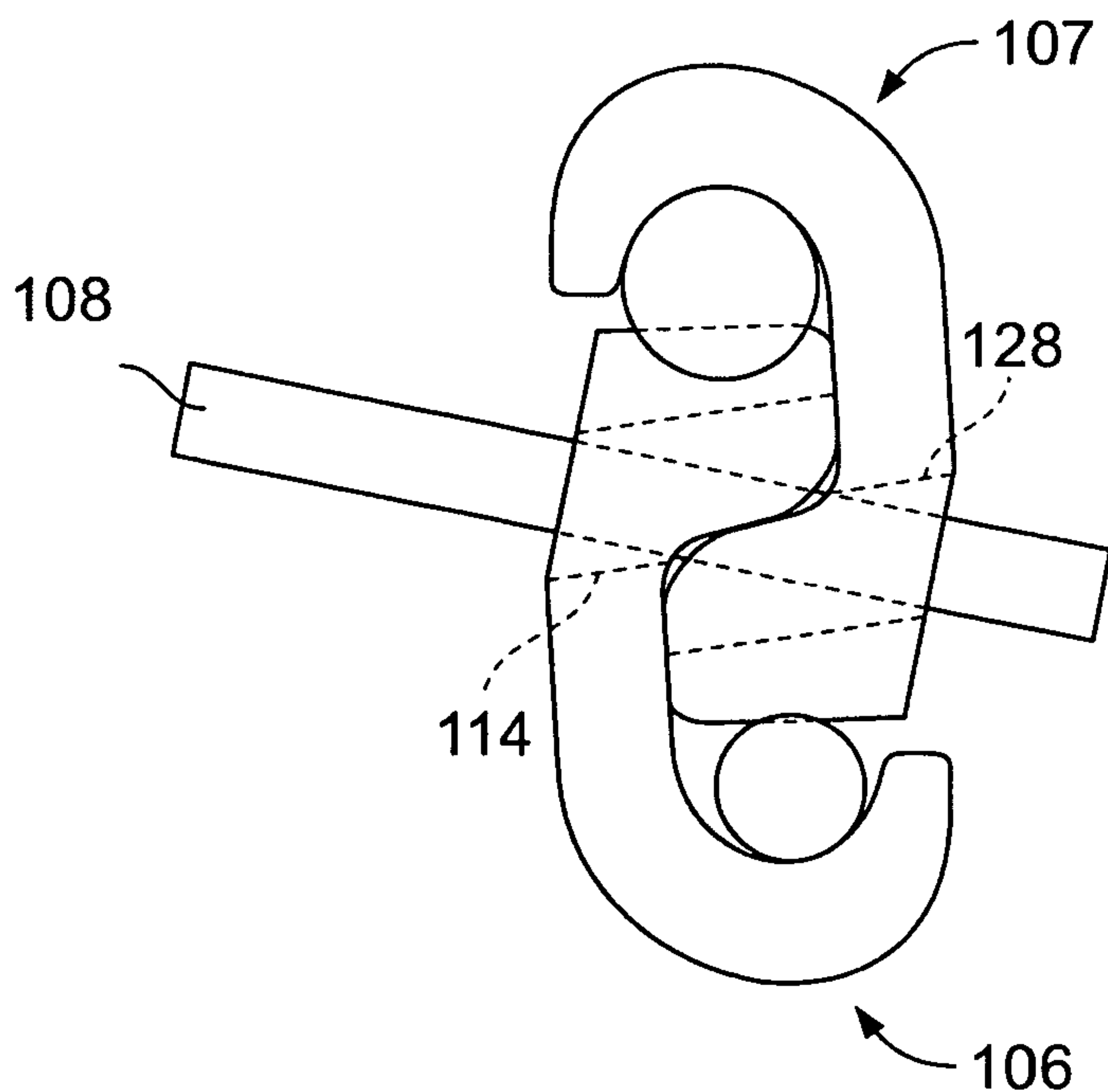
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(54) Title: COMBINATION WEDGE TAP CONNECTOR HAVING A VISUAL ALIGNMENT INDICATOR

**FIG. 6**

(57) Abstract: An electrical connector assembly includes a first conductive member having a first hook portion extending from a first base wedge portion and adapted to engage a first conductor, and a second conductive member having a second hook portion extending from a second wedge portion and adapted to engage a second conductor. The first wedge portion and the second wedge portion are adapted to nest with one another and be secured to one another. Each of the first and second conductive members includes a visual alignment indicator to define a final mating relation between the first and second conductive members once fully mated.

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## COMBINATION WEDGE TAP CONNECTOR HAVING A VISUAL ALIGNMENT INDICATOR

[0001] This invention relates generally to electrical connectors, and more particularly, to power utility connectors for mechanically and electrically connecting a tap or distribution conductor to a main electrical transmission conductor.

[0002] Electrical utility firms constructing, operating and maintaining overhead and/or underground power distribution networks and systems utilize connectors to tap main power transmission conductors and feed electrical power to distribution line conductors, sometimes referred to as tap conductors. The main power line conductors and the tap conductors are typically high voltage cables that are relatively large in diameter, and the main power line conductor may be differently sized from the tap conductor, requiring specially designed connector components to adequately connect tap conductors to main power line conductors. Generally speaking, three types of connectors are commonly used for such purposes, namely bolt-on connectors, compression-type connectors, and wedge connectors.

[0003] Bolt-on connectors typically employ die-cast metal connector pieces or connector halves formed as mirror images of one another, sometimes referred to as clam shell connectors. Each of the connector halves defines opposing channels that axially receive the main power conductor and the tap conductor, respectively, and the connector halves are bolted to one another to clamp the metal connector pieces to the conductors. Such bolt-on connectors have been widely accepted in the industry primarily due to their ease of installation, but such connectors are not without disadvantages. For example, proper installation of such connectors is often dependent upon predetermined torque requirements of the bolt connection to achieve adequate connectivity of the main and tap conductors. Applied torque in tightening the bolted connection generates tensile force in the bolt that, in turn, creates normal force on the conductors between the connector halves. Applicable torque requirements, however, may or may not be actually

achieved in the field and even if the bolt is properly tightened to the proper torque requirements initially, over time, and because of relative movement of the conductors relative to the connector pieces or compressible deformation of the cables and/or the connector pieces over time, the effective clamping force may be considerably reduced. Additionally, the force produced in the bolt is dependent upon frictional forces in the threads of the bolt, which may vary considerably and lead to inconsistent application of force among different connectors.

[0004] Compression connectors, instead of utilizing separate connector pieces, may include a single metal piece connector that is bent or deformed around the main power conductor and the tap conductor to clamp them to one another. Such compression connectors are generally available at a lower cost than bolt-on connectors, but are more difficult to install. Hand tools are often utilized to bend the connector around the cables, and because the quality of the connection is dependent upon the relative strength and skill of the installer, widely varying quality of connections may result. Poorly installed or improperly installed compression connectors can present reliability issues in power distribution systems.

[0005] Wedge connectors are also known that include a C-shaped channel member that hooks over the main power conductor and the tap conductor, and a wedge member having channels in its opposing sides is driven through the C-shaped member, deflecting the ends of the C-shaped member and clamping the conductors between the channels in the wedge member and the ends of the C-shaped member. One such wedge connector is commercially available from Tyco Electronics Corporation of Harrisburg, Pennsylvania and is known as an AMPACT Tap or Stirrup Connector. AMPACT connectors, however, tend to be more expensive than either bolt-on or compression connectors, and special application tooling, using explosive cartridges packed with gunpowder, has been developed to drive the wedge member into the C-shaped member. Different connectors and tools are available for various sizes of conductors in the field.

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[0006] AMPACT connectors are believed to provide superior performance over bolt-on and compression connectors. For example, the AMPACT connector results in a wiping contact surface that, unlike bolt-on and compression connectors, is stable, repeatable, and consistently applied to the conductors, and the quality of the mechanical and electrical connection is not as dependent on torque requirements and/or relative skill of the installer. Additionally, and unlike bolt-on or compression connectors, because of the deflection of the ends of the C-shaped member some elastic range is present wherein the ends of the C-shaped member may spring back and compensate for relative compressible deformation or movement of the conductors with respect to the wedge and/or the C-shaped member.

[0007] It would be desirable to provide a lower cost, more universally applicable alternative to conventional wedge connectors that provides superior connection performance to bolt-on and compression connectors.

[0008] According to an exemplary embodiment, an electrical connector assembly is provided including a first conductive member having a first hook portion extending from a first base wedge portion and adapted to engage a first conductor, and a second conductive member having a second hook portion extending from a second wedge portion and adapted to engage a second conductor. The first wedge portion and second wedge portion are adapted to nest with one another and be secured to one another. Each of the first and second conductive members includes a visual alignment indicator to define a final mating relation between the first and second conductive members once fully mated. Each wedge portion includes an abutment face, a wiping contact surface angled with respect to the abutment face, and a conductor contact surface extending substantially perpendicular to the abutment face, each visual alignment indicator extends from a respective one of the wiping contact faces toward a respective one of the conductor contact faces.

[0009] Optionally, at least one of the visual alignment indicators may include a groove formed in the respective one of the first and second wedge portions.

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The visual alignment indicators may define a final mating relation between the first and second conductive members once the first and second conductive members are fully mated. Each wedge portion may include a contact face engaging one another when the wedge portions are nested with one another, wherein the visual alignment

5 indicators

extend from a respective one of the contact faces. The visual alignment indicators may be linear and aligned with one another to define the final mating relation. Optionally, each wedge portion may include an abutment face, a wiping contact surface angled with respect to the abutment face, and a conductor contact surface extending substantially perpendicular to the abutment face, wherein each visual alignment indicator extends from a respective one of the wiping contact faces toward a respective one of the conductor contact faces.

[0010] According to another exemplary embodiment, an electrical connector assembly is provided for power utility transmission conductors. The assembly includes a first conductive member and a second conductive member separately fabricated from one another and cooperating to interconnect first and second conductors. Each of the first and second conductive member include a wedge portion and a deflectable channel portion extending from the wedge portion, wherein the wedge portion of the first conductive member has a first visual alignment indicator and the wedge portion of the second conductive member has a second visual alignment indicator. The wedge portion of the first conductive member is configured to nest within and be secured to the wedge portion of the second conductive member, and the wedge portion of the second conductive member is configured to nest within and be secured to the wedge portion of the first conductive member. A fastener extends through the wedge portion of each of the first and second conductive members, wherein the fastener is configured to fully join the first and second conductive members to one another. The first and second visual alignment indicators are aligned with one another to indicate when the first and second conductive members are fully joined to one another.

[0011] According to a further exemplary embodiment, an electrical connector assembly is provided for power utility transmission. The assembly includes a first conductive member and a second conductive member separately fabricated from one another. Each of the first and second conductive members includes a wedge portion and a deflectable channel portion extending from the wedge portion, wherein the wedge

portion of the first conductive member has a first visual alignment indicator and the wedge portion of the second conductive member has a second visual alignment indicator. The channel portion of the first conductive member is configured for receiving a main power line conductor at a spaced location from the wedge portion of the first conductive member. The channel portion of the second conductive member is configured for receiving a tap line conductor at a spaced location from the wedge portion of the second conductive member. A fastener joins the wedge portions of the first and second conductive members to one another until the visual alignment indicators are substantially aligned with one another.

[0012] Figure 1 is an exploded view of a connector assembly formed in accordance with an exemplary embodiment.

[0013] Figure 2 is a perspective view of the assembly shown in Figure 1 in an unmated position.

[0014] Figure 3 is a side elevational view of the assembly shown in Figure 2 in a fully opened or unmated position.

[0015] Figure 4 is another side elevational view of the assembly shown in Figure 2 in a first intermediate position.

[0016] Figure 5 is a side elevational view of the assembly shown in Figure 2 in a second intermediate position.

[0017] Figure 6 is a side elevational view of the assembly shown in Figure 2 in a fully closed or mated position.

[0018] Figure 7 is another side elevational view of the assembly shown in Figure 2 in the mated condition.

[0019] Figure 8 is a schematic side view of a portion of the assembly shown in Figure 2.

[0020] Figure 9 is a side elevational view of another embodiment of a connector assembly formed in accordance with an exemplary embodiment.

[0021] Figure 10 is a side elevational view of a known wedge connector assembly.

[0022] Figure 11 is a side elevational view of a portion of the assembly shown in Figure 10.

[0023] Figure 12 is a force/displacement graph for the assembly shown in Figure 10.

[0024] Figures 10 and 11 illustrate a known wedge connector assembly 50 for power utility applications wherein mechanical and electrical connections between a tap or distribution conductor 52 and a main power conductor 55 are to be established. The connector assembly 50 includes a C-shaped member 54 and a wedge member 56. The C-shaped member hooks over the main power conductor 55 and the tap conductor 52, and the wedge member 56 is driven through the C-shaped member 54 to clamp the conductors 52, 55 between the ends of the wedge member 56 and the ends of the C-shaped member 54.

[0025] The wedge member 56 may be installed with special tooling having for example, gunpowder packed cartridges, and as the wedge member 56 is forced into the C-shaped member 54, the ends of the C-shaped member are deflected outwardly and away from one another via the applied force  $F_A$  shown in Figure 11. As shown in Figure 10, the wedge member 56 has a height  $H_W$ , while the C-shaped member 54 has an height  $H_C$  between opposing ends of the C-shaped member where the conductors 52, 55 are received. The tap conductor 52 has a first diameter  $D_1$  and the main conductor 55 has a second diameter  $D_2$  that may be the same or different from  $D_1$ . As is evident from Figure 11,  $H_W$  and  $H_C$  are selected to produce an interference at each end of the C-shaped member 54 and the respective conductor 52, 55. Specifically, the interference  $I$  is established by the relationship:

$$I = H_w + D_1 + D_2 - H_C \quad (1)$$

With strategic selection of  $H_w$  and  $H_C$  the actual interference  $I$  achieved may be varied for different diameters  $D_1$  and  $D_2$  of the conductors 52 and 55. Alternatively,  $H_w$  and  $H_C$  may be selected to produce a desired amount of interference  $I$  for various diameters  $D_1$  and  $D_2$  of the conductors 52 and 55. Consistent generation of at least a minimum amount of interference  $I$  results in a consistent application of applied force  $F_A$  which will now be explained in relation to Figure 12.

[0026] Figure 12 illustrates an exemplary force versus displacement curve for the assembly 50 shown in Figure 10. The vertical axis represents the applied force,  $F_a$ , and the horizontal axis represents displacement of the ends of the C-shaped member 54 as the wedge member 56 is driven into engagement with the conductors 52, 55 and the C-shaped member 54. As Figure 12 demonstrates, certain amount of interference  $I$ , indicated in Figure 12 with a vertical dashed line, results in plastic deformation of the C-shaped member 54 that, in turn, provides a consistent clamping force on the conductors 52 and 55, indicated by plastic plateau in Figure 12. The plastic and elastic behavior of the C-shaped member 54 is believed to provide repeatability in clamping force on the conductors that is not possible with known bolt-on connectors or compression connectors. A need for specialized application tooling for such a connector assembly 50, together with an inventory of differently sized C-shaped members 54 and wedge members 56, renders the connector assembly 50 more expensive and less convenient than some user's desire.

[0027] Figure 1 is an exploded view of a connector assembly 100 formed in accordance with an exemplary embodiment and that overcomes these and other disadvantages. The connector assembly 100 is adapted for use as a tap connector for connecting a tap conductor 102 (shown in phantom in Figure 1), to a main conductor 104 (also shown in Figure 1) of a utility power distribution system. As explained in detail below, the connector assembly 100 provides superior performance and reliability to

known bolt-on and compression connectors, while providing ease of installation and lower cost relative to known wedge connector systems.

[0028] The tap conductor 102, sometimes referred to as a distribution conductor, may be a known high voltage cable or line having a generally cylindrical form in an exemplary embodiment. The main conductor 104 may also be a generally cylindrical high voltage cable line. The tap conductor 102 and the main conductor 104 may be of the same wire gage or different wire gage in different applications and the connector assembly 100 is adapted to accommodate a range of wire gages for each of the tap conductor 102 and the main conductor 104.

[0029] When installed to the tap conductor 102 and the main conductor 104, the connector assembly 100 provides electrical connectivity between the main conductor 104 and the tap conductor 102 to feed electrical power from the main conductor 104 to the tap conductor 102 in, for example, an electrical utility power distribution system. The power distribution system may include a number of main conductors 104 of the same or different wire gage, and a number of tap conductors 102 of the same or different wire gage. The connector assembly 100 may be used to provide tap connections between main conductors 104 and tap conductors 102 in the manner explained below.

[0030] As shown in Figure 1, the connector assembly 100 includes a tap conductive member 106, a main conductive member 107, and a fastener 108 that couples the tap conductive member 106 and the main conductive member 107 to one another. In an exemplary embodiment, the fastener 108 is a threaded member inserted through the respective conductive members 106 and 107, and a nut 109 and lock washer 111 are provided to engage an end of the fastener 108 when the conductive members 106 and 107 are assembled. In one embodiment, an inner diameter of the fastener bore 114 is larger than an outer diameter of the fastener 108, thereby providing some relative freedom of movement of the fastener 108 with respect to the fastener bore 114. While specific

fastener elements 108, 109 and 111 are illustrated in Figure 1, it is understood that other known fasteners may alternatively be used if desired.

[0031] The tap conductive member 106 includes a wedge portion 110 and a channel portion 112 extending from the wedge portion 110. A fastener bore 114 is formed in and extends through the wedge portion 110, and the wedge portion 110 further includes an abutment face 116, a wiping contact surface 118 angled with respect to the abutment face 116, and a conductor contact surface 120 extending substantially perpendicular to the abutment face 116 and obliquely with respect to the wiping contact surface 118.

[0032] The channel portion 112 extends away from the wedge portion 110 and forms a channel or cradle 119 adapted to receive the tap conductor 102 at a spaced relation from the wedge portion 110. A distal end 122 of the channel portion 112 includes a radial bend that wraps around the tap conductor 102 for about 180 circumferential degrees in an exemplary embodiment, such that the distal end 122 faces toward the wedge portion 110, and the wedge portion 110 overhangs the channel or cradle 119. The channel portion 112 is reminiscent of a hook in one embodiment, and the wedge portion 110 and the channel portion 112 together resemble the shape of an inverted question mark. The tap conductive member 106 may be integrally formed and fabricated from extruded metal, together with the wedge and channel portions 110, 112 in a relatively straightforward and low cost manner.

[0033] The main conductive member 107 likewise includes a wedge portion 124 and a channel portion 126 extending from the wedge portion 124. A fastener bore 128 is formed in and extends through the wedge portion 124, and the wedge portion 124 further includes an abutment face 130, a wiping contact surface 132 angled with respect to the abutment face 130, and a conductor contact surface 134 extending substantially perpendicular to the abutment face 130 and obliquely with respect to the wiping contact surface 132. In one embodiment, an inner diameter of the fastener bore 128 is larger than an outer diameter of the fastener 108, thereby providing some relative

freedom of movement of the fastener 108 with respect to the fastener bore 128 as the conductive members 106 and 107 are mated as explained below.

[0034] The channel portion 126 extends away from the wedge portion 124 and forms a channel or cradle 136 adapted to receive the main conductor 104 at a spaced relation from the wedge portion 124. A distal end 138 of the channel portion 126 includes a radial bend that wraps around the main conductor 104 for about 180 circumferential degrees in an exemplary embodiment, such that the distal end 138 faces toward the wedge portion 124, and the channel 136 overhangs the wedge portion 124. The channel portion 126 is reminiscent of a hook in one embodiment, and the wedge portion 124 and the channel portion 126 together resemble the shape of a question mark. The main conductive member 107 may be integrally formed and fabricated from extruded metal, together with the wedge and channel portions 124, 126 in a relatively straightforward and low cost manner.

[0035] The tap conductive member 106 and the main conductive member 107 are separately fabricated from one another or otherwise formed into discrete connector components and are assembled to one another as explained below. While one exemplary shape of the tap and main conductive members 106, 107 has been described herein, it is recognized that the conductive members 106, 107 may be alternatively shaped in other embodiments as desired.

[0036] In an exemplary embodiment, the tap conductive member 106 includes a first visual alignment indicator 140 and the main conductive member 106 includes a second visual alignment indicator 142. The first and second visual alignment indicators 140, 142 cooperate to visually define a final mating position of the tap and main conductive members 106, 107 as the tap and main conductive members 106, 107 are mated. During assembly of the connector assembly 100, the visual alignment indicators 140, 142 are used by the installer to determine a relative position of the tap conductive member 106 with respect to the main conductive member 107. The fastener 108 is tightened until the visual alignment indicators 140, 142 are positioned at

predetermined locations with respect to one another. In an exemplary embodiment, the fastener 108 is tightened until the visual alignment indicators 140, 142 are substantially aligned with one another. As such, the visual alignment indicators 140, 142 are used to define a final mating position of the tap and main conductive members 106, 107 independent of an amount of force induced upon the main and tap conductors 104 and 102 by the main and tap conductive members 107 and 106.

[0037] The first and second visual alignment indicators 140, 142 are exposed on at least one side 144 of each of the tap and main conductive members 106, 107. As such, the relative positions of the visual alignment indicators 140, 142 may be seen by the installer during assembly. Optionally, as illustrated in Figure 1, the first and second visual alignment indicators 140, 142 are exposed on both sides 144 of each of the tap and main conductive members 106, 107, however, the visual alignment indicators 140, 142 may be exposed on only one side 144 of each of the conductive members 106, 107 for proper alignment.

[0038] In the illustrated embodiment, each visual alignment indicator 140, 142 includes a groove 146 formed in the respective wedge portions 110 and 124. Each groove 146 extends from the respective wiping contact surface 118, 132. Optionally, each groove 146 extends substantially perpendicular from the wiping contact surface 118, 132, however, the grooves 146 may extend non-perpendicularly in alternative embodiments. In an exemplary embodiment, the grooves 146 are rectangular in shape and are formed by cutting or otherwise removing a portion of the tap or main conductive member 106, 107. Alternatively, the grooves 146 may have alternative shapes, and the grooves 146 may be formed, such as by a molding or forming operation during manufacture of the tap and main conductive members 106, 107.

[0039] The grooves 146 have a depth 148 measured from the respective wiping contact surface 118, 132 and a width 150 measured from the respective side 144. The depth 148 is selected to provide adequate visual indication of the relative positions of the grooves 146 with respect to one another during assembly of the connector assembly

100. The structural integrity of the wedge portion 110 or 124 may be taken into consideration in determining the depth 148. In the illustrated embodiment, the depth 148 is approximately 40% of the distance between the wiping contact surface 118 or 132 and the conductor contact surface 120 or 134. The depth 148 may be more or less than 40% in alternative embodiments. In the illustrated embodiment, the width 150 is approximately equal to the depth 148, however, the width may be varied in alternative embodiments.

[0040] In an alternative embodiment, the groove may be 100% of the width of the wedge portion 110, 124 and extend completely across the wiping contact surface 118, 132. In another alternative embodiment, the width 150 may be minimal, such as approximately 1% of the width of the wedge portion 110 or 124 such that the visual alignment indicators 140, 142 are merely marks on the sides 144 of the wedge portions 110, 124. In a further alternative embodiment, rather than a groove 144 having a width 150, a mark may be made on the side 144, such as by using paint or ink, or by changing a visual appearance of the material used for the conductive members 106, 107, such as scorching or blazing the side 144. Alternatively, a component may be added to the side 144 to represent the visual alignment indicators 140, 142. For example, a component may be welded or soldered to the side 144, a component may be adhered to the side 144, or a component may be otherwise fastened to the side 144. Other alternative types of visual alignment indicators may be used as well.

[0041] In one embodiment, the wedge portions 110 and 124 of the respective tap and the main conductive members 106, 107 are substantially identically formed and share the same geometric profile and dimensions to facilitate interfitting of the wedge portions 110 and 124 in the manner explained below as the conductive members 106, 107 are mated. The channel portions 112, 126 of the conductive members 106 and 107, however, may be differently dimensioned as appropriate to be engaged to differently sized conductors 102, 104 while maintaining substantially the same shape of the conductive members 106, 107. Identical formation of the wedge portions 110 and

124 provides for mixing and matching of conductive members 106 and 107 for differently sized conductors 102, 104 while achieving a repeatable and reliable connecting interface via the wedge portions 110 and 124.

[0042] As shown in Figure 1, the tap conductive member 106 and the main conductive member 107 are generally inverted relative to one another with the respective wedge portions 110 and 124 facing one another and the fastener bores 114, 128 aligned with one another to facilitate extension of the fastener 108 therethrough. The channel portion 112 of the tap conductive member 106 extends away from the wedge portion 110 in a first direction, indicated by the arrow A, and the channel portion 126 of the main conductive member 107 extends from the wedge portion 124 in a second direction, indicated by arrow B that is opposite to the direction of arrow A. Additionally, the channel portion 112 of the tap conductive member 106 extends around the tap conductor 102 in a circumferential direction indicated by the arrow C, while the channel portion 126 of the main conductive member 107 extends circumferentially around the main conductor 104 in the direction of arrow D that is opposite to arrow C.

[0043] When the channel portions 112, 126 are hooked over the respective conductors 102, 104 and when the conductive member 106, 107 are coupled together by the fastener elements 108, 109, 111, the abutment faces 116, 130 are aligned in an unmated condition as shown in perspective view in Figure 2, and in side elevational view in Figure 3. In the unmated condition, the first and second visual alignment indicators 140, 142 are off-set and not aligned with one another. The connector assembly 100 may be preassembled into the configuration shown in Figures 2 and 3, and hooked over the conductors 102 and 104 in the directions of arrows C and D relatively easily. As seen in Figure 3, and because the inner diameters of the fastener bores 114, 128 (shown in phantom in Figure 3) are larger than an outer diameter of the fastener 108, the fastener 108 is positionable in a first angular orientation through the wedge portions 110 and 124.

[0044] As illustrated in Figures 4-6, the larger diameter of the fastener bores 114, 128 relative to the fastener 108 permits the fastener 108 to float or move

angularly with respect to an axis of the bores 114, 128 as the conductive members 106, 107 are moved to a fully mated position. More particularly, the abutment faces 116, 130 of the wedge portions 110, 124 are moved in sliding contact with one another in the directions of arrows A and B as shown in Figure 4 until the wiping contact surfaces 118, 132 are brought into engagement as shown in Figure 5, and the wedge portions 110, 124 may then be moved transversely into a nested or interfitted relationship as shown in Figure 6 with the wiping contact surfaces 118, 132 in sliding engagement. All the while, and as demonstrated in Figures 4-6, the fastener 108 self adjusts its angular position with respect to the fastener bores as the fastener 108 moves from the initial position shown in Figure 3 to a final position shown in Figure 6. Moreover, and as demonstrated in Figures 4-6, the relative positions of the first and second visual alignment indicators 140, 142 are adjusted with respect to one another as the fastener 108 moves from the initial position shown in Figure 3 to a final position shown in Figure 6.

[0045] In the final position, the fastener 108 extends obliquely to each of the fastener bores 114, 128, and the nut 109 may be tightened to the fastener 108 to secure the conductive members 106, 107 to one another. Additionally, in the final position shown in Figure 6, the first and second visual alignment indicators 140, 142 are substantially aligned with one another to visually indicate to the installer that the conductive members 106, 107 are properly assembled. Optionally, select portions of the first and second visual alignment indicators 140, 142 may be aligned with one another to indicate that the conductive members 106, 107 are properly assembled. For example, one edge of the first the first visual alignment indicator 140 may be aligned with one edge of the second visual alignment indicator 142. Optionally, the first and second visual alignment indicators 140, 142 may provide a range of positions which indicate that the conductive members 106, 107 are properly aligned. The first and second visual alignment indicators 140, 142 may provide a target position for the tap and/or main conductive members 106, 107 and allow for a predetermined amount of tolerance with respect to the target position. Optionally, in the final position, the first and second visual alignment indicators 140, 142 may extend parallel to one another and may extend along a

common axis. Alternatively, the first and second visual alignment indicators 140, 142 may be non-parallel or angled with respect to one another.

[0046] Figure 7 illustrates the connector assembly 100 in a fully mated position with the nut 109 tightened to the fastener 108. As the conductive members 106, 107 are moved through the positions shown in Figures 4-6, the wiping contact surfaces 118, 132 slidably engage one another and provide a wiping contact interface that ensures adequate electrical connectivity. The angled wiping contact surfaces 118, 132 provide a ramped contact interface that displaces the conductor contact surfaces 120, 134 in opposite directions indicated by arrows A and B as the wiping contact surfaces 118, 132 are engaged. In addition, the conductor contact surfaces 120, 134 provide wiping contact interfaces with the conductors 102 and 104 as the connector assembly 100 is installed.

[0047] Movement of the conductor contact surfaces 120, 134 in the opposite directions of arrows A and B clamps the conductors 102 and 104 between the wedge portions 110 and 124, and the opposing channel portions 112, 126. The distal ends 122, 138 of the channel portions 112, 126 are brought adjacent to the wedge portions 110, 124 to the mated position shown in Figures 6 and 7, thereby substantially enclosing portions of the conductors 102, 104 within the connector assembly 100. In one embodiment, the abutment faces 116, 130 of the wedge portions 110, 124 contact the channel portions 126, 112 of the opposing conductive members 107 and 106 when the connector assembly 100 is fully mated. In such a position, the wedge portions 110, 124 are nested or mated with one another in an interfitting relationship with the wiping contact surfaces 118 and 132, the abutment faces 116 and 130, and the channel portions 112 and 126 providing multiple points of mechanical and electrical contact to ensure electrical connectivity between the conductive members 106 and 107.

[0048] In the fully mated position shown in Figures 6 and 7, the main conductor 104 is captured between the channel portion 126 of the main conductive member 107 and the conductor contact surface 120 of the tap conductive member wedge portion 110. Likewise, the tap conductor 102 is captured between the channel portion

112 of the tap conductive member 106 and the conductor contact surface 134 of the main conductive member wedge portion 124. As the wedge portion 110 engages the tap conductive member 106 and clamps the main conductor 104 against the channel portion 126 of the main conductive member 107 the channel portion 126 is deflected in the direction of Arrow E. The channel portion 126 is elastically and plastically deflected in a radial direction indicated by arrow E, resulting in a spring back force in the direction of Arrow F, opposite to the direction of arrow E to provide a clamping force on the conductor. A large contact force, on the order of about 4000 lbs is provided in an exemplary embodiment, and the clamping force ensures adequate electrical connectivity between the main conductor 104 and the connector assembly 100. Additionally, elastic spring back of the channel portion 126 provides some tolerance for deformation or compressibility of the main conductor 104 over time, because the channel portion 126 may effectively return in the direction of arrow F if the main conductor 104 deforms due to compression forces. Actual clamping forces may be lessened in such a condition, but not to such an amount as to compromise the integrity of the electrical connection. In an exemplary embodiment, the first and second visual alignment indicators 140, 142 allow a range of tolerance within the elastic range of the channel portion 126.

[0049] When fully mated, the abutment faces 116 and 130 may engage the channel portions 126 and 112 to form a displacement stop that defines and limits a final displacement relation between the tap and main conductive members 106 and 107. The displacement stop defines a final mating position between the tap and main conductive members 106 and 107 independent of an amount of force induced upon the main and tap conductors 104 and 102 by the main and tap conductive members 107 and 106. In such an embodiment, the first and second visual alignment indicators 140, 142 may provide a visual indication to the installer that the conductive members 106, 107 are in the final mating position and that the abutment faces 116 and 130 are engaged to the channel portions 126 and 112. In an alternative embodiment, the abutment faces 116 and 130 may be positioned a distance from the channel portions 126 and 112 in the final mating position.

[0050] Optionally, the displacement stop may be created from a stand off provided on one or both of the main and tap conductive members 107 and 106. For example, the stand off may be positioned proximate the fastener bore 128 and extend outward therefrom. Alternatively, the stand off may be created as mating notches provided in the wiping contact surfaces 118 and 132, where the notches engage one another to limit a range of travel of the main and tap conductive members 107 and 106 toward one another.

[0051] Likewise, the wedge portion 124 of the main conductive member 107 clamps the tap conductor 102 against the channel portion 112 of tap conductive member 106 and the channel portion 112 is deflected in the direction of arrow G. The channel portion 112 is elastically and plastically deflected in a radial direction indicated by arrow G, resulting in a spring back force in the direction of Arrow H opposite to the direction of arrow G. A large contact force, on the order of about 4000 lbs is provided in an exemplary embodiment, and the clamping force ensures adequate electrical connectivity between the tap conductor 102 and the connector assembly 100. Additionally, elastic spring back of the channel portion 112 provides some tolerance for deformation or compressibility of the tap conductor 102 over time, because the channel portion 112 may simply return in the direction of arrow H if the tap conductor 102 deforms due to compression forces. Actual clamping forces may be lessened in such a condition, but not to such an amount as to compromise the integrity of the electrical connection. In an exemplary embodiment, the first and second visual alignment indicators 140, 142 allow a range of tolerance within the elastic range of the channel portion 112.

[0052] Unlike known bolt connectors, torque requirements for tightening of the fastener 108 are not required to satisfactorily install the connector assembly 100. The first and second visual alignment indicators 140, 142 indicate to the installer when the conductive members 106, 107 are fully mated. The visual alignment indicators 140, 142 allows the nut 109 and fastener 108 to be continuously tightened until the visual

alignment indicators 140, 142 are properly oriented, independent of, and without regard for, any normal forces created by the tap and main conductors 102 and 104. In the fully mated condition, the interference between the conductors 102 and 104 and the connector assembly 100 produces a contact force adequate to provide a good electrical connection. The contact forces are created by interference between the channel portions 126, 112, and wedge portions 110, 124, and tap and main conductors 102 and 104. It is not necessary to measure the bolt torque in the mating the connector assembly 100 as the connector assembly 100 is fully mated when the visual alignment indicators 140, 142 are properly oriented. By virtue of the fastener elements 108 and 109 and the combined wedge action of the wedge portions 110, 124 to deflect the channel portions 112 and 126, the connector assembly 100 may be installed with hand tools, and specialized tooling, such as the explosive cartridge tooling of the AMPACT Connector system is avoided.

[0053] Optionally, when the abutment faces 116, 130 of the wedge portions 110, 124 contact the channel portions 126 and 112, the connector assembly 100 is fully mated. The displacement stop allows the nut 109 and fastener 108 to be continuously tightened until the abutment faces 116 and 130 fully seat against the channel portions 126 and 112, independent of, and without regard for, any normal forces created by the tap and main conductors 102 and 104.

[0054] It is recognized that effective clamping force on the conductors 102, 104 is dependent upon the geometry of the wedge portions, dimensions of the channel portions, and size of the conductors used with the connector assembly 100. Thus, with strategic selections of the positions of the visual alignment indicators 140, 142, the angles for the wiping contact surfaces 118, 130, and the radius and thickness of the curved distal ends 122 and 138 of the conductive members, varying degrees of clamping force may be realized when the conductive members 106 and 107 are used in combination as described above.

[0055] Figure 8 illustrates an interference created in the connector assembly 100 that produces the deflection and spring back in the connectors. While the

interference will be explained only in reference to the upper portion of the connector assembly 100, it is understood that the lower portion of the assembly operates in a similar manner. Figure 8 also illustrates alternative visual alignment indicators 160, 162 on the tap and main conductive members 106, 107.

[0056] The visual alignment indicators 160, 162 are represented by markings 160, 162 placed on the sides 144 of the conductive members 106, 107 rather than grooves formed in the conductive members 106, 107 as in the embodiments illustrated in Figures 1-7. The markings 160, 162 may be made on the side 144, such as by using paint or ink, or by changing a visual appearance of the material used for the conductive members 106, 107, such as scorching or blazing the side 144. In an exemplary embodiment, the markings 160, 162 are shaped differently than one another, however, the markings 160, 162 may be shaped similarly or identically. In the illustrated embodiment, the marking 160 is triangular and a point of the triangle is provided adjacent the wiping contact surface 118. The marking 162 is an elongated bar provided proximate the wiping surface 132. The bar represents a range of mating positions, wherein when the point of the marking 160 is aligned with the bar of the marking 162, the conductive members 106, 107 are properly mated. In an alternative embodiment, the marking 162 may be triangular, such that the conductive members 106, 107 are properly mated when the points of the triangles are aligned. The markings 160, 162 may take any shape and size that provides the installer with a visual indication of the relative position of the conductive members 106, 107, and/or that indicates a proper mating position of the conductive members 106, 107.

[0057] As shown in Figure 8, the wedge portion 110 of the tap conductive member 106 and the wedge portion 124 of the main conductive member 107 are fully engaged. A wedge height  $H_w$  extends between the conductor contact surfaces 120, 124 of the respective wedge portions 110, 124, and a clearance height  $H_{CL}$  extends between the conductor contact surface 134 of the wedge 124 and the inner surface 136 of the main conductive member channel portion 126. The main conductor 104, however,

has a diameter  $D_C$  prior to installation of the connector. An interference  $I$  is therefore created according to the following relationship:

$$I = H_w + D_C - H_{CL} \quad (2)$$

By strategically selecting  $H_w$  and  $H_{CL}$ , repeatable and reliable performance may be provided in a similar manner as explained above in relation to Figure 12, namely via elastic and plastic deformation of the conductive members, while eliminating a need for special tooling to assemble the connector.

[0058] Because of the deflectable channel portions 112, 126 in discrete connector components, the conductive members 106 and 107 may accommodate a greater range of conductor sizes or gages in comparison to conventional wedge connectors. Additionally, even if several versions of the conductive members 106 and 107 are provided for installation to different conductor wire sizes or gages, the assembly 100 requires a smaller inventory of parts in comparison to conventional wedge connector systems, for example, to accommodate a full range of installations in the field. That is, a relatively small family of connector parts having similarly sized and shaped wedge portions may effectively replace a much larger family of parts known to conventional wedge connector systems.

[0059] It is therefore believed that the connector assembly 100 provides the performance of conventional wedge connector systems in a lower cost connector assembly that does not require specialized tooling and a large inventory of parts to meet installation needs. Using low cost extrusion fabrication processes and known fasteners, the connector assembly 100 may be provided at low cost, while providing increased repeatability and reliability as the connector assembly 100 is installed and used. The combination wedge action of the conductive members 106 and 107 provides a reliable and consistent clamping force on the conductors 102 and 104 and is less subject to variability of clamping force when installed than either of known bolt-on or compression-type connector systems.

[0060] Figure 9 illustrates another embodiment of a connector assembly 200 that is constructed and operates in a similar manner to the assembly 100. Like the assembly 100, the assembly 200 includes a tap conductor 202, a main conductor 204, a tap conductive member 206, a main conductive member 207, and a fastener 208.

[0061] Each of the conductive members 206 and 207 are formed with respective wedge portions 210 and 212, and each of the wedge portions 210 and 212 defines a wiping contact surface 214, 216 and a conductor contact surface 217, 218. Optionally, and as shown in Figure 9, the conductor contact surfaces 217, 218 are rounded. Also, the geometry of the wedge portions 210, 212 are such that the ends of the wedge portions defining the conductor contact surfaces 217, 218 are angled with respect to the channel portions of the conductive members 206, 207.

[0062] Additionally, in the assembly 200, the wedge portions 210 and 212 are geometrically shaped so that fastener bores 220, 222 formed through the respective wedges more readily align with the fastener 208 than in the connector assembly 100, thereby reducing, if not limiting, the tendency of the fastener 208 to float and pivot relative to the conductive members 206, 207 as the assembly 200 is installed to the conductors. This construction is believed to permit complete engagement of the conductive members 206, 207 with a reduced amount of force applied to the fastener 208.

[0063] Figure 9 also illustrates alternative visual alignment indicators 230, 232 on the tap and main conductive members 206, 207. The visual alignment indicators 230, 232 are represented by markings 230, 232 placed on sides 234 of the conductive members 206, 207 rather than grooves formed in the conductive members 206, 207 as in the embodiments illustrated in Figures 1-7. The markings 230, 232 may be made on the side 234, such as by using paint or ink, or by changing a visual appearance of the material used for the conductive members 206, 207, such as scorching or blazing the side 234. In an exemplary embodiment, the markings 230, 232 are represented by circles placed adjacent to the wiping contact surfaces 214, 216. The conductive members 206, 207 are properly mated when the circles are aligned. The

markings 230, 232 may take any shape and size that provides the installer with a visual indication of the relative position of the conductive members 206, 207, and/or that indicates a proper mating position of the conductive members 206, 207.

[0064] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Dimensions, types of materials, orientations of the various components, and the number and positions of the various components described herein are intended to define parameters of certain embodiments, and are by no means limiting and are merely exemplary embodiments. Many other embodiments and modifications within the spirit and scope of the claims will be apparent to those of skill in the art upon reviewing the above description.

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**CLAIMS:**

1. An electrical connector assembly comprising:

a first conductive member comprising a first hook portion extending from a first base wedge portion, the first hook portion adapted to engage a first  
5 conductor;

a second conductive member comprising a second hook portion extending from a second wedge portion, the second hook portion adapted to engage a second conductor, wherein the first wedge portion and the second wedge portion are adapted to nest with one another and be secured to one another; and

10 wherein each of the first and second conductive members includes a visual alignment indicator representative of a mating relation between the first and second conductive members, and

wherein each wedge portion includes an abutment face, a wiping contact surface angled with respect to the abutment face, and a conductor contact  
15 surface extending substantially perpendicular to the abutment face, each visual alignment indicator extends from a respective one of the wiping contact faces toward a respective one of the conductor contact faces.

2. The connector assembly of claim 1, wherein at least one of the visual alignment indicators includes a groove formed in the respective one of the first and  
20 second wedge portions.

3. The connector assembly of claim 1, wherein the visual alignment indicators define a final mating relation between the first and second conductive members once the first and second conductive members are fully mated.

4. The connector assembly of claim 1, wherein the visual alignment  
25 indicators are linear, the visual alignment indicators being aligned with one another to define a final mating relation.

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5. The connector assembly of claim 1, wherein the first hook portion is adapted to extend around the first conductor in a first direction, and the second hook portion is adapted to extend around the second conductor in a second direction, the second direction opposite to the first direction.
- 5 6. The connector assembly of claim 1, wherein the first wedge portion and the second wedge portion are substantially identically formed.
7. The connector assembly of claim 1, further comprising a fastener coupling the first wedge portion to the second wedge portion.

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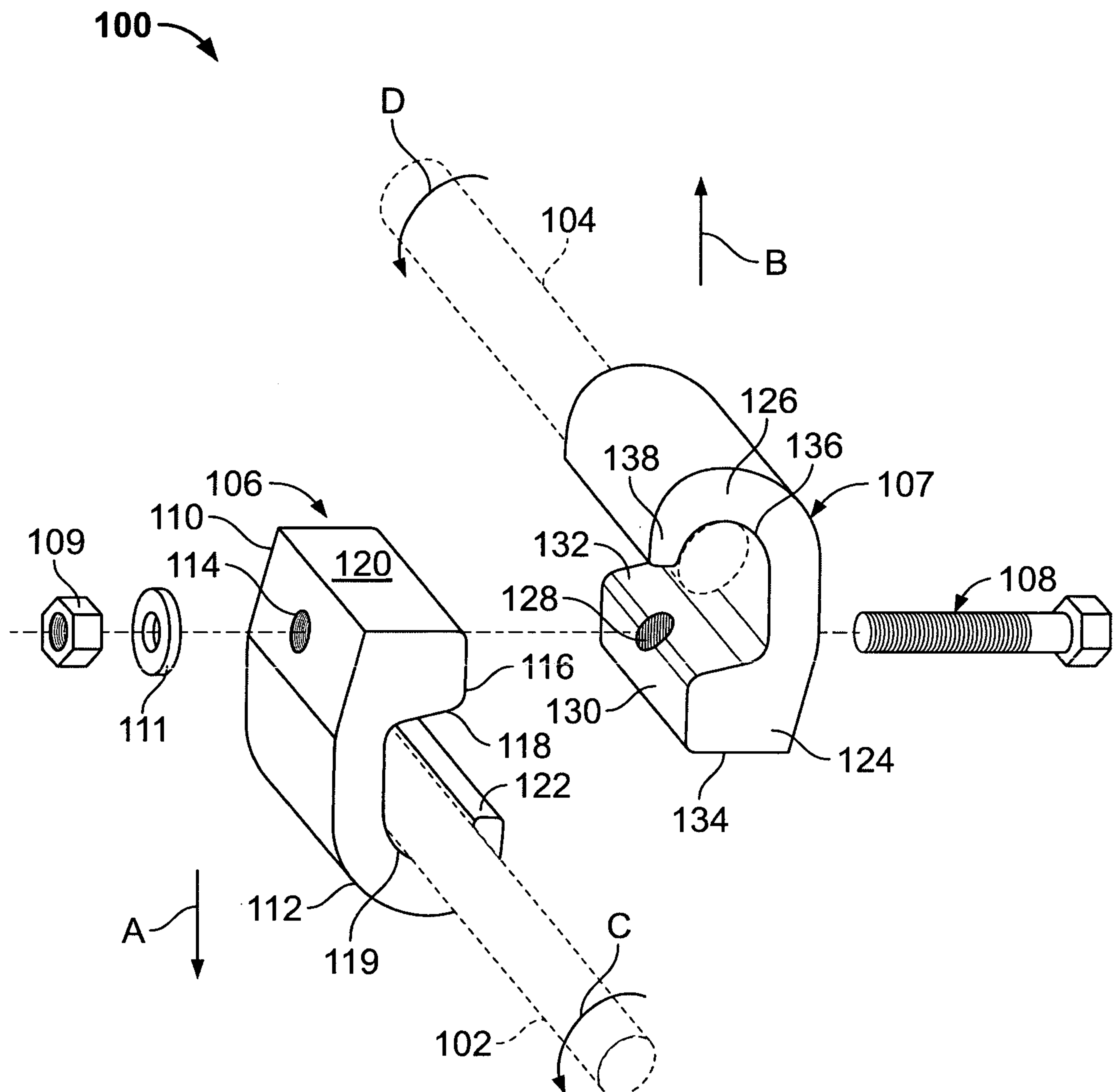
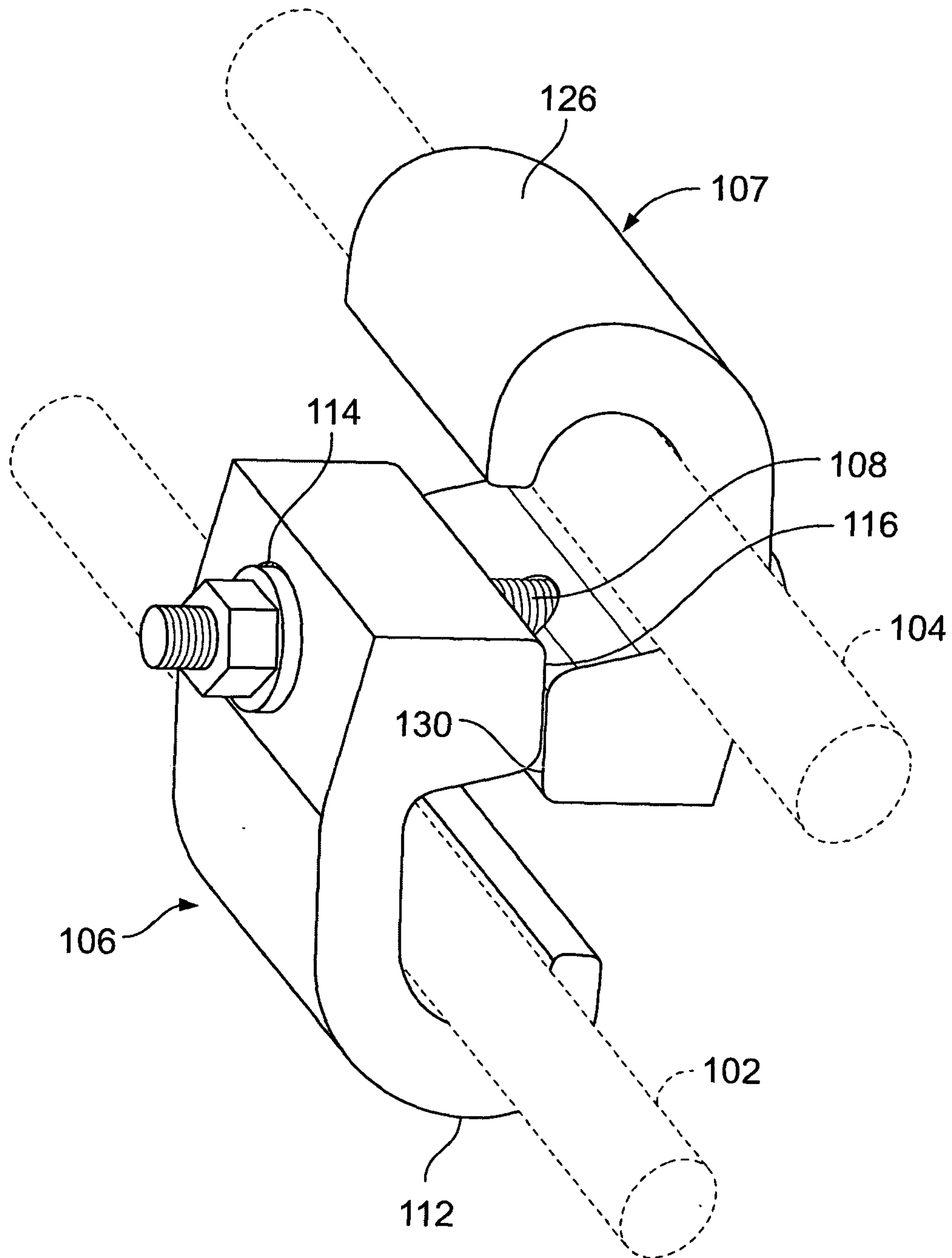


FIG. 1

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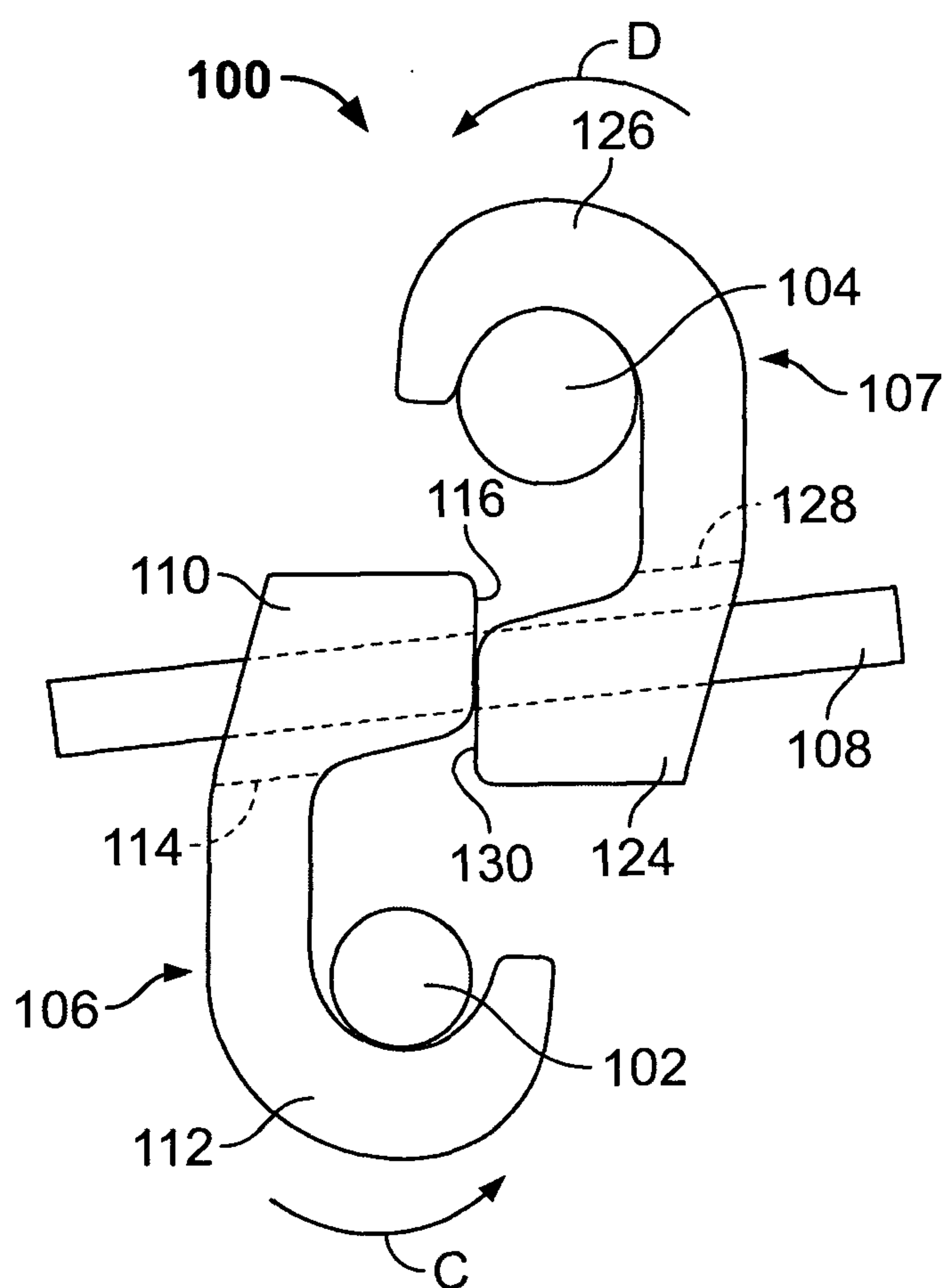


FIG. 3

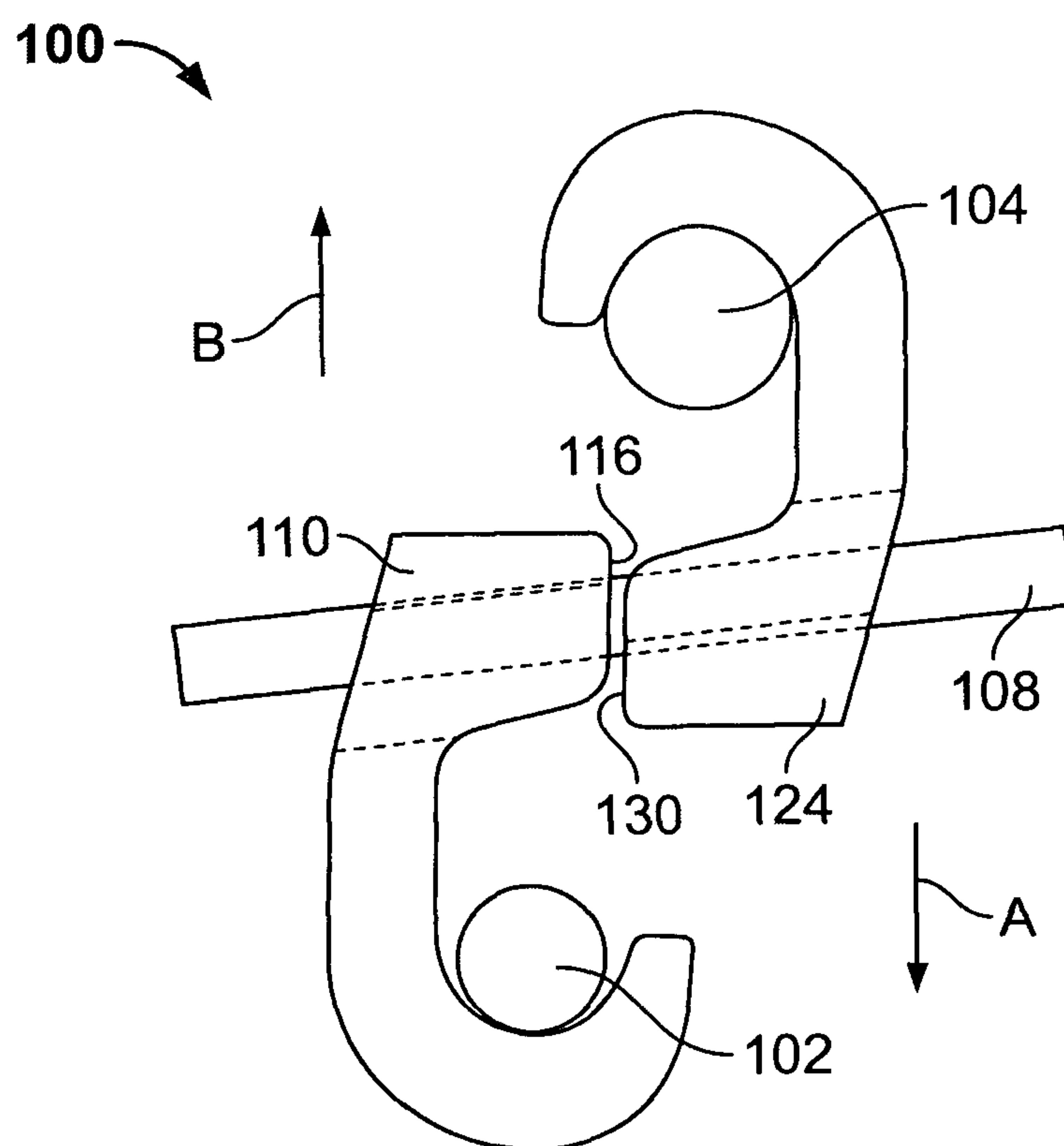


FIG. 4

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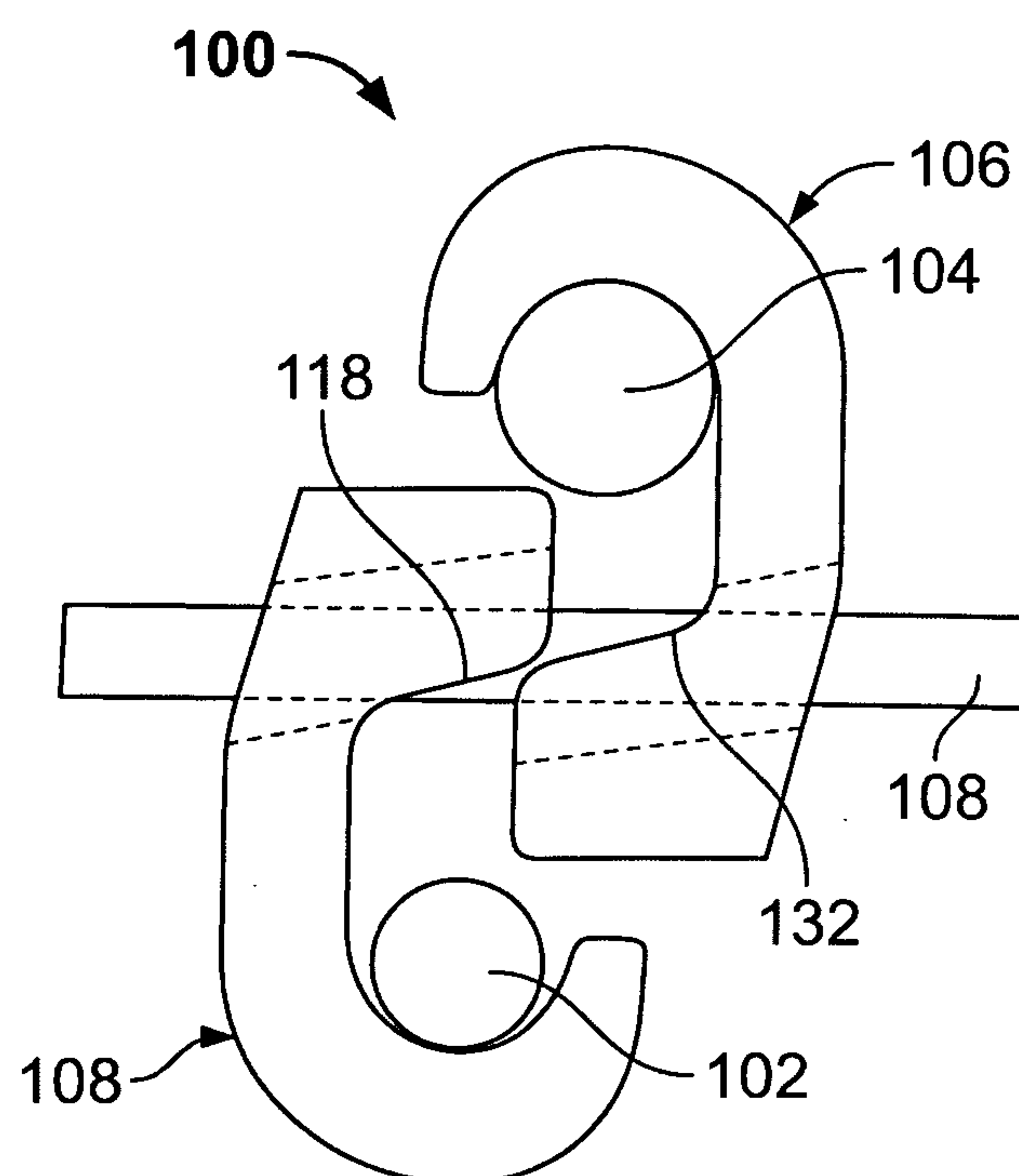


FIG. 5

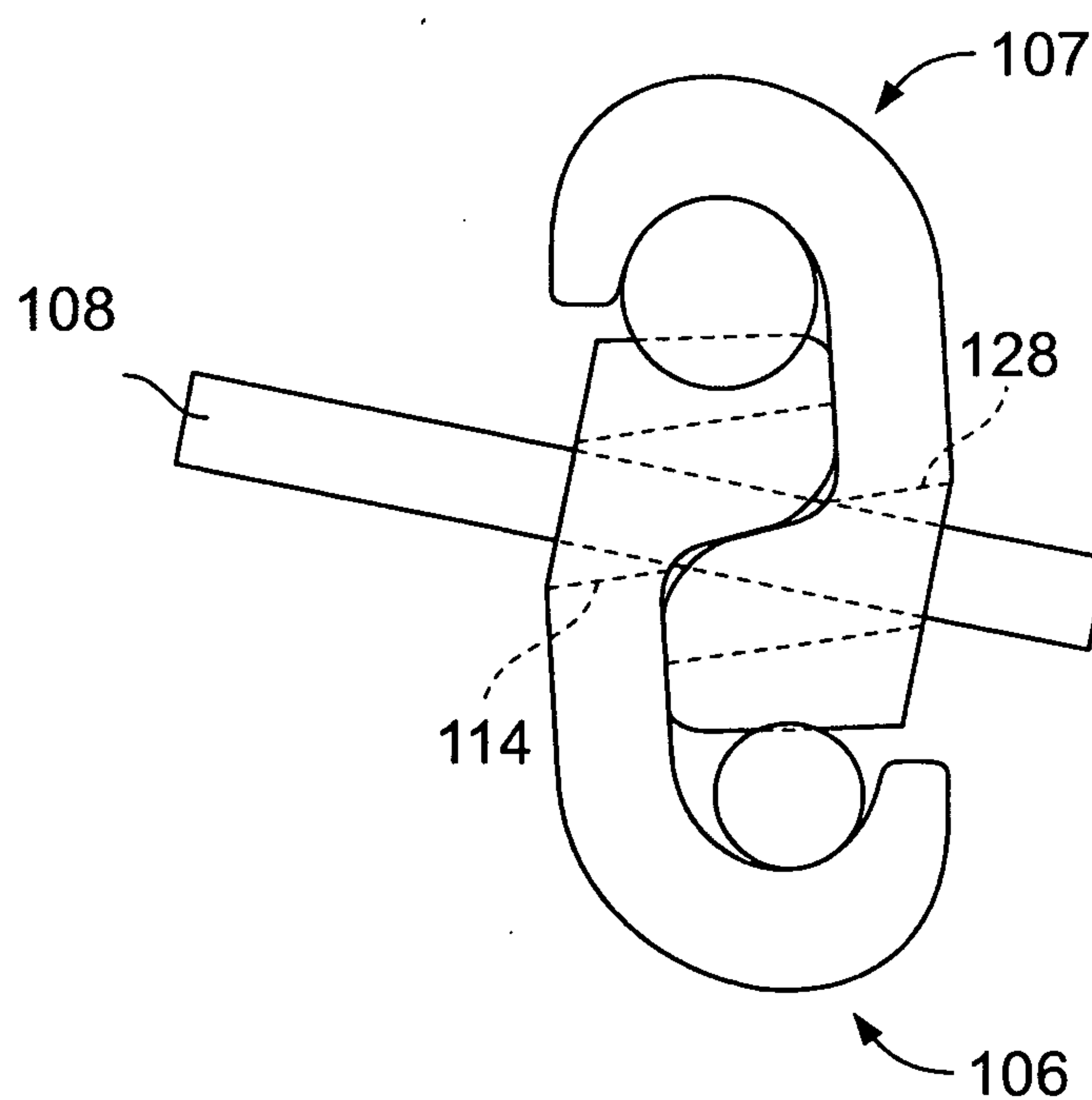


FIG. 6

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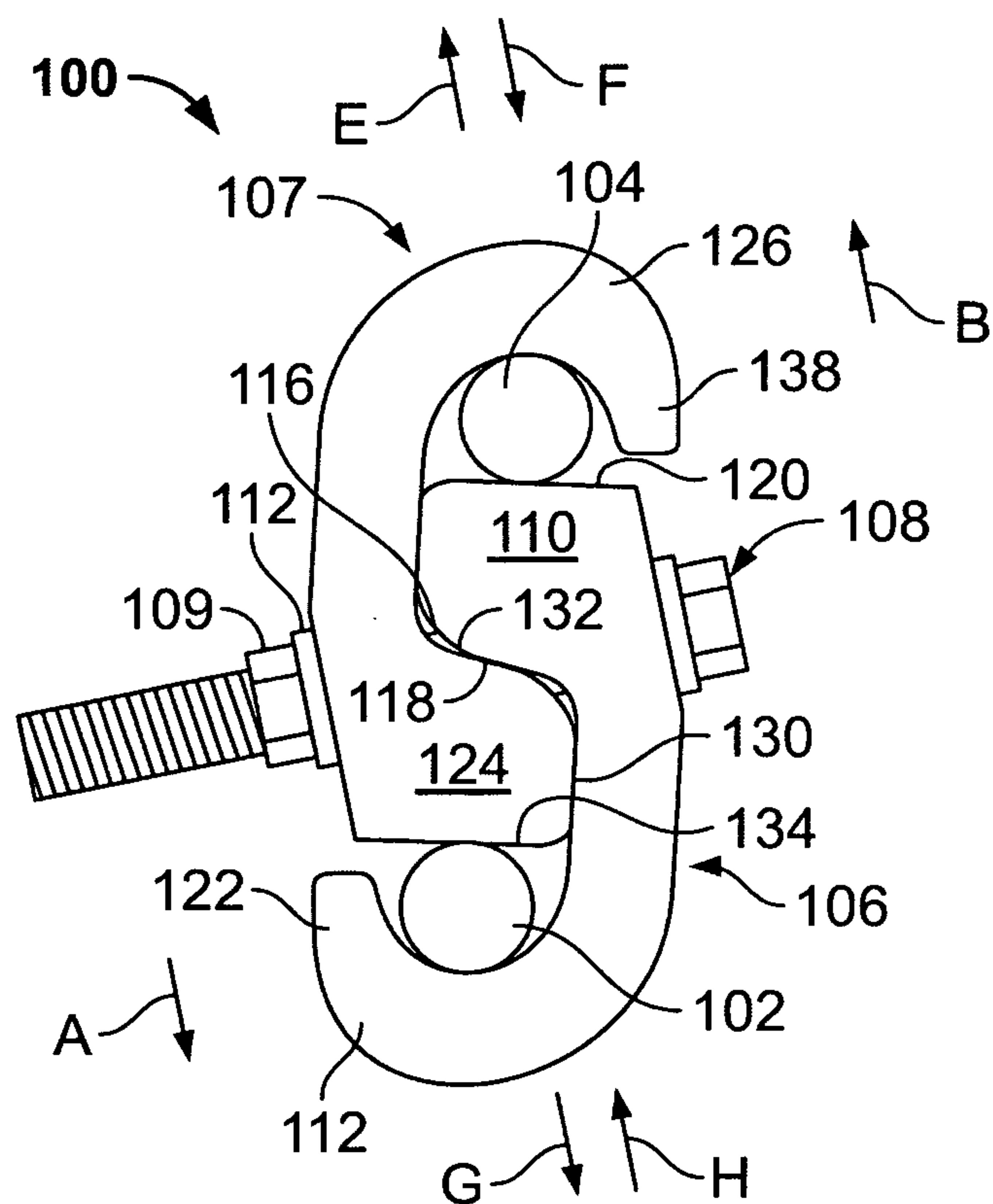


FIG. 7

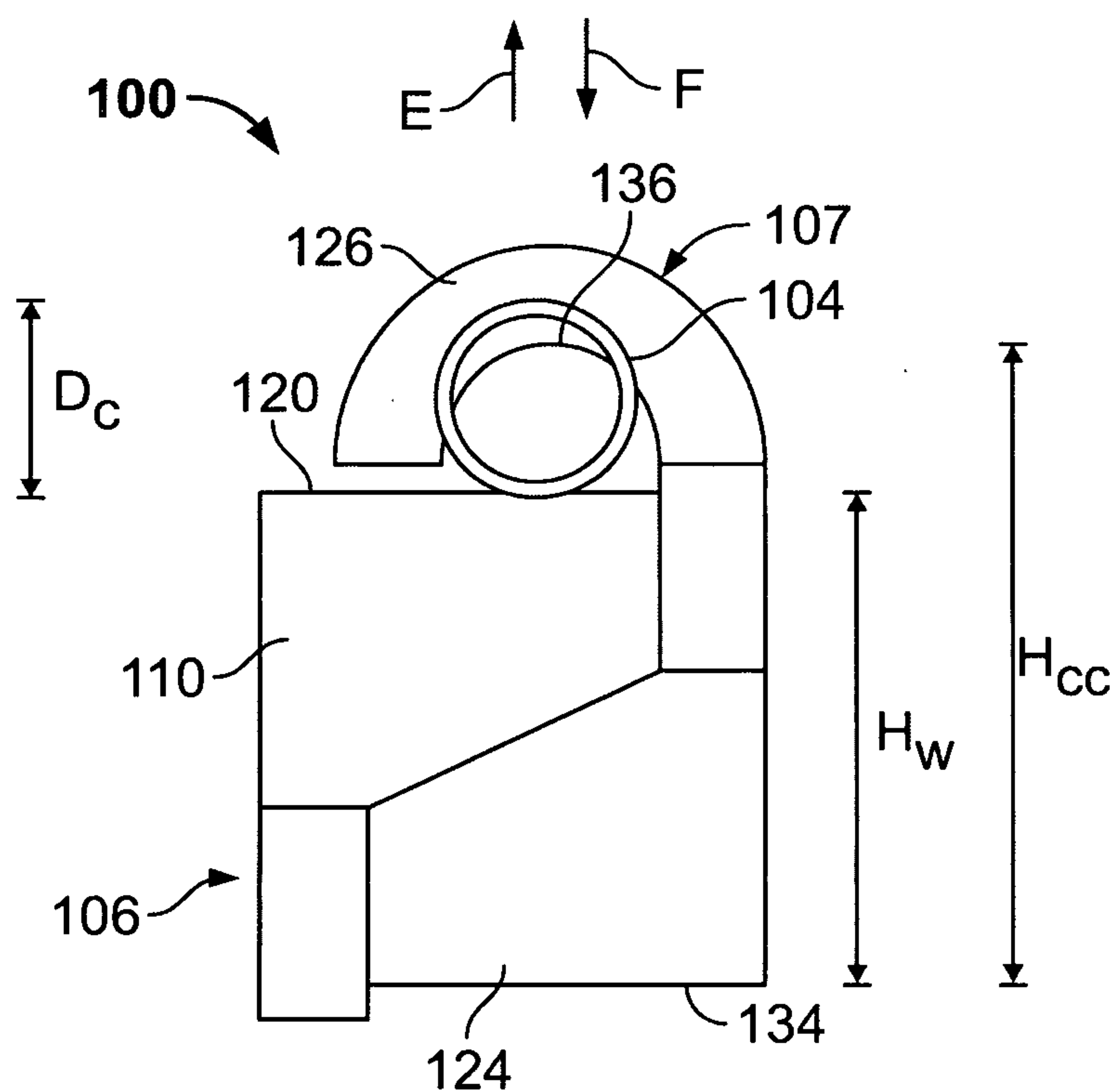


FIG. 8

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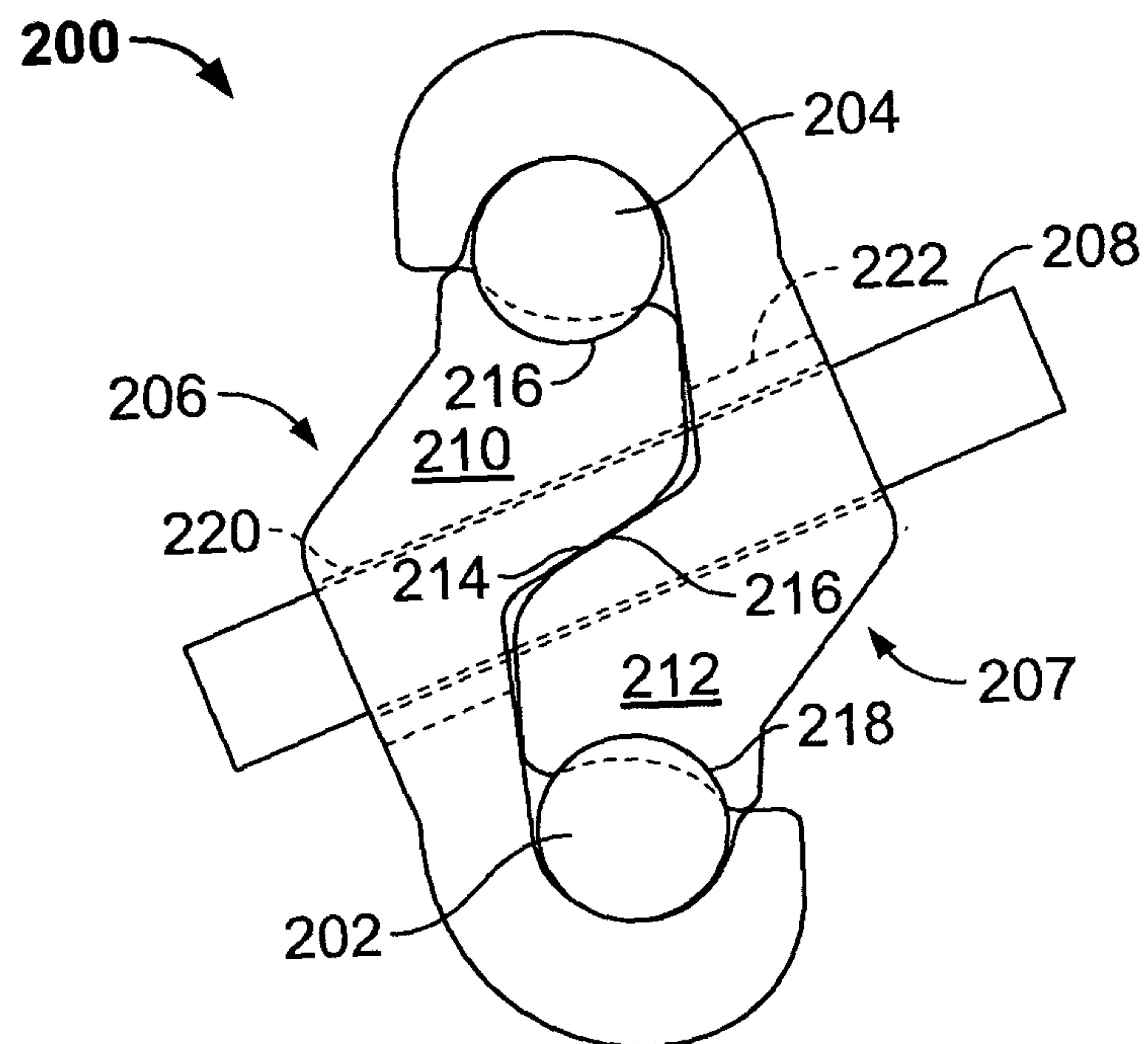
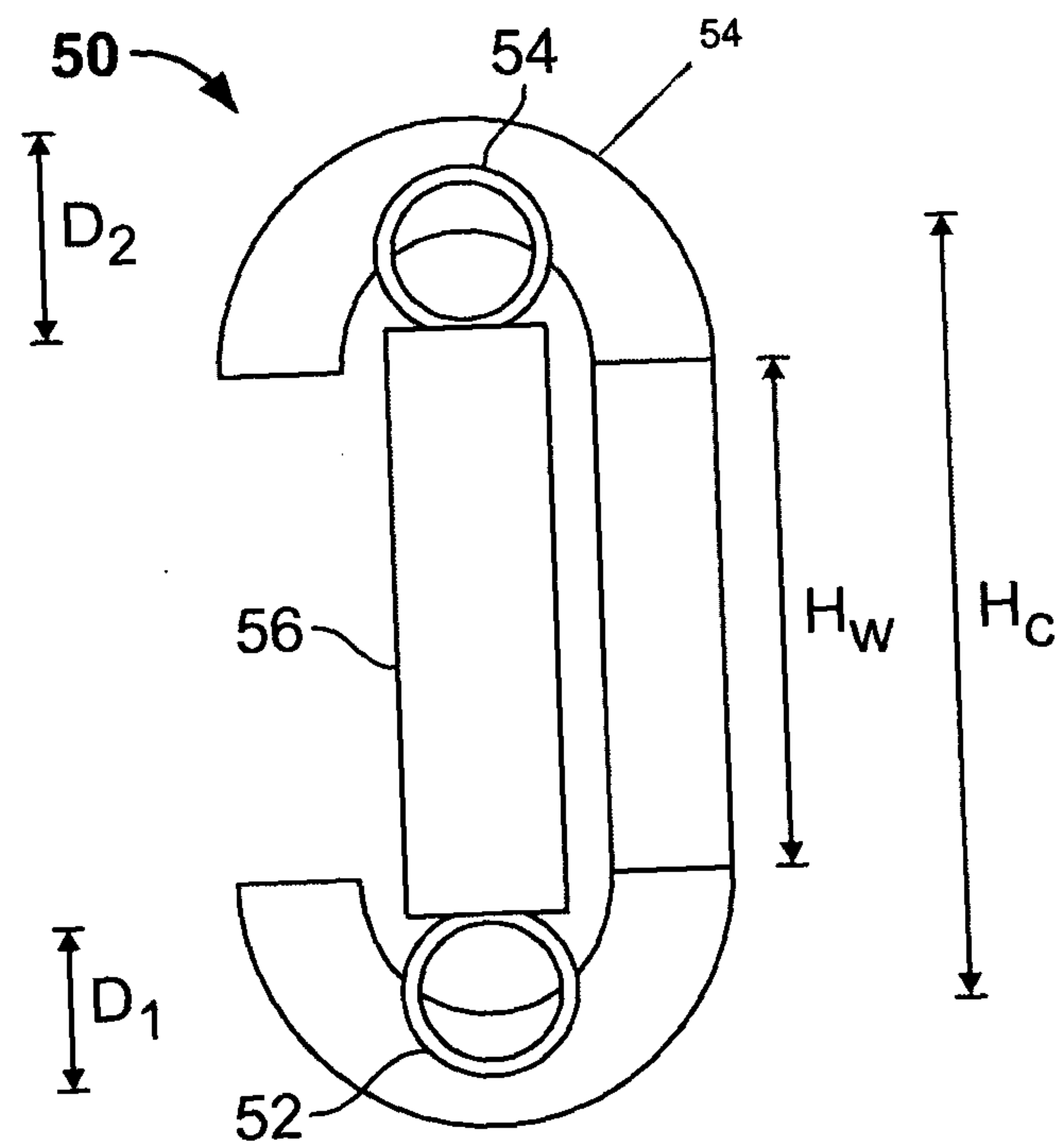
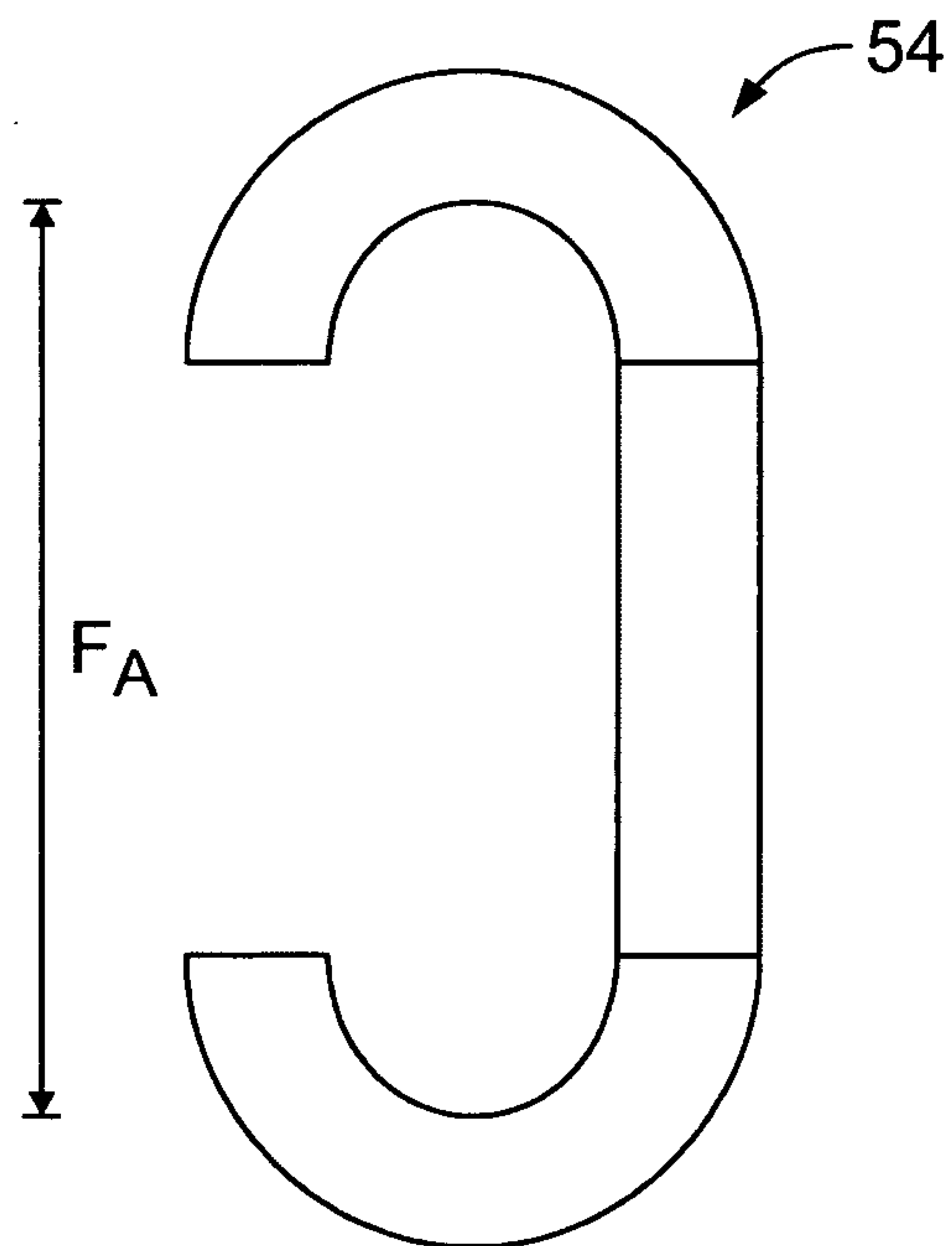


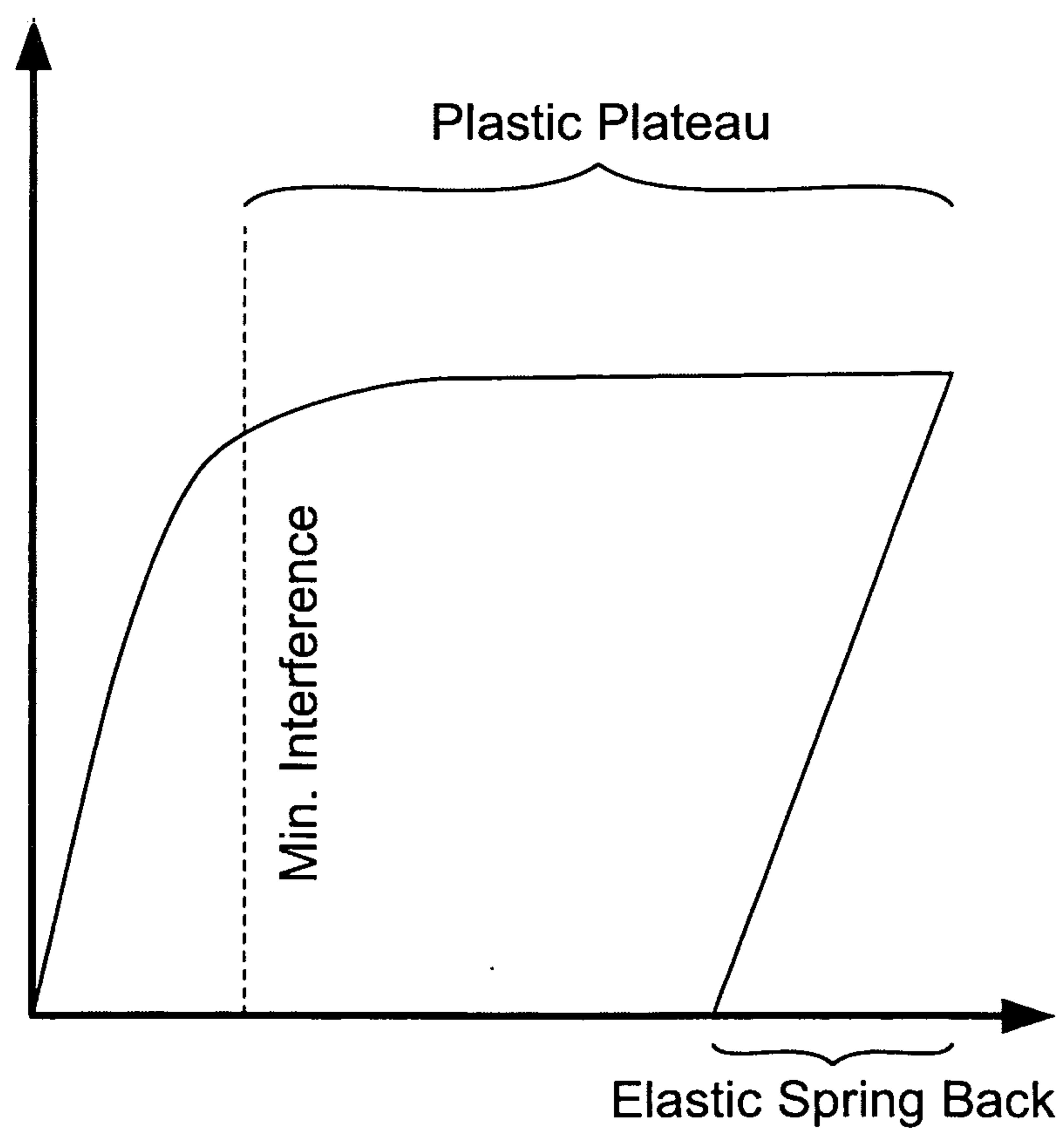
FIG. 9

FIG. 10  
(Prior Art)

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**FIG. 11**  
**(Prior Art)**



**FIG. 12**

