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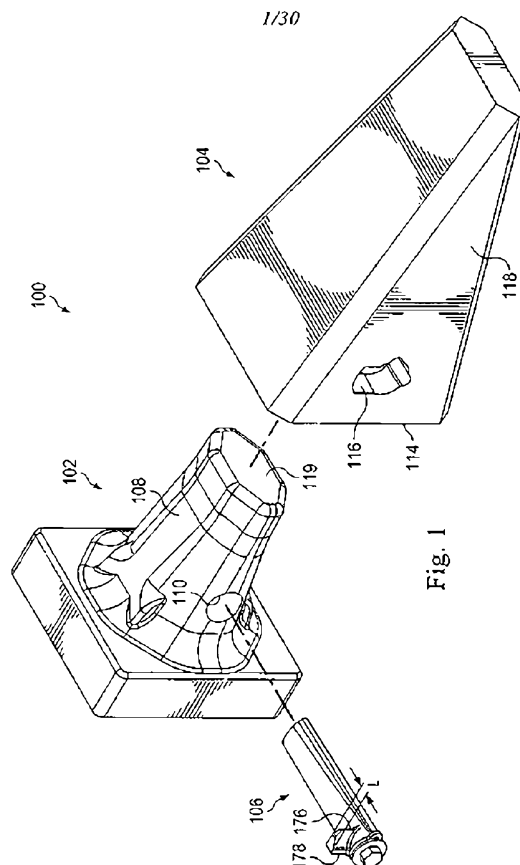
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54 Titre : Connector systems in earth engaging wear member assemblies.

57 Abrégé :

A fastener includes an elongated shaft having a head at the end, the head comprising a lock fin extending radially outward from the shaft. The head includes an engagement cavity. The fastener further includes a cap having an engagement protrusion for insertion into the engagement cavity of the cap such that rotation of the cap causes corresponding rotation of the head, the cap further comprising a contact portion having a plurality of radially outward facing planar surfaces. The fastener further includes a rotation resisting element having inward facing planar surfaces that fit with the radially outward facing planar surfaces of the contact portion, the rotation resisting element further including an interference feature extending radially outward, the rotation resisting element being resilient so as to allow but resist rotation of the cap with respect to the rotation resisting element.

Figure 1



CONNECTOR SYSTEMS IN EARTH ENGAGING WEAR MEMBER ASSEMBLIES

TECHNICAL FIELD

5 [0001] This disclosure is generally directed to earth engaging wear member assemblies including connectors for securing excavating wear members in place for use. More particularly, this disclosure is directed to fasteners that may use a biasing element to resist turning between locked and unlocked positions to selectively secure wear members to other wear members.

BACKGROUND

10 [0002] Material displacement apparatuses, such as excavating buckets found on construction, mining, and other earth moving equipment, often include replaceable wear portions such as earth engaging teeth. These are often removably attached to larger base structures, such as excavating buckets, and come into abrasive, wearing contact with the earth or other material being displaced. For example, excavating tooth assemblies provided on digging equipment, such as
15 excavating buckets and the like, typically comprise a relatively massive adapter portion which is suitably anchored to the forward bucket lip. The adapter portion typically includes a forwardly projecting nose. A replaceable tooth point typically includes a rear-facing cavity that releasably receives the adapter nose. To retain the tooth point on the adapter nose, generally aligned transverse openings may be formed on both the tooth point and the adapter nose, and a suitable
20 connector structure, such as a pin, is driven into and forcibly retained within the aligned openings to releasably anchor the replaceable tooth point on its associated adapter nose.

[0003] During normal operations, the tooth experiences loading in multiple directions. If the tooth is not positioned on the nose in a stable manner, the loads experienced by the tooth can cause additional wear on the adapter. A need accordingly exists for an improved wear member
25 assembly that selectively attaches the wear members to each other or to the bucket lip.

SUMMARY

[0004] According to some examples, an earth engaging wear member assembly may include an adapter comprising a longitudinally projecting nose portion with a transverse cavity formed
30 through the nose portion. The earth engaging wear member assembly may further include a wear member having a rear portion with a cavity for receiving the nose portion of the adapter. The wear member may have an outer surface for engaging the ground and an inner surface

5 defining the cavity. The wear member may include an aperture extending through a sidewall surface from the outer surface to the inner surface. The aperture may be alignable with the transverse cavity of the adapter when the nose portion is disposed within the cavity. The earth engaging wear member assembly may further include a fastener receivable in the aperture and the transverse cavity to prevent removal of the wear member from the adapter. The fastener may
10 include a body comprising a shaft and a head with a lock fin. The fastener may also include a rotation resisting element that may include a ring with a polygonal inner surface and an interference feature extending from an outer surface of the ring. The fastener may also include a cap that may include a contact portion with radially outward facing surfaces that correspond to the polygonal inner surface. The cap may be arranged to engage with the head of the body to
15 limit axial translation of the rotation resisting element. The rotation resisting element may be resilient so as to resist rotation of the body and cap relative to the rotation resisting element between a discrete number of rotational positions.

[0005] According to some examples, a fastener may include an elongated shaft having a head at the end. The head may include a lock fin extending radially outward from the shaft. The head
20 may include an engagement cavity. The fastener may further include a cap having an engagement protrusion for insertion into the engagement cavity of the cap such that rotation of the cap causes corresponding rotation of the head. The cap may further include a contact portion having a plurality of radially outward facing planar surfaces. The fastener may further include a rotation resisting element having inward facing planar surfaces that fit with the radially outward
25 facing planar surfaces of the contact portion. The rotation resisting element may further include an interference feature extending radially outward. The rotation resisting element may be resilient so as to allow but resist rotation of the cap with respect to the rotation resisting element.

[0006] According to one example, a method may include inserting a shaft of a locking mechanism through aligned holes of a wear member and an adapter, the wear member arranged
30 to engage ground and the adapter arranged to secure the wear member to a bucket lip, the shaft including a lock fin extending radially outward. The method further includes connecting a cap with a head of the shaft such that rotation of the cap causes corresponding rotation of the shaft, the cap being engaged through an inner portion of a rotation resisting element, the rotation resisting element having inward facing planar surfaces that fit with radially outward facing
35 planar surfaces of a contact portion of the cap, the rotation resisting element further including an interference feature extending radially outward. The method further includes rotating the cap and thereby the lock fin of the shaft between a locked position in which the lock fin is positioned

5 to prevent removal of the locking mechanism and an unlocked position in which the lock fin allows removal of the locking mechanism. Rotating between the locked and unlocked positions is resisted by the rotation resisting element.

[0007] According to some examples, a wear member assembly for an earth mover may include a support structure having a hole formed therein and a wear member removably attachable to the support structure. The wear member may have a hole formed therein sized differently than the hole in the support structure. The hole in the support structure may be alignable with the hole in the wear member. The wear member may also have an oblique surface facing a cavity in the wear member. The wear member assembly may also include a rotatable fastener receivable into the hole in the support structure and into the hole in the wear member in a manner that prevents removal of the wear member from the support structure. The fastener may include a body portion and a fixed radially extending lock fin extending only partially about a circumference of the body portion. The fastener may be axially receivable into the hole in the wear member and rotatable from an unlocked condition where the lock fin is aligned with the hole in the wear member to a locked condition where the lock fin is misaligned with the hole in the wear member. The body portion of the rotatable fastener comprising a distal end formed at an oblique angle wherein the oblique surface of the wear member cooperates with the distal end of the fastener to axially displace the fastener during rotation from the locked condition to the unlocked condition.

[0008] According to some examples, a rotatable fastener is receivable into a hole in both a support structure and a wear member in a manner that prevents removal of the wear member from the support structure. The fastener may include a main body having a body portion sized to be axially introduced into the hole of the support structure, the body portion having a distal end and a proximal end and having a longitudinal axis, the body portion having a substantially circular body in cross-section from the distal end to the proximal end, the body portion having an oblique end surface angled relative to the longitudinal axis within a range of about 20-70 degrees, the end surface disposed to engage an oblique bottom surface of a bore in one of the support structure and the wear member. The main body may also include a fixed radially extending lock fin spirally disposed on the body portion and extending only partially about a circumference of the body portion. The fastener may also include a locking detent protruding from a side of the main body at a location axially disposed between the proximal end and the lock fin, the locking detent being compressible relative to the body portion from a compressed condition to an uncompressed condition.

5 [0009] According to some examples, a rotatable fastener is receivable into a hole in both a support structure and a wear member in a manner that prevents removal of the wear member from the support structure. The fastener may include a main body having a body portion sized to be axially introduced into the hole of the support structure. The body portion may have a distal end and a proximal end and having a longitudinal axis. The body portion may have a
10 substantially circular body from the distal end to the proximal end. The body portion may have a substantially cylindrical first side and an opposing tapered second side. The body portion may be substantially circular in cross-section at the distal end. The main body may also include a fixed radially extending lock fin spirally disposed on the body portion and extending only partially about a circumference of the body portion. The fastener may also include a locking
15 detent protruding from a side of the main body at a location axially disposed between the proximal end and the lock fin. The locking detent may be compressible relative to the body portion from a compressed condition to an uncompressed condition.

[0010] It is to be understood that both the foregoing general description and the following drawings and detailed description are exemplary and explanatory in nature and are intended to
20 provide an understanding of the present disclosure without limiting the scope of the present disclosure. In that regard, additional aspects, features, and advantages of the present disclosure will be apparent to one skilled in the art from the following.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings illustrate implementations of the systems, devices, and
25 methods disclosed herein and together with the description, serve to explain the principles of the present disclosure.

[0012] Fig. 1 is an exploded perspective view of a wear member assembly according to one example of principles described herein.

[0013] Fig. 2 is a perspective view of a fastener for a wear member assembly according to one
30 example of principles described herein.

[0014] Fig. 3 is a side view of the fastener according to one example of principles described herein.

[0015] Fig. 4 illustrates a cross-sectional view of the fastening pin according to one example of principles described herein.

- 5 **[0016]** Fig. 5 illustrates a cross-sectional view of the assembled wear member assembly according to one example of principles described herein.
- [0017]** Fig. 6 illustrates a perspective view of a wear member according to one example of principles described herein.
- [0018]** Fig. 7 illustrates a hole of the wear member according to one example of principles described herein.
- 10 **[0019]** Fig. 8 illustrates a more detailed hole in an inner side of the wear member according to one example of principles described herein.
- [0020]** Fig. 9A illustrates a fastener in a first stage of securing a wear member to a support structure with a fastener according to one example of principles described herein.
- 15 **[0021]** Fig. 9B illustrates a fastener in a second stage of securing a wear member to a support structure with a fastener according to one example of principles described herein.
- [0022]** Fig. 9C illustrates a fastener in a final stage of securing a wear member to a support structure with a fastener according to one example of principles described herein.
- [0023]** Fig. 10 is view of an earth engaging wear member assembly according to one example incorporating principles described herein.
- 20 **[0024]** Fig. 11 illustrates an exploded view of a pin with a rotation resisting element according to an example incorporating principles described herein.
- [0025]** Fig. 12 illustrates a perspective view of the pin with a rotation resisting element according to an example incorporating principles described herein.
- 25 **[0026]** Fig. 13 illustrates a rotation resisting element according to an example incorporating principles described herein.
- [0027]** Fig. 14 is a view along the axis of the pin placed within the tooth according to an example incorporating principles described herein.
- [0028]** Fig. 15 illustrates a rotation resisting element with outer projections according to an example incorporating principles described herein.
- 30 **[0029]** Fig. 16 is a view along the axis of the pin placed within the tooth according to an example incorporating principles described herein.

5 [0030] Figs. 17A, 17B, and 17C are diagrams showing a cross-section of the fastener along the rotation resisting element in different rotational positions according to an example incorporating principles described herein.

 [0031] Figs. 18A and 18B illustrate various cross-sectional views of the pin in an unlocked position according to an example incorporating principles described herein.

10 [0032] Fig. 18C is a diagram showing an interior view of the cavity of the wear member according to an example incorporating principles described herein.

 [0033] Figs. 19A, 19B, and 19C illustrate various cross-sectional views of the pin in a locked position according to an example incorporating principles described herein.

15 [0034] Fig. 20 is a flowchart showing an illustrative method for inserting a fastener according to an example incorporating principles described herein.

 [0035] Fig. 21 is a diagram showing a perspective view of a pin with a rotation resisting element that has an inner ring and an outer ring according to one example of principles described herein.

20 [0036] Fig. 22 is a diagram of the outer ring according to one example of principles described herein.

 [0037] Fig. 23 is a diagram of the inner ring according to one example of principles described herein.

 [0038] Figs. 24A, 24B, and 24C are diagrams showing rotation of the pin with respect to the rotation resisting element of Fig. 21 according to one example of principles described herein.

25 [0039] These Figures will be better understood by reference to the following Detailed Description.

DETAILED DESCRIPTION

30 [0040] For the purposes of promoting an understanding of the principles of the present disclosure, reference will now be made to the implementations illustrated in the drawings and specific language will be used to describe them. It will nevertheless be understood that no limitation of the scope of the disclosure is intended. Any alterations and further modifications to the described devices, systems, methods, and any further application of the principles of the

5 present disclosure are fully contemplated as would normally occur to one skilled in the art to which the disclosure relates. In addition, this disclosure describes some elements or features in detail with respect to one or more implementations or Figures, when those same elements or features appear in subsequent Figures, without such a high level of detail. It is fully contemplated that the features, components, and/or steps described with respect to one or more
10 implementations or Figures may be combined with the features, components, and/or steps described with respect to other implementations or Figures of the present disclosure. For simplicity, in some instances the same or similar reference numbers are used throughout the drawings to refer to the same or like parts.

[0041] The present disclosure is directed to an earth engaging wear member assembly that
15 includes a support structure, such as a wear member adapter, securable to a bucket lip and another wear member such as a tooth. The assembly further includes a fastener to hold the tooth on the adapter. The fastener, such as a pin, rotates between an unlocked position in which the pin can be removed from its position within the tooth and a locked position in which the pin is prevented from being removed from its position within the tooth. The present disclosure
20 describes a pin configuration that provides resistance when rotating the pin between locked and unlocked positions. This resistance provides tactile feedback to the operator.

[0042] Fig. 1 is an exploded perspective view of a wear member assembly 100. According to the present example, the wear member assembly 100 includes a support structure 102, a wear member 104 such as an excavating tooth, and a fastener 106. In this implementation, the support
25 structure 102 is representatively a base adapter having a tapered front nose portion 108 with a leading end 119. Alternatively, the support structure could be an intermediate adapter or another type of support structure. Extending horizontally through the nose portion 108 between its opposite vertical sides is a connector opening 110 that is sized to receive the fastener 106.

[0043] The wear member 104 is a replaceable excavating tooth, but could also be an
30 intermediate adapter or other type of replaceable wear member. A tapered pocket area 112 extends forwardly through a rear end 114 of the wear member 104 and, as best illustrated in Fig. 6, is configured to complementarily receive the nose portion 108 when the wear member 104 is telescoped onto the nose portion 108. With the wear member 104 operatively disposed on the nose portion 108, connector pin openings 116 (only one of which is visible in Fig. 1) extending
35 through opposite exterior walls 118 of the wear member 104 into the pocket area 112 are aligned with the nose connector opening 110. As will be described further below, the wear member 104 includes interior side recesses such as a lock shoulder and/or other features that interface with the

5 fastener 106 and cooperate to secure the fastener 106 in place and thereby secure the wear member 104 to the support structure 102.

[0044] With reference now to Figs. 2-4, the fastener 106 comprises a main body 126 and a locking detent 128. The main body 126 is formed as a solid metal elongated cylindrical connector pin having a fixed axial length extending along a central longitudinal axis 130. In this
10 exemplary implementation, the main body 126 is formed of a single monolithic material. However, in other implementations, different portions of the main body 126 may be formed of separate materials coupled or otherwise connected together. In some implementations, different portions of the main body 126 may be welded to each other to form a monolithic structure without moving parts. The main body 126 includes a longitudinally extending body portion 132,
15 a radially extending lock fin 134, and a tool engaging feature 136.

[0045] The body portion 132 has a substantially circular cross-section along its length and includes a distal end 142 and a proximal end 144. In this implementation, the distal end 142 is substantially cylindrical and having a perimeter circumference having substantially the same radius. The body portion 132 includes a cylindrical portion 146 extending between the distal end
20 142 and the proximal end 144. In this example, the cylindrical portion 146 extends along the side having the lock fin 134. In addition, the body portion 132 includes a slightly tapered portion 148 extending between the distal end 142 and the proximal end 144. The slightly tapered portion 148 may be disposed on opposing side from the cylindrical portion 146. In some examples, the tapered portion 148 is on a side opposite the lock fin 134. In some examples, however, the
25 tapered portion 148 may not be directly opposite the lock fin 134.

[0046] Each of the cylindrical portion 146 and the tapered portion 148 has particular purposes. One purpose of the cylindrical portion 146 is to provide equal load distribution to the support structure 102 when the fastener 106 is disposed in the connector opening 110 (Fig. 1) of the support structure 102. This may be seen in the cross sectional view of Fig. 5, showing a cross-
30 sectional view of the assembled wear member assembly 100. Fig. 5 shows the cylindrical portion 146 of the fastener 106 facing and in abutting contact with an interior wall 160 of the connector opening 110 of the support structure 102. Because the cylindrical portion 146 interfaces with and engages with the interior wall 160 (and is disposed to face the leading end 119 of the support structure), which is shaped to match the cylindrical portion 146 of the fastener
35 106, applied loads will be evenly distributed along a load interface 162 corresponding to the interface of the cylindrical portion 146 and the interior wall 160. This may extend the useful life of the support structure 102 by reducing a chance of deformation that may occur over time with

5 unevenly distributed loads. In addition, the tapered portion 148 also has purpose. Still referring to Fig. 5, the tapered portion 148 is shown with an increasing separation from a back portion 164 of the interior wall 160. In this implementation, the separation is present due to the tapered portion 148, which, in this implementation, extends from the distal end 142 to the proximal end 144 of the body portion 132. The tapered portion 148 makes one side of the body portion 132
10 conically shaped. As may be understood from the above description, the cylindrical portion 146 forms the opposing side of the body portion 132. The tapered portion 148 provides additional clearance toward the distal end 142 for a relatively easier insertion and removal of the fastener 106 from the connector opening 110. During use, debris such as dirt or mud may enter any gaps or crevices between components, such as between the fastener 106 and the interior wall 160 of
15 the connector opening 110. This debris may make removal of the fastener 106 from the connector opening 110 more challenging. The tapered portion 148 reduces friction as the fastener 106 is removed from connector opening 110. In some implementations, the tapered portion 148 is formed at an angle relative to the longitudinal axis 130 in a range of 1-5 degrees. Other angles, both larger and smaller, are also contemplated. Some fastener implementations are
20 cylindrical along the entire length of the body portion 132. Other implementations are conical along the entire length of the body portion 132. Yet other implementations are also contemplated.

[0047] The distal end 142 of the body portion 132 may include an end surface 170 formed at an oblique angle 171 relative to the longitudinal axis 130. In some implementations, the end
25 surface 170 is angled at the angle 171 selected to be within a range of about 20 to 70 degrees relative to the longitudinal axis 130. Some implementations have an angle range of about 35 to 55 degrees. Some end surface implementations are angled at about 45 degrees. As will be described further below, this angled end surface may cooperate with the wear member 104 to form a release mechanism, or push-out feature, that helps remove the fastener 106 from the
30 support structure 102 and the wear member 104.

[0048] The radially extending lock fin 134 is, in the implementation shown, disposed toward the proximal end 144 of the main body 126. The lock fin 134 extends radially from the body portion 132. In some implementations, the lock fin 134 extends substantially from one side of the main body 126.

35 [0049] In the implementation shown, the lock fin 134 has a relatively larger transverse width W (Fig. 2) and a relatively smaller axial length L (Fig. 1). Other implementations have a lock fin 134 sized differently. Some lock fins are substantially fan shaped. Other lock fins have

5 alternative shapes. The lock fin 134 has a distal facing surface 172, a proximal facing surface 174, a leading edge 176, and a trailing edge 178. In some implementations, at least one of the distal facing surface 172 and the proximal facing surface 174 extends along a plane substantially perpendicular to the longitudinal axis 130. In other implementations, at least one of the distal facing surfaces 172 and the proximal facing surface 174 extend at an oblique angle relative to a
10 plane substantially perpendicular to the longitudinal axis 130. In such implementations, one or both of the distal and proximal facing surfaces 172, 174 of the lock fin 134 may spiral about a portion of the longitudinal axis 130. In some implementations, the distal facing surface 172 is formed substantially within a single plane perpendicular to the longitudinal axis 130, and the proximal facing surface 174 includes a tapered portion 177 forming an obliquely angled plane or
15 planar surface adjacent the leading-edge 176 and a planar portion 179 parallel to the distal facing surface 172 adjacent the trailing edge 178. In some implementations, a third planar portion 181 forms a taper extending from the planar portion 179 to the trailing edge 178. The planar portion 181 may be configured to dislodge and remove debris when the fastener 106 is rotated for removal from the wear member 104 and the support structure 102.

20 **[0050]** The leading-edge 176 and the trailing edge 178 may extend in substantially the same direction from the body portion 132. For example, they may be relatively parallel to each other. In some examples, they may deviate less than 10° from each other. Accordingly, the lock fin may be relatively rectangular shaped. In some implementations, the leading-edge 176 and the trailing edge 178 are angled relative to each other and may form an angle within a range of 0 to
25 60 degrees. Accordingly, the lock fin may be fan shaped. Yet other angles and shapes are also contemplated. In some implementations, the maximum distance between the leading-edge 176 and the trailing edge 178 may be equal to or less than a diameter of the body portion 132. In some implementations, the maximum distance between the leading-edge 176 and the trailing edge 178 may be greater than a radius of the body portion 132, but smaller than the diameter of
30 the body portion 132. In some implementations, the maximum distance between the leading-edge 176 and the trailing edge 178 may be greater than a diameter of the body portion. In some implementations, the axial length L or thickness of the lock fin 134 at the leading-edge 176 is less than the axial length L or thickness of the lock fin 134 at the trailing edge 178. In some implementations, the lock fin may have a radial height greater than the radius of the body
35 portion. In some implementations, the axial length L or thickness of the lock fin 134 at the leading-edge 176 is greater than the axial length L or thickness of the lock fin 134 at the trailing edge 178. In some examples, both the distal facing surface 172 and the proximal facing surface

5 174 of the lock fin 134 may be substantially parallel to each other. In other words, there may not be tapering of the distal facing surface 172.

[0051] The tool engaging feature 136 is disposed at the distal end 142 of the body portion 132 and is configured and arranged to interface with a tool that a user may employ to move the fastener 106 from an unlocked condition to a locked condition. In the exemplary implementation shown herein, the tool engaging feature 136 is formed as a hex head protruding from an end of the body portion 132. Other tool engaging feature implementations may include a recess or depression formed into an end of the body portion 132. The protrusion or the recess may be hex shaped as shown, or may be alternatively shaped as a square, a star, or other shape that may enable coupling to a tool.

15 [0052] In this implementation, the body portion 132 includes a groove 180 sized and arranged to receive the locking detent 128. The groove 180 may be disposed at the proximal end 144 between the lock fin 134 and the tool engaging feature 136. Here, the groove 180 is formed radially within a plane substantially perpendicular to the longitudinal axis 130. In some implementations, the groove 180 extends about only a portion of the circumference of the body portion 132. In other implementations, the groove 180 extends entirely about the circumference of the body portion 132. Here, as can be seen in Fig. 4, the groove 180 extends about only a portion of the circumference of the body portion 132 in order to minimize any chance of the locking detent 128 inadvertently sliding about the circumference of the body portion 132. Other spring designs are also contemplated, including elastomeric or polymeric systems.

25 [0053] The locking detent 128 may be carried on and supported by the body portion 132. The locking detent 128 may project radially outwardly from the body portion 132 and may help maintain the fastener 106 in a locked and/or unlocked condition as desired by a user. In the implementation shown, the locking detent 128 comprises a C-shaped snap ring that fits within the groove 180 and the body portion 132. Here, the C-shaped locking detent 128 includes a protruding portion 182 formed of a flexible protrusion and a spring portion 184 formed of legs of the C-shaped snap ring. In this implementation, the legs fit within the groove 180 so that they are flush with or below an exterior surface of the body portion 132. The protruding portion 182 projects radially outwardly beyond the exterior surface of the body portion 132. When the fastener 106 is rotated between an unlocked condition and a locked condition, the protruding portion 182 may be radially and elastically compressed. When the fastener 106 arrives at the unlocked condition and/or the locked condition, the protruding portion 182 may be permitted to spring radially back to its original condition. This may provide a user with a tactile feel

5 indicating that the fastener 106 is fully within the locked condition or the unlocked condition, while at the same time, it may help prevent inadvertent rotation of the fastener from the locked condition to the unlocked condition. This will become more apparent in the discussion below.

[0054] While the embodiment disclosed employs a snap ring style locking detent, other locking detents are also contemplated. For example, some detents have a shape other than C-
10 shape. Some extend completely around the body portion 132. Additional implementations employ an elastomeric projection extending from the exterior surface of the body portion 132. When moved between an unlocked and a locked condition, the elastomeric projection may compress and then expand when properly located at the locked or unlocked condition. The elastomeric locking detent would reduce the likelihood of inadvertent rotation during use from
15 the locked condition to the unlocked condition. Other locking detents include spring-loaded detents. Yet others are also contemplated.

[0055] Fig. 6 shows the wear member 104 in greater detail including the tapered pocket area 112 extending through the rear end 114. With reference to both Figs. 5 and 6, the wear member 104 includes connector pin openings 116 on both opposing sides of the wear member. In the
20 implementation shown, the connector pin openings 116 both extend from an exterior surface of the exterior walls 118 into the pocket area 112. In some alternative implementations, only one connector pin opening 116 extends from the exterior surface into the pocket area 112. In such an implementation, the opposing connector pin opening 116 may be formed only in the interior surface of the pocket area 112. As shown in Fig. 5, the connector pin openings 116 are aligned
25 so that the fastener 106 may extend and engage with the connector pin openings 116 on both opposing sides of the wear member 104.

[0056] In this implementation, the connector pin openings 116 include a release opening 202 and a locking opening 204. The release opening 202 is formed as a counterbore passage extending from the interior wall 203 of the wear member 104 to the exterior wall 118. In
30 accordance with this, the release opening 202 includes a larger diameter portion 206 and a smaller diameter portion 208. The larger diameter portion 206 is sized to receive the distal end 142 of the fastener 106. A bottom surface 210 of the larger diameter portion 206 is oblique relative to an axis through the larger diameter portion 206 that may also be parallel to the longitudinal axis 130 of the fastener 106 when the fastener 106 is disposed in the pin openings
35 116. In the implementation shown, the bottom surface 210 is angled to lie substantially parallel to the end surface 170 of the fastener 106 when the fastener is in a locked condition, in a manner shown in Fig. 5. The purpose of the oblique surface to cooperate with the end surface 170 (of

5 the push-out feature) to eject the fastener during rotation will be explained further below. The oblique surface is also oblique to a transverse axis that passes through both connector pin openings 116. This transverse axis may be coaxial with the axis 130 shown in Fig. 5.

[0057] The smaller diameter portion 208 extends from the bottom surface 210 to the exterior wall 118 of the wear member 104. The passage formed by the smaller diameter portion 208 may
10 provide access to the fastener 106 by a user. This may be helpful if for example the fastener 106 were to become lodged within the connector opening 110 of the support structure 102 or the connector pin openings 116 of the wear member 104. The passage may permit a user to force the fastener 106 through the connector opening 110. For example, a user may insert a shaft through the passage into contact with the distal end of the fastener 106, and may tap in the end of
15 the shaft to break loose the fastener 106 from the connector opening 110 and/or the connector pin openings 116. Some implementations also include a tool receiver that enables a user to pry the fastener from the connector pin opening 116 if needed. For example, the protrusion, the fin, or other features on the body portion may be used to pry the fastener 106 from the bore.

[0058] The locking opening 204 is shaped to axially receive the fastener 106 therethrough, and
20 permit the fastener 106 to be rotated from an unlocked condition to a locked condition. As used herein, the unlocked condition is a position that allows the fastener 106 to be removed from the locking opening 204. The locked condition is a position where the lock fin 134 is disposed behind a portion of the wall separating the pocket area 112 from the external side wall 118. The locking opening 204 therefore includes a shape that is larger than the axial profile of the fastener
25 106. The locking opening 204 is shown in detail in Figs. 7 and 8. Fig. 7 shows a perspective view of the external portion of the locking opening 204, while Fig. 8 shows an internal portion of the locking opening 204. As viewed in Fig. 7, the locking opening 204 has a central opening portion 209 having a generally bulbous shape, a first detent receiving region 211, a second detent receiving region 212, and a lock fin receiving region 214. The first and second detent receiving
30 regions 211, 212 extend radially outward from the central opening portion 209. A detent compressing region 216 formed in the exterior wall 118 of the wear member 104 separates the first and second detent receiving regions 211, 212. As best seen in Fig. 8, the pocket side of the wear member 104 includes a wear member lock portion 219 having a backside that forms a lock shoulder surface 220. In the implementation shown, the lock shoulder surface 220 is recessed
35 below the interior wall 203 of the pocket area 112. The lock shoulder surface 220 extends to a hard mechanical stop 222. When the fastener 106 is positioned in the locking opening 204, it can be rotated so that the lock fin 134 is behind the wear member lock portion 219 adjacent the

5 lock shoulder surface 220. The hard mechanical stop 222 may prevent over-rotation of the fastener 106, and may therefore ensure that the cylindrical portion of the fastener is properly aligned to interface with the load interface 162 of the connector opening 110 (Fig. 5).

[0059] Figs. 9A, 9B, and 9C illustrate a process for rotating the fastener 106 from an unlocked condition to a locked condition according to an exemplary implementation. These Figures show
10 an end view of the fastener 106, and a side view of the wear member 104. Figs. 9A illustrates the fastener 106 in an unlocked condition; Fig. 9B illustrates the fastener 106 in an intermediate position between the unlocked condition and the locked condition; and Fig. 9C illustrates the fastener 106 in a locked condition.

[0060] Fig. 9A shows the fastener 106 aligned for insertion through the locking opening 204.
15 In this position, the lock fin 134 is aligned with the lock fin receiving region 214, and the locking detent 128 is aligned with the first detent receiving region 211. In this alignment, the fastener 106 extends through the locking opening 204 of the wear member 104, through the connector opening 110 in the support structure 102, and into the release opening 202 in the wear member 104. At the same time, the distal end of the fastener may abut against the oblique, flat bottom
20 surface 210 of the release opening 202 (Figs. 5 and 7). With the fastener 106 disposed in this unlocked condition, a user may engage the tool engaging feature 136 with a rotation tool, such as a wrench or socket system, for example in order to rotate the fastener 106 from the unlocked condition.

[0061] Fig. 9B shows the fastener 106 in the process of being rotated from the unlocked
25 condition to the locked condition. As shown in Fig. 9B, the leading-edge 176 of the lock fin 134 begins to slide behind the wear member lock portion 219. At the same time, the locking detent 128 moves out of the first detent receiving region 211, and engages the structure forming the detent compressing region 216. As such, a user may tactilely feel additional resistance to rotation as the locking detent 128 compresses radially as it passes the detent compressing region
30 216. Implementations having a lock fin with a tapered proximal facing surface 174 may slide against the lock shoulder surface 220 (Fig. 8) forming a part of the wear member lock portion 219. Because the lock shoulder surface 220 is at an oblique angle, as the lock fin 134 travels along the lock shoulder surface 220, the fastener 106 is further axially displaced inwardly toward the release opening 202. The oblique nature of the flat bottom surface 210 of the larger diameter
35 portion 206 permits the fastener 106 to advance further into the release opening 202. A user will continue to rotate the fastener 106 to the locking condition.

5 [0062] Fig. 9C shows the fastener 106 in the locking condition. In this condition, the fastener is rotated until the lock fin 134 is fully behind the wear member lock portion 219. Here, the proximal facing surface 174 of the lock fin 134 may be engaged or position to interface with the lock shoulder surface 220. Also in this condition, the leading-edge 176 of the lock fin 134 may be engaged against the hard mechanical stop 222. In this position, the cylindrical portion of the
10 fastener 106 may be aligned with the load interface 162 of the support structure 102 (Fig. 5). At the same time, in this position, the end surface 170 of the fastener 106 may be substantially aligned with the oblique flat bottom surface 210 of the larger diameter portion 206 of the release opening 202. As can be seen in Fig. 9C, the locking detent 128 has moved off the detent compressing region 216 and into the second detent receiving region 212. Because the locking
15 detent 128 was compressed, a user may tactilely feel the release of the locking detent 128 as it moves into the second detent receiving region 212. This may signal to a user that the fastener has arrived in the locked condition. Furthermore, the locking detent 128 may prevent inadvertent rotation of the fastener 106 back toward the unlocked condition. For example, the relatively higher force required to rotate the locking detent 128 out of the second detent receiving
20 region 212 and onto the detent compressing region 216 may prevent the fastener from inadvertently and undesirably rotating when digging, excavating, pushing, or otherwise using the wear member for its intended purposes.

[0063] Importantly, the wear member assembly 100 is provided with a release assistance mechanism in the form of the tapered end of the fastener 106 and the oblique bottom surface 210
25 of larger diameter portion 206 of the release opening 202. When a user desires to remove the fastener 106, he or she may rotate the fastener 106 from the locked condition shown in Fig. 9C toward the unlocked condition shown in Fig. 9A. As this occurs, the oblique end of the fastener 106 abuts against the oblique bottom surface 210 of the larger diameter portion 206 of the release opening 202. These oblique surfaces force the fastener 106 to axially displace toward the
30 locking opening 204. When the fastener 106 displaces toward locking opening 204, and may ultimately project at least partially out of the locking opening 204, the fastener 106 may be more easily grasped and removed from the wear member 104. Accordingly, rotation in the counterclockwise direction may not only unlock the fastener 106, but may also partially eject the fastener 106.

35 [0064] With the wear member attached to additional structure, such as a bucket, debris such as dirt, mud, clay and so forth may fill the open portions of the locking opening 204. When the fastener is to be removed from the wear member 104, the trailing edge 178 becomes the leading-

5 edge intended to remove or break up hardened soil material in the locking opening 204. To accomplish this, the trailing edge 178 may be formed with a planar surface substantially parallel to the longitudinal axis 130.

[0065] In some implementations, the support structure 102 and the fastener 106 are configured so that the fastener 106 does not extend entirely through the support structure 102. In these
10 implementations, the support structure 102 may include the oblique bottom surface 210 shown in the release opening 202. That is, the support structure may include a bore on each side aligned with the pin openings 116 of the wear member 104 when the wear member is on the support structure.

[0066] The wear member assembly design described herein may provide additional advantages
15 unobtainable by systems in the prior art. The simplicity, reliability, and shape achieved by the fastener, the holes in the wear member, and the nature of the support structure may provide reliability as well as efficient, non-hammering attachment of a wear member to and removal from a support structure.

[0067] Figs. 10-19C show an additional implementation of a wear member assembly. Fig. 10
20 is a view of an earth engaging wear member assembly according to example implementations of the present disclosure. In the implementation shown, the wear member assembly 1000 includes a tooth (or wear member) 1004, a support structure such as an adapter 1002, and a fastener 1006.

[0068] The adapter 1002 includes a longitudinally projecting nose extending within a rear
25 cavity of the tooth 1004 (not shown in Fig. 10). The nose may include a transverse hole (not shown in Fig. 10) formed therein for receiving the fastener 1006. In this example implementation, the tooth 1004 also includes a hole through which the fastener 1006 can be inserted.

[0069] Fig. 11 illustrates an exploded view of the fastener 1006. Figure 12 illustrates an
assembled view of the fastener 1006. Figure 18A illustrates a cross-sectional assembled view of
30 the fastener 1006 disposed within other components of the wear assembly 1000. With reference to these figures, and according to the present example, the fastener 1006 includes rigid body comprising a main body 1201 and a cap 1212. The fastener 1006 also includes a rotation resisting element 1210. The cap 1212 is arranged to connect to the main body 1201 such that the rotation resisting element 1210 is held between the cap 1212 and the main body 1201.

5 [0070] In the present example, the main body 1201 includes a shaft 1204 and a head 1206. One end 1203 of the shaft 1204 includes a push-out feature 1202, or release mechanism, and the other end of the shaft 1204 supports and extends from the head 1206. In the present example, the head 1206 and the shaft 1204 form a single monolithic component. In some examples, the head 1206 may be a separate component connectable with the shaft 1204 to form a single rigid
10 unit. The shaft 1204 includes an elongated, cylindrical portion that is substantially circular in cross-section. In some examples, the shaft 1204 may taper towards the end 1203 to allow easier insertion into the transverse hole in the nose portion and the hole in the tooth 1104.

[0071] The push-out feature 1202 works in concert with the tooth 1104 or adapter 1102 so that as the shaft 1204 is rotated it is pushed out of the hole in which it is inserted. In the
15 implementation shown, the push-out feature 1202 may be a tapered end. In some implementations, the tapered end is a substantially planar surface angled at an oblique angle relative the longitudinal axis of the shaft 1204. The tapered end may engage against an angled edge within the tooth 1104 or the adapter 1002 as described above. Rotation of the shaft 1204 may cause the tapered end of the push out feature 1202 to slide against a corresponding tapered
20 surface in the tooth 1004 or the adapter 1002, forcing the shaft 1204 (and likewise the fastener 1006) to axially displace so that the fastener 1006 may be more easily grasped and removed from the wear member assembly 1000. In the implementation shown, the longitudinal axis 1213 of the shaft 1204 is also co-linear with the longitudinal axis of the fastener 1006.

[0072] The other end 1205 of the main body 1201 includes the head 1206. In this
25 implementation, the head 1206 has a larger cross-sectional diameter than the shaft 1204. The head 1206 includes an engagement cavity 1222 that opens along the axial direction at the proximal end of the shaft 1204. As will be explained in more detail below, the engagement cavity is sized and shaped to receive an engagement protrusion 1220 of the cap 1212. In the example implementation shown, the head 1206 also includes two pinholes 1207 that are sized
30 and shaped to receive a holding pin 1226. In the implementation shown, the pinholes 1207 are disposed on opposing sides of the engagement cavity 1222 so that the holding pin 1226 may be positioned in both pinholes 1207 at the same time. After the cap 1212 is inserted into the engagement cavity 1222, the holding pin 1226 may be inserted into the pinholes 1207 to hold the cap 1212 in place relative to the main body 1201. Although the implementation shown includes
35 a single holding pin 1226, other implementations use multiple holding pins. Yet others use mechanical attachment fasteners that are not holding pins. For example, some implementations

5 use adhesives, epoxies, welding, threads, or other engagement features to secure the cap 1212 to the main body 1201.

[0073] In this exemplary implementation, the head 1206 also includes a radially extending lock fin 1224. The lock fin 1224 assists with securing the fastener 1006 in place to secure the tooth 1004 onto the adapter 1002. For example, when the fastener 1006 is rotated into the locked position, the lock fin 1224 sits behind a surface of the tooth 1004 or adapter 1002 so as to prevent removal of the fastener 1006 from the tooth 1004 or adapter 1002. Likewise, when the fastener 1006 is in an unlocked position, the lock fin 1224 is positioned so as to fit through a recess or opening within the tooth 1004 or adapter 1002, thus allowing removal of the fastener 1006. Although the lock fin 1224 is disclosed as projecting from the head 1206 of the main body 1201, in other implementations, the lock fin is disposed on the cap 1212 or from the shaft 1204. In some implementations, the lock fin 1224 includes axially displaced surfaces 1225a, 1225b lying within parallel planes. In some implementations, one or both of the surfaces 1225a, 1225b are angled to lie within planes that are oblique to the longitudinal axis 1213. In some embodiments, these surfaces may be similar to the distal facing surfaces and the proximal facing surface 174 described with reference to Figs. 2-8 and 9A-9C. The lock fin 1224 may be sloped or sized similar to the lock fin 134 described herein.

[0074] The cap 1212 includes an engagement protrusion 1220, a contact portion 1218, and a head 1219. The engagement protrusion 1220 protruding axially from the contact portion 1218 and is sized and shaped to fit within the engagement cavity 1222, as shown in Figs. 11 and 18A. In the present example, the engagement protrusion 1220 is substantially square-shaped in cross-section. Thus, the engagement cavity 1222 is also substantially square-shaped. Accordingly, in the implementation shown, the engagement cavity 1222 and the engagement protrusion 1220 have substantially the same cross-sectional shape. Although shown as substantially square-shaped, other profiles or shapes may be used. In some implementations, the cross-sectional shape of the engagement cavity 1222 and the engagement protrusion 1220 are formed as rectangles, triangles, or other polygonal shapes. Yet other cross-sectional shapes are contemplated. Because of the matching shapes or surfaces, the cap 1212 and the main body 1201 may be rotationally fixed to each other. Some implementations do not rely on matching shapes or surfaces, but instead rely upon the holding pin 1226 or other holding structure to rotationally fix the cap 1212 and the main body 1201. As can be seen, the engagement protrusion 1220 in this implementation also includes a through-hole 1217. When the engagement protrusion 1220 is fully inserted into the engagement cavity 1222, the through-hole

5 1217 is aligned with the pinholes 1207 such that the holding pin 1226 may be inserted all the way through so as to hold the cap 1212 to the main body 1201. Other mechanisms for securing the cap 1212 to the main body 1201 such that rotation of the cap 1212 causes corresponding rotation of the main body 1201 are also contemplated.

10 [0075] In the present example, the contact portion 1218 is a noncircular circumferential profile forming an outer surface of a portion of the cap 1212, and is positioned adjacent the engagement protrusion 1220. The contact portion 1218 is sized and shaped to be received by the rotation resisting element 1210. In this implementation, the contact portion 1218 includes a plurality of substantially planar surfaces that face radially outward. These planar surfaces are separated by edges or corners 1229, and are designed to sit flat against inner surfaces of the rotation resisting element 1210 when the fastener is in either the locked or unlocked position. Although described as planar surfaces, the surfaces may have concave or convex portions separated by the edges or corners 1229.

20 [0076] The head 1219 of the cap 1212 may have a diameter that is similar to or substantially the same size as that of the head 1206 of the main body 1201. The head 1219 limits or prevents axial translation of the rotation resisting element 1210 while the cap 1212 is connected to the main body 1201. That is, the head 1219 secures the rotation resisting element 1210 in place axially, although the head 1219 and the entire cap 1212 may be selectively rotated relative to the rotation resisting element 1210. The head 1219 also includes a tool-connection feature shown as a hole 1216 that can be used to rotate the fastener 1106. In the present example, the hole 1216 is hex shaped and aligned with the longitudinal axis. Thus, a hex-shaped tool may be inserted into the hole 1216 and used to rotate the fastener 1106 relative to the remainder of the wear assembly 1100. In some examples, a plug 1214 may be inserted into the hole 1216 during normal operation of the wear member to prevent buildup of debris, such as dirt, within the hole 1216. The plug 1214 may be a rubber or polymeric plug that may be removed to provide access to the hole 1216. In some example, there may be a cut-out 1215 in one of the hexagonal sides of the hole 1216 that allows a tool, such as a screwdriver to slide in and remove the plug 1214. Additionally, the cut-out 1215 may provide a way for the tool to remove dirt and debris from the hole 1216 in case the plug 1214 is not used.

35 [0077] The rotation resisting element 1210, sometimes referred to as a locking detent or a clamp spring, is designed to resist undesired or unintentional rotation of the cap 1212 and the main body 1201, and allow desired or intentional rotational movement of the cap 1212 and main body 1201. The rotation resisting element 1210 may be similar to the spring-portion 184

5 described above. According to the present example, the rotation resisting element 1210 includes an inner contact feature 1211 and an interference feature 1209. The inner contact feature 1211 includes a plurality of inward facing planar surfaces that are configured to engage the outwardly facing surfaces of the contact portion 1218 of the cap 1212 such that the planar surfaces of the contact portion 1218 rotatably fit against planar surfaces of the inner contact feature 1211. The
10 rotation resisting element 1210 may be formed of a resilient material having resilient characteristics such that desired or intentional rotation of the cap 1212 and main body 1201 are allowed but undesired or unintentional rotation is resisted. Specifically, rotating the cap 1212 and main body 1201 relative to the rotation resisting element 1210 between a locked position and an unlocked position causes expansion, such as radial expansion, of the rotation resisting element
15 1210. Rotation of the cap 1212 relative to the rotation resisting element 1210 pushes the rotation resisting element 1210 outward. The compliant and elastic nature of the rotation resisting element 1210 provides resistance to this outward motion and thus provides resistance to rotation of the fastener 1006 between locked and unlocked positions. This provides tactile feedback to the user as the fastener rotates between an unlocked position and a locked position. As such, as a
20 user rotates the cap 1212 and the main body 1201 relative to the rotation resisting element 1210, resistance to rotation increases for a first portion of the rotation, and then decreases for a second portion of the rotation, providing the tactile feedback to the user. Because rotational resistance increases during rotation, the tendency of inadvertent rotation may be minimized or prevented.

[0078] In the present example, the interference feature 1209 is formed as a single protrusion
25 that is designed to fit within a recess or slot (not shown) in the tooth 1004 or adapter 1002. The recess provides mechanical interference that prevents rotation of the interference feature 1209 of the rotation resisting element 1210 relative to the tooth 1004 or adapter 1002. Accordingly, when the fastener 1006 is rotated relative to the tooth 1004 or the adapter 1002, the rotation resisting element 1210 is not.

30 [0079] Fig. 12 illustrates a perspective view of the fastener 1006 with a rotation resisting element 1210. The cap 1212 is secured to the head 2006 of the shaft 1204. Additionally, the rotation resisting element 1210 fits over the contact portion 1218 and is secured in place by the cap 1212 and is prevented from being removed without removal of the cap 1212.

[0080] In some examples, the rotation resisting element 1210 may be formed of a single
35 monolithic component as shown and described in Figs. 11-15. In some examples, however, the rotation resisting element 1210 may include more than one component as shown and described with reference to Figs. 21-24C. For example, the rotation resisting element 1210 may include a

5 biasing member and a separate ring-piece (not shown) that fits with the biasing member. In such an example, the biasing member may form some of the surfaces of the inner contact feature 1211 while the ring-piece may form some of the other inner surfaces of the inner contact feature 1211, or alternatively the biasing member may form all the surfaces of the inner contact feature 1211.

[0081] In some implementations, the rotation resisting element 1210 includes a position indicator 1221. The position indicator 1221 is a fixed feature that may be used for reference to identify the relative rotational position of the cap 1212. In the implementation shown, the position indicator 1221 is a depression formed in a surface of the rotation resisting element 1210. A brightly colored paint or marker may be applied so that the position indicator 1221 is easily identifiable to an operator. As can be seen in Fig. 12, The cap 1212 may also include position indicators 1223. In the example shown, the position indicators 1223 are shown as an open padlock and a closed padlock. In some implementations, the position indicators 1223 are simply lines, dots, depressions, or other indicator. In some implementations, these may be painted or colored to be easily visible to an operator. Some implementations do not include position indicators.

20 [0082] Fig. 13 illustrates a biasing member 1300 forming a part of or all of the exemplary rotation resisting element 1210. In the present example, the biasing member 1300 is a c-shaped member. The biasing member 1300 includes two flex arms 1302a, 1302b and the interference feature 1209. The arm 1302a includes an upper inward facing surface 1304a and the arm 1302b includes a lower upward facing surface 1304b. In this implementation, the surfaces 1304a, 25 1304b are substantially planar. When assembled with the cap 1212, the surfaces 1304a, 1304b may fit against the substantially planar surfaces of the contact portion 1218 (Fig. 2A). In the present example, the biasing member 1300 includes a single solid protrusion 1306 that forms the interference feature 1209.

[0083] In some examples, the biasing member 1300 may be made of a resilient material such as a plastic or polymer. In some examples, the biasing member 1300 may be made of a metal material that has sufficient flexibility. The resiliency allows the arms 1302a, 1302b to elastically flex apart when a rotational force is applied to the cap 1212 and thus the contact portion 1218. When the cap 1212 and main body 1201 are in the locked or unlocked positions, then the planar surfaces 1304a, 1304b will rest against or be disposed adjacent to corresponding planar surfaces 35 of the contact portion 1218, providing a biasing force against inadvertent rotation between the locking and unlocking position. However, as the contact portion is rotating, the resilient arms 1302a, 1302b may flex outward, allowing the biasing force to be overcome and allowing rotation

5 between locked and unlocked positions. Thus, the arms provide resistance to such rotational movement between locked and unlocked positions.

[0084] Fig. 14 shows the fastener 1006 disposed within an aperture or hole 1402 in a side of the tooth 1004. The head 1219 of the cap 1212 is visible while the main body 1201 is disposed in or through the hole 1402. As can be seen, the interference feature 1209 of the rotation
10 resisting element 1210 fits within a recess 1406 within the tooth 1004. Additionally, the lock fin 1224 fits within a lock fin receiving opening or an extension 1404 of the hole 1402. Fig. 14 shows the fastener 1006 in the unlocked position with the lock fin 1224 aligned within the extension 1404. With the lock fin 1224 aligned as shown, the fastener 1106 may be axially displaced and removed from the hole 1402 in the side of the tooth 1004. The unlocked and
15 locked positions will be described further below.

[0085] Fig. 15 illustrates another exemplary biasing member for use with or as a rotation resisting element, referenced by the numeral 1500. In a manner similar to the biasing member 1300 discussed herein, the biasing member 1500 includes two arms 1502a, 1502b each having an inner surface 1504a, 1504b that is designed to contact part of the contact portion 1218 of the cap
20 1212. The biasing member 1500 also defines an interference feature 1506 that includes two protrusions 1508a, 1508b. The protrusions 1508a, 1508b provide interference with the adapter 1002 or the tooth 1004 so as to resist rotation of the biasing member, even as the cap 1212 rotates.

[0086] Fig. 16 shows the fastener 1006 disposed within the aperture or hole 1402 in a side of the tooth 1004. As can be seen, the protrusions 1508a, 1508b of the rotation resisting element fit
25 within a recess 1406 within the tooth 1004. The lock fin 1224 fits within the lock fin opening or extension 1404. The fastener 1006 is shown in the unlocked position, and the description of Fig. 14 also applies here.

[0087] Figs. 17A-17C show a cross-section of the contact portion 1218 in different positions with respect to the inner contact feature 1211. Each of Figs. 17A and 17C illustrates the fastener 1006 in one of the locked and unlocked positions. For purposes of explanation only, Fig. 17A will be treated as the unlocked position and Fig. 17C will be referenced as the locked position. Fig. 17B shows the rotation midway between the locked and unlocked positions. Referring to Fig. 17A in the unlocked position, the lock fin 1224 is positioned so as to allow the fastener to be
30 removed from the wear member 1004 (not shown). In this position, an outer surface 1701 of the contact portion 1218 rests against an inner surface 1702 of the inner contact feature 1211. An
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5 outer surface 1703 of the contact portion 1218 faces the interference feature 1209. An outer surface 1705 of the contact portion 1218 rests against an inner surface 1706 of the inner contact feature 1211. An outer surface 1707 of the contact portion faces away from the interference feature 1209.

10 [0088] Fig. 17B illustrates the fastener approximately midway between the unlocked position (shown in Fig. 17A) and the locked position (shown in Fig. 17C). In this position, outer surface 1701 has moved away from inner surface 1702. Outer surface 1703 has moved towards inner surface 1706. Outer surface 1705 has moved away from inner surface 1706. Outer surface 1707 has moved towards inner surface 1702. This puts an outward force on the biasing member 1300. In some examples, the outward force pushes the two flex arms 1302a, 1302b of the biasing member 1300 outward. In some examples, the outward force compresses the material that forms the arms 1302a, 1302b while the arms remain substantially stationary. In either case, rotation between the locked position and the unlocked position is resisted, thus providing tactile feedback to an operator.

20 [0089] Fig. 17C illustrates the fastener in the locked position. Thus, the lock fin is positioned so as to prevent removal of the fastener from the wear member 1004 (not shown). After rotation to the locked position, outer surface 1701 now faces the interference feature 1209. Outer surface 1703 now sits against inner surface 1706. Outer surface 1705 now faces away from the interference feature 1209. Outer surface 1707 now sits against inner surface 1702.

25 [0090] While Figs. 17A – 17C illustrate only two discrete positions (locked and unlocked), it is understood that other implementations may include more discrete positions. For example, in the present example, there are four planar surfaces in both the inner contact feature 1211 and the contact portion 1218. Thus, there may be four discrete positions. In some examples, the contact portion 1218 and the inner feature 1211 may have a different number of planar surfaces and allow for a different number of discrete positions. For example, there may be three planar surfaces in a triangular shape, thus allowing three discrete positions. Alternatively, there may be five planar surfaces, thus allowing five discrete positions. In such cases, rotation between positions is resisted by the resilient rotation resisting element and thus tactile feedback is provided to the user who is rotating the fastener 1006. Also, for purposes of illustration, the rotational distance between the locked and unlocked positions is 90°. However, other implementations may be arranged to provide any rotational distance between locked and unlocked positions depending on the configuration of the contact portion 1218 and inner features 1211.

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5 **[0091]** As illustrated, the rotation resisting element 1210 remains in place while the contact portion 1218 of the cap 1212 rotates. In other words, the inner surfaces 1702, 1706, remain in place while the outer surfaces 1701, 1703, 1705, 1707 rotate.

10 **[0092]** Figs. 18A and 18B illustrate various cross-sectional views of the fastener 1006 in an unlocked position. Fig. 18A illustrates a cross-section along the longitudinal axis 1804 of the fastener 1006. According to the present example, the fastener 1006 is shown as inserted into the wear member 1004 and the adapter 1002, thereby preventing removal of the wear member 1004 from the adapter 1002. Specifically, the elongated main body 1201 extends through the adapter 1002 and extends into a recess 1802 formed within an inner surface 1801 on the far side of the wear member 1004. The recess 1802 includes an inwardly facing tapered surface 1803 shape to
15 cooperate with the push out feature 1202 of the fastener 1006. In this implementation, the lock fin 1224 is shown extending outward from the main body 1201, although other implementations have the lock fin 1224 extending outward from the cap 1212. While not quite clear from the perspective of Fig. 18A, the lock fin is in a position to allow the fastener 1006 to be removed. Fig. 18A also illustrates the fastener fully assembled with the cap 1212 secured to the main body
20 1201 with the rotation resisting element 1210 therebetween.

[0093] Fig. 18B illustrates a diagonal cross-section along the lock fin 1224. As illustrated, the lock fin 1224 is positioned so as to be aligned with the hole extension 1404, thus allowing the fastener 1006 to be removed. Additionally, the interference feature 1209 is shown positioned within the recess 1406.

25 **[0094]** Fig. 18C is a diagram showing a view from inside the cavity of the wear member 1004. This view shows the hole 1402 through which the lock pin may be inserted. When the lock pin 1006 is first inserted, the lock fin 1224 fits within pocket 1812. When the lock pin 1006 is rotated from the unlocked position to the locked position, the outer edge of the lock fin 1224 moves along adjacent surface 1818. Additionally, the proximal facing surface 1225a (shown in
30 Fig. 12) of the lock fin 1224 rests against ramped surface 1816. The ramped surface 1816 thus acts as a push-in feature because as the lock fin is rotated, the ramped surface pushes the lock pin 1006 along the axial direction further into the hole 1402. Then, the lock fin 1224 rests at pocket 1814 in the locked position. In some implementations, the ramped surface 1816 is a relatively planar ramp. Accordingly, there is a linear relationship between rotation and axial displacement
35 of the lock pin 1006 into the hole. In other implementations, the ramped surface 1816 has a relatively smooth curvature. Accordingly, there is a nonlinear relationship between rotation and an axial displacement of the lock pin 1006 into the hole. In yet other implementations, the

5 ramped surface 1816 has a plurality of surfaces that may form a stepped relationship. For example, Fig. 18C shows surface 1816 being formed of a plurality of levels or stages. In the example shown, the surface 1816 includes three stages, shown as a flat 1816a, a ramp 1816b, and another flat 1816c. As the lock pin 1006 rotates, the lock fin slides over the flat 1816a with minimal axial displacement of the lock pin 1006. It then slides over the ramp 1816b causing
10 more axial displacement of the lock pin 1006, thereby pushing in the lock pin 1006. It then slides over the flat 1816c to be secured in the locked position. Other arrangements are also contemplated.

[0095] Figs. 19A, 19B, 19C illustrate various cross-sectional views of the fastener 1006 in a locked position. According to the implementation shown herein, the fastener 1006 is therefore
15 rotated 90° from the position shown in Figs. 18A and 18B. In the locked position, the fastener 1006 is advanced further into the holes 1404 in the wear member 1004 and the adapter 1002. As can be seen, the push out feature 1202 of the shaft 1204 forming a part of the main body 1201 fits adjacent the inwardly facing tapered surface 1803 in the wear member 1004. In some implementations, the fastener 1006 may extend only partially into the adapter 1002. In such an
20 implementation, the tapered surface 1803 may be formed as a part of the adapter 1002. As the fastener 1006 rotates, the push out feature 1202 engages the tapered surface 1803 and further rotation forces the fastener 1006 axially displace from the position shown in Fig. 19B to the position shown in Fig. 18A.

[0096] Fig. 19A is a view down the axis of the fastener 1006 placed within an aperture or hole
25 1402 in a side of the tooth 1004 and in the unlocked position. As can be seen, the interference feature 1209 of the rotation resisting element fits within a recess 1406 within the tooth 1004. Additionally, the lock fin is rotated to be positioned behind an inner surface of the wear member 1004.

[0097] Fig. 19B illustrates a cross-section of the fastener 1006 along the longitudinal axis
30 1804. While the shaft has been rotated such that the lock fin 1224 is in a different position, the rotation resisting element 1210 and its interference feature 1209 remain substantially within the same position within the recess 1406. In other words, the main body 1201 and the cap 1212 have been rotated while the rotation resisting element 1210 remains substantially in place.

[0098] Fig. 19C illustrates a diagonal cross-section along the lock fin 1224. As illustrated, the
35 lock fin 1224 sits behind an inner surface 1902 (also identified as the ramped surface 1816 in Fig. 18C) of the wear member 1004. Thus, the fastener 1006 is prevented from being removed.

- 5 **[0099]** Fig. 20 is a flowchart showing an illustrative method for inserting a fastener that has a rotation resisting element 1210 as described herein, according to an exemplary implementation. In the present example, the method 2000 includes, at 2002, inserting a shaft of a fastener through aligned holes of a first wear member and a second wear member. In some implementations the second wear member is an adapter or an intermediate adapter such as adapter 1002.
- 10 **[00100]** At 2004, the method 2000 further includes engaging the tool engaging feature by inserting a tool into a tool receiving hole in the fastener. The tool receiving hole may have a polygonal shape such as a hexagonal shape. Thus, the tool may have a similar shaped portion to engage the tool receiving hole.
- 15 **[00101]** The method 2000 further includes, at 2006, while preventing rotation of the spring clamp relative to the first wear member, rotating the main body and the cap of the fastener to overcome the biasing force of the spring clamp and to displace the main body and the cap from the unlocked position to the locked position. As this occurs, edges of the surfaces of the inwardly facing planar surfaces that fit with radially outward facing planar surfaces of the contact portion flex, compress, or displace arms of the rotation resisting element.
- 20 **[00102]** Fig. 21 is a diagram showing a perspective view of a pin 1006 with a multi-component rotation resisting element 2102 that has an inner ring 2106 and an outer ring 2104. The rotation resisting element 2102 works in conjunction with the main body 1201 and the cap 1212 like the rotation resisting element 1210 described above. Specifically, the main body 1201 and cap 1212 rotate together with respect to the rotation resisting element 2102. The components of the main
- 25 body 1201 and cap 1212 illustrated in Fig. 21 are similar to those illustrated in Fig. 11 and will not be repeated here.
- 30 **[00103]** The outer ring 2104 of the rotation resisting element 2102 includes an inward facing surface 2112 that is sized and shaped to fit against an outward facing surface 2114 of the inner ring 2106. The outer ring 2104 includes an interference feature 2108 may include one or more protrusions that are designed to fit within a recess or slot (not shown) in the tooth 1004 or adapter 1002. In the present example, the interference feature 2108 includes two protrusions 2110. However, in some examples, there may be a single protrusion such as the protrusion shown in Fig. 13. In some examples, the outer ring 2104 may be made of a rigid material such as a metal, a composite, or other material. Fig. 22 shows a closer view of the outer ring 2104.
- 35 **[00104]** The inner ring 2106 is sized and shaped to fit within the outer ring 2104. Specifically, the outward facing surface 2114 of the inner ring 2106 is designed to fit against the inward

5 facing surface 2112 of the outer ring 2104. The inner ring 2106 includes an ear portion 2113 shaped so that the outer surface 2114 is not circular. This prevents rotational movement of the inner ring 2106 with respect to the outer ring 2104. The inward facing surface 2112 of the outer ring 2104 also includes a corresponding noncircular shape. In some implementations, the inner ring 2106 is secured within the outer ring 2104 using an adhesive such as an epoxy, a weld, or
10 other adhesive. In some examples, the inner ring 2106 may not have an ear portion 2113 and instead be rotatable within the outer ring 2104. In such an example, the outer ring 2104 may have a polygonal shaped inner surface such that an inner ring with a similar polygonal surface can rotate between discrete positions within the outer ring 2104.

[00105] The inner ring 2106 includes a set of inward facing surfaces 2116. In the present
15 example, the inner ring 2106 includes four substantially planar inward facing surfaces 2116a, 2116b, 2116c, 2116d, which are shown in greater detail in Figs. 24A-24C. The inward facing surfaces 2116a, 2116b, 2116c, 2116d are sized and shaped to fit against the outward facing surfaces of the contact portion 1218 on the cap 1212. The inner ring 2106 may be made of a resilient material so that it is compressible by rotation of the contact portion 1218 of the cap
20 1212. For example, the inner ring 2106 may be made of rubber, polyurethane, high density polyethylene, polyoxymethylene, cast nylon, and other suitably resilient materials. Fig. 23 shows a closer view of the inner ring.

[00106] Figs. 24A, 24B, and 24C are diagrams showing rotation of the pin with respect to the rotation resisting element of Fig. 21. Fig. 24A shows the pin in an unlocked position. In such a
25 position, four planar inward facing surfaces 2116a, 2116b, 2116c, 2116d of the inner ring 2106 fit against four planar outward facing surfaces 1218a, 1218b, 1218c, 1218d of the contact portion 1218. Specifically, surface 2116a sits against surface 1218a. Surface 2116b sits against surface 1218b. Surface 2116c sits against surface 1218c. Surface 2116d sits against surface 1218d.

[00107] Fig. 24B shows the lock fin 1224 rotating between the unlocked position and the locked
30 position. When the main body 1201 is rotated, the contact portion 1218 is rotated with respect to the rotation resisting element 2102. Specifically, as described above, the interference feature 2108 sits within a slot or recess within the tooth 1004 or adapter 1002, which prevents the rotation resisting element 2102 from rotating with the main body 1201. Rotation of the contact portion 1218 with respect to the inner ring 2106 causes compression of portions of the inner ring
35 2106. Specifically, the rounded portions between the outward facing planar surfaces 1218a, 1218b, 1218c, 1218d press against the planar inward facing surfaces 2116a, 2116b, 2116c,

5 2116d. Thus, as seen in Fig. 24B, the compressible nature of the inner ring 2106 allows, but resists, rotation of the contact portion 1218 with respect to the rotation resisting element 2102.

[00108] As shown in Fig. 24C, the pin is in a locked position. In this position, surface 2116a sits against surface 1218d. Surface 2116b sits against surface 1218a. Surface 2116c sits against surface 1218b. Surface 2116d sits against surface 1218c.

10 [00109] Persons of ordinary skill in the art will appreciate that the implementations encompassed by the present disclosure are not limited to the particular exemplary implementations described above. In that regard, although illustrative implementations have been shown and described, a wide range of modification, change, combination, and substitution is contemplated in the foregoing disclosure. It is understood that such variations may be made to
15 the foregoing without departing from the scope of the present disclosure. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the present disclosure.

5 CLAIMS

What is claimed is:

1. An earth engaging wear member assembly comprising:
 - 10 an adapter comprising a longitudinally projecting nose portion with a transverse hole formed in the nose portion;
a wear member having a rear portion with a cavity for receiving the nose portion of the adapter, the wear member having an outer surface for engaging ground and an inner surface defining the cavity, the wear member comprising an aperture extending through a sidewall
15 surface from the outer surface to the inner surface, the aperture being alignable with the transverse hole of the adapter when the nose portion is disposed within the cavity;
a fastener receivable in the aperture and the transverse hole to prevent removal of the wear member from the adapter, the fastener comprising:
a main body having an outer surface sized and shaped to contact the wear member
20 or the adapter;
a rotation resisting element comprising a shaped, non-circular inner surface and an outwardly extending interference feature extendable outwardly beyond the outer surface of the main body; and
a contact portion having radially outward facing surfaces that slidingly interfere
25 with the non-circular inner surface of the rotation resisting element,
wherein the rotation resisting element is arranged to resist rotation of the body and contact portion relative to the rotation resisting element between a discrete number of rotational positions.
- 30 2. The earth engaging assembly of claim 1, wherein the rotation resisting element further comprises an outer ring and an inner ring fit within the outer ring.
3. The earth engaging assembly of claim 2, wherein the inner ring has an ear portion to prevent rotation of the inner ring with respect to the outer ring.
- 35 4. The earth engaging assembly of claim 2, wherein the non-circular inner surface of the rotation resisting element is on an inward facing surface of the inner ring.

- 5 5. The earth engaging assembly of claim 1, further comprising a lock fin radially projecting from the fastener, and wherein the discrete number of rotational positions includes a locked position in which the lock fin is set behind an inner surface of the wear member so as to prevent removal of the fastener from the aperture.
- 10 6. The earth engaging assembly of claim 1, wherein the discrete number of rotational positions includes an unlocked position in which a lock fin of the fastener does not prevent removal of the fastener.
- 15 7. The earth engaging assembly of claim 1, wherein the wear member comprises a slot and the interference feature fits within the slot of the wear member so as to prevent rotation of the rotation resisting element relative to the wear member.
- 20 8. The earth engaging assembly of claim 1, wherein the interference feature comprises a single projection.
- 25 9. The earth engaging assembly of claim 1, wherein the interference feature comprises multiple projections.
- 30 10. The earth engaging assembly of claim 1, further comprising a lock fin radially projecting from the fastener, the lock fin being disposed to mechanically prevent axial translation of the fastener out of the aperture in the wear member.
- 35 11. The earth engaging assembly of claim 10, further comprising a ramped surface within the cavity, the ramped surface positioned to engage with the lock fin such that rotation of the fastener pushes the fastener further into the transverse hole.
12. The earth engaging assembly of claim 1, wherein the rotation resisting element comprises a monolithic biasing member that includes the interference feature and at least two inner surfaces of the non-circular inner surface.
13. The earth engaging assembly of claim 1, further comprising an engagement projection that fits within an engagement cavity of a head to prevent rotation of the contact portion relative to the body.

5

14. The earth engaging assembly of claim 1, further comprising a cap, the engagement portion comprising a portion of the cap, wherein the cap further includes an tool-receiving hole for receiving a tool for rotating the fastener between a locked position and an unlocked position, the tool receiving hole having a cut-out on a side of the tool-receiving hole.

10

15. The earth engaging assembly of claim 14, further comprising a plug insertable into the tool-receiving hole of the cap.

15

16. A locking mechanism for attaching a first wear member to a second wear member, comprising:

main body shaped and arranged to prevent removal of a first wear member from a second wear member, the main body having an outer surface sized and shaped to contact at least one of the first wear member and the second wear member;

20

a cap operatively connected to the main body and rotatable relative to the first wear member and the second wear member when attaching the first wear member to the second wear member, the cap having a head portion disposed at an end of the locking mechanism;

a contact portion disposed between the main body and the head portion having a plurality of radially outward facing surfaces;

25

and a rotation resisting element disposed between the main body and the cap and having a plurality of inward facing surfaces that fit with the radially outward facing surfaces of the contact portion, the rotation resisting element further including an interference feature extending radially outwardly beyond the outer surface of the main body, the rotation resisting element being resiliently biased and disposed so as to selectively resist rotation of the cap relative to the rotation resisting element.

30

17. The locking mechanism of claim 16, wherein one of the main body and the cap includes an engagement cavity and the other of the main body and the cap includes an engagement protrusion insertable into the engagement cavity to connect the main body and the cap.

35

18. The locking mechanism of claim 16, wherein the cap and shaft are rotatable relative to the rotation resisting element between discrete positions as defined by the inward facing planar surfaces of the rotation resisting element.

- 5 19. The locking mechanism of claim 16, wherein the rotation resisting element further comprises a monolithic biasing member that includes the interference feature the inward facing planar surfaces.
- 10 20. The locking mechanism of claim 16, wherein the interference feature comprises two projections extending radially outward.
21. A method comprising:
inserting a fastener into aligned holes of a first wear member and a second wear member to connect the first wear member to the second wear member, the fastener comprising a rotation
15 resisting element comprising a radially outwardly extending interference feature, the rotation resisting element also comprising a body that engages surfaces of the first and second wear members and includes a radially outwardly extending lock fin; and rotating the fastener relative the first wear member between an unlocked position and a locked position, in which:
a) the lock fin rotates from the unlocked position that allows axial translational
20 movement of the fastener through the aligned holes and rotates to a locked position where the lock fin is positioned behind a portion of the first wear member in a manner that prevents axial translational removal of the locking mechanism from the aligned holes, and
b) the first wear member prevents rotation of the rotation resisting element while permitting rotation of the body, and
25 c) radially outwardly facing surfaces of a contact portion of the body radially displace inwardly facing surfaces of the rotation resisting element in a manner providing tactile feedback to user as the fastener moves between the unlocked position and the locked position.
- 30 22. The method of claim 21, further comprising inserting a tool into the body and wherein rotating the fastener is done by rotating the tool in the body.
23. The method of claim 21, further comprising, protecting flex arms of a rotation resisting element from debris with a monolithic ring-shaped piece.
- 35 24. A locking mechanism for attaching a first wear member to a second wear member, comprising:
a rigid body shaped and arranged to prevent removal of a first wear member from a second wear member, the rigid body having a head portion forming an end of the locking

5 mechanism, the rigid body having an outer surface sized and shaped to contact at least one of the first wear member and the second wear member;

a contact portion on the rigid body, the contact portion having a plurality of radially outward facing surfaces;

10 and a rotation resisting element disposed at least partially around the rigid body, the rotation resisting element having a plurality of inward facing surfaces that fit with the radially outward facing surfaces of the contact portion, the rotation resisting element further including an interference feature extending radially outwardly beyond the outer surface of the rigid body, the rotation resisting element being resiliently biased and disposed so as to selectively resist rotation of the contact portion relative to the rotation resisting element.

15 25. The locking mechanism of claim 24, wherein the rigid body comprises a main body and a cap that is coupled to the main body.

26. The locking mechanism of claim 25, wherein the cap is connectable to the main body
20 with the rotation resisting element positioned there between.

27. A fastener receivable into a hole in both a support structure and a wear member in a manner that prevents removal of the wear member from the support structure, the fastener comprising:

25 a contact portion having radially outward facing surfaces rotatable between a first position that secures the fastener in the opening of the nose portion and a second position that permits removal of the fastener from the opening of the nose portion;

a lock fin rotatable with the contact portion and extending radially outwardly beyond the contact portion to engage one of the support structure and the wear member
30 and selectively inhibit axial displacement of the fastener; and

a rotation resisting element disposed between the lock fin and a distal end of the fastener, the rotation resisting element comprising a non-circular inner surface that selectively engages the radially outward facing surfaces of the contact portion to resist rotation of the contact portion relative to the rotation resisting element between first
35 position and the second position.

28. The fastener of claim 27, wherein the rotation resisting element is C-shaped and comprises two flex arms.

5

29. An earth engaging wear member assembly comprising:

an adapter comprising a longitudinally projecting nose portion with a transverse opening formed in the nose portion;

10 a wear member having a rear portion with a cavity for receiving the nose portion of the adapter, the wear member having an outer surface for engaging ground and an inner surface defining the cavity, the wear member comprising an aperture extending through a sidewall surface from the outer surface to the inner surface, the aperture being alignable with the transverse opening of the adapter when the nose portion is disposed within the cavity;

15 a fastener receivable in the aperture and the transverse opening to prevent removal of the wear member from the adapter, the fastener comprising:

a contact portion having radially outward facing surfaces rotatable between a first position that secures the fastener in the opening of the nose portion and a second position that permits removal of the fastener from the opening of the nose portion; and

20 a rotation resisting element comprising a C-shaped, non-circular inner surface that selectively engages the radially outward facing surfaces of the contact portion to resist rotation of the contact portion relative to the rotation resisting element between first position and the second position.

30. The locking mechanism of claim 16, comprising a lock fin extending radially outwardly from one of the main body and the cap to engage one of the first and second wear members and selectively inhibit axial displacement of the locking mechanism.

31. The locking mechanism of claim 24, comprising a lock fin extending radially outwardly from the rigid body to engage one of the first and second wear members and selectively inhibit axial displacement of the locking mechanism.

32. A fastener receivable into a hole in both a support structure and a wear member in a manner that prevents removal of the wear member from the support structure, the fastener comprising:

35 a contact portion having radially outward facing surfaces rotatable between a first position that secures the fastener in the opening of the nose portion and a second position that permits removal of the fastener from the opening of the nose portion; and

5 a rotation resisting element comprising an outer ring and an inner ring, the outer
ring being rigid and having an inner surface and arranged to be non-rotatable relative to
the wear member, the inner ring comprising a non-circular inner surface that selectively
engages the radially outward facing surfaces of the contact portion to resist rotation of the
contact portion relative to the rotation resisting element between first position and the
10 second position.

33. The fastener of claim 32, wherein the inner surface of the outer ring is non-circular and
the outer surface of the inner ring is non-circular.

15 34. The fastener of claim 32, comprising a lock fin rotatable with the contact portion and
extending radially outwardly beyond the outer ring to engage one of the support structure and the
wear member and selectively inhibit axial displacement of the fastener.

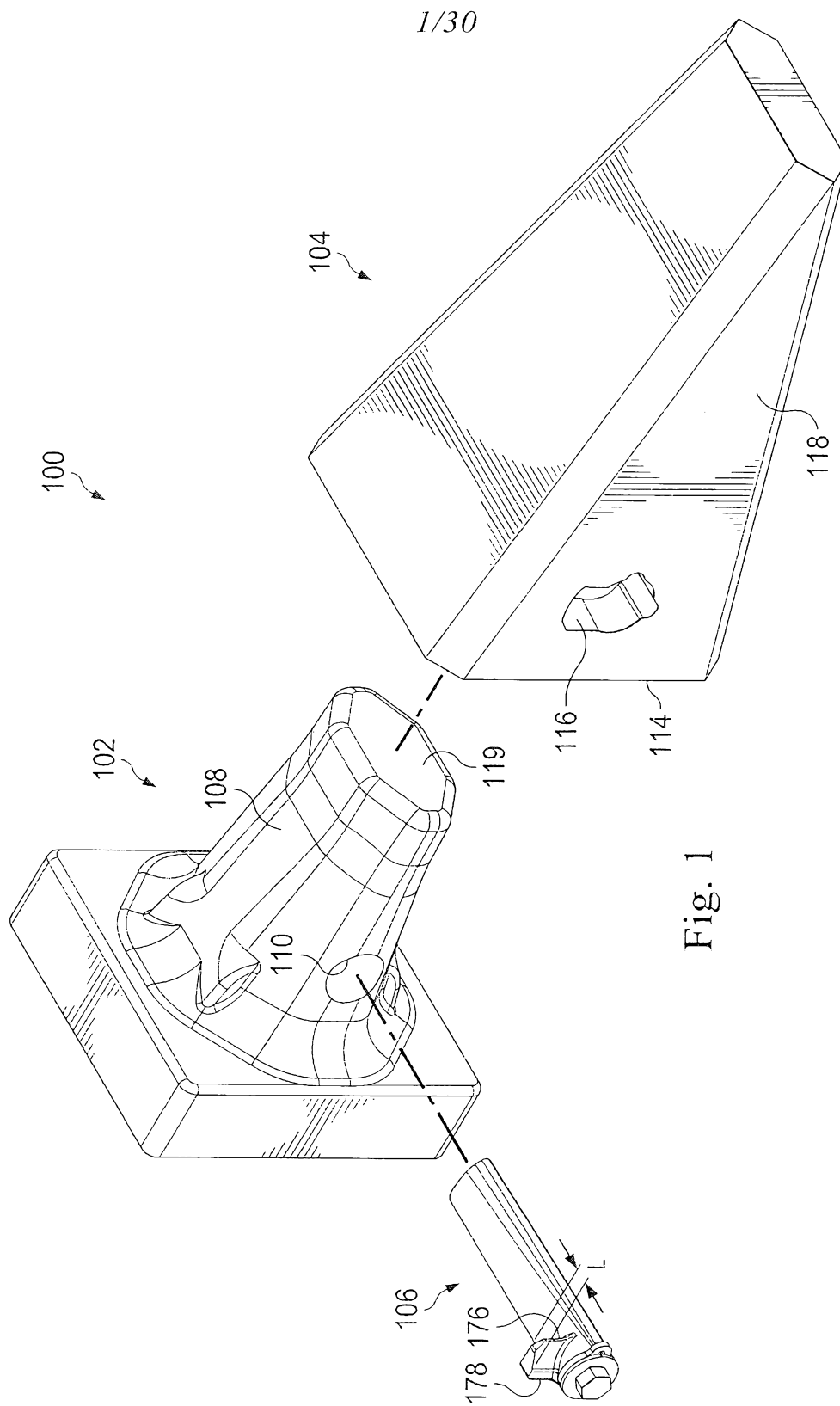
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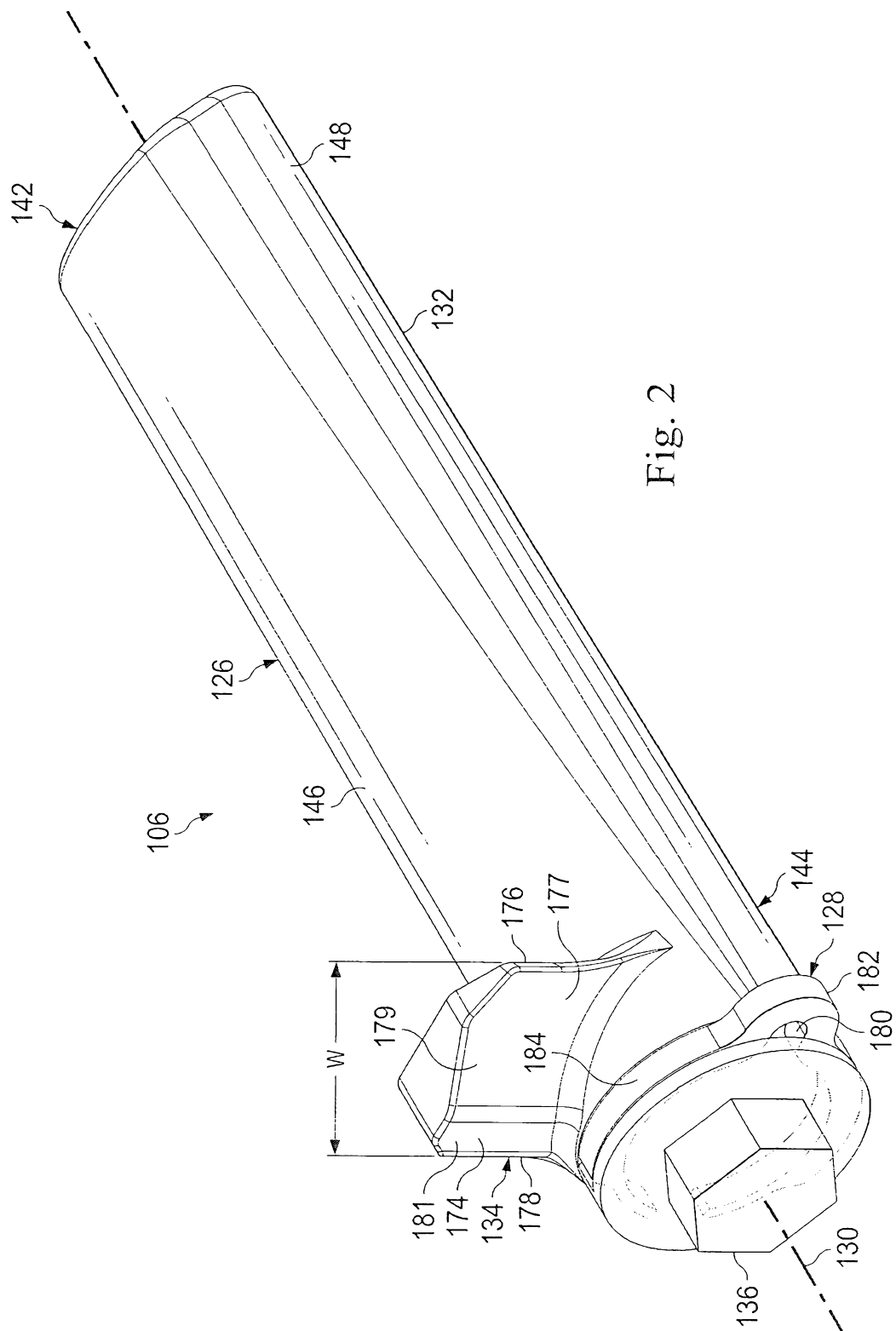
5 ABSTRACT

A fastener includes an elongated shaft having a head at the end, the head comprising a lock fin extending radially outward from the shaft. The head includes an engagement cavity. The fastener further includes a cap having an engagement protrusion for insertion into the engagement cavity of the cap such that rotation of the cap causes corresponding rotation of the head, the cap further comprising a contact portion having a plurality of radially outward facing planar surfaces. The fastener further includes a rotation resisting element having inward facing planar surfaces that fit with the radially outward facing planar surfaces of the contact portion, the rotation resisting element further including an interference feature extending radially outward, the rotation resisting element being resilient so as to allow but resist rotation of the cap with respect to the rotation resisting element.

Fig. 1



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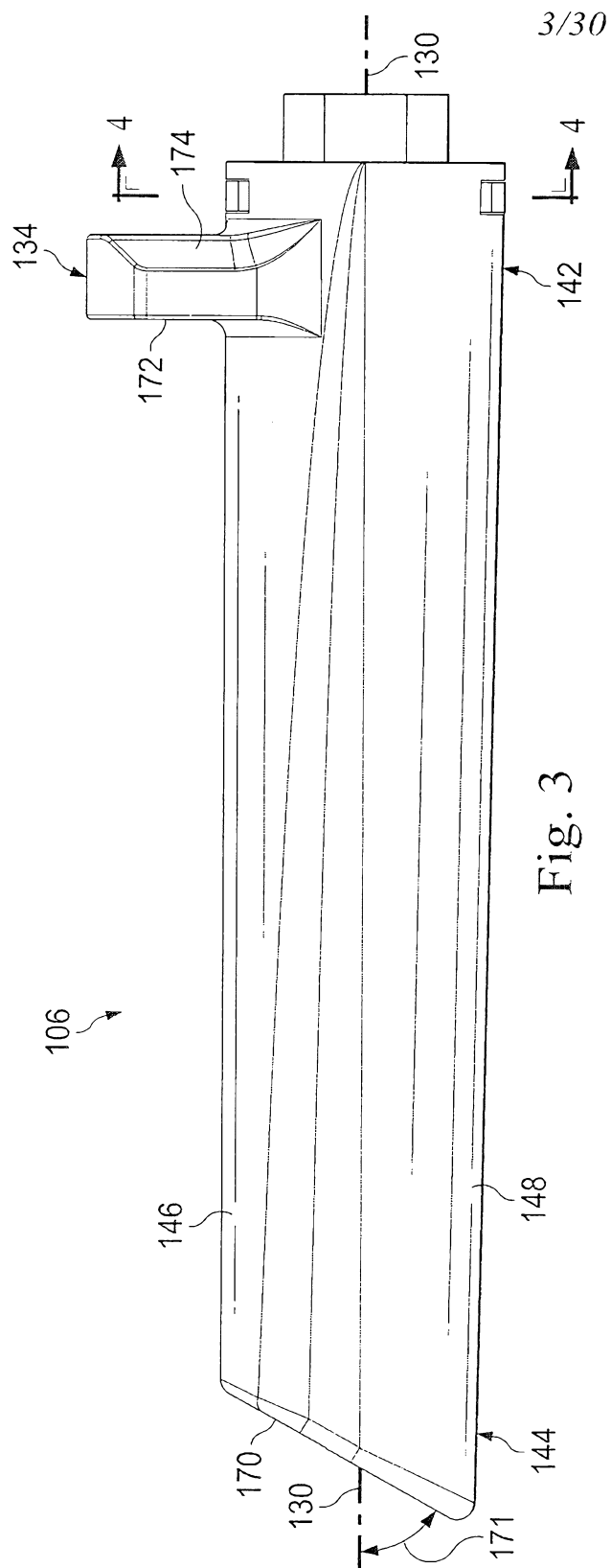


Fig. 3

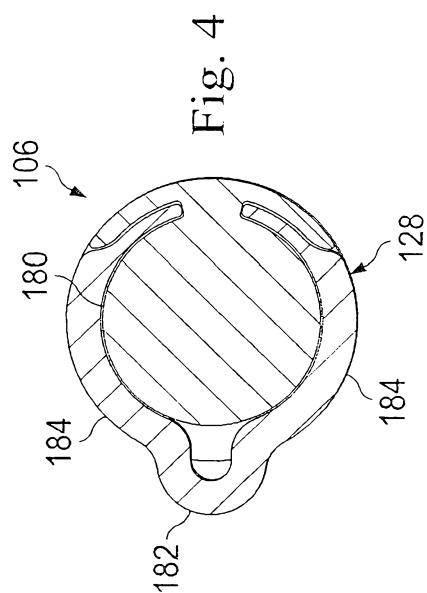


Fig. 4

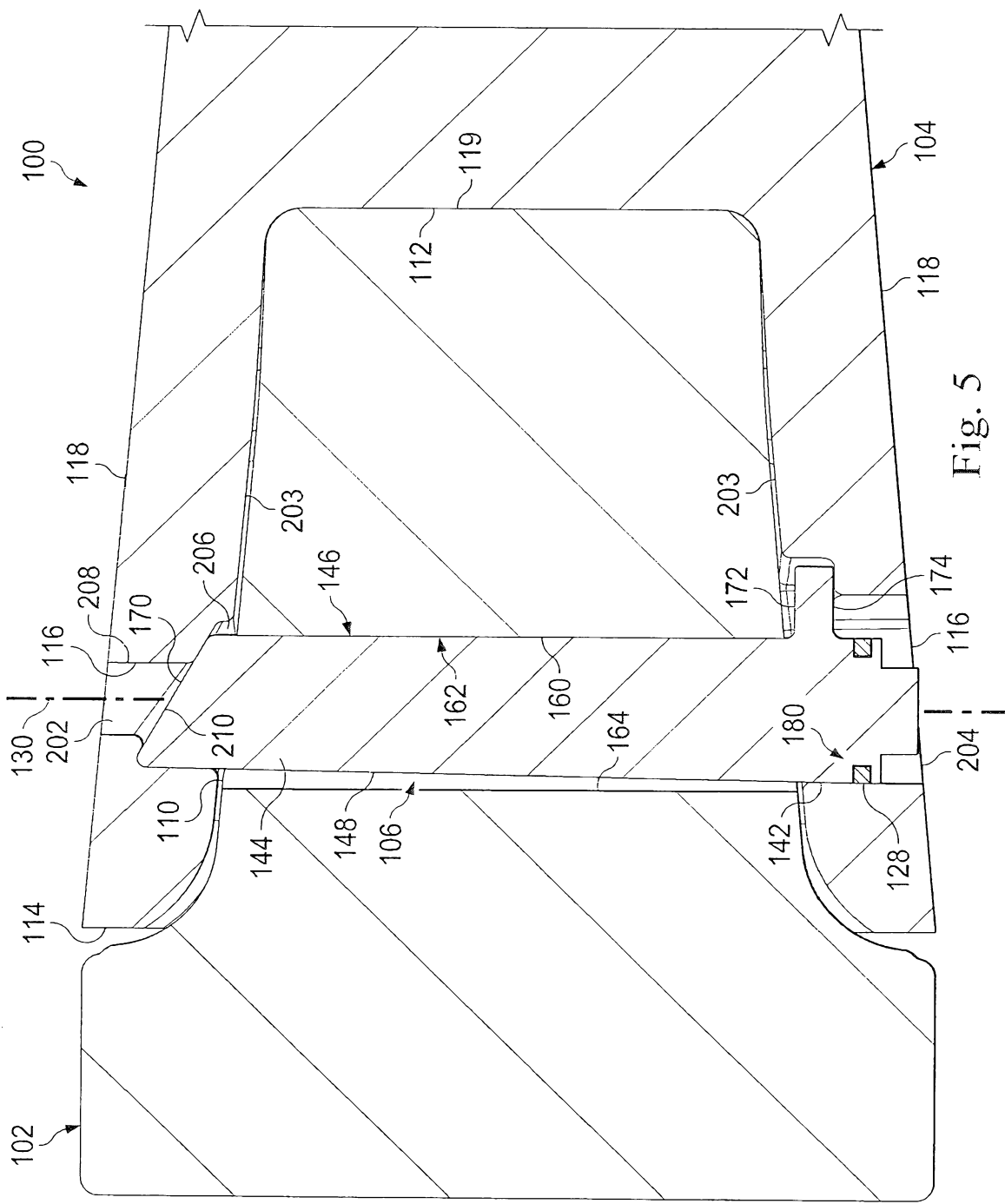
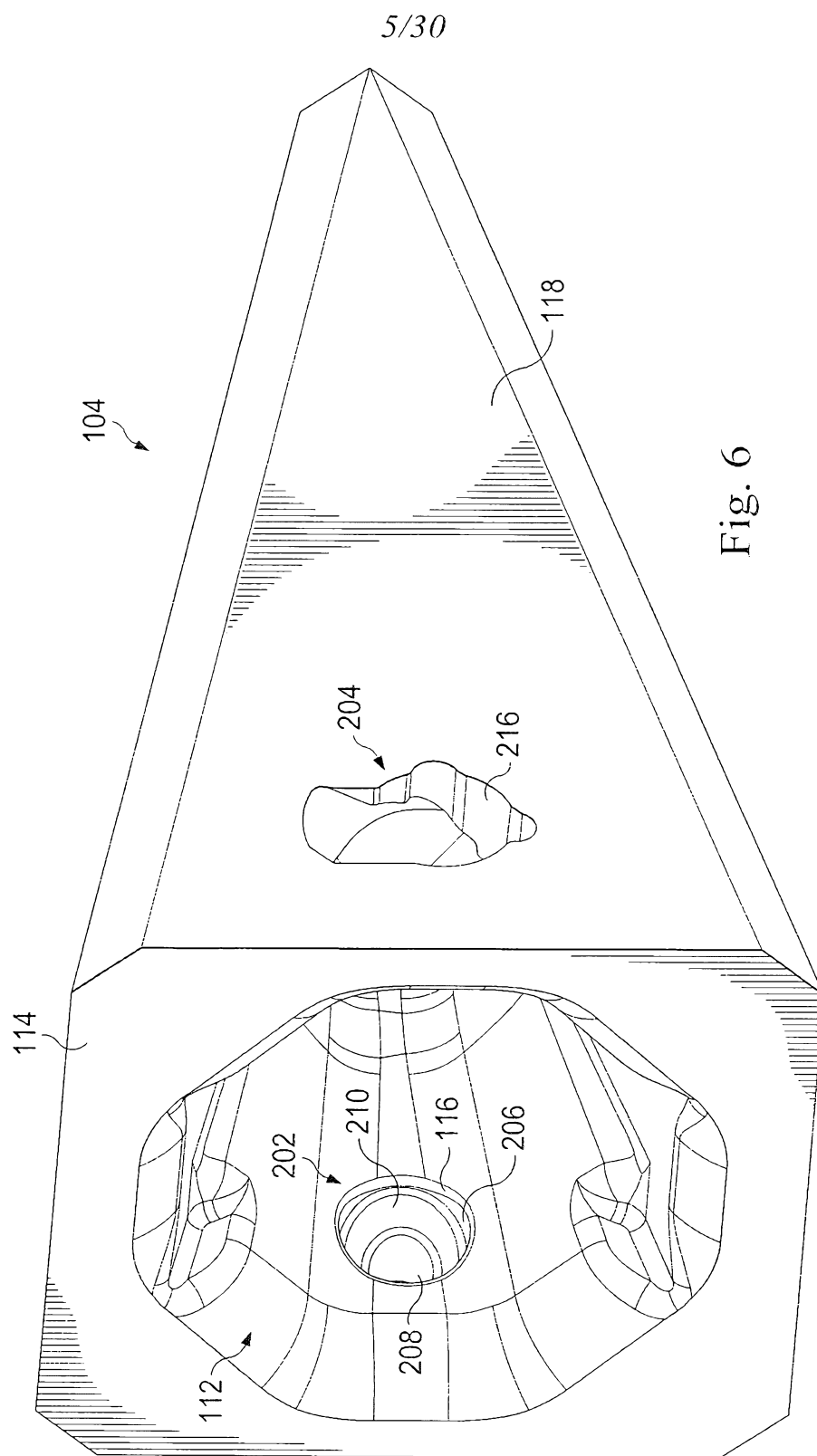


Fig. 5



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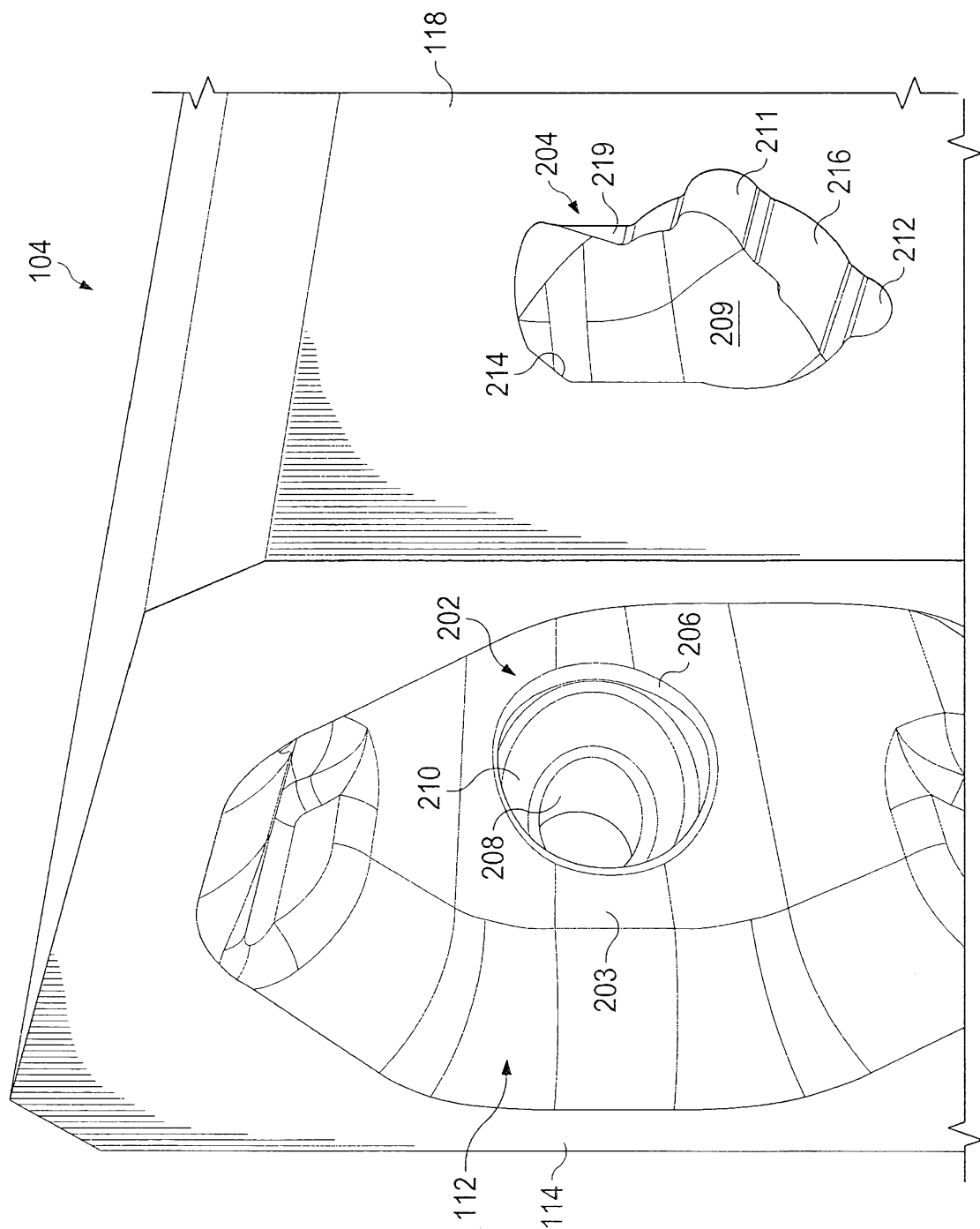


Fig. 7

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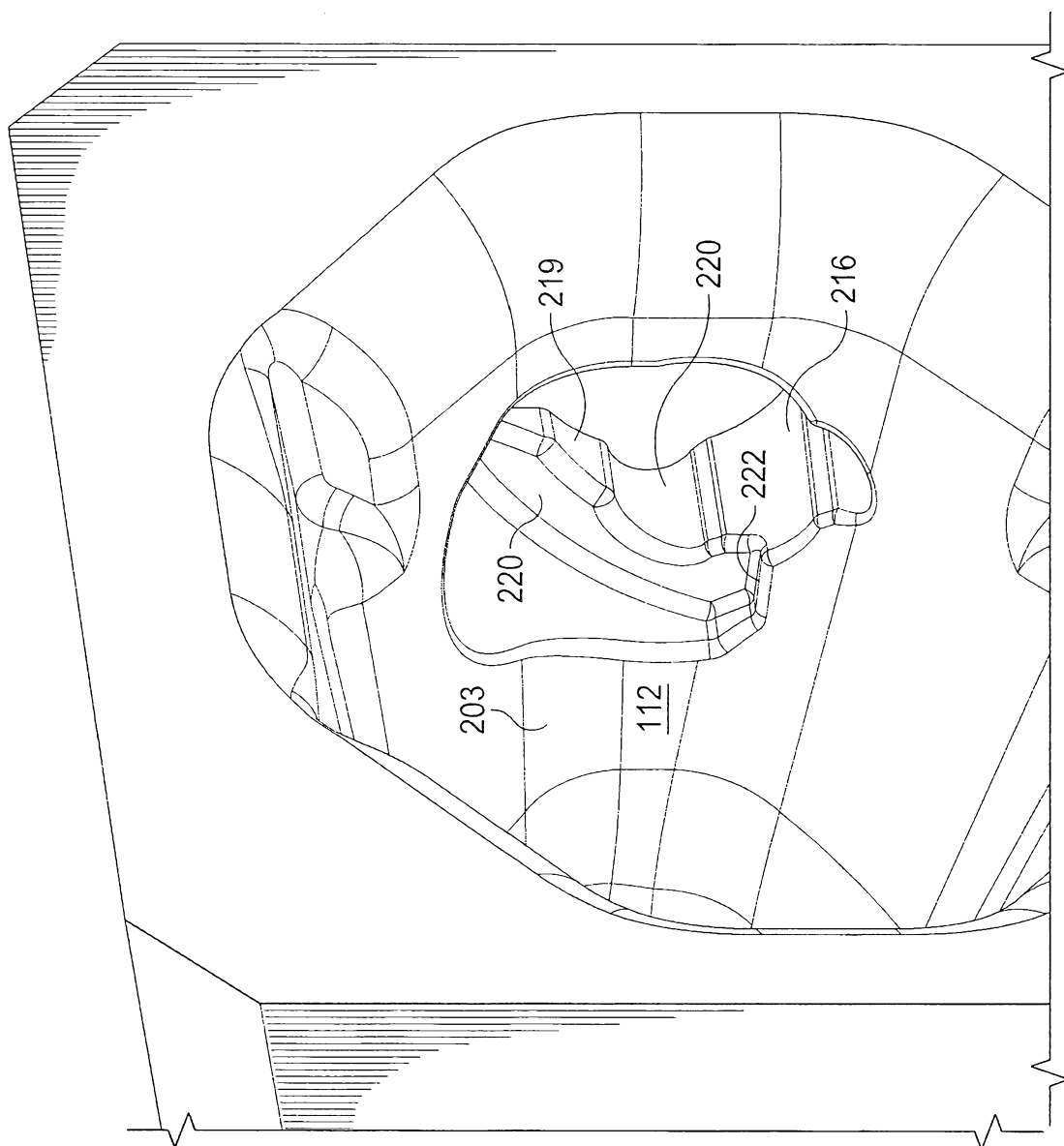


Fig. 8

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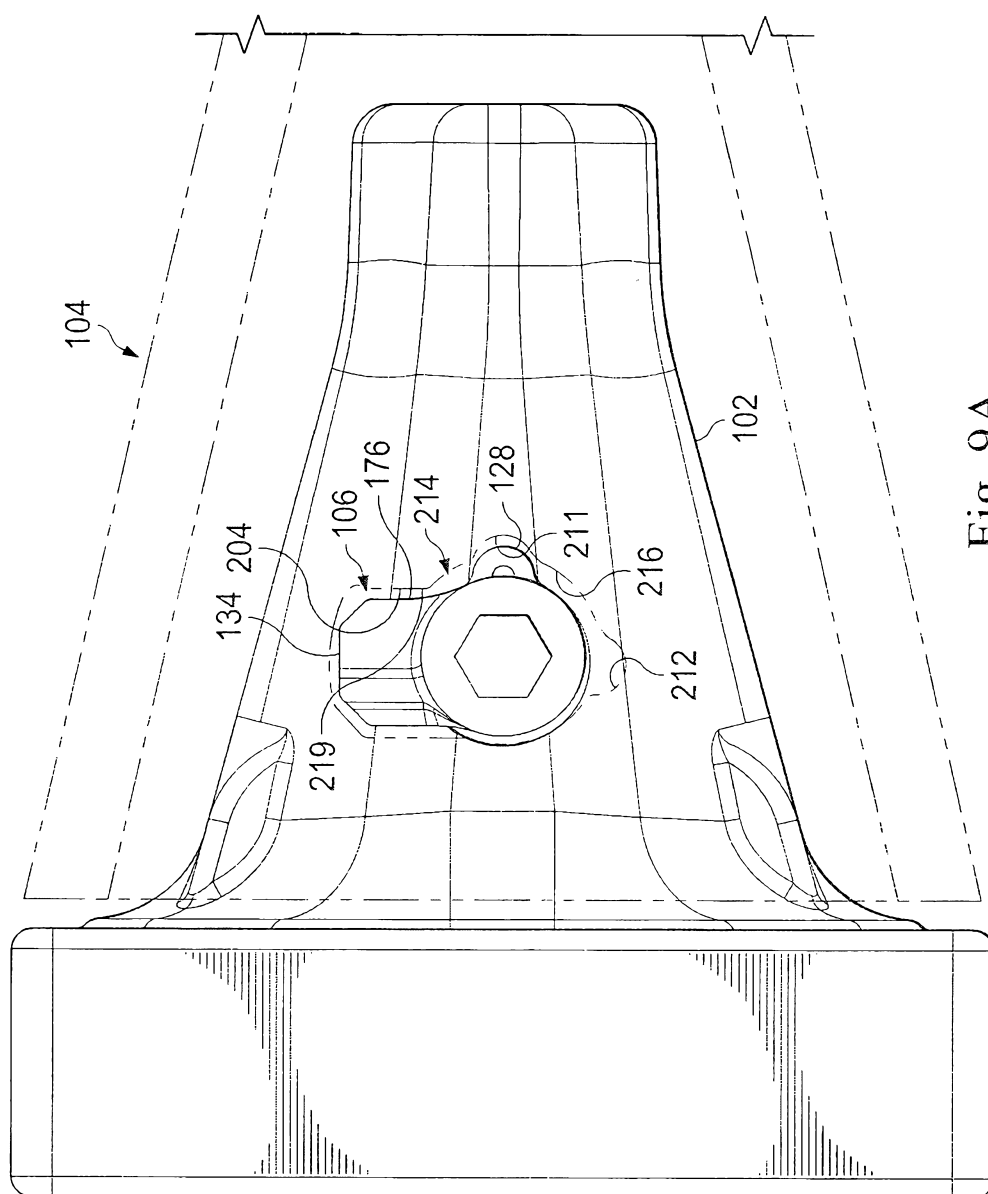


Fig. 9A

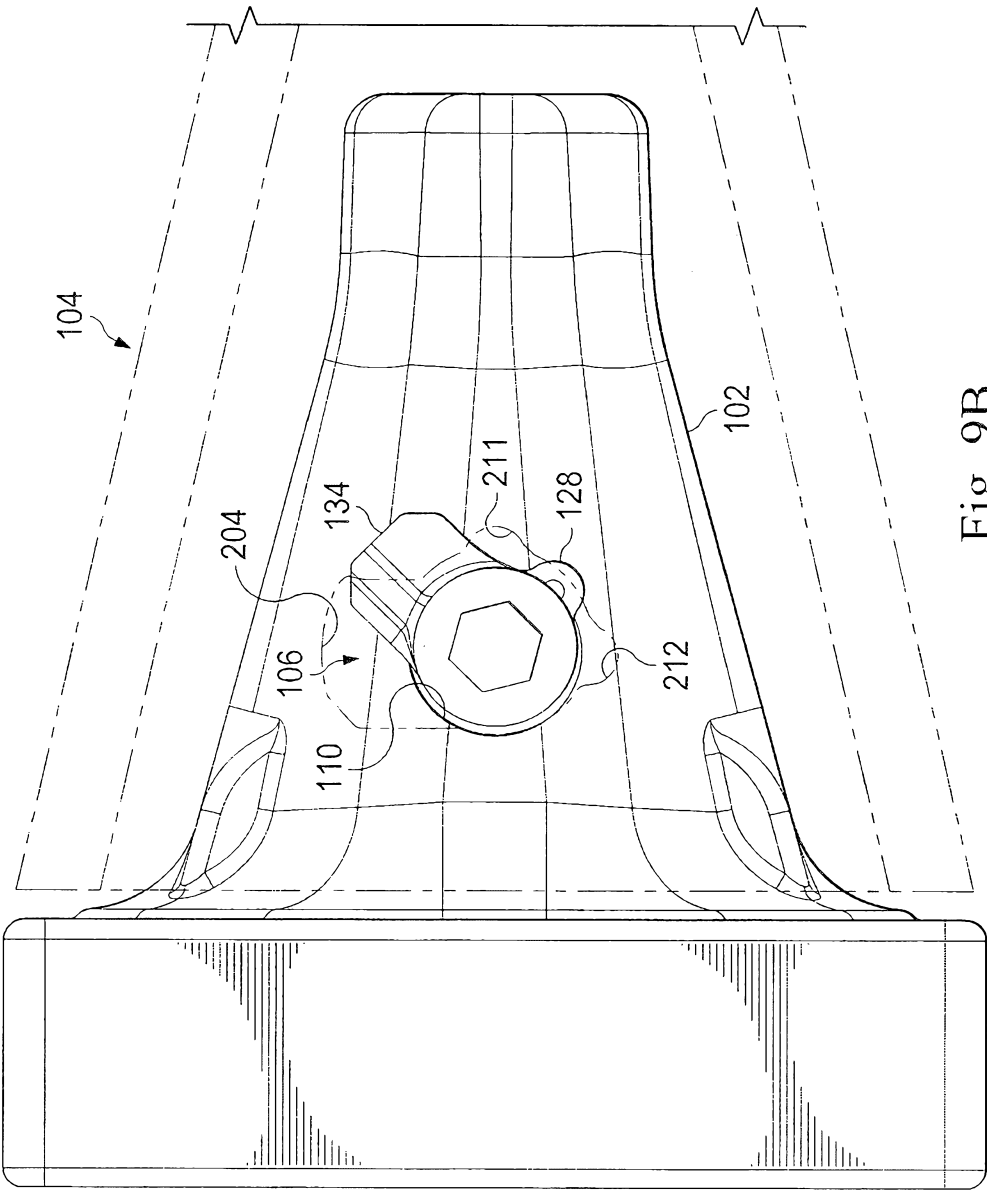


Fig. 9B

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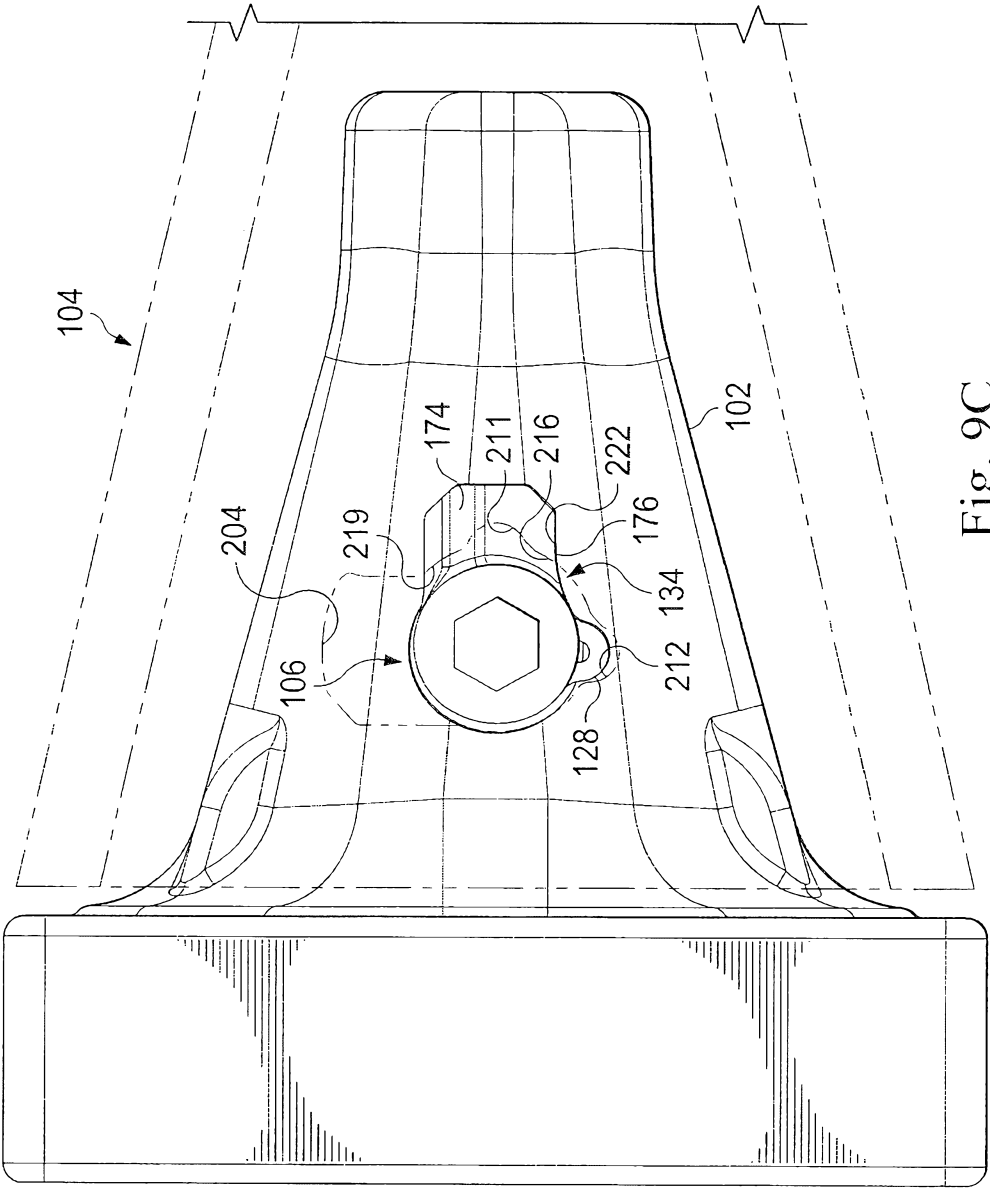


Fig. 9C

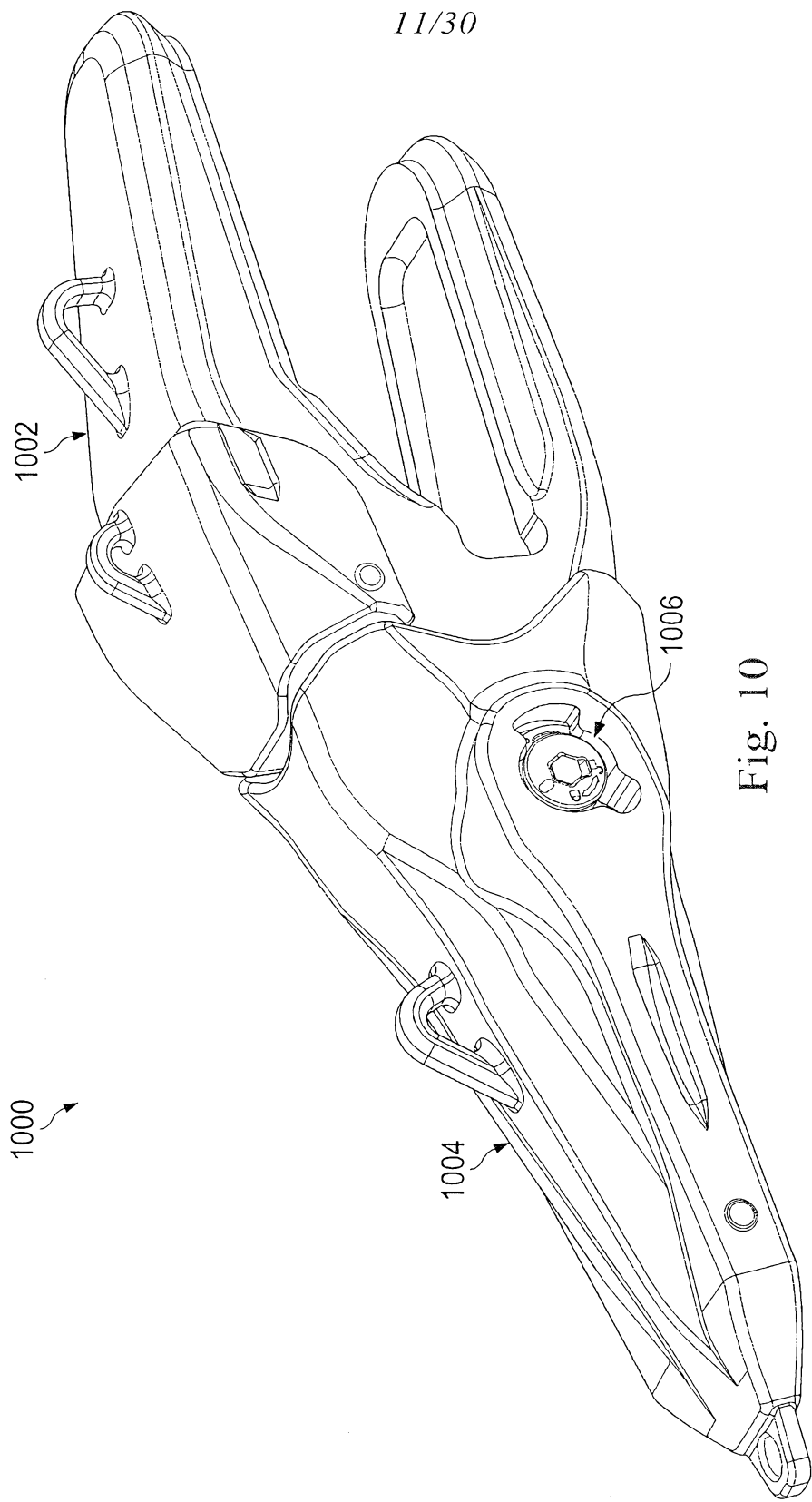
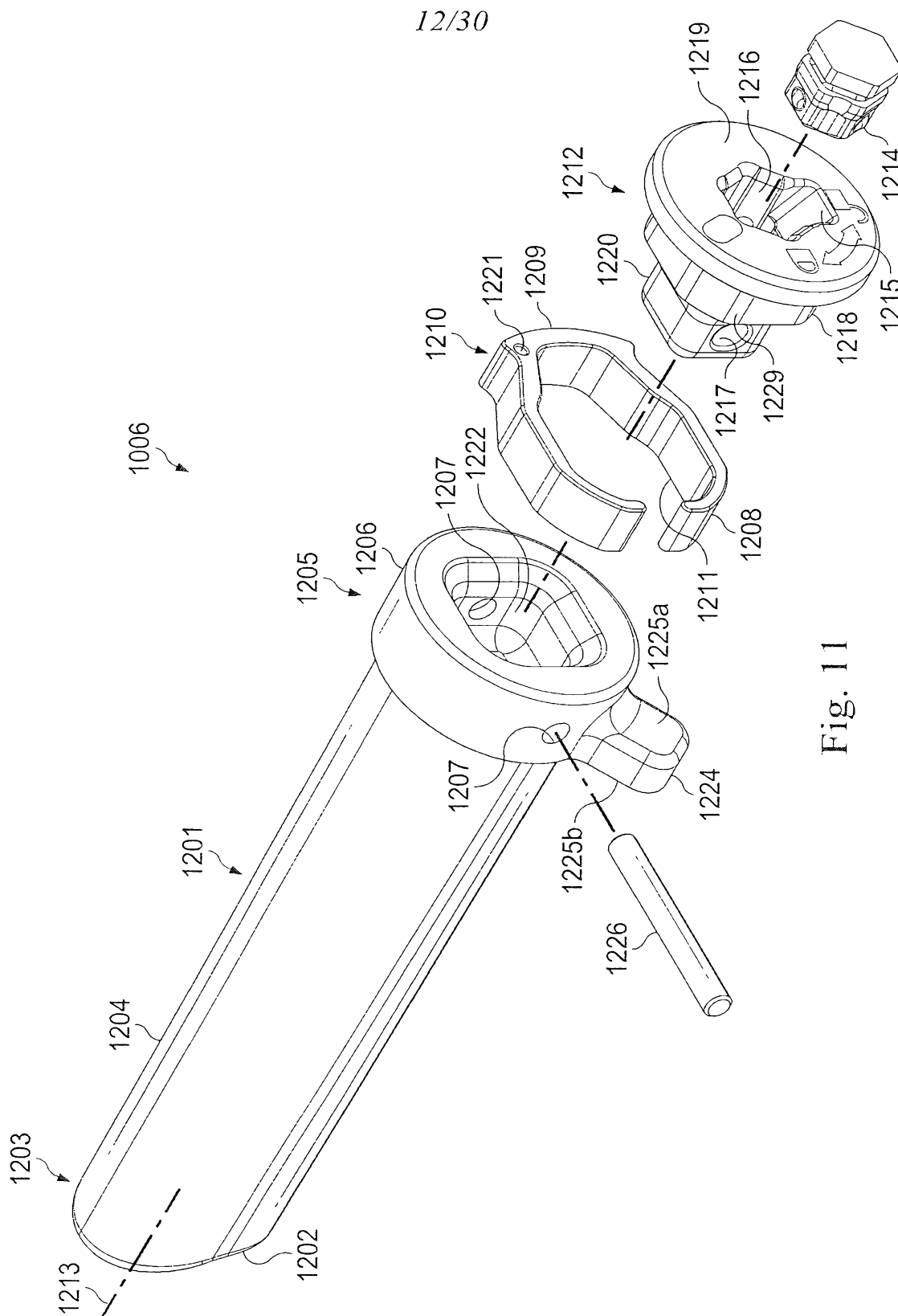
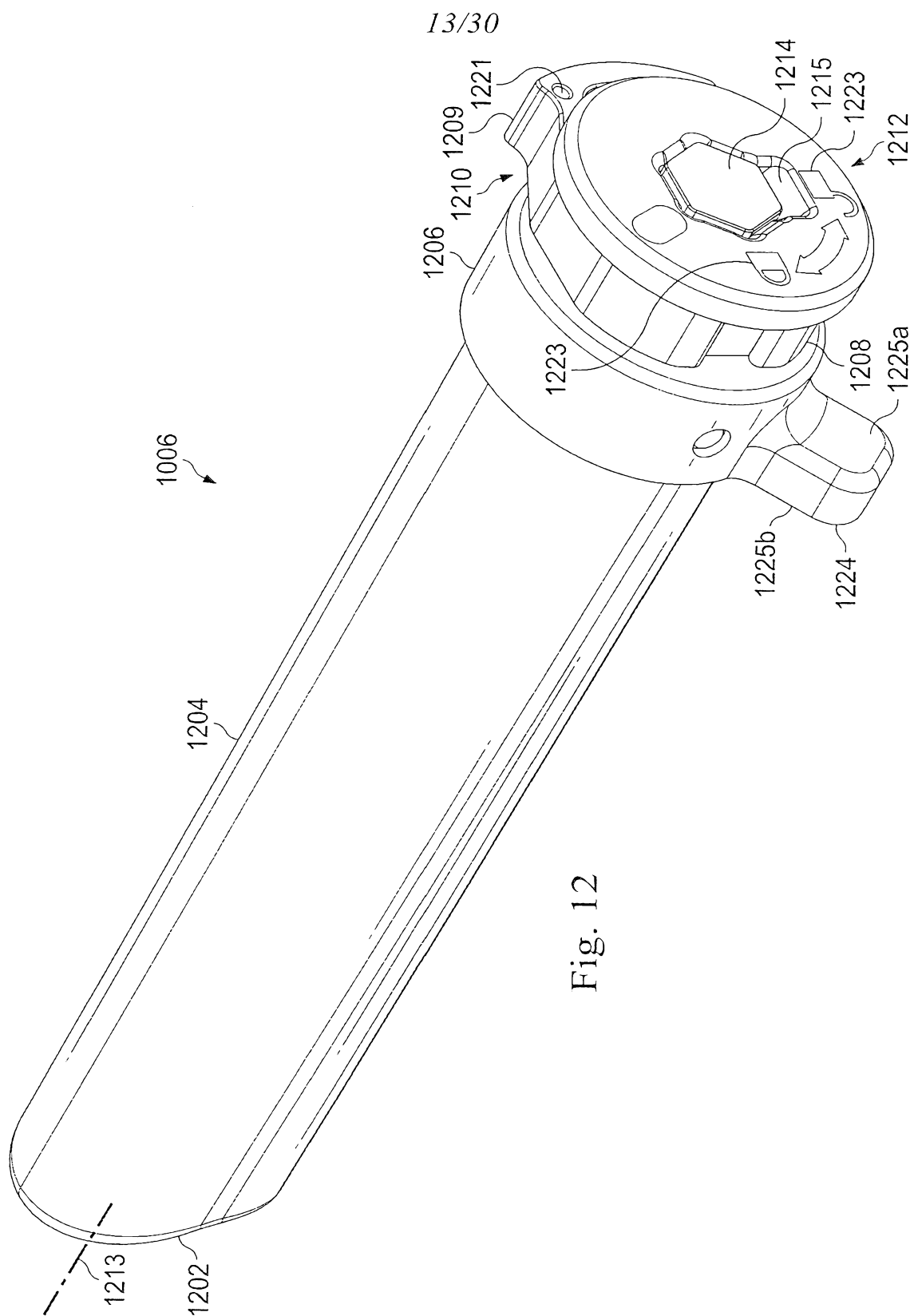


Fig. 10





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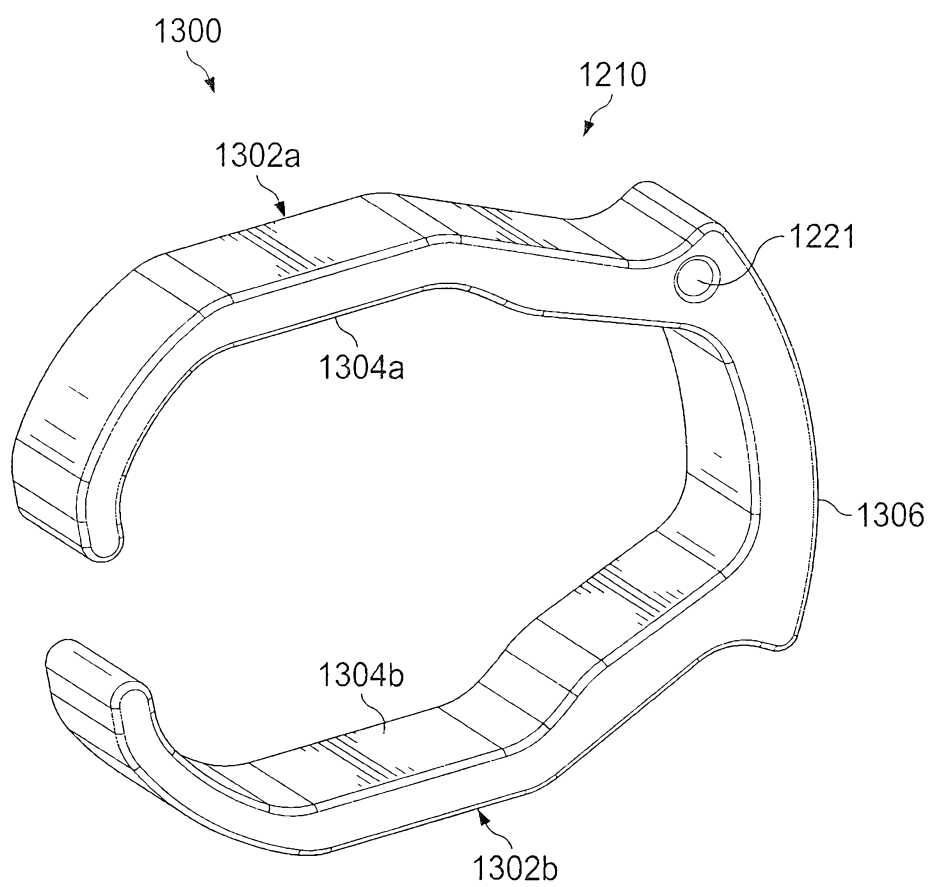


Fig. 13

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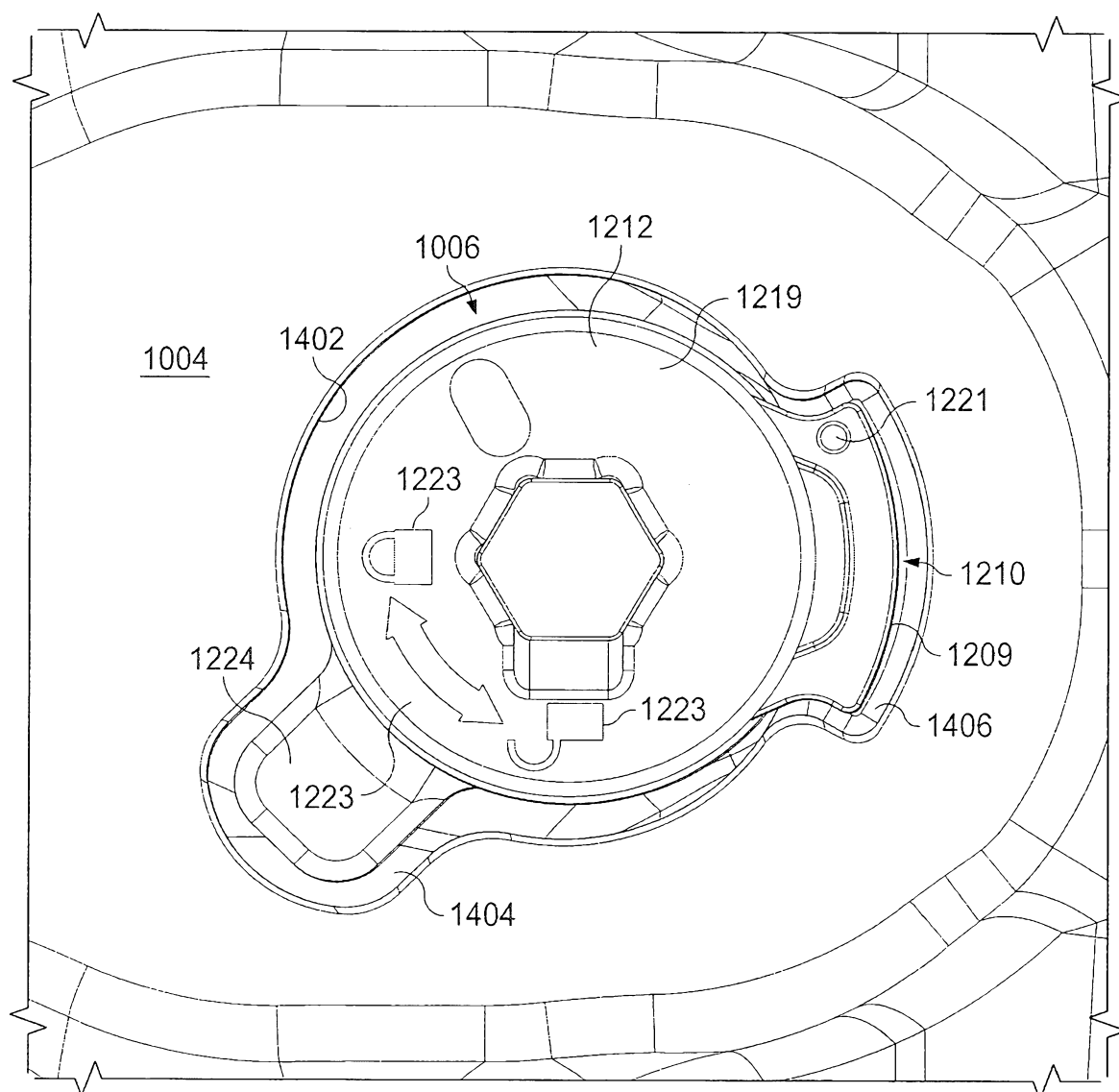


Fig. 14

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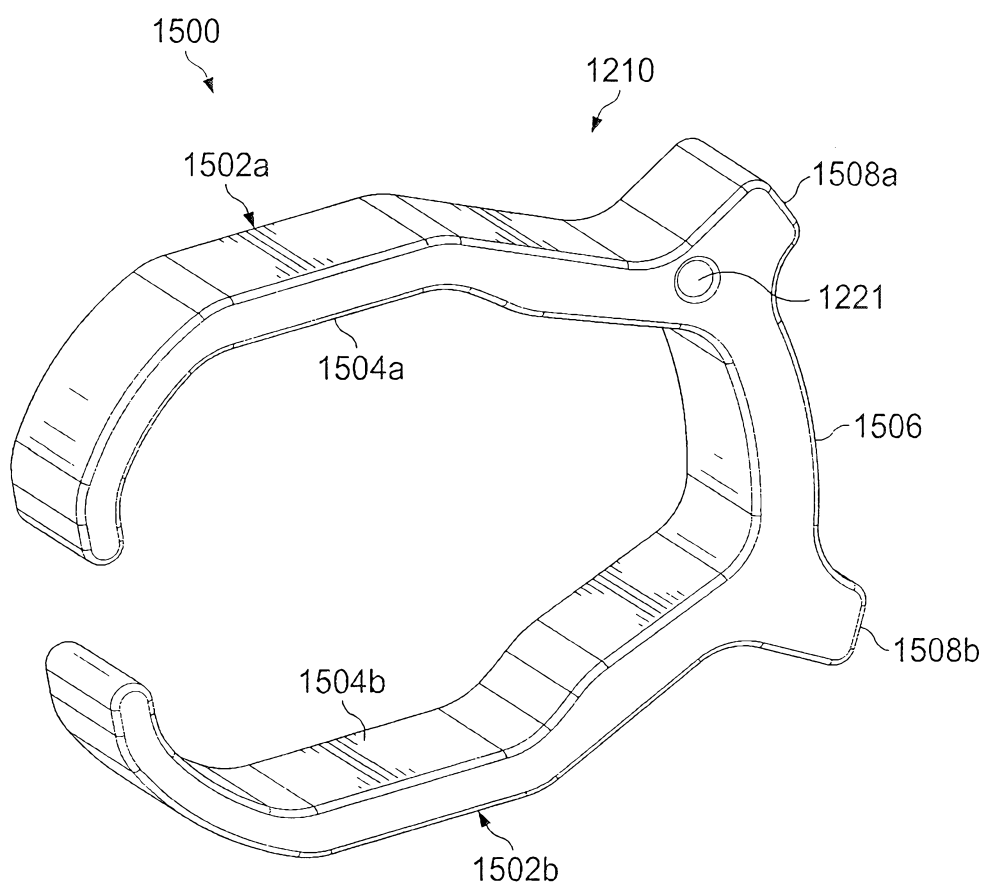


Fig. 15

Fig. 16

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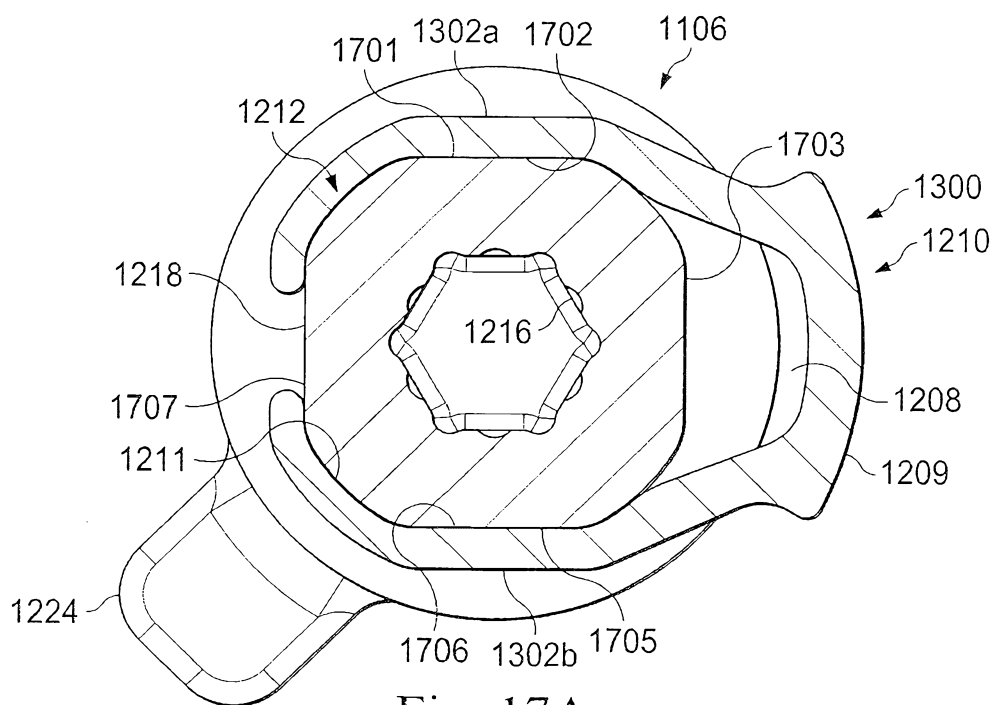


Fig. 17A

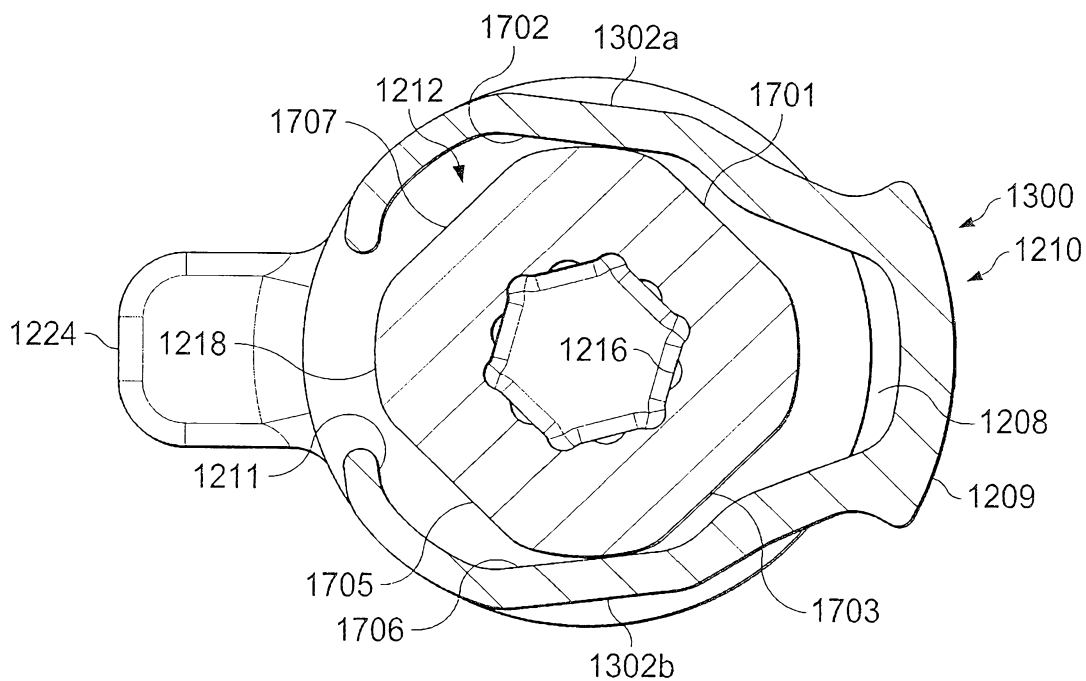


Fig. 17B

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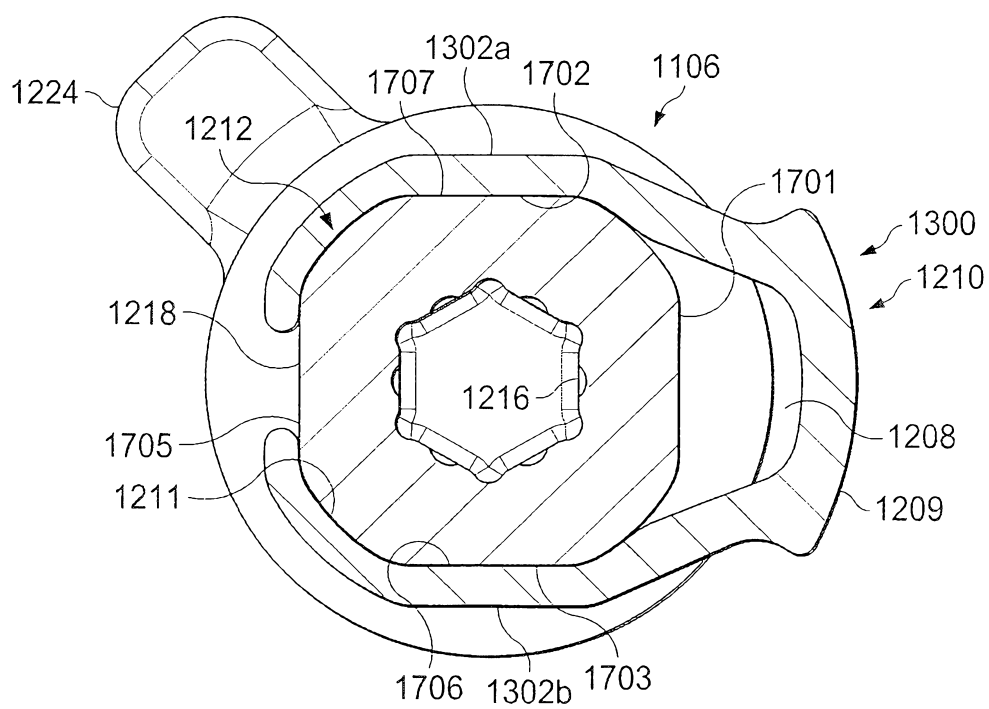


Fig. 17C

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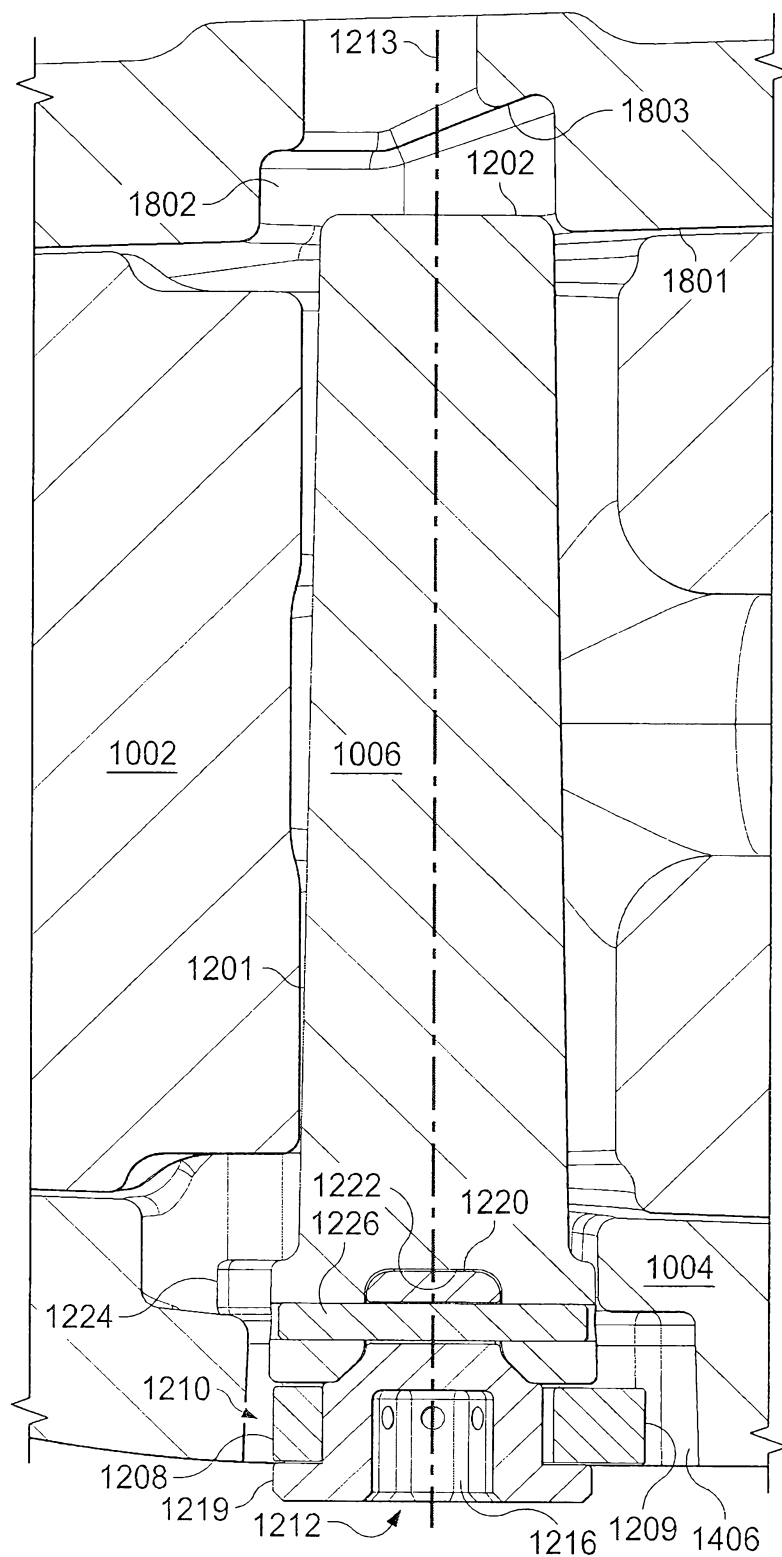


Fig. 18A

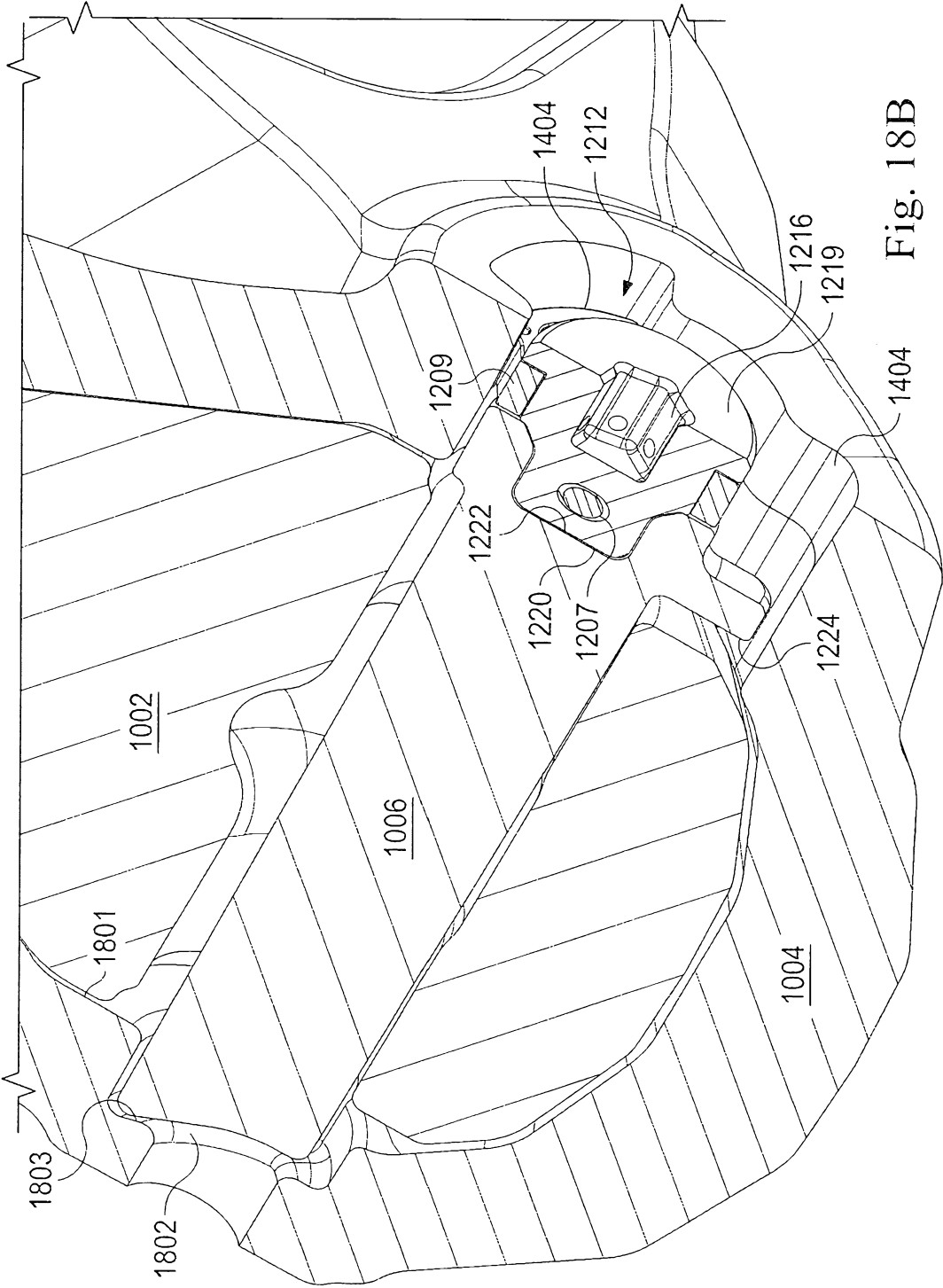


Fig. 18B

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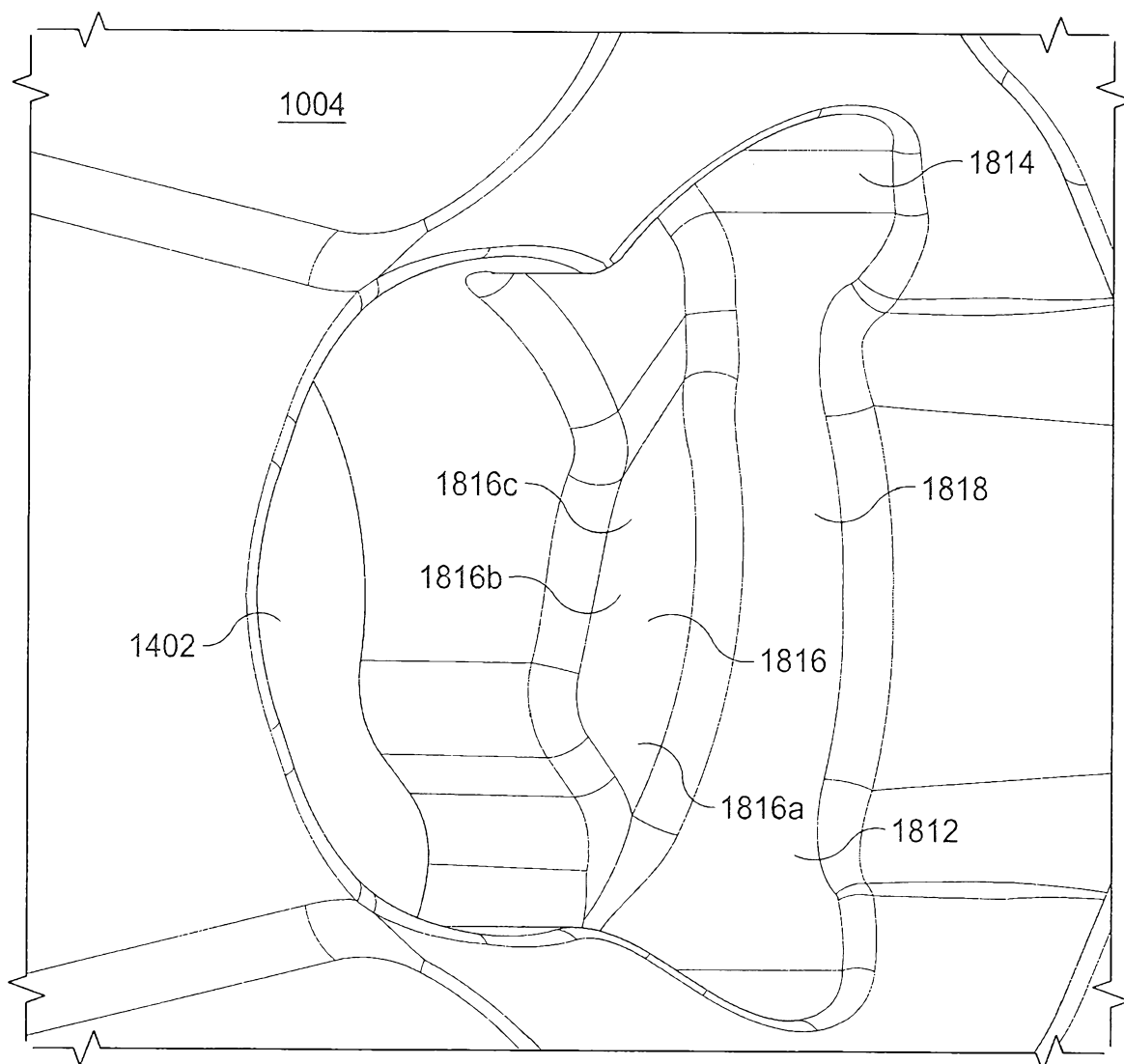


Fig. 18C

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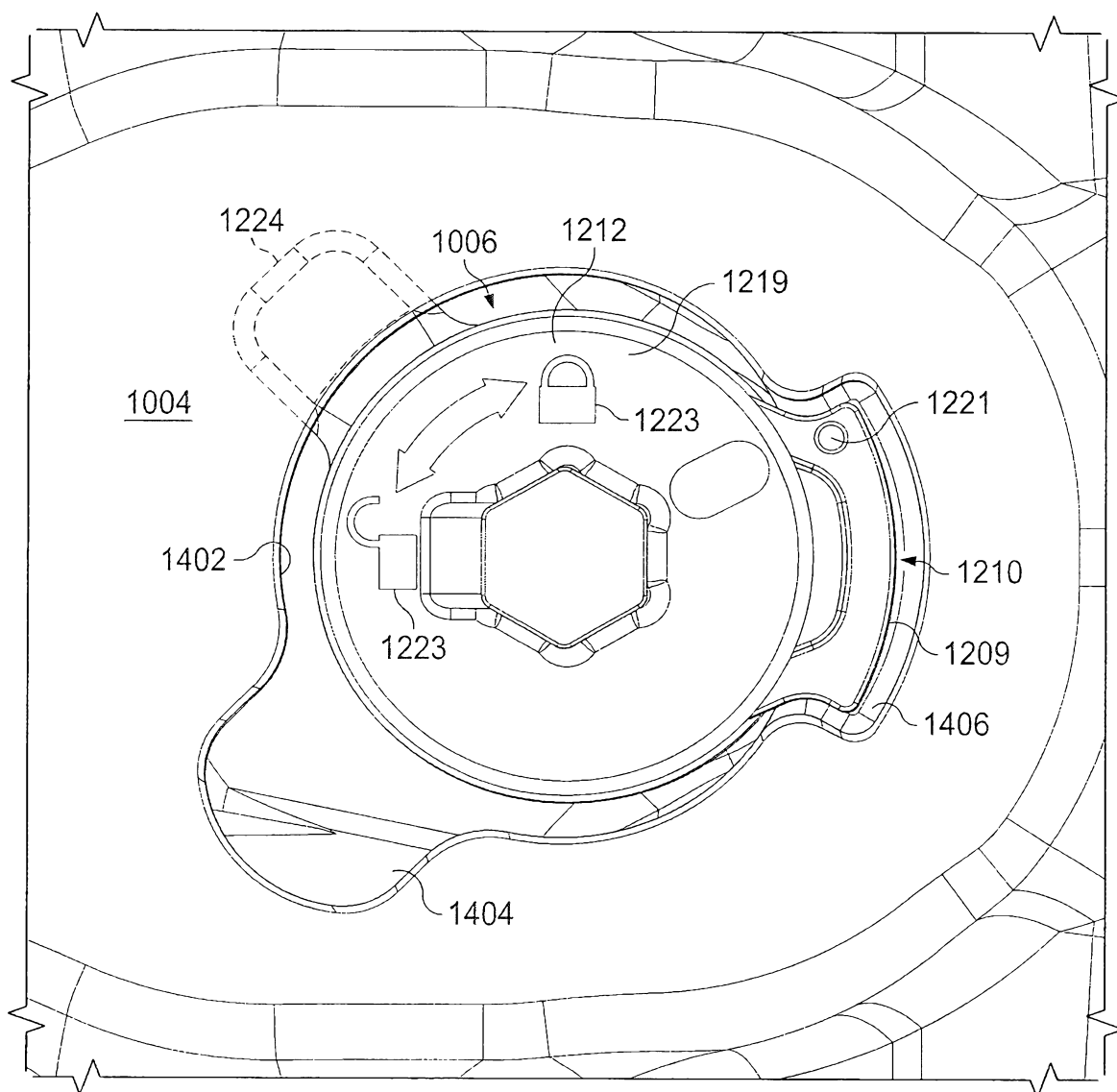


Fig. 19A

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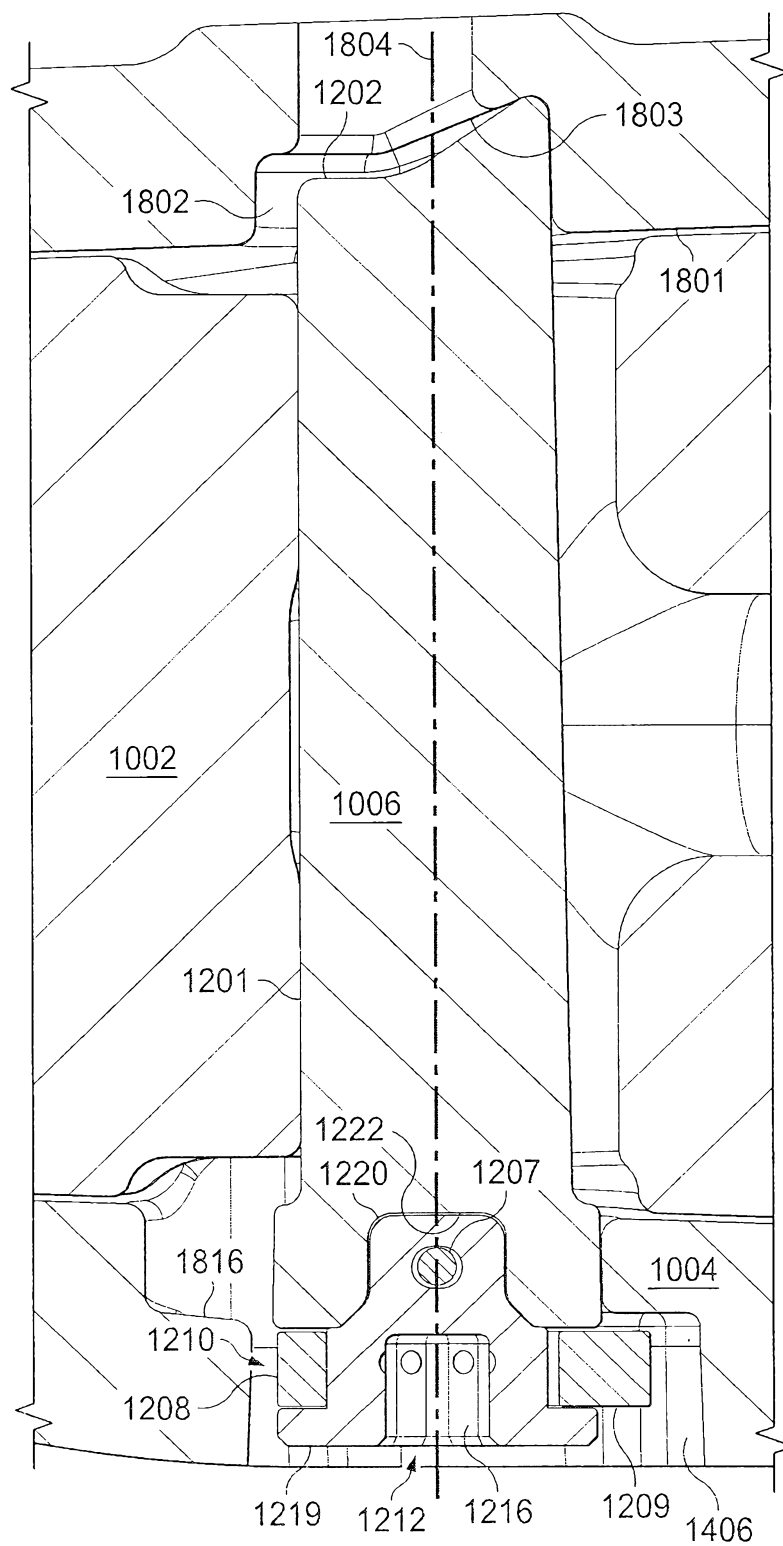


Fig. 19B

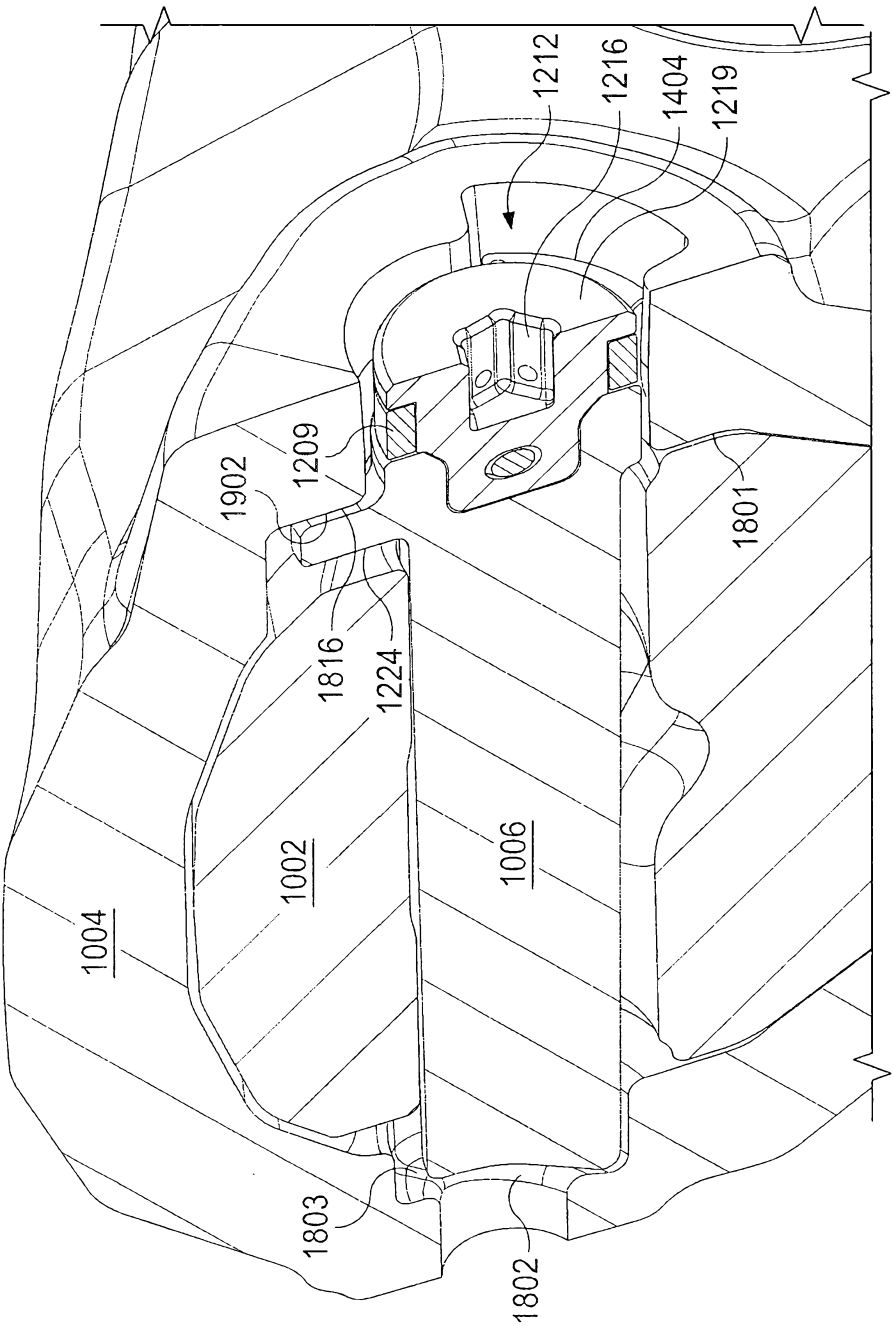


Fig. 19C

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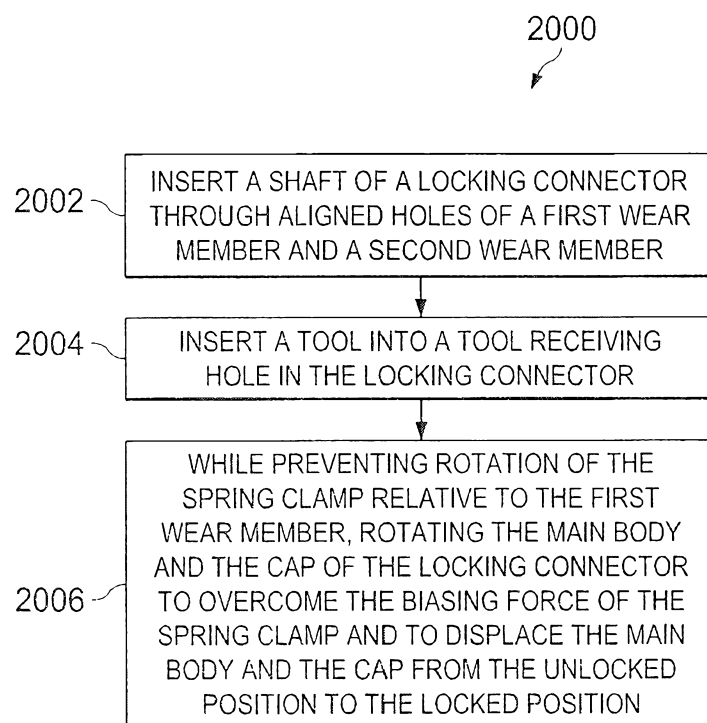


Fig. 20

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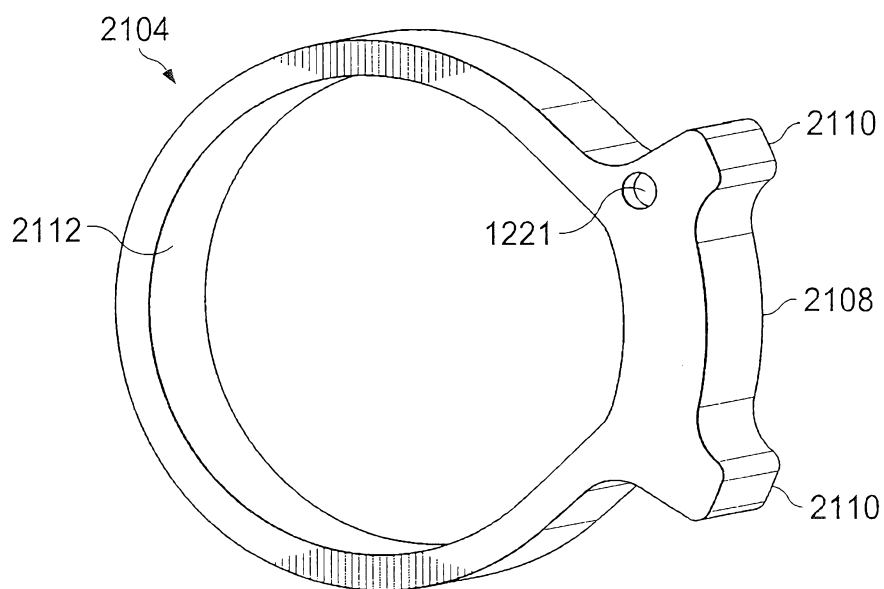


Fig. 22

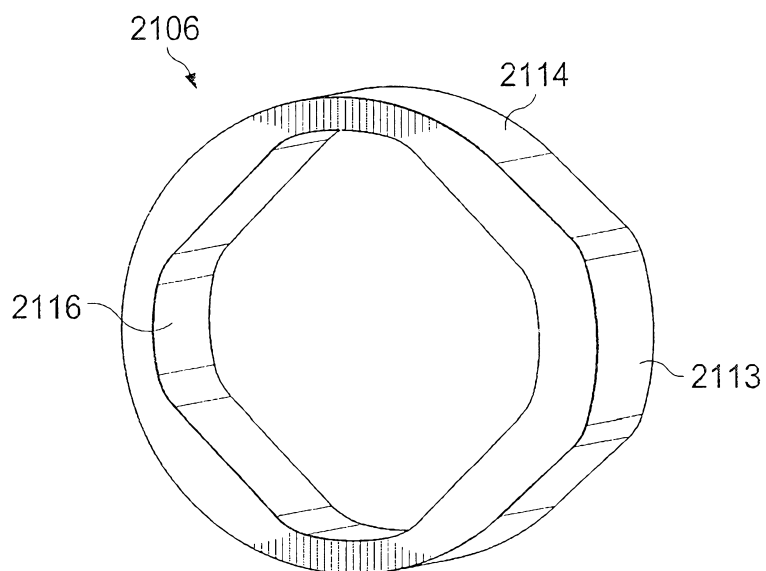
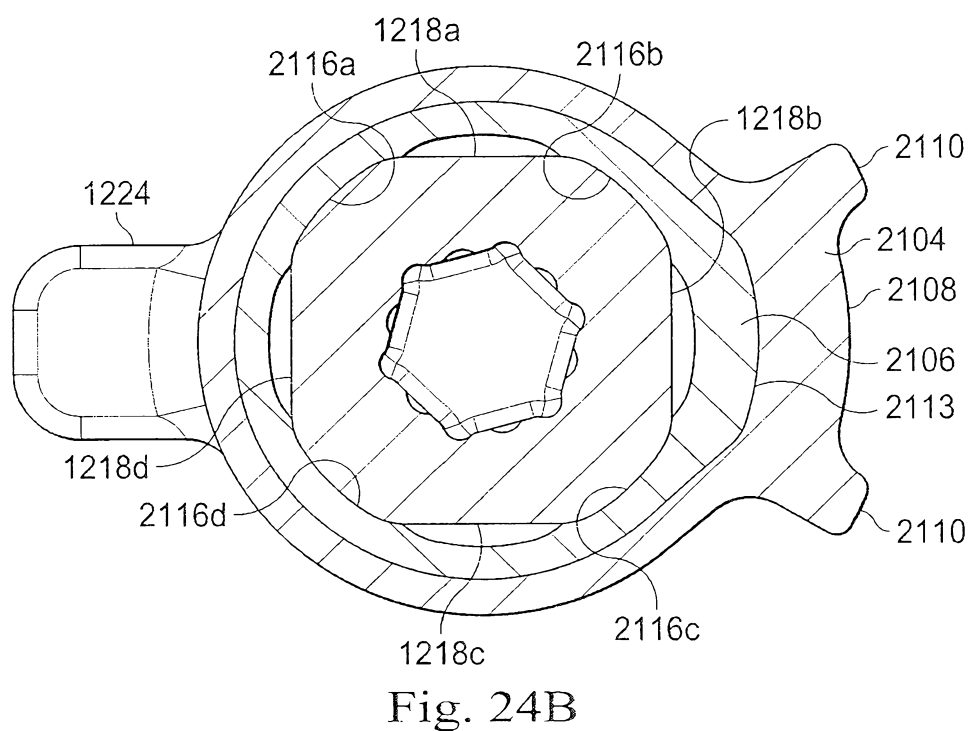
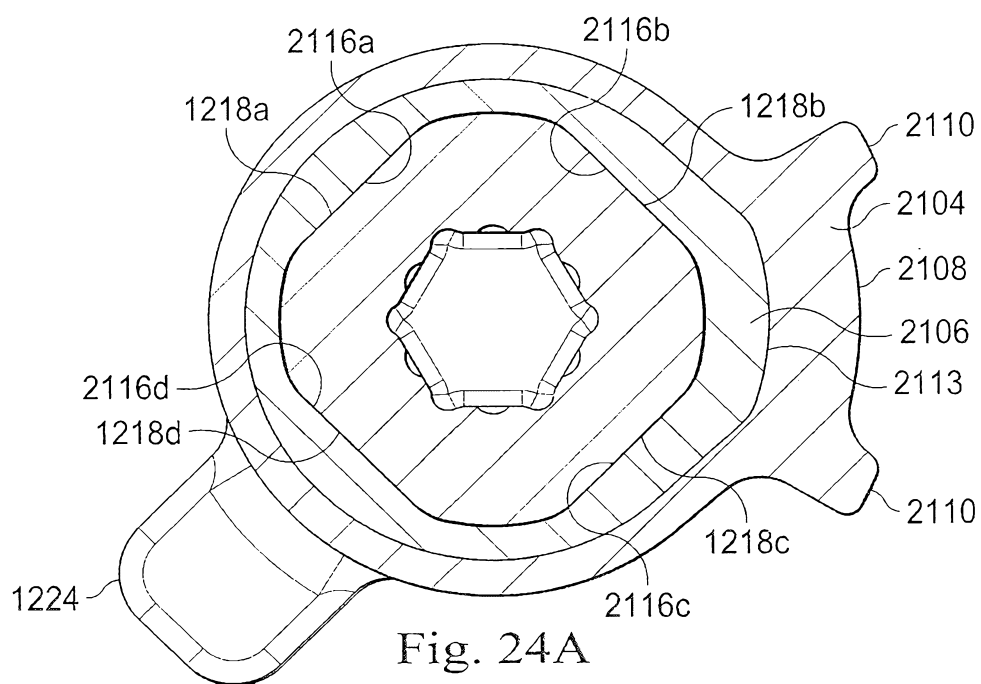


Fig. 23

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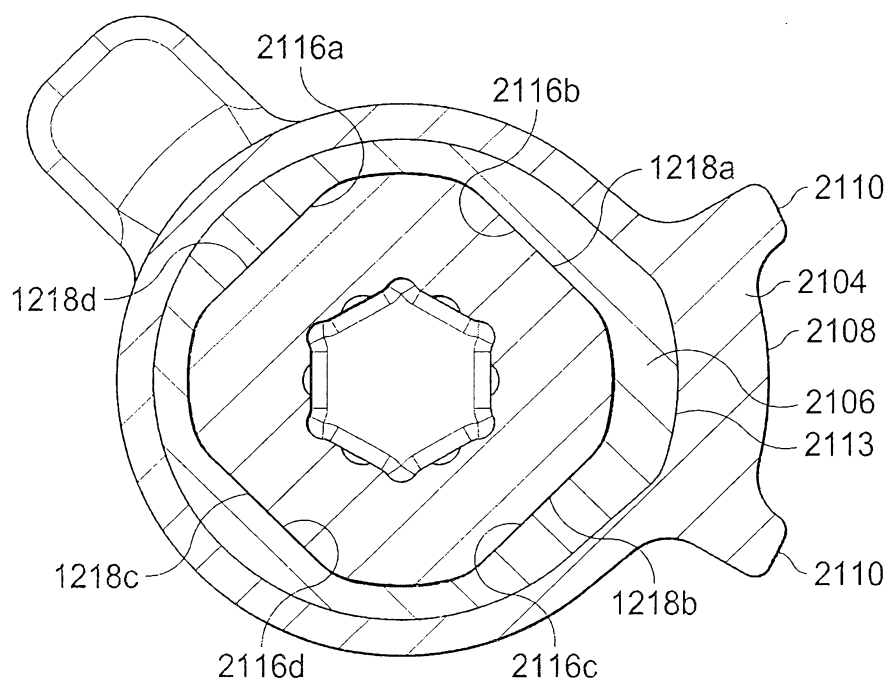


Fig. 24C