(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 538 469 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.04.2025 Bulletin 2025/16

(21) Application number: **25160262.9**

(22) Date of filing: **11.04.2022**

(51) International Patent Classification (IPC):
E02F 9/28 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
E02F 9/2833; E02F 9/2858; E02F 9/2883;
E02F 9/2841

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **12.04.2021 US 202163173939 P**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
22788735.3 / 4 323 591

(71) Applicant: **ESCO Group LLC**
Portland, OR 97210 (US)

(72) Inventors:
- **JOHNSTON, Christopher**
  PORTLAND 97229 (US)
- **ZENIER, Scott, H.**
  PORTLAND 97203 (US)
- **HANKLAND, Joel, S.**
  CANBY 97013 (US)
- **BINGHAM, Bruce, Christopher**
  WEST LINN 97068 (US)
- **OLLINGER, Charles, G., IV**
  PORTLAND 97202 (US)
- **STANGELAND, Kevin**
  OREGON CITY 97045 (US)
- **ENGLEN, Zachary, R.**
  SHERWOOD 97140 (US)

(74) Representative: **Argyma**
14 Boulevard de Strasbourg
31000 Toulouse (FR)

Remarks:
This application was filed on 26.02.2025 as a divisional application to the application mentioned under INID code 62.

(54) **WEAR ASSEMBLY**

(57) A wear member for attaching to a digging edge of a bucket includes a front end and bifurcated legs extending rearwardly from the front end. Each leg includes an inner surface to face the digging edge, a rear wall, and a lock opening to receive a lock therethrough. At least one of the bifurcated legs includes a front portion, a rear portion, and a coupling feature. The rear portion defines a stabilizing region comprising a front facing lateral wall forward of the rear wall.

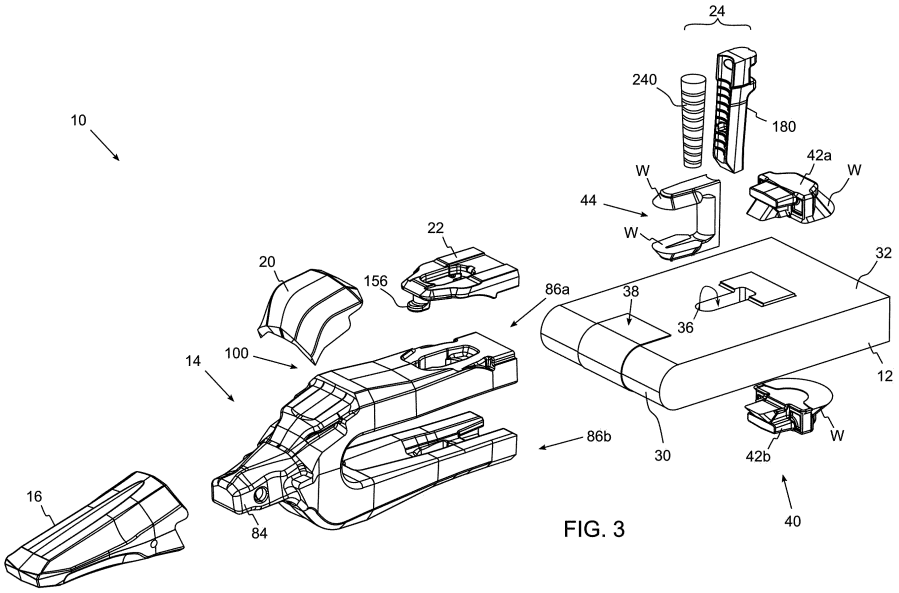

FIG. 3

EP 4 538 469 A2

Description

FIELD OF THE INVENTION

[0001] The present invention pertains to a wear assembly and particularly for the attachment of a wear member to the digging edge of a bucket or other excavator.

BACKGROUND OF THE INVENTION

[0002] It is a common practice to secure wear members in the form of teeth and shrouds along the digging edge of a bucket or other excavator to protect the front lip from premature wear. The teeth project forward of the lip to ease penetration and break up the ground to be gathered in the bucket. The shrouds are mounted to the lip between the teeth. As can be appreciated, the wear members, and particularly the teeth, are often used in harsh working conditions where they are subjected to very heavy loading and a high degree of wearing.

[0003] Excavating teeth are generally composed of a plurality of parts including, for example, an adapter, a point and a lock. The adapter has a rear mounting end configured for attachment to the front lip of the bucket, and a forwardly projecting nose for mounting the point. The point is a tapered member provided with a forward earth-penetrating end and rearwardly opening socket that receives the adapter nose. The lock is that part of the wear assembly that secures the point to the adapter. Although the points wear out most frequently, the adapters are also subjected to wear and require periodic replacement.

[0004] To enable replacement in the field, adapters have been developed that are mechanically attached to the bucket lip. The most common is known as a Whisler-style adapter (e.g. as shown in U.S. Pat. No. 4,267,653 to Hahn and U.S. Pat. No. 6,986,216 to Emrich and Briscoe). In these arrangements, the rear mounting end of the adapter comprises a pair of bifurcated legs which straddle the bucket lip. Each leg of the adapter includes an opening that is aligned with a through-hole or keyway formed in the lip of the bucket. A multi-part lock comprising a spool and a wedge is inserted into the aligned openings and through-hole to secure the adapter in place.

SUMMARY OF THE INVENTION

[0005] In one embodiment of the present invention, there is provided a wear member securely attached to the digging edge of an earth working equipment (e.g., the lip of a bucket) by a mechanical mechanism that facilitates easy installation and removal.

[0006] In accordance with another embodiment of the present invention, there is provided a wear member for attaching to a digging edge, where the digging edge defines a keyway therethrough. The wear member includes a front end, bifurcated legs extending rearwardly from the front end, each leg including an inner surface to face the digging edge, a rear wall, and a lock opening to receive a lock therethrough. At least one of the bifurcated legs further includes a front portion, a rear portion recessed relative to the front portion, and a coupling feature. The front portion defines a rearward facing lateral wall adjacent the rear portion. The rear portion defines a stabilizing region comprising a front facing lateral wall forward of the rear wall.

[0007] Optionally, one or both of the bifurcated legs may include a rear engagement structure.

[0008] Optionally, each leg includes a further front facing lateral wall forming a bearing surface and partially defining the lock opening and located at a rear end thereof.

[0009] Optionally, the front portion defines a rearward facing lateral wall adjacent the rear portion.

[0010] Optionally, the rear engagement structure comprises a slot that opens in the rear wall and inner surface of a leg and extends longitudinally to receive a boss on the digging edge, wherein the boss resists lateral forces. The boss on the digging edge may extend towards, but not actually touch during normal operation, the internal lateral wall. In effect, the internal lateral wall may operate primarily as a clearance surface rather than an abutment surface. Alternatively, the internal lateral wall may be configured to abut the boss on the digging edge during normal operation.

[0011] Optionally, the rear engagement structure comprises exterior opposed side surfaces of the leg for being received and surrounded by complementary surfaces of a retaining feature on the digging edge for resisting longitudinal and lateral forces.

[0012] Optionally, one of the lock openings extends longitudinally between the front portion and the rear wall to receive a lock therethrough and to allow part of a lock to move longitudinally therein prior to another part of the lock being inserted.

[0013] Optionally, the rear portion defines a ledge on each of opposing longitudinal sides of the lock opening.

[0014] Optionally, at least one of the bifurcated legs comprises an upper leg.

[0015] Optionally, at least one of the bifurcated legs comprises a lower leg.

[0016] Optionally, the other of the bifurcated legs also comprises: a front portion and a rear portion recessed relative to the front portion.

[0017] Optionally, the front portion is located between the front end and the lock opening.

[0018] Optionally, the rear portion is recessed relative to an outer surface of the front portion.

[0019] Optionally, the rear portion at least partially surrounds the lock opening.

[0020] Optionally, the coupling formation comprises a retaining surface on the front portion for engaging with a complementary coupling portion on a wear cap, so that the wear cap is prevented from moving away from the

wear member.

[0021] Optionally, the wear cap comprises a protrusion for receipt within an indentation in the wear member, so that the wear cap is prevented from moving in a rearward direction.

[0022] Optionally, the rear portion stabilizing region comprises a pair of indentations located on opposite sides of the lock opening.

[0023] Optionally, each indentation comprises the front facing lateral wall and a longitudinal wall extending from the front facing lateral wall and tapering towards the front portion. The longitudinal wall may not taper in any direction.

[0024] Optionally, the indentations further comprise a pair of upward facing ledges, each ledge being defined by a longitudinal side of the leg, one of the front facing lateral walls, and one of the longitudinal walls.

[0025] Optionally, one or both ledges tapers from the front facing lateral wall towards the front end so that a width of one or both ledges reduces towards the front end. The ledges may not taper in any direction, or may taper towards the rear end so that a width of one or both ledges reduces towards the rear end.

[0026] Optionally, the wear member has a forwardly projecting nose for mounting another component.

[0027] Optionally, the wear member is selected from the group consisting of an adapter, a tip, and a shroud.

[0028] Optionally, a front facing bearing wall on the wear member engages a rear surface of the lock received through the lock opening.

[0029] In another embodiment a wear member for attaching to a digging edge comprises a front end and bifurcated legs extending rearwardly from the front end. Each of the legs including an inner surface to face the digging edge and a rear wall. At least one of the legs has a lock opening to receive a lock therein. At least one of the legs includes a front portion and a rear portion recessed relative to the front portion. The front portion includes a rear facing lateral wall adjacent the rear portion to oppose a wear cap receivable in the recessed rear portion. The rear portion includes at least one front facing lateral wall forward of the rear wall which is suitable for engaging a wear cap in the rear portion and resisting rearward movement of the wear cap.

[0030] In another embodiment, a wear member for attaching to a digging edge comprises a front end and bifurcated legs extending rearwardly from the front end. At least one of the legs defines a lock opening to receive a lock therein, and a pair of indentations to each side of the lock opening, wherein each indentation includes a front facing wall for resisting rearward movement of a wear cap on the at least one leg.

[0031] In another embodiment, a wear member for an earth working equipment includes a pair of legs defining a cavity therebetween for receiving a base of the equipment. Each of the legs includes an inside surface to face the base, an opposite outer surface to face away from the base, and a through-hole opening in the inside surface and the outer surface. The hole in each leg has a rear end defined by an end surface that extends away from the base, wherein the end surface in one leg extends from the inside surface to the outer surface, and the end surface in the other leg extends from the inside surface to a step proximate the outer surface.

[0032] In another embodiment, a wear member for an earth working equipment includes at least one leg having an inside surface to face the base, an outside surface, a front end and a rear end, wherein the rear end of the leg includes mounting recesses in the outer surface for mounting a wear cap.

[0033] In accordance with another embodiment of the present invention, there is provided a wear member for attaching to a digging edge of a bucket, the wear member comprising a front end, bifurcated legs extending rearwardly from the front end, at least one of the legs defining a recessed shelf to receive a wear cap thereon, and a lock opening therethrough to receive a lock therein.

[0034] The wear member may comprise a shroud.

[0035] According to another embodiment of the present invention there is provided a wear assembly for attaching to a digging edge of a bucket, where the digging edge defines a keyway therethrough. The wear assembly comprises a wear member according to the above embodiment and any desired optional features in the above paragraphs, a rear wear cap mounted on a rear portion of the wear member, a lock comprising a co-operating spool and a wedge mounted in the lock opening defined by the wear member and retaining the rear wear cap on the wear member.

[0036] Optionally, the wear cap is mounted on a recessed rear portion of the wear member and defines a longitudinally extending opening in registration with the lock opening, and a profiled lower engagement surface.

[0037] Optionally, the profiled lower engagement surface comprises a front portion coupling feature, engagement wings, and a rear boss feature.

[0038] Optionally, the front portion coupling feature comprises a protrusion extending beyond an upper wear surface opposite the profiled lower engagement surface operable to engage with a complementary recess on a front portion of a wear member.

[0039] Optionally, the front portion coupling feature comprises a recess operable to engage with a complementary protrusion on a front portion of the wear member.

[0040] Optionally, each of the engagement wings comprises a rear facing wall for abutting against a corresponding front facing lateral wall located rearwardly on the wear member, and a downward facing surface aligned with a corresponding upward facing ledge defined by the wear member.

[0041] Optionally, each of the engagement wings tapers towards a front portion of the wear member.

[0042] Optionally, the rear boss feature comprises a rear facing wall for aligning with a front facing lateral wall defining the lock opening on the wear member.

[0043] Optionally, the rear boss feature further com-

prises a tongue extending towards the lock opening and operable to locate beneath a corresponding protruding arm of the spool so that the spool prevents the rear wear cap from moving in the upward direction.

[0044] In another embodiment, a wear assembly for earth working equipment comprises a wear member operable to couple to a digging edge of the earth working equipment, a wear cap configured to mount on the wear member, and a lock that secures the wear member to the digging edge and the wear cap to the wear member.

[0045] In another embodiment, a wear assembly for attaching to a digging edge comprises a wear member including a front end and bifurcated legs extending rearwardly from the front end. Each of the legs includes an inner surface to face the digging edge and a rear wall. At least one of the legs has a lock opening to receive a lock therein. A wear cap is mounted on the wear member. A lock is in the lock opening to retain the wear cap on the wear member and the wear member on the digging edge.

[0046] In another embodiment, a wear assembly for attaching to a digging edge comprises a wear member including a front end and bifurcated legs extending rearwardly from the front end. Each of the legs includes an inner surface to face the digging edge, an outer surface opposite the inner surface, and a rear wall. At least one of the legs including a recess in the outer surface, and at least one of the legs having a lock opening to receive a lock therein. A wear cap is mounted in the recess on the wear member. A lock is in the lock opening to retain the wear member on the digging edge.

[0047] In another embodiment, a wear assembly for earth working equipment comprises a wear member operable to couple to the digging edge of a bucket or other excavator, a wear cap configured to mount on the wear member, and a lock that secures the wear member to the digging edge and also secures the wear cap to the wear member.

[0048] In another embodiment, a wear assembly for earth working equipment includes a wear member having a pair of legs defining a cavity therebetween for receiving a base of the equipment. Each of the legs includes an inside surface to face the base, an opposite outer surface to face away from the base, and a through-hole opening in the inside surface and the outer surface that generally aligns with a keyway in the base. The hole in each leg has a rear end defined by an end surface that extends away from the base. A lock for securing the wear member to the base includes a spool and a wedge. The spool has a rearward-facing bearing surfaces to contact the end surfaces in the holes to resist forward motion of the respective leg during use without including arms on each end of the spool to contact step surfaces between the end surface and the outer surface in each of the legs.

[0049] In another embodiment, a wear assembly for an earth working equipment includes a wear member having at least one leg with an inside surface to face a base of the equipment, and a lock having a wedge and a spool to secure the wear member to a base of the equipment, wherein the wedge includes two threaded tapering portions and a cylindrical portion between the tapering portions.

[0050] According to another embodiment of the present invention, there is provided a wear cap for use with a wear member as part of a wear assembly, the rear wear cap defining an upper wear surface, a profiled lower engagement surface opposite the upper wear surface, and a longitudinally extending opening extending through the upper wear surface and the lower engagement surface, wherein the profiled lower engagement surface comprises a front portion coupling feature, engagement wings, and a rear boss feature.

[0051] Optionally, the front portion coupling feature comprises a protrusion extending beyond the upper wear surface and operable to engage with a complementary formation on a wear member.

[0052] Optionally, the front portion coupling feature comprises a recess operable to engage with a complementary protrusion on a wear member.

[0053] Optionally, the front portion coupling feature is located generally centrally at a front portion of the rear wear cap.

[0054] Optionally, each of the engagement wings comprises a rear facing wall for abutting against a corresponding front facing lateral wall located rearwardly on the wear member.

[0055] Optionally, each of the engagement wings tapers in mutually orthogonal directions towards a front portion of the wear member.

[0056] Optionally, the rear boss feature comprises a rear facing wall for aligning with a front facing lateral wall partially defining the lock opening on the wear member.

[0057] Optionally, the rear boss feature further comprises a tongue extending towards the lock opening and operable to locate beneath a corresponding protruding arm of the spool so that the spool prevents the wear cap from moving in the upward direction.

[0058] In another embodiment, a wear cap for use with a wear member attached to a digging edge of a bucket comprises an upper wear surface, a lower surface opposite the upper wear surface to engage the wear member, an opening extending through the upper wear surface and the lower engagement surface, a front coupling formation to engage the wear member to retain the wear cap on the wear member, and a rear boss to engage a lock to retain the wear cap to the wear member.

[0059] In another embodiment, a wear cap for use with a wear member to protect a rear portion thereof, the wear cap comprising an upper surface, a lower surface, a lock aperture extending through the upper and lower surfaces, a front coupling portion to engage the wear member and thereby retain the wear cap to the wear member.

[0060] In another embodiment, a wear cap for use with a wear member attached to a digging edge comprises an upper wear surface, a lower surface opposite the upper wear surface to engage the wear member, and engagement wings extending inward from the upper wear sur-

face, each including a rear facing bearing wall to engage a complementary front facing lateral wall on the wear member.

[0061] In another embodiment, a wear cap for use with a wear member to protect a rear portion thereof, the wear cap defining an upper surface, a profiled lower engagement surface, and a longitudinally extending opening extending through the upper and lower engagement surfaces, wherein the profiled lower engagement surface includes a front portion coupling formation to engage the wear member and thereby retain the wear cap to the wear member

[0062] According to another embodiment, there is provided a wear cap for use with a wear member to protect a rear portion thereof, the wear cap defining an upper surface, a profiled lower engagement surface, and a longitudinally extending opening extending through the upper and lower engagement surfaces, wherein the profiled lower engagement surface comprises a front portion coupling feature.

[0063] Optionally, the profiled lower engagement surface further comprises engagement wings and a rear boss feature.

[0064] According to another embodiment of the present invention there is provided a wear assembly comprising a wear member for attaching to a digging edge of a bucket, where the digging edge defines a keyway therethrough, and a rear wear cap mechanically attached to the wear member. The wear member comprises a front end and bifurcated legs extending rearwardly from the front end. Each leg includes an inner surface to face the digging edge, a rear wall, and a lock opening therethrough to receive a lock. At least one of the bifurcated legs further comprises a front portion, a rear portion recessed relative to the front portion, and a coupling feature. The rear portion defines a stabilizing region comprising a front facing lateral wall forward of the rear wall. The wear cap comprises a longitudinally extending opening extending therethrough and in registration with the lock opening during use, a front portion coupling feature operable to engage with the coupling feature, and engagement wings operable to engage with the stabilizing region, wherein the wear cap may be mechanically attached to the wear member by a lock used to secure the wear member to the digging edge.

[0065] In another embodiment, a wear assembly for an earth working equipment includes a wear member having at least one leg with an inside surface to face a base of the equipment, a wear cap overlying at least a portion of the wear member, and a lock to secure the wear cap to the wear member and the wear member to the base.

[0066] In another embodiment, a wear assembly for an earth working equipment includes a wear member having a pair of legs, each leg having an inside surface to face a base of the equipment, a first wear cap overlying at least a portion of one of the pair of legs, a second wear cap overlying at least a portion of the other of the pair of legs, and a lock to secure at least one of the wear caps to the wear member and the wear member to the base.

[0067] In another embodiment of the present invention, there is provided a wear assembly comprising: a wear member operable to couple securely to the digging edge of a bucket or other excavator; a component mounted on the wear member; and a lock that secures the wear member to the digging edge and also secures the component to the wear member.

[0068] Optionally, the lock comprises a multi-part lock. The multi-part lock may comprise multiple separate components that can be coupled and uncoupled. Alternatively, the multi-part lock may comprise multiple components that are coupled together but can move relative to each other to increase or decrease one or more external dimensions of the multi-part lock.

[0069] Optionally, the wear member comprises an adapter.

[0070] Optionally, the adapter may define an aperture therethrough for aligning with an aperture defined by the digging edge, and the lock may be mounted in the adapter and digging edge apertures.

[0071] Optionally, the component mounted on the adapter comprises a wear cap such as a rear wear cap.

[0072] Optionally, the wear member comprises a shroud.

[0073] Optionally, the component mounted on the shroud comprises a wear cap.

[0074] Optionally, the component may surround an aperture defined by the wear member.

[0075] According to another embodiment of the present invention there is provided a spool for use in releasably securing separable components together, the separable components defining a lock opening for receiving the spool, the spool having an elongate body extending along a body axis from a head portion to a leg portion, and comprising (i) a concave recess defined by a front side thereof; (ii) a profiled surface on a rear side thereof; (iii) a pair of arms at the head portion and extending away from the body axis on the rear side; and (iv) a pair of shoulders at or near the head portion and extending between the front side and the rear side.

[0076] Optionally, the profiled surface on the rear side includes an angled support located beneath one of the pair of arms, and a bearing surface on the leg portion, for engaging with a digging edge.

[0077] Optionally, the profiled surface on the rear side includes a head rear surface for engaging with a wear member.

[0078] Optionally, the leg portion is substantially free of any protrusions so that the spool can be inserted into the lock aperture without the leg portion catching on a digging edge or a wear member prior to full insertion thereof.

[0079] Optionally, the leg portion includes, at an end opposite the head portion, an arm extending away from the body axis on the rear side for engaging with a complementary recess in, or defined at least partially by, a wear member.

[0080] Optionally, the concave recess on the front side

defines a positive thread for engaging with a complementary recess thread on a wedge.

[0081] Optionally, the concave recess on the front side defines a recess thread for engaging with a complementary positive thread on a wedge.

[0082] Optionally, the concave recess on the front side defines an outer surface generally parallel to the body axis as the concave recess extends towards a lower section of the leg portion. Alternatively, the concave recess on the front side defines an outer surface (i) generally parallel to the body axis for part of its length, (ii) angled towards the body axis for part of its length, and optionally (iii) generally parallel to the body axis for part of its length, as the concave recess extends towards a lower section of the leg portion.

[0083] Optionally, the lower section defines a limit stop extending away from the body axis and protruding into the concave recess to prevent a wedge from protruding beyond the limit stop.

[0084] Optionally, the bearing surface slopes away from the body axis as it extends to an insertion end of the spool.

[0085] Optionally, the pair of shoulders are formed on either side of, and at or above, the lower arm of the pair of arms.

[0086] In another embodiment, a spool for use in releasably securing a wear member to a base for earth working equipment, the wear member and base cooperatively defining a lock opening for receiving the spool, the spool comprising an elongate body extending along a body axis. The body includes a head, a leg extending from the head, a front side, a rear side, and a pair of arms at the end with the head and extending away from the body axis on the rear side.

[0087] According to another embodiment of the present invention there is provided a wedge for use in releasably securing separable components together, the separable components defining a lock opening for receiving the wedge, the wedge comprising: an upper frusto-conical portion, a lower frusto-conical portion, and a central cylindrical portion between the upper and lower frusto-conical portions; the upper and lower frusto-conical portions defining an external thread.

[0088] Optionally, the diameter of the central cylindrical portion matches a diameter of the lowest part of the upper frusto-conical portion, and a diameter of the highest part of the lower frusto-conical portion.

[0089] Optionally, the external thread comprises a negative thread recessed therein.

[0090] Optionally, the frusto-conical portions have the same external surface taper angle.

[0091] Optionally, the cylindrical portion is unthreaded and un-tapered.

[0092] Optionally, a relatively wide, helically shaped land segment is formed between adjacent spiralling groove segments of the external thread.

[0093] Optionally, the helically shaped land segment defines a first bearing face to contact one separable component and an opposite second bearing face to contact the other separable component to thereby resist loading between the wedge and the components.

[0094] In another embodiment, a wedge for use in releasably securing a wear member to a base for earth working equipment, the wear member and the base cooperatively defining a lock opening for receiving the wedge, the wedge comprising an upper frusto-conical portion, a lower frusto-conical portion, and a central cylindrical portion between the upper and lower frusto-conical portions, wherein at least one of the upper and lower frusto-conical portions includes a thread.

[0095] These and other embodiments of the present invention will be apparent from the following description, given by way of example only, with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0096]

FIG. 1 is a perspective view of a wear assembly mounted on a lip, in accordance with one embodiment of the present invention.

FIG. 2 is a perspective partial cross-sectional view taken along line 2-2 in FIG. 1.

FIG. 3 is a perspective exploded view of the wear assembly and lip portion of FIG. 1.

FIG. 4 is a side view of the wear assembly of FIG. 1.

FIG. 5 is a front view of the wear assembly of FIG. 1.

FIG. 6 is a plan view from above of the wear assembly of FIG. 1.

FIG. 7 is a plan view from below of the wear assembly of FIG. 1.

FIG. 8 is a simplified side partial cross-sectional view corresponding to the view shown in FIG. 2 (without any cross hatching).

FIGS. 9A and 9B are simplified views of a part (lip bosses) of the wear assembly of FIG. 1.

FIG. 10 is a front perspective view of a part (a keyway insert) of the wear assembly of FIG. 1.

FIG. 11 is a plan view from above of the keyway insert of FIG. 10.

FIG. 12 is a front elevation view of the keyway insert of FIG. 10.

FIG. 13 is a front perspective view from above of a wear member (in the form of an adapter) forming part of the wear assembly of FIG. 1.

FIG. 14 is a side elevation view of the adapter of FIG. 13.

FIG. 15 is a top plan view of the adapter of FIG. 13.

FIG. 16 is a rear perspective view from below of the adapter of FIG. 13.

FIG. 17 is a rear elevation view of the adapter of FIG. 13.

FIG. 18 is a front elevation view of the adapter of FIG. 13.

FIG. 19 is a rear perspective view from above of the

adapter of FIG. 13.
FIG. 20 is a front perspective view from above of another part (a rear wear cap) of the wear assembly of FIG. 1.
FIG. 21 is a side elevation view of the rear wear cap of FIG. 20.
FIG. 22 is a top plan view of the rear wear cap of FIG. 20.
FIG. 23 is a below plan view of the rear wear cap of FIG. 20.
FIG. 24 is a front elevation view of the rear wear cap of FIG. 20.
FIG. 25 is a rear elevation view of the wear member of FIG. 20.
FIG. 26 is a rear perspective view from above of another part (a spool of a multi-part lock) of the wear assembly of FIG. 1.
FIG. 27 is a front perspective view from above of the spool of FIG. 26.
FIG. 28 is a front elevation view of the spool of FIG. 26.
FIG. 29 is a rear elevation view of the spool of FIG. 26.
FIG. 30 is a rear perspective view from below of the spool of FIG. 26.
FIG. 31 is a side elevation view of the spool of FIG. 26.
FIG. 32 is a plan view from below of the spool of FIG. 26.
FIG. 33 is a plan view from above of the spool of FIG. 26.
FIG. 34 is a front elevation view of another part (a wedge for use with the spool in a multi-part lock) of the wear assembly of FIG. 1.
FIG. 35 is a side elevation view of the wedge of FIG. 34 coupled to the spool of FIG. 26.
FIG. 36 is a plan view from above of the wedge of FIG. 34 coupled to the spool of FIG. 26.
FIG. 37 is a side elevation view of the wedge of FIG. 34 coupled to the spool of FIG. 26 and the keyway insert of FIG. 10.
FIG. 38 is an enlarged view of part of the partial cross-sectional view of the wear assembly shown in FIG. 8 prior to mounting of the rear wear cap of FIG. 20 and insertion of the wedge of FIG. 34.
FIG. 39 is a view similar to FIG. 38 but during mounting of the rear wear cap of FIG. 20 and prior to insertion of the wedge of FIG. 34.
FIG. 40 is a view similar to FIGS. 38 and 39 but after mounting of the rear wear cap of FIG. 20 and prior to insertion of the wedge of FIG. 34.
FIG. 41 is a simplified side view of an enlarged part (illustrated by circle A) of the cross sectional view of FIG. 8 after mounting of the rear wear cap of FIG. 20 and insertion of the wedge of FIG. 34.
FIG. 42 is a front elevation view of a stepped spool as an alternative to the spool of FIGS. 26 to 33.
FIG. 43 is a front perspective view from above of the stepped spool of FIG. 42.
FIG. 44 is a rear perspective view of a stepped keyway insert as an alternative to the a keyway insert of FIGS. 10 to 12.
FIG. 45 is a front elevation view of a stepped wedge as an alternative to the wedge of FIG. 34.
FIG. 46 is a front exploded perspective view from above of the stepped spool of FIG. 43, the stepped wedge of FIG. 45, and the stepped keyway insert of FIG. 44.
FIG. 47 is a rear exploded perspective view from above of the stepped spool of FIG. 43, the stepped wedge of FIG. 45, and the stepped keyway insert of FIG. 44.
FIG. 48 is a side elevation view of the stepped wedge of FIG. 45 coupled to the stepped spool of FIG. 43 and the stepped keyway insert of FIG. 44.
FIG. 49 is a perspective exploded view of the wear assembly, in accordance with yet another embodiment of the present invention, in proximity to a lip portion.
FIG. 50 is a perspective view of the wear assembly of FIG. 49 mounted on the lip portion.
FIG. 51 is a front perspective view of part (a shroud) of the wear assembly of FIG. 49.
FIG. 52 is a plan view from above of the shroud of FIG. 51.
FIG. 53 is a front elevation view of the shroud of FIG. 51.
FIG. 54 is a front perspective view of another part (a wear cap) of the wear assembly of FIG. 49.
FIG. 55 is a plan view from above of the wear cap of FIG. 54.
FIG. 56 is a front elevation view of the wear cap of FIG. 54.
FIG. 57 is a front perspective view of another part (a multi-part lock) of the wear assembly of FIG. 49.
FIG. 58 is a plan view from above of the multi-part lock of FIG. 57.
FIG. 59 is a front elevation view of the multi-part lock of FIG. 57.
FIG. 60 is an exploded front perspective view of the multi-part lock of FIG. 57.
FIG. 61 is a plan view from above of the wear assembly and lip portion of FIG. 50.
FIG. 62 is a front sectional view along line 62-62 of FIG. 61.
FIG. 63 is a simplified, enlarged front sectional view along line 62-62 of FIG. 61 during insertion of the multi-part lock of FIG. 57.

DETAILED DESCRIPTION OF THE INVENTION

[0097] Reference is first made to FIGS. 1 to 8, which show a wear assembly 10 and various parts thereof, according to an embodiment of the present invention. The FIGS. are simplified, and some FIGS. have reduced detail, to facilitate understanding and to prevent the views

from being cluttered.

[0098] In the example of FIGS. 1 to 8, the wear assembly 10 is mounted on a lip 12 of a bucket. Nevertheless, the wear assembly could be mounted to other digging edges and/or other earth working equipment.

[0099] In FIG. 1 three mutually orthogonal axes are illustrated. These axes comprise a longitudinal (forward and rearward) axis (labelled LONG.), a lateral (side to side) axis (labelled LAT.) and a levitational (or up and down) axis (labelled LEV.). As used herein, front and rear are generally used with respect to the longitudinal axis shown in FIG. 1. Likewise, up and down are used to identify directions along the levitational axis, e.g., as when the lip is oriented as in FIG. 1

[0100] The wear assembly 10 comprises a wear member 14 (in the form of an adapter in this embodiment) that mounts onto the lip 12, and a point or tip 16 that is mounted on a front end of the adapter 14. The wear assembly 10 further comprises an optional front wear cap 20, an optional rear wear cap 22, and a lock 24 that secures adapter 14 to the lip 12 and, when a rear wear cap 22 is used, simultaneously secures the wear cap 22 to the adapter 14. While one example wear assembly is shown, teeth having other designs could be used. As examples, an intermediate adapter could be provided, other kinds of locks could be used, etc.

[0101] For ease of discussion, the mounting of an adapter 14 to a lip 12 of a bucket is disclosed herein. Nevertheless, in other embodiments the wear members 14 may be shrouds, wing shrouds, solid points, wear plates, and the like, and the support structures may be digging edges on other equipment such as dredge cutter heads, rolling drums, blades, etc.

[0102] In this embodiment, the lip 12 defines the digging edge of a bucket or dipper of a cable shovel and includes a leading surface 30, an inner face 32 and an outer face 34. A through-hole or keyway 36 (best seen in FIG. 3) is provided in the lip 12 passing through inner face 32 and outer face 34.

[0103] The leading surface 30 is shown as a curved (or semi-circular) surface to accommodate part of the adapter 14, but other configurations are possible. The leading surface 30 may define a protrusion or a recess for engaging with a complementary recess or protrusion (respectively) of the adapter 14.

[0104] While only a small portion of the lip 12 is shown in the drawings, the lip 12 may include a series of through-holes 36 for the mounting of other teeth to the bucket. Various constructions (not shown) could also be provided between through-holes 36 for mounting shrouds. Different shapes and configurations of keyways 36 are also possible. The digging edge may also extend upward from the lip along the front edges of the bucket sidewalls and be fitted with wing shrouds optionally provided with features of the adapter or shroud embodiments disclosed herein.

[0105] The lip 12 further comprises a stabilization system 40. In the illustrated embodiment, the stabilization system 40 comprises an upper support or boss 42a, a lower support or boss 42b, and a keyway insert 44, though other configurations including more or fewer components, and components having different shapes to those illustrated, are possible. Any or all of these components could be omitted.

[0106] The stabilization system 40 increases the strength and/or stability of the wear member 14 on the lip 12, leading to longer service life of the wear member 14 and/or the lip 12 and/or a reduced maintenance requirement on the lip 12.

[0107] In the illustrated embodiment, the upper boss 42a, lower boss 42b, and keyway insert 44 are secured to the bucket lip 12 via welding (labelled "W" in FIGS. 1 to 8).

[0108] In other embodiments, the stabilization system may comprise other components. In one such example, one or more bosses or supports could be provided on the leading surface 30 of the lip 12.

[0109] In the illustrated embodiment, the bosses 42a, 42b are fixed to the lip 12 rearward of and in alignment with the through-hole 36. Preferably, the upper boss 42a is secured to extend along inner face 32 of lip 12 and the lower boss 42b is secured to extend along outer face 34 for each through-hole 36. Nevertheless, a single boss on the inner face 32 (or outer face 34) could be used, or alternatively, the bosses could be omitted. One or more bosses could alternatively or additionally be secured to the lip between the leading surface 30 and through-hole 36. A plurality of spaced bosses or supports could be provided to set outside each adapter leg on one or both sides of the lip in lieu of (or additionally) to central bosses received in the adapter legs 86a, 86b.

[0110] Although the bosses 42a, 42b are preferably welded to the lip 12, they could be formed as an integral portion of the lip 12 or secured in other ways. The bosses 42a, 42b are preferably cast in a harder alloy than the lip 12 to aid in reducing the rate of wear in and maintenance of the lip 12, but various alloys with the same or lesser hardness could be used.

[0111] In this embodiment, the bosses 42a, 42b are identical, but mounted on opposite surfaces 32, 34 of the lip 12 so that they are mirror images of each other; in other embodiments a lower boss, if provided, may have a different configuration to the upper boss.

[0112] Reference will now also be made to FIGS. 9A and 9B, in which each boss 42a, 42b is illustrated having a main body 50 receivable in a slot in the adapter, and a rear member 62 rearward of the adapter.

[0113] In the illustrated embodiment, main body 50 defines a central base 52 and laterally extending flanges or rails 54 along each side of the central base, thereby providing a T-shaped configuration. The rear member 62 includes one or more abutment surfaces 56 for abutting a rear end of the adapter 14 during digging, i.e., to resist the applied loads and rearward shifting of the adapter legs and so reduce the risk of adapter breakage. In FIGS. 1, 3, 4 and 8 the welds are illustrated and labelled with a "W". Each boss 42 may be similar to the bosses described in

U.S. Patent No. 6,986,216, although variations of the design illustrated therein may be used.

[0114] The abutment surface 56 may include one or more inserts 58 for additional hardness and/or other desired property.

[0115] The inner sides of the rails 54 define holding surfaces 60 that generally face the lip 12 to hold the adapter 14 to the lip 12 and/or resist vertical spreading of the adapter legs. The rails 54 are preferably fixed to the abutment surface 56 for support. The rails 54 may have a dovetail or other shape to support adapter legs. Alternatively, the rails may be omitted or replaced with an alternative support.

[0116] Although the bosses 42a, 42b have a one-piece construction in this embodiment, they may be defined by multiple parts coupled together or separately secured to the lip. Further, the main body 50 and/or rear member 62 may be used without the other. In the illustrated example, the rear member 62 is formed as part of its respective boss 42a, 42b, but in other examples the bosses 42a, 42b and rear member 62 may be formed as separate pieces, or all as part of the lip 12, which may be formed by casting or fabrication.

[0117] Reference will now also be made to FIGS. 10 to 12, which show the keyway insert 44 in more detail.

[0118] As best seen in FIG. 10, keyway insert 44 has a generally C-shaped configuration with a central body 70 and an inner arm 72 and an outer arm 74 extending therefrom.

[0119] In the illustrated embodiment, each of the arms 72, 74 includes a central protrusion 72a, 74a extending along its respective arm 72, 74 and defining a recess 72b, 74b on either side thereof to accommodate weld material (as shown in FIG. 3). Inner and outer arms 72, 74 overlie and are welded to the inner and outer faces 32, 34, respectively, of lip 12. Other configurations and/or securing arrangements are possible.

[0120] A rear surface 76 of central body 70 is arcuate to receive the front side of a wedge (described below). While rear surface 76 is preferably unthreaded, it could optionally include threads to engage the wedge in lieu of (or in addition to) the spool 180. Other shapes of rear surface are possible such as non-arcuate concave shapes or flat surfaces (particularly if other kinds of wedges are used such as, e.g., wedges driven by hammers or bolts).

[0121] The keyway insert 44 may have a different shape to that described. For example, a similar shape to that shown in U.S. Patent No. 6,986,216 may be used, or alternative shapes may be used.

[0122] Keyway insert 44 functions to provide a longer and more deformation resistant bearing surface against which a wedge can bear as compared with using just the lip 12 without the keyway 44. The arms 72, 74 may be the same or different lengths to each other, and may include plug welds. The arms 72, 74 may be of one piece construction, or composed of several components (e.g. the outer arm 74 may be composed of two components). The arms 72, 74 may be longer and extend farther from through-hole 36 even up to leading surface 30. With the use of longer arms (or for other reasons), one or both of the arms 72, 74 may be separate components welded to the lip 12 separate from the central body 70.

[0123] The arms 72, 74 optionally provide additional side support for the adapter 14 but could be used to support just the keyway insert 44.

[0124] Referring more particularly to FIGS. 13 to 19, the adapter 14 will now be described. The adapter 14 supports the point 16 and secures it to the lip 12.

[0125] Adapter 14 has a front end 80 and a rear end 82. The front end 80 includes a forwardly projecting nose 84 for mounting the earth-penetrating point 16. A pair of bifurcated legs 86a,b extend rearwardly from the front end 80 in a longitudinal direction and straddle the lip 12. The upper leg 86a is situated to engage the inner face 32 of the lip 12 and the lower leg 86b is situated to engage the outer face 34 of the lip 12.

[0126] Each leg 86a, 86b includes an inner surface 88a, 88b facing the lip 12, and defines a rear wall 90a, 90b. In this embodiment, the legs 86a, 86b are of equal (or approximately equal) length (although in other embodiments the legs 86a, 86b may have different lengths). A slot 92a, 92b is optionally provided in each of legs 86a, 86b to open in the rear wall 90a, 90b and inner surface 88a, 88b to receive a respective boss 42a, 42b.

[0127] An internal lateral wall 94a, 94b projects into the slot 92a, 92b from inner surface 95 (i.e., toward the lip 12) and optionally closes the front of the slots 92a, 92b. The slots are each dimensioned and shaped to receive the flanges 54 of the upper (inner) and lower (outer) bosses 42a, 42b, respectively. That is, in the illustrated embodiment, the sides of the slots 92a, 92b are provided with grooves to receive the rails on the sides of the bosses 42a, 42b. Each of the inner lateral walls 94a, 94b are axially spaced from the respective boss 42a, 42b, but could alternatively abut the boss to provide resistance to thrust loads. Each respective slot 92a, 92b cooperates with the received boss 42a, 42b to provide support to the respective adapter leg to resist shifting of the leg in side and/or upward/downward directions.

[0128] Each of the legs 86a, 86b includes a pair of opposite side surfaces 96a, 96b extending longitudinally from near the nose 84 to the rear wall 90a, 90b. The legs 86a, 86b are connected via a central portion 140 extending rearward from the front end 80 and have a rearward facing bearing surface 142. The front portion 144 of side surfaces 96a, 96b connects legs 86a, 86b. The pair of opposed side surfaces 96a, 96b may be bounded by one or more support (not shown) welded on or otherwise fixed to the lip 12 adjacent each side surface 96a, 96b. These exterior supports (not shown) could be in lieu of internal supports 42a, 42b and/or 72, 74.

[0129] The bearing surface 142 abuts against the lip leading surface 30 when the adapter 14 is mounted thereon. In the illustrated embodiment, bearing surface 142 is curved to complement the curved leading surface

30. It will be appreciated that various designs of leading surfaces on the lip 12 and a complementary bearing surface 142 on the adapter 14 are possible. The above is merely given by way of example. For example, the leading surface 30 may define a protrusion or a recess for engaging with a complementary recess or protrusion (respectively) of the adapter 14. As another example, the leading surface 30 and bearing surface 142 could each be angular or have a non-uniform curve.

[0130] The lower leg 86b defines an external lower surface 98 extending from a rear portion of the nose 84 to the rear end 82.

[0131] The upper leg 86a defines an external upper surface 100 extending from a rear portion of the nose 84 to the rear end 82, and having a front portion 102 and a rear portion 104. In the illustrated embodiment, rear portion 104 is recessed relative to the front portion 102 but it need not be. The rear portion 104 has an outer surface 105. The front portion 102 defines a rearward facing lateral wall 106 (best seen in FIG. 19) adjacent the rear portion 104 to define the front of the recessed rear portion 104.

[0132] In the illustrated embodiment, the rearward facing lateral wall 106 has a general C-shape when viewed from above, defining a central portion 107a generally parallel to the upper leg rear wall 90a and side portions 107b, each side portion 107b extending from the central portion 107a towards its respective upper opposed side portion 96a and the upper leg rear wall 90a. Other configurations of the rearward facing lateral wall 106 are also possible.

[0133] The upper leg 86a (in this embodiment, the rear portion 104) defines a lock opening 112. In the illustrated embodiment, lock opening 112 is elongated and includes a narrowed front portion 110 and a narrowed rear portion 114 (best seen in FIGS. 15 and 19), though other shapes are possible. In this embodiment, lock opening 112 is located in the rear portion, but it could be in both front and rear portions or only in the front portion.

[0134] The rear facing lateral wall 106 includes a projection 117 defining a retaining surface 118 on an underside thereof. In the illustrated embodiment, projection 117 is one the narrowed front portion 110. Retaining surface 118 acts as a coupling formation to retain a wear cap 22 to wear member 14.

[0135] In this embodiment, the retaining surface 118 overlies a coupling portion 163 on the wear cap 22 (described in more detail below). In the illustrated embodiment, coupling portion 163 is formed on a forwardly-extending tongue 163, but other embodiments are possible. For example, the projection 117 may be formed as a tongue with a retaining surface 118 for overlying an upward-facing surface of the rear wear cap 22. A plurality of retaining surfaces 118 could be provided on the adapter to retain the wear cap to the adapter. The retaining surface(s) 118 could be positioned at other locations besides the front end of the wear cap.

[0136] The retaining surface(s) 118 could optionally be biased (e.g., by an elastomer) to retract during installation of the wear cap and return to a retaining position when the wear cap is positioned in an installed position. Alternatively, the wear cap could include biased a coupling portion(s) that retracts during installation and returns to a retaining position beneath a retaining surface on the adapter when the wear cap is in an installed position. While in the illustrated embodiment, retaining surface(s) 118 cooperate with the lock to retain the wear cap 22 to wear member 14 (described below), retaining surface(s) 118 could retain the wear cap without use of the lock.

[0137] A step portion 125 of adapter 14 defines shelf 120 that is recessed from the rear portion outer surface 105. The shelf 120 defines a concave front facing surface 122 forming a bearing surface; other shapes are possible. The shelf 120 extends forward into the lock opening 108. A front facing central lateral wall 124 extends from the shelf 120 to the rear portion outer surface 105. The space defined by shelf 120 and lateral wall 124 receives the coupling portion 163 of wear cap 22.

[0138] A lower portion of the longitudinally extending lock opening 112 defines a pair of optional ledges 126 (best seen in FIGS. 13 and 15), each on an opposing longitudinal side thereof, extending from the concave front facing surface 122 towards the narrowed front portion 110. As described in more detail below, the ledges 126 prevent the spool 180 of lock 24 from falling through the lock opening 112.

[0139] The central portion of lock opening 112 is similarly dimensioned to, and is in registration with, the through-hole 36 in the lip 12, and a lock opening 128 defined by the lower leg 86b, to allow the lock 24 to fit therethrough, as described in more detail below.

[0140] The lower leg lock opening 128 is partially defined by a lateral wall 129 (forming a bearing surface) located at a rear end thereof (best seen in FIG. 13). The lateral wall 129 extends from the lower leg inner surface 95 to the lower leg external lower surface 98, though other arrangements are possible. For example, bearing surface 129 may extend only partially through lock opening 128. In another example, lock opening may could be closed at its lower end.

[0141] The upper surface rear portion 104 defines a stabilizing formation 130 near the rear end 82 including a front facing bearing wall 132 to resist rearward movement of the wear cap 22. In the illustrated embodiment, the stabilizing formation comprises a pair of indentations 130, each recessed relative to its respective upper opposed side surface 96a and rear portion outer surface 105. As best seen in FIGS. 13 and 14, each indentation 130 includes (i) a front facing bearing wall 132, (ii) a curved upward facing surface 134 rising from the front facing bearing wall 132 towards the front portion 102 and merging with the rear portion outer surface 105, and (iii) a longitudinal wall 136 extending between the curved upward facing surface 134 and the rear portion outer surface 105, and tapering towards the front portion 102.

Each indentation 130 is located rearward of the front portion 102 and forward of the upper leg rear wall 90a.

[0142] In other embodiments, the indentations 130 may have a different shape, or a different location, or the stabilizing formations may comprise protrusions rather than recesses. In other embodiments, the rear portion 104 may not be recessed relative to the front portion 102. In other embodiments, the front facing bearing wall(s) can be provided otherwise. In one example, front facing lateral wall 124 could resist rearward movement of the wear cap 22. In another example, a front facing lateral wall could be provided at the rear end of the wear cap 22 (not shown).

[0143] In the illustrated embodiment, a groove 131 extends along each of the outer sides of upper surface 100 of adapter leg 86a between the rear wall 90a and the respective indentation 130 to receive the sidewalls 171 of wear cap 22 to resist side loads on the wear cap. Alternatively, grooves 131 could be omitted such that sidewalls 171 extend along side surfaces 96a of leg 86a. Support for wear cap 22 to resist side loads could be otherwise provided.

[0144] In the illustrated embodiment, wear cap 22 is captured and retained against upward movement by retaining surface 118 of wear member 14 at a forward portion of wear cap 22 and by a retaining surface 194 of lock 24 at a rearward portion of the wear cap (as described below). The wear cap 22 is preferably not held tightly against the wear member by retaining surfaces 118, 194.

[0145] The wear cap 22 will now be described in more detail with reference to FIGS. 20 to 25. The wear cap 22 is formed from steel or other hard material, preferably harder than the material comprising the adapter 14. Wear cap 22 could optionally be formed as a composite member with an outer wear resistant surface.

[0146] The rear wear cap 22 is configured to mount on the rear portion 104 of the adapter 14 to provide protection against wear, but could be mounted at other locations in lieu of or in addition to on rear portion 104, e.g., on front portion 102 and/or lower leg 86b. In the illustrated embodiment, the upper wear surface 150 of the wear cap is aligned with or recessed from the outer surface of the front portion to minimize additional loading and/or wearing of the wear cap 22. Nevertheless, the rear portion 104 need not be recessed. For example, the rear portion could have the same extension as front portion 102 (or raised above front portion) with the wear cap set over adapter leg 86a.

[0147] The rear wear cap 22 preferably has a generally C-shaped configuration with a central wear panel to overlie a top of adapter leg 86a and opposite sidewalls 171 to extend along the sides of leg 86a and fit in grooves 131. The bottom ends of sidewalls 171 are preferably spaced from adapter 14, but could alternatively engage the adapter. Sidewalls 171 could be omitted and side support otherwise provided such as by the sides of the wear cap. In the illustrated embodiment, wear cap 22 comprises an upper wear surface 150, a profiled lower engagement surface 152 facing leg 86a, an opening 154 extending through the upper wear surface 150 and the lower engagement surface 152, a front coupling portion 156, engagement wings 158, and a rear coupling portion 160 (best seen in FIG. 25). In other embodiments, wear cap 22 may have different configurations.

[0148] In this embodiment, the front coupling portion 156 comprises a front facing wall 161 having a protrusion or tongue 163 at a lower portion thereof and extending forwards of the front facing wall 161 and beyond the upper wear surface 150. The coupling portion 156 is configured to engage with a complementary coupling formation (e.g., projection 117) on the adapter 14. The protrusion 156 may be located generally centrally on the rear wear cap 22 (when viewed from above or below, i.e. generally central in a lateral direction).

[0149] In other embodiments, the projection 156 may be split into two or more forward protrusions. In other embodiments, the front portion coupling portion may comprise a recess operable to engage with a complementary protrusion on the adapter. In other embodiments, the coupling portion may be a portion of the wear surface 150 over which retaining surface 118 extends.

[0150] Each of the engagement wings 158 extends down from sidewalls 171 and is complementarily received in a respective indentation 130 on the adapter 14. Each engagement wing 158 comprises a rear facing bearing wall 162 for abutting the corresponding front facing bearing wall 132 to resist rearward movement of the wear cap. Each engagement wing 158 also includes a downward facing surface 164 that opposes the corresponding upward facing surface 134. In the illustrated embodiment, downward facing surface 164 is spaced from upward facing surface 134, though they could contact. Each of the engagement wings 158 tapers both laterally (towards the respective side 136) and upwardly (towards the upper wear surface 150 of the rear wear cap 22) as the engagement wing 158 extends towards the front wall 168. Other shapes are possible. Alternatively, engagement wings 158 could be recesses in sidewalls 171 that receive complementary projections on the adapter.

[0151] In the illustrated embodiment, the upper wear surface 150 extends from a rear wall 166 extending the full width of the wear cap 22 to a front wall 168 having a general C-shape, complementary to the C-shape profile of the rearward facing lateral wall 106. That is, the front wall 168 comprises a narrowed central portion 169a and side portions 169b extending from either side 171 of the wear cap 22 to the narrowed central portion 169a. The front wall 168 has a complementary shape to the rearward facing lateral wall 106. The front and rear edges of wear cap 22, though, could have other shapes.

[0152] The rear coupling portion 160, in the illustrated embodiment, includes a boss extending downward from upper wear surface 150 to set on or oppose shelf 120. Boss 160 has a forwardly extending tongue 172 to be

retained by lock 24, and a generally central, rear facing wall 170 opposing the front facing central lateral wall 124 (best seen FIGS. 8 and 40). The tongue 172 is configured to locate beneath a corresponding retaining surface 194 of lock 24 (described in more detail below) so that the lock resists the wear cap 22 from moving in the upward direction away from the wear member.

[0153] The rear wear cap 22 further comprises a front facing wall 174 extending from an upper surface of the tongue 172 to the upper wear surface 150.

[0154] The rear boss feature 160 further comprises side walls 176 extending from opposing sides of the rear facing wall 170 to the forward facing tongue 172.

[0155] In the illustrated embodiment, lock 24 includes a spool 180 and wedge 240. Reference is now made to FIGS. 26 to 33, which illustrate part of the multi-part lock 24, namely a spool 180, in more detail.

[0156] The spool 180 comprises an elongate body 182 defining a body axis 184, and having a head 186 and a leg 188 extending from the head generally along the body axis 184. When viewed from the front or rear, the body axis 184 is aligned with a vertical axis 185 (the levitational axis in FIG. 1), but when viewed from either side, the body axis 184 is offset from the vertical axis 185 by a small angle with the bottom end of leg 188 forward of head 186. The small angle may be between 2 degrees and 10 degrees from the vertical. Other offset angles are possible (larger or smaller), or the body axis may be vertical (i.e. without any appreciable offset).

[0157] The head 186 optionally protrudes beyond the leg 188 in the lateral direction (labelled "LAT." in FIG. 28 (showing the front side of the spool 180) and FIG. 29 (showing the rear side of the spool 180)) and forms a pair of shoulders 190, each having a similar dimension (and preferably a complementary formation) to each of the ledges 126 of the adapter 14. In other embodiments, the surface of the shoulder 190 may not be complementary to the surface of the respective extended slot ledge 126. Different configurations are also possible. The shoulders 190 may also be omitted.

[0158] Spool 180 preferably includes two arms 192, 196 to capture a portion of the wear cap 22 and a portion of the wear member 14. Nevertheless, one retaining surface 194 such as one upper arm 192 could be used to retain the wear cap. Both arms could be omitted, e.g., if the retaining surface 194 is formed in a recess in the spool to receive a portion of the wear cap or if the wear cap is retained by other retaining surfaces on the adapter without the cooperation of the lock.

[0159] In the illustrated embodiment, the wear cap is retained to the wear member by at least one retaining surface 118 on the wear member and at least one retaining surface 194 on the lock. Nevertheless, the wear cap could be retained by at least one retaining surface only on the adapter or at least one retaining surface only on the lock.

[0160] In the illustrated embodiment, the head 186 defines an upper arm 192 at an upper portion thereof. The upper arm 192 extends rearward in a longitudinal direction (labelled "LONG." in FIG. 31). While the rear end 195 of upper arm 192 is shown as having a convex profile when viewed from above or below, it could have any shape. The upper arm 192 defines a retaining surface 194 on a lower portion thereof to overlie tongue 172 and retain wear cap 22 on adapter 14.

[0161] In the illustrated embodiment, the leg 188 defines a lower arm 196 at an upper portion thereof. Nevertheless, arm 196 could be provided on the head 186. The lower arm 196 extends in the same longitudinal direction as the upper arm 192, and also has a convex end surface 199 when viewed from above or below but could have any shape. The lower arm 196 defines an engagement surface 198 on an upper portion thereof. The retaining surface 194 and engagement surface 198 are optionally parallel to each other and are of similar dimensions. The lower arm engagement surface 198 is at approximately the same height as the shoulders 190. The lower arm 196 also defines, lower in this embodiment, angled lower surface 200 that opposes lip 12. Regardless of the particular shapes, spool arms 192, 196 receive and capture tongue 172 of wear cap 22 and step portion 125 of adapter 14. In embodiments where a rear wear cap is not used, the step portion 125 of the adapter can fill the space between upper arm 192 to lower arm 196 of spool 180. In such an arrangement, the step portion may be enlarged and/or the gap between the spool arms reduced. Other arrangements without a rear wear cap are possible including, for example, a spacer used in place of the wear cap, a gap existing between the step portion and one or both spool arms, the elimination of one or more spool arms, etc.

[0162] The upper and lower arms 192, 196 preferably extend generally perpendicular to the vertical axis 185, though other extensions are possible.

[0163] The head 186 defines a rear surface 201 having a slightly convex profile (but other shapes, such as a planar surface, are possible) and extending between the upper arm 192 and the lower arm 196. When mounted on the adapter 14, the rear surface 201 engages with the step portion 125 of the adapter 14 to resist forward movement of the adapter 14 from lip 12. Rear surface 201 also opposes the front end of tongue 172 of the rear wear cap 22 (best seen in FIGS. 8 and 40). Rear surface 201 of spool 180 is preferably spaced from tongue 172, but contact could be made.

[0164] Side surfaces 202 of the leg 188 extend generally parallel to the body axis 184 (and the vertical axis 185) for the length of the leg 188.

[0165] A rear surface 204 (best seen in FIG. 29) of the leg 188 extends generally parallel to the body axis 184 (which is longitudinally offset from vertical) along a middle section 206 of spool 180, extending from a lower part of the lower arm 196 to a lower section 208. In this embodiment, both the middle section 206 and lower section 208 of the rear surface 204 define slightly convex surfaces, but other surface profiles are possible. The lower section

208 defines a bearing surface 210 to contact lower leg 86b.

[0166] In the illustrated embodiment, the bearing surface 210 slopes rearwardly from a lower part of the middle section 206 to a foot 212 of the spool 180 and is generally parallel to the vertical axis 185.

[0167] In this embodiment, the head 186 and leg 188 have a single (unitary) construction, but in other embodiments, they may be separate parts that are coupled together. Other shapes of spool 180 are possible.

[0168] A front surface 214 of the spool 180 preferably extends generally parallel to the body axis 184 (which is longitudinally offset from the vertical axis 185) from a top 216 of the spool 180 to a bevel portion 218 near the bottom of the leg 188. The bevel portion 218 slopes rearwards and extends to the foot 212 at the bottom of the leg 188.

[0169] The junction of the bevel portion 218 and the foot 212 is on or near the body axis 184 (although in other embodiments this may not be the case).

[0170] In the illustrated embodiment, the front surface 214 defines an arcuate, concave recess 220 extending from the top 216 towards, and then partially beyond the start of, the bevel portion 218. A positive screw thread 222 formed of spaced helical ridges is provided on the arcuate recess 220, extending from a lower part of the head 186 to above the bevel portion 218, though other thread formations are possible. An optional screw thread stop 224 is provided at the lowest part of the positive screw thread 222 to prevent a wedge (described in more detail below) from being screwed beyond the stop 224. Front surface 214 could have other configurations to complement other kinds of wedges or other drivers.

[0171] In this embodiment, the middle and lower sections 206, 208 of the leg 188 are free of any lateral or longitudinal protrusions. This has the advantage that the leg 188 can be easily inserted into the longitudinally extending opening 154 in the rear wear cap 22, the lock opening 112 of the adapter upper leg 86a, the through-hole 36 of the lip 12, and the lock opening 128 of the adapter lower leg 86b, as will be described in more detail below. Also as described below, the wear cap 22 may be installed after insertion of spool 180.

[0172] However, in other embodiments, it may be desirable to add a lower arm (not shown) at or near either the lower part of the middle section 206 or an upper part of the lower section 208. This lower arm could help resist forces on the adapter 14 by engaging with (coupling to) the outer face 34 of the lip 12 or a feature defined by the adapter lower leg 86b.

[0173] Reference is now also made to FIGS. 34 to 38, which illustrate, *inter alia,* the other part of the 24 of this embodiment, namely a wedge 240, in more detail.

[0174] The wedge 240 comprises a cylindrical portion 246 having an external surface taper angle 248, which in this embodiment is approximately 3 degrees (although a smaller or larger taper angle is possible) relative to the vertical axis 185. The taper angle 248 is illustrated in FIG. 34 using a vertical broken line 252.

[0175] The cylindrical portion 246 defines an external negative thread (in the form of a helical groove having a relatively wide pitch) 254 recessed therein, though other thread formations could be used.

[0176] A relatively wide, helically shaped land segment 256 is formed between adjacent spiralling groove segments of the negative thread 254.

[0177] In one embodiment, the pitch of the thread 254 on the wedge 240 is approximately one inch (25mm) and the width of the thread is approximately ⅛ of an inch (3mm), although the pitch and width could be selected from a range of suitable values. The thread 254 is preferably formed with curved corners to form a robust thread that is not susceptible to peening or other damage. The upper (or rear) end 258 of the wedge 240 defines a turning formation 260 recessed therein to facilitate engagement with a tool, such as a wrench, for turning the wedge 240. In the preferred embodiment, formation 260 is a square socket, although other arrangements could be used.

[0178] The taper angle 248 can be selected to provide a desired take-up of the adapter 14 on the support structure, e.g., the lip 12. For example, if the taper angle 248 is increased, the rate at which the adapter 14 moves to the set position on the support structure is increased, but at the expense of tightening force (i.e., more torque is required to turn the wedge 240); conversely, if the taper angle 248 is decreased, the rate at which the adapter 14 moves to the set position on the support structure is decreased, but the tightening force is reduced. The taper angle 248 can be designed to match the particular task. In most cases, it is expected that the holding power of the lock 24 would be approximately the same provided the wedge 240 is not formed with too small a diameter at the forward (or lower) end 262 to provide sufficient strength.

[0179] As best seen in FIG. 37, which shows the wedge 240 received into the recess on the keyway insert 44 and into the recess 220 in the spool 180 and screwed into the thread 222 on the spool. The land segment 256 (between adjacent portions of the thread 248) provides a large surface area to press against both the rear surface 76 of the keyway insert 44 and the front surface 214 of the spool 180. The relatively large land segment 256 enables the lock 24 (comprising the spool 180 and wedge 240) to resist large loads with acceptable levels of stress and without the need for threads to be formed in a wall of the keyway 36 of the lip 12. The relatively wide pitch of the thread 254 also permits the wedge 240 to be quickly moved into and out of the spool 180.

[0180] Installation of the wear assembly 10 will now be described with particular reference to FIGS. 38 to 40, which show a small portion of the wear assembly 10 in enlarged view prior to mounting of the rear wear cap 22, during mounting of the rear wear cap 22, and after mounting the rear wear cap 22, respectively. FIG. 41 illustrates in enlarged detail a part of the wear assembly 10 of FIG. 8 once the lock 24 has been fully installed.

[0181] To mount the adapter 14, it is rearwardly slid onto the lip 12 with the upper leg 86a above the inner face 32 and the lower leg 86b below the outer face 34 so that the upper leg slot 92a slidingly engages with the upper boss 42a such that the slot 92a encloses the flanges 54 of the upper boss 42a. Similarly, the lower leg slot 92b slidingly engages with the lower boss 42b such that the slot 92b encloses the flanges 54 of the lower boss 42b.

[0182] When mounted in this way, the adapter 14 is positioned at the correct location on the lip 12, with the upper leg lock opening 112 is in registration with the lip through-hole (or keyway) 36 and the lower leg lock opening 128.

[0183] Once the adapter 14 is correctly positioned, the spool 180 is inserted (with the foot 212 and the bevel portion 218 as the leading surfaces) into the lock opening 112, the lip through-hole (or keyway) 36, and the lower leg lock opening 128. At this point, shoulders 190 of the spool 180 rest on the extended ledges 126 of the adapter 14, thereby preventing the spool 180 falling through the upper leg lock opening 112.

[0184] By moving the spool 180 forwards (in the direction of arrow C in FIG. 39), the wear cap 22 can be mounted on the adapter 14 by moving the wear cap 22 downwards (in the direction of arrow B in FIG. 38) and pivoting the front portion coupling structure 156 downwards and engaging it beneath the retaining surface 118 of the adapter 14. The rear wall 166 of the wear cap 22 can then be lowered towards the adapter 14 so that profiled lower engagement surface 152 of the wear cap 22 sets over the rear portion 104 of the upper surface 100. In particular, the forward facing tongue 172 sets on or over the shelf 120 of the adapter 14, the wear panel of wear cap sets on outer surface 105 of rear portion 104, and the rear facing walls 162 of the engagement wings 158 oppose the front facing bearing walls 132 of the indentations 130 of the adapter 14.

[0185] The downward facing surfaces 164 of the engagement wings 158 are position in proximity to the upward facing ledges 134 of the adapter 14, but they may remain spaced apart. The rear facing wall 170 of the wear cap 22 are also in proximity to the front facing central lateral wall 124, but may remain spaced apart.

[0186] The spool 180 can then be moved rearwards (in the direction of arrow D in FIG. 40), so that the following occurs: (i) the upper arm 192 and the lower arm 196 capture tongue 172 of wear cap 22 and step portion 125 of adapter 14 between them such that the retaining surface 194 of the upper arm 192 slides over, and remains above, the forward facing tongue 172 (of rear boss feature 160) of the rear wear cap 22; (ii) the rear surface 201 of the head of spool 180 abuts against the front-facing surface 122 of step portion 125 of adapter 14; (iii) the engagement surface 198 of the lower arm 196 slides under, and remains beneath, the step portion 125 of the adapter 14; and (iv) the bearing surface 210 of spool leg 188 abuts against, or is in proximity to, a forward facing portion of the lower leg 86b defining the lock opening 128.

[0187] It may be preferred to mount the wear cap 22 prior to inserting the spool 180. In such a case, the spool 180 is inserted through the longitudinally extending opening 154 in the wear cap 22, the lock opening 112, the lip through-hole (or keyway) 36, and the lower leg lock opening 128. Regardless of whether the spool 180 is inserted prior to or after the wear cap 22 is mounted, the remaining arrangement of the parts is the same.

[0188] The wedge 240 is inserted through the opening 154 in the wear cap 22. A wrench (or other convenient tool) is used to engage the turning formation 260 and to rotate the wedge 240 so that the thread 254 on the wedge engages with the complementary threads 222 on the spool 180. As the leading end 262 of the wedge 240 moves towards the thread stop 224, the wedge 240 urges the spool 180 rearwards. The screwing of the wedge continues until the wedge 240 tightens to a set level of torque with rear surface 201 of spool 180 pressed against front wall 122 of step portion 125 of adapter 14, and rear surface 210 of spool 180 pressed against front facing wall of lock opening in lower leg 86b. Nevertheless, it is possible when assembled that one of the rear surfaces 201 or 210 could remain spaced from its complementary bearing surface on the adapter and contact when loads are applied to the adapter and/or wear occurs.

[0189] As best seen in FIG. 41, insertion of the wedge 240 ensures that the rear wear cap 22 is retained on the adapter 14, and simultaneously ensures that the adapter 14 is retained on the digging edge 12. That is, tongue 163 sets under the retaining surface 118 on adapter 14 and tongue 172 sets underneath retaining surface 194 on lock 24 (i.e., the arm 192 of spool 180) to resist upward movement of the retainer away from the adapter (along the levitational axis). Since the wear cap is preferably not tightly held in place, the wear cap may rattle somewhat between the wear member and lock surfaces that contain the wear cap.

[0190] In the illustrated embodiment, lateral forces on the wear cap are primarily resisted by the inner surfaces of arms 171 bearing against the vertical walls of grooves 131 in the adapter.

[0191] To remove the adapter 14, the wedge 240 is turned counter-clockwise to drive the wedge 240 upward so that it can be lifted out of the wear assembly 10. The spool 180 is then moved forwards (in the direction of arrow C in FIG. 39) so that the upper and lower arms 192, 196 disengage from the tongue 172 of the rear wear cap 22 and the upper leg 86a of the adapter 14. The rear wear cap 22 can then be pivoted upwards and removed from the wear assembly 10, in the reverse process to that described with reference to FIGS. 38 to 40.

[0192] The spool 180 can then be removed from the wear assembly 10, and the adapter 14 can then be pulled from the lip 12.

[0193] The front wear cap 20, if used, can be mounted and removed in a conventional manner.

[0194] An alternative embodiment of the lock 324 will

now be described with reference to FIGS. 42 to 48.

[0195] FIG. 42 is a front elevation view of a stepped spool 280 as an alternative to the spool 180. The primary difference between the spool 180 and the stepped spool 280 is that the stepped spool 280 has an arcuate recess 320 on a front side comprising (i) a first portion 320a extending generally parallel to the body axis 184 for part of its length, (ii) a second portion 320b angled towards the body axis 184 for part of its length, and (iii) a third portion 320c extending generally parallel to the body axis 184 for part of its length, as the arcuate recess 320 extends towards the lower section 208 of the leg 188. In contrast, the arcuate recess 220 on the spool 180 is generally parallel to the body axis 184 along its length.

[0196] In embodiments where the stepped spool 280 is used, it is preferred to have a stepped keyway insert 344, as illustrated in FIG. 44.

[0197] The primary difference between the keyway insert 44 and the stepped keyway insert 344 is that the stepped keyway insert 344 has a rear surface 376 comprising (i) a first portion 376a extending generally parallel to the body axis 184 for part of its length, (ii) a second portion 376b angled towards the body axis 184 for part of its length, and (iii) a third portion 376c extending generally parallel to the body axis 184 for part of its length. In contrast, the keyway insert rear surface 76 is generally parallel to the body axis 184 along its length.

[0198] The stepped spool 280 and stepped keyway insert 344 are preferably used with a stepped wedge 340, as illustrated in FIG. 45.

[0199] The primary difference between the wedge 240 and the stepped wedge 340 is that the stepped wedge 340 comprises an upper frusto-conical portion 342, a lower frusto-conical portion 344, and a central cylindrical (or other shaped) portion 346 between the upper and lower frusto-conical portions 342, 344. The diameter of the central cylindrical portion 346 matches the diameter of the lowest part of the upper frusto-conical portion 342, and the highest part of the lower frusto-conical portion 344. The frusto-conical portions 342, 344 have the same external surface taper angle 348, which in this embodiment is approximately 5 degrees (although a smaller or larger taper angle is possible) relative to the vertical axis 185. The taper angle 348 is illustrated in FIG. 45 using a vertical broken line 352.

[0200] In a similar way to wedge 240, the external negative thread (in the form of a helical groove having a relatively wide pitch in this example) 254 extends substantially for the entire length of the stepped wedge 340, though other kinds of thread could be used. The thread continues from the upper frusto-conical portion 342, across the cylindrical portion 346 (also referred to as a step portion), and then along the lower frusto-conical portion 344. However, in other embodiments, the cylindrical portion 346 may be unthreaded. In another embodiment, only one of the frusto-conical portions of the wedge could be threaded. In another embodiment, the central portion does not contact the spool 280 and/or the front support 344. Having the cylindrical portion 346 allows a wider taper (a larger taper angle 348) on the frusto-conical portions 342, 344 without reducing the diameter of the wedge 340, which could lead to an increased risk of the wedge 340 breaking during use.

[0201] When the lock 324 is assembled, as shown in FIG. 48, the upper frusto-conical portion 342 of the wedge 340 aligns with both the first portion 320a of the spool 280 (on the rear side), and the first portion 376a of the stepped keyway insert 344 (on the front side). Similarly, the lower frusto-conical portion 344 of the wedge 340 aligns with both the third portion 320c of the spool 280 (on the rear side), and the third portion 376c of the stepped keyway insert 344 (on the front side). The central cylindrical portion 346 of the wedge 340 aligns with both the second portion 320b of the spool 280 (on the rear side), and the second portion 376b of the stepped keyway insert 344 (on the front side).

[0202] Providing the wedge with complementary stepped components allows for more take up and/or more securely holding the adapter 14 to the lip 12.

[0203] Locks 24, 324 have a number of advantages. For example, lock 24, 324 directly retains two components (the wear member 14 and the rear wear cap 22), whereas prior art locks directly retain one of the wear member or wear cap. The lock 24, 324 provides retention in two orthogonal directions, i.e., it holds the wear member 14 back into the digging edge 12, and it holds wear cap 22 from moving up from the wear member 14.

[0204] The lock 24, 324 is only required to hold the rearward portion of the wear cap 22 vertically downwards, all other loads are directed to stabilizing surfaces. The lock 24, 324 is isolated from loads applied to the rear wear cap 22. Failure of the rear wear cap 22 will not jeopardize the primary function of the lock 24, 324 to secure the adapter 14 to the lip 12.

[0205] The method of installation for the disclosed embodiments is to pivot (or rotate) the wear cap 22 into place (compared with prior art wear caps that require linear installation, i.e., with wear cap rails being moved through grooves on the adapter). The rear wear cap 22 is removed in a direction orthogonal to material flow (vertically up), which means that the rear wear cap 22 rotates / pivots then pulls straight away from the adapter 14 (and any fines therebetween or thereon) instead of sliding on a rail.

[0206] The lock 24, 324 retains the rear wear cap 22 in a direction orthogonal to material flow. The multi-part lock 24, 324 has stabilizing features which prevent excess migration of any part of the lock 24, 324 if the rear wear cap 22 is lost.

[0207] Other advantages of this embodiment relate to the spool 180, 280. The spool 180, 280 only requires arms at the upper end of the spool. Any engagement on adapter lower leg 86b is limited for rearward longitudinal force (into the bucket) and forward motion of the adapter lower leg 86b. The spool 180, 280 has features (e.g., shoulders 190) that prevent it from falling through the

adapter 14 during installation and removal. The spool 180 is retained in a way that allows it to slide longitudinally forward, thereby releasing the rear wear cap 22.

[0208] The lock 24, 324 installs and removes from the upper side of the lip 12 only, and it will not fall through to the underside of the bucket. This improves safety of personnel in installing and, particularly, removing the adapter 14. Convenient sliding of spool 180, 280 after removal of the wedge 240, 340 allows the rear wear cap 22 to be changed without removal of the spool 180, 280. Vertical retention features are only provided on the adapter upper leg 86a. There is no need to pry the bottom of the spool 180, 280 rearward to release engagement with adapter 14. There are fewer system components, and a simpler installation and removal process, compared with having a dedicated lock for the rear wear cap 22. The lock 24, 324 may be usable in multiple GET configurations (for example, with or without a rear wear cap 22).

[0209] Other lock arrangements may be used than the ones described above. For example, a similar design of wedge and spool arrangement to that shown in U.S. Patent No. 6,986,216 may be used, or alternative designs may be used. Wedges driven by a hammer, bolts or other arrangements could be used instead of a threaded wedge and spool. Other locks without a wedge or spool could be used. The lock may comprise one or more than two components.

[0210] The design of the above embodiment has various manufacturing benefits including, for example, reduced fit requirements for the adapter lock combination. Fit areas are more localized in the upper leg 86a of the adapter 14 (rather than both the upper and lower legs 86a, 86b). The spool fit does not span the adapter legs 86a, 86b. A simplified lower leg 86b design provides more options for manufacturing.

[0211] The design of wedge 340 has a dramatically increased take-up / taper angle, made possible by a step between the tapered portions. This step allows for a large taper angle while retaining an acceptable diameter at both the top and bottom of the wedge 340. By tapering only the surfaces that contact the other components (keyway insert 344 and spool 280) the total height range and strength of the lock 324 can be maximized. The take-up may be double that of prior art wedges.

[0212] Another embodiment of the present invention will now be described with reference to FIGS. 49 to 63 which illustrate a wear assembly 410 mounted on a conventional lip 412 of a bucket (not shown). In this embodiment, the lip 412 is of a type that does not define an aperture through which a wear member couples to the lip 412. The lip 412 comprises a series of spaced bases 417 (only one is illustrated in FIG.49); typically each base 417 is provided between adjacent noses for supporting teeth. Each base 417 is configured to accommodate a wear member 412 thereon. In this embodiment, the wear member 412 is a shroud.

[0213] The wear assembly 410 comprises the shroud 414, a wear cap 422, and a lock 424 for holding the shroud 414 to the digging edge 412 and for simultaneously holding the wear cap 422 to the shroud 414.

[0214] The shroud 414 protects the bucket lip 412 and directs earthen material into the bucket. The wear cap 422 protects the upper leg of the shroud 414 and, in the illustrated embodiment, around the lock aperture and the lock.

[0215] In this embodiment, the base 417 is a cast part of the lip 412, but in other embodiments it could be attached by welding or mechanical attachment. In any event, each shroud 414 is placed over a base 417 on the front edge of the lip 412.

[0216] The base 417 may comprise a harder wearing material than the remaining part of the lip 412, for example if the base is welded into the lip, (or may have a hard wearing coating thereon) to resist wear caused by the shroud 414 during operation. Nevertheless, the other parts of the lip 412 are not necessarily softer than the base 417.

[0217] Each base 417 comprises a front surface 419, an upper surface 421, side surfaces 423 and an upstanding boss 425 generally centrally located between the side surfaces 423 and protruding above the upper surface 421. The boss 425 has a rear surface 427 against which the lock 424 abuts when holding the shroud 414 in place. The base 417 and shroud 414 have complementary surfaces to allow mutually stable and secure coupling.

[0218] In the illustrated embodiment, front surface 419 defines a slightly convex curved shape which curves about two generally perpendicular axes, though other configurations are possible. In particular, front surface 419 is curved generally about a vertical axis so that it curves rearward as it approaches each respective side surface 423, and is also curved generally about a horizontal axis so that it also curves rearward as it approaches the upper surface 421, and a lower surface (not visible in the drawings) opposite the upper surface 421. However, other designs and configurations of a boss are possible.

[0219] Shroud 414 includes a front-facing wearable portion 429 and a rear-facing mounting portion 431. The shroud 414 comprises a pair of spaced apart legs 433, 435 that define a cavity 437 therebetween and that meet at a central portion 439 (best seen in FIGS. 49 and 50). The cavity 437 is generally open along its sides so that legs 433, 435 straddle the side surfaces 423 of the base 417 on the lip 412 when the shroud 414 is mounted thereon.

[0220] The shroud 414 defines a recess 441 on the upper leg 433, which in this embodiment is at an upper, central location, to receive a wear cap 422. In the illustrated embodiment, the recess 441 is nearer a rear edge 443 of the upper leg 433 than front edge 445, but other arrangements are possible. The rear edge 443 extends across substantially the entire width of the upper leg 433. The front, rear and/or side walls of recess 441 preferably resist forward, rearward and/or side movement of the wear cap relative to the wear member, though wear cap

422 may be loosely held in the recess.

[0221] The upper leg 433 defines a wear cap shelf 447 (best seen in FIG. 49) within, but recessed with respect to, the wear cap aperture 441. The shelf 447 is located at a depth to set the wear cap 422, when mounted on the shelf 447, flush with an outer surface of the upper leg 433. Nevertheless, the wear cap could protrude therefrom or be recessed relative to the outer surface of upper leg 433.

[0222] The shelf 447 defines a lock opening 449 comprising a boss aperture portion 449a and a lock aperture portion 449b. The boss aperture portion 449a is dimensioned to be placed over and surround the boss 425 of the base 417. To conform to the shape of the boss 425 (which tapers towards the front surface 419 of the lip 412), the boss aperture portion 449a has sidewalls 451 that taper towards the front of the shroud 414. The lock aperture portion 449b extends laterally beyond the boss aperture portion 449a and has generally parallel sidewalls 453, the lock aperture portion 449b being dimensioned to receive the lock 424 (as described in more detail below).

[0223] A ridged protruding surface 455 is located generally centrally on the upper leg 433 outer surface and extends from the wear cap aperture 441 to the shroud front edge 445, with the ridge portion 457 extending longitudinally. This ridged protruding surface 455 provides additional protection against wear during use of the shroud 414.

[0224] The wear cap shelf 447 has a generally flat upper surface 458 and, on an underside of the parallel sidewalls 453, a convex lower surface 459 (best seen in FIG. 63). Other shapes could be used.

[0225] The wear cap 422 will now be described in more detail with particular reference to FIGS. 54 to 56.

[0226] The wear cap 422 comprises a generally flat underside 461 (best seen in FIG. 56) and a profiled upper surface 463 defining sloping surfaces 465 on opposite lateral sides thereof, and inclined surfaces 467 between the sloping surfaces 465, each rising from its respective sloping surface 465 to a central ridge 469 extending longitudinally. The wear cap, though, could have different shapes.

[0227] In the illustrated embodiment, the profiled upper surface 463 has a similar shape to the ridged protruding surface 455 so that when the upper wear cap 422 is mounted in the wear cap aperture 441, the profiled upper surface 463 becomes a continuation of the ridged protruding surface 455.

[0228] The wear cap 422 also defines a lock aperture 471 therethrough, extending from the upper surface 463 to the underside 461. The lock aperture 471 is generally slot shaped, and generally centrally located on the upper wear cap 422, extending laterally across the profiled upper surface 463. Other shapes are possible.

[0229] A pair of longitudinally extending projections 473 (best seen in FIG. 55) are located beneath opposing lateral sides of the lock aperture 471 and extend into the area defined by the lock aperture 471. In this embodiment, the longitudinally extending projections 473 have convex upper surfaces 474 (best seen in FIG. 63), though other shapes are possible. These longitudinally extending projections 473 define coupling portions that are engaged by the lock 424, as will be described in more detail below.

[0230] The lock 424 will now be described in more detail with reference to FIGS. 57 to 63, which illustrate various views thereof. The lock 424 is essentially the same as the lock described with reference to FIGS. 6 to 15 in U.S. patent number 10,612,214 (which is owned by the applicant), and so will only be described briefly herein. However, in other embodiments, different designs of locks may be used. As can be seen from FIGS. 57 to 63, the lock 424 includes separable pieces, or components, but is typically in the form of an integral unit during use.

[0231] In the illustrated embodiment, lock 424 includes two bodies or components 481, 483, that are pivotally coupled together for movement about a lateral axis 485 (best seen in FIG. 60) between a locked condition (see FIGS. 59 and 62) and an unlocked condition (see FIG. 63). The bodies could be movably adjusted in other ways such as shifting linearly relative to each other instead of pivoting.

[0232] Relative pivoting or hinging of the two components 481, 483 may be accomplished with a hinge mechanism 487. In the illustrated example, the hinge mechanism 487 includes an integral post 489 projecting from an inner face 491 of the first component 481. An inner face 493 of the second component 483 includes a complementary hole (not shown) sized and is located to receive the post 489 thereby pivotally coupling the first and second components 481, 483 together in an assembly for limited movement about lateral axis 485. However, a different hinge mechanism may be used in other embodiments.

[0233] In this embodiment, the pivot axis 485 is generally parallel to the longitudinal axis (see FIG. 49) of wear member 414 and perpendicular to the inner (or contact) faces 491, 493. The pivot connection could have other constructions. For example, the hinge mechanism 487 could have other constructions including, for example, forming each component with a hole for receiving a pivot pin secured in place by retaining rings or the like.

[0234] Each component 481, 483 defines half of a frusto-conical channel 495, 497 such that when the components 481, 483 are aligned they combine to form a frusto-conical channel 499 for receiving a threaded pin 501. Other kinds of retainers could be used to secure the lock bodies 481, 483 in their extended position.

[0235] One or optionally both frusto-conical channels may define a thread (positive or negative) for engaging with a complementary thread (negative or positive) of the threaded pin 501. In other embodiments, neither the frusto-conical channels nor the pin may be threaded. Other shapes of channels and pins are possible. The channel(s) could also be partially threaded or threaded in a discontinuous way.

[0236] A hex socket 503 or other tool engaging formation is provided at the top of the threaded pin 501 for turning the threaded pin 501. When the threaded pin 501 is screwed into the frusto-conical channel 499, the components 481, 483 are locked in position (as shown in FIG. 59).

[0237] When the threaded pin 501 is removed, components 481, 483 are unlocked and can pivot about axis 485 from the locked configuration to the unlocked configuration, where the length of the lock 424 is shorter than in the locked position.

[0238] In other embodiments, pin 501 could take many different forms and be received in other openings provided in one or both components.

[0239] The lock 424 has first and second end walls 511, 513 on opposite lateral sides thereof.

[0240] Each end wall 511, 513 has a pair of lobes or arms 515, 517 spaced from each other and having generally convex outer surfaces. A concave end wall surface 519 is defined between the upper 515 and lower 517 lobe on each end wall 511, 513. One arm 515 on each end 511, 513 includes a retaining surface 594 that overlies a respective projection 473 on the wear cap 422 to resist upward movement of the wear cap away from the wear member 414.

[0241] The upper lobe or arm 515 defines a downward facing retaining surface 594 (similar in some respects to retaining surface 194 of upper arm 192 of spools 180 and 280). Similarly, the lower lobe or arm 517 defines an upward facing engagement surface 598 (similar in some respects to engagement surface 198 of lower arm 196 of spools 180 and 280). The downward facing retaining surfaces 594 complement (and are designed to be located just above) the convex upper surfaces 474 of the longitudinally extending shelves 473 of the upper wear cap 422. Similarly, upward facing engagement surfaces 598 complement (and are designed to be located just below) the convex lower surfaces 459 of the wear cap shelf 447 of wear member 414.

[0242] In other embodiments, the downward facing retaining surfaces 594 and the upper surfaces of the longitudinally extending projections 473 may have different profiles to those described above.

[0243] The lock 424 includes features to aid removal thereof using a removal tool 601 of the type described in U.S. patent number 10,612,214.

[0244] To install the wear assembly 410, if the shroud is shipped and/or stored with the lock in position, the lock is first removed. If the wear assembly has a release position for the lock (e.g., as disclosed in US Patent 10,612,214), the lock 424 is left or moved to a higher position. Alternatively, the lock can be supplied separately and installed as needed.

[0245] The shroud 414 is aligned with the base 417 and located thereon in such a way that the sidewalls of the boss aperture portion 451 surround the lateral sides of the boss 425, and the coupling aperture 449 is aligned with an area immediately rearward of the boss 425. The wear cap 422 is then placed in the wear cap aperture 441 until the underside 461 of the wear cap 422 rests on the wear cap shelf 447. Optionally, the shroud could be installed on the lip with the wear cap already in place.

[0246] With the lock 424 pivoted in the unlocked position, it is inserted through the lock aperture 471 of the upper wear cap 422, rearwards of the boss 425 (shown in broken line in FIG. 63 for ease of understanding), to the position illustrated in FIG. 63. The lock 424 is then pivoted to the locked position (illustrated in FIGS. 61 and 62). During this pivoting movement, the concave end wall surfaces 519 at each end 511, 513 of the lock 424 engage with, and rotate around, the convex lower surfaces 459 of the lock aperture sidewalls 453, and the convex upper surfaces 474 of the longitudinally extending shelves 473. The flat underside 461 of the wear cap 422 and the flat upper surface 458 of the shelf 447 on the shroud 414 contact each other or, alternatively, provide a close fit if fit pads are used. As a result, the lock 424 provides a strong and secure mechanical mechanism for resisting heavy loading and preventing release of the wear cap 422 from the wear member 414, or the wear member 414 from the digging edge 412.

[0247] The upper and lower lobes or arms 515, 517 prevent the upper wear cap 422 from moving in the levitational axis (for example, vertically upwards), though wear cap 422 can be loosely retained. The lower leg 435 prevents the shroud 414 from moving in the levitational axis (for example, vertically upwards) though grooves and rails (not shown) could also be provided in the boss and shroud. In a similar manner as for conventional lips and locks, the boss 425 and lock 424 prevent the shroud 414 from moving forwards.

[0248] Removal of the wear assembly 410 from the lip 412 is performed in the reverse order to that described above, optionally using the removal tool 601 to unlock the lock 424.

[0249] It will now be appreciated that the above embodiment has the advantage that one lock 424 simultaneously secures both the wear cap 422 to the shroud 414 and the shroud 414 to the lip 412.

[0250] Other lock arrangements may be used than the one described above.

[0251] The systems, devices, and methods disclosed herein are examples of applications of the principles of this disclosure in practice, and a wide variety of other examples are possible. Therefore, the scope of this disclosure is not limited to the details of the wear assembly 10, 410 and the methods described herein and/or depicted in the drawings. Various other examples as well as many changes may be made without departing from the scope and broader aspects of the disclosure as defined in the claims. For example, an adapter similar to adapter 14 may be used without the wear cap 22; or with a pair of rear wear caps 22, one mounted on each of the legs 86a, 86b or on multiple positions on one or both legs 86a, 86b. In other embodiments, a spool having rearward arms (similar to the design shown in U.S. Patent No. 6,986,216 or

as used in conventional Whisler type designs) may be used. In other embodiments, the lock may comprise a plurality of components held together as a single unit, but the components being moveable relative to other. Aspects of the disclosure have been described in terms of illustrative examples thereof. Numerous other examples, modifications, and variations within the scope of the appended claims will occur to persons of ordinary skill in the art from a review of this disclosure. The features in one example can be used with features of another example. The examples given and the combination of features disclosed are not intended to be limiting in the sense that they must be used together. Relative directional terms such as inner, inward, outer, upward, and the like are provided to ease understanding and are not intended to restrict any direction the parts labelled thereby may face during use.

Claims

1. A wear assembly for attaching to a digging edge of an earth working equipment, the wear assembly comprising:

   • a wear member including a front end and bifurcated legs extending rearwardly from the front end, each of the legs including a front portion, a rear portion rearward of the front portion, an inner surface to face the digging edge, an outer surface opposite the inner surface, and a rear wall, and at least one of the legs having a lock opening;
   • a wear cap mounted on the wear member to overlie at least the outer surface of one of the legs in the rear portion proximate the rear end; and
   • a lock in the lock opening to retain the wear member on the digging edge.

2. A wear assembly according to claim 1, wherein the lock in the lock opening retains the wear cap on the wear member and the wear member on the digging edge.

3. A wear assembly according to claim 1 or 2, wherein the wear member includes a recess in the outer surface into which the wear cap is received.

4. A wear assembly according to any of claims 1-3, wherein the wear cap includes a top portion overlying the top surface of one of the legs, and a pair of sidewalls overlying opposite sides of the one leg to resist side loads on the wear cap.

5. A wear assembly according to any of claims 1-4, wherein the wear cap includes an upper wear surface, a lower surface opposite the upper wear surface to engage the wear member, a front coupling formation to engage the wear member, and a rear coupling formation to engage a lock, and wherein the front and rear coupling formations retain the wear cap to the wear member.

6. A wear cap according to claim 5, wherein the front coupling formation includes a protrusion extending forward beyond the upper wear surface and operable to engage with a complementary formation on a wear member.

7. A wear assembly according to any of claims 1-4, wherein the wear member includes at least one front facing lateral wall, and the wear cap includes at least one rear facing bearing surface to engage the at least one front facing lateral wall to resist rearward movement of the wear cap.

8. A wear assembly according to claim 7, wherein the wear member includes an indentation on each side of the lock opening, each of the indentations includes one said front facing lateral wall, the wear cap includes a projection to fit into each of the indentations, and each of the projections includes one said rear facing bearing surface.

9. A wear assembly according to any of claims 1-8, wherein the wear member includes at least one retaining surface that faces generally in a same direction as the inner surface of the leg with the wear cap, and which is suitable for overlying a portion of the wear cap to resist movement of the wear cap away from the wear member.

10. A wear assembly according to any of claims 1-9, wherein the lock includes at least one retaining surface that faces generally in a same direction as the inner surface of the leg with the wear cap, and which is suitable for overlying a portion of the wear cap to resist movement of the wear cap away from the wear member.

11. A wear assembly according to any of claims 1-10, wherein the lock includes a pair of arms that capture a portion of the wear cap and a portion of the wear member therebetween.

12. A wear assembly according to any of claims 1-11, wherein the wear cap includes an opening in registration with the lock opening.

13. A wear assembly of any of claims 1-12, wherein the lock includes a spool and a wedge.

14. A wear assembly according to any of claim 1-13, wherein each of the legs includes a lock opening for receiving the lock.

15. A wear assembly of any of claims 1-14, wherein the wear member is an adapter with a nose to support a point.

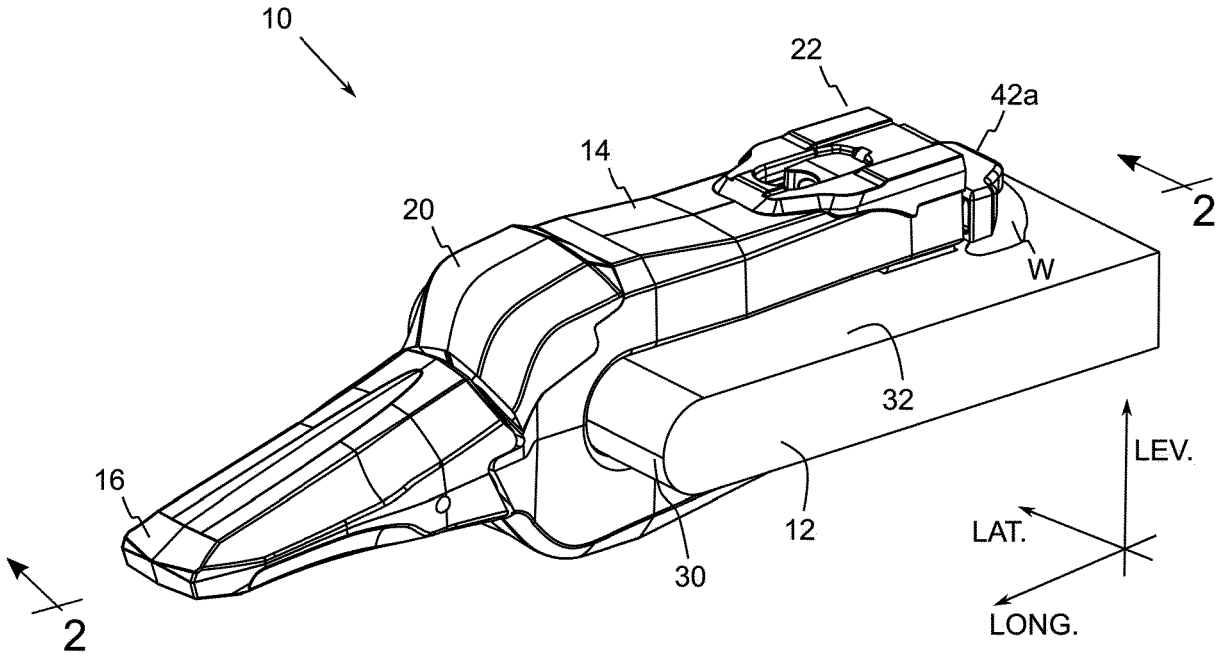
10
22
42a
14
20
2
W
32
LEV.
16
12
LAT.
30
2
LONG.

FIG. 1

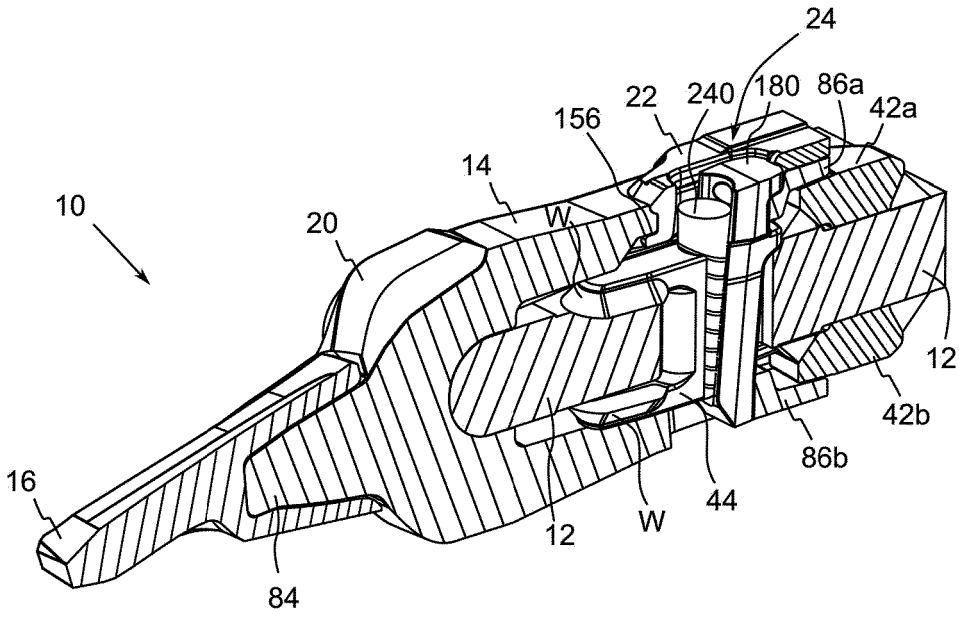
24
22
240
180
86a
42a
156
14
10
20
W
12
42b
86b
16
44
12
W
84

FIG. 2

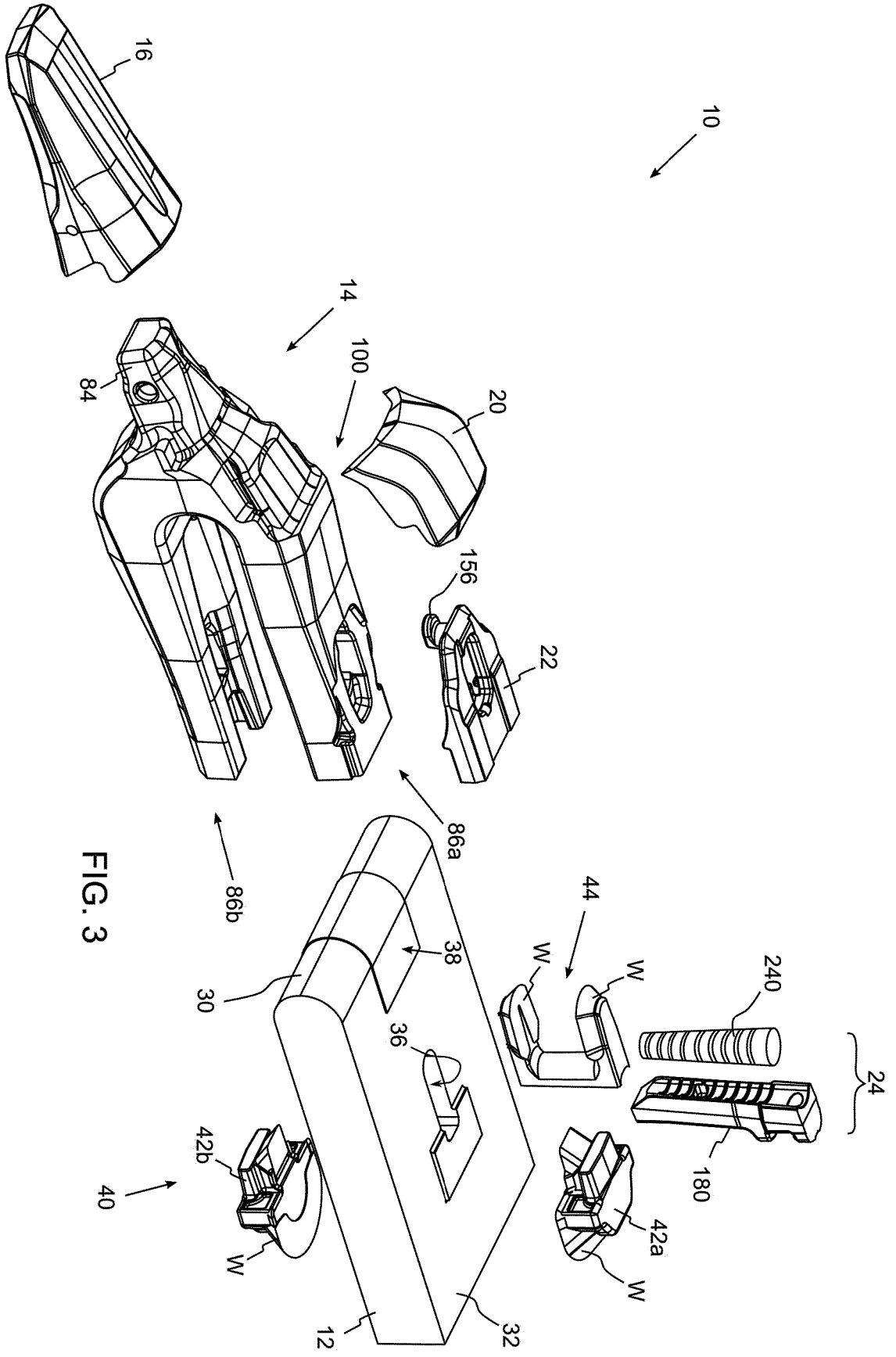
16
10
14
100
84
20
156
22
86a
86b
44
W
W
240
24
38
30
36
42b
40
W
180
42a
W
12
32

FIG. 3

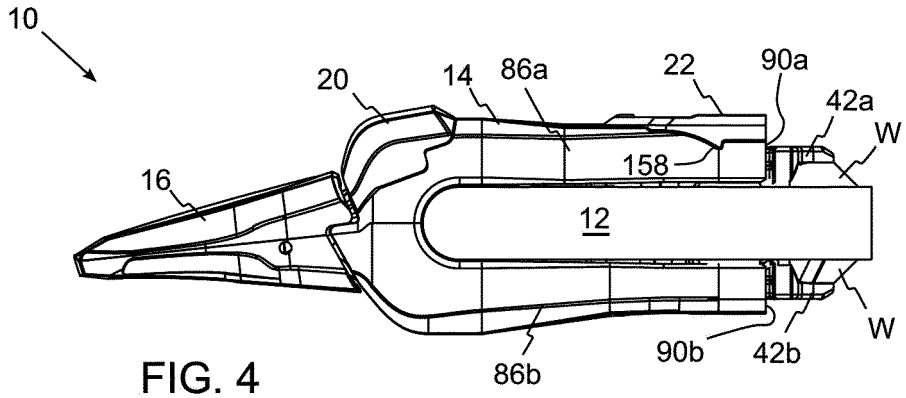

FIG. 4

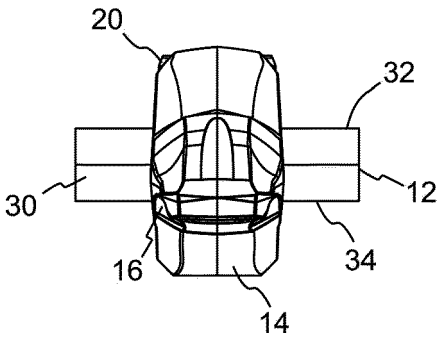

FIG. 5

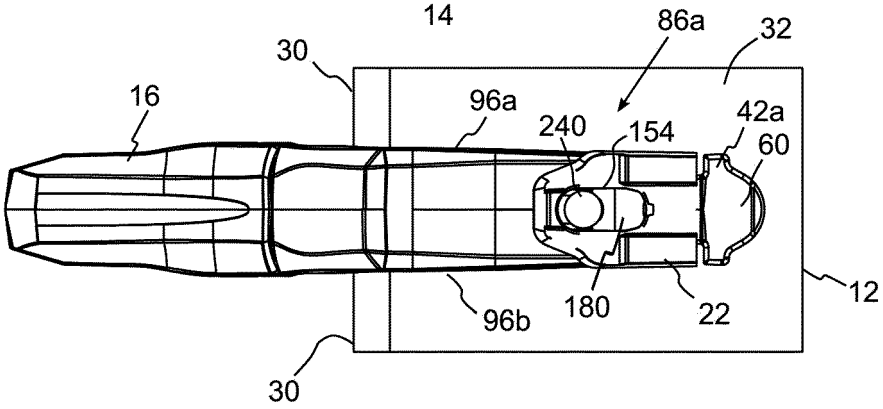

FIG. 6

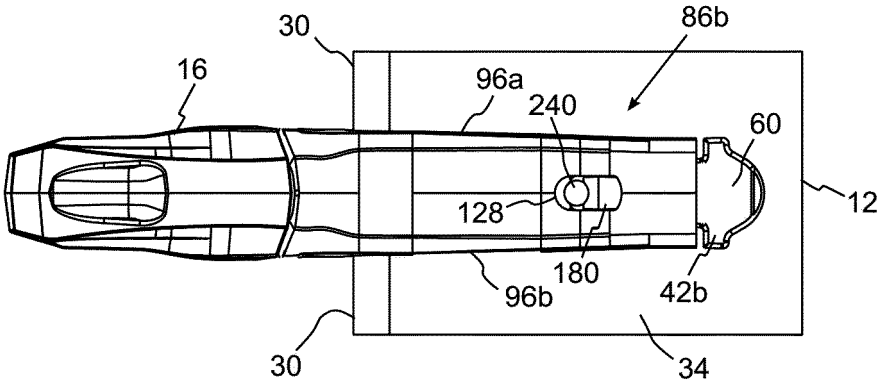

FIG. 7

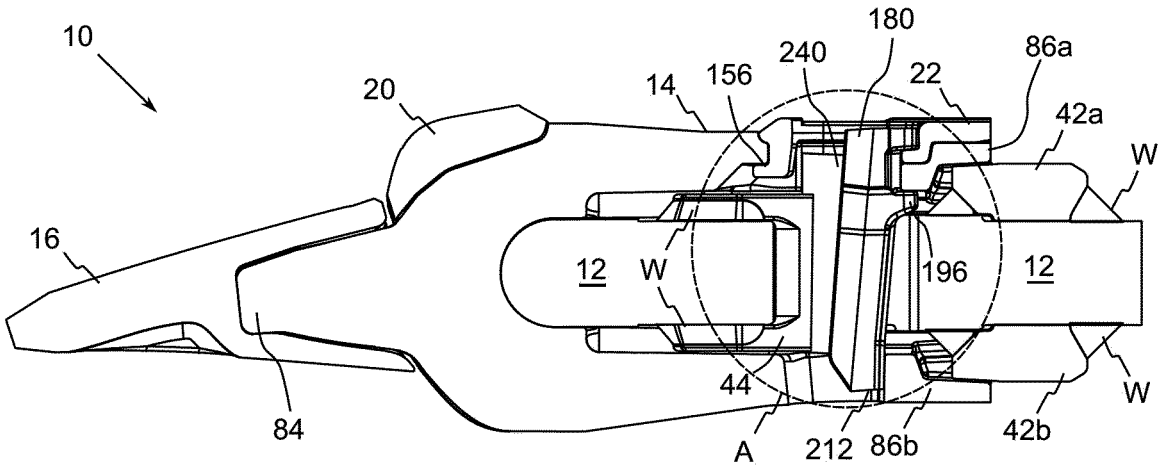

FIG. 8

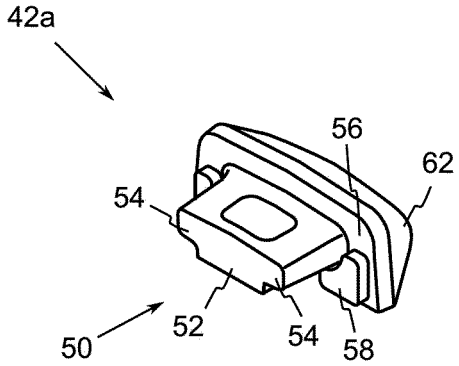

FIG. 9A

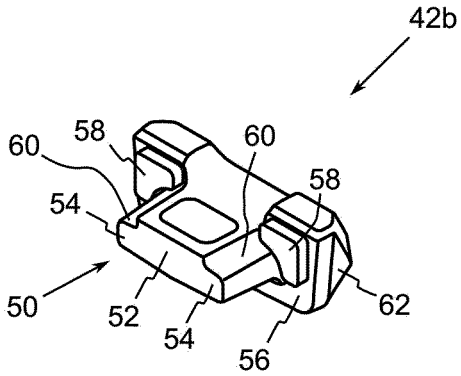

FIG. 9B

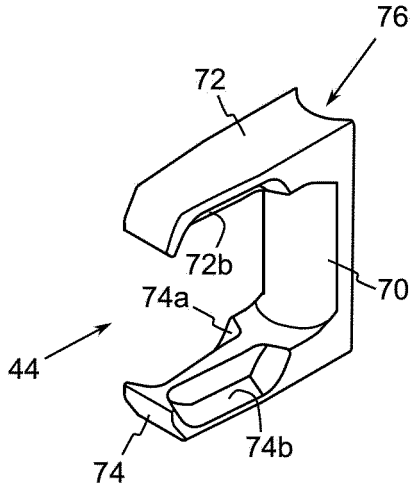

FIG. 10

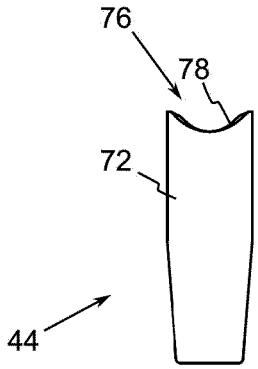

FIG. 11

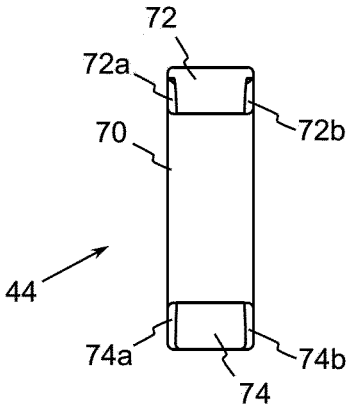

FIG. 12

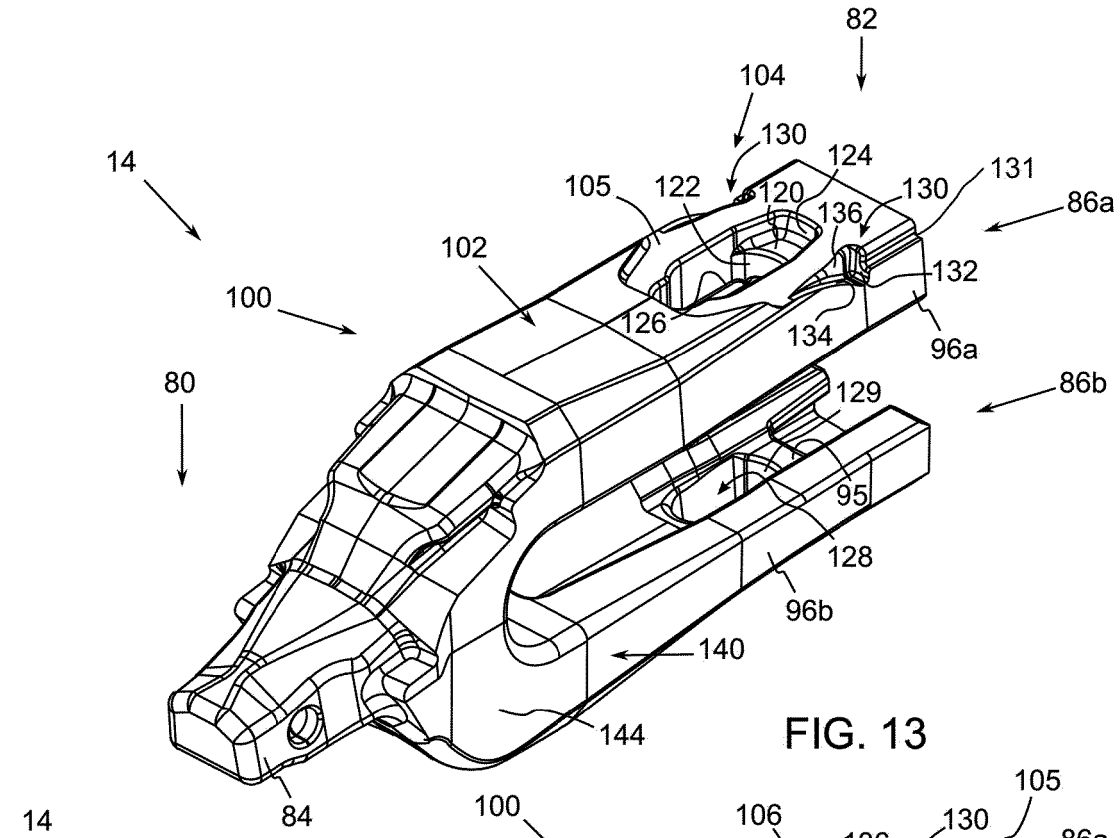

FIG. 13

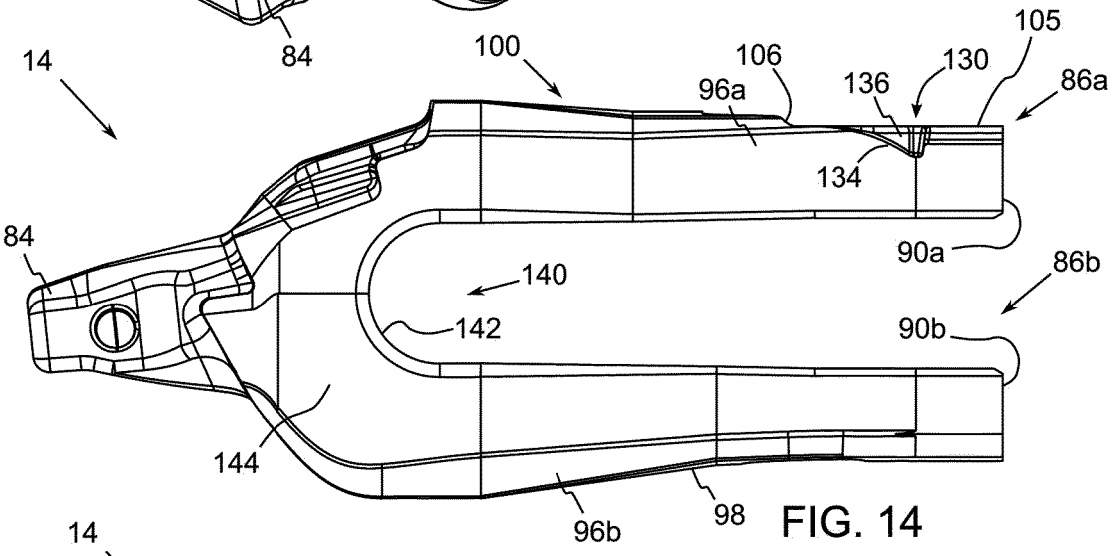

FIG. 14

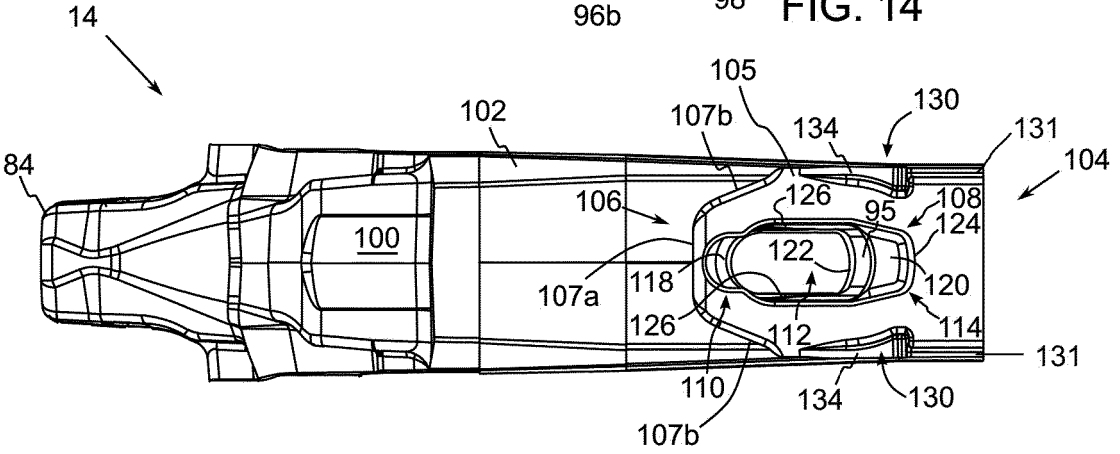

FIG. 15

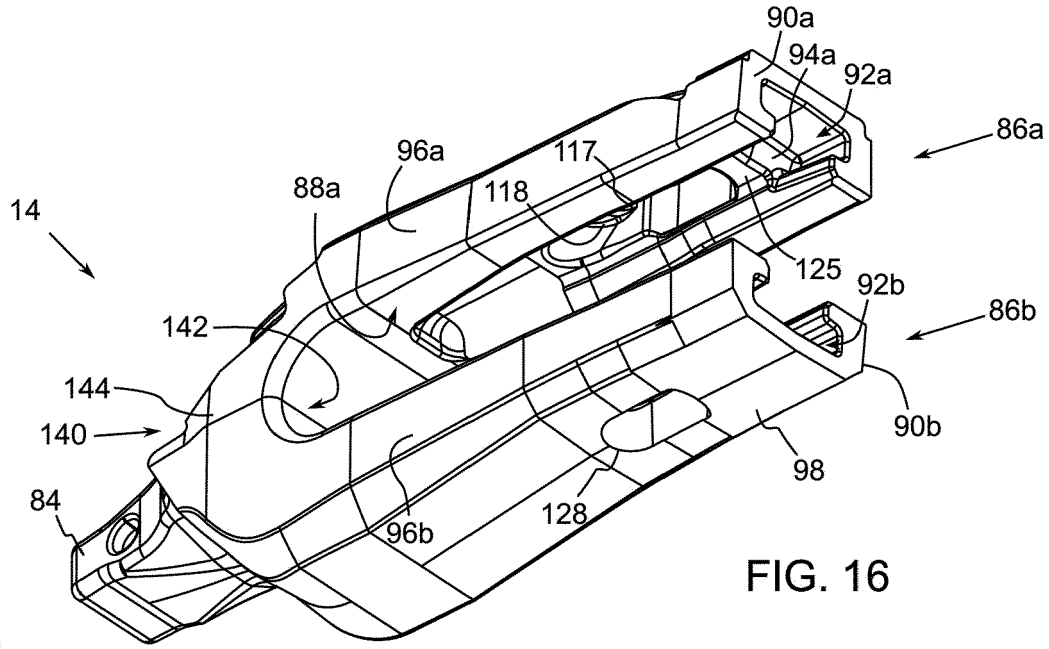

FIG. 16

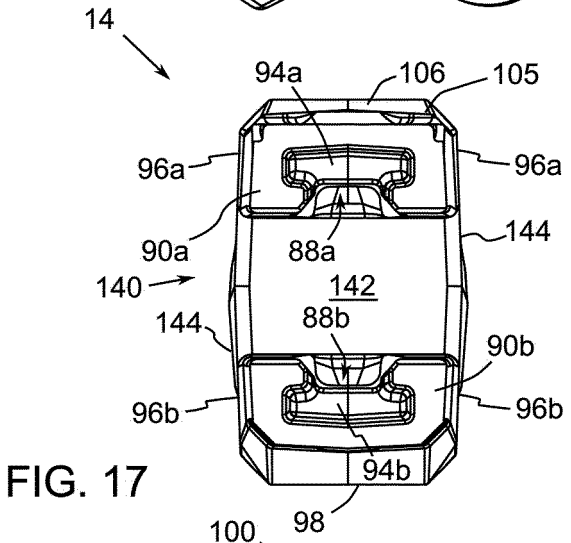

FIG. 17

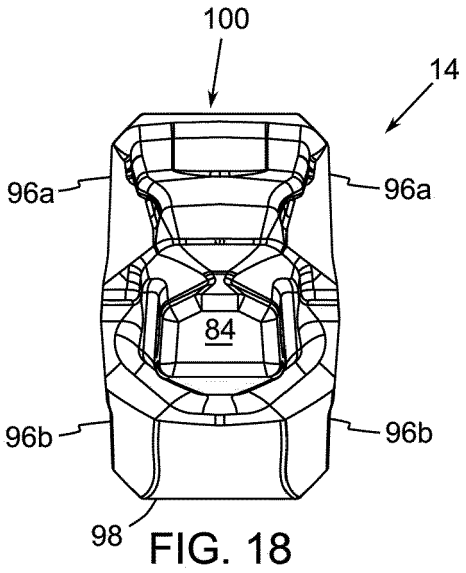

FIG. 18

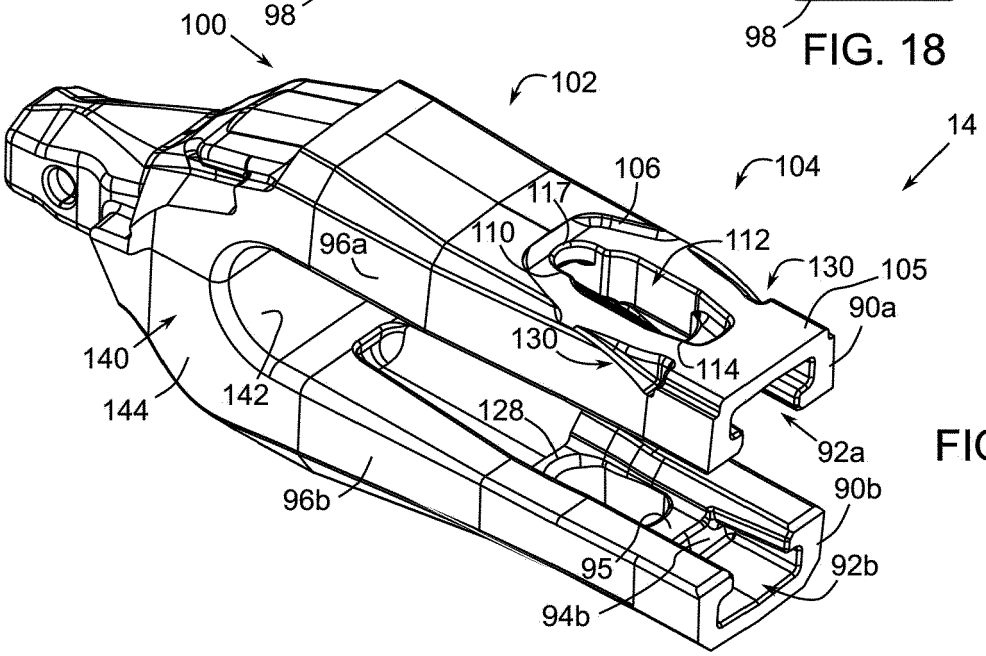

FIG. 19

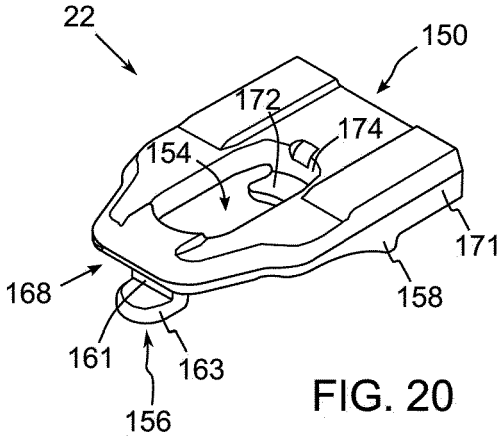

FIG. 20

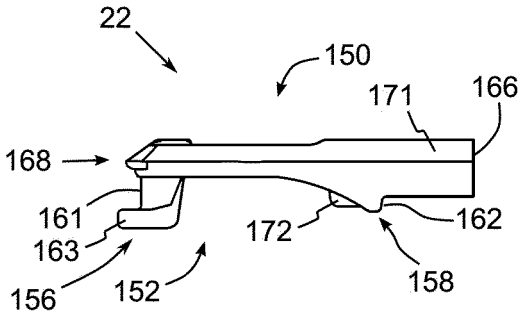

FIG. 21

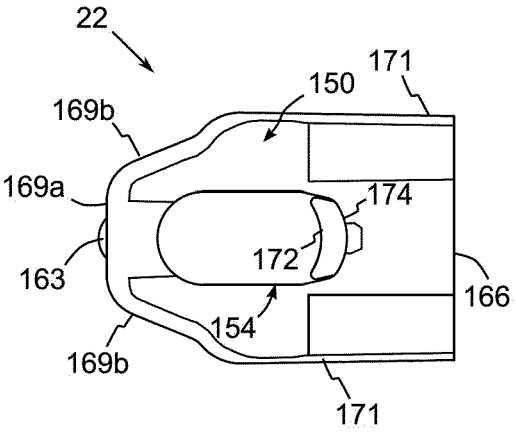

FIG. 22

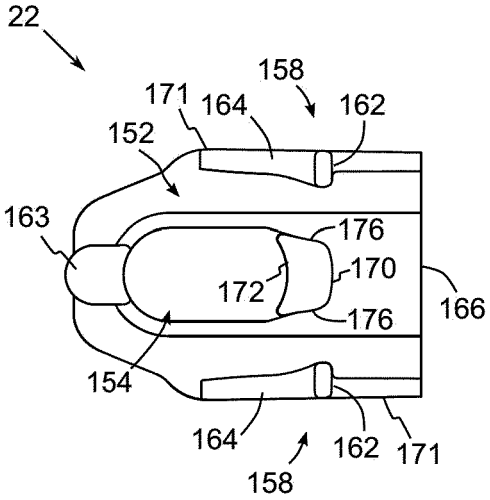

FIG. 23

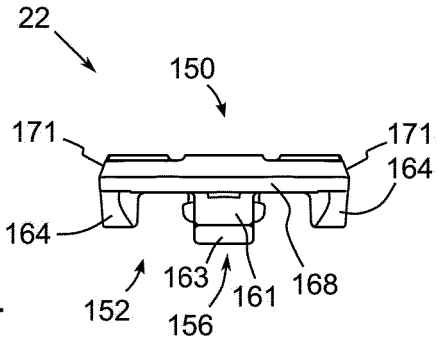

FIG. 24

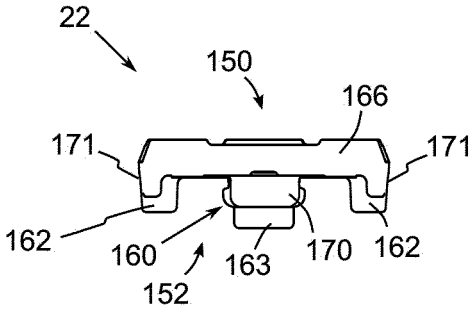

FIG. 25

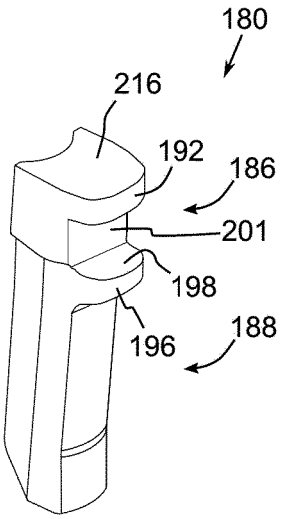

FIG. 26

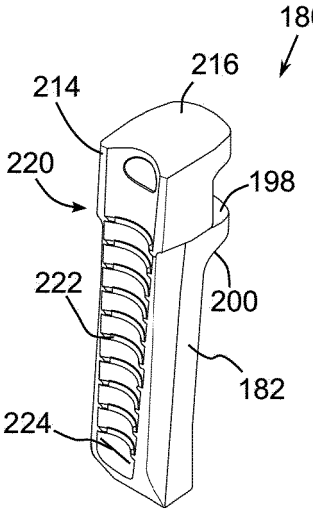

FIG. 27

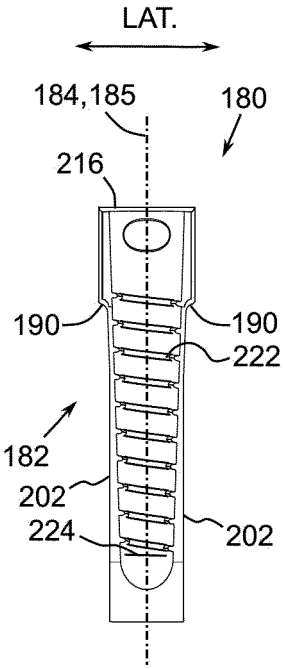

FIG. 28

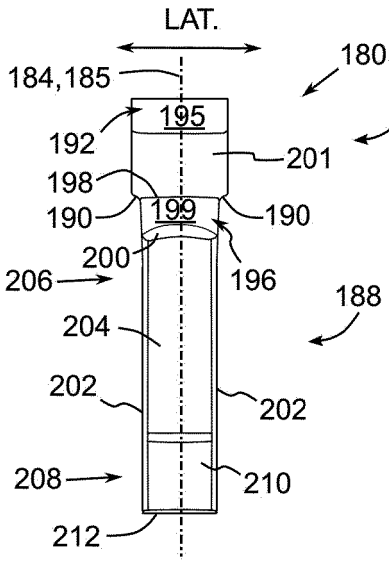

FIG. 29

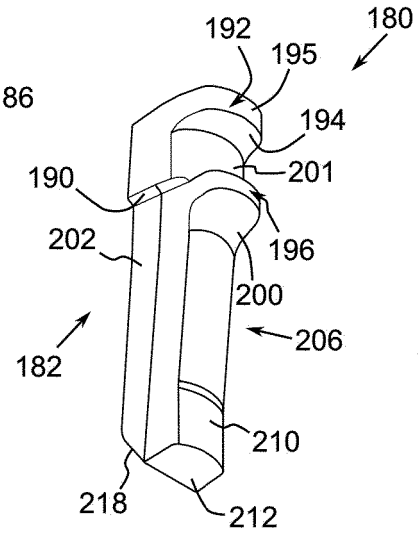

FIG. 30

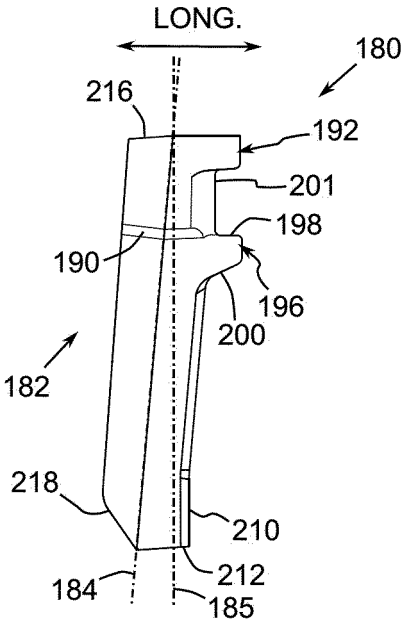

FIG. 31

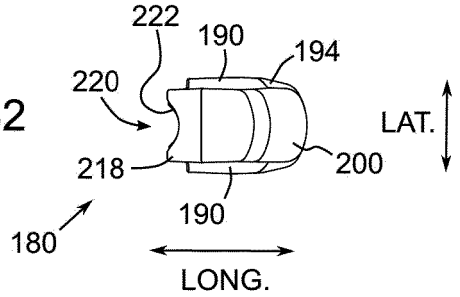

FIG. 32

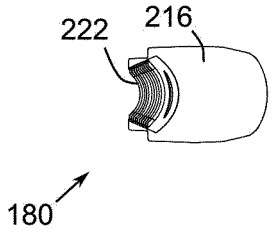

FIG. 33

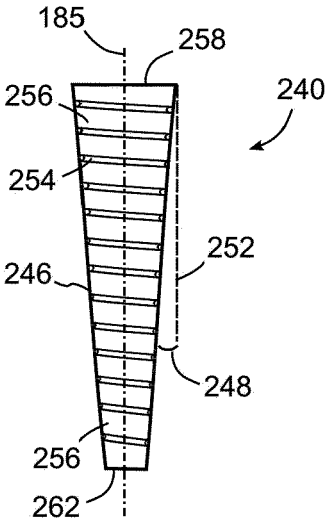

FIG. 34

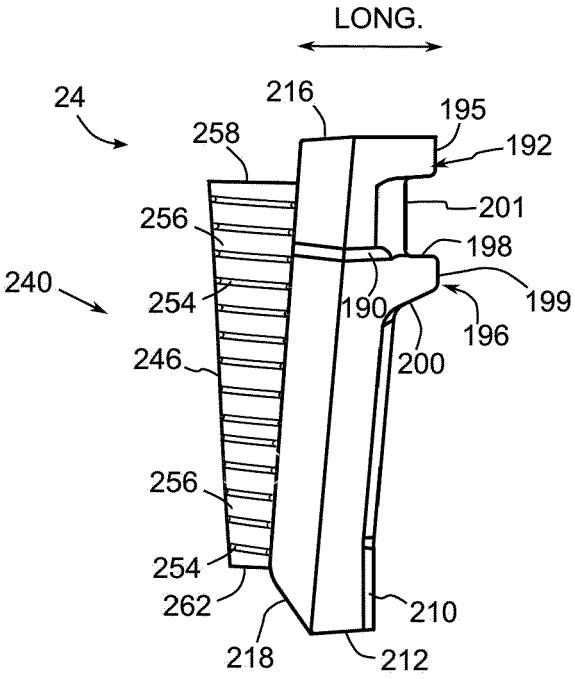

FIG. 35

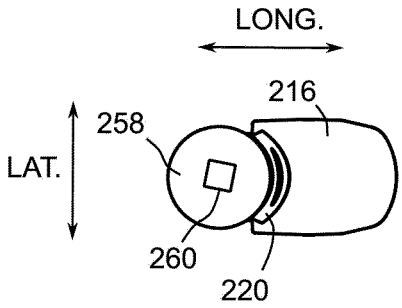

FIG. 36

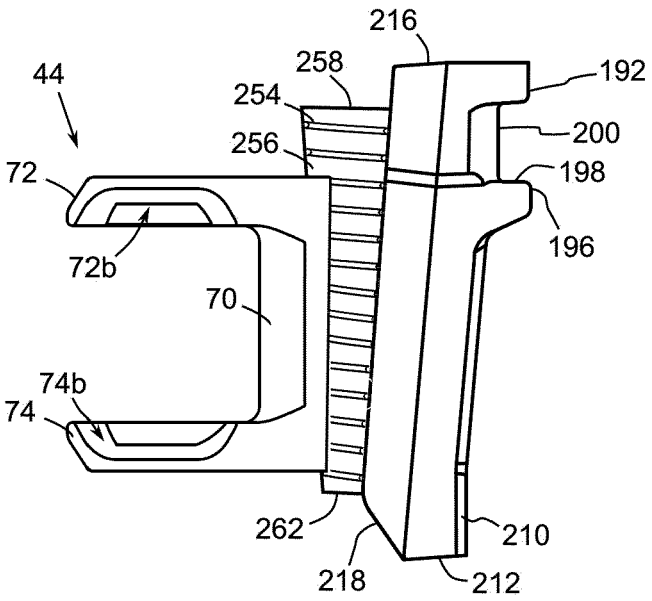

FIG. 37

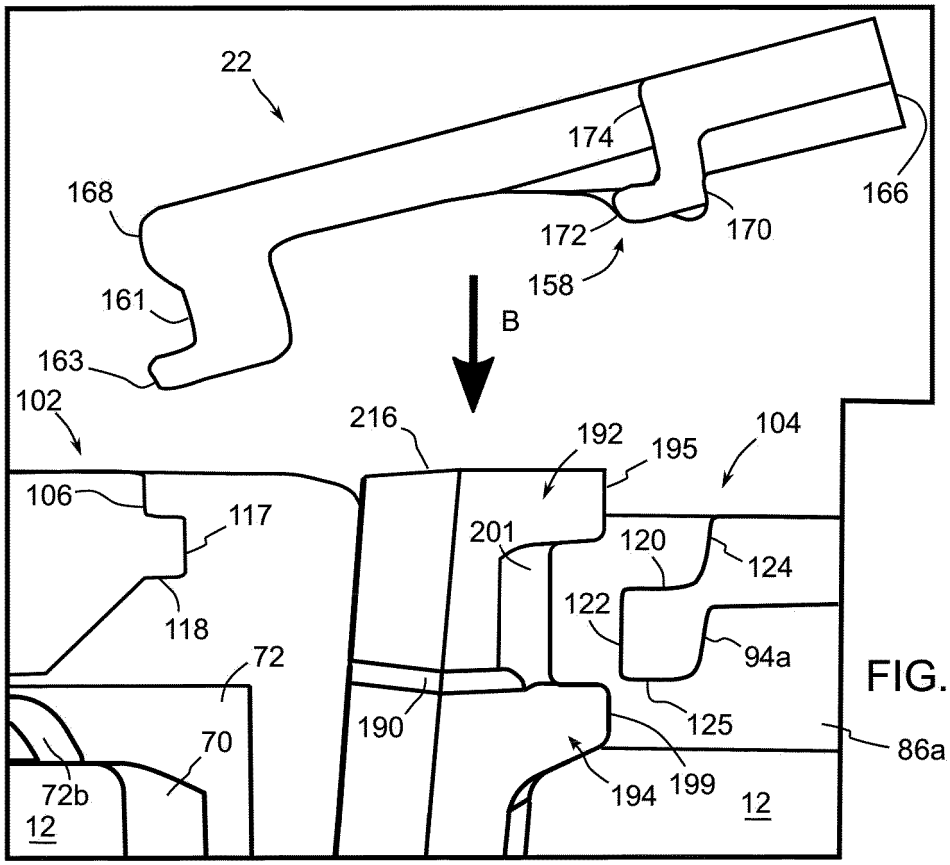
22
174
168
166
172
170
158
161
B
163
102
216
192
195
104
106
117
201
120
124
122
118
94a
72
190
125
86a
70
194
199
72b
12
12

FIG. 38

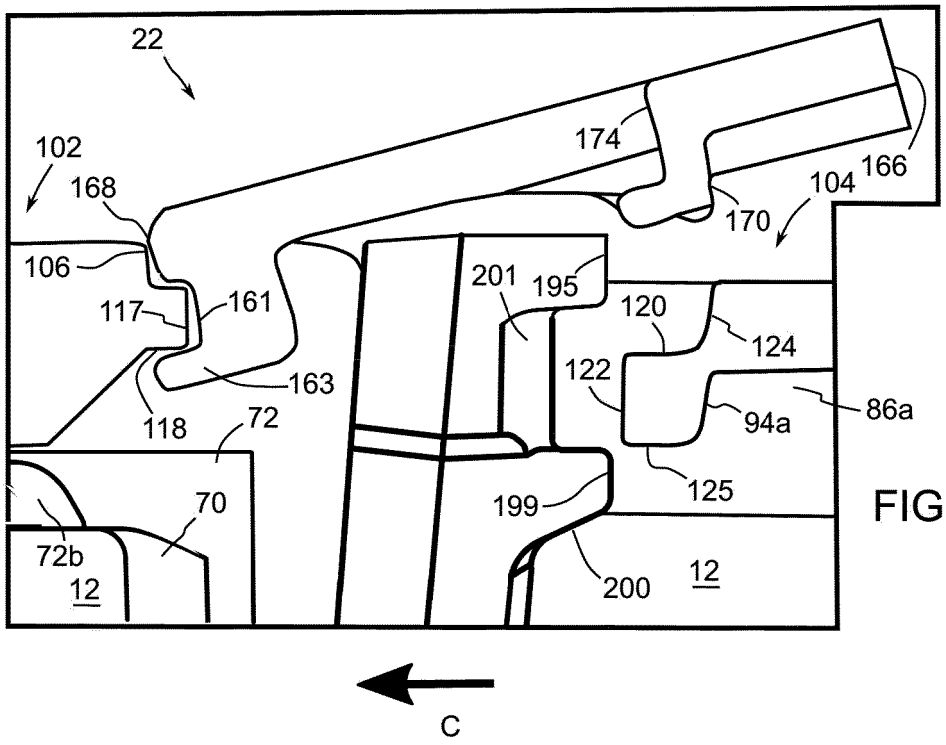
22
174
102
168
166
104
170
106
201
195
161
120
117
124
122
163
86a
118
72
94a
125
70
199
72b
12
200
12
C

FIG. 39

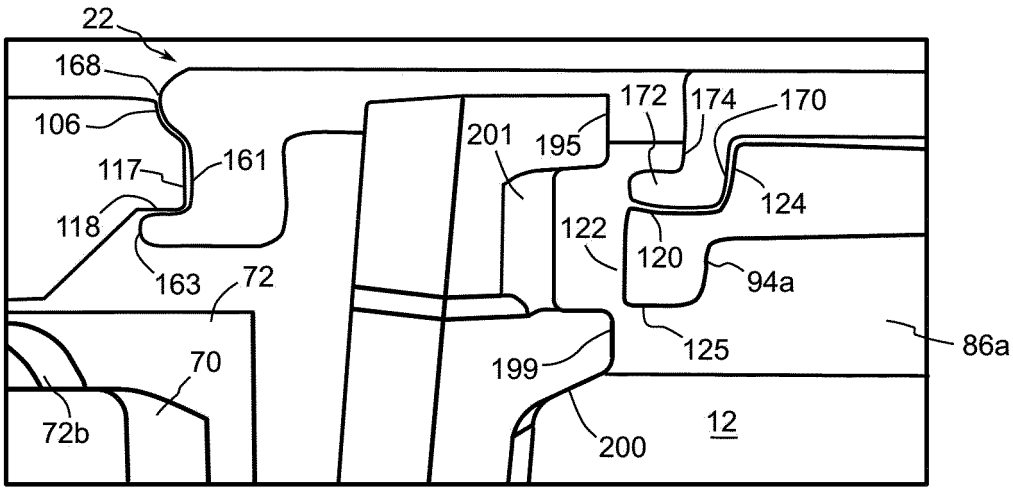
22
168
106
117
118
161
163
72
70
72b
201
195
172
174
170
124
122
120
94a
125
199
200
12
86a

FIG. 40

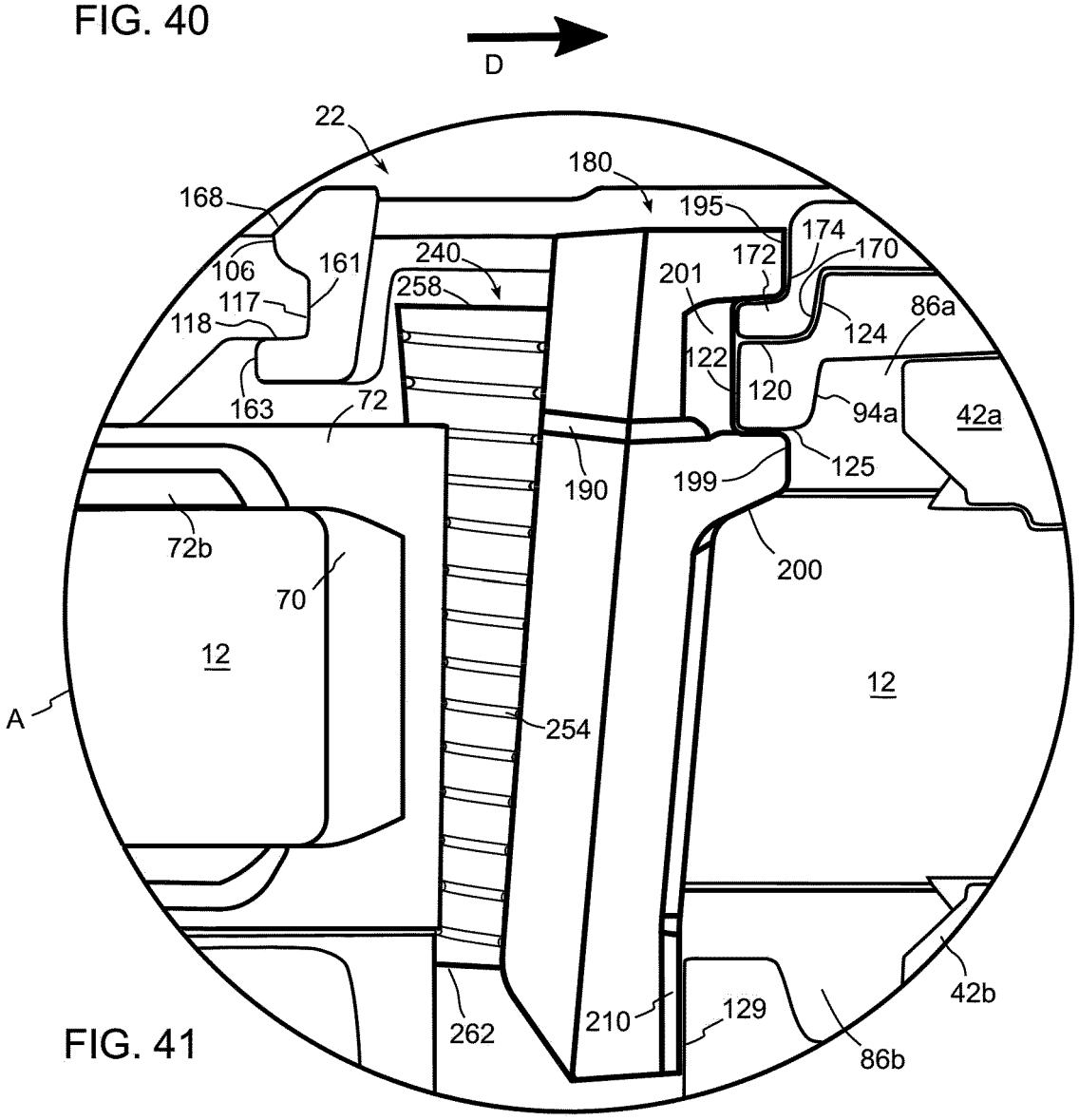
D
22
180
168
195
174
172
170
240
258
201
106
161
117
118
163
72
124
86a
122
120
94a
42a
125
190
199
72b
70
200
12
12
A
254
262
210
129
86b
42b

FIG. 41

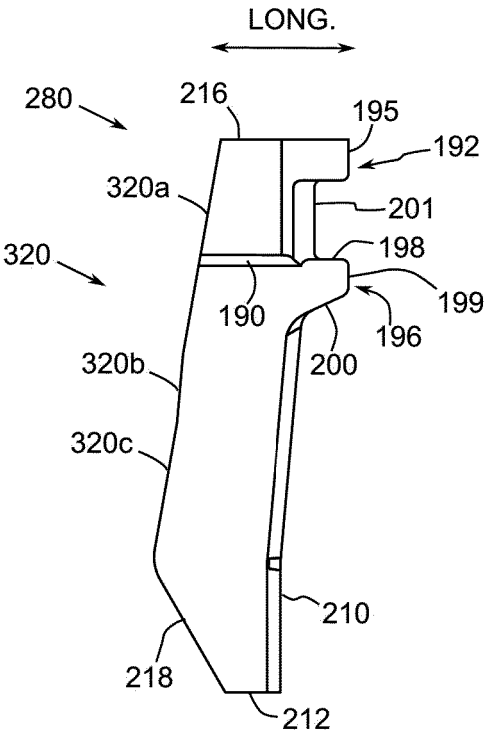

FIG. 42

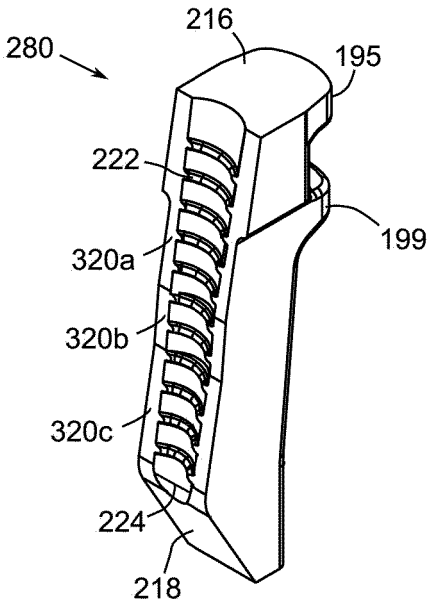

FIG. 43

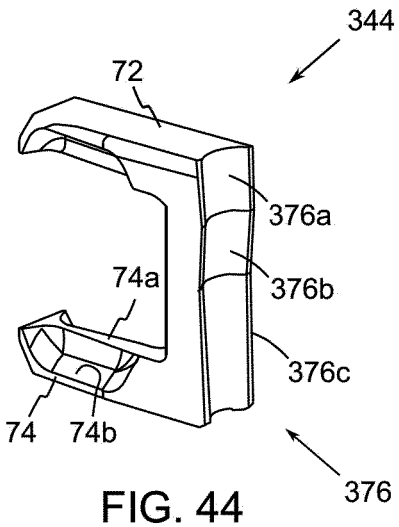

FIG. 44

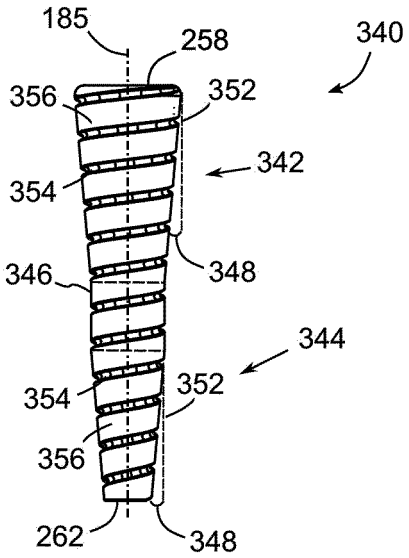

FIG. 45

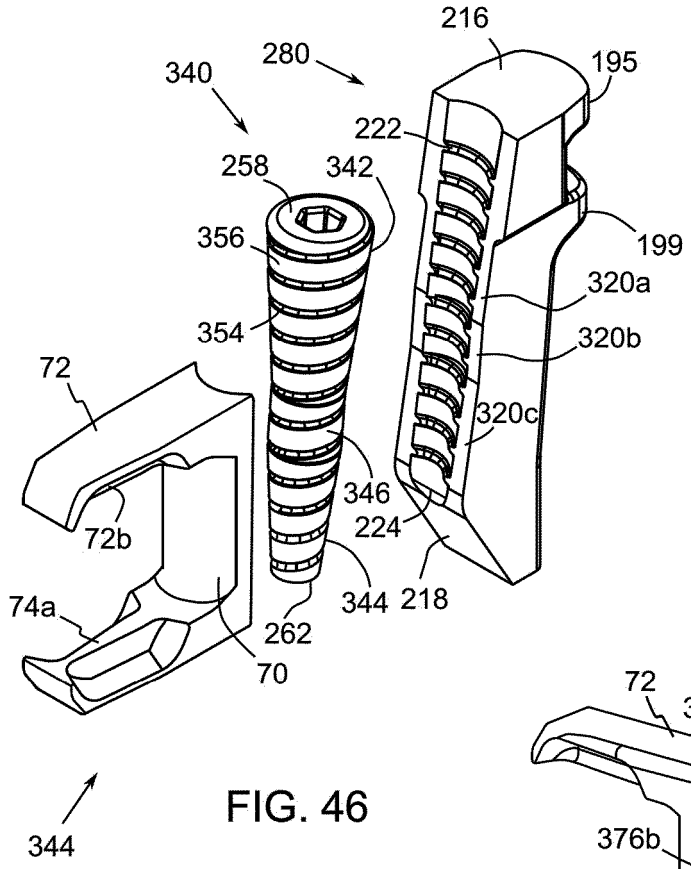

FIG. 46

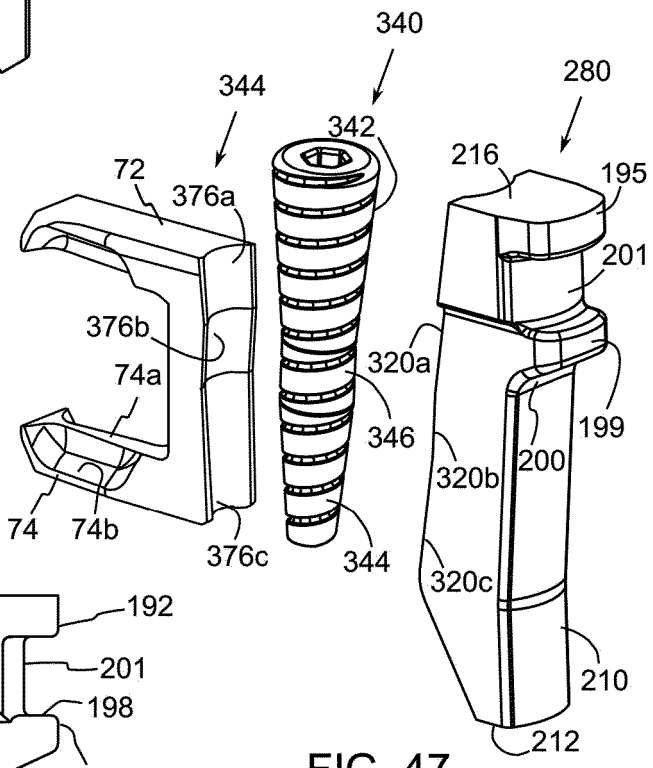

FIG. 47

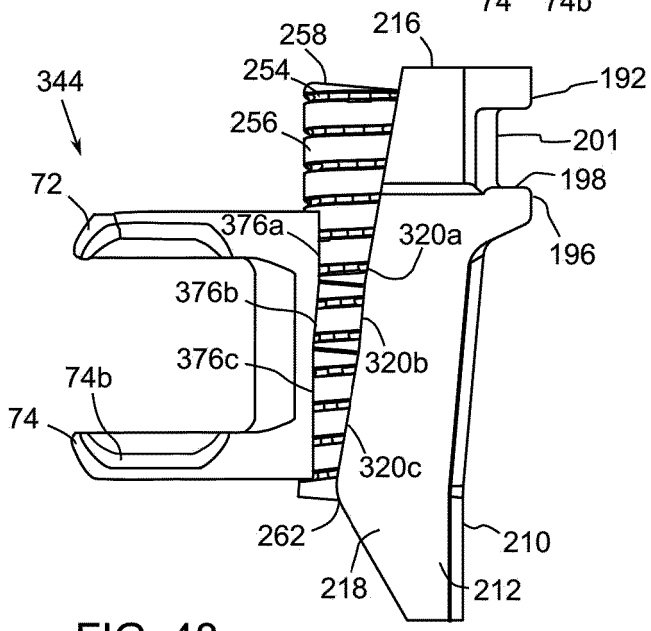

FIG. 48

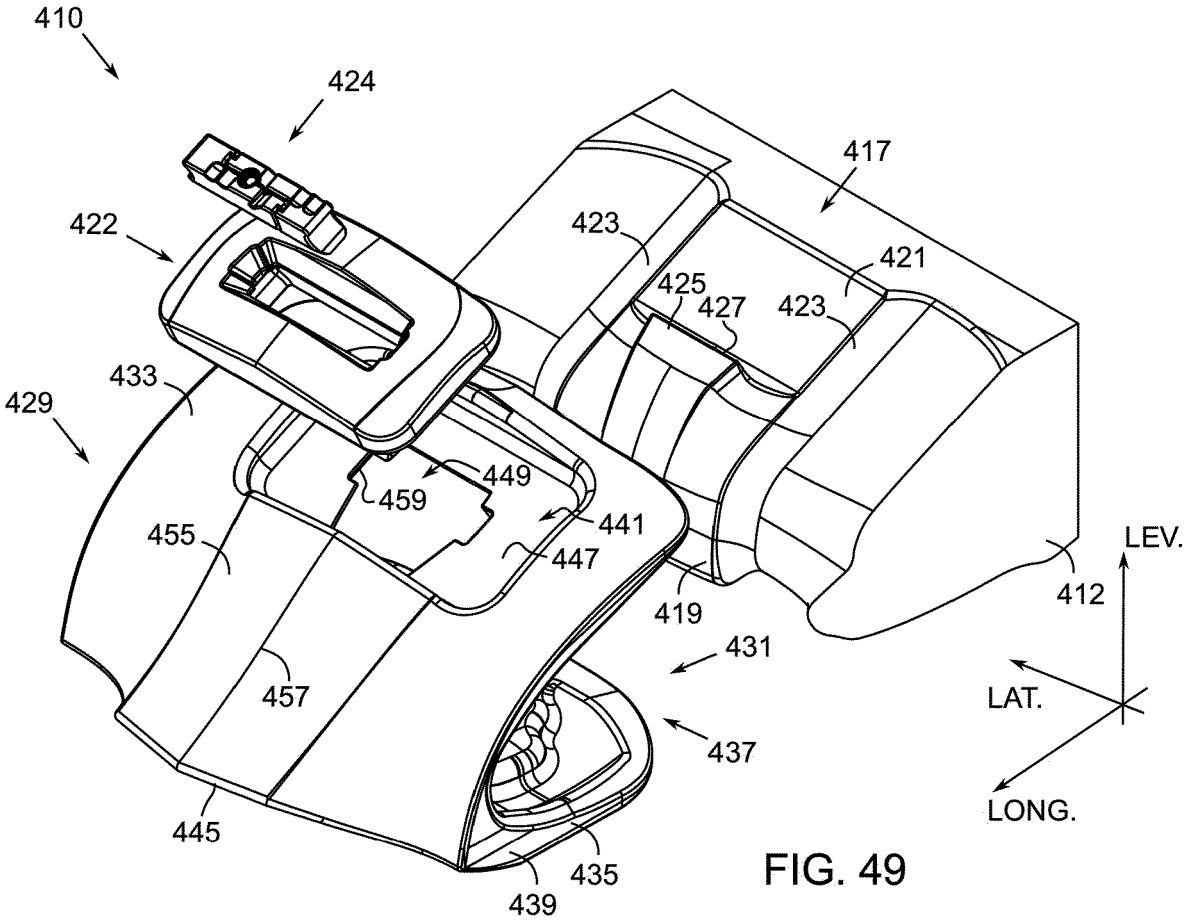
410
424
417
422
423
421
425
427
423
433
429
449
459
441
455
447
419
412
LEV.
431
457
LAT.
437
LONG.
445
435
439

FIG. 49

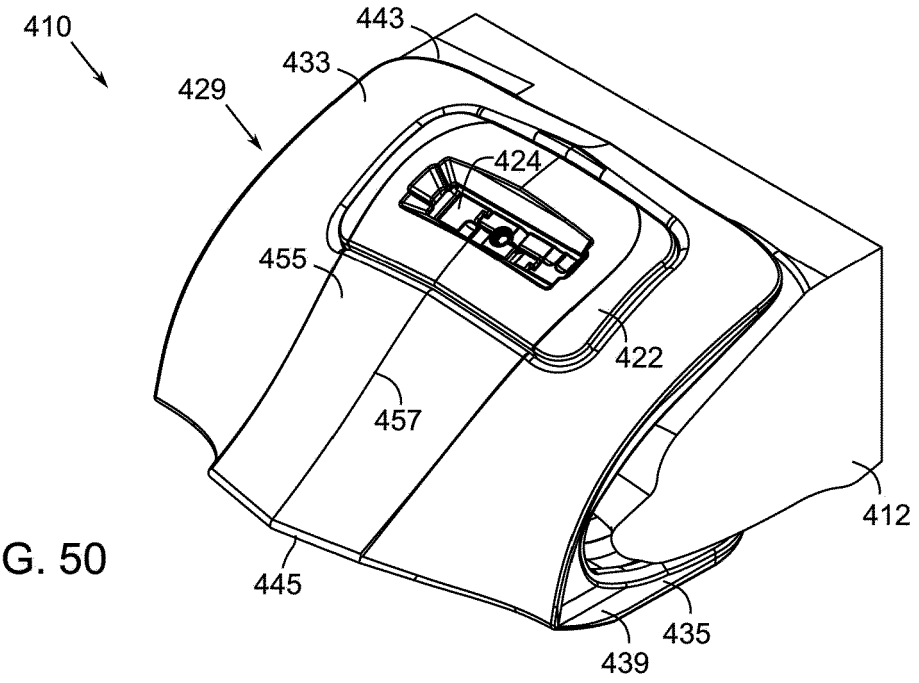
410
443
433
429
424
455
422
457
412
445
435
439

FIG. 50

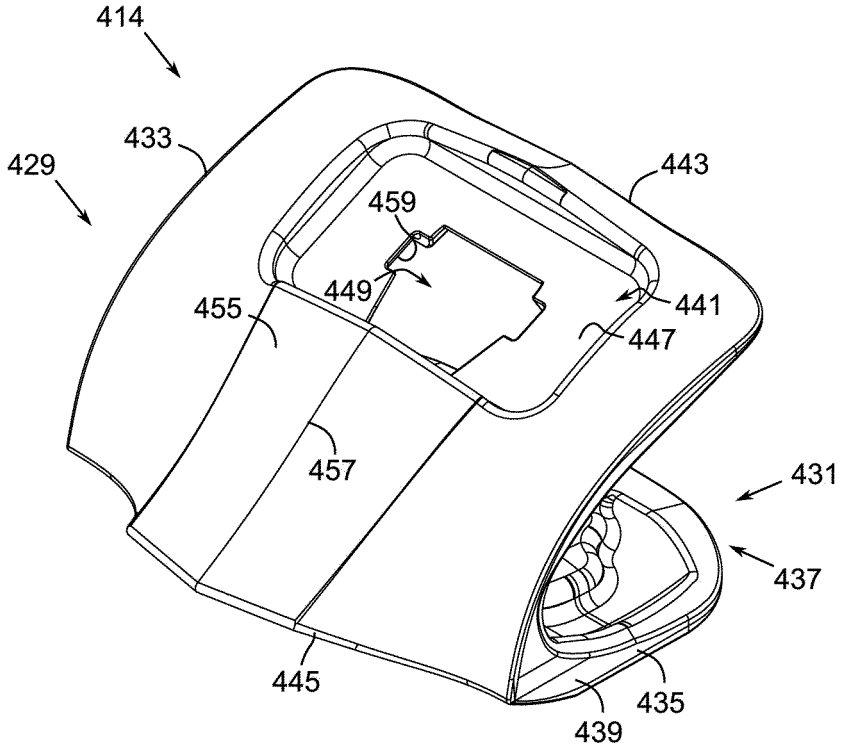

FIG. 51

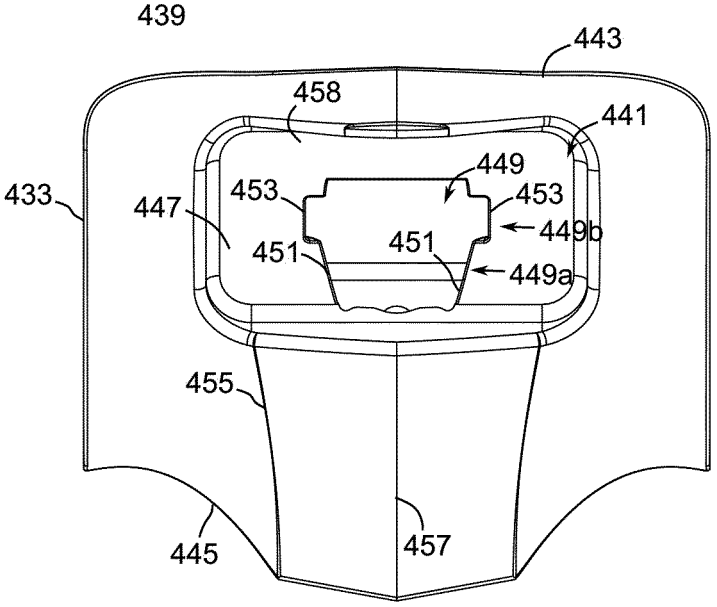

FIG. 52

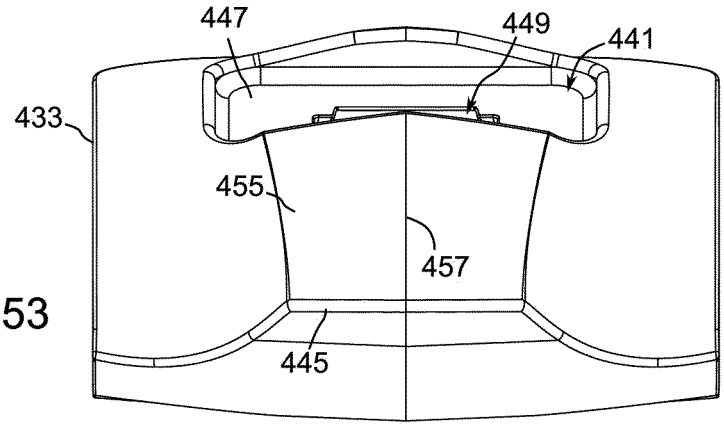

FIG. 53

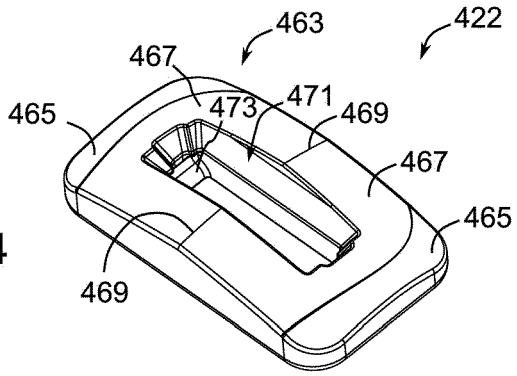

FIG. 54

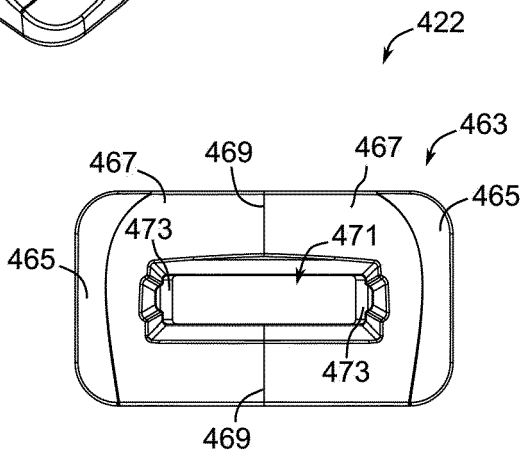

FIG. 55

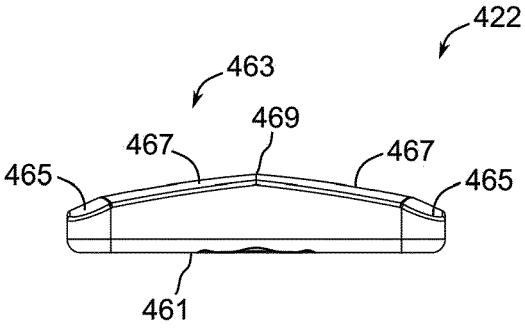

FIG. 56

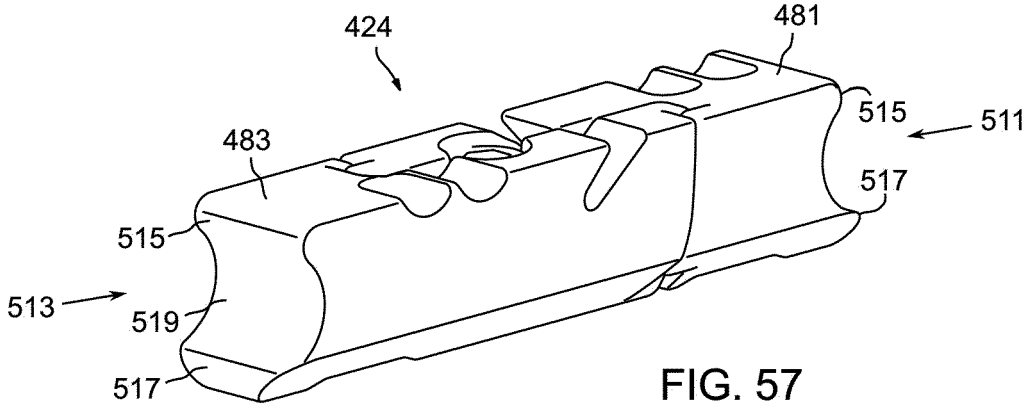

FIG. 57

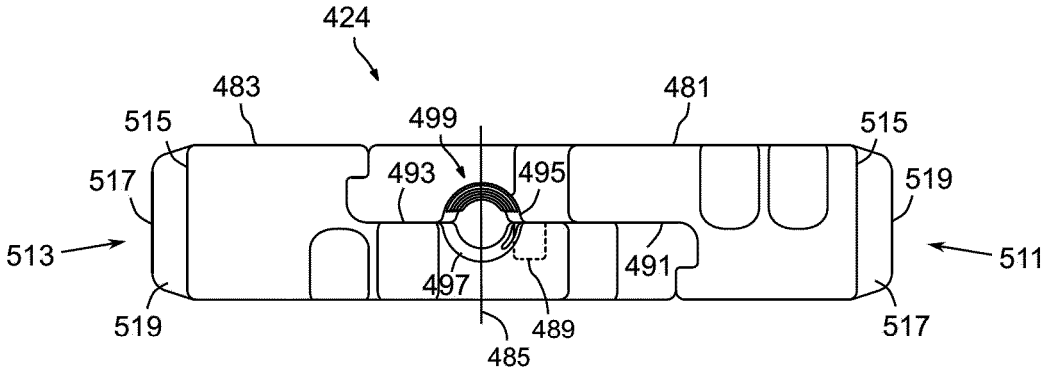

FIG. 58

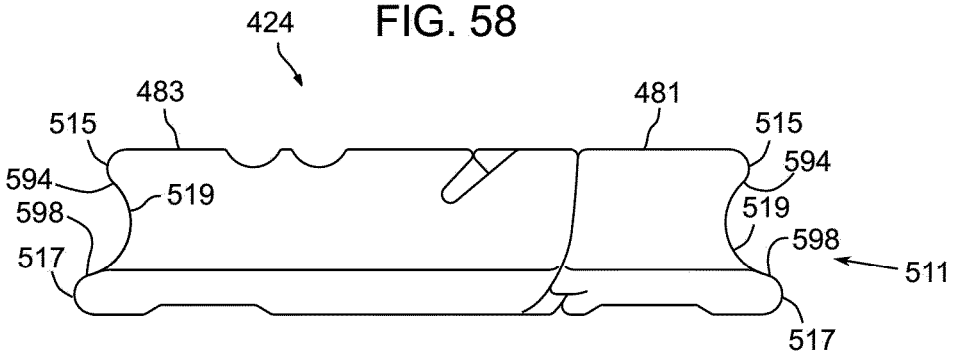

FIG. 59

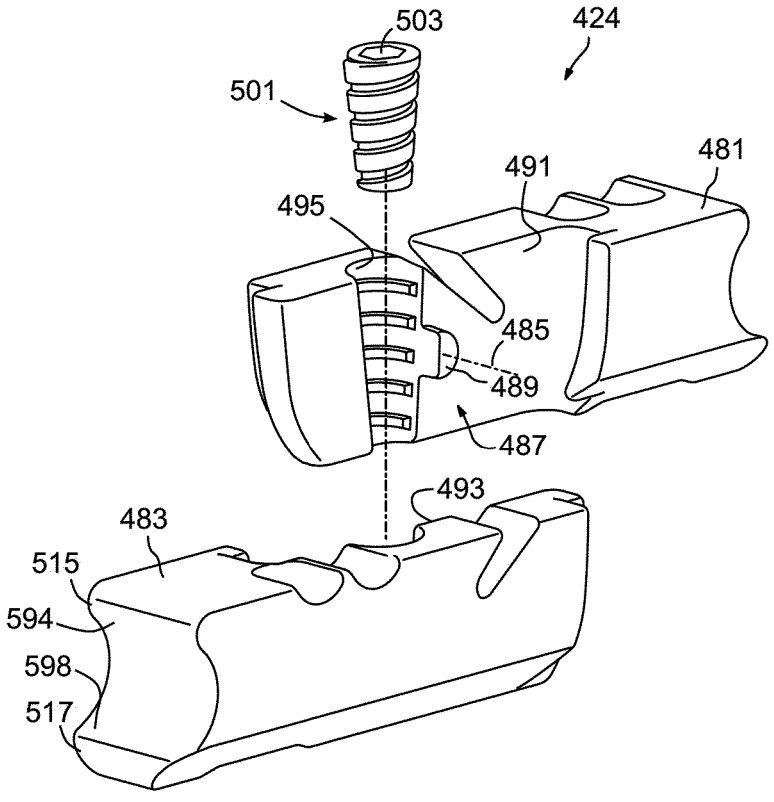

FIG. 60

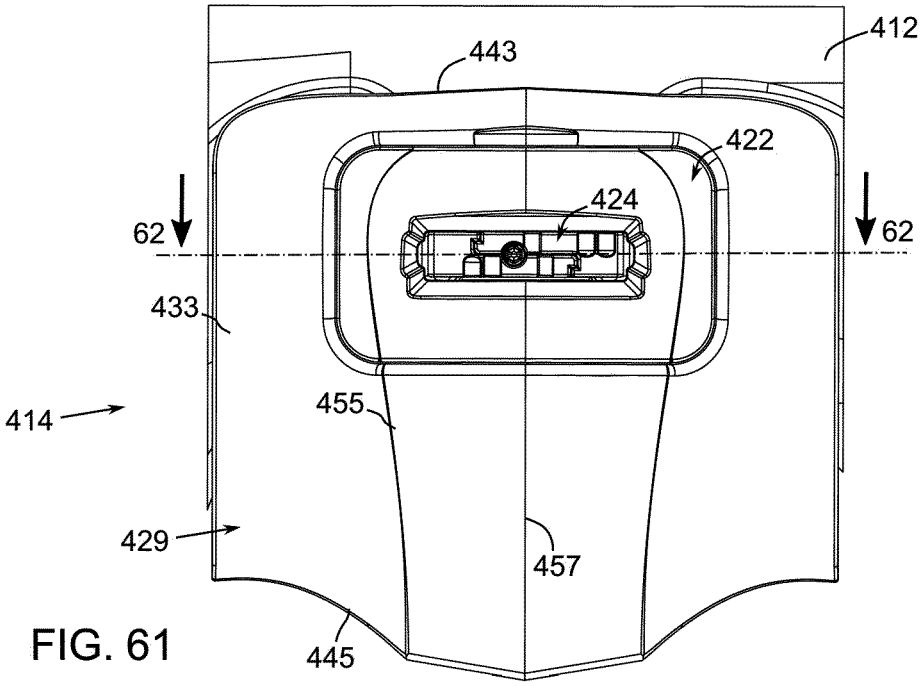

FIG. 61

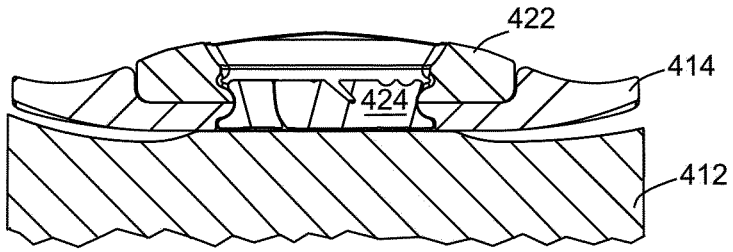

FIG. 62

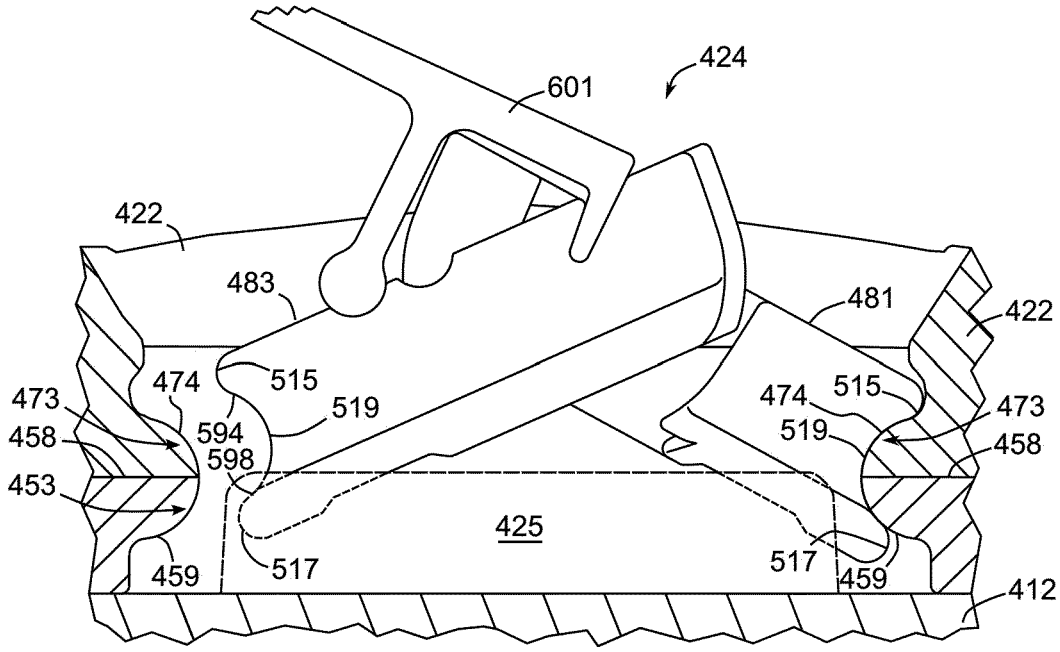

FIG. 63

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4267653 A, Hahn **[0004]**
- US 6986216 B, Emrich and Briscoe **[0004] [0113] [0121] [0209] [0251]**
- US 10612214 B **[0230] [0243] [0244]**