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Manson et al.

(54) BIPLANAR FORCEPS REDUCERS AND METHODS OF USE

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(21) Appl. No.: **19/203,857**

(22) Filed: **May 9, 2025**

Related U.S. Application Data

(63) Continuation of application No. 17/522,164, filed on Nov. 9, 2021, now Pat. No. 12,318,121.

(60) Provisional application No. 63/111,606, filed on Nov. 9, 2020.

Publication Classification

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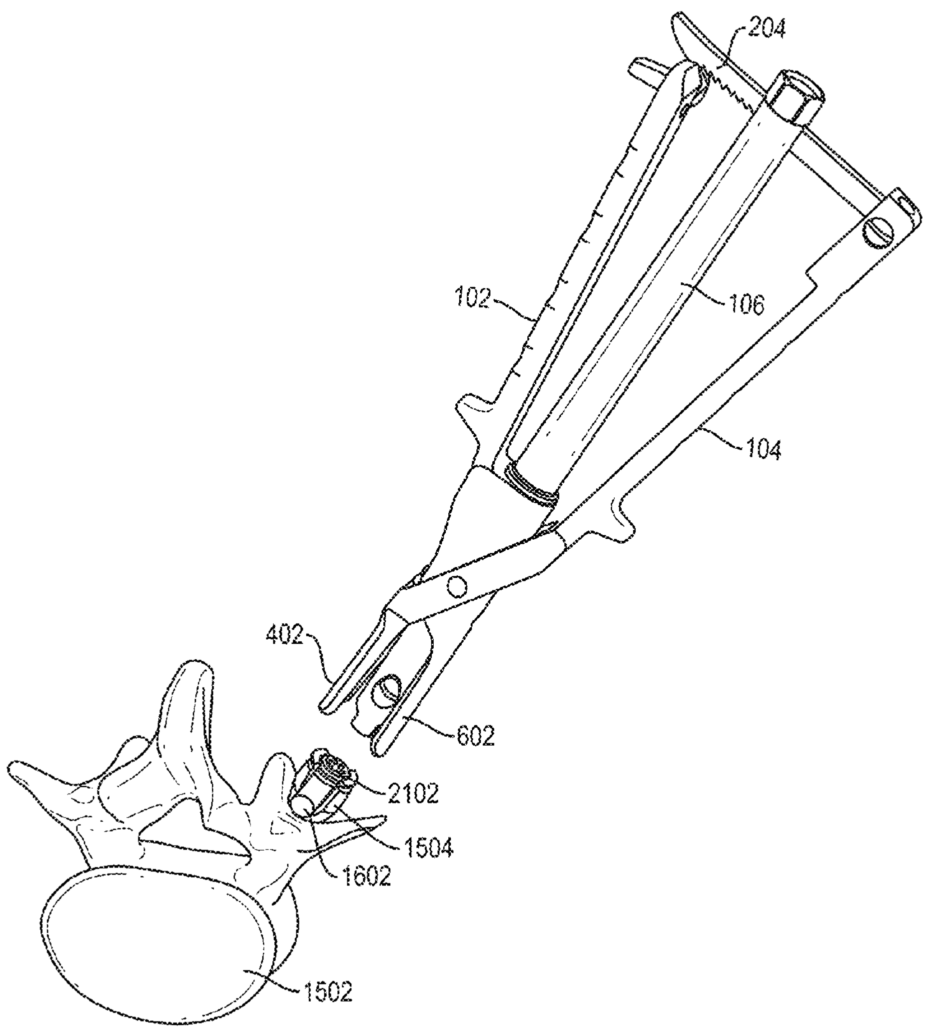
A61B 17/70 (2006.01)

(52) **U.S. Cl.**
CPC *A61B 17/7086* (2013.01)

(57) **ABSTRACT**

Biplanar forceps reducer instruments and methods are disclosed herein. The instruments disclosed herein can engage an implant, such as a bone anchor receiver head, and reduce or move a spinal fixation element, such as a rod, in two planes to move the rod into a channel formed in the receiver head. Further, the biplanar forceps reducer instruments disclosed herein can allow for introduction and tightening of a set screw using an inserter that can pass through a cannulated tube of the reducer. The low profile and biplanar reduction functionality can allow a single type of reducer instrument to couple with each bone anchor along a spinal fixation construct and remain in position until the construct is secured in position.



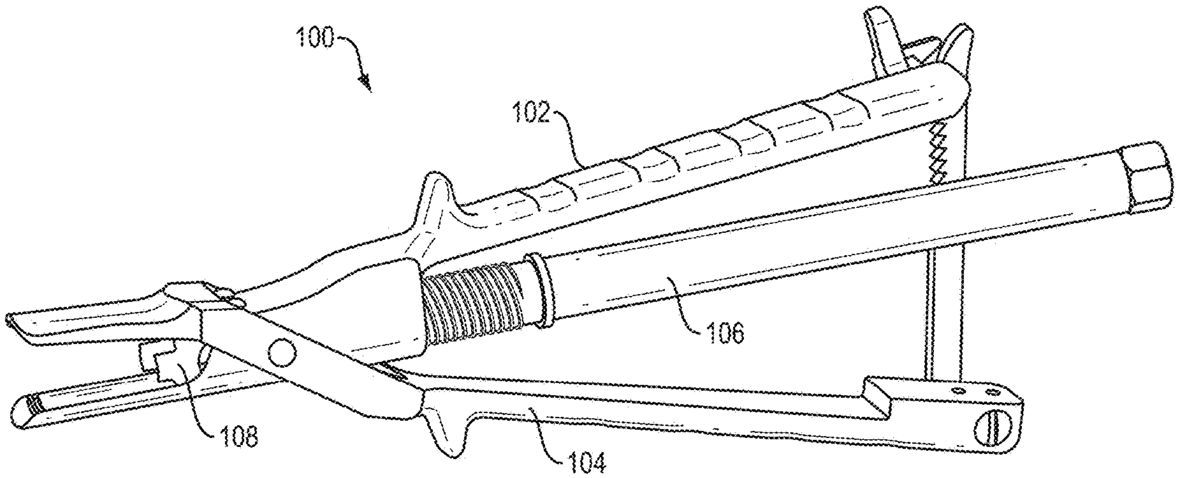


FIG. 1A

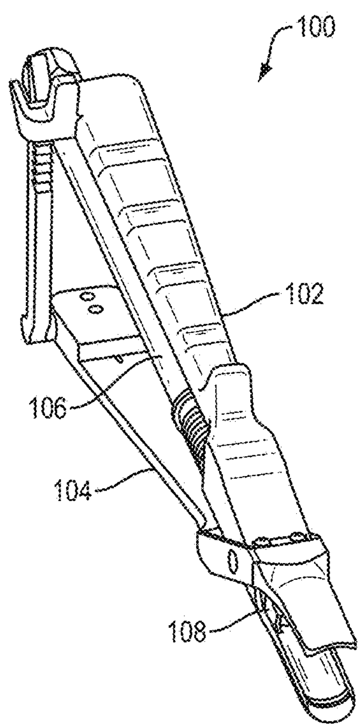


FIG. 1B

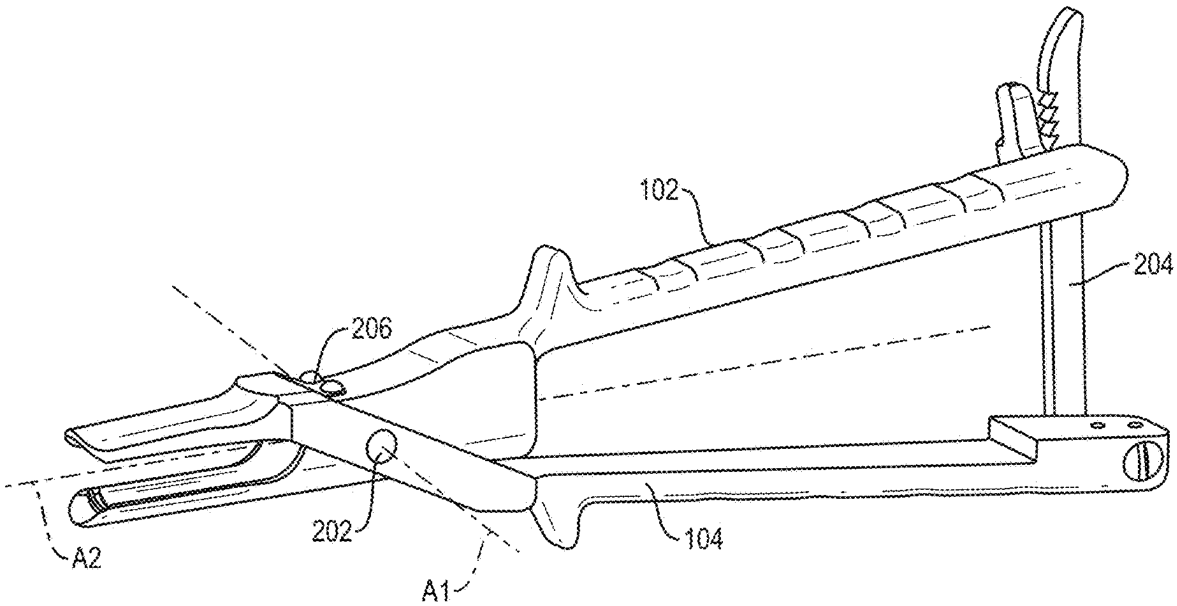


FIG. 2

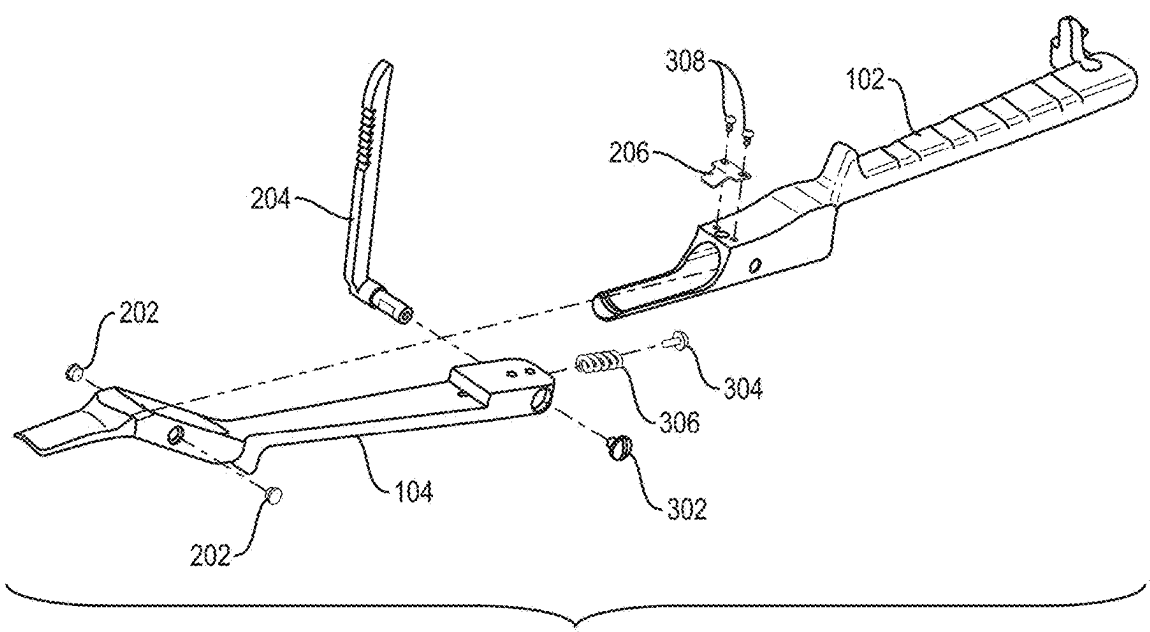


FIG. 3

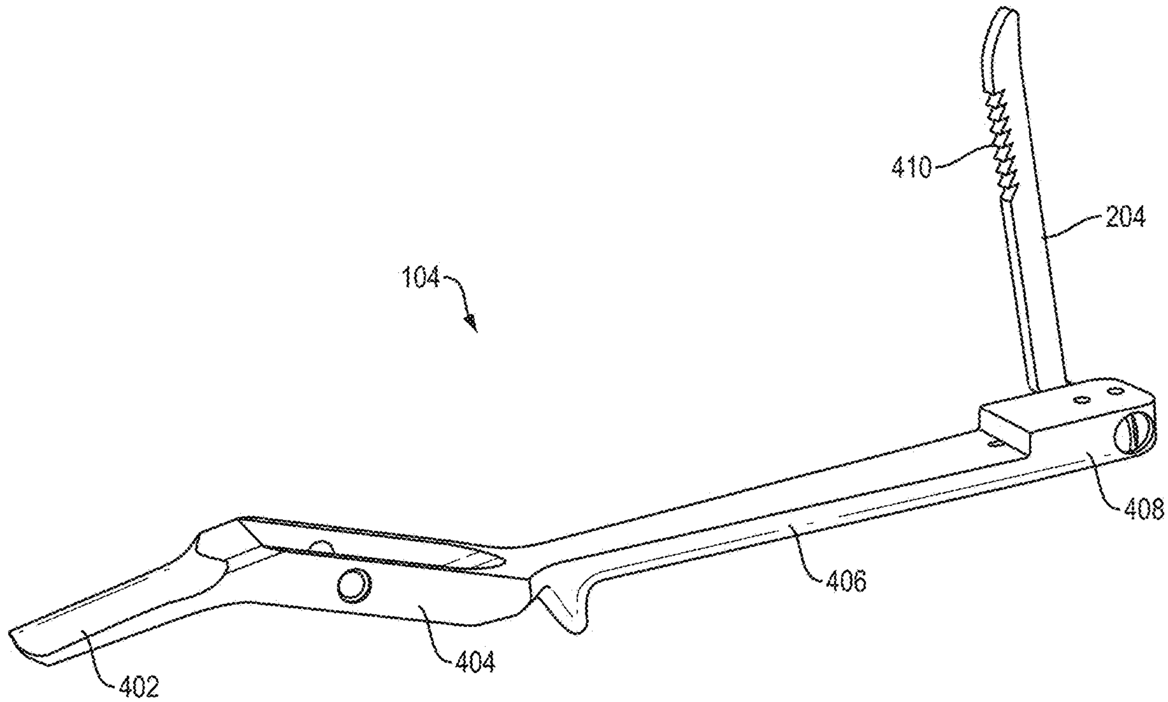

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FIG. 4A

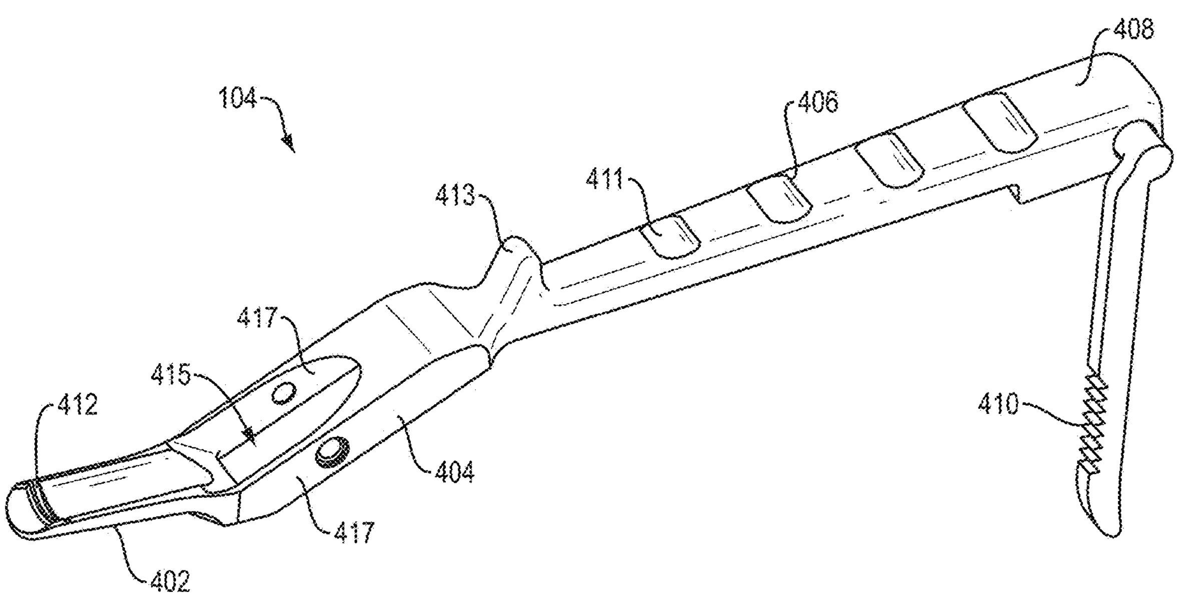
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FIG. 4B

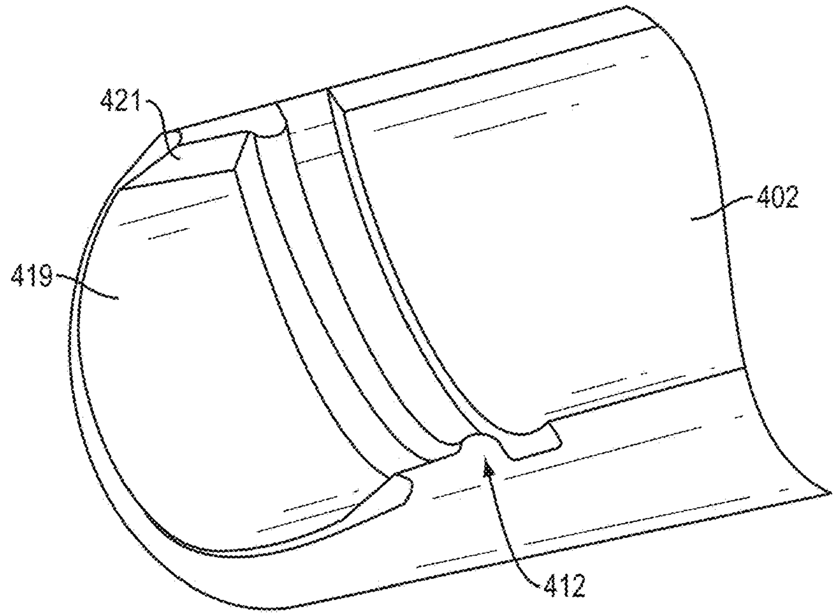

FIG. 4C

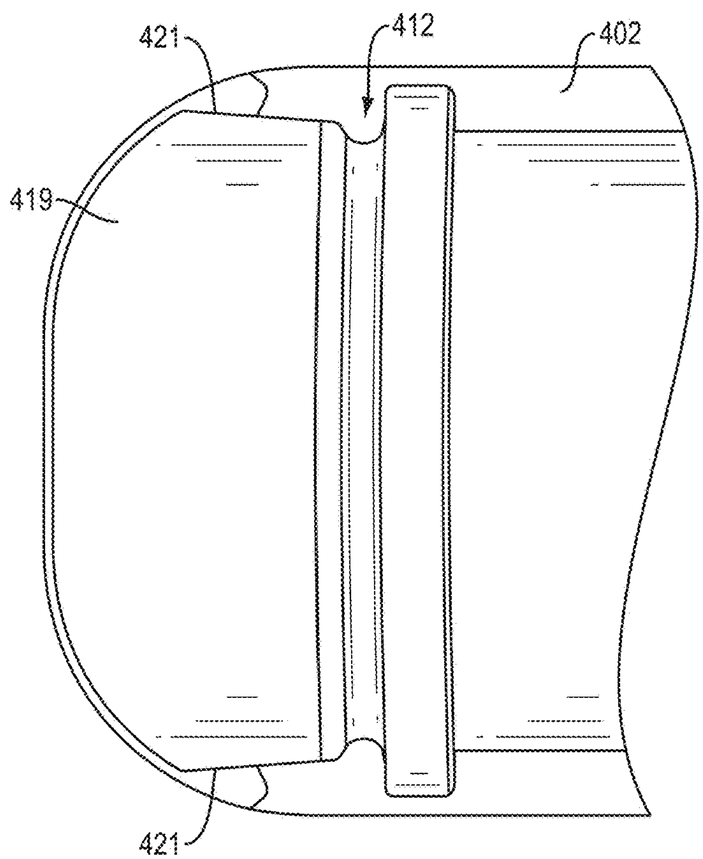

FIG. 4D

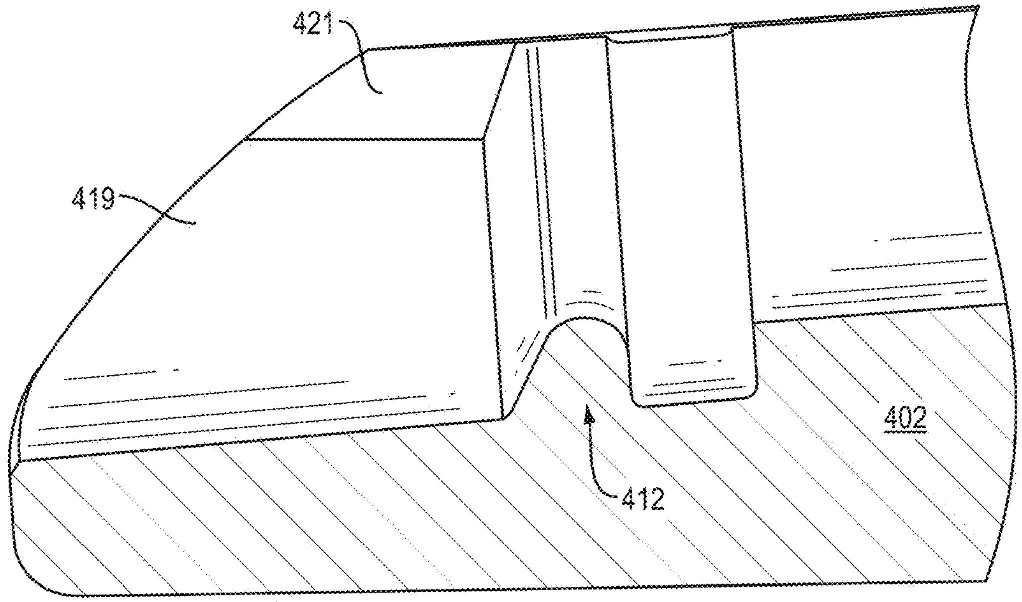

FIG. 4E

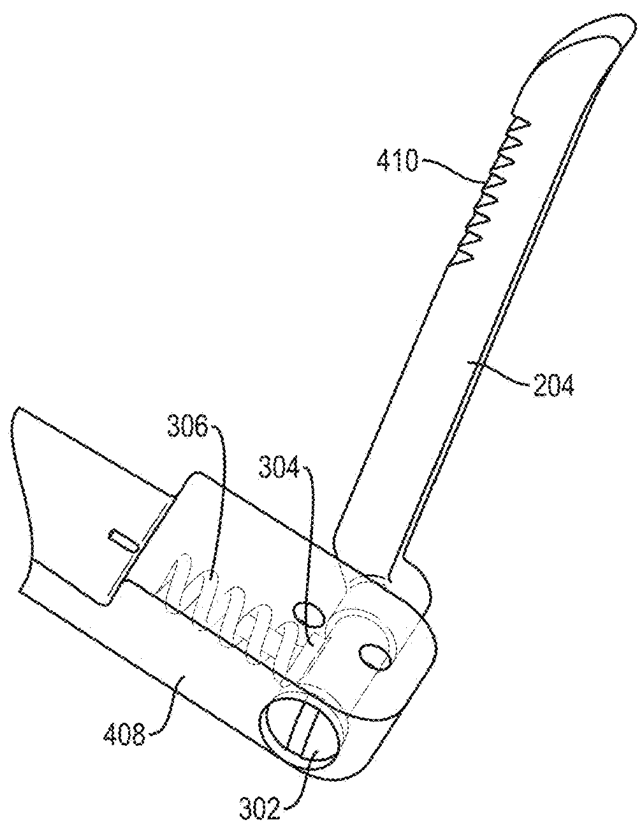

FIG. 5

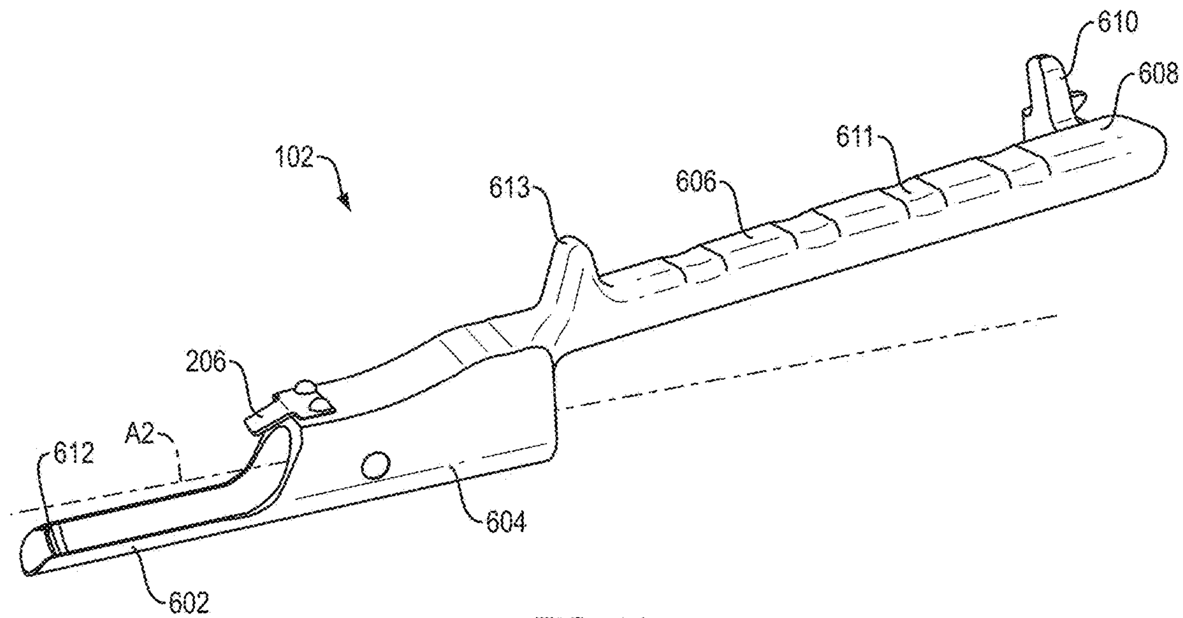
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FIG. 6A

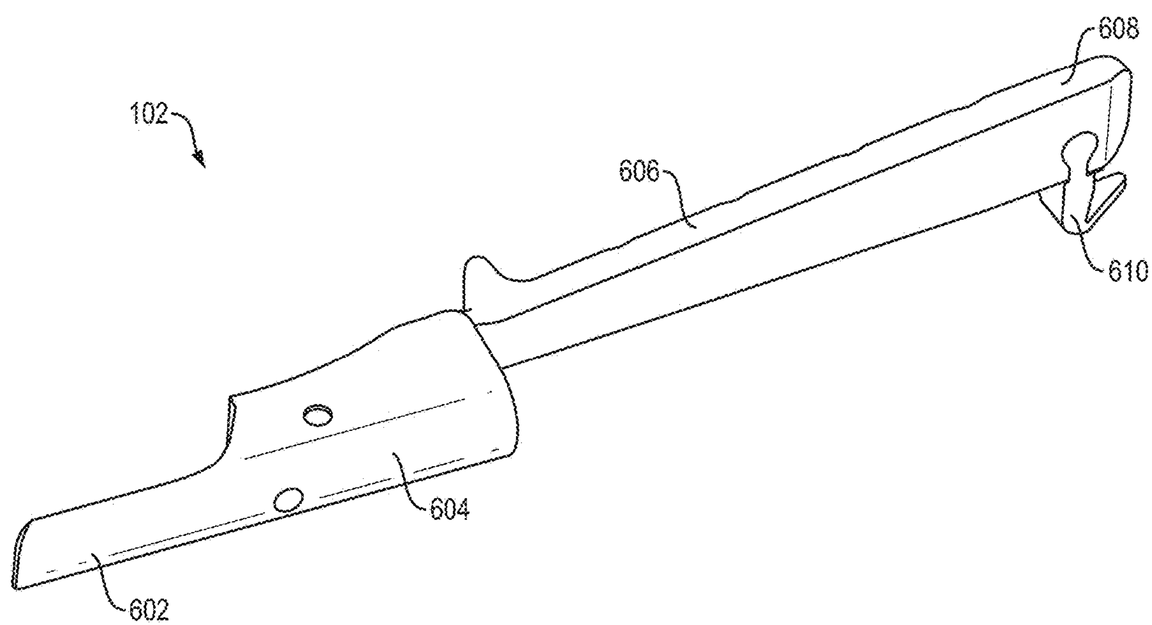
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FIG. 6B

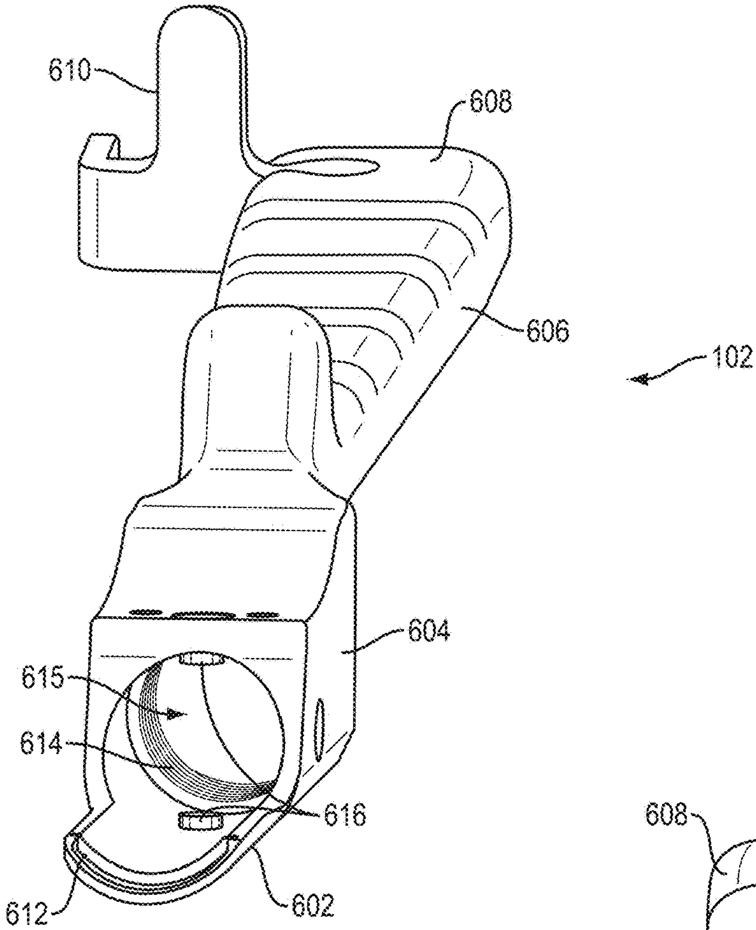
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FIG. 6C

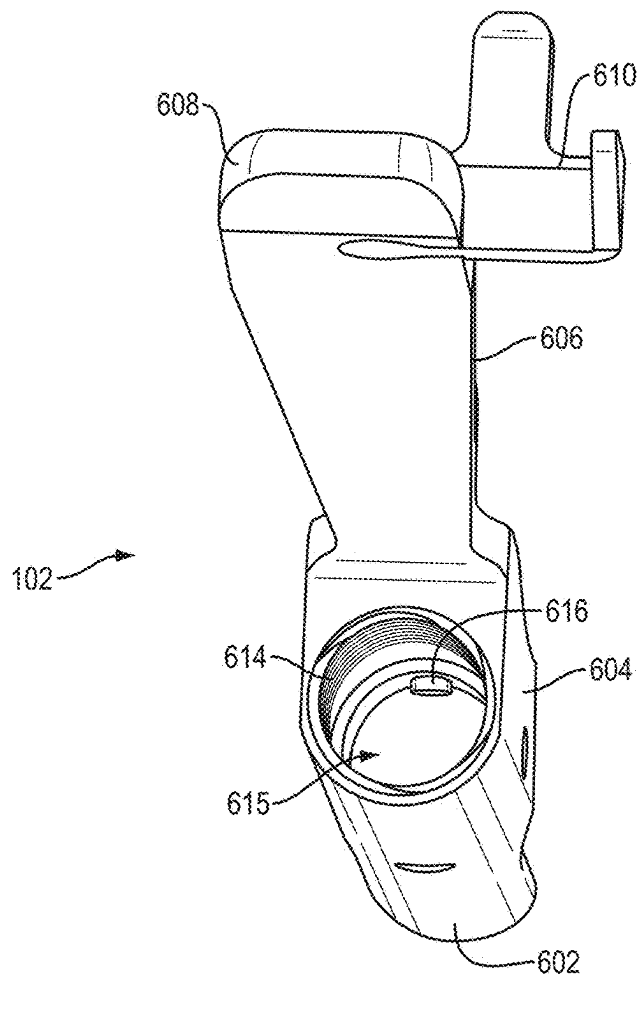
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FIG. 6D

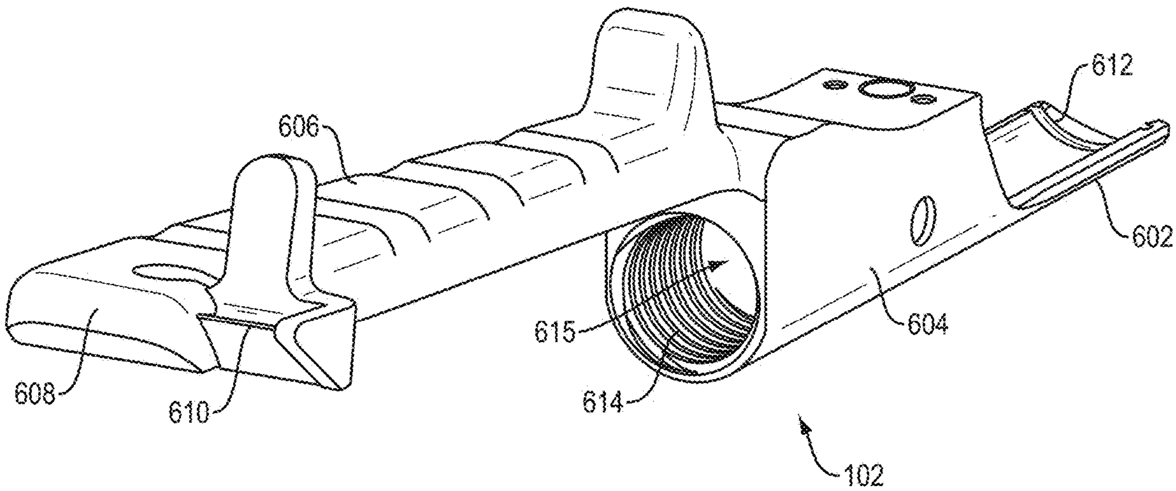
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FIG. 6E

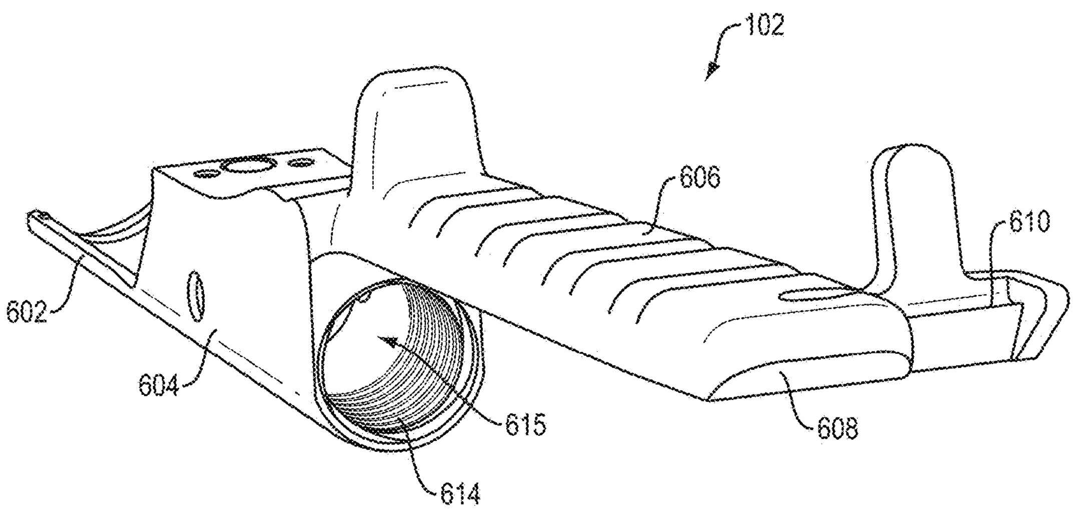
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FIG. 6F

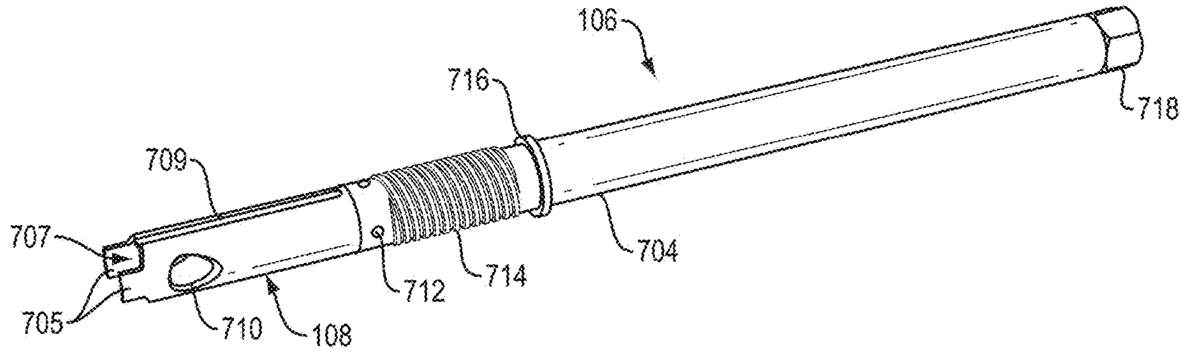


FIG. 7

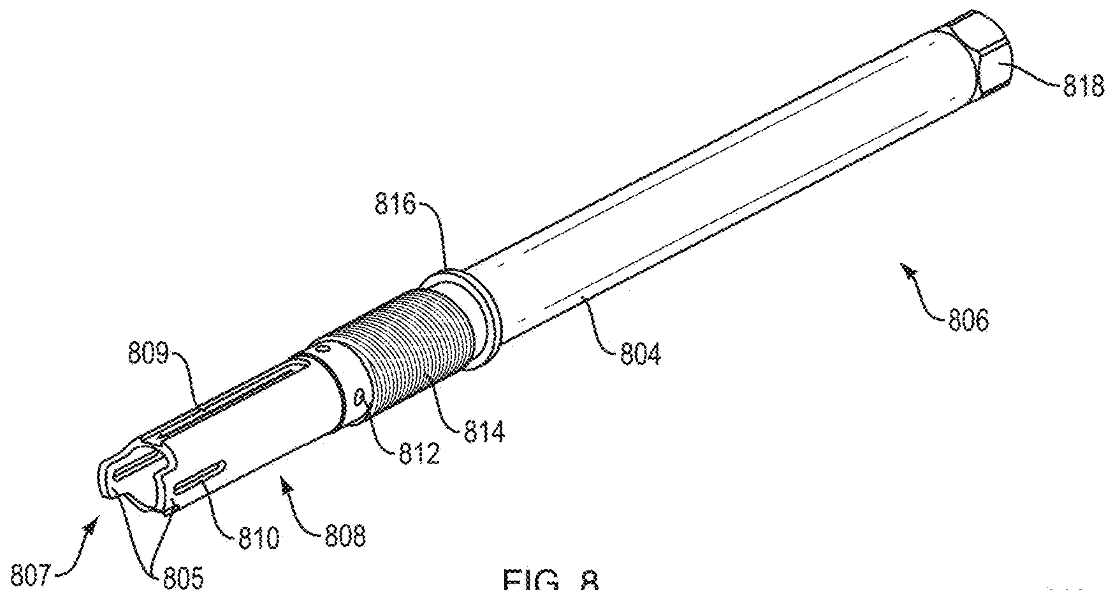
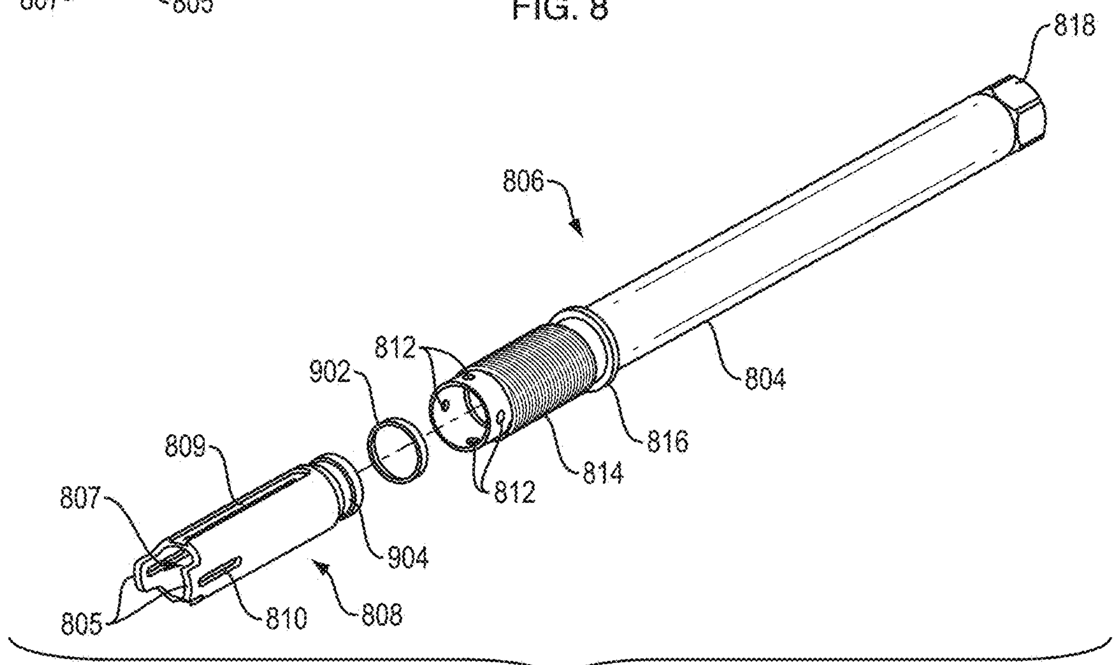


FIG. 8



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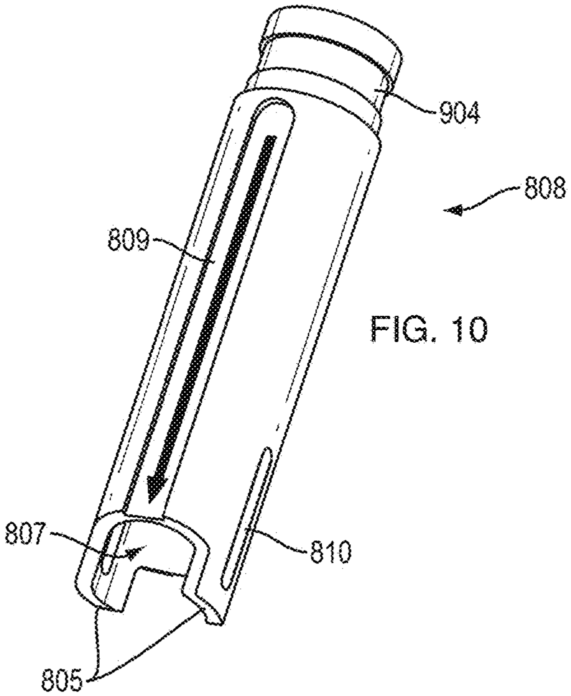

FIG. 10

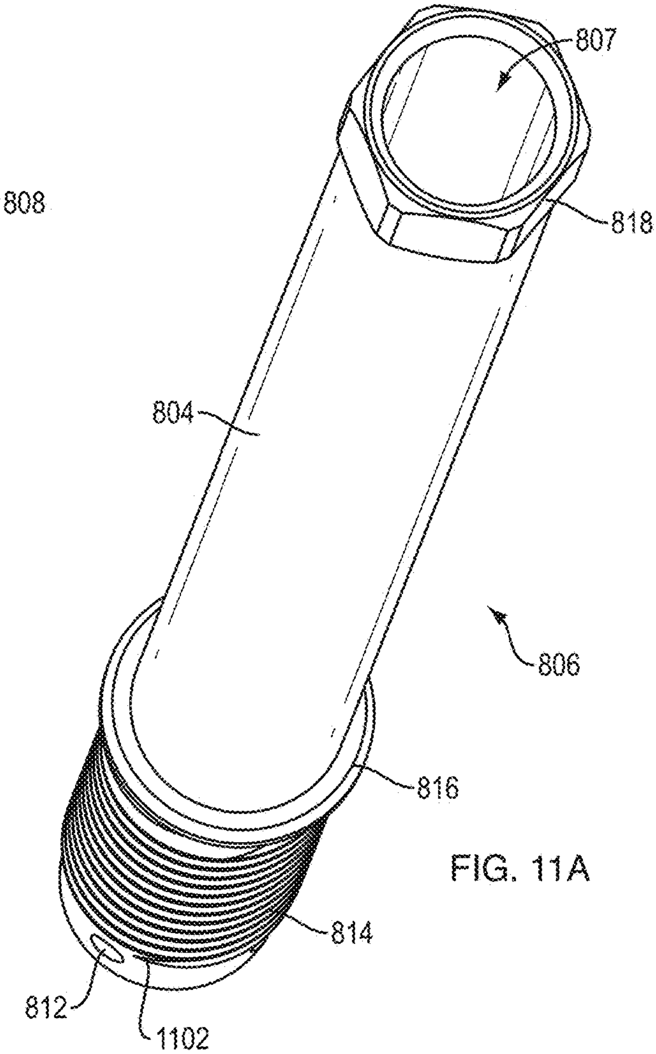

FIG. 11A

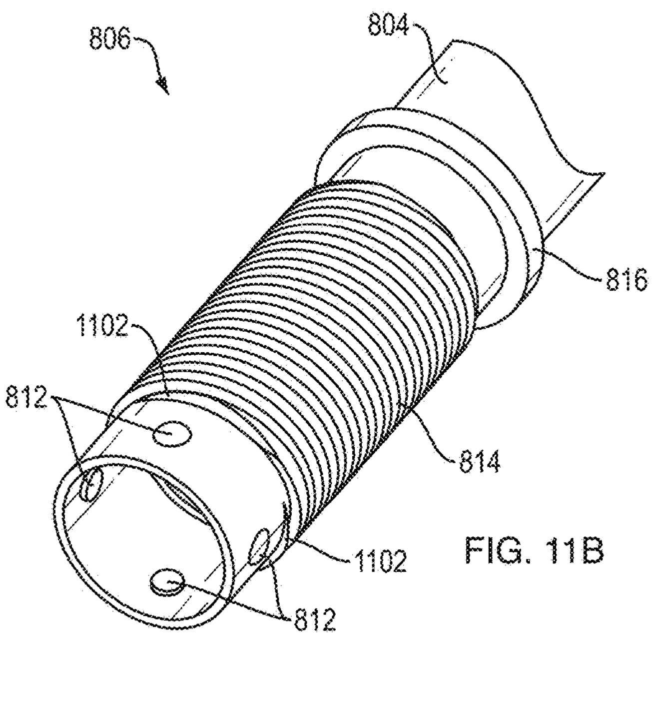

FIG. 11B

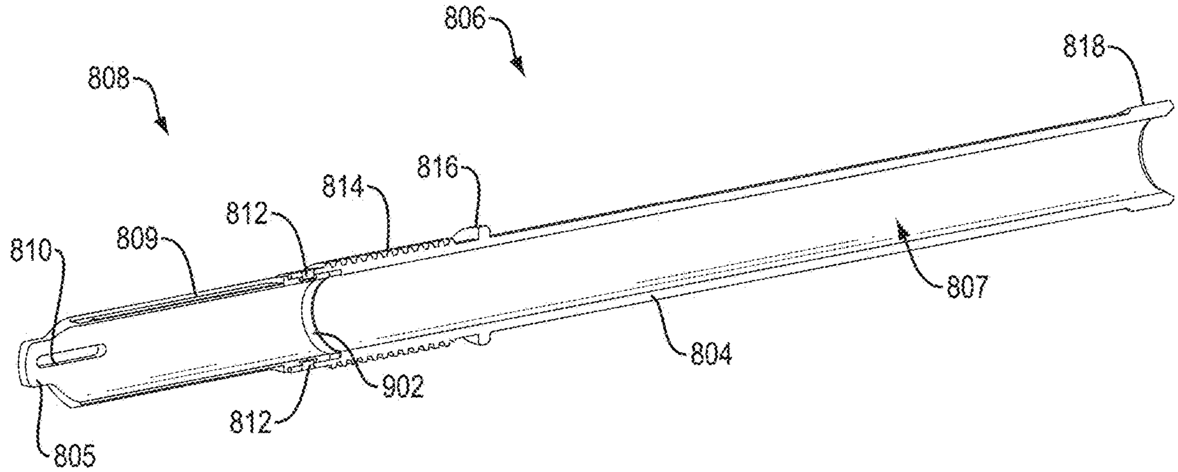

FIG. 12A

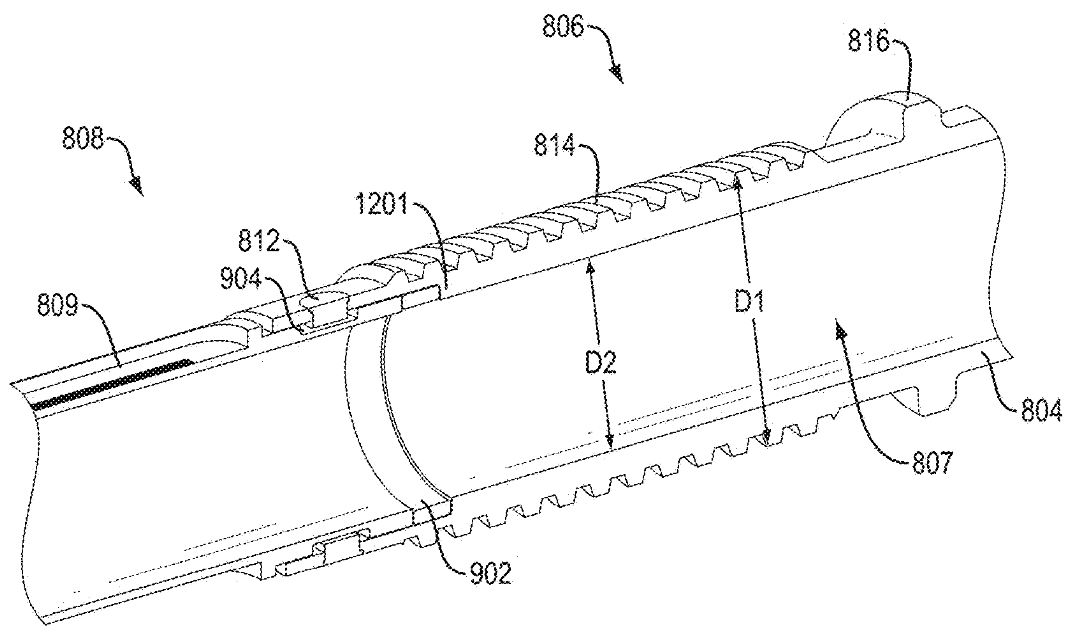

FIG. 12B

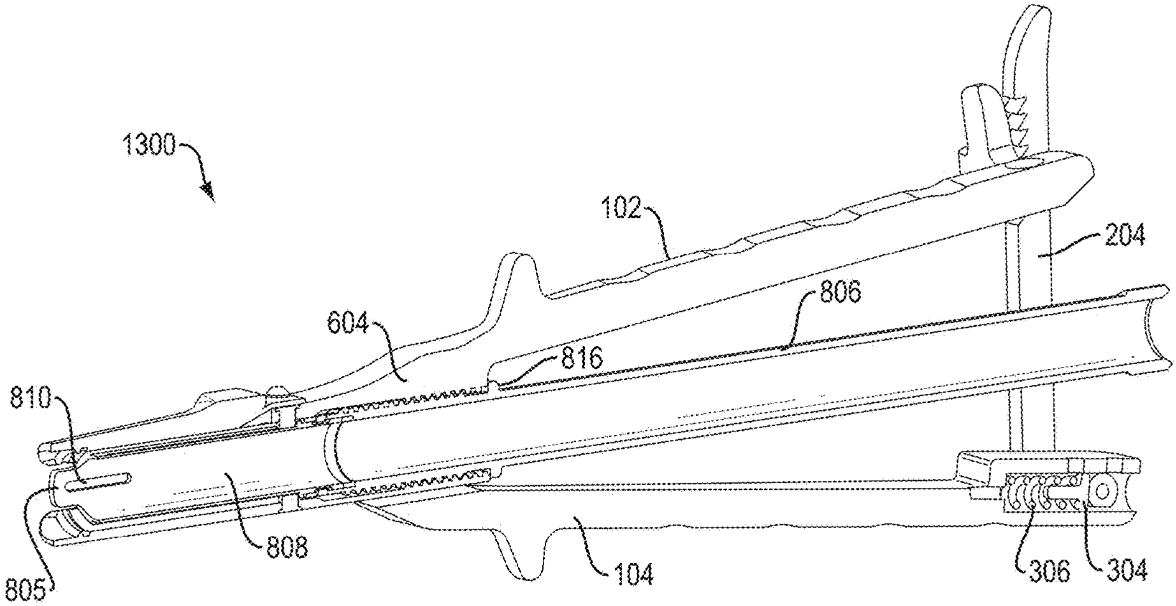
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FIG. 13

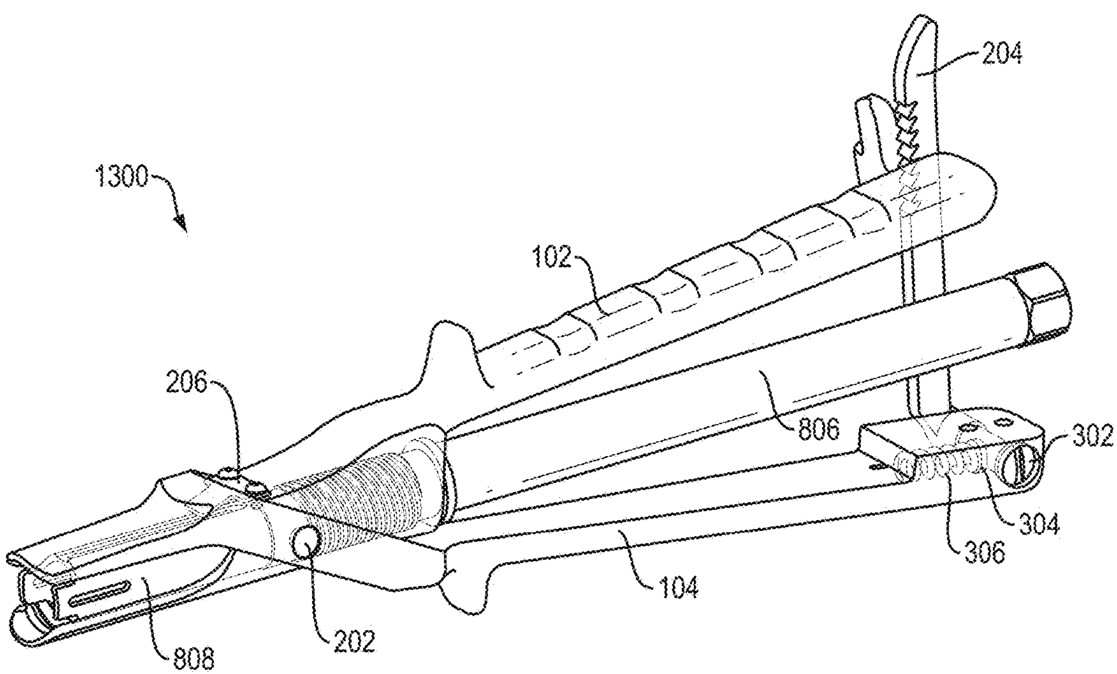
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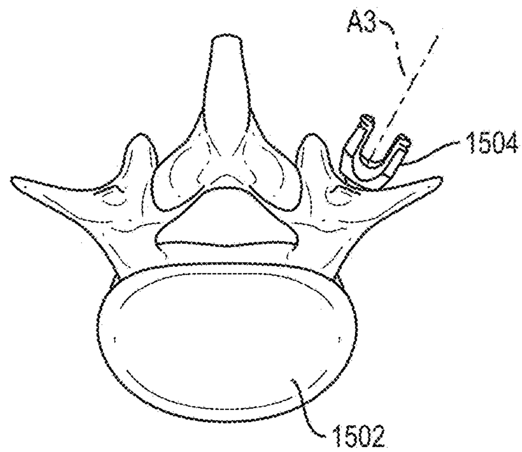
FIG. 14



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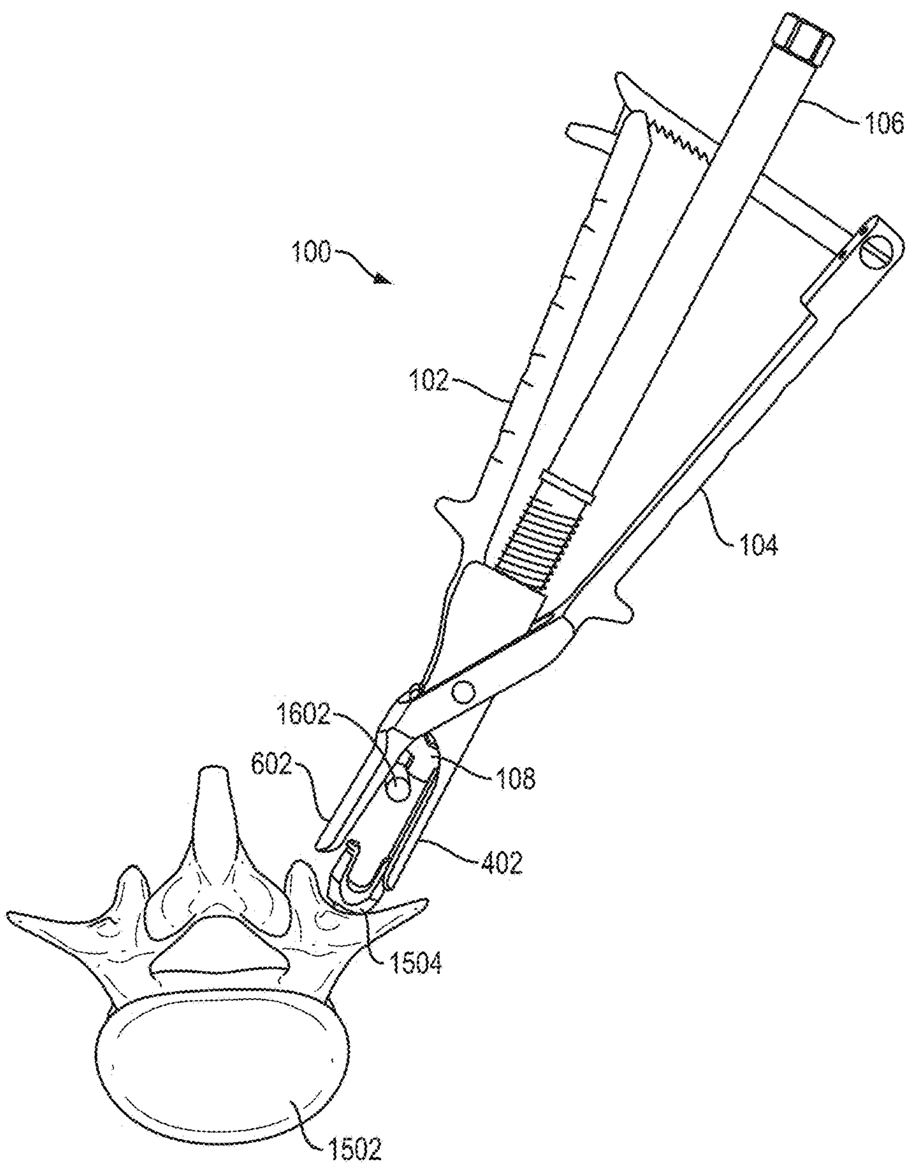

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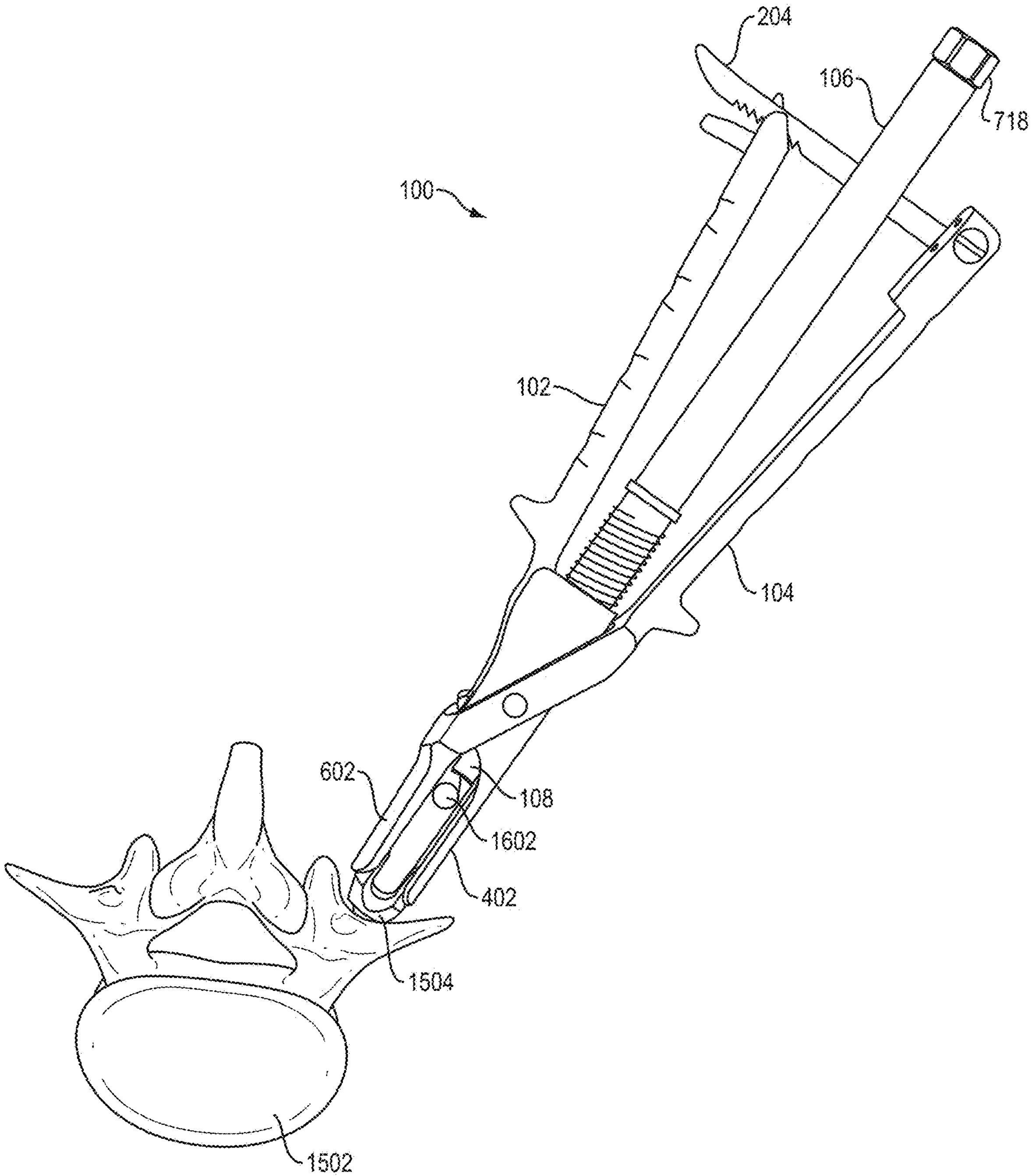
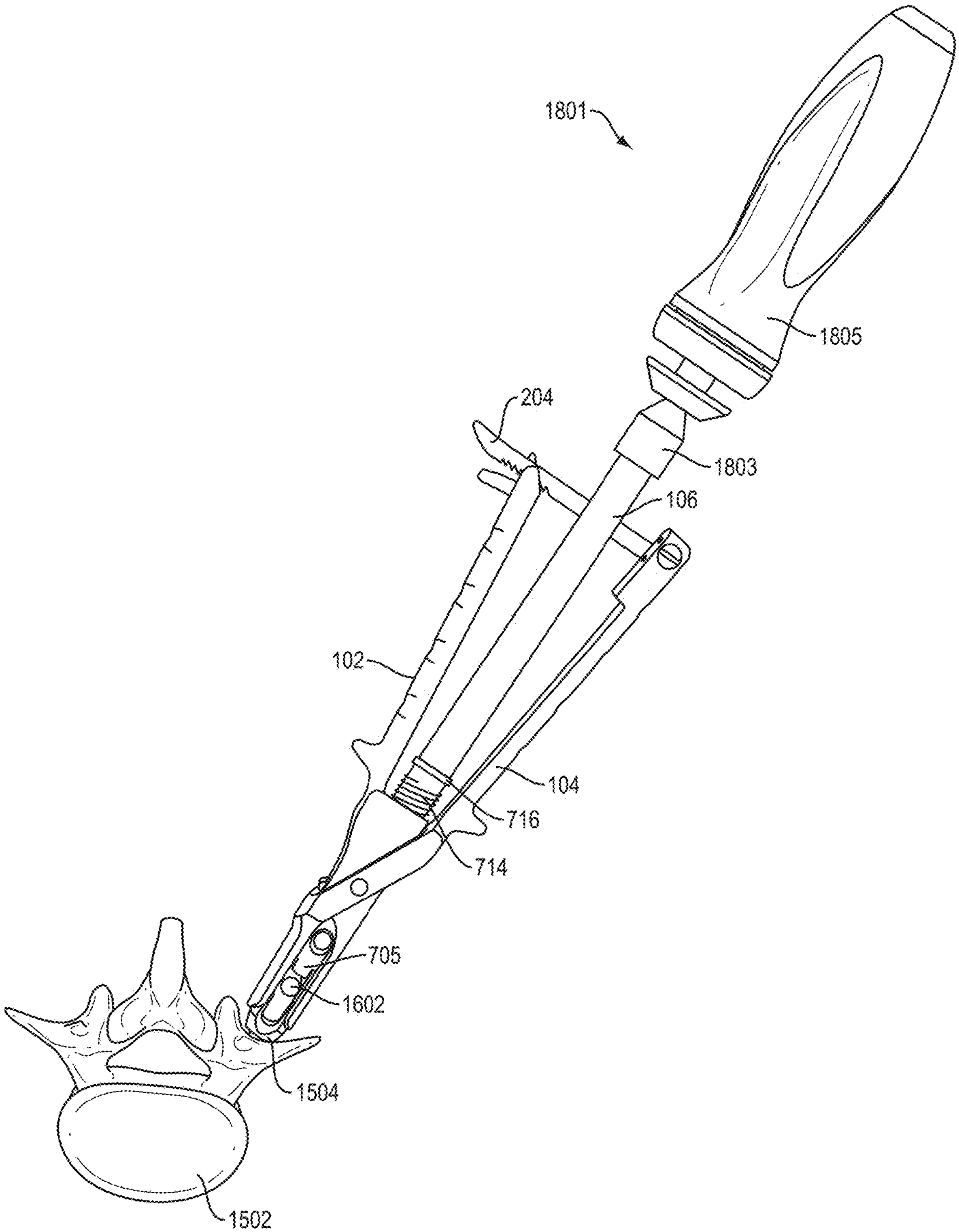


FIG. 17



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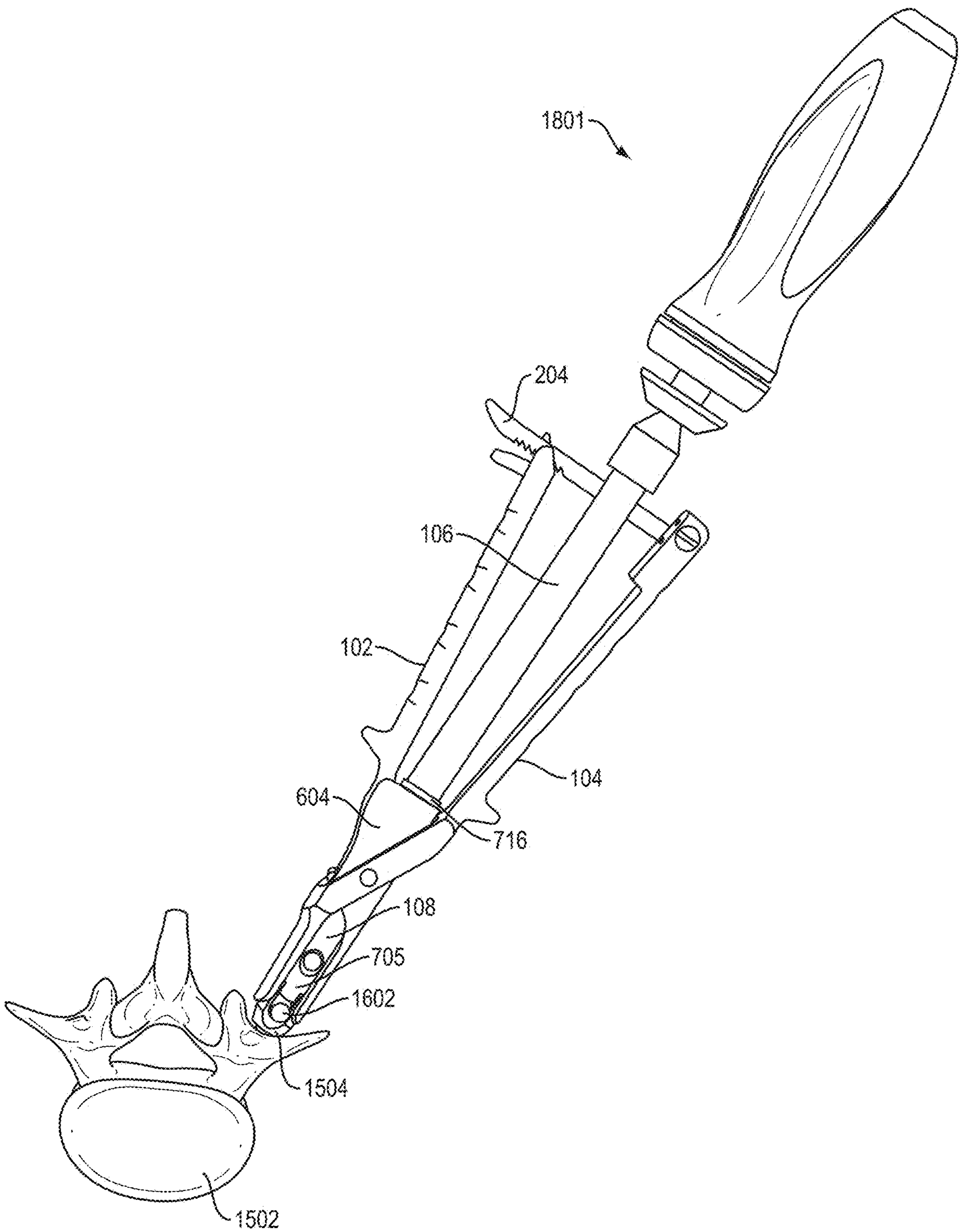

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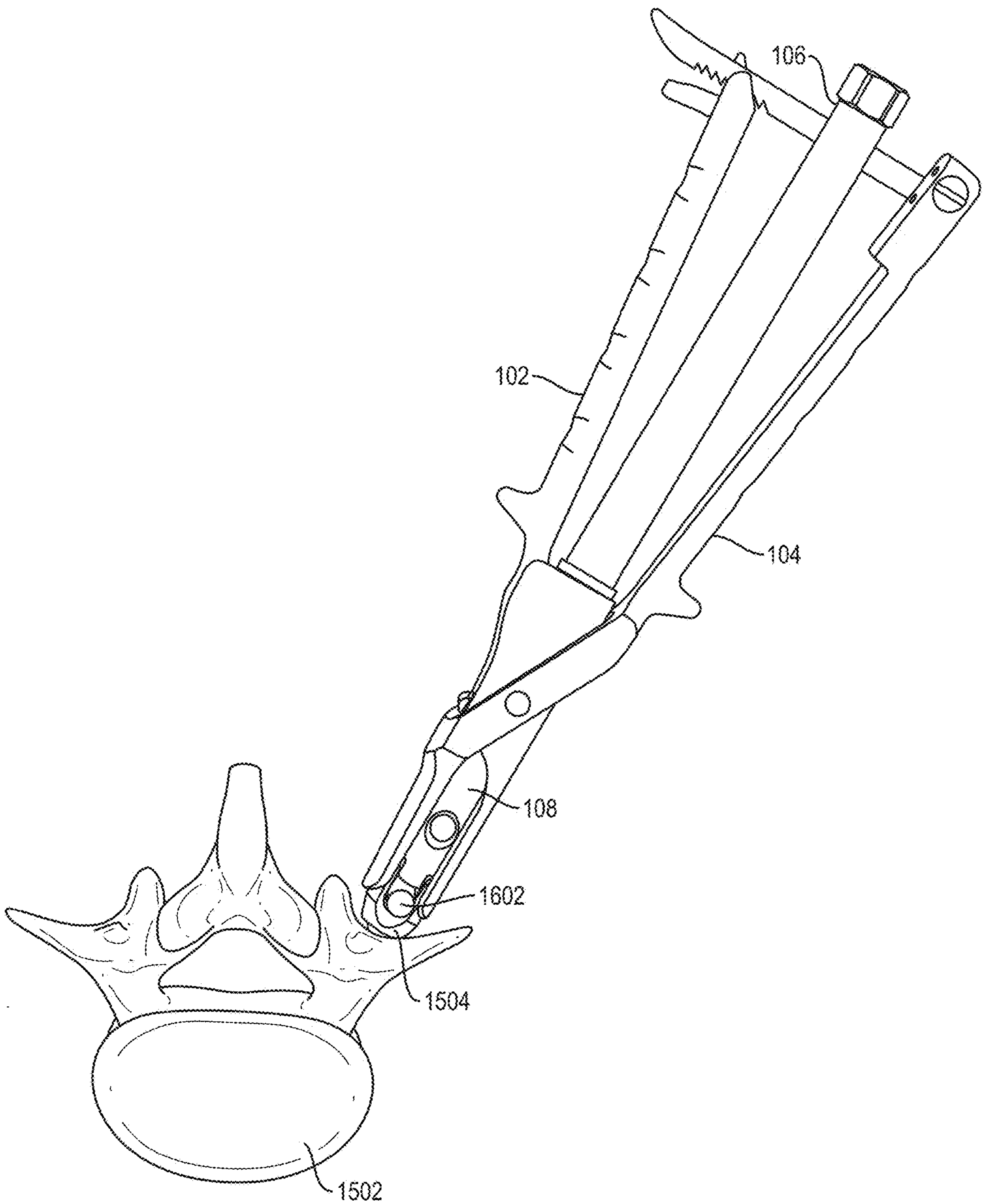

FIG. 20

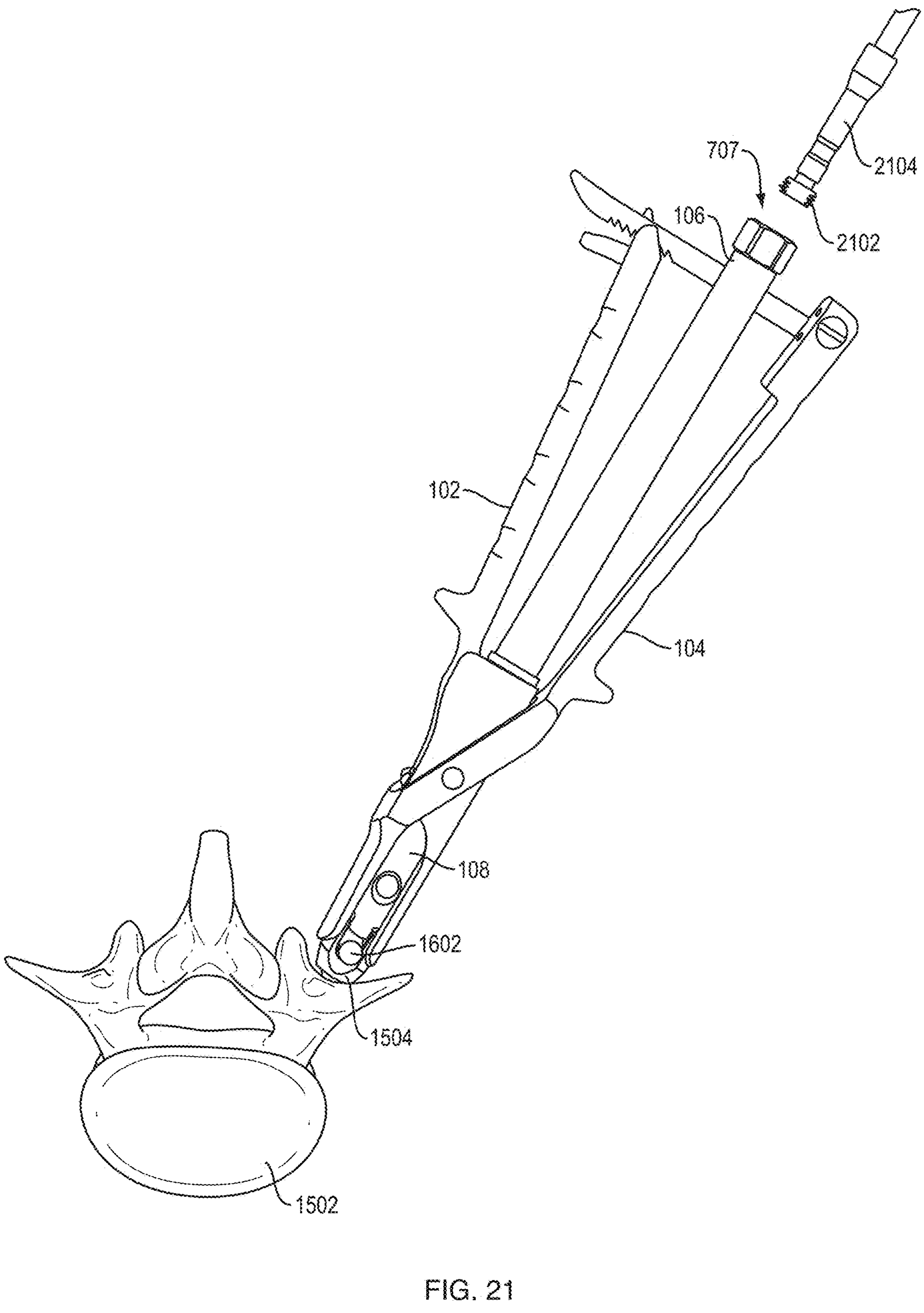

FIG. 21

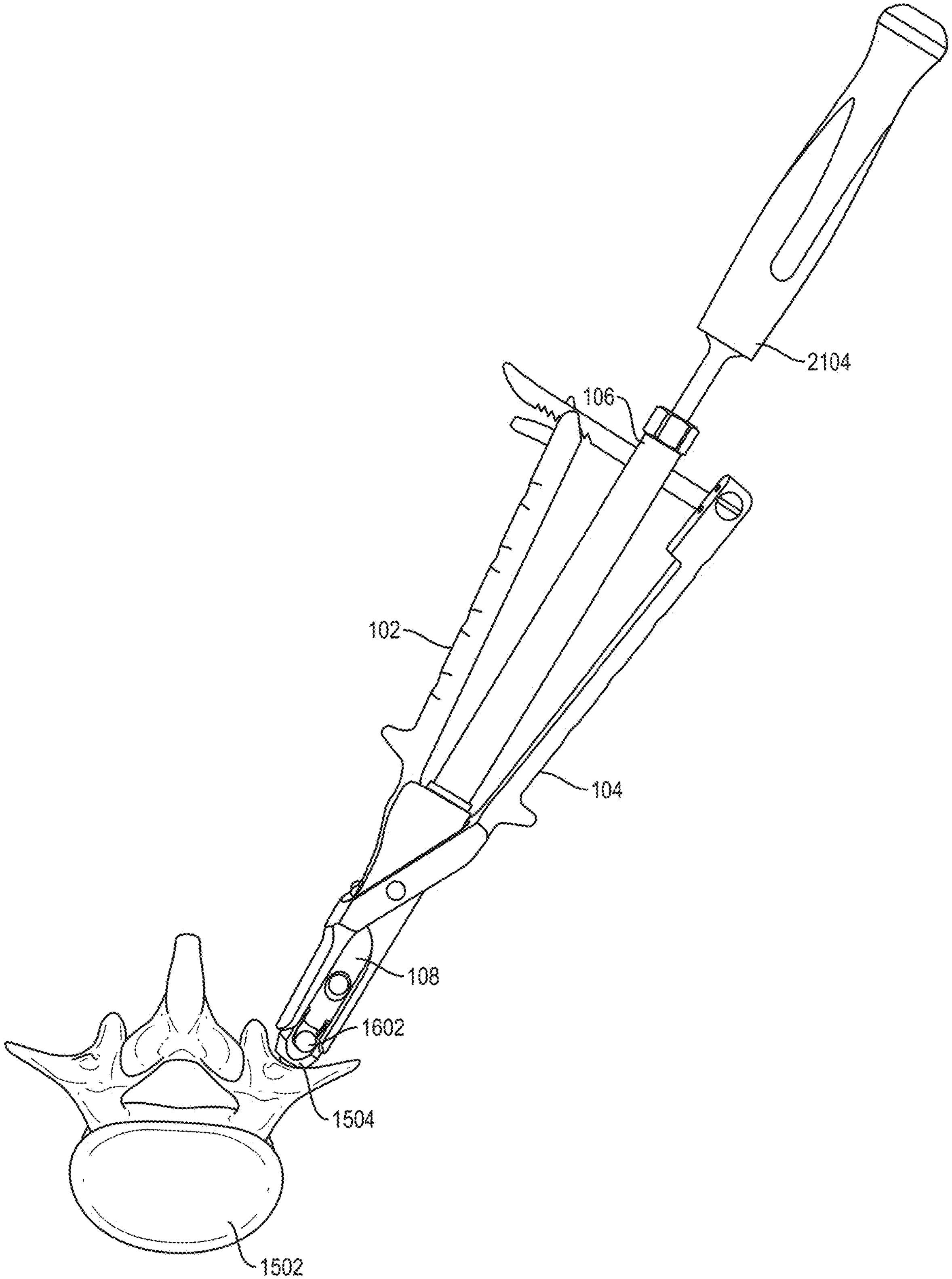

FIG. 22

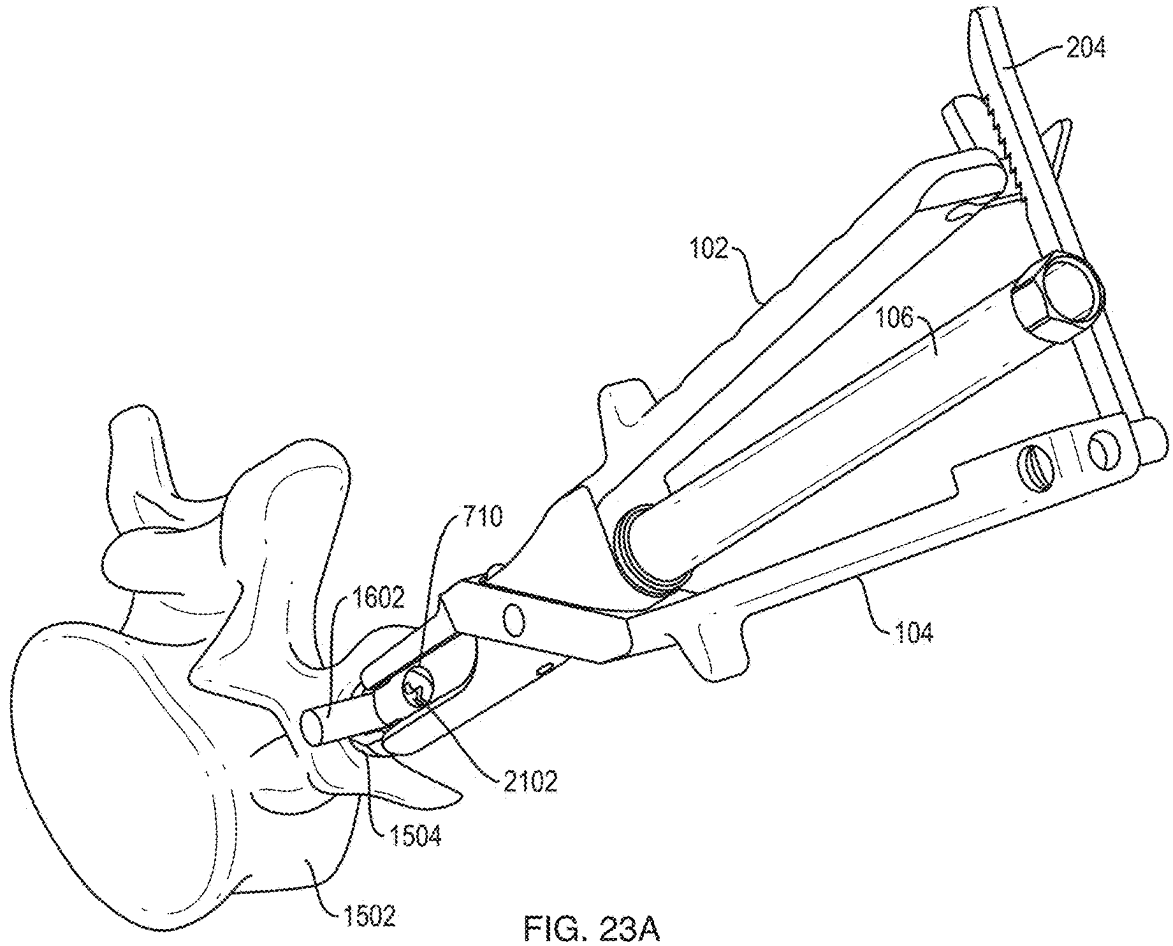

FIG. 23A

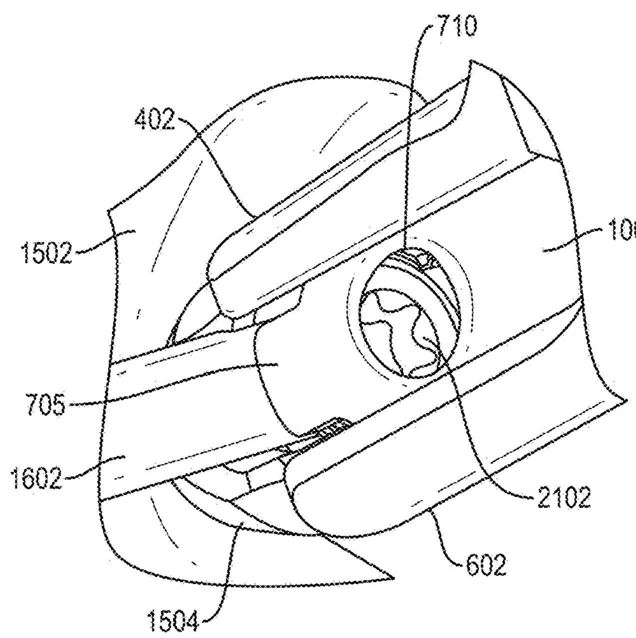

FIG. 23B

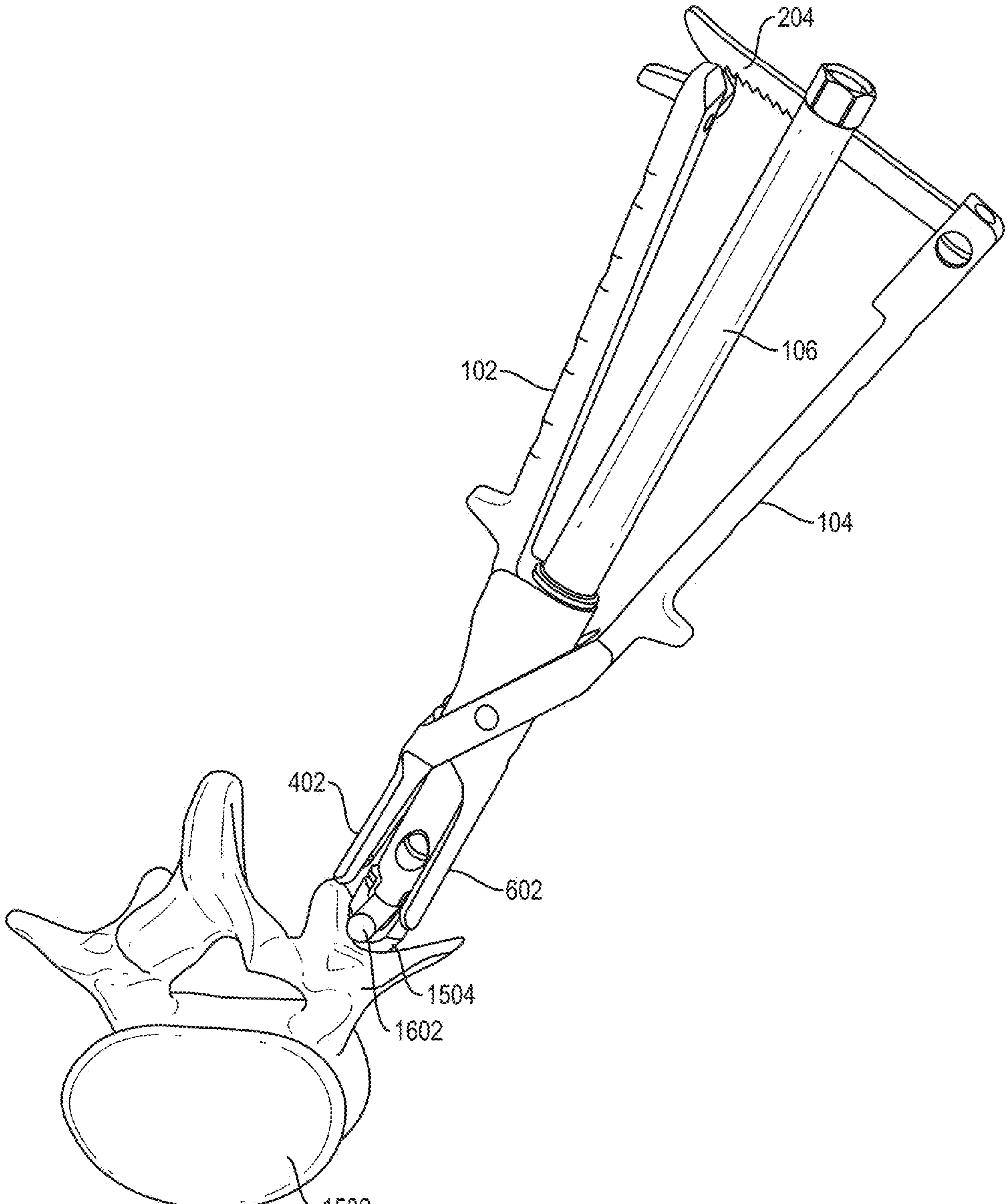

FIG. 24

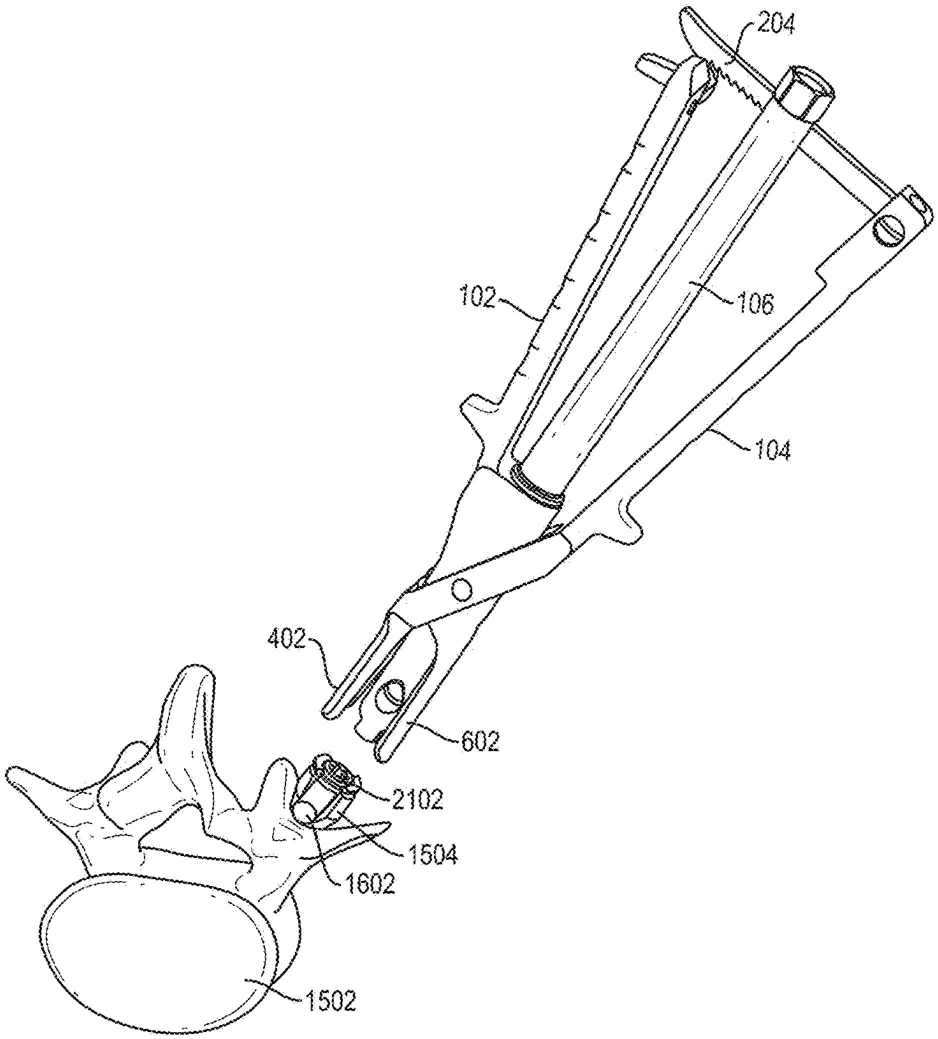
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FIG. 25

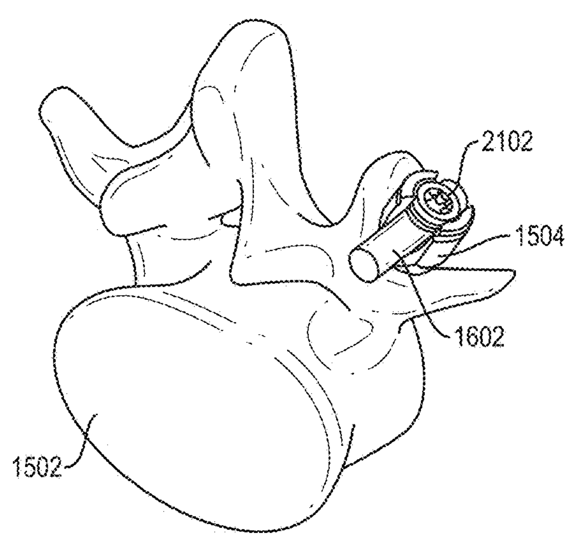
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FIG. 26

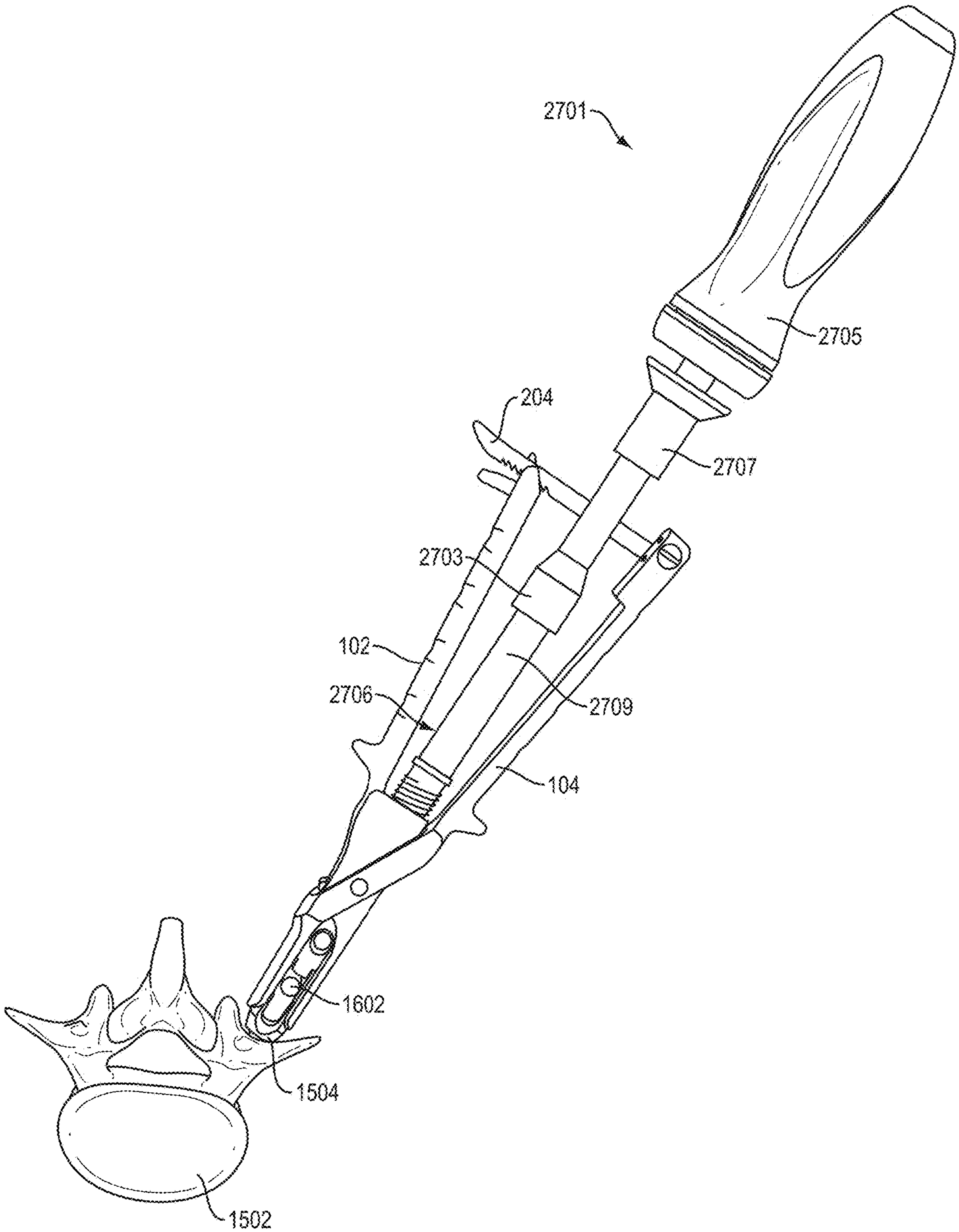


FIG. 27A

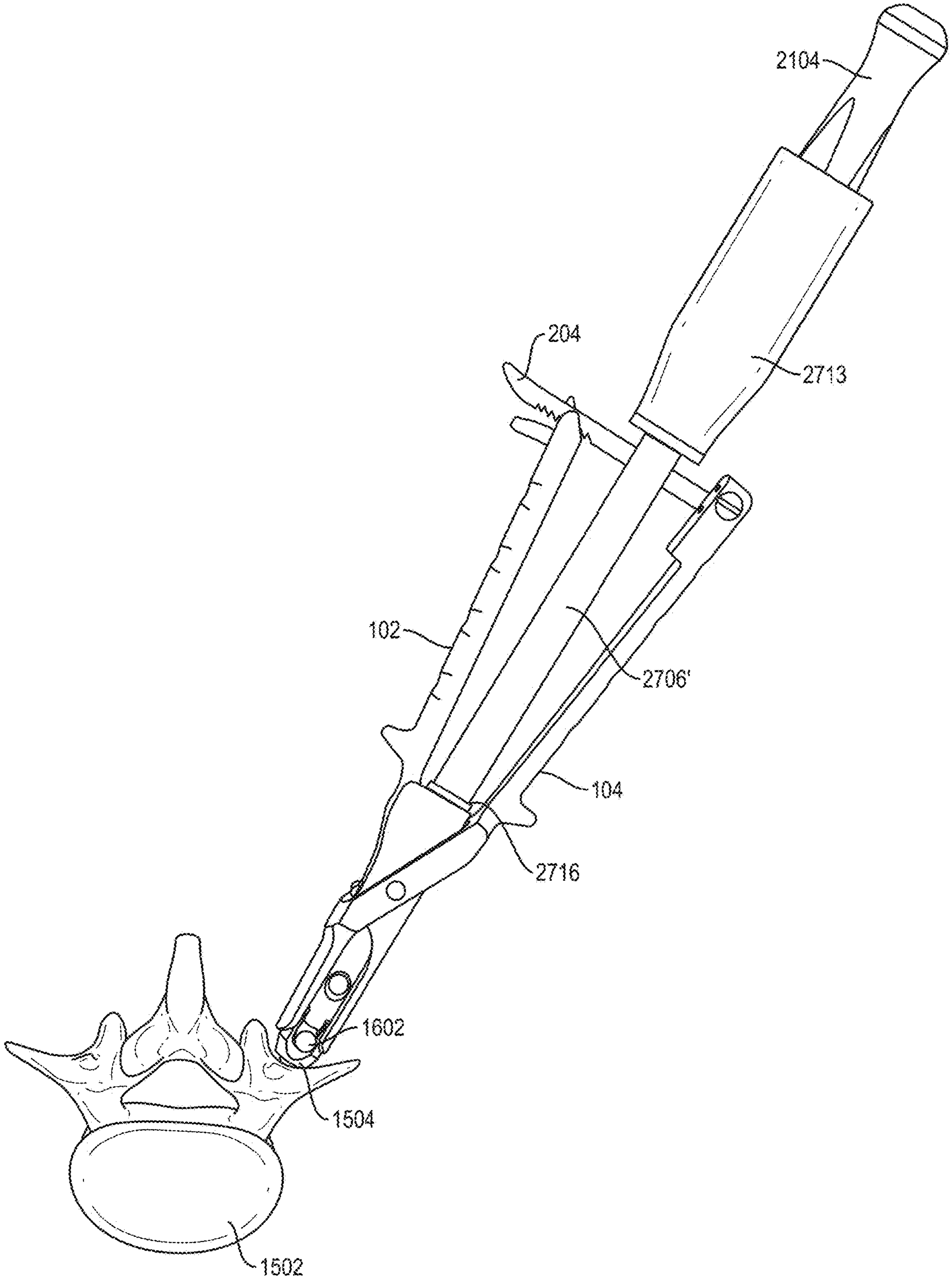


FIG. 27B

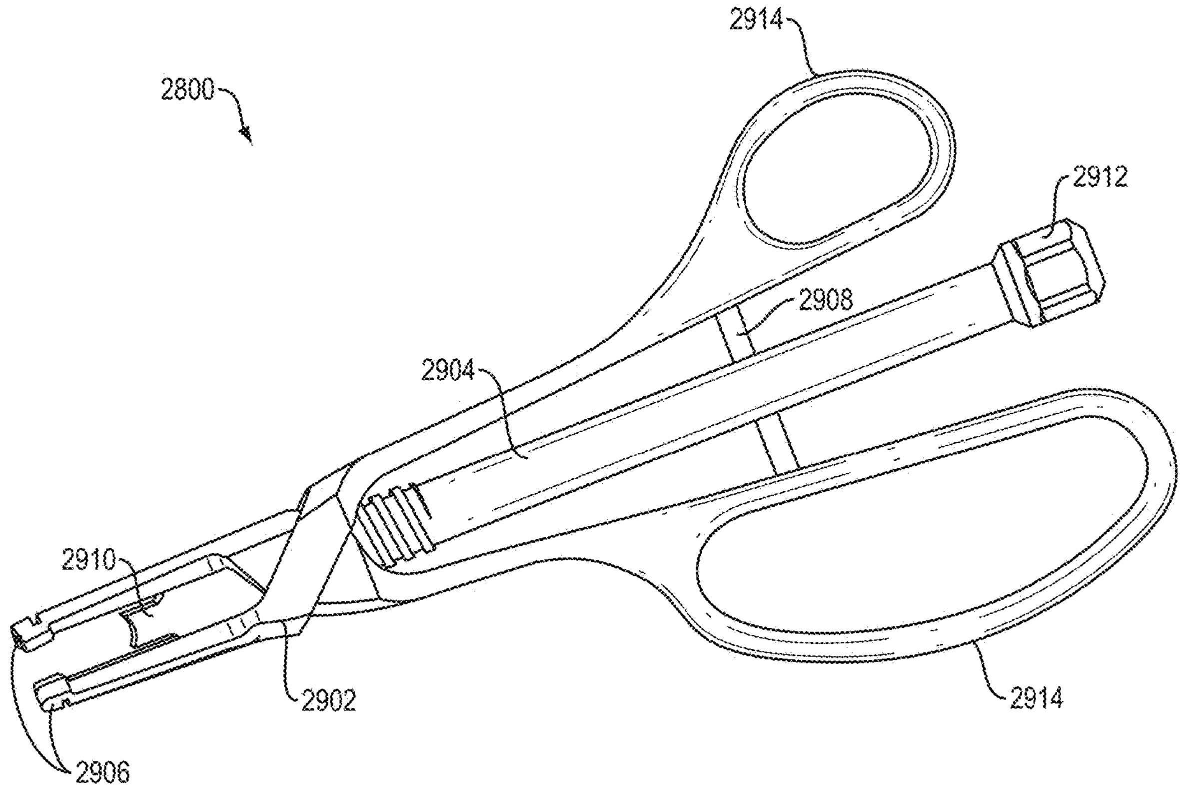


FIG. 28

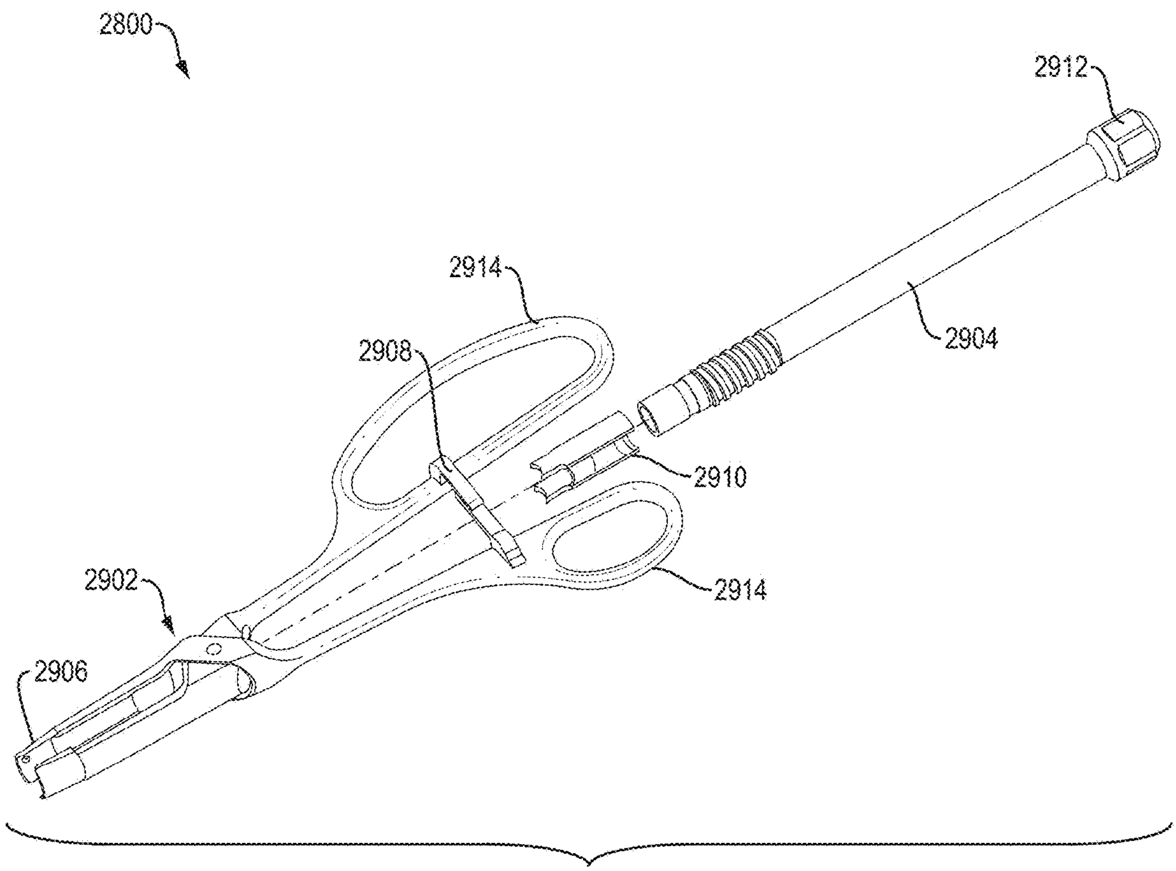


FIG. 29

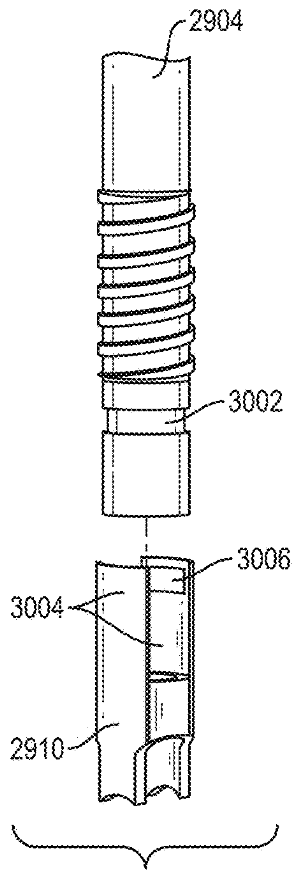


FIG. 30

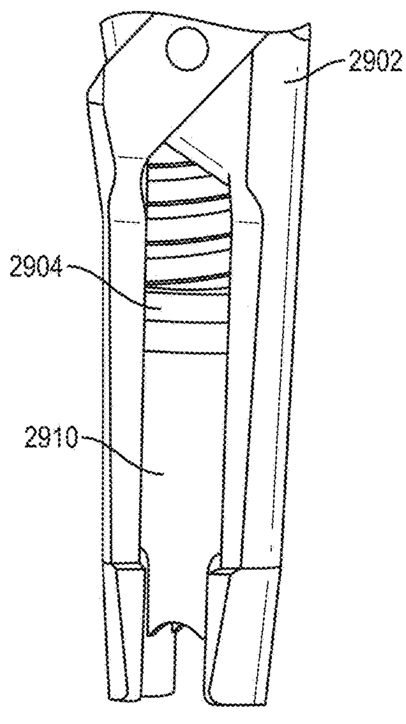


FIG. 31

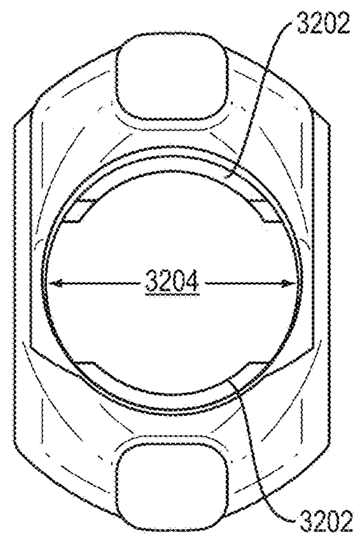


FIG. 32

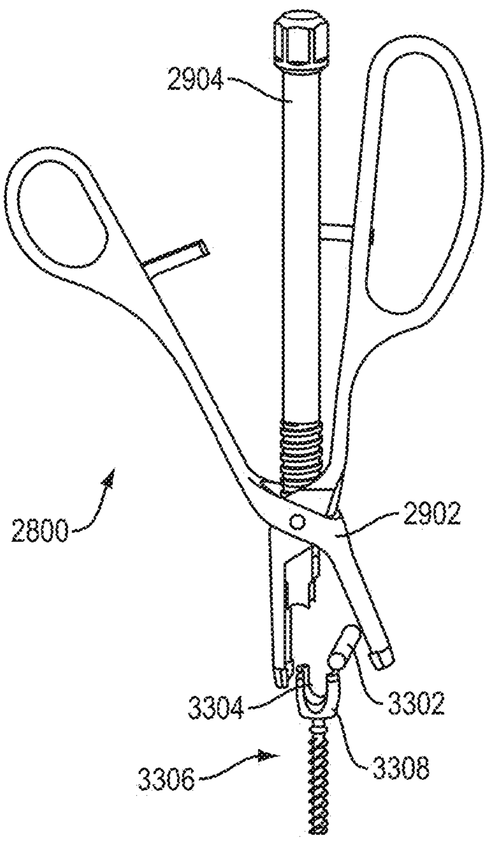


FIG. 33

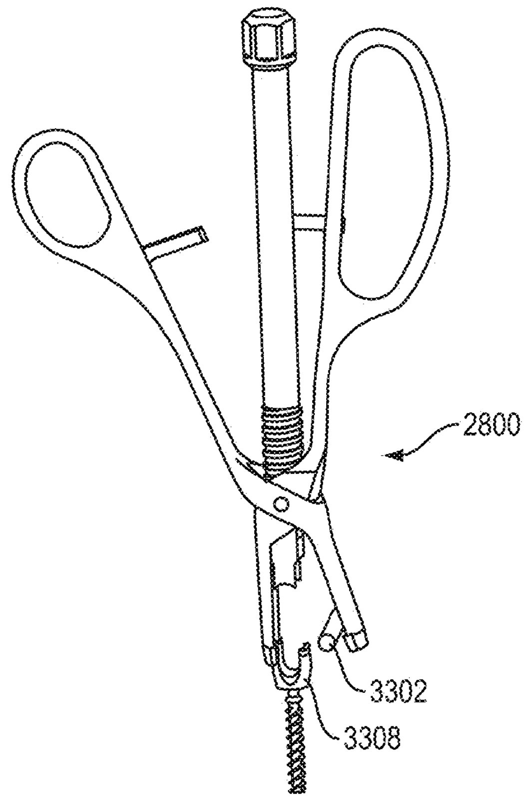


FIG. 34

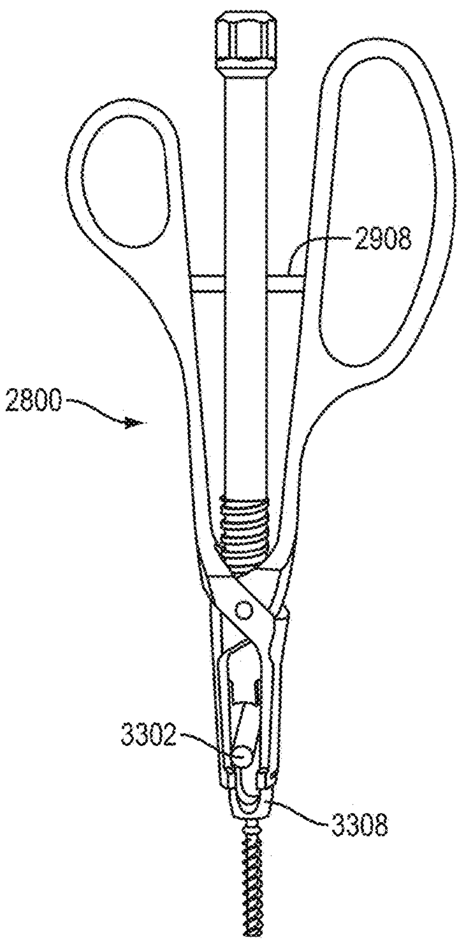


FIG. 35

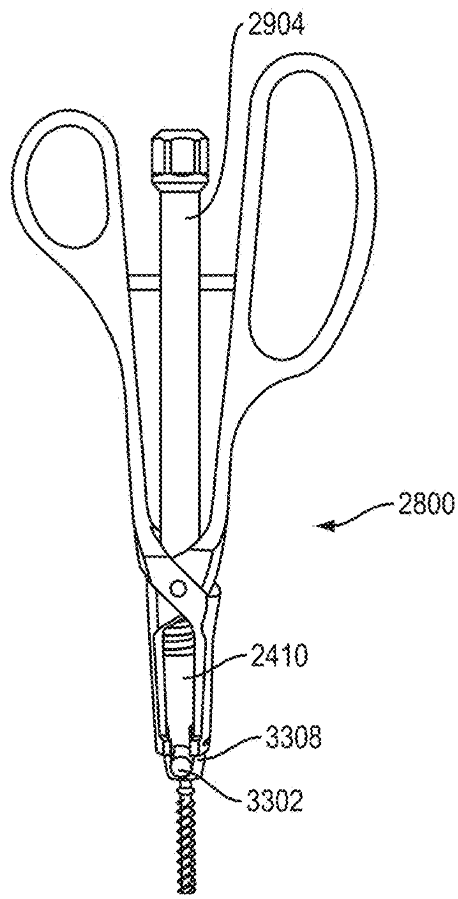


FIG. 36

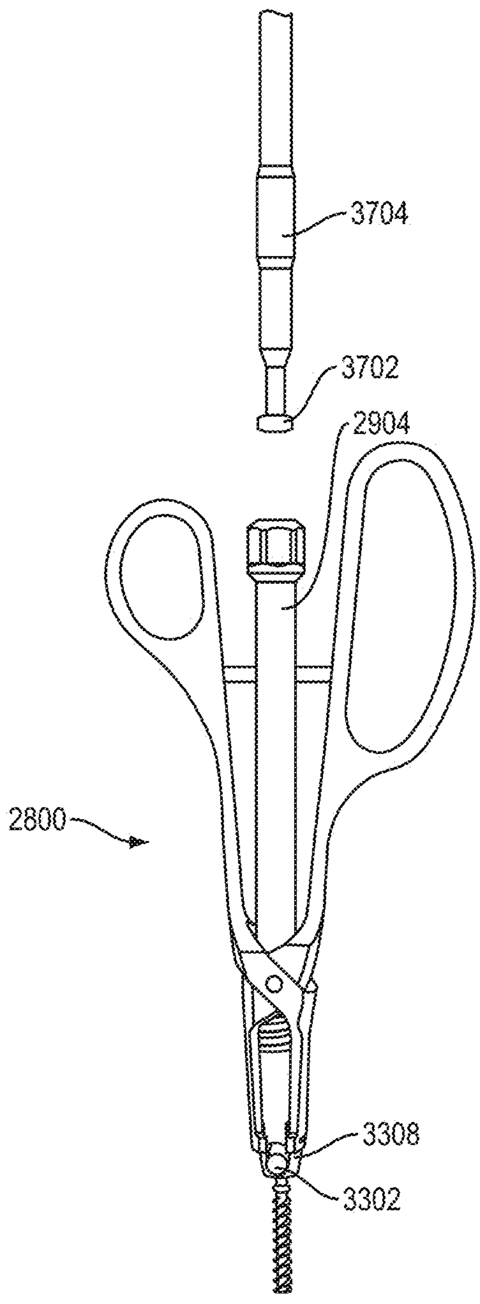


FIG. 37

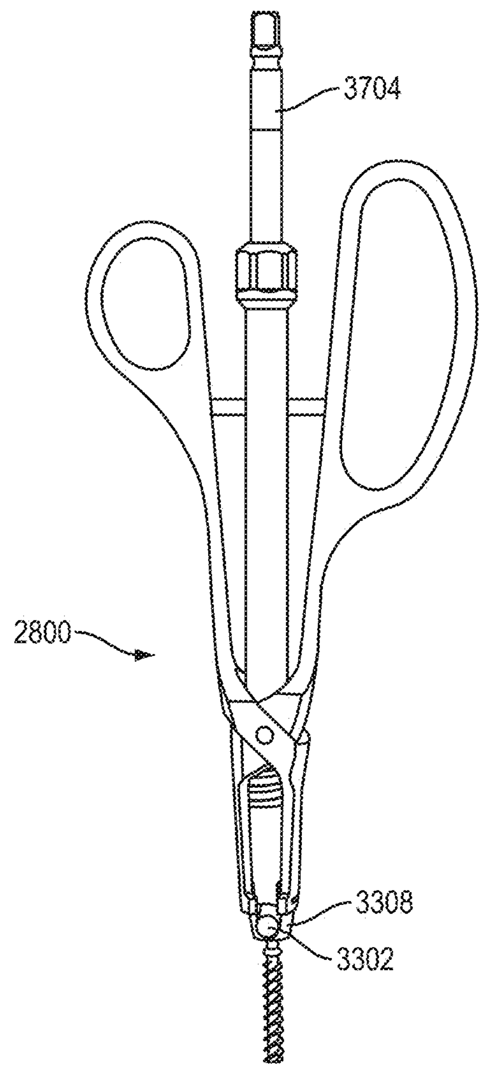


FIG. 38

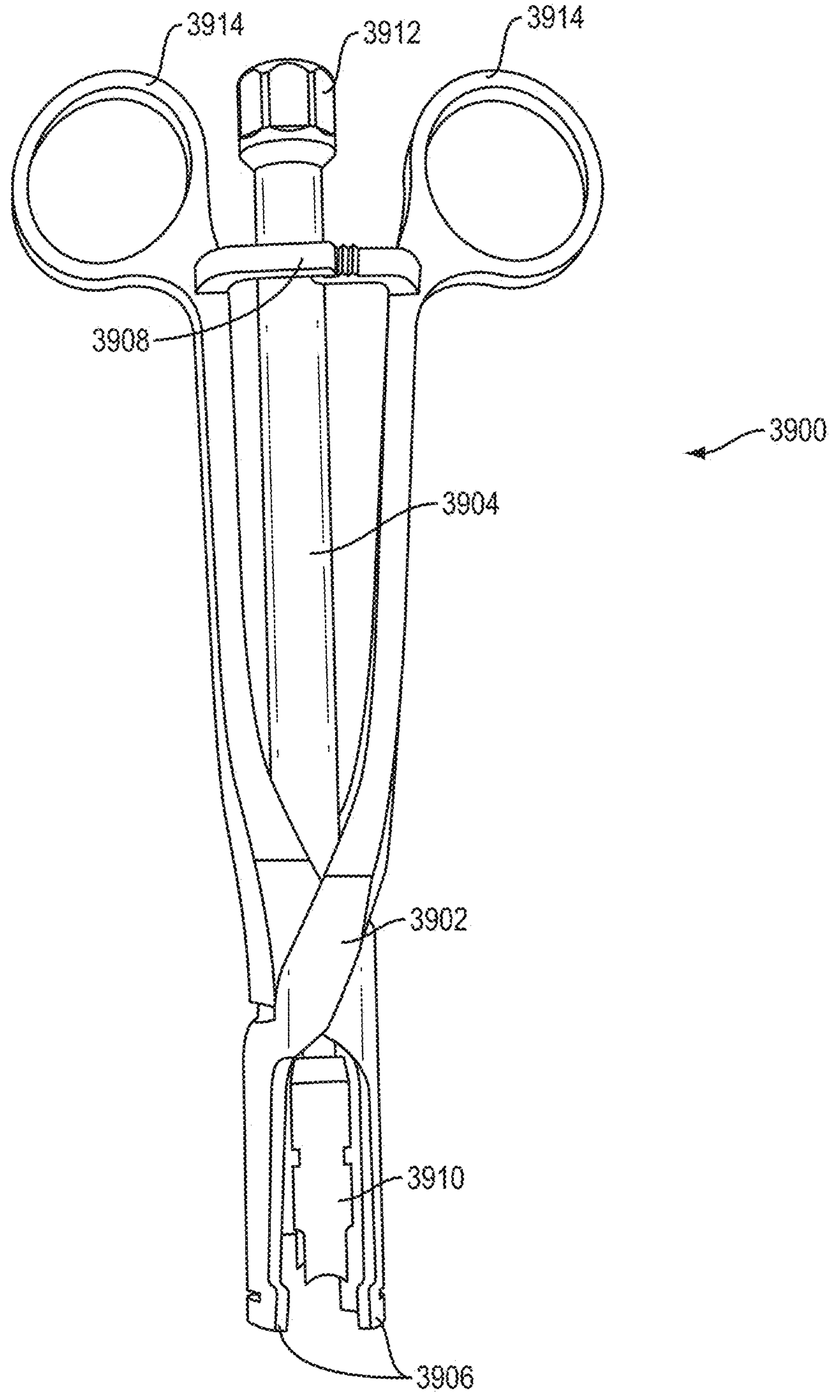
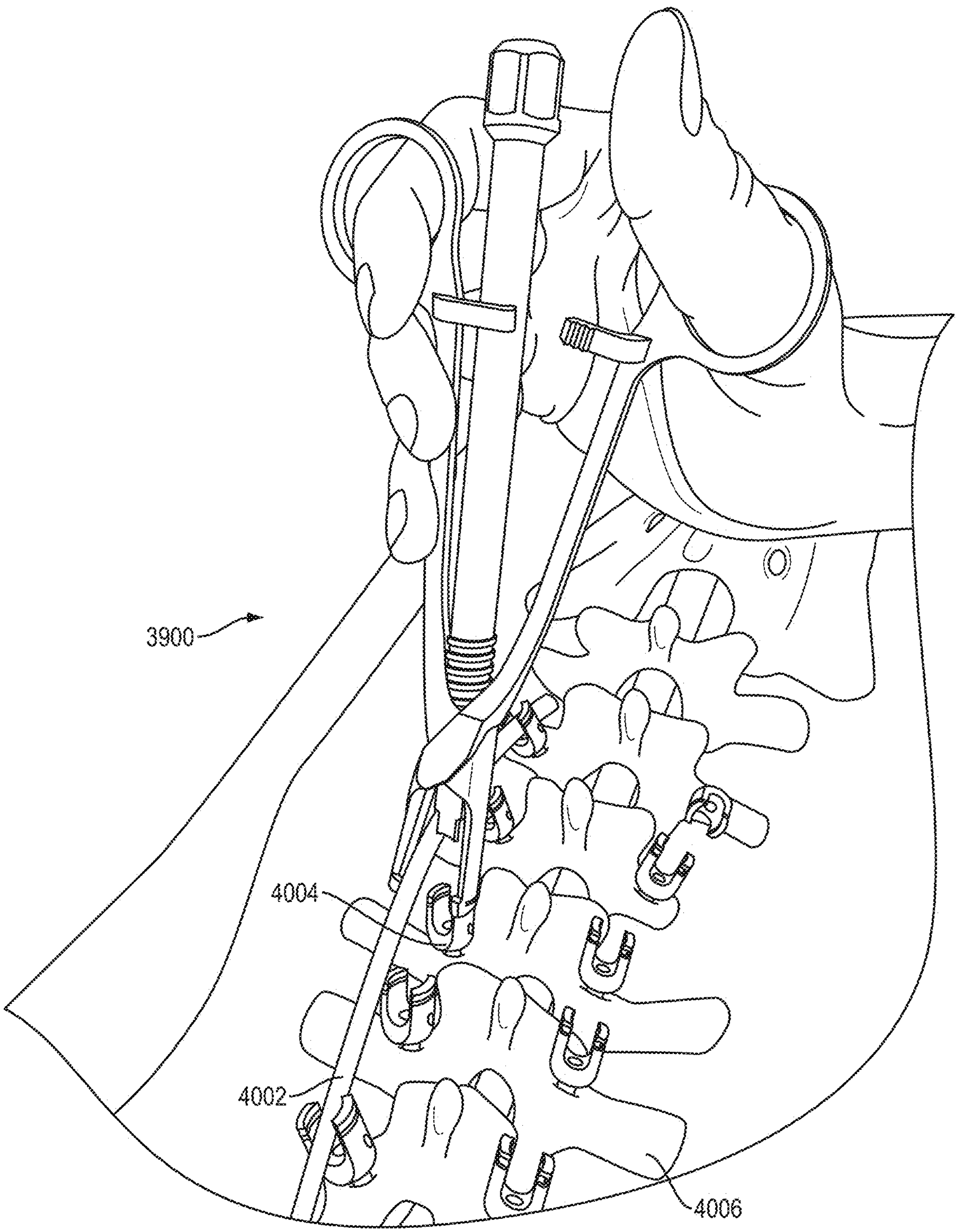


FIG. 39



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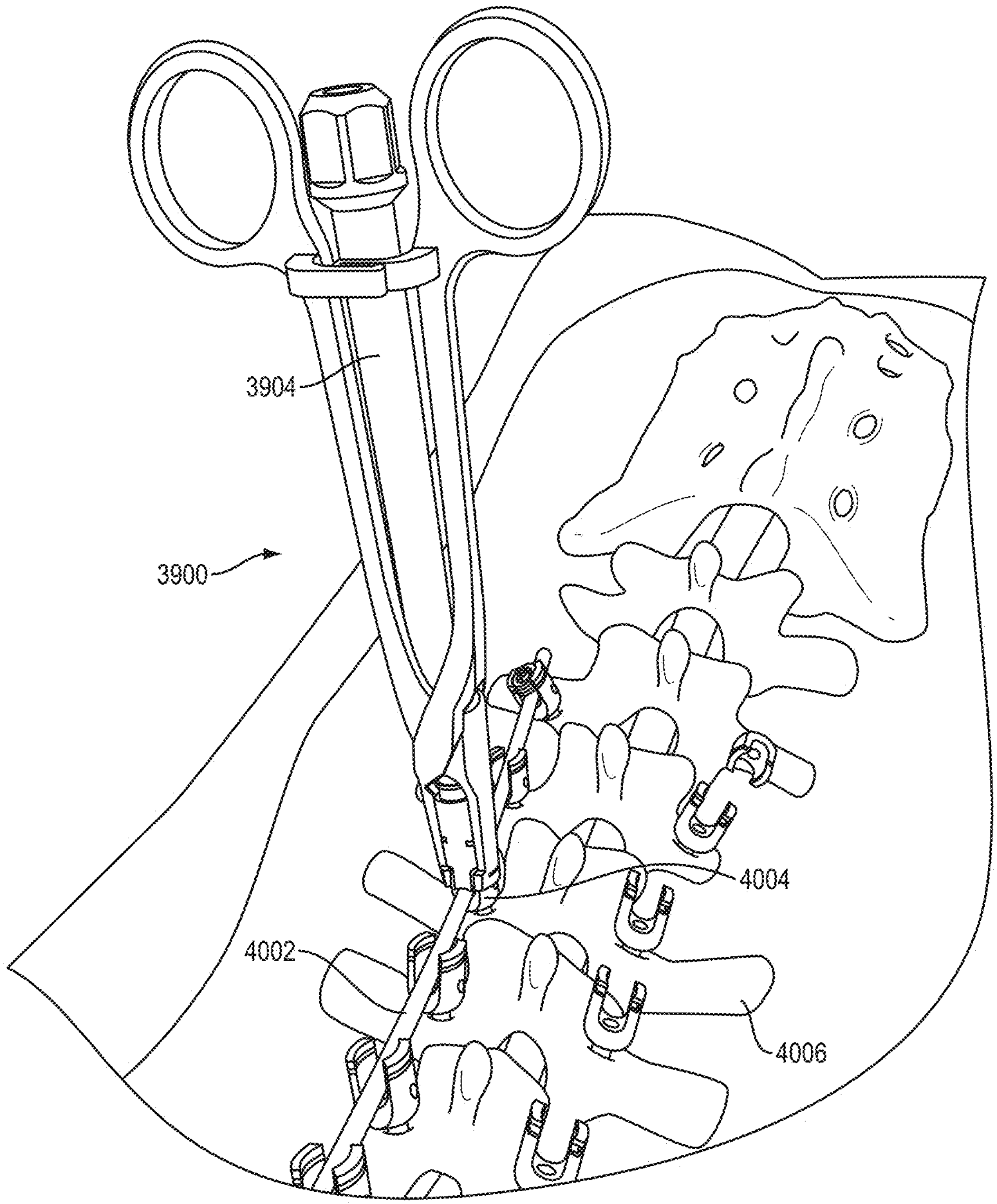

FIG. 41

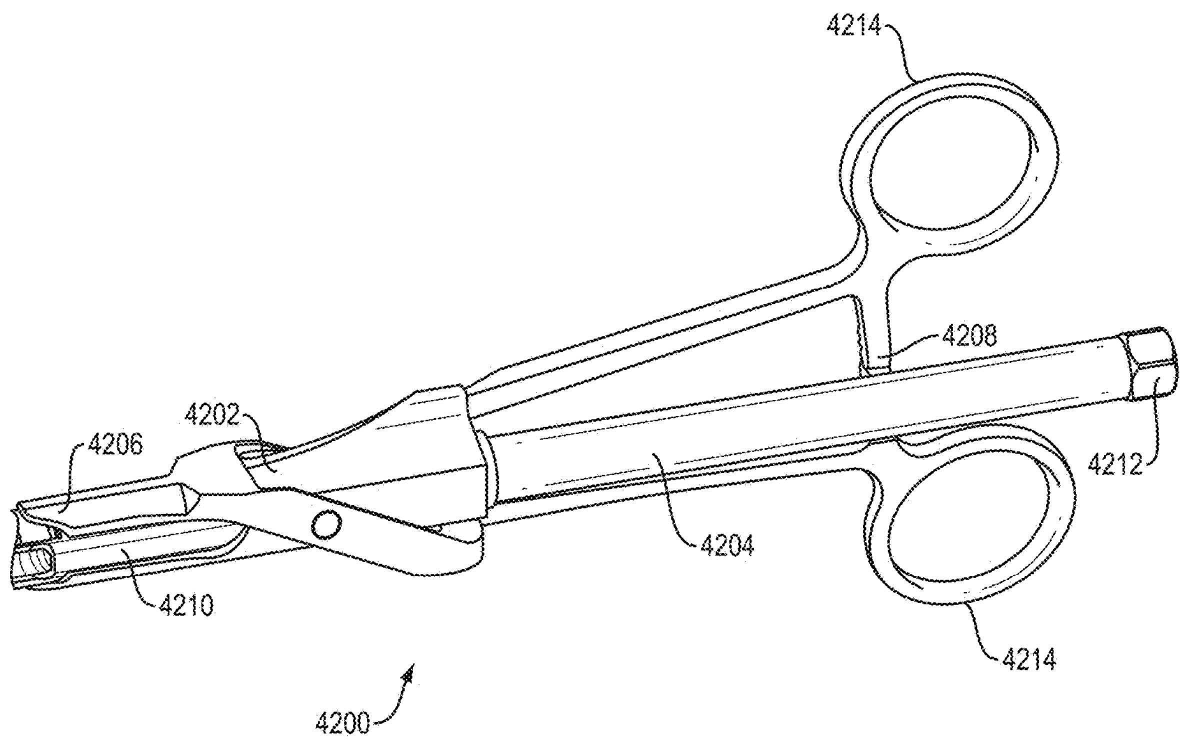

FIG. 42

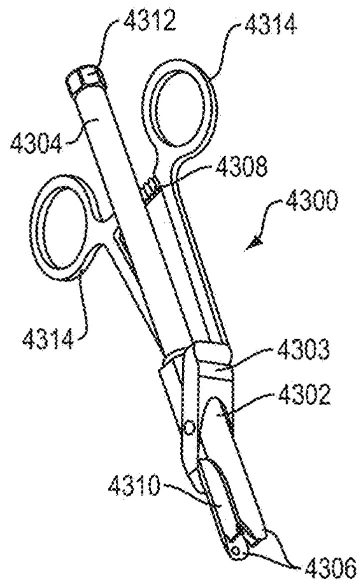

FIG. 43A

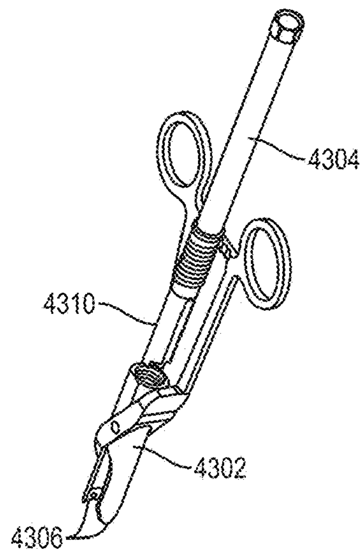

FIG. 45

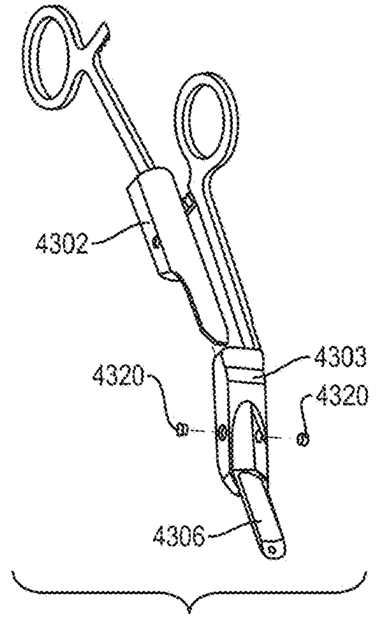

FIG. 46

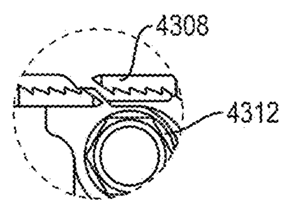

FIG. 43C

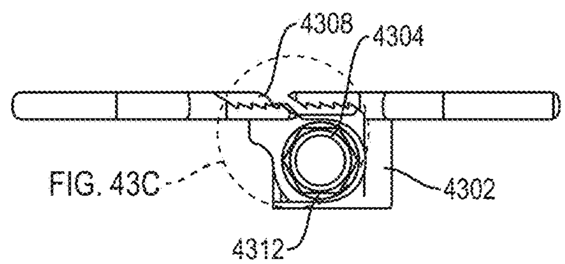

FIG. 43B

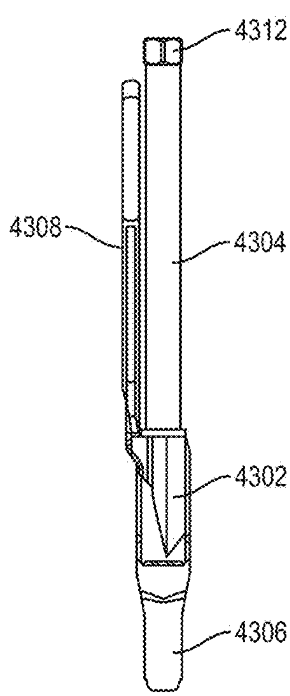

FIG. 43D

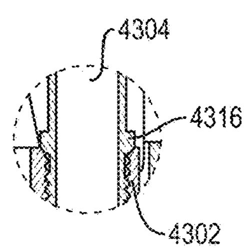

FIG. 44B

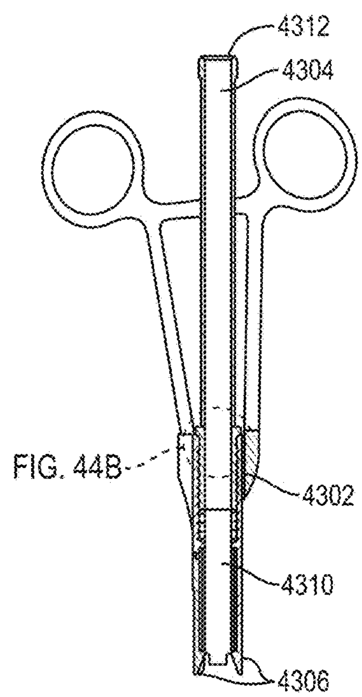

FIG. 44A

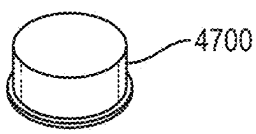

FIG. 47A

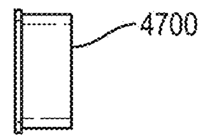

FIG. 47B

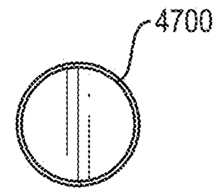

FIG. 47C

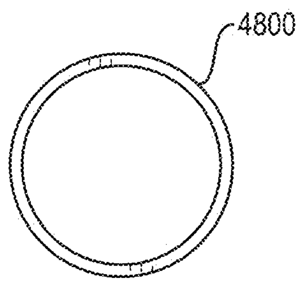

FIG. 48A

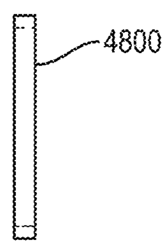

FIG. 48B

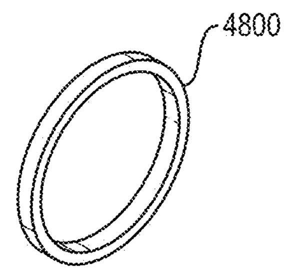

FIG. 48C

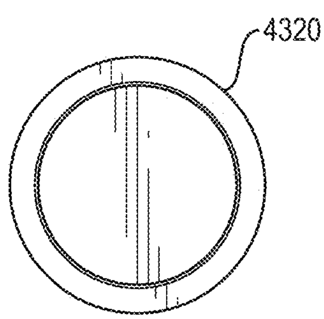

FIG. 49A

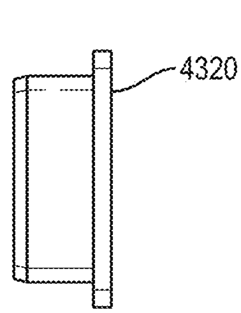

FIG. 49B

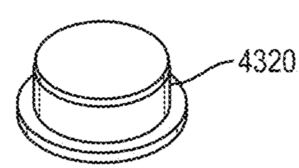

FIG. 49C

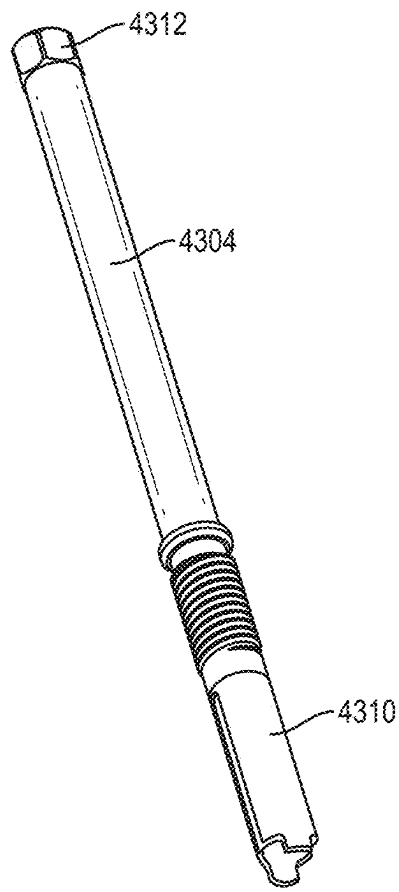

FIG. 50A

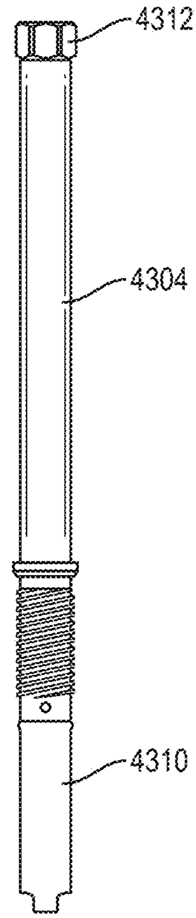

FIG. 50B

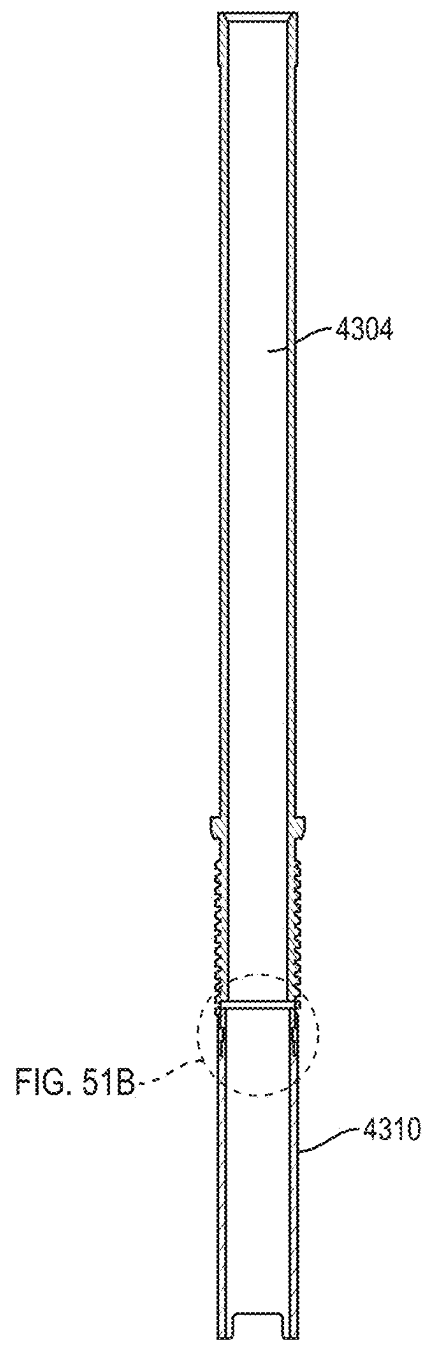

FIG. 51A

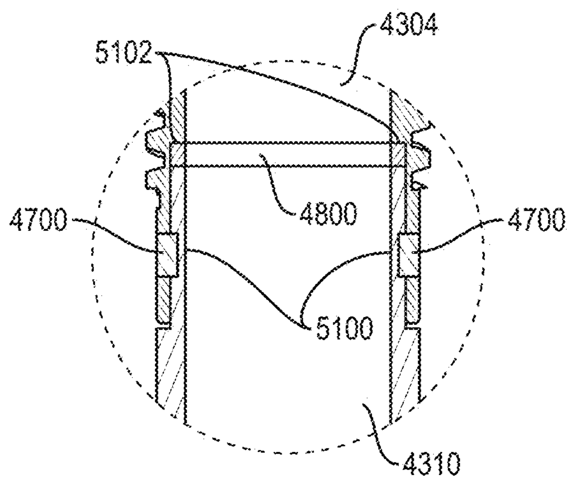

FIG. 51B

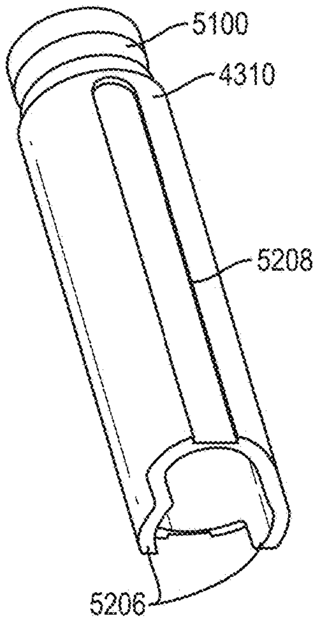

FIG. 52A

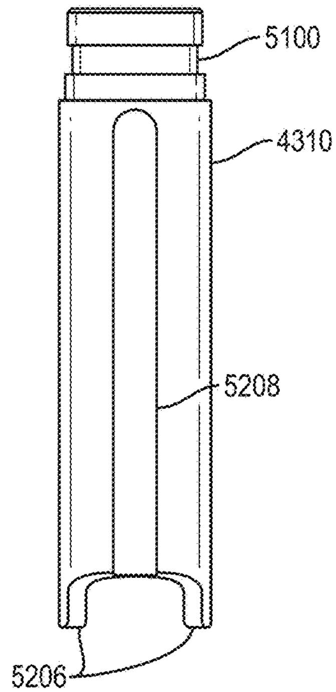

FIG. 52B

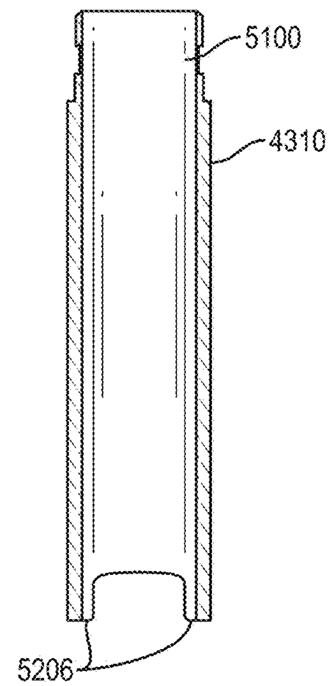

FIG. 53

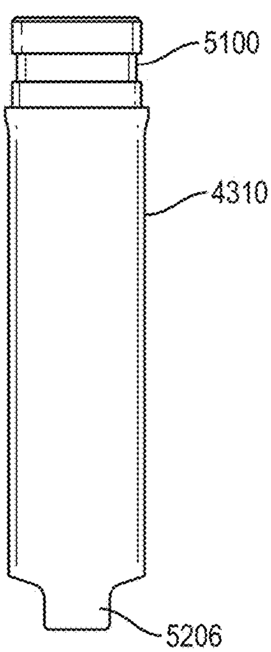

FIG. 52C

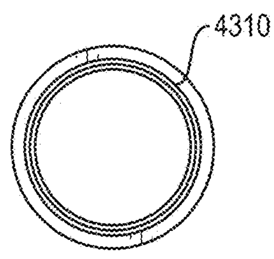

FIG. 52D

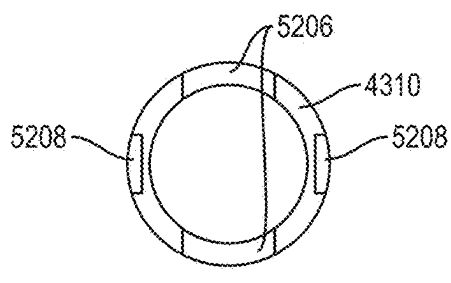

FIG. 52E

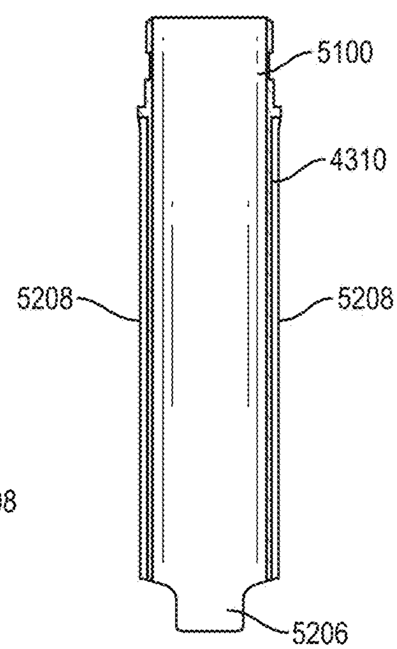

FIG. 54

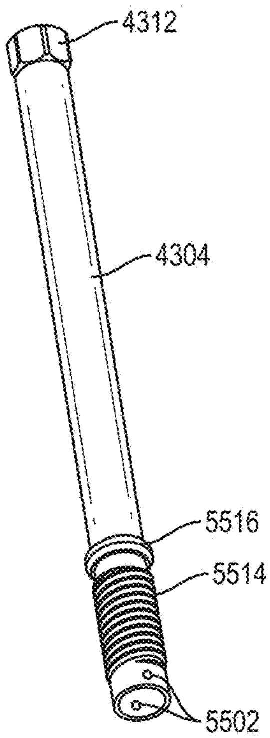

FIG. 55A

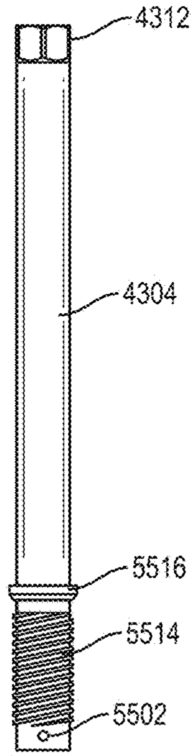

FIG. 55B

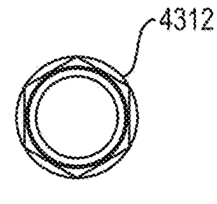

FIG. 55C

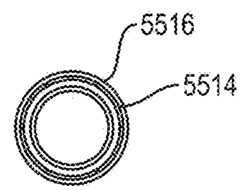

FIG. 55D

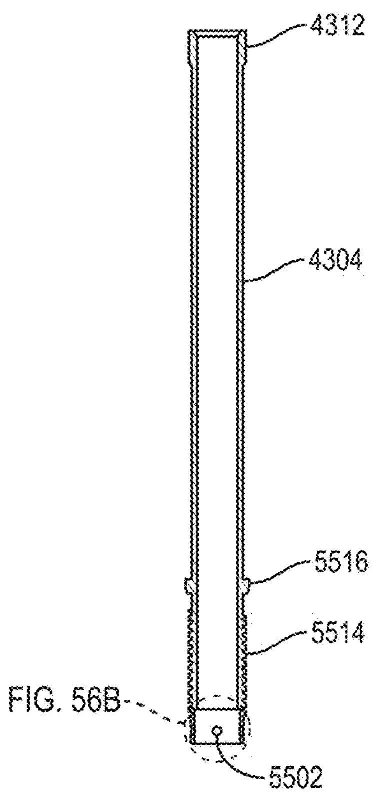

FIG. 56A

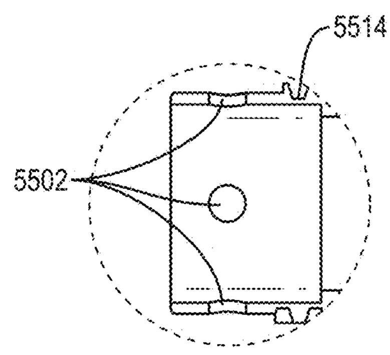

FIG. 56B

FIG. 57B

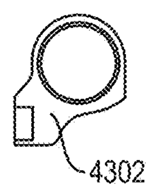

FIG. 57C

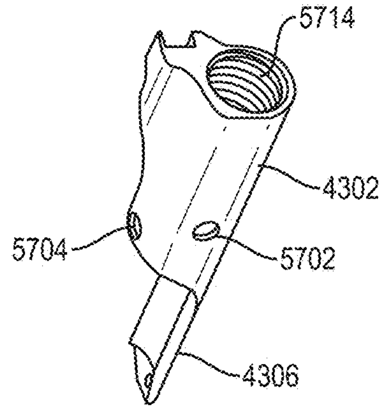

FIG. 57A

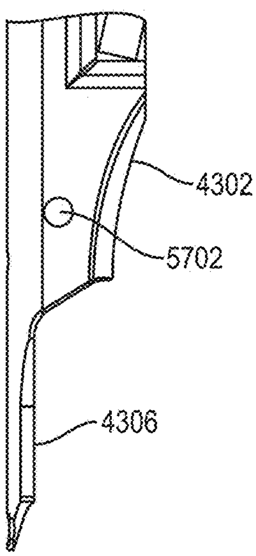

FIG. 57D

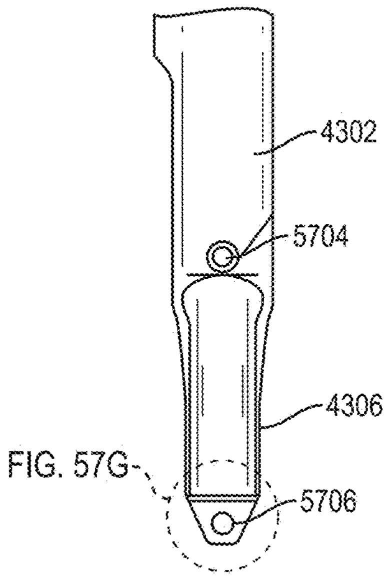

FIG. 57E

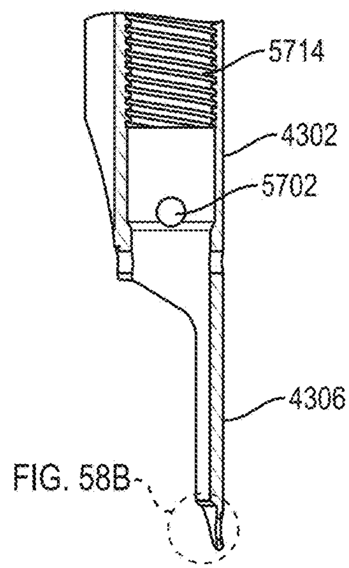

FIG. 58A

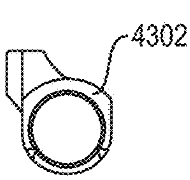

FIG. 57F

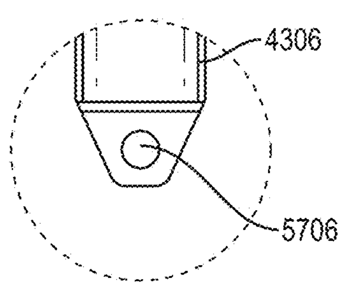

FIG. 57G

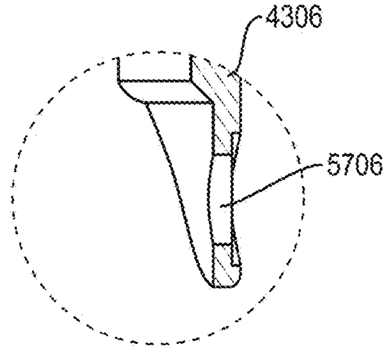

FIG. 58B

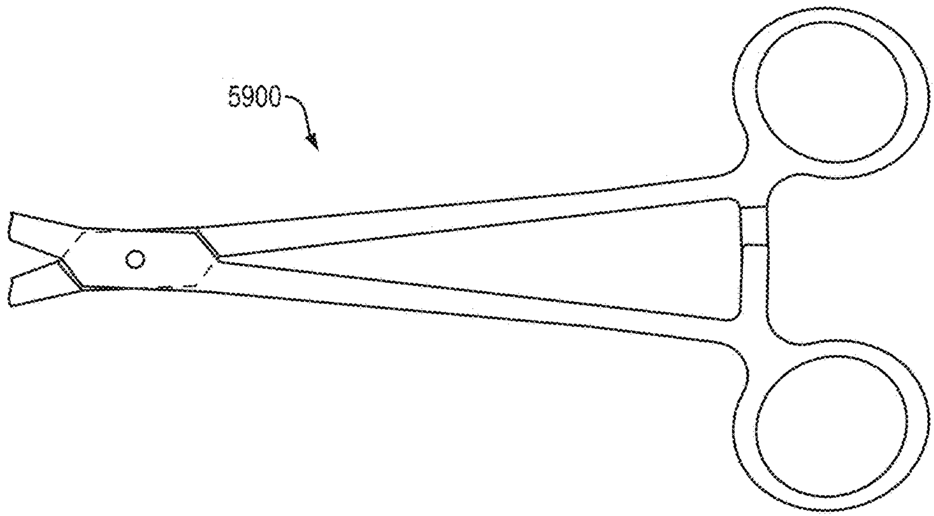

FIG. 59

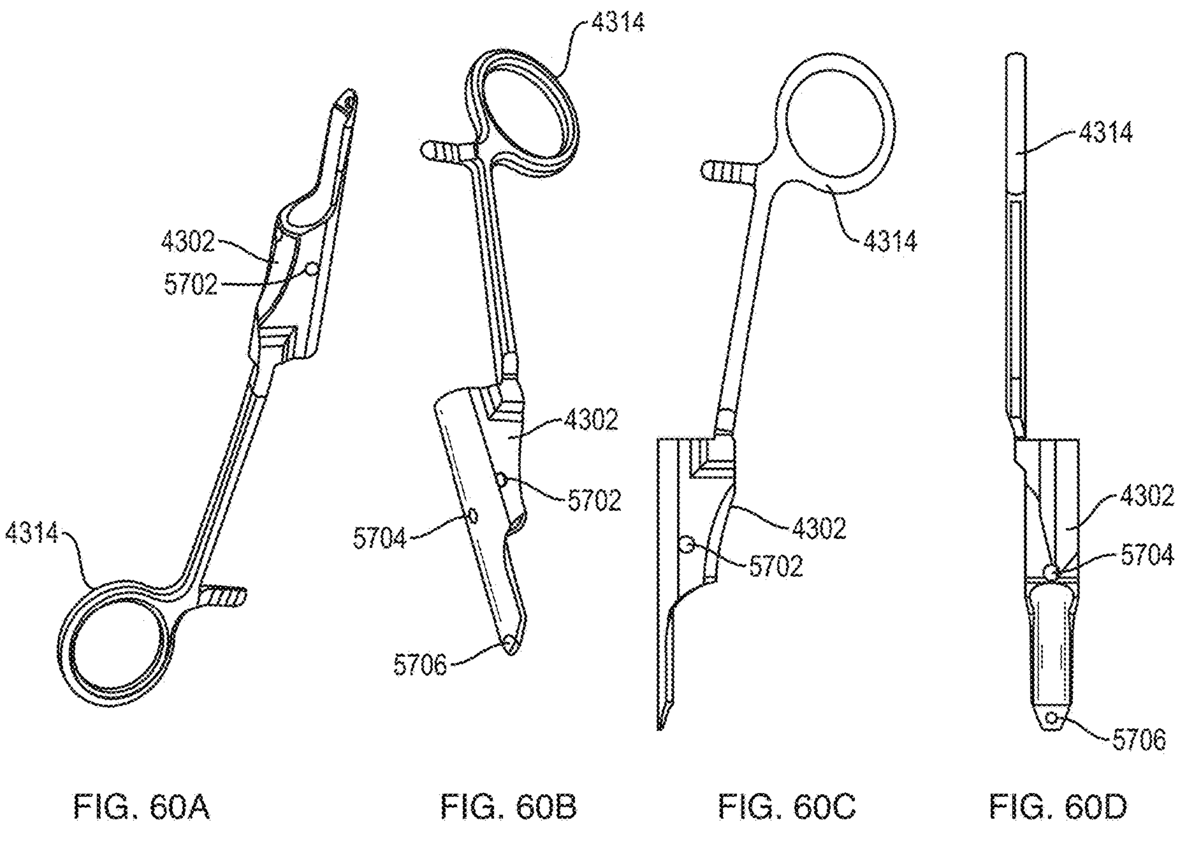

FIG. 60A FIG. 60B FIG. 60C FIG. 60D

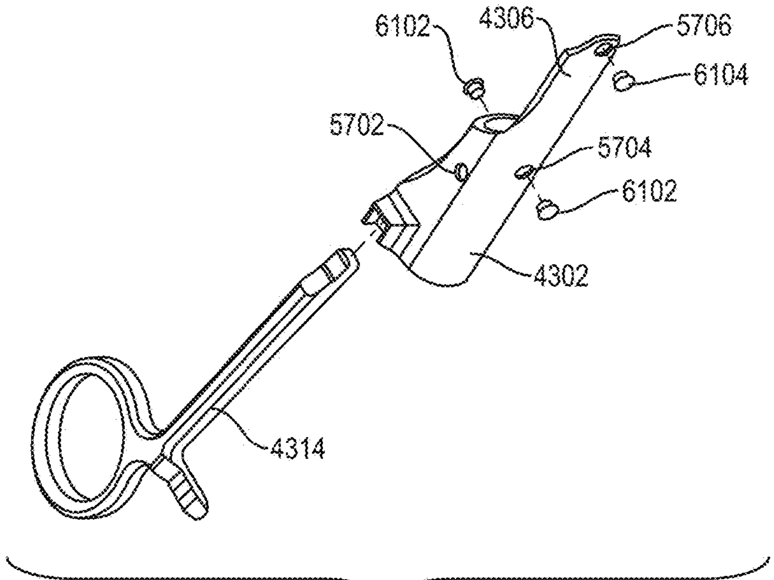

FIG. 61

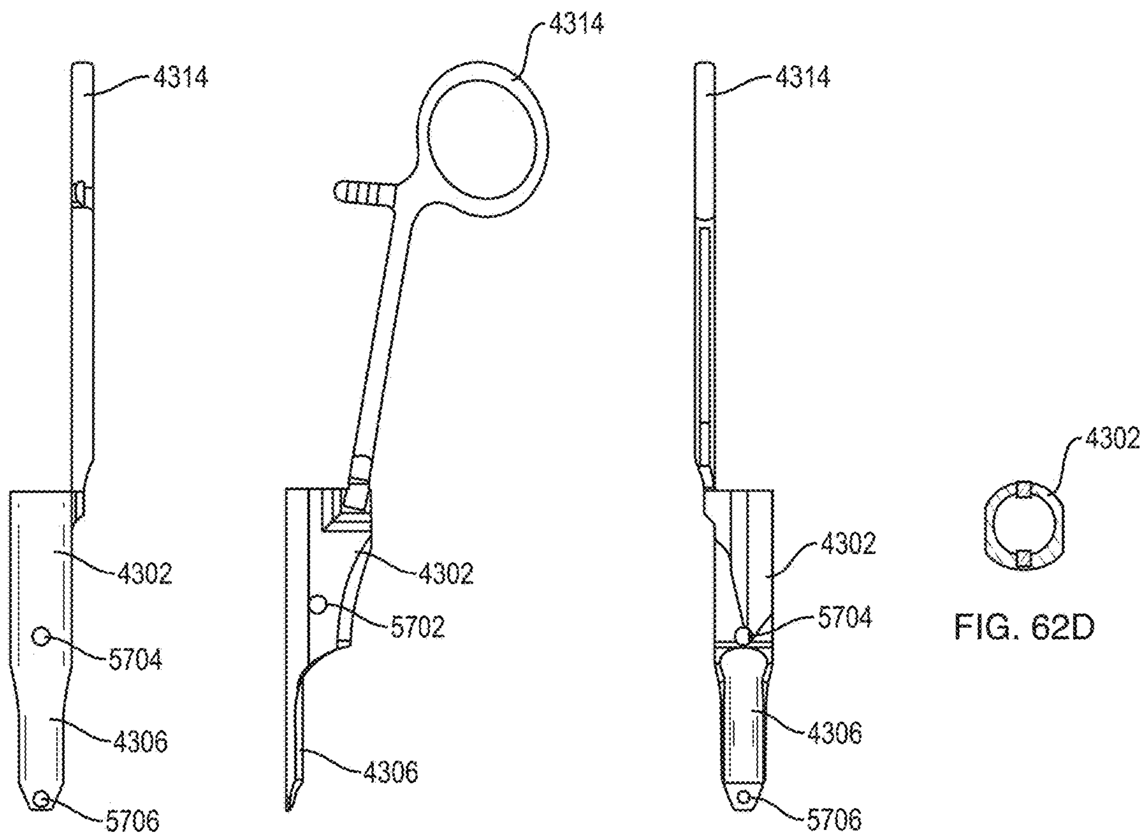

FIG. 62D

FIG. 62A

FIG. 62B

FIG. 62C

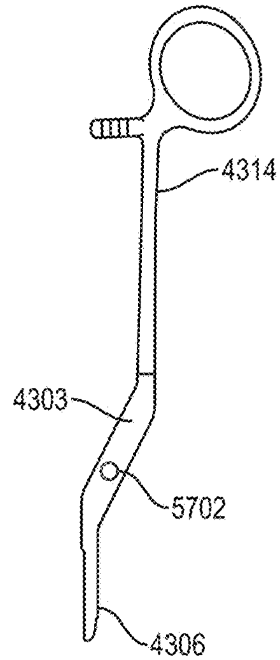

FIG. 63A

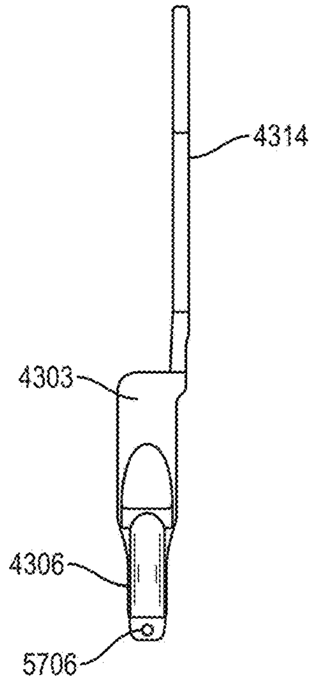

FIG. 63B

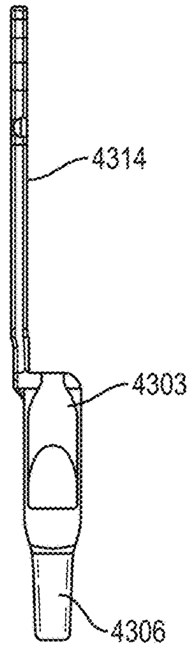

FIG. 63C

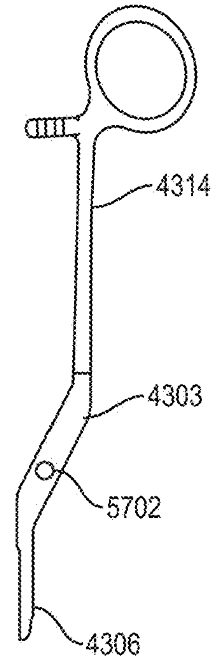

FIG. 63D

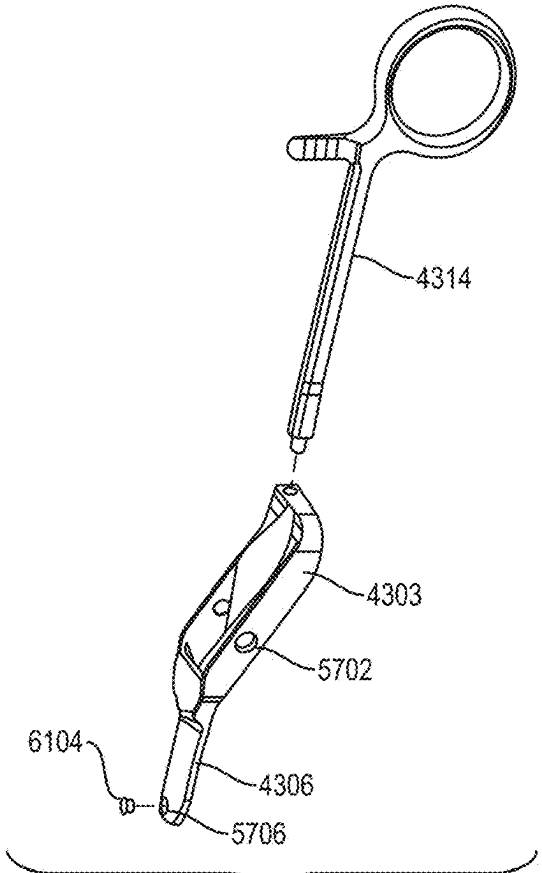

FIG. 64

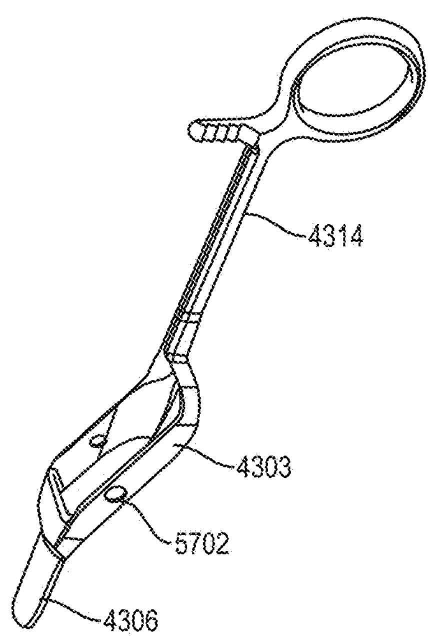

FIG. 63E

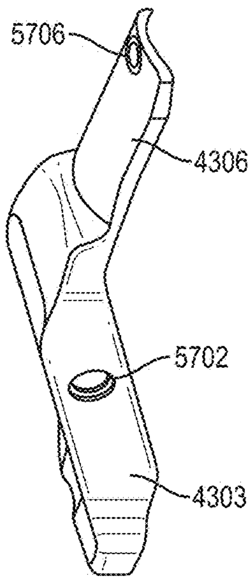

FIG. 65A

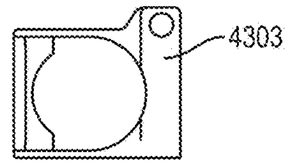

FIG. 65B

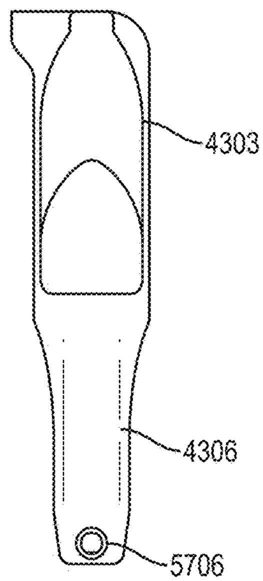

FIG. 65C

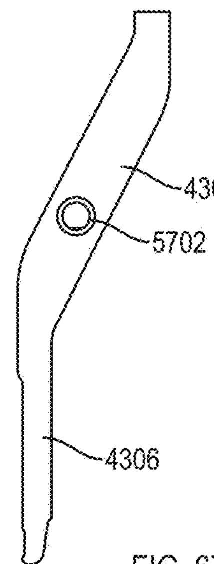

FIG. 65D

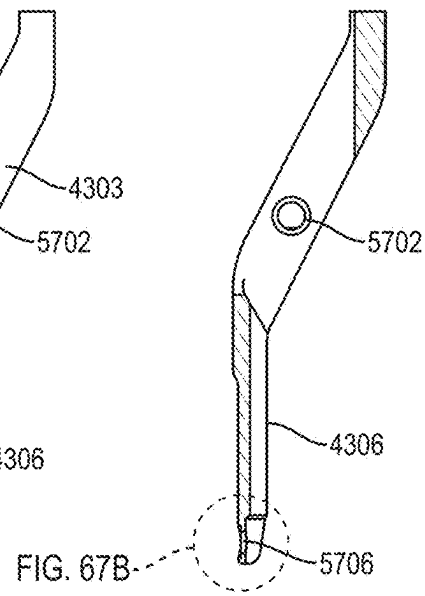

FIG. 67A

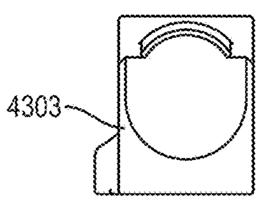

FIG. 65E

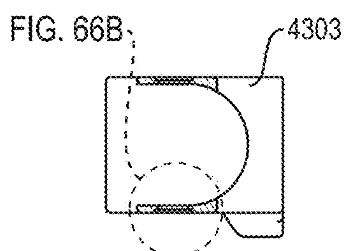

FIG. 66A

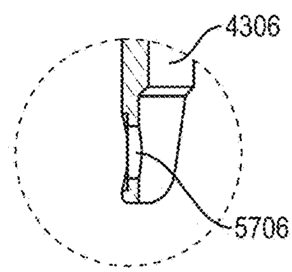

FIG. 67B

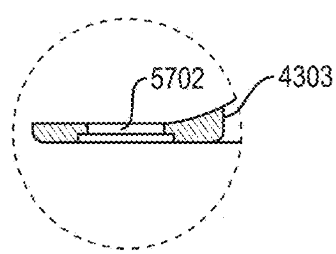

FIG. 66B

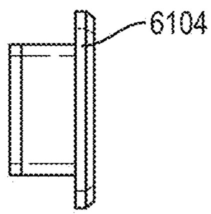

FIG. 68A

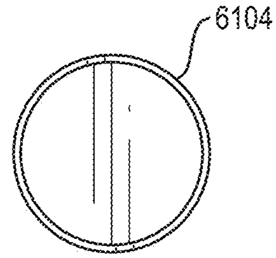

FIG. 68B

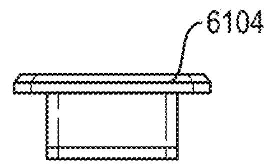

FIG. 68C

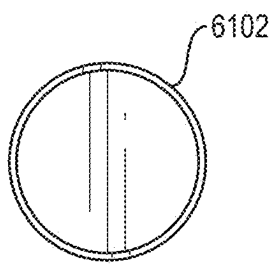

FIG. 69A

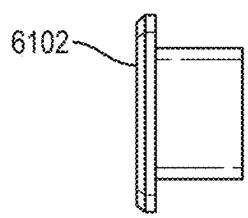

FIG. 69B

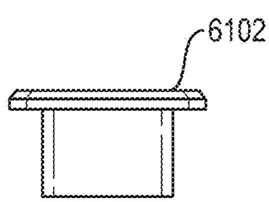

FIG. 69C

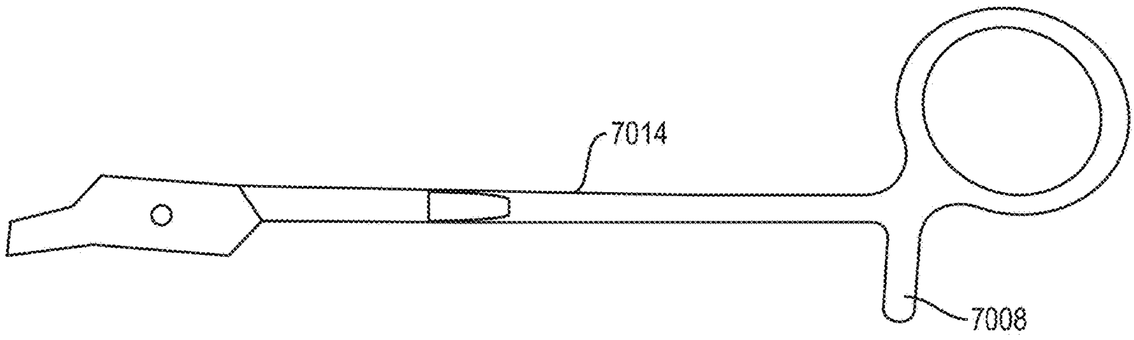

FIG. 70

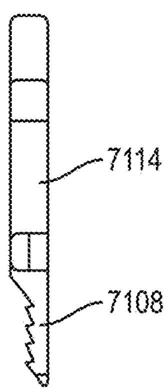

FIG. 71A

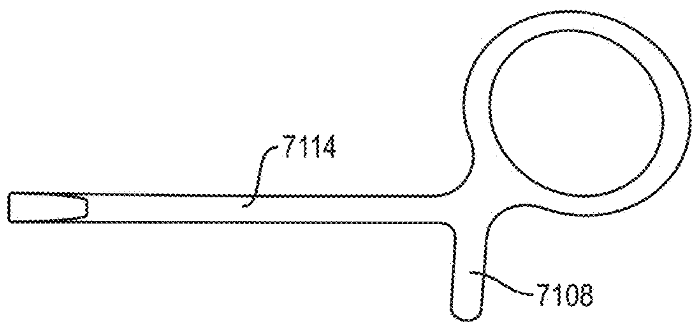

FIG. 71B

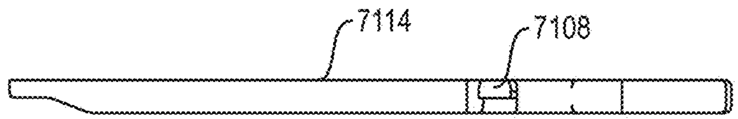

FIG. 71C

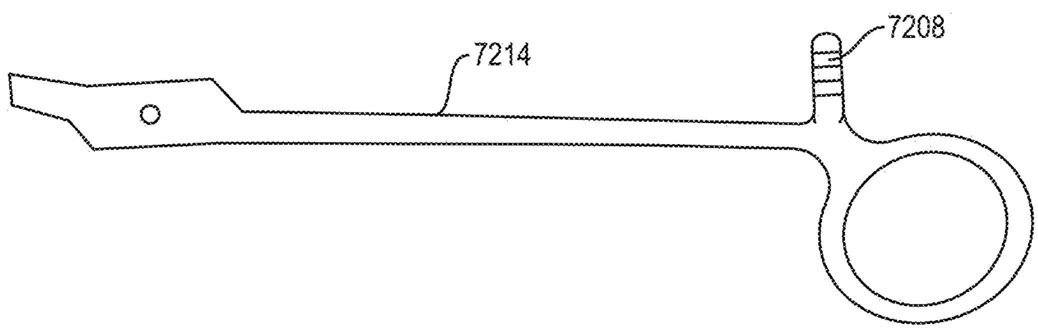

FIG. 72

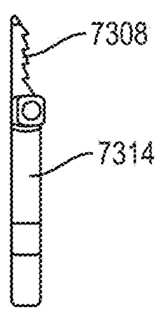

FIG. 73A

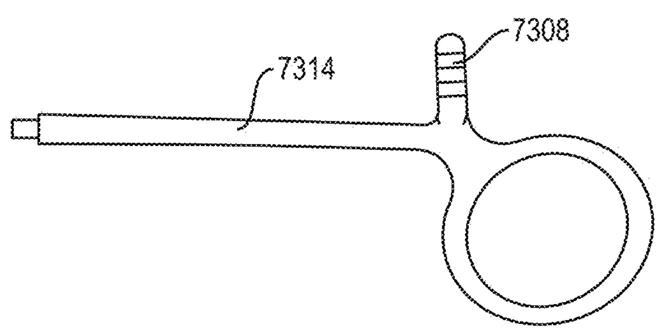

FIG. 73B

BIPLANAR FORCEPS REDUCERS AND METHODS OF USE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 17/522,164, filed on Nov. 9, 2021. U.S. application Ser. No. 17/522,164 claims the benefit of U.S. Provisional Application No. 63/111,606, filed on Nov. 9, 2020. The entire contents of each of these applications are hereby incorporated by reference.

FIELD

[0002] This disclosure relates generally to surgical instruments and methods of use and, more particularly, to surgical instruments utilized to move one object relative to another, e.g., move a rod or spinal fixation element relative to an implanted bone anchor or other spinal fixation construct component during spine surgery.

BACKGROUND

[0003] During spine surgery, such as procedures to correct deformities in the spine, fixation constructs are often assembled to hold the spine in a desired shape. Such constructs often include a plurality of implanted bone anchors along multiple vertebrae and a connecting spinal fixation element, such as a rod, that is received within a head of each of the bone anchors and secured using a set screw. In many cases, the bone anchors are first implanted in the vertebrae, a rod is then positioned relative to the bone anchor heads, and set screws applied to secure the rod relative to each bone anchor.

[0004] It can be challenging to position the rod to be received in the head of each bone anchor. In some cases, a rod can be positioned offset from a bone anchor head both dorsally and medially-laterally such that the rod must be translated in both the sagittal plane and the coronal plane to capture it with the bone anchor head. This challenge can be particularly prevalent in procedures to correct deformities, as longer fixation constructs are often used along with uniplanar bone anchor heads that pivot in only one direction, though similar challenges can be faced when using bone anchor heads that move polyaxially as well.

[0005] Prior approaches to overcoming such challenges involve the use of multiple instruments. For example, a first instrument can be utilized to laterally translate a rod over a bone anchor head, and axial reduction of the rod into the bone anchor head can be performed with a second instrument. Often this is accomplished by attaching a lateral reducing instrument to a first bone anchor to move the rod over one or more bone anchors along a portion of a spinal fixation construct. An axial reducer can then be attached to an adjacent bone anchor and used to translate the rod axially into the bone anchor head.

[0006] Such prior approaches can have drawbacks. For example, use of instruments that can reduce, or translate, a rod in only one plane requires the use of additional instrumentation to complete a procedure. Further, since different reducing instruments are attached to different vertebral levels, load sharing among reducers is not possible. Still further, in some cases reducing instruments must be removed prior to set screw insertion due to interference with set screw insertion devices, or such devices must be loaded in a reducer instrument prior to loading a set screw. Both of these requirements can reduce flexibility and complicate a procedure. Finally, some prior instruments are too bulky to fit alongside adjacent instrumentation or around anatomy, especially when bone anchor heads are close together.

[0007] Accordingly, there is a need for improved instruments and methods for reducing or moving one component, such as a spinal fixation rod, relative to another component, such as a bone anchor, including improved instruments and methods for reducing or moving a component in multiple planes.

SUMMARY

[0008] Disclosed herein are biplanar forceps reducer instruments and methods of use that address these and other challenges of prior approaches. The biplanar forceps reducer instruments disclosed herein can engage an implant, such as a bone anchor receiver head, and reduce or move a spinal fixation element, such as a rod, in two planes to move the rod into a channel formed in the receiver head. Further, the biplanar forceps reducer instruments disclosed herein can allow for introduction and tightening of a set screw using an inserter that can pass through a cannulated tube of the reducer. The low profile and biplanar reduction functionality can allow a single type of reducer instrument to couple with each bone anchor along a spinal fixation construct and remain in position until the construct is secured in position.

[0009] In one aspect, a surgical instrument can include a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a threaded lumen defining a longitudinal axis. The instrument can also include a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm. The instrument can further include a tube having a threaded outer surface portion disposed within the threaded lumen, a depth stop formed proximal to the threaded portion, and a drive feature at a proximal end of the tube configured to removably couple with a driver to impart torque to the tube. The instrument can also include a rod-engaging tip rotatably coupled to a distal end of the tube. Further, the first and second arms can be configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip can be configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

[0010] Any of a variety of alternative or additional features can be included and are considered within the scope of the present disclosure. For example, in some embodiments, the depth stop can define a maximum outer diameter of the tube. In certain embodiments, the depth stop can be a shoulder formed around at least a portion of the circumference of the tube.

[0011] In some embodiments, the lumen can include continuous threads formed around a circumference thereof. Further, in certain embodiments an inner lumen of the tube can be accessible from a proximal end of the tube through the drive feature. Moreover, in some embodiments the rod-engaging tip can include an inner lumen coaxially disposed with the inner lumen of the tube.

[0012] In some embodiments, the rod-engaging tip can include an opening formed in a distal portion of a sidewall to facilitate viewing contents of an inner lumen of the rod-engaging tip.

[0013] In certain embodiments, a distal end of at least one of the first and second arms can include a protrusion configured to extend into a recess of a bone anchor receiver member. Further, the protrusion can be a pin disposed in a bore formed in the distal end of at least one of the first and second arms. In some embodiments, the protrusion can be a ridge extending across a width of the arm. The ridge or other protrusion can extend across an entire width of the arm or, in some embodiments, can extend across only a portion of a width of the arm or include one or more breaks along its length. In certain embodiments, the protrusion can be disposed proximal to a distal-most end of the arm and an inner surface of the arm distal to the protrusion can have a conical tapering profile. In some embodiments, the inner surface of the arm can include sidewalls extending outward from the inner surface at lateral ends of the arm, and opposed, inward-facing surfaces of each sidewall can have a planar tapering profile.

[0014] In certain embodiments, the instrument can further include a lock configured to selectively maintain a position of the first and second arms relative to one another. In some embodiments, the lock can be coupled to a proximal portion of one or more of the first and second arms, and a proximal end of the tube can be disposed distal to the lock.

[0015] In another aspect, a surgical method can include positioning a first arm of a reducer instrument against a bone anchor receiver member, as well as positioning a second arm of the reducer instrument against a spinal fixation element. The method can further include positioning a threaded outer surface portion of a tube of the reducer instrument within a threaded lumen formed in a housing of the first arm of the reducer instrument. The method can also include pivoting the first and second arms of the reducer instrument toward one another to translate the spinal fixation element laterally toward a longitudinal axis defined by the threaded lumen. The method can further include coupling a driver to a drive feature formed at a proximal end of the tube, and rotating the tube of the reducer instrument to translate the spinal fixation element axially along the longitudinal axis until a depth stop formed on the tube proximal to the threaded outer surface portion contacts the housing.

[0016] As with the instruments described above, the methods disclosed herein can include any of a variety of additional or alternative steps that are considered within the scope of the present disclosure. For example, in some embodiments the method can further include engaging a lock to maintain a position of the first and second arms relative to one another after pivoting the first and second arms toward one another.

[0017] In certain embodiments, the method can also include separating the driver from the proximal end of the tube after rotating the tube to translate the spinal fixation element axially. Further, the method can include inserting a set screw through an inner lumen of the tube and coupling the set screw with the receiver member. Still further, the method can include visually inspecting the set screw while coupled to the receiver member using an opening formed in a distal portion of a sidewall of rod-engaging tip coupled to the tube.

[0018] In another aspect, a surgical instrument can include a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a lumen defining a longitudinal axis, the lumen having continuous threads formed around a circumference thereof. The instrument can further include a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm, and a tube having a threaded outer surface portion disposed within the lumen. The instrument can further include a rod-engaging tip rotatably coupled to a distal end of the tube, the rod-engaging tip being constrained against rotation relative to the housing by a protrusion coupled to the housing that is received in a recess of the rod-engaging tip. Further, the first and second arms can be configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip can be configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

[0019] A number of additional or alternative features can be included. For example, in some embodiments, the threads on the outer surface portion of the tube can have a plurality of starts. In some embodiments, the threads on the outer portion of the tube can have three starts. Further, in certain embodiments an outer diameter of the threaded outer surface portion of the tube can be less than or equal to about 45% larger than a diameter of an inner lumen of the tube. In certain embodiments, an outer diameter of the threaded outer surface portion of the tube can be less than or equal to about 40%, about 35%, about 30%, about 25%, or about 20% larger than a diameter of an inner lumen of the tube. Utilizing such a configuration can minimize an outer diameter of the threads of the tube and provide a lower profile instrument to access a surgical site through a smaller opening or with less interference for adjacent anatomy or instrumentation.

[0020] In another aspect, a surgical instrument can include opposed arms pivotably coupled to one another, a tube threadably coupled to the opposed arms, and a rod-engaging tip rotatably coupled to the tube. Further, the opposed arms can be configured to laterally translate a spinal fixation element when pivoted toward one another and the rod-engagement tip can be configured to axially translate the spinal fixation element when the tube is rotated relative to the opposed arms and the rod-engagement tip.

[0021] As with the aspects and embodiments described above, a number of additional or alternative features are possible. For example, in some embodiments one of the opposed arms can include a housing having a threaded lumen formed therein. Further, in some embodiments the tube can include external threads formed thereon that interface with the threaded lumen of the body. The external threads formed on the tube can include a plurality of starts. In some embodiments, the external threads formed on the tube can include three starts. Further, in some embodiments an outer diameter of the external threads of the tube can be less than or equal to about 45% larger than a diameter of an inner lumen of the tube. In certain embodiments, an outer diameter of the threaded outer surface portion of the tube can be less than or equal to about 40%, about 35%, about 30%, about 25%, or about 20% larger than a diameter of an inner lumen of the tube. Utilizing such a configuration can minimize an outer diameter of the threads of the tube and provide a lower profile instrument to access a surgical site through a smaller opening or with less interference for adjacent anatomy or instrumentation.

[0022] In certain embodiments, the tube can include a depth stop formed proximal to the external threads. The depth stop can defines a maximum outer diameter of the tube in certain embodiments. The depth stop can have a variety of forms, and can be a shoulder formed around at least a portion of the circumference of the tube in some embodiments.

[0023] In some embodiments, the threaded lumen can include continuous threads formed around a circumference thereof. In certain embodiments the housing can include a protrusion received within a recess of the rod-engaging tip to constrain the rod-engaging tip against rotation relative to the housing.

[0024] In certain embodiments, the opposed arms can include opposed proximally-extending handles for user actuation. In some embodiments, the opposed arms can include a lock to maintain their relative position. The lock can include a ratchet in certain embodiments. In some such embodiments, the ratchet can be offset from a longitudinal axis of the tube. In certain embodiments, the lock can be coupled to a proximal portion of one or more of the opposed arms, and a proximal end of the tube can be disposed distal to the lock.

[0025] In some embodiments, the tube can include a drive feature formed at a proximal end thereof to facilitate rotation of the tube. In certain embodiments, an inner lumen of the tube can be accessible from a proximal end of the tube through the drive feature. In some embodiments, the rod-engaging tip can include an inner lumen that is coaxial with the inner lumen of the tube. In certain embodiments, the rod-engaging tip can include an opening formed in a distal portion of a sidewall to facilitate viewing contents of the inner lumen of the rod-engaging tip.

[0026] In certain embodiments, a distal end of at least one of the opposed arms can include an engagement feature configured to interface with a complementary feature of a bone anchor receiver member. In some embodiments, the engagement feature can include a protrusion configured to extend into a recess of a bone anchor receiver member. For example, the protrusion can be a pin disposed in a bore formed in the distal end of the arm, or a ridge extending across a width of the arm. The ridge or other protrusion can extend across an entire width of the arm or, in some embodiments, can extend across only a portion of a width of the arm or include one or more breaks along its length. In some embodiments, the engagement feature can be disposed proximal to a distal-most end of the arm and an inner surface of the arm distal to the protrusion can have a conical tapering profile. Further, in certain embodiments the inner surface of the arm can include sidewalls extending outward from the inner surface at lateral ends of the arm, and opposed, inward-facing surfaces of each sidewall can have a planar tapering profile.

[0027] In another aspect, a surgical method can include positioning a first arm of a reducer instrument against a bone anchor receiver member, and positioning a second arm of the reducer instrument against a spinal fixation element. The method can further include pivoting the first and second arms of the reducer instrument toward one another to laterally translate the rod toward the receiver member, and rotating a tube of the reducer instrument to axially translate the spinal fixation element toward the receiver member.

[0028] A number of additional or alternative steps can be included. For example, in some embodiments, the method can further include inserting a set screw through a lumen formed in the tube and coupling the set screw to the receiver member. Further, the method can include visually inspecting the set screw while coupled to the receiver member using an opening formed in a distal portion of a sidewall of a rod-engaging tip coupled to the tube.

[0029] In certain embodiments, the method can also include locking a position of the first and second arms relative to one another.

[0030] In some embodiments, the method can include positioning a threaded outer surface portion of the tube within a threaded lumen formed in a housing coupled to one or more of the first arm and the second arm. In certain embodiments, rotating the tube can be continued until a depth stop formed on the tube proximal to the threaded outer surface portion contacts the housing.

[0031] In some embodiments, the method can further include coupling a driver to a drive feature formed at a proximal end of the tube prior to rotating the tube to axially translate the spinal fixation element. The method can also include separating the driver from the proximal end of the tube after rotating the tube to axially translate the spinal fixation element.

[0032] In certain embodiments, the method can also include engaging a lock to maintain a position of the first and second arms relative to one another after pivoting the first and second arms toward one another.

[0033] Any of the features or variations described herein can be applied to any particular aspect or embodiment of the present disclosure in a number of different combinations. The absence of explicit recitation of any particular combination is due solely to avoiding unnecessary length or repetition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] The aspects and embodiments of the present disclosure can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[0035] FIG. **1**A is a perspective view of one embodiment of a biplanar forceps reducer instrument of the present disclosure;

[0036] FIG. **1**B is another perspective view of the instrument of FIG. **1**A;

[0037] FIG. **2** is a perspective view of opposed forceps arms of the instrument of FIG. **1**A;

[0038] FIG. **3** is an exploded view of the opposed forceps arms of FIG. **2**;

[0039] FIG. **4**A is a top perspective view of a first forceps arm of the instrument of FIG. **1**A;

[0040] FIG. **4**B is a bottom perspective view of a first forceps arm of FIG. **4**A;

[0041] FIG. **4**C is a detail perspective view of a distal portion of FIG. **4**B;

[0042] FIG. **4**D is a detail top view of a distal portion of FIG. **4**B;

[0043] FIG. **4**E is a detail longitudinal cross-sectional view of a distal portion of FIG. **4**B;

[0044] FIG. **5** is a partially-transparent detail view of a proximal portion of the forceps arm of FIG. **4**A;

[0045] FIG. **6**A is a top perspective view of a second forceps arm of the instrument of FIG. **1**A;

[0046] FIG. **6**B is a bottom perspective view of a second forceps arm of FIG. **6**A;

[0047] FIG. **6**C is a front perspective view of a second forceps arm of FIG. **6**A;

[0048] FIG. 6D is a rear perspective view of a second forceps arm of FIG. 6A;

[0049] FIG. 6E is another rear perspective view of a second forceps arm of FIG. 6A;

[0050] FIG. 6F is another rear perspective view of a second forceps arm of FIG. 6A;

[0051] FIG. 7 is a perspective view of a reducer tube and rod-engaging reduction tip of the instrument of FIG. 1A;

[0052] FIG. 8 is a perspective view of another embodiment of a reducer tube and rod-engaging reduction tip according to the present disclosure;

[0053] FIG. 9 is an exploded view of the reducer tube and rod-engaging reduction tip of FIG. 8;

[0054] FIG. 10 is a perspective view of the rod-engaging reduction tip of FIG. 8;

[0055] FIG. 11A is a perspective view of the reducer tube of FIG. 8;

[0056] FIG. 11B is a detail view of a distal portion of the reducer tube of FIG. 11A;

[0057] FIG. 12A is a longitudinal cross-sectional view of the reducer tube and rod-engaging reducer tip of FIG. 8;

[0058] FIG. 12B is a detail view of a distal portion of the reducer tube and a proximal portion of the rod-engaging reducer tip of FIG. 12A;

[0059] FIG. 13 is a longitudinal cross-sectional view of one embodiment of a biplanar forceps reducer instrument of the present disclosure;

[0060] FIG. 14 is a partially-transparent perspective view of the instrument of FIG. 13;

[0061] FIG. 15 is a perspective view of one embodiment of a bone screw implanted in a vertebra;

[0062] FIG. 16 is a perspective view of the instrument of FIG. 1 capturing a bone screw and spinal fixation rod;

[0063] FIG. 17 is a perspective view of the instrument of FIG. 1 laterally reducing a spinal fixation rod;

[0064] FIG. 18 is a perspective view of the instrument of FIG. 1 axially reducing a spinal fixation rod using a driver;

[0065] FIG. 19 is a perspective view of the instrument of FIG. 1 after axially reducing a spinal fixation rod;

[0066] FIG. 20 is a perspective view of the instrument of FIG. 1 after removal of a driver;

[0067] FIG. 21 is a perspective view of a set screw being inserted through the instrument of FIG. 1;

[0068] FIG. 22 is another perspective view of a set screw being inserted through the instrument of FIG. 1;

[0069] FIG. 23A is a perspective view of the instrument of FIG. 1 after insertion of a set screw;

[0070] FIG. 23B is a detail view of a distal portion of FIG. 23A;

[0071] FIG. 24 is a perspective view of the instrument of FIG. 1 releasing from a bone screw;

[0072] FIG. 25 is a perspective view of the instrument of FIG. 1 withdrawing from a bone screw;

[0073] FIG. 26 is a perspective view of a bone screw and spinal fixation rod fastened to a vertebra;

[0074] FIG. 27A is a perspective view of one embodiment of a biplanar forceps reducer and driver according to the present disclosure;

[0075] FIG. 27B is a perspective view of one embodiment of a biplanar forceps reducer with integrated driver according to the present disclosure;

[0076] FIG. 28 is a perspective view of one embodiment of a biplanar forceps reducer according to the present disclosure;

[0077] FIG. 29 is an exploded view of the instrument of FIG. 28;

[0078] FIG. 30 is an exploded view of a rod-engaging reducer tip and a distal portion of a reducer tube of the instrument of FIG. 28;

[0079] FIG. 31 is a detail side view of a distal portion of the instrument of FIG. 28;

[0080] FIG. 32 is detail end view of a forceps body of the instrument of FIG. 28;

[0081] FIG. 33 is a perspective view of the instrument of FIG. 28 approaching a bone screw and spinal fixation rod;

[0082] FIG. 34 is a perspective view of the instrument of FIG. 28 capturing a bone screw and spinal fixation rod;

[0083] FIG. 35 is a perspective view of the instrument of FIG. 28 laterally reducing a spinal fixation rod;

[0084] FIG. 36 is a perspective view of the instrument of FIG. 28 axially reducing a spinal fixation rod;

[0085] FIG. 37 is a perspective view of a set screw being inserted through the instrument of FIG. 28;

[0086] FIG. 38 is another perspective view of a set screw being inserted through the instrument of FIG. 28;

[0087] FIG. 39 is a perspective view of one embodiment of a biplanar forceps reducer according to the present disclosure;

[0088] FIG. 40 is a perspective view of the instrument of FIG. 39 capturing a bone screw and spinal fixation rod;

[0089] FIG. 41 is a perspective view of the instrument of FIG. 39 after laterally and axially reducing a spinal fixation rod into a bone screw;

[0090] FIG. 42 is a perspective view of one embodiment of a biplanar forceps reducer according to the present disclosure;

[0091] FIG. 43A is a perspective view of one embodiment of a biplanar forceps reducer according to the present disclosure;

[0092] FIG. 43B is an end view of the instrument of FIG. 43A;

[0093] FIG. 43C is a detail view of the instrument of FIG. 43B;

[0094] FIG. 43D is a top view of the instrument of FIG. 43A;

[0095] FIG. 44A is a longitudinal cross-sectional view of the instrument of FIG. 43A;

[0096] FIG. 44B is a detail view of a middle portion of FIG. 44A;

[0097] FIG. 45 is a partial-exploded view of the instrument of FIG. 43A;

[0098] FIG. 46 is another partial-exploded view of the instrument of FIG. 43A;

[0099] FIG. 47A is a perspective view of one embodiment of a pin used to couple a reducer tube and rod-engaging reducer tip according to the present disclosure;

[0100] FIG. 47B is a side view of the pin of FIG. 47A;

[0101] FIG. 47C is an end view of the pin of FIG. 47A;

[0102] FIG. 48A is an end view of one embodiment of a thrust washer according to the present disclosure;

[0103] FIG. 48B is a side view of the thrust washer of FIG. 48A;

[0104] FIG. 48C is a perspective view of the thrust washer of FIG. 48A;

[0105] FIG. 49A is an end view of one embodiment of a pin used to couple opposing forceps arms according to the present disclosure;

[0106] FIG. 49B is a side view of the pin of FIG. 49A;

[0107] FIG. **49**C is a perspective view of the pin of FIG. **49**A;

[0108] FIG. **50**A is a perspective view of a reducer tube and rod-engaging reducer tip of the instrument of FIG. **43**A;

[0109] FIG. **50**B is a side view of a reducer tube and rod-engaging reducer tip of the instrument of FIG. **43**A;

[0110] FIG. **51**A is a longitudinal cross-sectional view of a reducer tube and rod-engaging reducer tip of the instrument of FIG. **43**A;

[0111] FIG. **51**B is a detail view of a middle portion of FIG. **51**A;

[0112] FIG. **52**A is a perspective view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0113] FIG. **52**B is a top view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0114] FIG. **52**C is a side view a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0115] FIG. **52**D is a first end view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0116] FIG. **52**E is a second end view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0117] FIG. **53** is a longitudinal cross-sectional view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0118] FIG. **54** is another longitudinal cross-sectional view of a rod-engaging reducer tip of the instrument of FIG. **43**A;

[0119] FIG. **55**A is a perspective view of a reducer tube of the instrument of FIG. **43**A;

[0120] FIG. **55**B is a side view of a reducer tube of the instrument of FIG. **43**A;

[0121] FIG. **55**C is a first end view of a reducer tube of the instrument of FIG. **43**A;

[0122] FIG. **55**D is a second end view of a reducer tube of the instrument of FIG. **43**A;

[0123] FIG. **56**A is a longitudinal cross-sectional view of a reducer tube of the instrument of FIG. **43**A;

[0124] FIG. **56**B is a detail view of a distal portion of FIG. **56**A;

[0125] FIG. **57**A is a perspective view of a forceps body of the instrument of FIG. **43**A;

[0126] FIG. **57**B is a first end view of a forceps body of the instrument of FIG. **43**A;

[0127] FIG. **57**C is a second end view of a forceps body of the instrument of FIG. **43**A;

[0128] FIG. **57**D is a side view of a forceps body of the instrument of FIG. **43**A;

[0129] FIG. **57**E is top view of a forceps body of the instrument of FIG. **43**A;

[0130] FIG. **57**F is a third end view of a forceps body of the instrument of FIG. **43**A;

[0131] FIG. **57**G is a detail view of a distal portion of FIG. **57**E;

[0132] FIG. **58**A is a longitudinal cross-sectional view of a forceps body of the instrument of FIG. **43**A;

[0133] FIG. **58**B is a detail view of a distal portion of FIG. **58**A;

[0134] FIG. **59** is a side view of one embodiment of forceps handles according to the present disclosure;

[0135] FIG. **60**A is a perspective view of a first forceps arm of the instrument of FIG. **43**A;

[0136] FIG. **60**B is another perspective view of a first forceps arm of the instrument of FIG. **43**A;

[0137] FIG. **60**C is a side view of a first forceps arm of the instrument of FIG. **43**A;

[0138] FIG. **60**D is a top view of a first forceps arm of the instrument of FIG. **43**A;

[0139] FIG. **61** is an exploded view of a first forceps arm of the instrument of FIG. **43**A;

[0140] FIG. **62**A is a bottom view of a first forceps arm of the instrument of FIG. **43**A;

[0141] FIG. **62**B is another side view of a first forceps arm of the instrument of FIG. **43**A;

[0142] FIG. **62**C is another top view of a first forceps arm of the instrument of FIG. **43**A;

[0143] FIG. **62**D is an end view of a first forceps arm of the instrument of FIG. **43**A;

[0144] FIG. **63**A is a side view of a second forceps arm of the instrument of FIG. **43**A;

[0145] FIG. **63**B is a bottom view of a second forceps arm of the instrument of FIG. **43**A;

[0146] FIG. **63**C is a top view of a second forceps arm of the instrument of FIG. **43**A;

[0147] FIG. **63**D is another side view of a second forceps arm of the instrument of FIG. **43**A;

[0148] FIG. **63**E is a perspective view of a second forceps arm of the instrument of FIG. **43**A;

[0149] FIG. **64** is an exploded view of a second forceps arm of the instrument of FIG. **43**A;

[0150] FIG. **65**A is a perspective view of a pivot arm of the instrument of FIG. **43**A;

[0151] FIG. **65**B is an end view of a pivot arm of the instrument of FIG. **43**A;

[0152] FIG. **65**C is a top view of a pivot arm of the instrument of FIG. **43**A;

[0153] FIG. **65**D is a side view of a pivot arm of the instrument of FIG. **43**A;

[0154] FIG. **65**E is a second end view of a pivot arm of the instrument of FIG. **43**A;

[0155] FIG. **66**A is a transverse cross-sectional view of a pivot arm of the instrument of FIG. **43**A;

[0156] FIG. **66**B is a detail view of an end of FIG. **66**A;

[0157] FIG. **67**A is a longitudinal cross-sectional view of a pivot arm of the instrument of FIG. **43**A;

[0158] FIG. **67**B is a detail view of a distal portion of FIG. **66**A;

[0159] FIG. **68**A is a side view of a pin used to aid coupling a forceps arm with a bone screw according to the present disclosure;

[0160] FIG. **68**B is an end view of the pin of FIG. **68**A;

[0161] FIG. **68**C is a top view of the pin of FIG. **68**A;

[0162] FIG. **69**A is an end view of pin used to prevent rotation of a rod-engaging reducer tip according to the present disclosure;

[0163] FIG. **69**B is a side view of the pin of FIG. **69**A;

[0164] FIG. **69**C is a top view of the pin of FIG. **69**A;

[0165] FIG. **70** is a side view of a forceps handle according to the present disclosure;

[0166] FIG. **71**A is an end view of a forceps handle according to the present disclosure;

[0167] FIG. **71**B is a side view of a forceps handle of FIG. **71**A;

[0168] FIG. **71**C is a top view of a forceps handle of FIG. **71**A;

[0169] FIG. **72** is a side view of a forceps handle according to the present disclosure;

[0170] FIG. **73**A is an end view of a forceps handle according to the present disclosure; and

[0171] FIG. 73B is a side view of a forceps handle of FIG. 73A.

DETAILED DESCRIPTION

[0172] Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices, systems, and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. The devices, systems, and methods specifically described herein and illustrated in the accompanying drawings are non-limiting embodiments. The features illustrated or described in connection with one embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present disclosure. Additionally, to the extent that linear, circular, or other dimensions are used in the description of the disclosed devices and methods, such dimensions are not intended to limit the types of shapes that can be used in conjunction with such devices and methods. Equivalents to such dimensions can be determined for different geometric shapes, etc. Further, like-numbered components of the embodiments can generally have similar features. Still further, sizes and shapes of the devices, and the components thereof, can depend at least on the anatomy of the subject in which the devices will be used, the size and shape of objects with which the devices will be used, and the methods and procedures in which the devices will be used.

[0173] Disclosed herein are biplanar forceps reducer instruments and methods of use that can facilitate engaging an implant, such as a bone anchor receiver head, and reducing or moving a spinal fixation element, such as a rod, in two planes to move the rod into a channel formed in the receiver head. Further, the biplanar forceps reducer instruments disclosed herein can allow for introduction and tightening of a set screw using an inserter that can pass through a cannulated tube of the reducer. The low profile and biplanar reduction functionality can allow a single type of reducer instrument to couple with each bone anchor along a spinal fixation construct and remain in position until the construct is secured in position.

[0174] FIGS. **1**A and **1**B illustrate one embodiment of a biplanar forceps reducer instrument **100** according to the present disclosure. The instrument **100** includes a first arm **102** and a second arm **104** that are pivotably coupled to one another, as well as a reducer tube **106** threadably coupled to the opposed first and second arms and a rod-engaging tip **108** that is rotatably coupled to the reducer tube. As explained in more detail below, the instrument **100** operates by using the opposed first and second arms **102**, **104** to capture a spinal fixation element, such as a rod, and a bone anchor, such as a proximal receiver member of a bone anchor assembly. The instrument **100** can reduce, or translate, the rod in multiple dimensions, e.g., laterally and axially. By way of example, a user can squeeze the proximal portions of the first and second arms **102**, **104** toward one another to cause the distal portions thereof to also move toward one another. Contacting one arm to a spinal fixation element and the other to a bone anchor can allow the lateral reduction or translation of the rod into alignment over the bone anchor. Subsequently, the tube **106** can be rotated, which can result in distal translation of the rod-engaging tip **108** rotatably coupled thereto. The rod-engaging tip **108** can contact the rod and reduce or translate it distally into, e.g., a rod-receiving seat of the bone anchor. Finally, a rod locking element, such as a set screw, can be introduced to the bone anchor through a lumen formed in the reducer tube **106** and rod-engaging tip **108**.

[0175] FIG. **2** illustrates the opposed first and second arms **102**, **104** in isolation, and FIG. **3** shows an exploded view of the assembly. The first and second arms **102**, **104** are pivotably coupled with one another by pins **202** that allow the arms to pivot relative to one another about an axis A **1** that is transverse to a longitudinal axis A **2** of the instrument. The opposed outer handles of the instrument can also include a lock **204** configured to maintain a relative position of the handles or arms, and a biasing element **206** that can be configured to bias the arms in a desired direction. For example, in the illustrated embodiment a portion of the lock **204** can be coupled to a proximal end of the second arm **104** using a screw **302**. A leaf spring **206** can be utilized as a biasing element and secured to the first arm **102** using screws **308**. The leaf spring **206** can contact a portion of the second arm **104** to urge the first and second arms into an open configuration relative to one another. FIG. **3** also illustrates a mechanism that can be utilized to provide friction and maintain a position of a portion of the lock **204** until, e.g., positively moved by a user. The mechanism can include a pin **304** disposed in a bore formed in the second arm **104** such that one end of the pin is in contact with a portion of the lock **204**. A coil spring **306** or other biasing element can urge the pin **304** against the portion of the lock **204** to provide a friction or drag force against movement of the lock relative to the second arm **104**. This mechanism is illustrated in greater detail in FIG. **5**.

[0176] FIGS. **4**A-**4**E illustrate the second arm **104** in greater detail. The second arm **104** can include a distal portion **402** configured to contact a spinal fixation element and/or bone anchor, a pivot arm **404**, a proximal handle **406**, and a proximal end portion **408** that can include the lock **204**. Also shown in these figures is the ratchet bar **410** of the lock **204**.

[0177] The proximal handle **406** of the second arm **104** can include a number of different features to facilitate a user grasping and manipulating the handle. For example, the proximal handle **406** can include one or more depressions **411** configured to seat a user's fingers. In some embodiments, the proximal handle **406** of the second arm **104** can include one or more finger loops configured to receive a user's fingers, as shown, for example, in FIGS. **28**, **39**, **42**, and **43**. In still other embodiments, the proximal handle **406** can include grip or comfort-enhancing features, such as a silicone or other material overmolded portion to facilitate grasping. In some embodiments, the proximal handle **406** can also include one or more protrusions configured to assist user's in maintaining their grip when imparting axial forces to the instrument **100**. For example, the second arm **104** includes a protrusion **413** formed at a distal position along the handle **406** to prevent a user's hand from slipping off the handle when, e.g., urging the instrument distally to couple with a bone anchor receiver member.

[0178] The pivot arm **404** can extend at an oblique angle relative to longitudinal axes defined by the distal portion **402** and the proximal handle **406**. The pivot arm **404** can also define a recess **415** between opposed struts **417** that can receive the first arm **102** therethrough during assembly and operation. The opposed struts **417** can include bores to receive the pins **202** that pivotably couple the first and second arms **102**, **104**.

[0179] The distal portion **402** can have a curved profile to accommodate passage of the reducer tube **106** and/or rod-engaging tip **108**, as well as to facilitate coupling with a bone anchor receiver member that can have a generally curved shape at the interface between the two components. The distal portion **402** can also include an engagement feature **412** formed along a distal portion thereof that can be configured to interface with a complementary feature on a bone anchor receiver member to facilitate coupling between the two components.

[0180] FIGS. **4**C-**4**E illustrate the distal end of the distal portion **402** in greater detail. As shown in the figures, the engagement feature **412** can be a protrusion **412**, such as a ridge extending across a width of the arm, that can be configured to be received within a slot or other recess formed in a proximal outer surface portion of a bone anchor receiver member to facilitate coupling between the components. The ridge or other protrusion can extend across an entire width of the arm or, in some embodiments, can extend across only a portion of a width of the arm or include one or more breaks along its length. Example bone anchors having such features are described in U.S. Pat. No. 7,179,261, the entire contents of which are incorporated by reference herein. Other engagement feature configurations are possible as well, including reversing the above-described configuration such that a protrusion formed on a bone anchor is received in a recess formed in the distal portion **402**. It is also possible to utilize other geometries, e.g., a pin extending from the inner surface of the distal portion **402** that can be received within a bore formed in a receiver member of a bone anchor. An example of a pin disposed in a bore formed in the distal portion **402** can be seen in the embodiment of FIG. **43**.

[0181] In some embodiments, the engagement feature **412** can be disposed proximal to a distal-most end of the arm's distal portion **402** and an inner surface of the arm distal to the engagement feature can be configured to facilitate alignment and coupling of the instrument with a bone anchor receiver member. For example, an internal surface **419** of the arm can have a shape or profile that is complementary to an outer surface of the bone anchor in order to facilitate coupling even in the event there is some amount of misalignment, whether that be, e.g., lateral or rotational misalignment along an axis of a rod, rotational misalignment along a longitudinal axis of the instrument **100**, etc. In some embodiments, for example, the inner surface **419** can include a tapered profile complementary to an outer surface of opposed arms of a polyaxial bone anchor receiver head. In some instances, the inner surface **419** can include a conical tapering profile that is complementary to the conical tapering profile of a receiver member. Such an arrangement can allow for some pivoting misalignment between the receiver head and the instrument **100** that can be corrected as the instrument is advanced distally relative to the receiver head. In other embodiments, however, the profile can be flat without any tapering. Even in such a configuration, the additional extension of the distal portion of the arm beyond the engagement feature **412** can facilitate alignment and coupling between the instrument **100** and a bone anchor receiver member.

[0182] Further, the inner surface **419** can include sidewalls **421** extending outward from the inner surface **419** at lateral ends thereof. The sidewalls **421** can similarly include a tapering profile to aid alignment with a receiver member of a bone anchor, e.g., by self-correcting for rotational misalignment about the longitudinal axis of the instrument as the instrument is advanced distally relative to the bone anchor. In some embodiments, the opposed, inward-facing surfaces of each sidewall **421** can have a planar tapering profile that can be complementary to a planar tapering profile of abutting surfaces on a bone anchor receiver member. The various tapered surfaces can accommodate misalignment when coupling the instrument **100** to a bone anchor such that advancement of the instrument over the bone anchor forces the two components into proper alignment just prior to positive engagement of the pivoting arms **102**, **104** with the anchor to simplify attachment of the instrument **100** to the anchor. As noted, the receiver member can include one or more complementary tapering profiles to the tapered surfaces provided on the outer sleeve. Further details on features of the anchor that can be utilized with the instruments disclosed herein can be found in U.S. Pat. Nos. 10,039,578 and 10,299,839, as well as U.S. Provisional Appl. No. 63/157,362, entitled "Multi-Feature Polyaxial Screw" and filed on Mar. 5, 2021. The entire contents of each of these applications are incorporated by reference herein.

[0183] FIG. **5** illustrates the portion of the lock **204** coupled to the second arm **104** in greater detail. As noted above, the lock **204** can include a ratchet bar **410** rotatably coupled to the proximal portion **408** of the second arm **104** by being disposed in a bore formed in the proximal portion of the second arm and secured with screw **302**. In addition, a drag or friction force can be applied to the ratchet bar **410** using a pin **304** disposed in a transversely-oriented bore formed in the proximal portion **408** of the second arm **104**. The pin **304** can be urged against a portion of the ratchet bar **410** using a coil spring **306** or other biasing element.

[0184] FIGS. **6**A-**6**F illustrate the first arm **102** in greater detail. The first arm **102** can include a distal portion **602**, a housing **604**, a proximal handle **606**, and a proximal end **608** that include a catch **610** that forms a complementary portion of the lock **204** and interfaces with the ratchet bar **410**. The distal portion **602** can be similar to the distal portion **402** of the second arm **104** described above, including an engagement feature **612** and similarly configured surface profiles to facilitate coupling with a bone anchor receiver member. Similarly, the proximal handle **606** can be a mirror or similarly configured as the proximal handle **406** of the second arm **104** described above, including the use of features like finger-recesses **611** and a protrusion **613** to assist during application of axial forces to the first arm **102**.

[0185] The housing **604** can include a lumen **615** having threads **614** formed along at least a portion of a surface thereof. The lumen **615** can define the longitudinal axis A **2** of the instrument **100**, or at least the longitudinal axis A **2** along which the reducer tube **106** and rod-engaging tip **108** translate during reduction maneuvers. The threads **614** formed on the surface of the lumen **615** can be continuous and extend around a circumference thereof, i.e., around an entire perimeter of the lumen **615**. This can be in contrast to partial-circumference thread forms interrupted by longitudinal slots, etc. In some embodiments, however, such a configuration could be utilized in connection with a biplanar forceps reducer according to the present disclosure, e.g., to prevent rotation of a rod-engaging tip without using protrusions formed on the housing **604**. More details on such a configuration and other features can be found in U.S. Pat. No. 8,647,347, the entire contents of which are incorporated by reference herein.

[0186] The lumen **615** of the housing **604** can also include one or more protrusions **616** extending from a surface thereof at a position distal to the threads **614**. As explained in more detail below, the one or more protrusions **616** can be received within a recess of the rod-engaging tip **108** to prevent relative rotation between the tip and the first arm **102**. Other configurations are also possible, however, including, for example, a feature formed along the distal portion **602** rather than in the housing **604**, any of a variety of cooperating shapes, protrusions, and recesses that can prevent relative rotation, etc.

[0187] FIG. **7** illustrates the reducer tube **106** and rod-engaging tip **108** in greater detail. The reducer tube **106** is rotatably coupled to the rod-engaging tip **108**, i.e., the two components can rotate relative to one another but are prevented from axially translating relative to one another. The rod-engaging tip **108** can include opposed extensions **705** formed at a distal end thereof that can be sized and shaped to contact a spinal fixation element, such as a rod, during an axial reduction maneuver. The extensions **705** can also be configured to extend into a U-shaped gaps formed between opposed arms of a bone anchor receiver member, such that the rod-engaging tip **108** can axially reduce a rod into the receiver member without interfering with delivery of a set screw or other locking element, as described below. Also to facilitate delivery of a set screw or other locking element, the rod-engaging tip **108** and reducer tube **106** can define an inner lumen **707**, and the portions thereof extending through each component **106**, **108** can be coaxially aligned.

[0188] The rod-engaging tip **108** can also include one or more openings **710** formed in a sidewall to facilitate viewing into the lumen **707**. This can be useful to facilitate visualizing placement of a set screw or locking element delivered through the lumen **707**, as described in more detail below.

[0189] The rod-engaging tip **108** can also include a groove **709** or other recess formed in an outer surface thereof and extending at least partially along a length thereof. The groove **709** can receive the protrusion **616** formed on the surface of the lumen **615** of the housing **604** in order to prevent relative rotation between the tip **108** and the first arm **102**.

[0190] As noted above, the reducer tube **106** and rod-engaging tip **108** can be rotatably coupled in a manner that permits relative rotation while preventing relative axial translation between the components. This can be accomplished using pins **712** disposed through bores formed in the reducer tube **106** and extending into an interior of the reducer tube. The pins can be received within a groove formed in a proximal end of the rod-engaging tip **108**, as described in more detail below.

[0191] The reducer tube **106** can include a threaded outer surface portion **714** configured to interface with the threads **614** formed on the surface of the lumen **615** of the housing **604**. A depth stop **716** can be formed on the reducer tube **106** at a position proximal to the threads **714**. The depth stop **716** can be configured to contact a proximal portion of the housing **604** in order to limit the distal advancement of the reducer tube **106** and rod-engaging tip **108** relative to the first and second arms **102**, **104**. This depth can be configured to allow for the reduction of multiple diameter spinal fixation rods, e.g., 5.5 mm and 6 mm diameter rods, while providing sufficient reduction to allow a set screw or other locking element to engage a receiver member (e.g., threads of a set screw to engage with threads formed on a proximal surface of a receiver member) and prevent excessive reduction that can create tension and inhibit easy decoupling of the instrument from the receiver member after the set screw or other locking element is installed. For example, in some embodiments the depth stop can be positioned to provide about 6.5 mm of clearance between a distal end of the rod-engaging tip **108** and the base of a bone anchor receiver member rod slot at maximum axial reduction when the depth stop **716** contacts the housing **604**. Such a configuration can allow using the device with both 5.5 mm and 6 mm rods with the benefits noted above. The depth stop **716** can have a variety of forms, including any of a variety of protrusions formed on an outer surface of the reducer tube **106** around part of or an entirety of its circumference. In the illustrated embodiment, the depth stop **716** is a shoulder formed around a circumference (i.e., an entire perimeter) of the reducer tube **106**.

[0192] An intermediate portion **704** can extend proximally from the depth stop to a drive feature **718** formed on a proximal end of the reducer tube **106**. The intermediate portion **704** can have a variety of shapes, diameters, and lengths. In the illustrated embodiment, the intermediate portion **704** has a generally cylindrical shape. The drive feature **718** formed at a proximal end of the reducer tube **106** can allow for modular coupling of a driver handle, powered driver, or other torque application implement to the reducer tube **106** in order to effect rotation of the tube and axial reduction of a spinal fixation element. The drive feature **718** can also permit access to the lumen **707** therethrough, e.g., as shown in FIG. **11**A described below. The drive feature **718** can have a variety of forms and sizes. In some embodiments, the drive feature **718** can include one or more flats to facilitate the application of torque thereto. In the illustrated embodiment, the drive feature **718** is a hex feature having six flat portions disposed around a circumference of the reducer tube **106**. Further, in the illustrated embodiment an outer diameter of the depth stop **716** can be greater than an outer diameter of any other portion of the reducer tube **106** (e.g., greater than the outer diameter of the threaded portion **714** or the drive feature **718**). Utilizing a lower profile drive feature **718** can reduce the footprint of the instrument **100** while still allowing a larger driver handle (e.g., a T-handle, powered driver, etc.) to be coupled to the instrument when needed.

[0193] FIGS. **8**-**12**B illustrate another embodiment of a reducer tube **806** and a rod-engaging tip **808** in greater detail. The reducer tube **806** and rod-engaging tip **808** are similar to the embodiments described above, including the use of distal extensions **805** formed on the rod-engaging tip **808**, a lumen **807** extending through the two components, and a groove **809** to receive a protrusion formed on the housing **604**. The rod-engaging tip **808** includes a differently-shaped opening **810** or window formed in a sidewall thereof. In particular, the opening is extended along a longitudinal axis of the tip **808** but compressed in the radial dimension. The reducer tube **806** includes similar pins **812** or other protrusions (e.g., integrally-formed protrusions,

protrusions of different shape, etc.) that can be used to couple the reducer tube to the rod-engaging tip, as well as threads **814**, depth stop **816**, intermediate portion **804**, and drive feature **818**.

[0194] The exploded view of FIG. **9** and the cross-sectional views of FIGS. **12**A and **12**B illustrate the rotatable coupling of the reducer tube **806** and rod-engaging tip **808** in greater detail. For example, the pins **812** or other protrusions extending into an interior of the reducer tube **806** are visible, as well as the groove **904** formed in the rod-engaging tip **808** where the pins ride to allow for relative rotation while preventing relative translation. Also shown is a thrust washer **902** disposed between a proximal end of the rod-engaging tip **808** and an interior shoulder **1201** (see FIG. **12**B) formed along a distal portion of the reducer tube **806**.

[0195] FIGS. **10-11**B show the rod-engaging tip **808** and reducer tube **806** in isolation to better illustrate their features. Of note in FIG. **11**B is the detail view of the threads **814** formed on the outer surface of the reducer tube **806**. Any of a variety of thread forms can be utilized with the instruments of the present disclosure. In some embodiments, it can be desirable to utilize a thread form that is low profile in order to minimize an outer diameter of the threaded portion **814**, which can allow minimization of a size of the housing **604** and resulting instrument **100**. For example and with reference to the detail cross-sectional view of FIG. **12**B, in some embodiments an outer diameter D**1** of the threaded outer surface portion of the tube can be less than or equal to about 45% larger than a diameter D**2** of an inner lumen **807** of the tube **806**. In certain embodiments, the outer diameter D**1** of the threaded outer surface portion of the tube can be less than or equal to about 40%, about 35%, about 30%, about 25%, or about 20% larger than the diameter D**2** of the inner lumen **807** of the tube **806**. For example, in one embodiment the diameter D**1** can be about 13 mm and the diameter D**2** can be about 9 mm. Utilizing such a configuration can minimize an outer diameter of the threads of the tube and provide a lower profile instrument to access a surgical site through a smaller opening or with less interference for adjacent anatomy or instrumentation.

[0196] In some embodiments it can also be desirable to provide thread forms with lower mechanical advantage, which can provide better tactile feedback to a user during a reduction maneuver. In some embodiments, thread forms with one or more starts can be utilized and, in some embodiments, a thread forms with a plurality of starts can be utilized. In the illustrated embodiment, a thread form with three starts **1102** (the third start is not visible) is illustrated, as shown in FIG. **11**B.

[0197] FIGS. **13** and **14** illustrate one embodiment of a biplanar reducer instrument **1300** according to the present disclosure that incorporates the first and second arms **102**, **104** discussed above with the reducer tube **806** and rod-engaging tip **808**. These figures also illustrate in greater detail the placement and operation of the biasing element **206** that can bias the arms **102**, **104** toward an open configuration and the lock **204** with drag force mechanism.

[0198] FIGS. **15-26** illustrate a method of operation of a biplanar forceps reducer instrument according to the present disclosure. FIG. **15** illustrates one embodiment of a vertebral body **1502** and a bone anchor or implant **1504** (also shown is a longitudinal axis A **3** of the implanted bone anchor). FIG. **16** shows the vertebral body **1502** and implant **1504** with a spinal fixation element **1602**, e.g., a rod, disposed in a position that is both laterally (e.g., transverse to the longitudinal axis A **3** of the implanted bone anchor) and axially (e.g., parallel to the longitudinal axis A **3** of the implanted bone anchor) offset relative to the bone anchor. FIG. **16** also shows the introduction of the biplanar forceps reducer instrument **100**, in particular a first positioning of the instrument in which a distal portion **402** of the first arm **102** is docked against one side of the bone anchor **1504** and the distal portion **602** of the second arm **104** is used to capture the laterally offset rod **1602**.

[0199] FIG. **17** illustrates a lateral reduction step that can be achieved by actuating the first and second arms **102**, **104**. In particular, a user can bring proximal handle portions of the arms **102**, **104** toward one another to cause the distal portions **402**, **602** to pivot toward one another. This movement will urge the rod **1602** and the implant **1504** toward one another in a lateral direction (e.g., a direction transverse to the longitudinal axis of the instrument or the implant), ultimately bringing the rod into lateral alignment with the implant along a longitudinal axis, as shown in FIG. **17**. Actuation of the arms **102**, **104** can also result in the distal portions **402**, **602** of both arms being docked to the implant **1504** (e.g., such that engagement features formed thereon interface with complementary features formed on opposed outer surfaces of the implant). Still further, FIG. **17** shows the lock **204** maintaining a relative position of the first and second arms **102**, **104** such that a user need not maintain force applied to the arms to pivot them toward one another.

[0200] FIG. **18** illustrates the introduction of a modular driver **1801** that can be coupled to a proximal drive feature **718** of the reducer tube **106** to effect rotation thereof. The driver **1801** can include a coupling feature **1803** at a distal end thereof and a proximal handle **1805**. The coupling feature can be configured to interface with the drive feature **718** in a manner that permits application of torque to the reducer tube **106**. In the illustrated embodiment, the coupling feature can be a hex socket **1803** configured to receive the hex drive feature **718** formed on the reducer tube **106**. As noted above, an of a variety of alternative drive and coupling feature geometries can be utilized. Further, while a hand-actuated driver **1801** is illustrated, in other embodiments a differently-configured hand-powered (e.g., a T-handle, etc.) or powered (e.g., electric, pneumatic, hydraulic, etc.) actuator can be utilized.

[0201] Once the driver **1801** is assembled to the reducer tube **106**, a user can rotate the reducer tube to effect axial translation or reduction of the rod **1602** toward the implant **1504**. In particular, and as described above, rotation of the reducer tube **106** can cause distal advancement thereof relative to the arms **102**, **104** and implant coupled thereto due to the threaded coupling between the reducer tube and the housing **604** of the first arm **102**. Distal advancement of the reducer tube **106** can cause distal advancement of the rod-engaging tip **108** since these components are coupled in a manner that allows for relative rotation but prevents relative translation. The rod-engaging tip **108** can be prevented from rotating relative to the arms **102**, **104** by the protrusion formed on the housing **604** of the first arm **104** riding within the longitudinal groove **709** of the rod-engaging tip. As the rod-engaging tip **108** advances distally, the distal-most extensions **705** formed thereon can contact the rod **1602** and urge it distally toward the implant **1504**. Lateral movement of the rod **1602** can be prevented by the distal portions **402**, **602** of the arms **102**, **104**.

[0202] FIG. **19** illustrates a fully reduced position of the rod **1602** within a seat of a receiver member of the implant **1504** when the reducer tube **106** has been advanced to a point where the depth stop **716** contacts a proximal end of the housing **604** of the first arm **102**. Following reduction, the driver **1801** can be removed from the instrument **100**, as shown in FIG. **20**.

[0203] With the modular driver **1801** separated from the reducer tube **106**, a set screw **2102** or other locking element can be advanced toward the implant **1504** through the inner lumen **707** of the reducer tube **106**. In particular, the set screw **2102** can be coupled to a distal end of an inserter **2104** and the inserter can be utilized to advance the set screw into the lumen **707** from the proximal end of the reducer tube **106**, as shown in FIG. **21**. Once the set screw **2102** reaches the implant **1504**, the inserter **2104** can be utilized to engage the set screw with threads formed on a proximal portion of the implant receiver member, as shown in FIG. **22**. As noted above, the depth stop **716** and configuration of the instrument **100** can be such that it does not achieve a true final position of the rod **1602** (i.e., where the rod is bottomed out against a distal portion of a rod seat of the receiver member), but instead reduces the rod far enough to allow a set screw to engage threads in the receiver member. This can allow final reduction and tightening of the rod to be performed using the set screw **2102** and inserter **2104**. This will also allow for easier separation of the instrument **100** by reducing tension in the coupling with the implant **1504** and rod **1602**.

[0204] Once the inserter **2104** is utilized to tighten the set screw **2102** to a desired degree, the inserter **2104** can be removed proximally and withdrawn from the inner lumen **707** of the reducer tube **106** and rod-engaging tip **108**. Placement of the set screw **2102** can be verified visually through the opening **710** formed in the sidewall of the rod-engaging tip **108**, as shown in FIGS. **23**A and **23**B.

[0205] FIG. **24** illustrates a next method step in which the instrument **100** is separated from the implant **1504**. This can be accomplished by releasing the lock **204** (e.g., pivoting the ratchet bar **410** out of engagement with the catch **610**) and allowing the first and second arms **102**, **104** to pivot away from one another to separate the distal portions **402**, **602** thereof from the implant **1504**. The instrument **100** can then be withdrawn proximally, as shown in FIG. **25**. This leaves the final implanted bone anchor **1504** with fully reduced rod **1602** secured by set screw **2102**, as shown in FIG. **26**.

[0206] FIGS. **27**A and **27**B illustrate alternative embodiments of biplanar forceps reducer instruments. FIG. **27**A, for example, illustrates an embodiment in which a reducer tube **2706** having a shorter intermediate portion **2709** is utilized. In particular, the reducer tube **2706** can include an intermediate portion **2709** that is short enough in length that the proximal end drive feature of the reducer tube is disposed distal to the lock **204** and/or proximal ends of the arms **102**, **104**. In order to avoid interference with the proximal portions of the arms **102**, **104** and lock **204** during operation, a driver **2701** can be utilized that includes an extended intermediate portion **2707** between its coupling feature **2703** and proximal handle **2705**.

[0207] FIG. **27**B illustrates another embodiment in which a reducer tube **2706'** includes an integrated driver handle **2713** rather than the modular configuration described above. In such an embodiment, the reducer tube driver handle **2713** can still provide access to an inner lumen thereof through its proximal end, such that a set screw inserter **2104** can be utilized to deliver a set screw, as shown in FIG. **27**B.

[0208] Still other alternative embodiments are also contemplated and provided in the present disclosure. For example, FIGS. **28-35** illustrate views of one embodiment of a biplanar forceps reducer **2800** according to the present disclosure. The exploded view of FIG. **29** shows that the instrument **2800** includes lateral reduction forceps **2902** with internal reduction threads that interface with a hollow axial reducer tube **2904** having external reduction threads formed thereon. Opposed distal tips **2906** of the forceps **2902** include implant engagement features that can interface with portions of a bone anchor receiver head, such as opposed sides or features formed on opposed sides, e.g., notches, grooves, holes, etc. The forceps **2902** can include a ratchet lock **2908** that is offset from the longitudinal axis of the reducer tube to ensure no interference between these components. A rod-engaging reduction tip **2910** can be coupled to a distal end of the reducer tube **2904** in a manner that allows relative rotation of the tip about a longitudinal axis of the tube but prevents axial translation or separation of the components. The rod-engaging tip **2910** can be disposed between the opposed lateral reduction forceps **2902** and prevented from rotating relative thereto such that the tip remains properly oriented to engage a rod even as the axial reducer tube is rotated. Finally, a driver feature **2912** or handle can be formed on a proximal end of the axial reducer tube **2904** to facilitate rotation of the tube to effect axial reduction of a rod disposed between the opposed jaws of the lateral reduction forceps **2902**.

[0209] FIG. **30** illustrates the distal end of the axial reducer tube **2904** and the rod-engaging tip **2910**. The axial reducer tube **2904** and rod-engaging tip **2910** can be hollow to allow for set screw passage while minimizing tube outer diameter. This can contribute to lower instrument profile and improve the ability to use the instrument in tight spaces, e.g., on adjacent closely spaced vertebral levels, etc. The distal end of the reducer tube **2904** can include a groove **3002** and the proximal end of the rod-engaging tip **2910** can include opposed wings **3004** with a feature **3006** that snaps into the groove **3002** of the reducer tube to allow free rotation about a longitudinal axis of the tube while preventing axial translation or separation thereof.

[0210] As shown in FIGS. **31** and **32**, the body of the forceps **2902** can include internal threads **3202** to interface with the external threads of the reducer tube. The threads **3202** can include bilateral slots **3204** formed therein to allow the rod-engaging tip **2910** to pass through. Further, the opposed wings or arms **004** of the rod-engaging tip can articulate with the distal portion of the lateral reducer forceps jaws to prevent rotation of the rod-engaging tip **2910** as the axial reducer tube is rotated through the threads formed on the forceps body **2902**.

[0211] FIGS. **33-38** illustrate a method of using the instrument **2800** described above. In FIG. **33**, the illustrated rod **3302** is positioned both laterally and axially offset from the channel **3304** of the bone anchor **3306** receiver head **3308**. The reducer forceps **2902** are moved to an open position and the reducer tube **2904** is rotated to withdraw it proximally. The reducer is positioned to capture both the rod **3302** and receiver head **3308** between distal forceps arms or jaws. In FIG. **34**, the reducer instrument **2800** engages the rod **3302** and receiver head **3308** by positioning a first forceps jaw or arm against the bone anchor receiver head and a second forceps jaw or arm against the rod that is laterally and axially offset from the receiver head. FIG. **35** shows the lateral rod translation or reduction accomplished by bringing the forceps handles toward one another and causing the distal forceps jaws or arms to move toward one another. The ratchet lock **2908** of the forceps can maintain the lateral reduction and allow for step-wise, incremental reduction engaging sequential teeth of the ratchet lock. Further, closing the forceps jaws or arms toward one another can lock the forceps to the bone anchor receiver head **3308** by bringing the second forceps jaw or arm into contact with the receiver head. As noted above, the receiver head **3308** can include one or more features (e.g., notches, grooves, indentations, protrusions, etc.) that can interface with complementary features formed on inner surfaces of the distal forceps jaws or arms to facilitate more secure locking of the forceps to the receiver head.

[0212] With lateral reduction complete, the rod can be axially reduced into the channel of the receiver head, as shown in FIG. **36**. This is accomplished by rotating the reducer tube **2904** using the drive feature formed at its proximal end. Rotation of the reducer tube **2904** through the threads formed on the forceps body causes translation of the rod-engaging tip **2910** along the distal forceps arms or jaws. The rod-engaging tip translates distally and forces the rod **3302** in the same direction toward the channel **3304** of the receiver head **3308**. This axial reduction can be maintained by virtue of the threaded connection between the reducer tube and forceps body.

[0213] FIG. **37** illustrates introduction of a set screw **3702** and set screw insertion instrument **3704** through the cannula of the reducer tube **2904**. Using this cannula access, the set screw **3702** can be delivered to the receiver head **3308** of the bone anchor and installed to secure capture of the rod **3302** within the channel **3304** of the receiver head. FIG. **38** illustrates tightening of the set screw **3702** using the inserter **3704** positioned within the cannula of the reducer tube **2904**. Introduced to the bone anchor in this manner, the set screw **3702** can be provisionally and finally tightened to complete spinal fixation construct without the need to remove the biplanar forceps reducer.

[0214] FIG. **39** illustrates another embodiment of a biplanar forceps reducer **3900** that is similar to the reducer **2800** discussed above, including lateral reduction forceps **3902** with internal reduction threads that interface with a hollow axial reducer tube **3904** having external reduction threads formed thereon. The instrument **3900** likewise includes opposed distal tips **3906** of the forceps **3902** that can interface with portions of a bone anchor receiver head, a ratchet lock **3908** that is offset from the longitudinal axis of the reducer tube, a rod-engaging reduction tip **3910** coupled to a distal end of the reducer tube **3904** in a manner that allows relative rotation of the tip about a longitudinal axis of the tube but prevents axial translation or separation of the components, and a driver feature **3912** or handle formed on a proximal end of the axial reducer tube **3904** to facilitate rotation of the tube to effect axial reduction of a rod disposed between the opposed jaws of the lateral reduction forceps **3902**. The reducer **3900**, however, utilizes a different configuration of user-graspable handles/finger loops **3914** from the handles/finger loops **2914** utilized in the reducer **2800**. Any of a variety of finger loops or other user-graspable handle configurations can be employed. Several examples are disclosed in the embodiments described herein, but any combination of grips is possible and contemplated by the present disclosure.

[0215] FIG. **40** illustrates a rod **4002** that is positioned both laterally and dorsally relative to one or more bone anchors **4004** implanted in the vertebrae of a patient's spine **4006**. In such a case, the rod **4002** needs to be translated in two planes to be received within the channel formed in the receiver heads of the implanted bone anchors **4004**: medially in the coronal plane and anteriorly in the sagittal plane. The figure shows the biplanar forceps reducer **3900** disposed to impart lateral and axial reduction to the rod **4002** relative to a bone anchor **4004**. In some procedures, additional reducer instruments can be coupled to each of the adjacent bone anchors (or all of the bone anchors) and used together to provide the required reduction forces.

[0216] FIG. **41** illustrates the biplanar forceps reducer **3900** after imparting lateral and axial reduction forces to move the rod **4002** into the channels of the implanted receiver heads of bone anchors **4004**. The lateral reduction can be maintained by virtue of the locking forceps handles and the axial reduction can be maintained by virtue of the threaded engagement between the reducer tube and the forceps body. From the illustrated configuration, a user can introduce a set screw through the cannulated reducer tube **3904** and provisionally or finally lock the rod **4002** into position relative to the implanted bone anchor **4004**.

[0217] FIG. **42** illustrates another embodiment of a biplanar forceps reducer **4200** that is similar to the reducers **2800**, **3900** discussed above, including lateral reduction forceps **4202** with internal reduction threads that interface with a hollow axial reducer tube **4204** having external reduction threads formed thereon. The instrument **4200** likewise includes opposed distal tips **4206** of the forceps **4202** that can interface with portions of a bone anchor receiver head, a ratchet lock **4208** that is offset from the longitudinal axis of the reducer tube, a rod-engaging reduction tip **4210** coupled to a distal end of the reducer tube **4204** in a manner that allows relative rotation of the tip about a longitudinal axis of the tube but prevents axial translation or separation of the components, and a driver feature **4212** or handle formed on a proximal end of the axial reducer tube **4204** to facilitate rotation of the tube to effect axial reduction of a rod disposed between the opposed jaws of the lateral reduction forceps **4202**. The reducer **4200**, however, utilizes a different configuration of user-graspable handles/finger loops **4214** from those utilized in the above-described reducers. M ore particularly, the handles **4214** in the instrument **4200** are offset from the longitudinal axis of the reducer tube **4204**, such that they lie in a plane with the ratchet lock **4208**. In contrast, the user-graspable handles **2914** and **3914** are aligned with the longitudinal axis of the reducer tube and only the ratchet lock **4208** extends to a position offset from the longitudinal axis of the reducer tube.

[0218] FIGS. **43**A-**73**B illustrate additional views of embodiments of the biplanar forceps reducer instruments disclosed herein. M ore particularly, FIGS. **43**A-**43**D illustrate various views of a biplanar forceps reducer **4300** similar to the reducer **4200** described above, including forceps **4302**, reducer tube **4304**, ratchet lock **4308**, reducing tip **4310**, and drive feature **4312**. FIGS. **44**A and **44**B illustrate cross-sectional views of the reducer **4300** showing interaction of the reducer tube **4304** with the forceps body **4302** and the shoulder **4316** formed on the tube that serves as a depth stop for distal advancement of the tube relative to the forceps body. FIG. **45** illustrates the proximal removal of the reducer tube **4304** and reducing tip **4310** from the forceps body **4302**. FIG. **46** illustrates an exploded view of the two forceps handles that are coupled by pins **4320** to facilitate pivoting movement therebetween.

[0219] FIGS. **47**A-**47**C illustrate various views of a dowel pin **4700** that can be used to couple the reducer tube and rod-engaging end in a manner that permits relative rotation and prevents relative axial translation. This component can be seen in the detail cross-sectional view of FIG. **51**B that illustrates the reducer tube and rod-engaging tip assembly. The detail cross-sectional view of FIG. **51**B shows the dowel pin **4700** of FIG. **47** disposed in holes formed in the distal portion of the reducer tube **4304** and extending into a groove **5100** formed in the proximal portion of the rod-engaging tip **4310** to couple these components in a manner that allows rotation and prevents axial translation. Also shown in this view is the thrust washer **4800** of FIGS. **48**A-**48**C disposed between the reducer tube **4304** and rod-engaging tip **4310**. M ore particularly, the thrust washer **4800** is disposed at a proximal end of the rod-engaging tip **4310** and interfaces at its proximal end with a distal-facing shoulder **5102** formed on an inner surface of the reducer tube **4304**.

[0220] FIGS. **49**A-**49**C illustrate various views of a rotation pin **4320** that can be used to couple the opposed arms of the forceps **4302**, as shown in FIG. **46**.

[0221] FIGS. **50**A and **50**B illustrate various view of the reducer tube **4304** and rod-engaging tip **4310**. FIGS. **51**A and **51**B illustrate these components in cross-section to show their coupling, as described above.

[0222] FIGS. **52**A-**52**E illustrate various views of the rod-engaging tip **4310** that interfaces with the reducer tube **4304** and forceps **4302** to provide translation without rotation in connection with rotation of the reducer tube. FIGS. **53** and **54** illustrate different cross-sectional views of the rod-engaging tip **4310**. In particular, these figures highlight the groove **5100** formed at a proximal end of the rod-engaging tip and configured to receive the pins **4700** to couple the tip to the reducer tube **4304** in a manner that allow for relative rotation. Also shown is the longitudinal or axial groove **5208** formed in opposing sides of the outer surface of the tip **4310** that can receive a pin or other protrusion formed on an inner surface of a lumen of the forceps **4302** to maintain a rotational position of the tip **4310** as it translates in response to rotation of the tube **4304**.

[0223] FIGS. **55**A-**55**D illustrate various views of the reducer tube **4304**, including holes **5502** near a distal end thereof that receive the dowel pins **4700** of FIG. **47**. Also shown is the drive feature **4312**, threads **5514** that engage with the forceps **4302**, and shelf **5516** that serves as a stop against further distal advancement of the reducer tube **4304** relative to the forceps **4302**. FIGS. **56**A and **56**B illustrate different cross-sectional views of the reducing tube **4304**.

[0224] FIGS. **57**A-**57**G illustrate various views of the forceps body **4302**, including the internal threads **5714** formed thereon and holes **5702** that receive the rotation pins **4320** of FIGS. **49**A-**49**C to join the opposed forceps arms or jaws. FIGS. **58**A and **58**B illustrate cross-sectional views of the forceps body **4302**. Also shown in these figures is a hole **5704** that can accommodate a pin **6102** (see FIGS. **61** and **68**A-**68**C) that extends into the inner lumen of the forceps body **4302**. This pin can, for example, be received within the groove **5208** formed in the rod-engaging tip **4310** to maintain its rotational position relative to the forceps body **4302** as the reducer tube **4304** is rotated to cause translation of the rod-engaging tip **4310**. One or more of these holes can be formed in the forceps body **4302** (e.g., two opposing pins **6102** are shown in FIG. **61**) and the pin can be secured in a number of manners, including use of adhesives, welding, other mechanical fastening, etc. Further, in some embodiments, a protrusion or other feature can be integrally formed with the body rather than inserting a pin through a hole.

[0225] These figures also illustrate a further hole **5706** formed in a distal end of the distal tip **4306** of the forceps. This hole can accommodate a pin **6104** (see FIGS. **61** and **67**A-**67**C) that extends radially inward from the distal tip **4306** and can be received in, for example, a hole or bore formed in a receiver head of a bone screw in order to facilitate coupling between the distal tip **4306** of the forceps and the receiver head. One or more of these holes can be formed in the forceps body **4302** and the pin can be secured in a number of manners, including use of adhesives, welding, other mechanical fastening, etc. Further, in some embodiments, a protrusion or other feature can be integrally formed with the body rather than inserting a pin through a hole. And, as described above, in other embodiments different shapes, such as a shoulder or ridge, etc., can be utilized.

[0226] FIG. **59** illustrates one embodiment of proximal forceps handles **5900** including rings to accept user fingers and a ratchet lock. As noted above, a variety of different forceps handle shapes, whether including finger rings or not, can be utilized.

[0227] FIGS. **60**A-**60**D, **61**, and **62**A-**62**D illustrate various views of the forceps body **4302** and proximal handles/finger rings **4314**, which can be integrally formed or joined by any of a variety of techniques, including mechanical coupling with bolts, welding, adhesives, etc.

[0228] FIGS. **63**A-**63**E and **64** illustrate various view of the forceps pivot arm **4303** that couples to the forceps body **4302** of FIGS. **60**A-**62**D to form the opposed forceps jaws or arms. FIGS. **65**A-**67**B illustrate various views of portions of the pivot arm **4303** of FIGS. **63**A-**64**.

[0229] FIGS. **68**A-**68**C illustrate various views of an implant locking pin **6104** that can be received within a bore **5706** of each distal forceps jaw or arm (e.g., as shown in FIGS. **60**A-**62**D and **63**A-**67**B). The locking pins **6104** can be configured to protrude from an inner surface of the forceps jaws and be received within a recess formed in a bone anchor receiver member to aid the forceps in locking to the receiver head.

[0230] FIGS. **69**A-**69**C illustrate various views of an alignment pin **6102** that can be received within a bore **5704** formed in the forceps body, as shown in FIGS. **60**A-**62**D. In the illustrated embodiment, these alignment pins **6102** can extend into longitudinal grooves **5208** formed in the sides of the rod-engaging tip **4310** (as shown in FIGS. **52**A-**54**) to prevent the rod-engaging tip **4310** from rotating relative to the forceps body **4302** as it translates relative thereto when the reducer tube **4304** is rotated through the threads **5714** formed on an inner surface of the forceps body.

[0231] FIGS. **70**-**73**B illustrate various views of proximal handles **7014**, **7114**, **7214**, **7314** that can be used with the forceps reducers disclosed herein, including rings to accept user fingers for actuation and ratchet locks **7008**, **7108**, **7208**, **7308** to maintain lateral reduction.

[0232] The instruments disclosed herein can be constructed from any of a variety of known materials. Exemplary materials include those which are suitable for use in surgical applications, including metals such as stainless steel, titanium, nickel, cobalt-chromium, or alloys and combinations thereof, polymers such as PEEK, ceramics, carbon fiber, and so forth.

[0233] The devices and methods disclosed herein can be used in minimally-invasive surgery and/or open surgery. While the devices and methods disclosed herein are generally described in the context of surgery on a human patient, it will be appreciated that the methods and devices disclosed herein can be used in any of a variety of surgical procedures with any human or animal subject, or in non-surgical procedures.

[0234] The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[0235] The devices described herein can be processed before use in a surgical procedure. First, a new or used instrument can be obtained and, if necessary, cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument can be placed in a closed and sealed container, such as a plastic or TY VEK bag. The container and its contents can then be placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation can kill bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container can keep the instrument sterile until it is opened in the medical facility. Other forms of sterilization known in the art are also possible. This can include beta or other forms of radiation, ethylene oxide, steam, or a liquid bath (e.g., cold soak). Certain forms of sterilization may be better suited to use with different portions of the device due to the materials utilized, the presence of electrical components, etc.

[0236] Further features and advantages based on the above-described embodiments are possible and within the scope of the present disclosure. Accordingly, the disclosure is not to be limited by what has been particularly shown and described. All publications and references cited herein are expressly incorporated herein by reference in their entirety, except for any definitions, subject matter disclaimers or disavowals, and except to the extent that the incorporated material is inconsistent with the express disclosure herein, in which case the language in this disclosure controls.

[0237] Examples of the above-described embodiments can include the following:

[0238] 1. A surgical instrument, comprising:

[0239] a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a threaded lumen defining a longitudinal axis;

[0240] a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm;

[0241] a tube having a threaded outer surface portion disposed within the threaded lumen, a depth stop formed proximal to the threaded portion, and a drive feature at a proximal end of the tube configured to removably couple with a driver to impart torque to the tube; and

[0242] a rod-engaging tip rotatably coupled to a distal end of the tube;

[0243] wherein the first and second arms are configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip is configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

[0244] 2. The instrument of example 1, wherein the depth stop defines a maximum outer diameter of the tube.

[0245] 3. The instrument of any of examples 1 to 2, wherein the depth stop is a shoulder formed around at least a portion of the circumference of the tube.

[0246] 4. The instrument of any of examples 1 to 3, wherein the lumen includes continuous threads formed around a circumference thereof.

[0247] 5. The instrument of any of examples 1 to 4, wherein an inner lumen of the tube is accessible from a proximal end of the tube through the drive feature.

[0248] 6. The instrument of example 5, wherein the rod-engaging tip includes an inner lumen coaxially disposed with the inner lumen of the tube.

[0249] 7. The instrument of any of examples 1 to 6, wherein the rod-engaging tip includes an opening formed in a distal portion of a sidewall to facilitate viewing contents of an inner lumen of the rod-engaging tip.

[0250] 8. The instrument of any of examples 1 to 7, wherein a distal end of at least one of the first and second arms includes a protrusion configured to extend into a recess of a bone anchor receiver member.

[0251] 9. The instrument of example 8, wherein the protrusion is a pin disposed in a bore formed in the distal end of at least one of the first and second arms.

[0252] 10. The instrument of example 8, wherein the protrusion is a ridge extending across a width of the arm.

[0253] 11. The instrument of any of examples 8 to 10, wherein the protrusion is disposed proximal to a distal-most end of the arm and an inner surface of the arm distal to the protrusion has a conical tapering profile.

[0254] 12. The instrument of example 11, wherein the inner surface of the arm includes sidewalls extending outward from the inner surface at lateral ends of the arm, and opposed, inward-facing surfaces of each sidewall have a planar tapering profile.

[0255] 13. The instrument of any of examples 1 to 12, further comprising a lock configured to selectively maintain a position of the first and second arms relative to one another.

[0256] 14 The instrument of example 13, wherein the lock is coupled to a proximal portion of one or more of the first and second arms, and a proximal end of the tube is disposed distal to the lock.

[0257] 15. A surgical method, comprising:

[0258] positioning a first arm of a reducer instrument against a bone anchor receiver member;

[0259] positioning a second arm of the reducer instrument against a spinal fixation element;

[0260] positioning a threaded outer surface portion of a tube of the reducer instrument within a threaded lumen formed in a housing of the first arm of the reducer instrument;

[0261] pivoting the first and second arms of the reducer instrument toward one another to translate the spinal fixation element laterally toward a longitudinal axis defined by the threaded lumen;

[0262] coupling a driver to a drive feature formed at a proximal end of the tube;

[0263] rotating the tube of the reducer instrument to translate the spinal fixation element axially along the longitudinal axis until a depth stop formed on the tube proximal to the threaded outer surface portion contacts the housing.

[0264] 16. The method of example 15, further comprising engaging a lock to maintain a position of the first and second arms relative to one another after pivoting the first and second arms toward one another.

[0265] 17. The method of any of examples 15 to 16, further comprising separating the driver from the proximal end of the tube after rotating the tube to translate the spinal fixation element axially.

[0266] 18. The method of example 17, further comprising inserting a set screw through an inner lumen of the tube and coupling the set screw with the receiver member.

[0267] 19. The method of example 18, further comprising visually inspecting the set screw while coupled to the receiver member using an opening formed in a distal portion of a sidewall of rod-engaging tip coupled to the tube.

[0268] 20. A surgical instrument, comprising:

[0269] a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a lumen defining a longitudinal axis, the lumen having continuous threads formed around a circumference thereof;

[0270] a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm;

[0271] a tube having a threaded outer surface portion disposed within the lumen;

[0272] a rod-engaging tip rotatably coupled to a distal end of the tube, the rod-engaging tip being constrained against rotation relative to the housing by a protrusion coupled to the housing that is received in a recess of the rod-engaging tip;

[0273] wherein the first and second arms are configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip is configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

[0274] 21 The instrument of example 20, wherein the threads on the outer surface portion of the tube have a plurality of starts.

[0275] 22. The instrument of example 21, wherein the threads on the outer portion of the tube have three starts.

[0276] 23. The instrument of any of examples 20 to 22, wherein an outer diameter of the threaded outer surface portion of the tube is less than or equal to about 45% larger than a diameter of an inner lumen of the tube.

[0277] 24. A surgical instrument, comprising:

[0278] opposed arms pivotably coupled to one another;

[0279] a tube threadably coupled to the opposed arms; and

[0280] a rod-engaging tip rotatably coupled to the tube;

[0281] wherein the opposed arms are configured to laterally translate a spinal fixation element when pivoted toward one another and the rod-engagement tip is configured to axially translate the spinal fixation element when the tube is rotated relative to the opposed arms and the rod-engagement tip.

[0282] 25. The instrument of example 24, wherein one of the opposed arms includes a housing having a threaded lumen formed therein.

[0283] 26. The instrument of example 25, wherein the tube includes external threads formed thereon that interface with the threaded lumen of the body.

[0284] 27. The instrument of example 26, wherein the external threads formed on the tube include a plurality of starts.

[0285] 28. The instrument of example 27, wherein the external threads formed on the tube include three starts.

[0286] 29. The instrument of any of examples 26 to 28, wherein an outer diameter of the external threads of the tube is less than or equal to about 45% larger than a diameter of an inner lumen of the tube.

[0287] 30 The instrument of any of examples 26 to 29, wherein the tube includes a depth stop formed proximal to the external threads.

[0288] 31 The instrument of example 30, wherein the depth stop defines a maximum outer diameter of the tube.

[0289] 32 The instrument of any of examples 30 to 31, wherein the depth stop is a shoulder formed around at least a portion of the circumference of the tube.

[0290] 33. The instrument of any of examples 25 to 32, wherein the threaded lumen includes continuous threads formed around a circumference thereof.

[0291] 34 The instrument of any of examples 25 to 33, wherein the housing includes a protrusion received within a recess of the rod-engaging tip to constrain the rod-engaging tip against rotation relative to the housing.

[0292] 35. The instrument of any of examples 24 to 34, wherein the opposed arms include opposed proximally-extending handles for user actuation.

[0293] 36 The instrument of any of examples 24 to 35, wherein the opposed arms include a lock to maintain their relative position.

[0294] 37 The instrument of example 36, wherein the lock includes a ratchet.

[0295] 38. The instrument of example 37, wherein the ratchet is offset from a longitudinal axis of the tube.

[0296] 39. The instrument of any of examples 36 to 38, wherein the lock is coupled to a proximal portion of one or more of the opposed arms, and a proximal end of the tube is disposed distal to the lock.

[0297] 40. The instrument of any of examples 24 to 39, wherein the tube includes a drive feature formed at a proximal end thereof to facilitate rotation of the tube.

[0298] 41. The instrument of example 40, wherein an inner lumen of the tube is accessible from a proximal end of the tube through the drive feature.

[0299] 42 The instrument of any of examples 24 to 41, wherein the tube includes an inner lumen and the rod-engaging tip includes an inner lumen that is coaxial with the inner lumen of the tube.

[0300] 43. The instrument of any of examples 24 to 42, wherein the rod-engaging tip includes an opening formed in a distal portion of a sidewall to facilitate viewing contents of an inner lumen of the rod-engaging tip.

[0301] 44 The instrument of any of examples 24 to 43, wherein a distal end of at least one of the opposed arms includes an engagement feature configured to interface with a complementary feature of a bone anchor receiver member.

[0302] 45. The instrument of example 44, wherein the engagement feature includes a protrusion configured to extend into a recess of a bone anchor receiver member.

[0303] 46. The instrument of example 45, wherein the protrusion is a pin disposed in a bore formed in the distal end of the arm.

[0304] 47 The instrument of example 45, wherein the protrusion is a ridge extending across a width of the arm.

[0305] 48. The instrument of any of examples 44 to 47, wherein the engagement feature is disposed proximal to a distal-most end of the arm and an inner surface of the arm distal to the protrusion has a conical tapering profile.

[0306] 49. The instrument of example 48, wherein the inner surface of the arm includes sidewalls extending outward from the inner surface at lateral ends of the arm, and opposed, inward-facing surfaces of each sidewall have a planar tapering profile.

[0307] 50. A surgical method, comprising:

[0308] positioning a first arm of a reducer instrument against a bone anchor receiver member;

[0309] positioning a second arm of the reducer instrument against a spinal fixation element;

[0310] pivoting the first and second arms of the reducer instrument toward one another to laterally translate the rod toward the receiver member;

[0311] rotating a tube of the reducer instrument to axially translate the spinal fixation element toward the receiver member.

[0312] 51. The method of example 50, further comprising inserting a set screw through a lumen formed in the tube and coupling the set screw to the receiver member.

[0313] 52. The method of example 51, further comprising visually inspecting the set screw while coupled to the receiver member using an opening formed in a distal portion of a sidewall of a rod-engaging tip coupled to the tube.

[0314] 53. The method of any of examples 50 to 52, further comprising locking a position of the first and second arms relative to one another.

[0315] 54. The method of any of examples 50 to 53, further comprising positioning a threaded outer surface portion of the tube within a threaded lumen formed in a housing coupled to one or more of the first arm and the second arm.

[0316] 55. The method of example 54, wherein rotating the tube is continued until a depth stop formed on the tube proximal to the threaded outer surface portion contacts the housing.

[0317] 56. The method of any of examples 50 to 55, further comprising coupling a driver to a drive feature formed at a proximal end of the tube prior to rotating the tube to axially translate the spinal fixation element.

[0318] 57. The method of example 56, further comprising separating the driver from the proximal end of the tube after rotating the tube to axially translate the spinal fixation element.

[0319] 58. The method of any of examples 50 to 57, further comprising engaging a lock to maintain a position of the first and second arms relative to one another after pivoting the first and second arms toward one another.

What is claimed is:

1. A surgical instrument, comprising:

a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a threaded lumen defining a longitudinal axis;

a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm;

a tube having a threaded outer surface portion disposed within the threaded lumen, a depth stop formed proximal to the threaded portion, and a drive feature at a proximal end of the tube configured to removably couple with a driver to impart torque to the tube; and

a rod-engaging tip rotatably coupled to a distal end of the tube;

wherein the first and second arms are configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip is configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

2. The instrument of claim **1**, wherein the depth stop defines a maximum outer diameter of the tube.

3. The instrument of claim **1**, wherein the depth stop is a shoulder formed around at least a portion of the circumference of the tube.

4. The instrument of claim **1**, wherein the lumen includes continuous threads formed around a circumference thereof.

5. The instrument of claim **1**, wherein an inner lumen of the tube is accessible from a proximal end of the tube through the drive feature.

6. The instrument of claim **5**, wherein the rod-engaging tip includes an inner lumen coaxially disposed with the inner lumen of the tube.

7. The instrument of claim **1**, wherein the rod-engaging tip includes an opening formed in a distal portion of a sidewall to facilitate viewing contents of an inner lumen of the rod-engaging tip.

8. The instrument of claim **1**, wherein a distal end of at least one of the first and second arms includes a protrusion configured to extend into a recess of a bone anchor receiver member.

9. The instrument of claim **8**, wherein the protrusion is a pin disposed in a bore formed in the distal end of at least one of the first and second arms.

10. The instrument of claim **8**, wherein the protrusion is a ridge extending across a width of the arm.

11. The instrument of claim **8**, wherein the protrusion is disposed proximal to a distal-most end of the arm and an inner surface of the arm distal to the protrusion has a conical tapering profile.

12. The instrument of claim **11**, wherein the inner surface of the arm includes sidewalls extending outward from the inner surface at lateral ends of the arm, and opposed, inward-facing surfaces of each sidewall have a planar tapering profile.

13. The instrument of claim **1**, further comprising a lock configured to selectively maintain a position of the first and second arms relative to one another.

14. The instrument of claim **13**, wherein the lock is coupled to a proximal portion of one or more of the first and second arms, and a proximal end of the tube is disposed distal to the lock.

15. A surgical method, comprising:

positioning a first arm of a reducer instrument against a bone anchor receiver member;

positioning a second arm of the reducer instrument against a spinal fixation element;

positioning a threaded outer surface portion of a tube of the reducer instrument within a threaded lumen formed in a housing of the first arm of the reducer instrument;

pivoting the first and second arms of the reducer instrument toward one another to translate the spinal fixation element laterally toward a longitudinal axis defined by the threaded lumen;

coupling a driver to a drive feature formed at a proximal end of the tube;

rotating the tube of the reducer instrument to translate the spinal fixation element axially along the longitudinal axis until a depth stop formed on the tube proximal to the threaded outer surface portion contacts the housing.

16. The method of claim **15**, further comprising engaging a lock to maintain a position of the first and second arms relative to one another after pivoting the first and second arms toward one another.

17. The method of claim **15**, further comprising separating the driver from the proximal end of the tube after rotating the tube to translate the spinal fixation element axially.

18. The method of claim **17**, further comprising inserting a set screw through an inner lumen of the tube and coupling the set screw with the receiver member.

19. The method of claim **18**, further comprising visually inspecting the set screw while coupled to the receiver member using an opening formed in a distal portion of a sidewall of a rod-engaging tip coupled to the tube.

20. A surgical instrument, comprising:

a first arm having a proximal end, a distal end, and a housing disposed therebetween, the housing including a lumen defining a longitudinal axis, the lumen having continuous threads formed around a circumference thereof;

a second arm having a proximal end and a distal end, the second arm pivotably coupled to the first arm;

a tube having a threaded outer surface portion disposed within the lumen;

a rod-engaging tip rotatably coupled to a distal end of the tube, the rod-engaging tip being constrained against rotation relative to the housing by a protrusion coupled to the housing that is received in a recess of the rod-engaging tip;

wherein the first and second arms are configured to translate a spinal fixation element laterally toward the longitudinal axis when pivoted toward one another and the rod-engaging tip is configured to translate the spinal fixation element axially along the longitudinal axis when the tube is rotated relative to the housing.

21. The instrument of claim **20**, wherein the threads on the outer surface portion of the tube have a plurality of starts.

22. The instrument of claim **21**, wherein the threads on the outer portion of the tube have three starts.

23. The instrument of claim **20**, wherein an outer diameter of the threaded outer surface portion of the tube is less than or equal to about 45% larger than a diameter of an inner lumen of the tube.

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