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(54) **Title:** SURGICAL NAVIGATION TRACKER, SYSTEM, AND METHOD

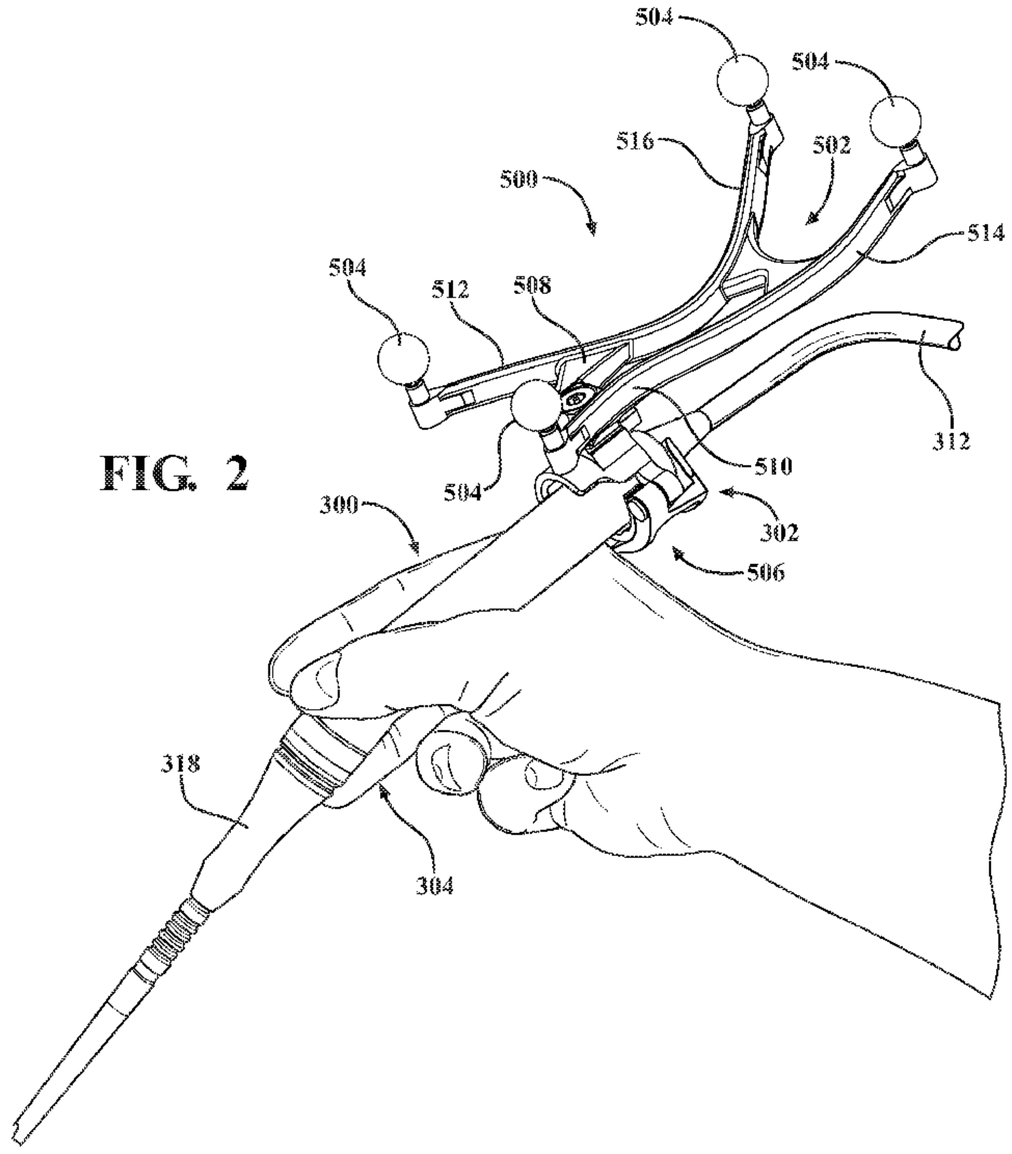


FIG. 2

(57) **Abstract:** A surgical navigation tracker, system, and method including a tracker array and mount, which facilitate consistent alignment and position tracking of a powered surgical handpiece are provided. The mount comprises a base having a complementary shape to the surgical instrument and a clamp. The clamp is fixed to the base and may include a latch mounted to a clamp base for selective displacement relative thereto. The latch has a clamp surface configured to engage the surgical instrument. The tracker array may include a tracker frame, which may be coupled to the mount, and plurality of markers. The tracker frame may be manufactured via an additive manufacturing process to optimize shape and surface finish of the tracker to improve performance. More specifically, the tracker frame comprises arms for supporting the markers, which may have a hollow cross-section to reduce weight of the tracker.

[Continued on next page]

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SURGICAL NAVIGATION TRACKER, SYSTEM, AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The subject patent application claims priority to and all the benefits of United States Provisional Patent Application № 62/927,279, filed on 29 October, 2019, and United States Provisional Patent Application № 63/084,331, filed on 28 September, 2020, the entire contents of which are incorporated by reference herein.

BACKGROUND

[0002] Certain accessories, by way of example and not limitation, a tracking marker, have been permanently fixed to and may comprise part of an associated surgical instrument. There is a need for an accessory mount for use with a surgical instrument that allows easy installation and removal of such an accessory and provides consistent alignment of the accessory with the surgical instrument.

SUMMARY

[0003] A tracker clamp for a surgical instrument, the tracker clamp comprising: a tracker frame having a proximal end and a distal end and comprising a mounting portion to receive the handheld surgical instrument on an insertion axis, wherein said mounting portion comprises: a lower cradle defining a first channel portion; a first resilient arm having a fixed end coupled to said lower cradle and a free end; a second resilient arm having a fixed end coupled to said lower cradle and a free end, wherein said free end of said second resilient arm is spaced from said free end of said first resilient arm, and wherein said first resilient arm and said second resilient arm cooperate to define a second channel portion; first and second arm bosses each coupled to said free end of one of said first resilient arm and said second resilient arm; an alignment surface arranged on said lower cradle and configured to engage the handheld surgical instrument; a lever pivotably coupled to said first

and second arm bosses and movable between a clamped position and an unclamped position, wherein movement of said lever between said unclamped position and said clamped position urges said free end of said first resilient arm and said free end of said second resilient arm toward each other.

[0004] A tracker for a surgical instrument, the tracker clamp comprising: a tracker frame comprising a clamp to receive the surgical instrument on an insertion axis; a lever pivotably coupled to said clamp and movable between a clamped position and an unclamped position for securing the surgical instrument; a tracker array coupled to said tracker frame and comprising at least three tracked faces arranged in a non-parallel relationship, each tracked face comprising at least three tracking markers, wherein said at least three tracked faces define a tracker perimeter about said insertion axis.

[0005] A tracked surgical system comprising: a handheld surgical instrument defining an instrument axis; a tracker for tracking a position of said handheld surgical instrument, said tracker comprising: tracker frame having an insertion axis; a clamp configured to receive said handheld surgical instrument along said insertion axis; at least three tracked faces arranged in a non-parallel relationship about said insertion axis, said three tracked faces collectively defining a tracker perimeter; a lever pivotably coupled to said clamp and defining a clamped position to secure said handheld surgical instrument with said instrument axis aligned with said insertion axis, wherein said lever is within said tracker perimeter in said clamped position.

[0006] A system of one or more computers can be configured to perform particular operations or actions by virtue of having software, firmware, hardware, or a combination of them installed on the system that in operation causes or cause the system to perform the actions. One or more computer programs can be configured to perform particular operations or actions by virtue of

including instructions that, when executed by data processing apparatus, cause the apparatus to perform the actions. One general aspect includes a tracker array for a handheld surgical instrument. The tracker array may also include a unitary body portion may include an arm protruding therefrom, where said arm has an outer surface and defines a hollow interior having an inner surface. The array also includes a marker post coupled to an end of said arm spaced from said body portion, where said marker post is configured to engage a tracking marker. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0007] One general aspect includes a tracker array for a handheld surgical instrument. The tracker array may also include a unitary body portion may include an arm protruding therefrom and a marker support portion coupled to said arm opposite said body portion, where said arm has an outer surface and defines a hollow interior having an inner surface. The array also includes a tracking marker coupled to said marker support portion. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0008] One general aspect includes a method of manufacturing a tracker array for a handheld surgical instrument. The method of manufacturing may also include providing a powdered titanium alloy. The manufacturing also includes sintering the titanium alloy and forming a unitary body portion with a plurality of arms protruding therefrom, where the plurality of arms each have a hollow cross section defined by an outer surface and an inner surface, and where the inner surface defines an interior. The manufacturing also includes removing unsintered powdered titanium alloy from the interior of the plurality of arms. The manufacturing also includes refining the outer surface of the plurality of arms to an Ra surface roughness to between 1m and 7m. Other

embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0009] One general aspect includes an attachment member for a tracker. The attachment member may also include a mount body having an attachment portion for engaging a tracking array and a mounting portion, where said mounting portion has an inner surface that defines an instrument receiving aperture extending therethrough along an insertion axis for receiving a surgical instrument. The member also includes a plurality of alignment seats protruding from said inner surface toward said insertion axis, where a first group of said plurality of alignment seats are radially arranged about said insertion axis and a second group of said plurality of alignment seats are radially arranged about said insertion axis and axially spaced from said first group. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0010] One general aspect includes an attachment member for a tracker. The attachment member may also include a mount body having an attachment portion for engaging a tracking array and a mounting portion, where said mounting portion has an inner surface that defines an instrument receiving aperture extending therethrough along an insertion axis for receiving a surgical instrument. The member also includes a plurality of alignment seats protruding from said inner surface toward said insertion axis. The member also includes a clamp latch pivotably coupled to said mount body and movable about a latch axis between an unclamped position and a clamped position, said clamp latch having a lobe portion engageable with said mount body and a retention surface spaced along said latch axis from said mount body, where when said clamp latch is in said

clamped position said lobe portion is configured to deform said mount body and said retention surface is configured to selectively restrict movement of the surgical instrument in at least one axial direction for securing said mount body to the surgical instrument. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0011] One general aspect includes a tracker clamp for a surgical instrument. The tracker clamp may also include a tracker frame having a proximal end and a distal end and may include a mounting portion to receive the surgical instrument on an insertion axis, where said mounting portion may include: a lower cradle defining a first channel portion; a first resilient arm having a fixed end coupled to said lower cradle and a free end; a second resilient arm having a fixed end coupled to said lower cradle and a free end, where said free end of said second resilient arm is spaced from said free end of said first resilient arm, and where said first resilient arm and said second resilient arm cooperate to define a second channel portion; first and second arm bosses each coupled to said free end of one of said first resilient arm and said second resilient arm; an alignment surface arranged on said lower cradle and configured to engage the surgical instrument. The clamp also includes a lever pivotably coupled to said first and second arm bosses and movable between a clamped position and an unclamped position, where movement of said lever between said unclamped position and said clamped position urges said free end of said first resilient arm and said free end of said second resilient arm toward each other. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0012] One general aspect includes a tracker for a surgical instrument. The tracker may also include a tracker frame may include a clamp to receive the surgical instrument on an insertion axis.

The tracker also includes a lever pivotably coupled to said clamp and movable between a clamped position and an unclamped position for securing the surgical instrument. The tracker also includes a tracker array coupled to said tracker frame and may include at least three tracked faces arranged in a non-planar relationship, each tracked face may include at least three tracking markers, where said at least three tracked faces define a tracker perimeter about said insertion axis. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0013] One general aspect includes a tracked surgical system. The tracked surgical system may also include a handheld surgical instrument defining an instrument axis. The system also includes a tracker for tracking a position of said handheld surgical instrument, said tracker may include: tracker frame having an insertion axis; a clamp configured to receive said handheld surgical instrument along said insertion axis; at least three tracked faces arranged in a non-planar relationship about said insertion axis, said three tracked faces collectively defining a tracker perimeter; and a lever pivotably coupled to said clamp and defining a clamped position to secure said handheld surgical instrument with said instrument axis aligned with said insertion axis, where said lever is within said tracker perimeter in said clamped position. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Advantages of the present disclosure will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

[0015] FIG. 1 is an exemplary surgical suite showing a surgical navigation system.

[0016] FIG. 2 is an environmental view of a second example of a tracker and a surgical instrument being grasped by a user.

[0017] FIG. 3 is a perspective view of the tracker and the surgical instrument of FIG. 2.

[0018] FIG. 4 is a perspective view of the tracker of FIG. 3 without the surgical instrument.

[0019] FIG. 5 is a front view of the tracker of FIG. 4 showing a tracking array and an attachment member.

[0020] FIG. 6 is a distal end view of the attachment member of FIG. 5 showing a clamp latch in an unclamped position.

[0021] FIG. 7 is a distal end view of the attachment member of FIG. 5 showing the clamp latch in a clamped position.

[0022] FIG. 8 is a proximal end perspective view of the attachment member of FIG. 5.

[0023] FIG. 9 is distal end perspective view of the attachment member of FIG. 5.

[0024] FIG. 10 is a bottom side perspective view of the tracking array of FIG. 5.

[0025] FIG. 11 is a cutaway perspective view of the tracking array of FIG. 5 showing a hollow interior.

[0026] FIG. 12 is a close-up perspective view of a marker support portion of the tracking array of FIG. 5 showing one step of a method of manufacturing the tracking array.

[0027] FIG. 13 is a close-up perspective view of a marker support portion of the tracking array of FIG. 5 showing another step of the method of manufacturing the tracking array.

[0028] FIG. 14 is a distal-end perspective view of another example of a tracker comprising a tracker clamp securing the tracker to a surgical instrument.

[0029] FIG. 15 is a distal-end perspective view of the tracker of FIG. 14 comprising a tracker clamp securing the tracker to a surgical instrument.

[0030] FIG. 16 is a side view of the tracker and surgical instrument of FIG. 14.

[0031] FIG. 17 is a top view of the tracker and surgical instrument of FIG. 14.

[0032] FIG. 18 is a proximal end view of the tracker of FIG. 14.

[0033] FIG. 19 is a top-side perspective view of the tracker of FIG. 14.

[0034] FIG. 20 is a proximal-bottom perspective view of the tracker and insertion axis of FIG. 19.

[0035] FIG. 21 is a cross-sectional view of the tracker of FIG. 19, the tracker clamp, and a lever in an unclamped position.

[0036] FIG. 22 is a cutaway perspective view of the tracker clamp and tracker clamp of FIG. 19, with the lever shown spaced from the tracker clamp.

[0037] FIG. 23 is a perspective view of the tracker of FIG. 19 shown with a battery tray spaced from the tracker.

[0038] FIG. 24 is a cross-sectional side view of the tracker and surgical instrument of FIG. 16 showing the lever in the unclamped position.

[0039] FIG. 25 is a cross-sectional side view of the tracker and surgical instrument of FIG. 16 showing the lever in the clamped position.

[0040] FIG. 26 is a close-up view of the tracker and the surgical instrument of FIG. 25 showing the lever and a stop member of the tracker.

[0041] FIG. 27 is a perspective view of another exemplary accessory mount with an example accessory.

[0042] FIG. 28 is an exploded view of the accessory mount and accessory of FIG. 27.

[0043] FIG. 29 is a rear view of an example instrument with the mount and accessory of FIG. 27 mounted thereto with an example latch in an engaged position.

[0044] FIG. 30 is a rear view of the instrument of FIG. 29 with the latch in a released position.

[0045] FIG. 31 is a perspective view of the accessory mount of FIG. 27 disposed over and in engagement with an example instrument housing.

[0046] FIG. 32 is a sectional side view of the instrument housing and the mount and the accessory of FIG. 29 in the direction of arrows 6.

[0047] FIG. 33 is a sectional view of the mount of FIG. 29 in a direction of arrows 7.

[0048] FIG. 34 is a perspective view of an example mount base of the mount of FIG. 27.

[0049] FIG. 34A is an enlarged perspective view of an example key of the base mount of FIG. 34.

[0050] FIG. 34B is a sectional view of the key of FIG. 34A through the first section plane 34B in the direction of arrow 34B'.

[0051] FIG. 34C is a sectional view of the key of FIG. 34A through the second section plane 34C in the direction of arrow 34C'.

[0052] FIG. 34D is a sectional view of the key of FIG. 34A through the second section plane 34D in the direction of arrow 34D'.

[0053] FIG. 35 is a broken-out detail of the mount base of FIG. 34 illustrating an example detent surface of an example clamp base.

[0054] FIG. 36 is a first perspective view of an example clamp latch of the accessory mount of FIG. 27 oriented to show an example detent projection.

[0055] FIG. 37 is a second perspective view of the clamp latch of FIG. 36 oriented to show a clamp surface.

[0056] FIG. 38 is a first perspective view of a broken-out section of the instrument of FIG. 29, with an example keyway shown.

[0057] FIG. 39 is a second perspective view of a broken-out section of the instrument of FIG. 29, with the keyway shown.

[0058] FIG. 40 is a perspective view of an example alternative accessory mount.

[0059] FIG. 41 is a perspective view of the accessory mount of FIG. 40, with the example mount base withdrawn from an example receiver.

[0060] FIG. 42 is a perspective view of an example alternative mount receiver.

[0061] FIG. 43 is an exploded view of the mount receiver of FIG. 42.

[0062] FIG. 44 is a perspective view of the mount base of FIG. 42.

DETAILED DESCRIPTION

[0063] With reference to the figures, wherein like numerals indicate like parts throughout the several views, the present disclosure includes a tracker, shown generally at 128 in Fig. 1, for a handheld surgical instrument 300 a surgical navigation system 102 and a method for operating the tracker 128. Fig. 1 illustrates an exemplary surgical system 100 that may comprise the surgical navigation system 102 for tracking one or more surgical instrument assemblies 130 including the surgical instrument 300 and the tracker 128 to assist the medical professional, such as a surgeon, in executing a medical procedure.

[0064] The surgical navigation system 102 may comprise a navigation interface that includes one or more display units 104 and one or more user inputs 106. The display unit 104 of the surgical navigation system 102 may be configured to display various prompts or data entry boxes. For example, the display unit 104 may be configured to display a text box or prompt that allows the surgeon to manually enter or select the type of surgical procedure to be performed. The display

unit 104 may also be configured to display patient data, such as a pre-operative image or scan. As described above, the pre-operative image may be based on MRI scans, radiological scans, or computed tomography (CT) scans of the patient's anatomy. The preoperative image may be uploaded to the surgical navigation system 102 and displayed on the display unit 104. The display unit 104 may be further configured to display a surgical plan for a medical procedure overlaid on the patient data or image. The surgical plan may include the surgical pathway for executing the medical procedure or planned trajectory or orientation for the medical instrument during the medical procedure. The surgical plan may also include overlaying the position and/or orientation of an implant or medical device to be inserted during the medical procedure on the patient data or image. It is contemplated that the surgical navigation system 102 may comprise a display unit 104 configured to display and/or project a holographic image of surgical pathway for executing the medical procedure or planned trajectory or orientation for the medical instrument during the medical procedure. This may include projecting the surgical pathway onto the patient or other surface in the operating room. It may also include a projection of the surgical pathway onto the head unit worn by the surgeon, such as a lens, shield, or glasses of the head unit. An exemplary configuration of surgical navigation system 102 including a display unit worn by the surgeon to display the target trajectory and/or target location is disclosed in U.S. Patent Application Pub. № 2020/0085511, which is hereby incorporated by reference in its entirety.

[0065] The user input 106 may be configured to allow the surgeon to input or enter patient data or modify the surgical plan. The patient data may comprise patient images, such as pre-operative images of the patient's anatomy. These images may be based on MRI scans, radiological scans, or computed tomography (CT) scans of the patient's anatomy. The patient data may also include additional information related to the type of medical procedure being performed, the

patient's anatomical features, the patient's specific medical condition, and/or operating settings for the surgical navigation settings. For example, in performing a spinal surgery, the surgeon may enter information via the user input 106 related to the specific vertebra on which the medical procedure is being performed. The surgeon may also input various anatomical dimensions related to the vertebrae and/or the size and shape of a medical device or implant to be inserted during the medical procedure. The user input 106 may also be configured to allow the surgeon to select, edit or manipulate the patient data. For example, the surgeon may identify and/or select anatomical features from the patient data. This may include selecting the surgical site, such as selecting the vertebra and/or specific area on the vertebra where the medical procedure is to be performed.

[0066] The surgical navigation system 102 may further comprise a navigation processor 108. The navigation processor 108 can be located on a personal computer or laptop computer. The navigation processor 108 may be in communication with the user input 106, display unit 104, central processing unit (CPU) and/or other processors, memory (not shown), and storage (not shown). The navigation processor 108 may further comprise software and/or operating instructions related to the operation of the surgical navigation system 102 and to implement the various routines and/or methods disclosed herein. The software and/or operating instructions may comprise a planning system configured to find an accurate position and/or angular alignment of the surgical instruments 300 in relation to the patient 120. The navigation processor 108 may be in wired or wireless communication with the surgical instrument assemblies 130, directly or indirectly.

[0067] The surgical navigation system 102 may also comprise a tracking unit, or localizer 122, including one or more sensors 124. The sensors may comprise cameras, such as CCD cameras, CMOS cameras, and/or optical image cameras, magnetic sensors, radio frequency sensors, or any other sensor adapted to detect and/or sense the position of a tracker 128 of the surgical instrument

assemblies 130. One exemplary localizer 122 is capable of detecting radiation or light from the plurality of markers and of generating a localizer signal representative of the detected radiation or light. An exemplary surgical navigation system 102 may be configured to utilize a tracker 128 with a fixed spatial relation between tracking markers. Description of various suitable localizers that may be utilized can be found in U.S. Patent № 10,531,926, which is hereby incorporated by reference in its entirety.

[0068] The processor 108 may be capable of receiving the localizer signal. The processor 108 may further be capable of registering and tracking the tracker 128 based on the received sensor signal. Based on the localizer signal, the processor is also capable of calculating an orientation and/or position of the tracker 128 relative to the localizer 122. The processor 108 may have access to information about the spatial relation. In such a case, three-dimensional images captured by a stereo camera would not be required and the camera may only comprise a single two-dimensional image sensor.

[0069] The processor 108 may further be configured to receive and/or store information of a patient's body 20 (e.g., a computed tomography scan and/or tracking signal of the patient's body). The processor 108 may then calculate a position and/or orientation of the surgical instrument 300 relative to the patient's body 20. The processor 108 may be configured to generate a visual or acoustic signal indicative of the tracking of the surgical instrument 300. The visual signal may be displayed on the display unit. The processor 108 may be a part of a computing device separate from the localizer. Alternatively, the localizer may comprise the processor.

[0070] Fig. 2 shows a perspective view of a first configuration of the tracker 500 and the surgical instrument 300. The surgical instrument 300 has a proximal end 302 and a distal end 304 that are spaced along an instrument axis A1. In many cases, such as shown in Fig. 2, the surgical

instrument 300 transfers mechanical energy along the instrument axis A1 from a source (e.g. a motor or an ultrasonic transducer) arranged near the proximal end 302 to an attachment 318 coupled to the distal end 304 of the surgical instrument 300. One example of this arrangement is shown in Fig. 2, where the surgical instrument 300 is illustrated with a high-speed drill attachment. Here, the surgical instrument 300 may include a housing 310, a motor (not shown) disposed in the housing 310, a flexible supply cable 312 protruding from the housing 310 in a proximal region, and an attachment interface near the distal end 304 of the surgical instrument 300. Exemplary surgical instruments can be found in U.S. Patent № 8,597,316 and U.S. Patent № 10,537,339, which are hereby incorporated by reference.

[0071] The tracker 500 is operable with the surgical instrument 300 and the surgical navigation system 102 to determine the position and/or orientation of the surgical instrument 300 or a component thereof within an operating room. In order to accurately determine the position of the surgical instrument 300, the tracker 500 is coupled to the surgical instrument 300 and configured to prevent relative movement therebetween during a surgical procedure. Additionally, the tracker 500 should be coupled to the surgical instrument 300 so as to maximize visibility of the tracker 500 by the surgical navigation system 102. It should also be appreciated that certain features of the described trackers may be used to track a patient, another device in the operating room, or even a medical professional.

[0072] While the surgical instrument 300 is shown throughout the figures as a high-speed drill, the tracker 500 may be utilized with surgical instruments 300 other than high-speed drills. For example, the tracker 500 could be coupled to a handheld ultrasonic ablation tool or a biopsy needle or a portion of a robotic device, such as robotic end effector, a robotic arm or other device in the operating room. Similarly, the tracker 500 could be adapted to couple to other surgical instruments

(not shown) such as a handheld drill, a saw, or a bur. Again, similarly, the attachment 318 coupled to the distal end 304 of the surgical instrument 300 is shown in Fig. 2 as an angled attachment, which drives a rotary tool on an axis (not shown) different than the instrument axis A1. For example, the attachment could be straight, angled at 15 degrees, 45 degrees, etc.; the attachment could be of various lengths such as 30mm, 50mm, etc.

[0073] In some cases, surgical instruments may have little mass and may be structurally weak. When a heavy tracker is attached to such a handheld surgical instrument, the tracker shifts the center of mass, which can be tiresome (e.g., due to a torque applied at the holding hand). Furthermore, the surgical instrument may deform (elastically or plastically) or even be damaged due to the weight of the attached heavy tracker. The trackers 128, 316, 500, 652 illustrated throughout the figures may have a reduced weight. Therefore, the above-mentioned disadvantages are reduced or eliminated in certain configurations. The handheld surgical instrument 300 may be less tiresome to hold by hand and may be less likely to be deformed by the weight of the tracker.

[0074] Referring now to Fig. 2, a close-up perspective view of the surgical instrument 300 and one implementation of a tracker 500 is shown. Here, the tracker 500 may comprise a tracking array 502 for supporting a plurality of tracking markers 504, and an attachment member 506 for securing the tracking array 502 to the surgical instrument 300. The tracking array 502 may be removably coupled to the attachment member 506 to facilitate removal and installation on the surgical instrument 300, as will be discussed in further detail below.

[0075] When the navigation system 102 determines the position and orientation of the tracking array 502, it is advantageous that the tracking array 502 remains in the same position relative to the surgical instrument 300 to maximize accuracy. In order to maximize accuracy, it is therefore advantageous for the tracking array 502 and/or the attachment member 506 to be sufficiently rigid

so as to prevent deformation or movement of the markers of the tracking array 502 relative to the surgical instrument 300. The desire to minimize bending or deformation of the tracking array 502 is limited by the desire to minimize the weight of the tracking array 502. Both of the aforementioned desires may also be limited by the desire to increase precision by having a large tracking array 502, and the desire to eliminate obstruction to the surgeon operating the surgical instrument 300 by having a compact tracking array 502.

[0076] Here, in an exemplary configuration, the tracking array 502 may comprise a unitary body portion 508 and at least one arm 510, 512, 514, 516 protruding therefrom. The unitary body portion 508 may comprise a valley portion 520 that is complementarily engageable with a wedge portion 550 of the attachment member 506, described below. The body portion 508 may define a fastener aperture 522, which may receive a fastener for urging the valley portion 520 into the wedge portion 550 and for securing the tracking array 502 to the attachment member 506. A reference plane 560 is defined parallel to and spaced from an axis of the handheld surgical instrument 300, as shown in Fig. 4. As will be discussed in further detail below, the tracking array 502 may be arranged above the surgical instrument 300 and generally on the reference plane 560. The tracking array 502 may also be coupled to the attachment member 506 in other manners, such as with a snap fit coupler or a magnetic coupler. Furthermore, the array may not include distinct arm portions in certain configurations.

[0077] The at least one arm 510, 512, 514, 516 may be further defined as a first arm 510, 514 and a second arm 512, 516, or alternatively a pair of distal arms 510, 512, and a pair of proximal arms 514, 516. Each arm 510, 512, 514, 516 protrudes from the body portion 508 to an end spaced from the body portion 508 and comprises a marker support portion 518 arranged at the end spaced from the unitary body portion 508. Each marker support portion 518 may define a post bore 526,

which may be configured to receive a marker post 528, which may be configured to engage a tracking marker 504. In the implementations of the tracking array 500, 652, 852 shown in Figs. 2-13 and 27-44 the tracking markers may be reflective spheres or retroreflectors, which reflect light (typically infrared) that is visible to the localizer. The tracker illustrated in connection with Figs. 1 and 14-26 utilizes tracking markers which are LED emitters, which emit infrared light that is visible to the localizer. It is contemplated that the LED tracking markers shown and described below could be utilized in place of the spherical tracking markers. When configured as LED emitters the tracking post 528 may be omitted and the tracking markers mounted directly on the marker support portions 518. It is further contemplated that power may be provided to the LED emitters through wires disposed in the post bore 526. Other configurations are contemplated.

[0078] Each arm 510, 512, 514, 516 further has a length and a width. The length 532 and width 534 of one arm 516 are illustrated in Fig. 4. A ratio of the length 532 to the width 534 may exceed 4. Said differently, each of the arms 510, 512, 514, 516 may have a length that is at least 4x greater than the width. While the length 532 and width 534 are only illustrated and numbered in connection with one of the arms 516 it should be appreciated that each arm 510, 512, 514, 516 may have a respective length and a respective width, which may differ between each arm, such that the ratio of the length and the width may exceed 4.

[0079] The tracking array 502 may be configured such that one or more of the arms 510, 512, 514, 516 are curved along their length. The curve may have a constant radius or a radius that varies along the length of the arm 510, 512, 514, 516. Each arm 510, 512, 514, 516 may be curved in only one direction, or may be curved in multiple directions. For example, as shown in the front view of the tracking array 502 of Fig. 5, the arms 510, 512, 514, 516 may curve in a direction that is perpendicular to the reference plane 560. The arms 510, 512 may curve away, or up, from the

reference plane 560. The arms 514, 516 may first curve away, or down, from the reference plane 560 and then may curve up toward the reference plane 560. Additionally, the arms 510, 512, 514, 516 may curve in a direction that is along the reference plane 560. The arms 510, 512, 514, 516 may be curved in a direction that is parallel to the reference plane 560. As shown in Fig. 5, the arms 514, 516 protrude from the body portion 508 and initially extend toward each other. As the distance from the body portion 508 increases along the length, each of the arms 514, 516 may curve away from one another and extend in a direction away from each other. Alternative arrangements are contemplated.

[0080] One way in which obstruction to the surgeon is minimized is to position the arms 510, 512, 514, 516 of the tracking array 502 away from a working end of the surgical instrument 300. The arms may be configured with different lengths such that the marker support portions 518 are arranged with a proximal bias. More specifically, the pair of proximal arms 514, 516 extends a first distance from the body portion 508 and the pair distal arms 510, 512 extends a second distance from the body portion 508, the first distance being greater than the second distance. Said differently, the marker support portions 518 arranged proximal of the body portion 508 are spaced further from the body portion 508 than the marker support portions 518 arranged distal of the body portion 508.

[0081] To this end, the tracking array 502 may be configured at different angles relative to the insertion axis A2 such that the marker support portions 518 are arranged with an axially central bias. Said differently, the marker support portions 518 are spaced in the proximal to distal direction at a distance greater than the spacing transverse to the insertion axis A2. The tracking array 502 has a length 536 and a width 538 defined by the arms 510, 512, 514, 516, and a ratio of the length 536 to the width 538 is greater than 1.5. More specifically the distance 536 that the marker support

portions 518 on the pair of proximal arms 514, 516 are spaced from the corresponding marker support portions on the distal arms 510, 512 is at least 1.5x greater than the distance 538 that the marker support portions on the first arm 510, 514 are spaced from the corresponding marker support portions on the second arm 512, 516.

[0082] The tracking array 502 may further comprise a bridge portion 524 spaced in a proximal direction from the body portion 508 and extending between the first arm 514 and the second arm 516. In this way, the bridge portion 524, the first arm 514, the second arm 516, and the unitary body portion 508 cooperate to define an opening 530 in the tracking array 502.

[0083] Also referencing Fig. 11, a cutaway view of the tracking array 502 is illustrated showing inner and outer surfaces of the tracking array 502. In the tracking array 502 shown here, the arms 510, 512, 514, 516 may have an outer surface 540 and an inner surface 542, which cooperate to define a hollow interior 544 of the arms 510, 512, 514, 516. The outer surface 540 and the inner surface 542 further define a cross-sectional area 562 of each arm 510, 512, 514, 516, which may be the area of the outer surface 540 less the area surrounded by the inner surface 542. The cross-sectional area 562 may be measured at any point along the length of the arms 510, 512, 514, 516.

[0084] In some implementations of the tracking array 502, the cross-sectional area 562 of one or more of the arms 510, 512, 514, 516 may independently be constant, or uniform, along the length of the arm 510, 512, 514, 516. As shown in Fig. 11, the cross-sectional area 562 of one or more of the arms 510, 512, 514, 516 may vary, or be non-uniform, along the length of the arm 510, 512, 514, 516. In addition to the cross-sectional area 562 being non-uniform, the hollow interior 544 has a cross-sectional profile, or shape, along the length of the arm 510, 512, 514, 516, which may vary at various positions along the length of the arm 510, 512, 514, 516. For example, the

cross-sectional profile may increase in size, or decrease in size, toward the spaced end of each arm 510, 512, 514, 516. More specifically, the arm 510, 512, 514, 516 may have a first cross-sectional area at a first distance, or proximal (nearer) to the body portion 508, and a second cross-sectional area at a second distance, or distal to (farther) the body portion 508. The second cross-sectional area may be less than the first cross-sectional area such that the arm 510, 512, 514, 516 is tapered along the length. In some implementations the cross-sectional profile may be relatively small near the body portion 508 and the marker support portion 518, and be relatively large in a portion of the arm 510, 512, 514, 516 between the body portion 508 and the marker support portion 518. Said differently, as the arm 510, 512, 514, 516 protrudes from the body portion 508, the cross-sectional profile may begin at a first dimension, increase in size relative to the first dimension at a first distance from the body portion 508, and at a second distance from the body portion 508 the cross-sectional profile may decrease in size relative to the first dimension.

[0085] At the spaced end of each arm 510, 512, 514, 516 the post bore 526 is defined in the marker support portion 518. The post bore 526 may be sized so as to intersect with the hollow interior 544 of the respective arm 510, 512, 514, 516. The intersection between the hollow interior 544 and the post bore 526 may form an opening through which the hollow interior 544 and the post bore 526 are in communication. Said differently, the post bore 526 is an opening into the hollow interior 544 of the respective arm 510, 512, 514, 516. The hollow interior 544 of each arm 510, 512, 514, 516 may be accessible through the respective post bore 526 prior to the marker post 528 being inserted into the post bore 526 and coupled to the arm 510, 512, 514, 516. During assembly of the tracking array 502, the marker post 528 is inserted into the post bore 526 and coupled to the arm 510, 512, 514, 516. The marker post 528 may be sized substantially the same as the post bore 526 such that the marker post 528 encloses the hollow interior 544 of the arm 510,

512, 514, 516, thereby preventing ingress of any contaminants during use. The marker post 528 may comprise a material that is similar to the body portion 508 such that the marker post 528 may be coupled to the arm 510, 512, 514, 516 via a welding process. Alternatively, some implementations may couple the arm 510, 512, 514, 516 and the marker post 528 via other processes such as, for example, via a threaded engagement, an adhesive, or an interference fit. The marker post 528, body portion 508, and/or the arms 510, 512, 514, 516 may comprise titanium or stainless steel.

[0086] Similar to the arms 510, 512, 514, 516 as described above, the body portion 508 may have an outer surface 546 and an inner surface 548 that cooperate to define a hollow interior 552 of the body portion 508. The hollow interior 552 of the body portion 508 may be in communication with the hollow interior 544 of the arms 510, 512, 514, 516 such that each arm 510, 512, 514, 516 is in communication with one another by way of the body portion 508. Said differently, the tracking array 502 may comprise several portions, each of which has a hollow interior enclosed by a shell and is in communication with one another. As mentioned above, the body portion 508 defines the fastener aperture 522 extending therethrough. As shown here the fastener aperture 522 may be defined by a pillar formed in the hollow interior 552 of the body portion 508 so as to prevent access via the fastener aperture 522. Alternative arrangements are contemplated.

[0087] Similar again to the arms 510, 512, 514, 516 and body portion 508 described above, the bridge portion 524 may have an outer surface 554 and an inner surface 556 that cooperate to define a hollow interior 558 of the bridge portion 524. The hollow interior 558 of the bridge portion 524 may be in communication with the hollow interior 544 of the arms 510, 512, 514, 516 and, by extension, the hollow interior 552 of the body portion 508. Said differently, the tracking array 502

may comprise several portions, each of which has a hollow interior enclosed by a shell and is in communication with one another.

[0088] An additional factor that may contribute toward increased accuracy of the navigation system 102 is management of undesired reflections of IR light, which may be difficult to distinguish from the tracking markers 504 coupled to the tracking array 502. In order to reduce undesired reflections, the tracking array 502 may employ one or more features that lower the reflectivity of the tracking array 502 or prevent reflections from converging to form a point reflection. One method for reducing the reflectivity of the tracking array 502 may be to reduce the size and quantity of planar, or flat, surfaces on the tracking array 502. As shown here, the outer surfaces 540 of the arms 510, 512, 514, 516 may be curved, which reduces the ability of a point source light to reflect toward the navigation localizer 122 and be misidentified as a tracking marker 504. By curving the outer surfaces 540, 546, 554 of each portion of the tracking array 502, reflections from any light sources are scattered and diffused so as to not be misidentified as a tracking marker 504. The arms 510, 512, 514, 516 may be curved both in the cross-sectional profile (i.e. with rounded corners) and along the length of the arm 510, 512, 514, 516, as described above.

[0089] Undesired reflections may further be prevented by texturing the outer surface 540 of the arms 510, 512, 514, 516, the outer surface 546 of the body portion 508, and the outer surface 554 of the bridge portion 524 to achieve a predetermined surface roughness. For example, the outer surfaces 540, 546, 554 may be textured to an Ra surface roughness of between 1μm and 7μm. More specifically, the Ra value may be between 2μm and 6μm. More specifically still, the Ra value may be between 3.2μm and 3.6μm. Other values are contemplated.

[0090] In some implementations, the tracking array 502 may be formed using an additive manufacturing process, or commonly known as 3D printing. One such type of additive

manufacturing process is selective laser sintering, in which a powdered material is sintered, or solidified, to form a unitary body. The material is sintered layer by layer to create each portion of the unitary body portion 508 and the arms 510, 512, 514, 516. Some implementations of the tracking array 502 may comprise a metal powder that has been sintered together. For example, the tracking array 502 may comprise titanium or stainless steel. Other materials are contemplated. Descriptions of exemplary additive manufacturing processes can be found in U.S. Patent № 7,537,664, U.S. Patent № 9,456,901, and U.S. Patent Application Pub. № 2020/0215610, which are hereby incorporated by reference.

[0091] The sintered metal powder may initially have an outer surface 540, 546, 554 that does not match the predetermined surface roughness as described above. Texturing the outer surfaces 540, 546, 554 may comprise refining the surface finish with an abrasive media, such as by tumbling with ceramic media. Alternatively, a coating may be applied to the outer surfaces 540, 546, 554 that matches the predetermined surface roughness. In some implementations, the texturing may comprise one or more of a shot-peening, media blasting, or etching process to increase the surface roughness to the desired value.

[0092] Other steps are performed in the additive manufacturing process of the tracking array 502 prior to texturing the outer surfaces 540, 546, 554. A method of manufacturing the tracking array 502 as shown in Figs. 2-13 is described blow. The method may comprise a step of providing a powdered material, such as titanium or a titanium alloy. The method may further comprise a step of sintering the powdered titanium and forming the unitary body portion 508 with the plurality of arms 510, 512, 514, 516 protruding therefrom, as shown in Figs. 10-13. The step may further comprise forming the marker support portions 518 on each of the arms 510, 512, 514, 516. The plurality of arms 510, 512, 514, 516 each have a hollow cross-section defined by the outer surface

540 and the inner surface 542 such that the inner surface 542 defines the hollow interior 544. As described above, the powdered titanium may be sintered using a laser.

[0093] The method may further comprise the step of forming the outer surface 546 and the inner surface 548 of the body portion 508 such that the inner surface 548 defines the hollow interior 552 of the body portion 508. The hollow interior 552 of the body portion 508 may be in communication with the hollow interior 544 of the arms 510, 512, 514, 516. Similarly, the method may further comprise the step of forming the outer surface 554 and the inner surface 556 of the bridge portion 524 such that the inner surface 556 defines the hollow interior 558 of the bridge portion 524. The hollow interior 558 of the bridge portion 524 may be in communication with the hollow interior 544 of the arms 510, 512, 514, 516 and the hollow interior 552 of the body portion 508.

[0094] Once the unitary body portion 508 has been sintered, the method may further comprise the step of removing the unsintered powdered titanium from the hollow interior 544, 552, 558. As mentioned above, each of the marker support portions 518 may define a post bore 526, which is open to the hollow interior 544 of the arms 510, 512, 514, 516. The unsintered powder may be removed from the hollow interior 544 of the arms 510, 512, 514, 516 and the hollow interior 552, 558 of the body portion 508 and the bridge portion 524 through the post bores 526.

[0095] The method may further comprise a step of removing a portion of the sintered titanium powder to define the marker support portion 518. The removed portion 519 of the marker support portion 518 is shown in Fig. 12. Here, the shape of the marker support portion 518 is refined to create a reference surface that may be used in subsequent manufacturing steps. Additionally, the method may comprise a step of removing a portion of the sintered titanium to define the post bore 526, which may provide access to the hollow interior 544 of the respective arm 510, 512, 514, 516.

In one implementation of the method, the post bore 526 may be partially defined during the sintering step such that the step of removing the unsintered powdered titanium is performed prior to the step of removing the sintered titanium to define the post bores 526, in which the post bores 526 are enlarged. Alternatively, the step of removing the sintered titanium to define the post bores 526 may be performed prior to the step of removing the unsintered powdered titanium.

[0096] The method may further comprise a step of refining the outer surface 540 of the plurality of arms 510, 512, 514, 516 and the outer surfaces 546, 554 of the body portion 508 and the bridge portion 524 to an Ra surface roughness to between 1µm and 7µm. As described in further detail above, the Ra surface roughness may be refined to a greater or lesser degree. The method may further comprise a step of inserting the marker post 528 into each of the post bores 526 and enclosing the hollow interior of the respective arm 510, 512, 514, 516 as well as the hollow interior 552, 558 of the body portion 508 and the bridge portion 524. As mentioned above, following the step of inserting the marker post 528 into the post bore 526, the marker post 528 may be coupled to the marker support portion 518 by welding.

[0097] As mentioned above, the tracker 500 comprises the tracking array 502 and the attachment member 506. It should be appreciated that the tracking array 502 may be used with other configurations of the attachment member other than 506, and similarly, the attachment member 506 may be used with tracking arrays other than the tracking array 502. Referring to Figs. 4-9, the attachment member 506 is shown detached from the surgical instrument 300. The attachment member 506 may comprise a mount body 570 having an attachment portion 572 for engaging the tracking array 502 and a mounting portion 574 for engaging the surgical instrument 300. The mounting portion 574 has an inner surface 576 that defines an instrument receiving

aperture 578 extending through the mounting portion 574 along an insertion axis A2 for receiving the surgical instrument 300.

[0098] Best shown in Figs. 6 and 7, the attachment member 506 may further comprise a plurality of alignment seats 580 protruding from the inner surface 576 toward the insertion axis A2. The alignment seats 580 may be radially arranged about the insertion axis A2 to define an aperture diameter 582. In order to promote accurate alignment with, and secure coupling to, the surgical instrument 300 the plurality of alignment seats 580 may be arranged into two groups; a first group of alignment seats 580A positioned at a first axial position, and a second group of alignment seats 580B positioned at a second axial position. The first group of alignment seats 580A may be arranged at a different axial position than the second group of alignment seats 580B, which is to say the first axial position and the second axial position may be spaced from one another along the insertion axis A2. The second group of alignment seats 580B may be axially spaced from the first group of alignment seats 580A. In some implementations the alignments seats 580 may not be arranged into two groups and may be continuous in the direction of the insertion axis A2. For example, the alignment seats 580 may be radially arranged about the insertion axis A2 and may clamp onto the surgical instrument 300 in a line contact pattern.

[0099] Some implementations of the attachment member 506 may be adapted to more securely couple to a surgical instrument 300 having a non-uniform diameter. To this end, the first group of alignment seats 580A may define a first aperture diameter and the second group of alignment seats 580B may define a second aperture diameter. The first aperture diameter and the second aperture may be different from one another to complement the diameter of the surgical instrument 300. In some implementations the attachment member 506 may comprise stainless steel. Alternatively, the attachment member 506 may comprise titanium similar to the tracking array 502.

[0100] The attachment member 506 may further comprise a gripping member 584 having a fixed end 586 coupled to the mount body 570 and a free end 588 spaced therefrom. The gripping member 584 may have a generally curved shape, which may be arranged about the insertion axis A2 so as to partially define the instrument receiving aperture 578. Here, the gripping member 584 is arranged axially spaced from the mounting portion 574 in a distal direction. As will be discussed below, the gripping member 584 is elastically deformable. Here, elastically deformable means that the free end 588 of the gripping member 584 may be displaced relative to the fixed end 586 upon application of a force to the free end 588, but will return to its original position prior to displacement in the absence of the force without causing damage to, or permanently (plastically) deforming the gripping member 584. As can be seen in Figs. 4 and 9, the first group of alignment seats 580A may be arranged on the gripping member 584.

[0101] The attachment member 506 may further comprise a clamp base 590 and a clamp latch 592. The clamp latch 592 aids in the retention of the attachment member 506 on the surgical instrument 300. The clamp base 590 may be fixed to, and may be formed integrally with, the mounting portion 574. The clamp base 590 may be coupled to the mounting portion 574 of the mount body 570 adjacent to the free end 588 of the gripping member 584. The clamp latch 592 is pivotably coupled to the clamp base 590 ang movable about a latch axis A3 between an unclamped position (Figs. 4-6) and a clamped position (Fig. 7). The clamp latch 592 is pivotable by the user relative to the mount body 570 for securing the mount body 570, and therefore the tracking array 502, to the surgical instrument 300.

[0102] To this end, the clamp latch 592 may comprise a latch body 594 and a retention surface 596 coupled to the latch body 594 to selectively restrict movement of the surgical instrument 300 in at least one axial direction. As will be discussed in further detail below, the retention surface

596 may be spaced along the latch axis A3 from the mount body 570. By spacing the retention surface 596 from the mount body 570 a portion of the surgical instrument 300 may be disposed between the retention surface 596 and the mount body 570 when the surgical instrument 300 is received in the instrument receiving aperture 578 and the clamp latch 592 is in the clamped position.

[0103] Similar to the clamp latch 680 of Figs. 27-30, the latch body 594 may be pivotably mounted to the clamp base 590 for selective displacement relative thereto between the clamped position, that is, an engaged position, and the unclamped position, that is, a released position. Alternatively, the latch body 594 may be slidably mounted to the clamp base 590. When pivotably mounted to the clamp base 590, the latch body 594 may be pivotably disposed on a pivot pin 604 which may be unitarily fixed to the clamp base 590, for example by laser welding. A portion of the latch body 594 may be arranged distally of the clamp base 590. The pivot pin 604 may define or be aligned with the latch axis A3. The latch axis A3 may be substantially parallel to the insertion axis A2. The latch body 594 may be able to axially translate along the latch axis A3 in addition to pivoting thereabout. As shown in Fig. 9, a clamp spring 606 may be disposed between the latch body 594 and the clamp base 590. The clamp spring 606 may function in a similar manner as the clamp spring shown in Fig. 33 and discussed below. The clamp spring 606 biases the retention surface 596 towards the mount body 570. The clamp spring 606 may be more particularly disposed between the latch body 594 and clamp base 590 such that as the latch body 594 compresses the clamp spring 606 to contact the clamp base 590, any axial movement of the latch body 594 is reduced. The clamp spring 606 may be in part in a pocket of the latch body 594. The retention surface 596 may be angled at least in part to facilitate selective engagement of the retention surface 596 with a proximal surface, that is, a proximal end 302 of the surgical instrument 300.

[0104] Referring now to Figs. 5-9, the clamp latch 592 may further comprise a lobe portion 598 protruding from the latch body 594 transverse to the latch axis A3. The lobe portion 598 is arranged on the latch body 594 such that when the clamp latch 592 is in the clamped position the lobe position 598 is nearer to the insertion axis A2 than when the clamp latch 592 is in the unclamped position. The lobe portion 598 may be further configured to engage the gripping member 584 when the clamp latch 592 is in the clamped position. More specifically, the lobe portion 598 may be configured such that as the clamp latch 592 is moved from the unclamped position to the clamped position the lobe portion 598 engages the free end 588 of the gripping member 584, which deflects the free end 588 of the gripping member 584. In Figs. 5 and 6, the clamp latch 592 is pivoted to the unclamped position and the lobe portion 598 is disengaged from the gripping member 584. In Fig. 7 the clamp latch 592 is shown pivoted to the clamped position with the lobe portion 598 engaging the free end 588 of the gripping member 584 such that the gripping member 584 is deformed, which reduces the diameter of the instrument receiving aperture 578.

[0105] Accuracy and repeatability of coupling between the surgical instrument 300 and the tracking array 502 may be enhanced by the relative positioning of the lobe portion 598 and the retention surface 596. Specifically, the lobe portion 598 is positioned on the latch body 594 to protrude in a different direction than the retention surface 596. More specifically, the lobe portion 598 is arranged on the latch body 594 such that as the clamp latch 592 is pivoted about the latch axis A3 from the unclamped position (Fig. 23) toward the clamped position (Fig. 24) the retention surface 596 engages the proximal end 324 of the surgical instrument 300 prior to the lobe portion 598 engaging the free end 588 of the gripping member 584. This arrangement results in a staged, or sequential, coupling process, which enhances the repeatability. Because the retention surface

596 engages the surgical instrument 300 before the lobe portion 598 clamps the gripping member 584 around the instrument housing 310, the surgical instrument 300 is able to be biased into the instrument receiving aperture 578 by the retention surface 596, thereby preventing partial or incomplete engagement between the mount body 570 and the instrument 300. Once the surgical instrument 300 has been urged into a fully seated position with the instrument receiving aperture 578 and the latch body is pivoted further toward the clamped position, the lobe portion 598 begins to deflect the gripping member 584 to secure the attachment member 506 to the surgical instrument 300. More generally, in some implementations, the attachment portion 572 operates to secure the surgical instrument 300 in a distal direction before the one or more alignment seats 580 secure the housing 310 about its outer periphery.

[0106] Due to clamp latch 592 comprising both the retention surface 596 and the lobe portion 598, the surgical instrument 300 is able to be secured in both the axial direction along the insertion axis A2 as well as concentrically with the insertion axis A2. Specifically, the retention surface 596 engages the proximal end 302 of the surgical instrument 300 to urge the surgical instrument 300 in a distal direction and into engagement with a proximal face of the mount body 570, which prevents the surgical instrument 300 from moving in the proximal direction relative to the attachment member 506. Deflection of the free end 588 of the gripping member 584 clamps the alignment seats 580A around the housing 310 of the surgical instrument 300, which prevents movement of the surgical instrument 300 relative to the insertion axis A2.

[0107] Referring specifically to Fig. 9, the attachment portion 572 can be seen in greater detail. As mentioned above, the mount body 570 may comprise the attachment portion 572 and the mounting portion 574, the attachment portion 572 being configured to engage the tracking array 502. To this end, the attachment portion 572 may comprise a wedge portion 550 having two wedge

faces 600, and a fastener 602. The wedge faces 600 are spaced from the mounting portion 574 and arranged at an angle transverse to the insertion axis A2. The wedge faces 600 are configured to be complementary to the valley portion 520 of the tracking array 502 to facilitate secure alignment therebetween, as described above. Here, the fastener 602 takes the form of a threaded aperture in the attachment portion 572 which may receive a screw for biasing the wedge portion 550 and the valley portion 520 into engagement.

[0108] Turning now to Figs. 14-26 a perspective view of another configuration of the tracker 316 and the surgical instrument 300.

[0109] In order to facilitate removably coupling the tracker 316 to the surgical instrument 300, the tracker 316 comprises a tracker frame 322 having a proximal end 324 and a distal end 326. The tracker frame 322 comprises a mounting portion 328 and defines an insertion axis A2 along which the surgical instrument 300 is received. The insertion axis A2 extends from a distal surface 330 at the distal end 326 in a proximal direction to an insertion face 332, which is generally perpendicular to the insertion axis A2 and faces the proximal end 324. As will be discussed in further detail below, the surgical instrument 300 engages with the tracker 316 from the proximal end 324 of the tracker frame 322 to engage the insertion face 332 with the surgical instrument 300 along the insertion axis A2.

[0110] The mounting portion 328 comprises a lower cradle 334, which defines a first channel portion 336 and an orientation plane 352. The orientation plane 352 is parallel to the insertion axis A2 and divides the tracker 316 into two generally symmetrical halves. The mounting portion 328 further comprises a first resilient arm 338 coupled to the lower cradle 334 on one side of the orientation plane 352 and a second resilient arm 340 coupled to the lower cradle 334 on the other side of the orientation plane 352. Each of the first resilient arm 338 and the second resilient arm

340 has a fixed end coupled to the lower cradle 334, and a free end spaced from each other. The first resilient arm 338 and the second resilient arm 340 cooperate to define a second channel portion 346 adjacent to the first channel portion 336. The mounting portion 328 further comprises first and second arm bosses 342, 344, each coupled to the free end of one of the respective first and second resilient arms 338, 340. Space between the free ends of the first and second resilient arms 338, 340 allows the first and second resilient arms 338, 340 to flex slightly, which displaces the first and second arm bosses 342, 344 relative to each other, thereby reducing a distance defined therebetween.

[0111] The second channel portion 346 defined by the first resilient arm 338 and the second resilient arm 340 cooperates with the first channel portion 336 to define an instrument engaging aperture 348 in the insertion face 332. The instrument engaging aperture 348 receives the surgical instrument 300 from the proximal end 324 to engage with the housing 310. The mounting portion 328 further comprises an outlet face 350 opposite the insertion face 332 and facing the distal end 326 of the tracker frame 322. The outlet face 350 may be recessed proximally from the distal surface 330 of the tracker frame 322.

[0112] Best shown in Figs. 18, and 20-22, the mounting portion 328 may further comprise an alignment surface 354 arranged on the lower cradle 334 and configured to engage the surgical instrument 300. In some implementations, the alignment surface 354 may be further defined as a first alignment surface 354A, a second alignment surface 354B, and a third alignment surface 354C. The first alignment surface 354A, the second alignment surface 354B, and the third alignment surface 354C may collectively define an alignment member, which may protrude from the insertion face 332 in a proximal direction. The first alignment surface 354A and the second alignment surface 354B may be arranged on opposite sides of the orientation plane 352 and

oriented and not parallel to the insertion face 332. Said differently, the first alignment surface 354A and the second alignment surface 354B may be oriented so as to be parallel to each other. Alternatively, the first alignment surface 354A and the second alignment surface 354B may be oriented at opposite angles to each other so as to meet at a point spaced from the insertion face 332 forming a tapered alignment member. The first alignment surface 354A and the second alignment surface 354B may be spaced from the instrument engaging aperture 348 and the first channel portion 336 in a direction that is away from the second channel portion 346, shown towards the bottom of Fig. 21.

[0113] The alignment surface 354 may also be configured similar to the engagement surfaces 676A, 676B and the alignment surface 678 described above in connection with Figs. 34-34D for engaging with the keyway 720 of the powered surgical instrument 300, shown in Figs. 20 and 22.

[0114] As shown here, the third alignment surface 354C may be spaced proximally from the lower cradle 334 and positioned adjacent to the first alignment surface 354A and the second alignment surface 354B extending therebetween. The third alignment surface 354C may be parallel to the insertion face 332 such that the alignment member formed by the first alignment surface 354A, the second alignment surface 354B, and the third alignment surface 354C has a rectangular shape. However, as mentioned above, the first and second alignment surfaces 354A, 354B may be oriented non-parallel to each other to form an alignment member having a trapezoidal, or tapered, shape.

[0115] The tracker frame 322 may further comprise a plurality of preload fingers 356 extending proximally from the insertion face 332. As shown in Fig. 20, a first preload finger 356A is coupled to the lower cradle 334 and a second preload finger 356B is coupled one of the resilient arms 338, 340. The preload fingers 356 are radially arranged around the insertion axis A2 and

spaced from the instrument engaging aperture 348 such that a portion of the insertion face 332 is disposed between each of the preload fingers 356 and the instrument engaging aperture 348. At an end opposite the insertion face 332, each of the preload fingers 356 may comprise a ridge portion 358 that protrudes toward the insertion axis A2. The ridge portion 358 may be spaced from the insertion face 332 for urging the surgical instrument 300 toward the insertion face 332.

[0116] Similar to the resilient arms 338, 340, the preload fingers 356 may be resiliently flexible, which facilitates biasing engagement of the ridge portions 358 with the surgical instrument 300 for providing a retention force between the tracker 316 and the surgical instrument 300. As will be discussed in further detail below, the retention force may aid assembly by maintaining full engagement between the tracker 316 and the surgical instrument 300 when the lever 360 is in the unclamped position.

[0117] The instrument engaging aperture 348 is configured to receive the surgical instrument 300 such that the instrument axis A1 is aligned with the insertion axis A2 of the mounting portion 328. The first channel portion 336 and the second channel portion 346 may be generally concentric with the housing 310 of the surgical instrument 300 to facilitate complementary engagement therebetween, but non-circular profiles are also contemplated. More specifically, the distal end 304 of the surgical instrument 300 is inserted along the insertion axis A2 into the instrument engaging aperture 348 in a proximal to distal direction. The distal end 304 of the surgical instrument 300 protrudes from the outlet face 350 as the mounting portion 328 is slid toward the proximal end 302 of the surgical instrument 300. The proximal end 302 of the surgical instrument 300 engages the alignment surface 354 to angularly align and rotationally fix the surgical instrument 300 within the tracker frame 322.

[0118] As mentioned above, the tracker 316 may be clamped to the surgical instrument 300 in a secure and reliable manner. To this end, the tracker 316 may further comprise a lever 360, which is operable to effect clamping the tracker 316 to the surgical instrument 300. The lever 360 is pivotably coupled to the resilient arms, and more specifically, the first and second arm bosses 342, 344, and is movable between a clamped position (Fig. 30) and an unclamped position (Fig. 29). Pivoting movement of the lever 360 about a lever axis A4 between the unclamped position and the clamped position urges the free end of the first resilient arm 338 and the free end of the second resilient arm 340 toward each other. Said differently, movement of the lever 360 moves the first arm boss 342 and the second arm boss 344 relative to each other.

[0119] Each arm boss 342, 344 may define a pivot bore 362, which in turn define the lever axis A4 about which the lever 360 moves between the clamped and unclamped positions. The pivot bores 362, and therefore the lever axis A4 are arranged perpendicular to the insertion axis A2 of the tracker frame 322. The lever 360 may comprise two pins 364, which are supported in the pivot bores 362 and arranged on the lever axis A4. The engagement between the pins 364 and the pivot bores 362 facilitates the pivoting movement of the lever 360 between the clamped position and the unclamped position. Alternatively, the lever 360 and the arm bosses 342, 344 may be configured with the pins 364 protruding from the arm bosses 342, 344 and the pivot bore 362 defined in the lever 360.

[0120] In order to effect movement of the resilient arms 338, 340, each arm boss 342, 344 may have a follower surface 366, which may be defined by a helical surface formed around the lever axis A4. The follower surface 366 has a sloped profile, the height of which varies according to its angle relative to the lever axis A4. Similarly, the lever 360 may have two cam surfaces 368 that are engageable with the follower surfaces 366 on the arm bosses 342, 344. The cam surfaces 368

on the lever 360 may be defined by a helical surface formed around the pins 364, which is complementary to and facing the helical surface of the follower surfaces 366. Here too, the cam surfaces 368 have a sloped profile, the height of which varies according its angle relative to the pins 364. Relative movement between the cam surfaces 368 and the follower surfaces 366 causes the complementary helical surfaces to slide along each other and displace the arm bosses 342, 344 according to the height of the sloped profiles. This relative movement may result from angular rotation of the cam surfaces 368 by pivoting the lever 360 from the unclamped position to the clamped position.

[0121] One or both of the follower surfaces may define an assembly ramp 370, which slopes away from the lever axis A4 reducing a thickness of the respective arm boss 342, 344. The assembly ramp 370 aids assembly of the lever 360 by gradually flexing the resilient arms 338, 340 and easing alignment of the pins 364 into the pivot bores 362.

[0122] As shown in Figs. 21 and 22, the lever 360 may comprise a lever body 372, which may include a leg portion 374, a tab portion 376, and an upper surface 378 with a generally triangular shape defined by the leg portion 374 and the tab portion 376. The pins 364 may be positioned on the leg portion 374 protruding toward each other below the upper surface 378. The lever 360 may further comprise a catch 380 spaced from the pins 364 and below the tab portion 376 for securing the lever 360 in the clamped position. The catch 380 may be configured to engage a stop member 388, discussed below, in the clamped position and prevent unintended movement of the lever 360.

[0123] When the user pivots the lever 360 from the unclamped position to the clamped position the arm bosses 342, 344 are moved closer together, which reduces a diameter or size of the instrument engaging aperture 348. When the surgical instrument 300 is inserted in the instrument engaging aperture 348 and the lever 360 pivoted into the clamped position, the resilient arms 338,

340 are tightened against the housing 310 of the surgical instrument 300 and prevent relative movement therebetween.

[0124] The tracker frame 322 may further comprise an elongated portion 382 supported on the mounting portion 328 and extending proximally and in a direction generally parallel to the insertion axis A2. The elongated portion 382 may have a top face 384, which may define a cutout 386 extending through the elongated portion 382 in a direction generally perpendicular to the insertion axis A2. The top face 384 may have a generally triangular shape when viewed from above, and the elongated portion 382 may taper from the distal end 326 to the proximal end 324. The lever 360 may be at least partially disposed in the cutout 386 and the upper surface 378 may be generally aligned with the top face 384 when the lever 360 is in the clamped position.

[0125] The elongated portion 382 may further comprise a stop member 388 disposed in the cutout 386. The stop member 388 may have a bumper surface 390 and a flange 392 configured to engage the lever 360. The bumper surface 390 may be recessed below the top face 384 of the elongated portion 382 to provide clearance for the lever 360 in the cutout 386 allowing the upper surface 378 to align with the top face 384 of the elongated portion 382 in the clamped position. The clamped position of the lever 360 is defined by the angular position of the lever 360 when the tab portion 376 is abutting the bumper surface 390. As mentioned above, in the clamped position the catch 380 of the lever 360 engages the flange 392 of the stop member 388 to capture the lever 360 and prevent unintentional movement toward the unclamped position.

[0126] Near the distal end 326 of the tracker frame 322, the tracker 316 may comprise a battery tray 406 slidably engaged with the tracker frame 322. The battery tray 406 may be configured to be releasably coupled to the elongated portion 382 in order to place a battery in electrical communication with LED tracking markers. The battery tray 406 may be configured as a single-

use switch using an isolating material that is prevents current flow from the battery until the battery tray 406 has been fully inserted into the tracker frame 322. While the battery tray 406 shown here engages with the tracker frame 322 in a distal to proximal direction, the battery tray 406 may be coupled in other ways. Alternatively, the battery tray 406 may be implemented as a battery cage that is coupled to a circuit board and configured to slidably receive the battery. Other implementations are contemplated, for instance, the tracker may use passive reflective elements instead of the LEDs mentioned above, such as reflective spheres. In such an implementation, no battery and switch would be needed. Alternatively, the tracking marker could be a pattern that could be used to determine a unique viewing direction. One exemplary implementation of LED tracking markers is shown in U.S. Patent Application Pub. № 2019/0321108, which is hereby incorporated by reference.

[0127] In the tracker 316 shown here in Figs. 14-26, the tracker frame 322 may comprise a metal, such as titanium, a polymer such as nylon, or an epoxy resin, such as aromatic epoxy amine resin. The tracker frame may comprise any other suitable material for use in a medical setting, providing the necessary rigid structure to the tracker 316. As such, the tracker frame 322 may be formed using an injection molding or additive manufacturing process, which forms the tracker frame 322 as a single unitary body. By forming the tracker frame 322 as a single unitary body certain manufacturing steps may be eliminated. Furthermore, dimensional accuracy of the tracker frame 322 may be increased by reducing tolerance stack-ups. In addition, by eliminating any joints between pieces, the stiffness of the tracker frame 322 may be increased. Geometry that would be formed for the purpose of joining multiple pieces together may be eliminated further reducing the weight of the tracker frame 322 and the need to control the accuracy of mating surfaces. In another

exemplary implementation of the tracker, the tracker frame 322 may be formed using a stereolithography process and an epoxy resin.

[0128] In order to track the position and orientation of the surgical instrument 300, the tracker 316 may further comprise a tracker array 394 having a plurality of tracking markers 396 optionally arranged on one or more tracked faces 400A, 400B, 400C and coupled to the tracker frame 322. A first tracked face 400A is arranged on the top face 384 of the elongated portion 382, a second tracked face 400B is arranged beside the elongated portion 382 and the mounting portion 328 on the first side of the orientation plane 352, and a third tracked face 400C is arranged beside the elongated portion 382 and the mounting portion 328 on the second side of the orientation plane 352. The tracker array 394 may further have a tracker profile 398 defined perpendicular to the insertion axis A2 comprising three radial segments. The tracked faces 400A, 400B, 400C may be aligned with a respective radial segment 402A, 402B, 402C, each side oriented non-parallel to the others, for example approximately 120 degrees. The plurality of tracked faces 400A, 400B, 400C are positioned such that each tracked face 400A, 400B, 400C is oriented in a different direction from each other. The first tracked face 400A may be aligned with the first radial segment 402A, the second tracked face 400B may be aligned with the second radial segment 402B, and the third tracked face 400C may be aligned with the third radial segment 402C. Other number of arrays and/or number of sides are also contemplated.

[0129] When viewed from the distal end 326, the tracker profile 398 has a tracker perimeter defined by an exterior surface of each of the tracked faces 400A, 400B, 400C around the insertion axis A2. The tracker perimeter has a first projected area and a second projected area. The first projected area is defined when the lever 360 is in the clamped position and within the tracker perimeter. The second projected area is defined when the lever 360 is in the unclamped position

and at least partially outside the tracker perimeter. Because the lever 360 may be positioned between the first tracked face 400A and the instrument axis A1 as well as parallel to the first tracked face 400A, the lever 360 may be within the tracker perimeter in the clamped position and therefore the first projected area may be less than the second projected area.

[0130] As shown in Figs. 14 and 19, at least one of the tracking markers 396 may be positioned on the elongated portion 382 distally of the mounting portion 328 and at least another one of the tracking markers 396 may be positioned proximally of the mounting portion 382. In some implementations, such as shown here, the tracker array 394 may comprise at least three tracking markers 396, wherein the at least tracking markers 396 define a marker plane on one of the tracked faces 400A, 400B, 400C. At least one of the tracking markers 396 may be arranged in each of the radial segments 402A, 402B, 402C to facilitate increased visibility to the navigation system. The at least three tracking markers 396 may further define vertices of a face boundary 404, which is a 2D area enclosed by the at least three tracking markers 396. For example, the face boundary 404 is shown on the first tracked face 400A on the top face 384 of the elongated portion 382. Here, the face boundary 404 encloses the area of the cutout 386 such that the lever 360 is within the face boundary 404.

[0131] Turning now to Figs. 27-39, an example surgical instrument 300 may be equipped with an accessory 652, an illustrated example accessory being a tracker 652 intended for use as part of a surgical navigation system 102. An example alternative accessory may be a pointer (not shown). The tracker 652 may be selectively connected to the surgical instrument 300 with a surgical accessory mount system 654, 854. The surgical accessory mount system 654, 854 includes an accessory mount 656, 856 to which the tracker 652 is or may be attached, and a receiver 658, 858 which may comprise part of the surgical instrument 300.

[0132] The surgical instrument 300 may comprise an instrument housing 310, a drive motor 662 disposed within the housing 310, the receiver 658 and one of a power source and a power source connection for electrical connection with the drive motor. An attachment 318, may be disposed at a distal end 304 of the housing 310. An electrical conductor cable 312 may provide a power source connection with an electrical power source (not shown). A protective cable boot may be disposed over the cable 312 at an exit from the housing 310. The surgical instrument 300 may also include the receiver 658. The receiver 658 may incorporate other parts of the surgical instrument 300 to serve as part of the receiver 658. For example, the housing 310 may serve as a pilot portion of the receiver 658, with the housing 310 receiving the mount 656. The receiver 658 may also include a plurality of, by way of example and not limitation, two being an example plurality, receiver contact surfaces 666A, 666B, and a receiver alignment surface 668. The receiver 658 may define an instrument axis A1.

[0133] The mount 656 may include a mount base 672. The mount base 672 may define a sliding axis A2 that may be substantially aligned with the instrument axis A1 when the mount base 672 is engaged with the receiver 658. The sliding axis A2 connects a first end 673 of the mount base 672 with a second end 675 of the mount base 672. The axes A1 and A2 need not be precisely collinear. The first end 673 of the mount base 672 may further include a first engagement surface 676A and a second engagement surface 676B for engaging the receiver contact surfaces 666A, 666B in the installed position. The mount base 672 may also include a base alignment surface 678 for engagement with or proximity to the receiver alignment surface 668 in the installed position. The alignment surface 678 may be provided by an axially extending alignment key 679 of the mount base 672.

[0134] The mount 656 also includes a clamp 680 that is fixed to the mount base 672. The clamp 680 aids in the retention of the mount 656 on the instrument housing 310. The clamp 680 may include a clamp base 681 and a clamp latch 682. The clamp base 681 is fixed to, and may be formed integrally with, the mount base 672. The clamp latch 682 may define a clamp surface 684. For the clamp 680 of Figs. 27-39, the clamp surface 684 is disposed on an engagement projection 686 of the latch 682. The clamp surface 684 is spaced a first distance T1 from the first end 673 of the mount base 672. A value of T1 may be substantially equal to a thickness T2 of a receiver ring 718. The clamp latch 682 may be pivotably mounted to the clamp base 681 for selective displacement relative thereto between a clamped position, that is, an engaged position, and an unclamped position, that is, a released position. Alternatively, the clamp latch 682 may be slidably mounted to the clamp base 681. When pivotably mounted to the base 681, the latch 682 may be pivotably disposed on a pivot pin 688 which may be unitarily fixed to the clamp base 681. The pivot pin 688 may define a latch axis A3. The latch axis A3 may be substantially parallel to the sliding axis A2. The latch 682 may be able to axially translate along the latch axis A3 in addition to pivoting thereabout. A clamp spring 692 may be disposed between the clamp latch 682 and the clamp base 681. The spring 692 biases the clamp surface 684 towards the engagement surfaces 676A, 676B. The spring 692 may be more particularly disposed between the latch 682 and a head 694 of the pivot pin 688. The spring 692 may be in part in a pocket 696 of the latch. The clamp surface 684 may be angled at least in part to facilitate selective engagement of the clamp surface 684 with a proximal surface, that is, a proximal-most surface 697 of the surgical instrument 300.

[0135] The clamp 680 may include a spring-loaded clamp detent 698. The clamp detent 698 may include a first detent surface 700 formed in the clamp base 681 and a second detent surface 702 formed on the latch 682. The first detent surface 700 may be defined by one of detent

projection 704 and a detent groove 706, and the second detent surface 702 may be defined by the other of the detent groove 706 and the detent projection 704. This illustrated example detent 698 has two detent projections 704 formed as part of the latch 682 and defining the second detent surface 702. The example detent 698 further includes a detent groove 706 that receives the detent projections 704. The detent groove 706 may include a detent peak 708 and a pair of adjacent detent valleys 710. The spring 692 biases the latch 682 toward the clamp base 681, causing the projections 704 to engage the detent groove 706.

[0136] The mount base 672 of Figs. 27-39 may be ring-shaped. The ring-shaped mount base 672 may be referred to as a mount ring 672. The term ring, as used herein, includes any shape that substantially circumscribes another shape. Ring may include, by way of example and not limitation, a shape that is circular, square, triangular, hexagonal, and oval. What is meant by "substantially circumscribes" is that the ring may be but need not be closed. That is, the ring need not be continuous for its entire perimeter, and need only circumscribe enough of the circumference of the receiver to resist falling off of the receiver. The ring shape of the mount base 672 provides it with an example female configuration that is able to be received by the housing 310. The receiver's housing 310 may have a cylindrical shape that provides it with an example male configuration.

[0137] The example tracker 652 may include a tracker frame 712 to which a plurality of markers 714 may be attached. Such markers 714 may be passive markers, by way of example and not limitation, reflective spheres 714 as illustrated. Alternatively, the markers may be active markers, by way of example and not limitation, light emitting diodes (not shown). As discussed below, the tracker 652 may be formed integrally with the accessory mount 656. Alternatively, the

tracker 652 may be selectively joined to the accessory mount 656 at an accessory coupling 716 of the mount base 672.

[0138] The receiver 658 may include the receiver ring 718. The receiver ring 718 may be shaped in accord with the above description of a ring. The alignment surface 678 of the mount base 672 may be provided by the alignment key 679 received by a keyway 720 in the receiver ring 718. The keyway 720 may be formed as a notch in the receiver ring 718 unitarily fixed to the housing 310. The receiver ring 718 may be shaped in accord with the above description of a ring and may be of the same or similar shape as the mount base ring 672. The receiver ring 718 may be part of the accessory mount 656 fixed to the housing 310.

[0139] The engagement surfaces 676A, 676B of the mount base 672 may be located on the proximal side of the mount base 672, on opposite sides of the key 679. The receiver contact surfaces 666A, 666B of the receiver 658 may be located on a distal side of the receiver ring 718, on opposite sides of the keyway 720 for alignment with and engagement with the engagement surfaces 676A, 676B of the mount base. Inside corners of the keyway 720 may be radiused or include radiused nubs which define the receiver contact surfaces 666A, 666B thereat.

[0140] As shown in Figs. 34 through 34C, the engagement surfaces 676A, 676B may be substantially equally spaced from a first orientation plane 34' coincident with the sliding axis A2 with both engagement surfaces 676A, 676B on a common side of the first orientation plane 34'. The engagement surfaces 676A, 676B may be substantially equally spaced from and on opposite sides of a second orientation plane 34". The second orientation plane 34" intersects the first orientation plane 34' at the sliding axis A2, and is therefore also coincident with the sliding axis A2. The second orientation plane 34" is substantially normal to the first orientation plane 34'.

[0141] The engagement surfaces 676A, 676B, viewed from a direction normal to the first orientation plane 34', as shown in the section through a first section plane 34B in the direction of arrow 34B' in Fig. 34B, may each be oriented at an angle α of more than zero degrees and less than ninety degrees to the sliding axis A2. An example value of α, provided for purposes of illustration and not limitation, may be 45 degrees. Surfaces 676A and 676B, as illustrated in Fig. 34B, face away from the axis A2 and the first orientation plane 34'. The engagement surfaces 676A and 676B may each be a mirror image of each other, reflected about the second orientation plane 34". The first section plane 34B is parallel to the first orientation plane 34' and intersects the engagement surfaces 676A, 676B. Consistent with the above, a first section edge 676A' may be an intersection of the first engagement surface 676A with the first section plane 34B. A second section edge 676B' may be an intersection of the second engagement surface 676B with the first section plane 34B. The first section edge 676A' and the second section edge 676B' are each at the angle α of more than zero degrees and less than ninety degrees to the sliding axis A2.

[0142] The engagement surfaces 676A, 676B may further be at a compound angle to the sliding axis A2 with each surface 676A, 676B a mirror image of the other. The engagement surfaces 676A, 676B, viewed from a direction normal to the second orientation plane 34", as respectively shown in the section through a second section plane 34C in the direction of arrow 34C' in Fig. 34C and the section through a third section plane 34D in the direction of arrow 34D' in Fig. 34D, may each be further oriented at an angle β of more than zero degrees and less than ninety degrees to the sliding axis A2 and the second orientation plane 34". The second section plane 34C is parallel to the second orientation plane 34" and intersects the first engagement surface 676A. The third section plane 34D is parallel to the second orientation plane 34" and intersects the second engagement surface 676B. An example value of β, provided for purposes of illustration

and not limitation, may be 45 degrees. Surface 676A as illustrated in Fig. 34C, and likewise surface 676B as illustrated in Fig. 34D, face toward the axis A2 and the second orientation plane 34". Consistent with the above, a third section edge 676A" is an intersection of the first engagement surface 676A with the second section plane 34C. The third section edge 676A" is at the angle β of more than zero degrees and less than ninety degrees to the sliding axis A2 and the second orientation plane 34". Likewise, a fourth section edge 676B" is an intersection of the second engagement surface 676B with the third section plane 34D. The fourth section edge 676B" is at the angle β of more than zero degrees and less than ninety degrees to the sliding axis A2 and the second orientation plane 34". The engagement surfaces 676A and 676B may also be separated from each other by an angle γ about the sliding axis A2 as shown in Fig. 29. An example value of γ may be 24 degrees. Alternative values of γ may be employed as discussed below.

[0143] An inside diameter D1 of the mount base 672 is slightly larger than an outside diameter D2 of the instrument housing 310 to facilitate a slip-fit therebetween. The slip-fit facilitates easy installation of the accessory mount 656 over the instrument housing 310 and easy removal of the accessory mount 656 therefrom. This slip fit allows the mount base 672, and thus the sliding axis A2, to be out of alignment, that is, displaced, relative to the instrument axis A1. Such movement may result in the sliding axis A2 being radially offset from the instrument axis A1 when the clamp latch 682 is in the engaged position. Alternatively, or in combination with a radial offset, the sliding axis A2 may be cocked relative to the instrument axis A1. A magnitude of such relative displacement may be limited by factors including a magnitude of difference between the diameters D1 and D2, and an axial length of the mount base 672.

[0144] With the latch 682 in the engaged position, contact of the mount base 672 with the receiver 658 will occur at a secondary contact surface, with such contact stabilizing the mount base

672 on the receiver 658. The secondary contact surface aids in defining a repeatable installed position of the mount base 672 and the tracker 652 on the instrument housing 310. Depending on the system geometry, the secondary contact surface may occur at one of a proximal end of the mount base, or at a distal end of the mount base 672.

[0145] A resistance of the tracker 652 to pivoting, or otherwise stated, toggling, relative to the housing 310 responsive to a force against the tracker 652 is at least in part a function of a leverage of a clamping force applied across an effective lever arm. The clamping force may be induced by the spring 692 and applied by the clamp surface 684 against the proximal-most surface 697. The clamping force may be applied across the effective lever arm. The effective lever arm may extend between a location of contact between the clamp surface 684 and the proximal-most surface 697, and a line connecting the locations of engagement between the engagement surfaces 676A, 676B with the contact surfaces 666A, 666B. The lever arm may decrease in length as the angle γ increases in value. A first maximum lever arm length may occur when the angle γ is zero. The first lever arm length may decrease from the first maximum as γ is increased, until reaching a value of y where the lever arm becomes zero. An example value of γ where the lever arm may equal zero is 180 degrees. Further increasing the angle γ beyond the angle γ at which the lever arm is zero will increase the length of the lever arm, with the lever arm reaching a second maximum when the angle γ reaches 360 degrees. Practical limits, discussed below, make the use of zero and 360 degrees as values of γ impractical.

[0146] Accordingly, the value of γ should be chosen so the lever arm is long enough to ensure that the available clamp force can maintain the secondary engagement surface of the mount base 672 in engagement with the receiver during use of the surgical instrument. A first example range for γ may extend between zero and 120 degrees. A second example range for γ may extend

between 240 and 360 degrees. Having the angle γ be at precisely either zero or 360 degrees may allow the tracker 652 to pivot laterally, that is, pivot about an intersection of the second orientation plane 34" and a third orientation plane (not shown) that is perpendicular to both the first orientation plane 34' and the second orientation plane 34". An example value of the angle γ, in combination with the angle α being 45 degrees and the angle β being 45 degrees, sufficient to resist toggling may be 24 degrees. Another example value of the angle γ sufficient to avoid toggling may be 336 degrees.

[0147] The accessory mount 656 may be used in the following way.

[0148] When the tracker frame 712 is not formed integrally as a unit with the mount base 672, it may be fixed thereto by a removable fastener, such as, by way of example and not limitation, a threaded fastener (not shown) if it is desired to be able to conveniently separate the frame 712 from the base 672. If it is desired to permanently and unitarily fix the frame 712 to the base 672, the frame 712 and the base 672 may be fixed to each other by any suitable means, including but not limited to adhesive bonding, welding, brazing, a one-way snap-fit mechanical connection, and so on.

[0149] The mount base 672 may be placed on the instrument housing 310 for engagement with the receiver 658. As a first step, the mount base 672 may be oriented so that the clamp 680 is facing a distal end of the housing 310. The sliding axis A2 of the mount base 672 may be substantially aligned with the instrument axis A1 of the instrument housing 310 and the receiver 658. The mount base 672 may be moved in a proximal direction along the housing 310 until it is near the receiver ring 718. The mount base 672 is rotated about the sliding axis A2 as may be required to align the key 679 of the mount base 672 with the keyway 720 of the receiver ring 718. The base alignment surface 678 comes into contact with the receiver alignment surface 668 as the

key 679 is received by the keyway 720. Receipt of the key 679 by the keyway 720 aligns the engagement surfaces 676A, 676B with the receiver contact surfaces 666A, 666B.

[0150] The clamp latch 682 is pivoted from the released position shown in Fig. 30 to the engaged position shown in Fig. 29. As the latch 682 moves from the released position to the engaged position, the clamp surface 684 of the clamp engagement projection 686 presses against the proximal-most surface 697. As the latch 682 is moved to the engaged position, a ramp angle of the clamp surface 684 may cause the latch 682 to be axially displaced along the latch axis A3 and away from the clamp base 681. Such axial displacement is resisted by the spring 692. The spring 692 biases the mount base 672 against the receiver ring 718. In the engaged position, the engagement surfaces 676A, 676B of the mount base are pressed against the receiver contact surfaces 666A, 666B.

[0151] The detent 698 between the clamp base 681 and the latch 682, in combination with the spring 692 helps to maintain the clamp latch 682 in each of the engaged and released positions. The first detent surface, defined by the detent groove 706 of the clamp base 681, receives the second detent surface, the detent projection of the latch 682. The detent groove 706 has a first detent valley, i.e., an engaged valley 710 and a second detent valley, i.e., a released valley 710, on opposite sides of the detent peak 708. When the latch 682 is rotated from the released position to the engaged position, the detent projection 704 of the latch 682, slides from the released valley 710, across the peak 708 to the engaged valley 710. The resistance of the latch 682 to rotation increases as the projection 704 is forced to climb the peak 708, as the spring 692 is further compressed with the associated axial movement of the latch 682 along the instrument axis A1. The resistance tends to maintain the latch 682 in whichever one of the engaged position and the released position that the latch 682 is in. The latch 682 thus resists an unintended release of the

mount base 672 from the instrument housing 310 when the latch 682 is in the engaged position. The illustrated example detent 698 is symmetric as between the released valley 710 and the engaged valley 710 relative to the detent peak 708, requiring substantially the same amount of force or torque being applied to the latch 682 to move it from the released position to the engaged position, as to move the latch from the engaged position to the released position. An alternative embodiment (not shown) of the detent 698 may have an engaged valley that is not symmetrical with the released valley. The engaged valley may be much as illustrated, while the released valley may be less deep than the engaged valley. With such a configuration, a much lower force or torque may be required to be applied to the latch 682 move the latch 682 from the released position into the engaged position than a force or torque required to move the latch 682 from the engaged position to the released position.

As the latch 682 is pivoted from the released position to the engaged position, the engagement surfaces 676A, 676B are pressed into contact with the receiver contact surfaces 666A, 666B. The clamping force between the mount base 672 and the receiver ring 718 induced by the spring 692 presses the engagement surfaces 676A and 676B into contact with the respective receiver contact surfaces 666A, 666B. The outward orientation of the surfaces 676A and 676B as provided by the angle d illustrated in Fig. 34B centers the key 679 with respect to the keyway when the clamp latch 682 is in the engaged position. The downward orientation of the surfaces 676A and 676B as provided by the angle β illustrated in Fig. 34C biases the mount base 672 upward at the surfaces 676A and 676B. The secondary contact surface of the mount base 672 is brought into engagement with the receiver 658. A repeatable installed position of the accessory, the illustrated example accessory being the tracker 652, is thus achieved by the mount system 654. More specifically, such a repeatable installed position is achieved for a particular specimen of the tracker 652

mounted to a particular specimen of the mount base 672 when disposed on and clamped to a particular specimen of the receiver 658.

[0152] An alternative accessory mount 856 is illustrated in Figs. 40-44. Here, the surgical instrument 850 may comprise an instrument housing 860, a drive motor 862 disposed within the housing 860, a receiver 858 and one of a power source and a power source connection for electrical connection with the drive motor. An electrical conductor cable 863 may provide a power source connection with an electrical power source (not shown). A protective cable boot may be disposed over the cable 863 at an exit from the housing 860. A cutting implement may be disposed at a distal end of the housing 860. The receiver 858 may include a plurality of receiver contact surfaces 866A, 866B, and a receiver alignment surface 868 and may define an instrument axis A1. Here too, there may be two receiver contact surfaces.

[0153] The mount 856 may include a mount base 872. The mount base 872 may define a sliding axis A2 that may be substantially aligned with the instrument axis A1 when the mount base 872 is engaged with the receiver 858. The sliding axis A2 connects a first end 873 of the mount base 872 with a second end 875 of the mount base 872. The axes A1 and A2 need not be precisely collinear. The mount base 872 of Figs. 40-44 may include a T-shaped slider 879 at a bottom of the base 872. The T-shaped slider 879 may define the first end 873, the second end 875, and a base alignment surface 878. The base alignment surface 878 is for engagement with the receiver alignment surface 868 in the installed position. A first engagement surface 876A and a second engagement surface 876B of the mount base 872 may be located on opposite corners of the first end 873 of the mount base 872, for alignment with and engagement with the contact surfaces 866A, 866B of the receiver 858.

[0154] The mount 856 also includes a clamp 880 that is fixed to the mount base 872. The clamp 880 aids in the retention of the mount 856 on the instrument housing 860. The clamp 880 may include a clamp base 881 and a clamp latch 882. The clamp base 881 is fixed to, and may be formed integrally with, the mount base 872. The clamp latch 882 may define a clamp surface 884. For the clamp 880 of Figs. 40-44, the clamp surface 884 may be disposed on a distal side of the latch 882. The clamp is spaced a distance T3 from the first end 873 of the mount base 872. A value of T3 may be substantially equal to a thickness T4 of a receiver plate 918. The clamp latch 882 may be pivotably mounted to the clamp base 881 for selective displacement relative thereto between a clamped position, that is, an engaged position, and an unclamped position, that is, a released position. The latch 882 may be pivotably disposed on a pivot pin 888 which may be unitarily fixed to the clamp base 881. The pivot pin 888 may define a latch axis A5. The latch axis A5 may be substantially parallel to the sliding axis A2. The latch 882 may be able to axially translate along the latch axis A5 in addition to pivoting thereabout. A clamp spring (not shown) consistent with the clamp spring 692 may be disposed between the clamp latch 882 and the clamp base 881. The clamp spring biases the clamp surface 884 towards the engagement surfaces 876A, 876B. The spring may be more particularly disposed between the latch 882 and a head 894 of the pin 888. The spring may be in part in a pocket (not shown) similar to the disposition of the spring 692 in the pocket 696 of the clamp 680. The clamp surface 884 may be angled at least in part to facilitate selective engagement of the clamp surface 884 with a proximal surface, that is, a proximal-most surface 897 of the mount receiver 858 of the surgical instrument 850. The clamp 880 may also include a clamp detent (not shown) like the clamp detent 698.

[0155] The receiver 858 may include a T-slot block 917 and the receiver plate 918. The T-slot block 917 includes a T-slot 920 for slidable receipt of the T-shaped slider 879. The T-slot

block 917 may be unitarily fixed to the housing 860. The receiver plate 918 is disposed at a proximal end of the T-slot block 917 and blocks a proximal end of the T-slot 920. The receiver plate 918 includes the receiver contact surfaces 866A, 866B on a distal surface for disposition at an end of the T-slot 920. The contact surfaces 866A, 866B may be spheroidal, each offering a radial surface. The receiver plate 918 may be fixed to the proximal end of the T-slot block 917 over the T-slot 920 by any known means, including but not limited to welding, brazing, adhesive bonding, rivets, and threaded fasteners. Yet alternatively, the T-slot block and the receiver plate 918 may be formed as a single, one-piece unit by, for example, additive manufacturing. The T-slot 920 of the receiver 858 provides the receiver 858 with an example female configuration able to receive the T-shaped slider 879 of the mount base 872. The T-shaped slider 879 of the mount base, fitting inside the slot 920, has an example male configuration.

[0156] The accessory mount 856 may be used in the following way.

[0157] The mount base 872 may be slid into the receiver 858 for mounting on the instrument housing 860. As a first step, the mount base 872 may be oriented so that the clamp 880 is facing a distal end of the receiver 858. The sliding axis A2 of the mount base 872 may be substantially aligned with the instrument axis A1 of the receiver 858. The T-shaped slider 879 of the mount base 872 may be moved in a proximal direction toward and into the T-slot 920, with the base alignment surface 878 coming into contact with or proximity to the receiver alignment surface 868 as the T- shaped slider 879 is received by the T-slot 920. The surfaces 878 and 868 cooperatively align the engagement surfaces 876A, 876B with contact surfaces 866A, 866B. Movement of the slider 879 in the slot 920 in the proximal direction is limited by contact of the engagement surfaces 876A, 876B with the contact surfaces 866A, 866B.

[0158] The clamp latch 882 is pivoted from the released position shown in solid lines in Fig. 41 to the engaged position shown in solid lines in Fig. 40. As the latch 882 moves from the released position to the engaged position, the clamp surface 884 of the clamp engagement projection 886 presses against the proximal-most surface 897. As the latch 882 is moved to the engaged position, a ramp angle of the clamp surface 884 may cause the latch 882 to be axially displaced along the latch axis A5 and away from the clamp base 881. Such axial displacement is resisted by the spring. The spring biases the mount base 872 against the receiver plate 918. In the engaged position, the engagement surfaces 876A, 876B of the mount base are pressed against the receiver contact surfaces 866A, 866B.

[0159] The detent between the clamp base 881 and the latch 882, in combination with the spring helps to maintain the clamp latch 882 in each of the engaged and released positions as described in the description of the detent 698. The detent resistance tends to maintain the latch 882 in whichever one of the engaged position and the released position that the latch 882 is in, thus resisting an unintended release of the mount base 872 from the instrument housing 860 when the latch 882 is in the engaged position.

[0160] As the latch 882 is pivoted from the released position to the engaged position, the engagement surfaces 876A, 876B are pressed into contact with the receiver contact surfaces 866A, 866B. The clamping force between the mount base 872 and the receiver plate 918 induced by the spring presses the engagement surfaces 876A and 876B into contact with the respective receiver contact surfaces 866A, 866B. The T-shaped slider engagement surfaces 876A and 876B are illustrated as being oriented at compound angles, consistent with the illustrated orientation of the engagement surfaces 876A and 876B. The engagement surfaces 876A and 876B of the T-shaped slider 879 are pressed against the contact surfaces 866A and 866B, laterally centering the slider

879 with respect to the slot 920 and the contact surfaces 866A, 866B when the clamp latch 882 is in the engaged position. The downward orientation of the engagement surfaces 876A and 876B biases the mount base 872 upward at the engagement surfaces 876A and 876B. A secondary contact surface of the mount base 872, much like the secondary contact surface of the mount base 672, is brought into engagement with the receiver 858. A repeatable installed position of the accessory mount 856 is thus achieved by the mount system 854.

[0161] The trackers disclosed and described above and shown throughout the figures may be used for applications other than for tracking a handheld surgical instrument. For example, the trackers may be fitted to devices such as a robotic arm, a robotic hand-held device, a patient's anatomy, a bone, etc. The trackers may further be used as reference trackers for medical devices such as a CT scanner, a navigation cart, a calibration device, etc. Similarly, the attachment mechanisms and clamps disclosed and described above and shown throughout the figures may be used for applications other than optical trackers. For example, the mounts may be used to couple electromagnetic trackers, ultrasonic trackers, active optical markers, passive optical markers, retroreflectors, light emitting diodes (LEDs), etc. Other implementations are contemplated.

[0162] In the drawings, the same reference numbers indicate the same elements. Further, some or all of these elements could be changed. With regard to the media, processes, systems, methods, heuristics, *etc.* described herein, it should be understood that, although the steps of such processes, *etc.* have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words,

the descriptions of processes herein are provided for the purpose of illustrating certain implementations and should in no way be construed so as to limit the claims.

[0163] As used herein, the adverbs "substantially" and "generally" mean that a shape, structure, measurement, quantity, time, *etc.* may deviate from an exact described geometry, distance, measurement, quantity, time, *etc.*, because of imperfections in materials, machining, manufacturing, transmission of data, computational speed, *etc.*

[0164] Relative orientations and directions (by way of example, distal, proximal, upper, lower, bottom, rearward, front, rear, back, outboard, inboard, inward, outward, lateral, left, right) are set forth in this description not as limitations, but for the convenience of the reader in picturing at least one embodiment of the structures described. Such exemplary orientations may be from the perspective of a user of the instrument, with "proximal" understood to mean towards a user holding the instrument, and away from a surgical site to which the instrument may be directed, and "distal" understood to mean away from a user and towards the surgical site.

[0165] All terms used in the claims are intended to be given their ordinary meanings as understood by those knowledgeable in the technologies described herein unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," *etc.* should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary.

[0166] Several examples have been discussed in the foregoing description. However, the examples discussed herein are not intended to be exhaustive or limit the invention to any particular form. The terminology that has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations are possible in light of the above teachings and the invention may be practiced otherwise than as specifically described.

[0167] Clauses:

[0168] A disclosed mount for a powered surgical handpiece comprises a clamp and a plurality of engagement surfaces facilitating consistent alignment of the accessory with a housing of the handpiece. The mount may be alternatively configured to slide over a receiver or inside a receiver.

[0169] An accessory mount for providing consistent alignment of an accessory with a powered handpiece tool includes a mount base and a clamp. The mount base has one of a male configuration and a female configuration of a size and shape complementary to a receiver having the other of the female configuration and the male configuration. The mount base defines a sliding axis connecting a first end and a second end. The mount base includes a plurality of engagement surfaces on the first end and a base alignment surface substantially parallel to the sliding axis. The clamp is fixed to the mount base and includes a clamp base unitarily fixed to the mount base. A clamp latch is mounted to the clamp base for selective displacement relative thereto and has a clamp surface spaced a first distance from the first end of the mount base. A spring is disposed between the clamp latch and the clamp base, and axially biases the clamp surface toward the engagement surfaces. One of an accessory and an accessory coupling is fixed to the mount base.

[0170] The accessory mount and the components thereof may comprise additional features and modifications as set forth below, such features and modifications being included separately or in combination with each other, with such combinations being limited only by mutual exclusivity.

[0171] The mount base may be a ring.

[0172] The engagement surfaces may include a first engagement surface and a second engagement surface with the first and second engagement surfaces being separated from each other by an angular range about the sliding axis of one of a first range between zero degrees and 120 degrees and a second range between 240 degrees and 360 degrees.

[0173] The base alignment surface may be sized and oriented and shaped for engagement with a receiver alignment surface of the powered handpiece tool.

[0174] The mount base may be a ring that is sized and shaped for receipt by a housing of the powered handpiece tool with the housing being at least in part the receiver.

[0175] The base alignment surface may be provided by a key fixed to the ring for receipt by a keyway of the receiver.

[0176] The base alignment surface may be provided by a key fixed to the base for receipt by a keyway of the receiver. A first of the engagement surfaces may be adjacent to a first side of the key. A second of the engagement surfaces may be adjacent to a second side of the key. The engagement surfaces may be separated by an angular range about the sliding axis of one of a first range between zero degrees and 120 degrees and a second range between 240 degrees and 360 degrees.

[0177] The engagement surfaces may include a first engagement surface and a second engagement surface that are both on a common side of a first orientation plane that is coincident with the sliding axis. The engagement surfaces may be on opposite sides of a second orientation plane that is coincident with the sliding axis. The second orientation plane is substantially normal to the first orientation plane. A first section plane is parallel to the first orientation plane and intersects the engagement surfaces. A first section edge is an intersection of the first engagement surface with the first section plane. A second section edge is an intersection of the second engagement surface with the first section plane. The first section edge and the second section edge may each be at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0178] The engagement surfaces may be set at compound angles. A second section plane is parallel to the second orientation plane and intersects the first engagement surface. A third section

edge is an intersection of the first engagement surface with the second section plane. The third section edge is at an angle of more than zero degrees and less than ninety degrees to the sliding axis. A third section plane is parallel to the second orientation plane and intersects the second engagement surface. A fourth section edge is an intersection of the second engagement surface with the third section plane. The fourth section edge is at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0179] The first engagement surface and the second engagement surface may be substantially equally spaced from the first orientation plane. The engagement surfaces may be substantially equally spaced from the second orientation plane. The engagement surfaces may be each substantially a mirror image of the other about the second orientation plane.

[0180] The engagement surfaces may be set at compound angles with each engagement surface substantially a mirror image of the other about the second orientation plane. A second section plane is parallel to the second orientation plane and intersects the first engagement surface. A third section edge is an intersection of the first engagement surface with the second section plane. The third section edge is at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0181] The clamp surface may be angled at least in part to facilitate selective engagement of the clamp surface with a proximal surface of the handpiece tool.

[0182] The latch may be pivotably connected to the clamp base.

[0183] The latch may be pivotably mounted to the clamp base for pivoting about a pivot axis substantially parallel to the sliding axis.

[0184] The clamp may include a spring-loaded detent.

[0185] A pivot axis substantially parallel to the sliding axis may be defined by a pivot pin disposed at least in part in each of the clamp base and the latch. The detent may include a first detent surface formed in the clamp base and a second detent surface formed on the latch. The spring may be disposed between a head of the pivot pin and one of the latch and the clamp base. The spring may bias the first and second detent surfaces against each other.

[0186] The detent may include a detent projection on one of the latch and the clamp base, and a detent groove on the other of the latch and the clamp base. The detent groove may have a peak and a valley.

[0187] The detent groove may be disposed in the clamp base and the detent projection may be on the latch.

[0188] The pivot pin may be unitarily fixed to the clamp base and the latch may be able to pivot thereon and to translate axially therealong.

[0189] The latch may have a pocket that receives a head of the pivot pin. The spring may be disposed in the pocket between the head and the latch, and may bias the latch against the clamp base.

[0190] The accessory may be a tracker frame accommodating a plurality of markers.

[0191] The markers may include reflective spheres.

[0192] The markers include light emitting diodes.

[0193] The engagement surfaces may be located on a proximal side of the mount base.

[0194] A surgical accessory mount system comprises a powered handpiece tool and an accessory mount. The powered handpiece tool includes a handpiece housing, a drive motor, and a receiver. The drive motor is disposed within the housing. The receiver has one of a male configuration and a female configuration, and has a receiver alignment surface. The accessory

mount comprises a mount base, a clamp, and one of an accessory and an accessory coupling. The mount base has the other of the female configuration and the male configuration of a size and shape complementary to the receiver. The mount base defines a sliding axis connecting a first end and a second end. The mount base also defines a plurality of engagement surfaces on the first end and a base alignment surface substantially parallel to the sliding axis. The clamp is fixed to the mount base and including a clamp base, a clamp latch, and a spring. The clamp base is unitarily fixed to the mount base. The clamp latch is mounted to the clamp base for selective displacement relative thereto. The clamp latch has a clamp surface spaced a first distance from the first end of the mount base. The spring is disposed between the clamp latch and the clamp base and axially biases the clamp surface toward the engagement surfaces. The one of an accessory and an accessory coupling is fixed to the mount base.

[0195] The surgical accessory mount system and the components thereof may comprise additional features and modifications as set forth below, such features and modifications being included separately or in combination with each other, with such combinations being limited only by mutual exclusivity.

[0196] The engagement surfaces may include a first engagement surface and a second engagement surface that are both on a common side of a first orientation plane that is coincident with the sliding axis. The engagement surfaces may be on opposite sides of a second orientation plane that is coincident with the sliding axis. The second orientation plane is substantially normal to the first orientation plane. A first section plane is parallel to the first orientation plane and intersects the engagement surfaces. A first section edge is an intersection of the first engagement surface with the first section plane. A second section edge is an intersection of the second

engagement surface with the first section plane. The first section edge and the second section edge may each be at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0197] The engagement surfaces may be set at compound angles. A second section plane is parallel to the second orientation plane and intersects the first engagement surface. A third section edge is an intersection of the first engagement surface with the second section plane. The third section edge may be at an angle of more than zero degrees and less than ninety degrees to the sliding axis. A third section plane is parallel to the second orientation plane and intersects the second engagement surface. A fourth section edge is an intersection of the second engagement surface with the third section plane. The fourth section edge is at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0198] The first engagement surface and the second engagement surface may be substantially equally spaced from the first orientation plane. The engagement surfaces may be substantially equally spaced from the second orientation plane. The engagement surfaces may be each substantially a mirror image of the other about the second orientation plane.

[0199] The engagement surfaces may be set at compound angles with each engagement surface substantially a mirror image of the other about the second orientation plane. A second section plane is parallel to the second orientation plane and intersects the first engagement surface. A third section edge is an intersection of the first engagement surface with the second section plane. The third section edge is at an angle of more than zero degrees and less than ninety degrees to the sliding axis.

[0200] The clamp surface may be angled at least in part to facilitate selective engagement of the clamp surface with a proximal surface of the handpiece tool.

[0201] The base alignment surface may be provided by one of a key and a keyway fixed to the mount base for engagement with the other of the keyway and the key of the powered handpiece tool respectively.

[0202] The base alignment surface may be provided by a key fixed to the mount base for receipt by a keyway of the handpiece tool and the mount base includes two engagement surfaces with a first of the engagement surfaces adjacent to a first side of an alignment surface and a second of the engagement surfaces adjacent to a second side of the alignment surface substantially opposite the first side.

[0203] The engagement surfaces may be at a compound angle to the sliding axis.

[0204] A tracker component for a handheld surgical instrument, the tracker component comprising a body portion, the body portion has an outer surface and defines a hollow interior having an inner surface, and a tracking marker. The body portion may be part of the tracker array, or may be part of the attachment portion.

[0205] A method of manufacturing a tracker component is also contemplated. The method comprising the steps of: providing a powdered titanium alloy; sintering the titanium alloy and forming a tracker component having a body portion having a hollow cross section defined by an outer surface and an inner surface, and wherein the inner surface defines an interior, removing unsintered powdered titanium alloy from the interior of the hollow cross-section; and optionally refining the outer surface to an Ra surface roughness to between 1µm and 7µm.

CLAIMS

What is claimed is:

1. A tracker array for a handheld surgical instrument, the tracker array comprising:

a unitary body portion comprising an arm protruding therefrom, wherein said arm has an outer surface and defines a hollow interior having an inner surface; and

a marker post coupled to an end of said arm spaced from said body portion, wherein said marker post is configured to engage a tracking marker.

2. The tracker array of claim 1, wherein said arm comprises a marker support portion arranged at said end spaced from said body portion, wherein said marker support portion defines a post bore in communication with said hollow interior of said arm, and wherein said marker post is disposed in said post bore.

3. The tracker array of claim 2, wherein said hollow interior of said arm is accessible through said post bore prior to said marker post being coupled to said arm.

4. The tracker array of claims 2 or 3, wherein said marker post encloses said post bore and said hollow interior of said arm.

5. The tracker array of any preceding claim, wherein said marker post is welded to said arm.

6. The tracker array of claim 1, wherein said outer surface of said arm has an Ra surface roughness between 1 μm and 7μm.

7. The tracker array of any preceding claim, wherein said body portion has an outer surface and an inner surface defining a hollow interior, wherein said hollow interior of said body portion is in communication with said hollow interior of said arm.

8. The tracker array of any preceding claim, wherein said outer surface of said arm is curved for reducing reflections.

9. The tracker array of any preceding claim, wherein said arm has a first cross-sectional area proximal to said body portion and a second cross-sectional area distal to said body portion, wherein said second cross-sectional area is less than said first cross-sectional area.

10. The tracker array of any preceding claim, wherein said arm is further defined as a first arm and a second arm, and wherein said tracker array further comprises a bridge portion spaced from said unitary body portion and extending between said first arm and said second arm.

11. The tracker array of claim 10, wherein said bridge portion has an outer surface and an inner surface defining a hollow interior, wherein said hollow interior of said bridge portion is in communication with said hollow interior of said first arm and said second arm.

12. The tracker array of claim 10 or 11, wherein said bridge portion, said first arm, said second arm, and said unitary body portion cooperate to define an opening in said tracker array.

13. The tracker array of any preceding claim, wherein a reference plane is defined parallel to and spaced from an axis of the handheld surgical instrument, and wherein said arm is curved in a first direction along said reference plane and in a second direction perpendicular to said reference plane.

14. The tracker array of claim 1, wherein a cross-sectional profile is defined by said outer surface and said inner surface of said hollow interior of said arm, and wherein said cross-sectional profile is non-uniform along said arm.

15. The tracker array of any preceding claim, wherein said arm is further defined as a first pair of arms and a second pair of arms, wherein said first pair of arms extends a first distance

from said body portion and said second paid of arms extends a second distance from said body portion, said first distance greater than said second distance.

16. The tracker array of claim 15, wherein said tracker array has a length and a width defined by said first pair of arms and said second pair of arms, wherein a ratio of said length to said width is greater than 1.5.

17. The tracker array of any preceding claim, wherein said unitary body portion is formed using an additive manufacturing process.

18. The tracker array of claim 17, wherein said unitary body portion is formed from a sintered metal powder.

19. The tracker array of claim 18, wherein said sintered metal powder comprises titanium.

20. The tracker array of any preceding claim, wherein said arm has a length and a width, and wherein a ratio of said length to said width exceeds 4.

21. A tracker array for a handheld surgical instrument, the tracker array comprising:

a unitary body portion comprising an arm protruding therefrom and a marker support portion coupled to said arm opposite said body portion, wherein said arm has an outer surface and defines a hollow interior having an inner surface; and

a tracking marker coupled to said marker support portion.

22. A method of manufacturing a tracker array for a handheld surgical instrument, the method comprising the steps of:

providing a powdered titanium alloy;

sintering the titanium alloy and forming a unitary body portion with a plurality of arms protruding therefrom, wherein the plurality of arms each have a hollow cross section defined by an outer surface and an inner surface, and wherein the inner surface defines an interior;

removing unsintered powdered titanium alloy from the interior of the plurality of arms; and

refining the outer surface of the plurality of arms to an Ra surface roughness to between 1μm and 7μm.

23. The method of claim 22, further comprising the step of forming an inner surface and an outer surface of the unitary body portion, wherein the inner surface of the unitary body portion defines an interior in communication with the interior of the plurality of arms.

24. The method of claim 22 or 23, further comprising the step of removing a portion of the sintered titanium alloy to define a marker support portion on each of the plurality of arms.

25. The method of claim 24, further comprising the step of removing a portion of the sintered titanium alloy to define a post bore in each of the marker support portions, wherein the interior of a respective one of the plurality of arms is accessible through the post bore.

26. The method of claim 25, further comprising the step of inserting a marker post in each of the post bores and enclosing the interior of the respective one of the plurality of arms.

27. The method of claim 25 or 26, wherein the unsintered powdered titanium alloy is removed from the interior of the plurality of arms through the post bore of the respective one of the plurality of arms.

28. An attachment member for a tracker comprising:

a mount body having an attachment portion for engaging a tracking array and a mounting portion, wherein said mounting portion has an inner surface that defines an instrument receiving aperture extending therethrough along an insertion axis for receiving a surgical instrument; and

a plurality of alignment seats protruding from said inner surface toward said insertion axis, wherein a first group of said plurality of alignment seats are radially arranged about said insertion axis and a second group of said plurality of alignment seats are radially arranged about said insertion axis and axially spaced from said first group.

29. The attachment member of claim 28, wherein said first group of said plurality of alignment seats defines a first diameter and wherein said second group of said plurality of alignment seats defines a second diameter, said first diameter different than said second diameter.

30. The attachment member of claim 28 or 29, further comprising a gripping member having a fixed end coupled to said mount body and a free end, wherein said gripping member is arranged about said insertion axis and partially defines said instrument receiving aperture, and wherein said gripping member is elastically deformable.

31. The attachment member of claim 30, wherein said first group of said plurality of alignment seats is arranged on said gripping member.

32. The attachment member of claim 30 or 31, further comprising a clamp base coupled to said mount body adjacent to said free end of said gripping member and a clamp latch pivotably coupled to said clamp base, wherein said clamp latch is movable between an unclamped position and a clamped position for securing said mount body to the surgical instrument.

33. The attachment member of claim 32, wherein said clamp latch is pivotable relative to said mount body about a latch axis and comprises a latch body and a retention surface coupled

to said latch body configured to selectively restrict movement of the surgical instrument in at least one axial direction.

34. The attachment member of claim 33, wherein said retention surface is spaced along said latch axis from said mount body such that a portion of the surgical instrument is disposed between said retention surface and said mount body when the surgical instrument is received in said instrument receiving aperture and said clamp latch is in said clamped position.

35. The attachment member of claim 34, wherein a portion of said latch body is arranged distally of said clamp base.

36. The attachment member of claim 35, wherein said clamp latch further comprises a spring arranged between said latch body and said clamp base for biasing said latch body in a distal direction.

37. The attachment member of any of claims 33-36, wherein said clamp latch further comprises a lobe protruding from said latch body transverse to said latch axis, wherein said lobe is configured to engage said free end of said gripping member when said clamp latch is in said clamped position.

38. The attachment member of claim 37, wherein said lobe is arranged on said latch body such that as said clamp latch is moved from said unclamped position toward said clamped position said retention surface engages the surgical instrument prior to said lobe engaging said gripping member.

39. The attachment member of claim 37 or 38, wherein said lobe engages said free end of said gripping member such that said lobe deflects said free end when said clamp latch is moved between said unclamped position and said clamped position.

40. The attachment member of claim 37, 38, or 39, wherein said lobe is nearer to said insertion axis when said clamp latch is in said clamped position than when said clamp latch is in said unclamped position.

41. The attachment member of any one of claims 28-40, wherein said mount body comprises stainless steel.

42. The attachment member of any one of claims 28-41, wherein said attachment portion comprises two wedge faces spaced from said insertion axis for engaging a tracking array and further comprises a fastener for biasing the tracking array toward said wedge faces.

43. An attachment member for a tracker comprising:

a mount body having an attachment portion for engaging a tracking array and a mounting portion, wherein said mounting portion has an inner surface that defines an instrument receiving aperture extending therethrough along an insertion axis for receiving a surgical instrument;

a plurality of alignment seats protruding from said inner surface toward said insertion axis; and

a clamp latch pivotably coupled to said mount body and movable about a latch axis between an unclamped position and a clamped position, said clamp latch having a lobe portion engageable with said mount body and a retention surface spaced along said latch axis from said mount body, wherein when said clamp latch is in said clamped position said lobe portion is configured to deform said mount body and said retention surface is configured to selectively restrict movement of the surgical instrument in at least one axial direction for securing said mount body to the surgical instrument.

44. The attachment member of claim 43, wherein said lobe portion is arranged such that as said clamp latch is pivoted from said unclamped position toward said clamped position said

retention surface engages the surgical instrument prior to said lobe portion engaging said mount body.

45. A tracker clamp for a surgical instrument, the tracker clamp comprising:

a tracker frame having a proximal end and a distal end and comprising a mounting portion to receive the surgical instrument on an insertion axis, wherein said mounting portion comprises:

a lower cradle defining a first channel portion;

a first resilient arm having a fixed end coupled to said lower cradle and a free end;

a second resilient arm having a fixed end coupled to said lower cradle and a free end, wherein said free end of said second resilient arm is spaced from said free end of said first resilient arm, and wherein said first resilient arm and said second resilient arm cooperate to define a second channel portion;

first and second arm bosses each coupled to said free end of one of said first resilient arm and said second resilient arm;

an alignment surface arranged on said lower cradle and configured to engage the surgical instrument; and

a lever pivotably coupled to said first and second arm bosses and movable between a clamped position and an unclamped position, wherein movement of said lever between said unclamped position and said clamped position urges said free end of said first resilient arm and said free end of said second resilient arm toward each other.

46. The tracker clamp of claim 45, wherein said mounting portion is configured to receive the surgical instrument from said distal end of said tracker frame.

47. The tracker clamp of claim 45 or 46, wherein each of said arm bosses has a follower surface and said lever has a cam surface engageable with said follower surface, and wherein

movement of said lever between said clamped position and said unclamped position slides said cam surface along said follower surface to displace said free ends of said resilient arms.

48. The tracker clamp of any one of claims 45-47, wherein each of said first and second arm bosses defines a pivot bore, and wherein said lever comprises a pair of pins supported for pivoting movement in one of said pivot bores.

49. The tracker clamp of claim 48, wherein said pivot bore defines a lever axis about which said lever moves between said clamped position and said unclamped position, and wherein said lever axis is arranged perpendicular to said insertion axis.

50. The tracker clamp of any one of claims 45-49, wherein said tracker frame further comprises an elongated portion, wherein said elongated portion comprises a stop member configured to be engaged by said lever, and wherein engagement of said lever and said stop member defines said clamped position.

51. The tracker clamp of any one of claims 45-50, wherein said alignment surface is further defined as a first alignment surface and a second alignment surface, and wherein the first alignment surface and the second alignment surface are arranged on opposite sides of an orientation plane that is parallel and aligned with said insertion axis.

52. The tracker clamp of claim 51, wherein said mounting portion further comprises a third alignment surface spaced from said lower cradle in a direction parallel to said insertion axis, and wherein said third alignment surface is adjacent to said first alignment surface and said second alignment surface.

53. The tracker clamp of claim 51 or 52, wherein said first alignment surface and said second alignment surface are spaced from said first channel portion in a direction opposite said second channel portion.

54. The tracker clamp of any one of claims 45-53, wherein said mounting portion further comprises an insertion face perpendicular to said insertion axis and facing said distal end, and wherein said first channel portion and said second channel portion cooperate to define an instrument engaging aperture in said insertion face.

55. The tracker clamp of claim 54, wherein said instrument engaging aperture has an aperture diameter, and wherein movement of said lever from said unclamped position to said clamped position reduces said aperture diameter such that said first channel portion and said second channel portion exert a radial force on the surgical instrument.

56. The tracker clamp of claim 54 or 55, wherein said tracker frame further comprises a preload finger extending from said insertion face and spaced from said instrument engaging aperture, said preload finger comprising a ridge portion protruding toward said insertion axis and spaced from said insertion face for urging the surgical instrument toward said insertion face.

57. The tracker clamp of claim 56, wherein said preload finger is further defined as a first preload finger and a second preload finger, and wherein said first preload finger is coupled to said lower cradle and said second preload finger is coupled to one of said first resilient arm and said second resilient arm.

58. The tracker clamp of any one of claims 54-57, wherein said alignment surface is further defined as a first alignment surface and a second alignment surface, and wherein the first alignment surface and the second alignment surface are not parallel to said insertion face.

59. The tracker clamp of claim 58, wherein said first alignment surface and said second alignment surface are parallel.

60. The tracker clamp of claim 45, wherein said tracker frame further comprises a proximal surface at said proximal end, and wherein said mounting portion further comprises an outlet face, said outlet face recessed distally from said proximal surface.

61. The tracker clamp of any one of claims 45-60, further comprising a plurality of tracking markers coupled to said tracker frame, wherein at least one of said plurality of tracking markers is positioned distally of said mounting portion and at least one of said plurality of tracking markers is positioned proximally of said mounting portion.

62. The tracker clamp of any one of claims 45-61, wherein said tracker frame has a unitary construction and comprises a polymer material.

63. The tracker clamp of any one of claims 45-62, further comprising a tracker array having at least three tracking markers coupled to said tracker frame, wherein said at least three tracking markers define a marker plane spaced from said insertion axis, and wherein said lever is parallel to said marker plane in said clamped position.

64. The tracker clamp of claim 63, wherein said lever is positioned between said marker plane and said insertion axis in said clamped position.

65. The tracker clamp of claim 63 or 64, wherein said at least three markers define a tracked face having a face boundary, and wherein said lever is within said face boundary.

66. The tracker clamp of any one of claims 45-65, further comprising a tracker array having a tracker profile defined perpendicular to said insertion axis, said tracker profile having a first radial segment, a second radial segment, and a third radial segment, wherein said tracker array

comprises at least three tracking markers coupled to said tracker frame, wherein at least one of said at least three tracking markers is positioned in each of said first radial segment, said third radial segment and said third radial segment.

67. The tracker clamp of claim 66, wherein said tracker profile has a first area when said lever is in said clamped position and a second area when said lever is in said unclamped position, and wherein said first area is less than said second area.

68. A tracker for a surgical instrument, the tracker comprising:

a tracker frame comprising a clamp to receive the surgical instrument on an insertion axis;

a lever pivotably coupled to said clamp and movable between a clamped position and an unclamped position for securing the surgical instrument; and

a tracker array coupled to said tracker frame and comprising at least three tracked faces arranged in a non-planar relationship, each tracked face comprising at least three tracking markers, wherein said at least three tracked faces define a tracker perimeter about said insertion axis.

69. The tracker of claim 68, wherein said lever is within said tracker perimeter in said clamped position.

70. The tracker of claim 69, wherein said lever is partially outside said tracker perimeter in said unclamped position.

71. The tracker of any one of claims 68-70, wherein said lever is substantially parallel to one of said tracked faces in said clamped position.

72. A tracked surgical system comprising:

a handheld surgical instrument defining an instrument axis;

a tracker for tracking a position of said handheld surgical instrument, said tracker comprising:

tracker frame having an insertion axis;

a clamp configured to receive said handheld surgical instrument along said insertion axis;

at least three tracked faces arranged in a non-planar relationship about said insertion axis, said three tracked faces collectively defining a tracker perimeter; and

a lever pivotably coupled to said clamp and defining a clamped position to secure said handheld surgical instrument with said instrument axis aligned with said insertion axis, wherein said lever is within said tracker perimeter in said clamped position.

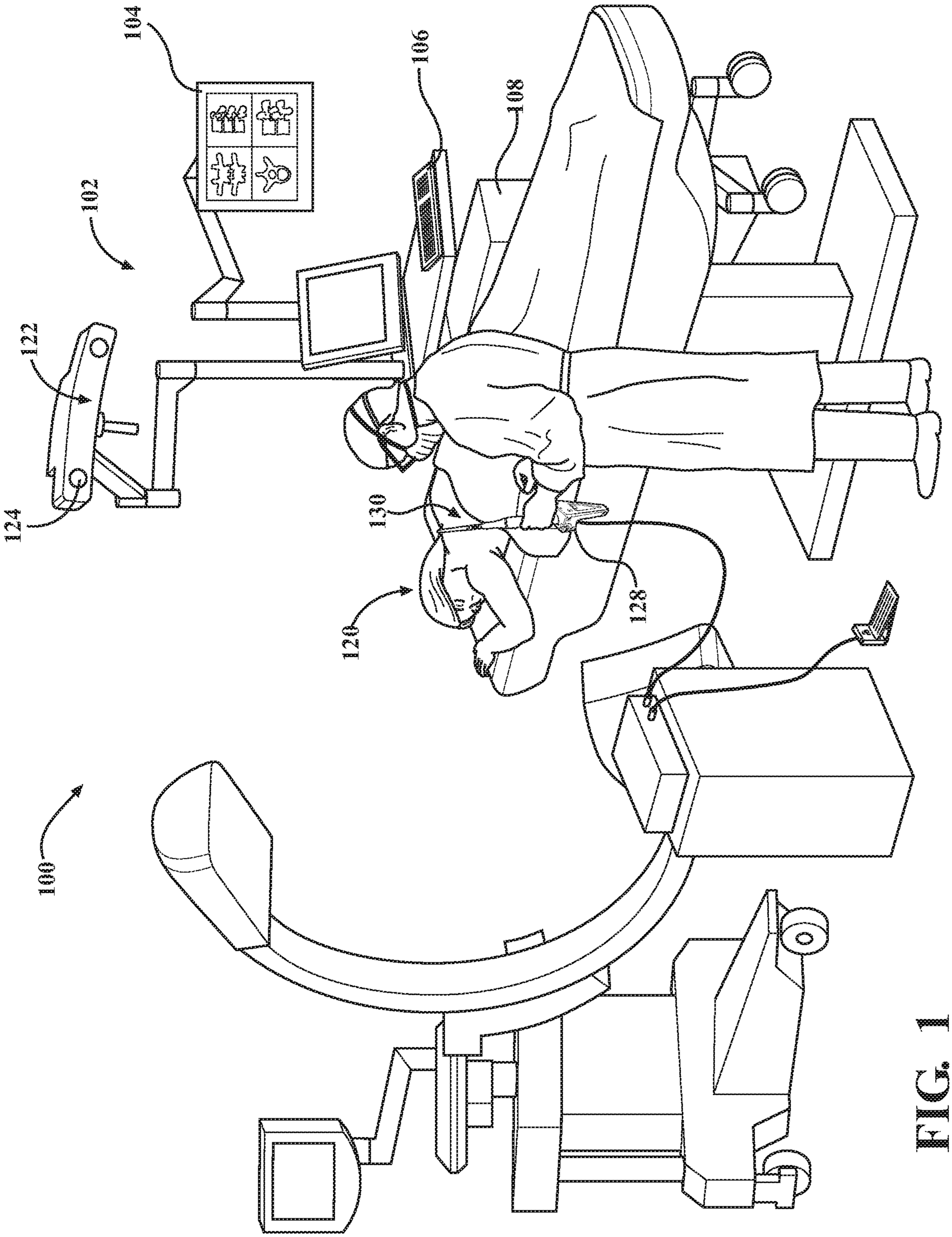


FIG. 1

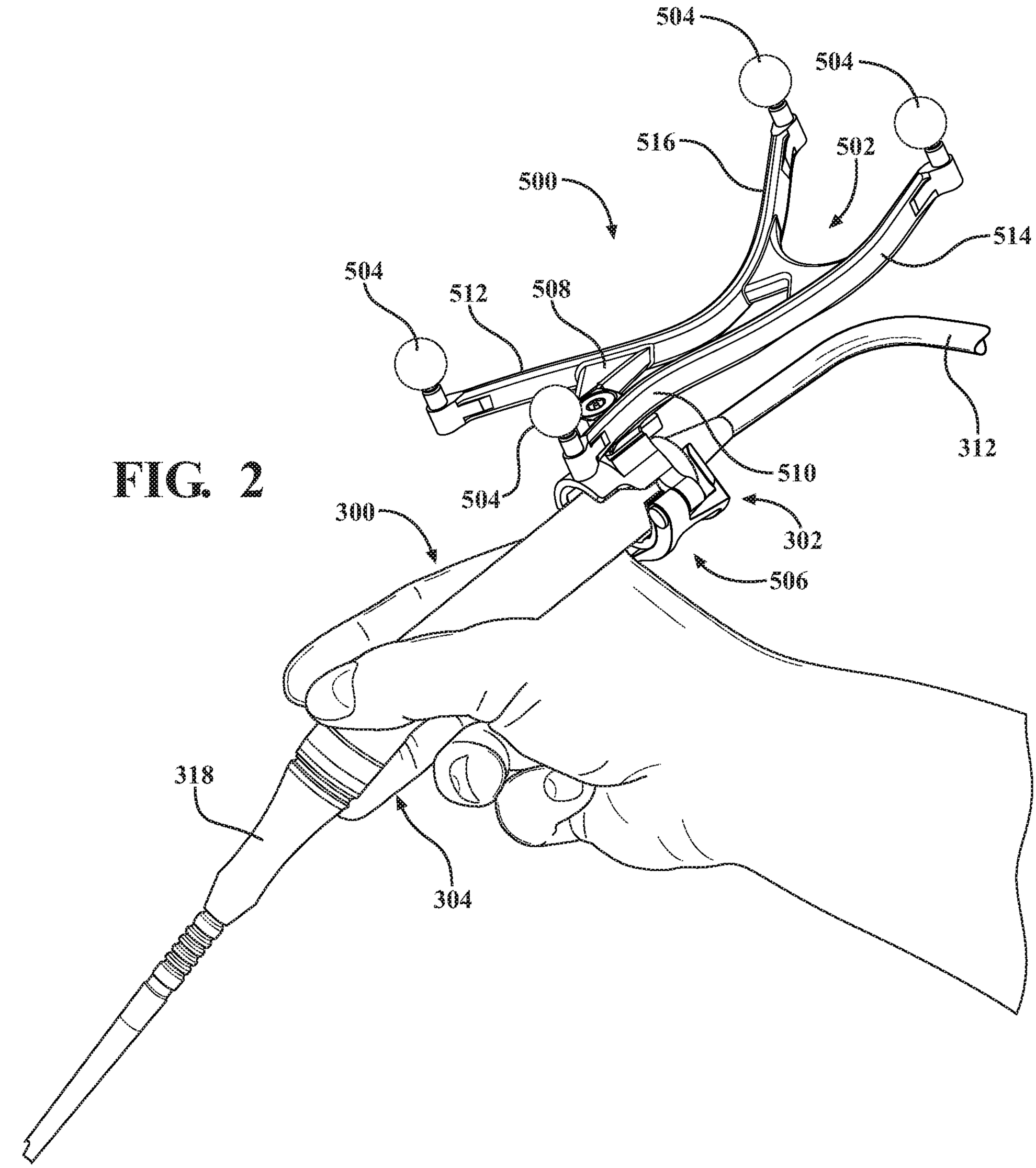

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FIG. 2

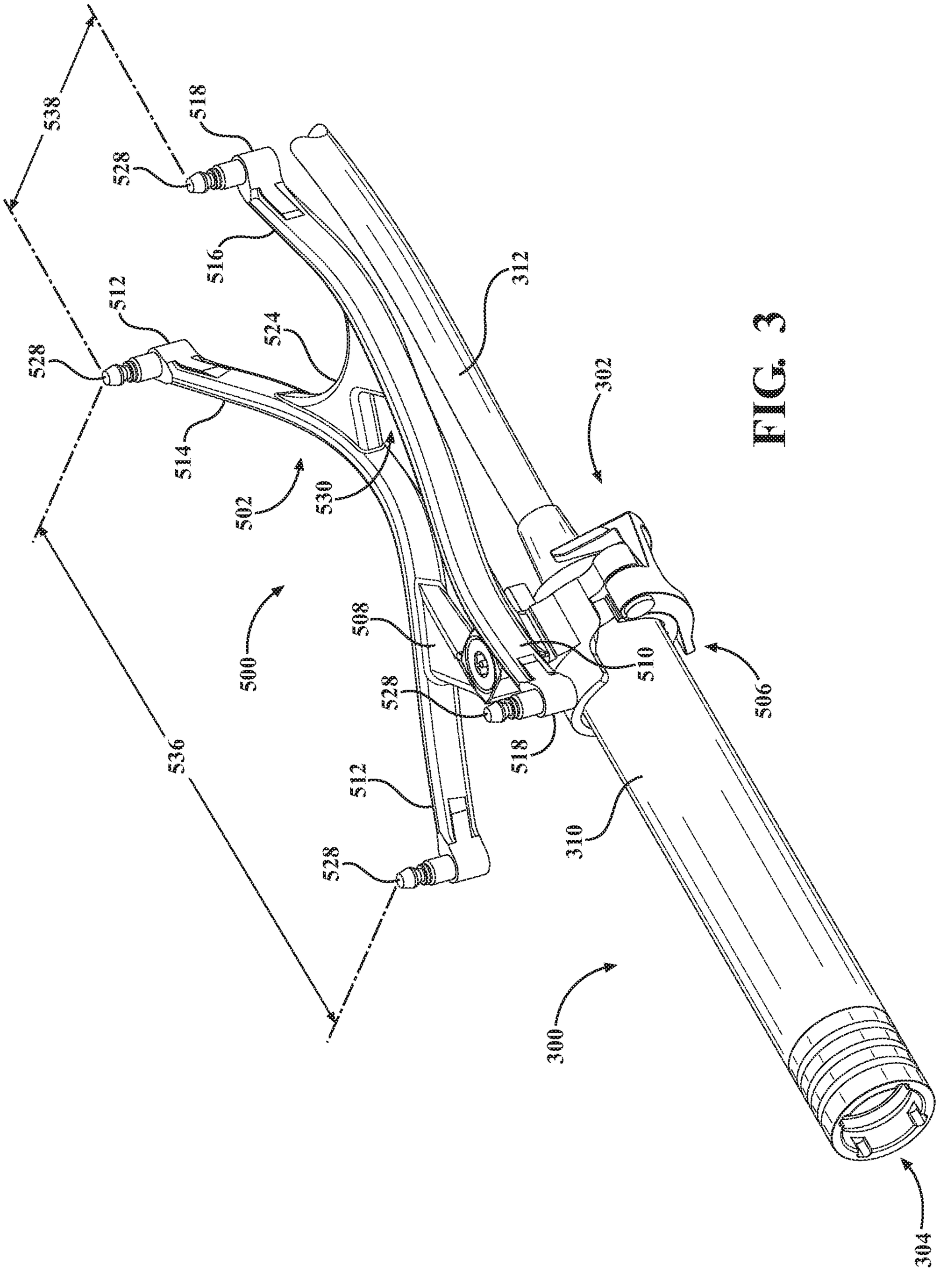

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FIG. 3

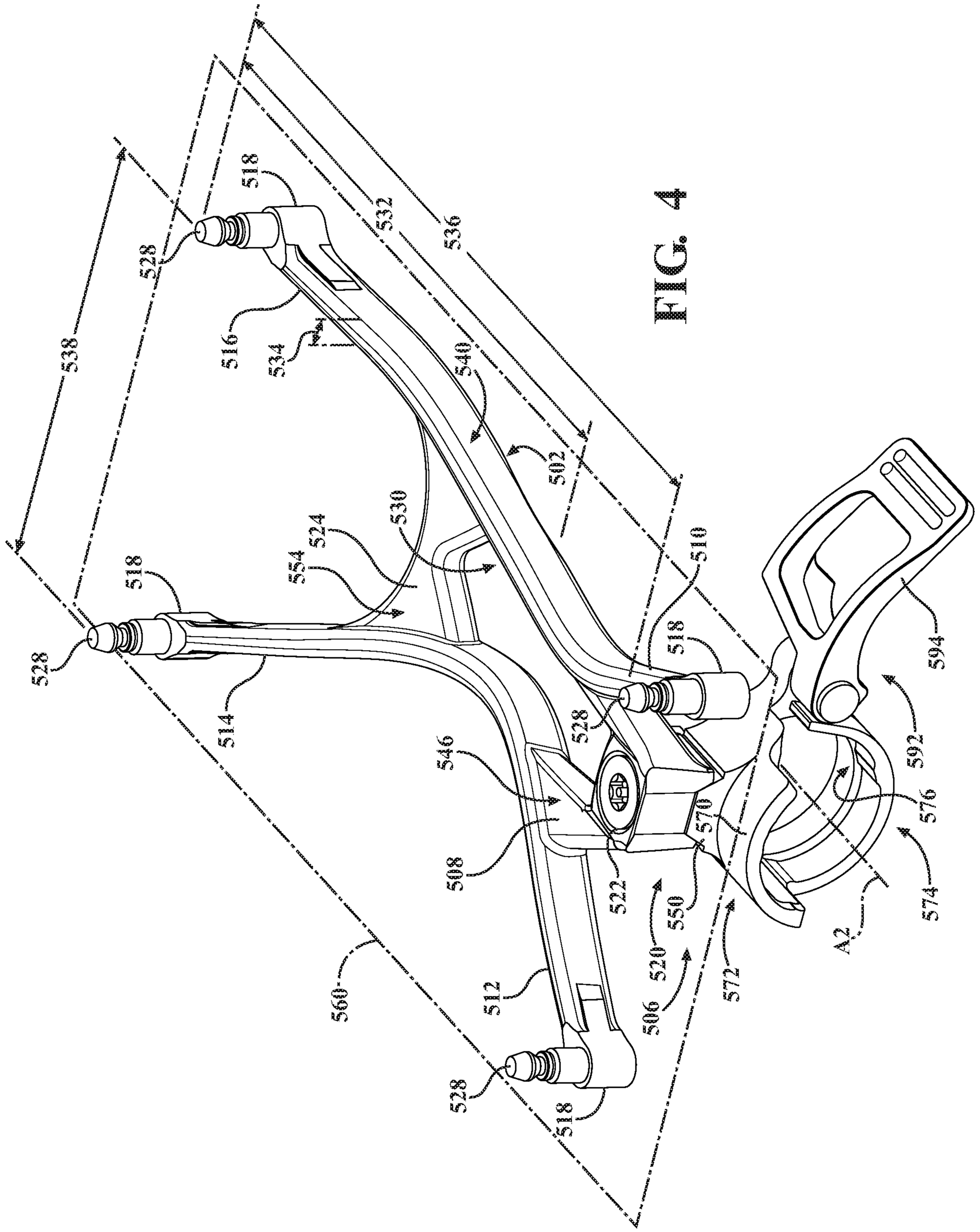

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FIG. 4

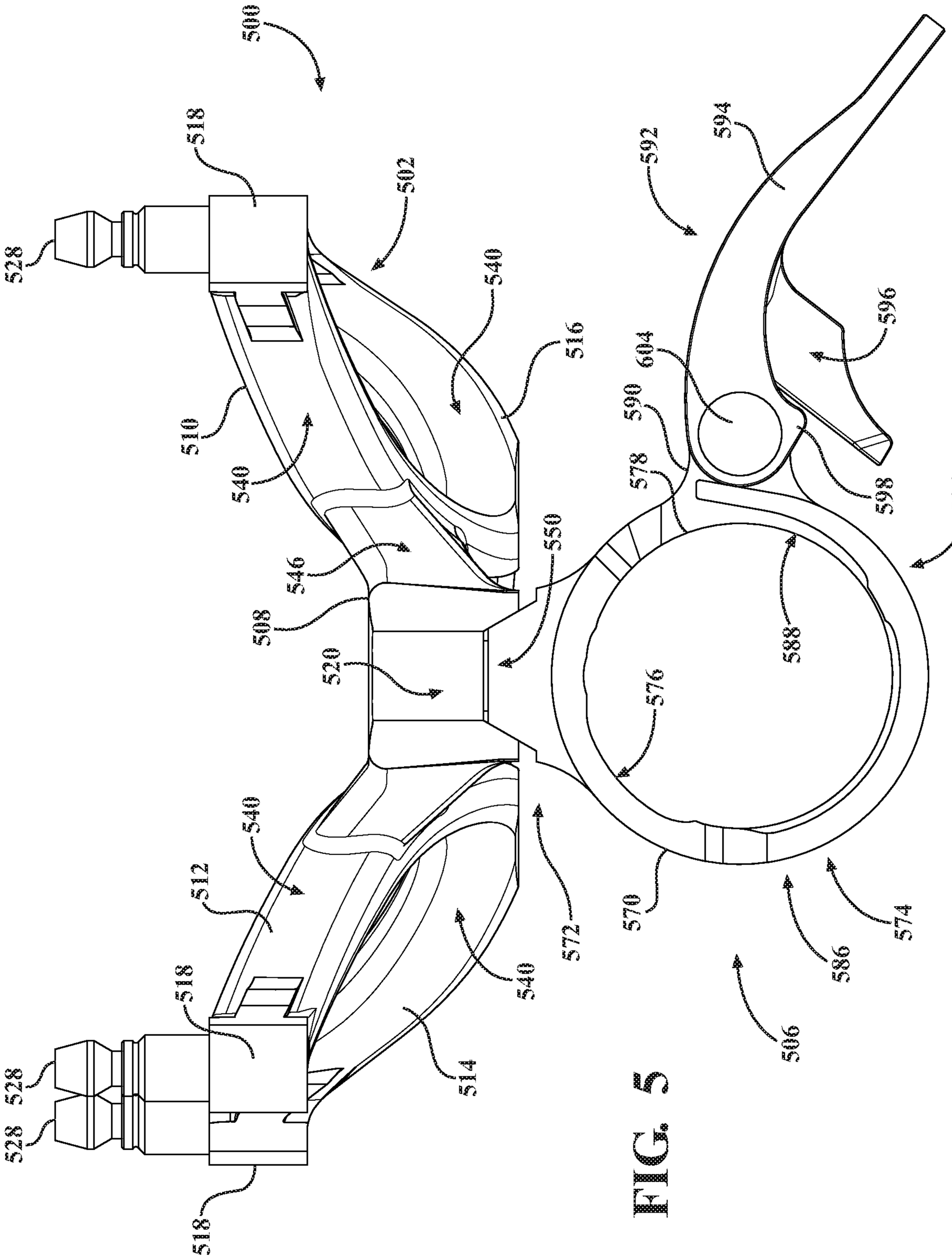

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FIG. 5

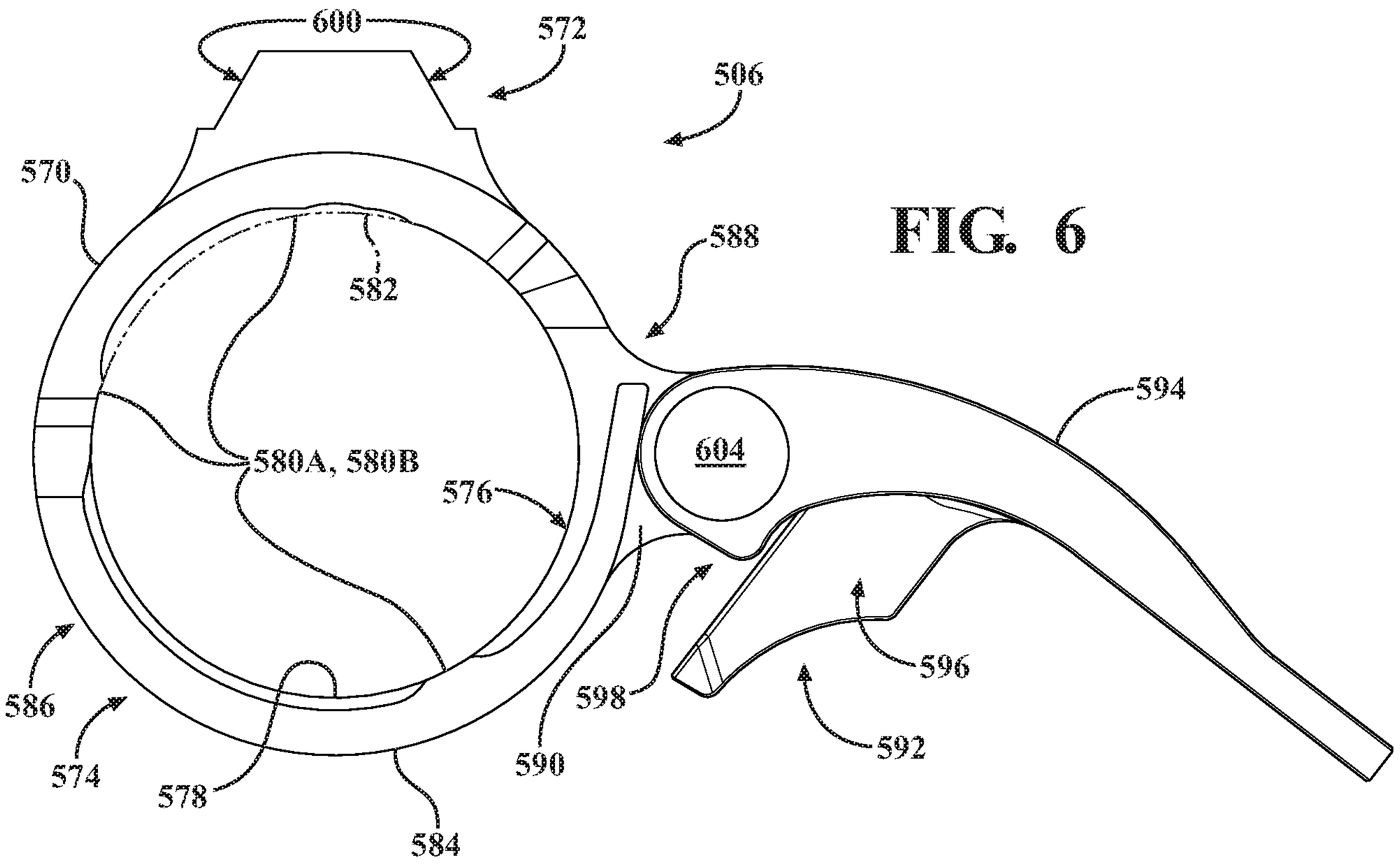
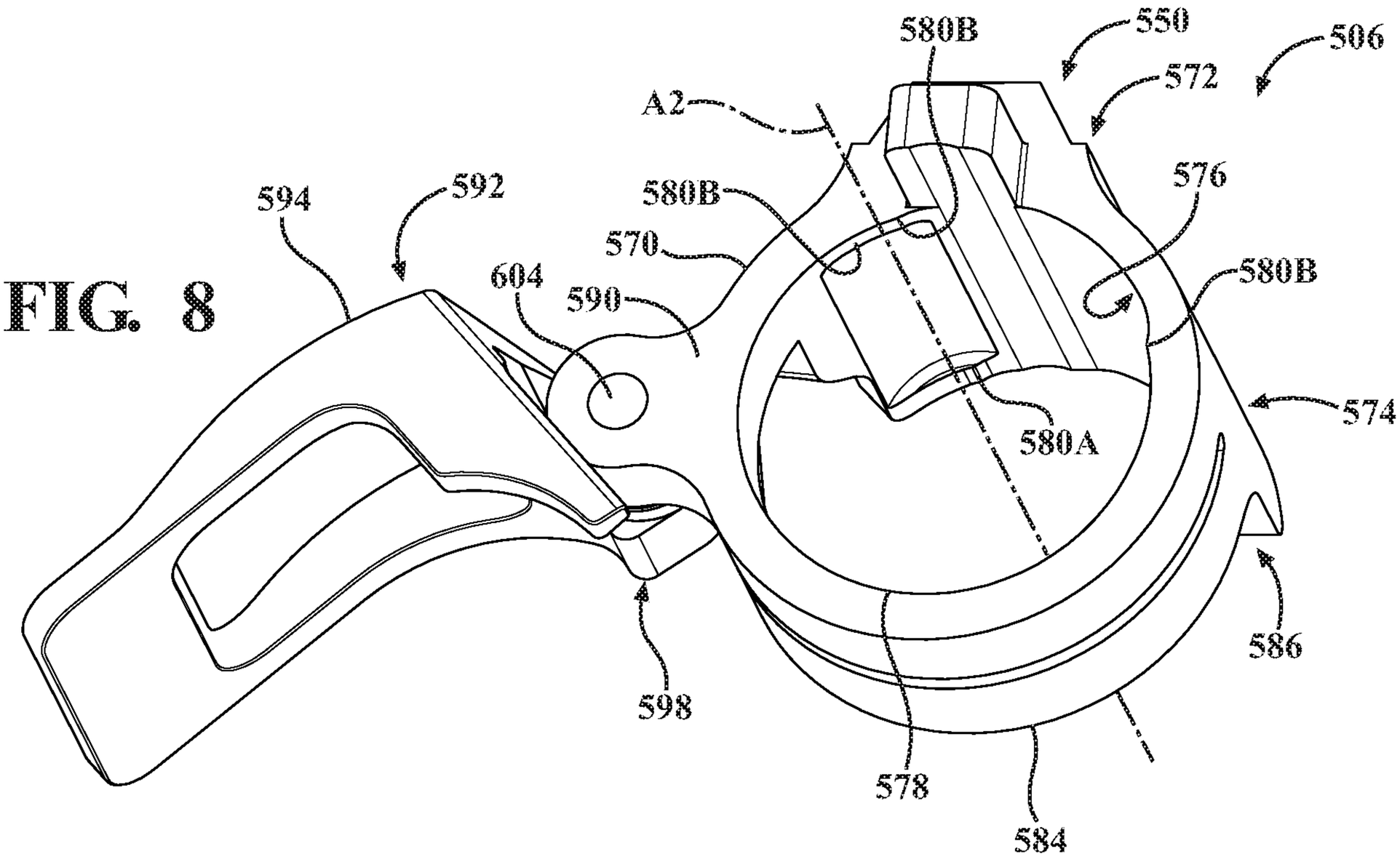

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FIG. 6

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FIG. 7

FIG. 8


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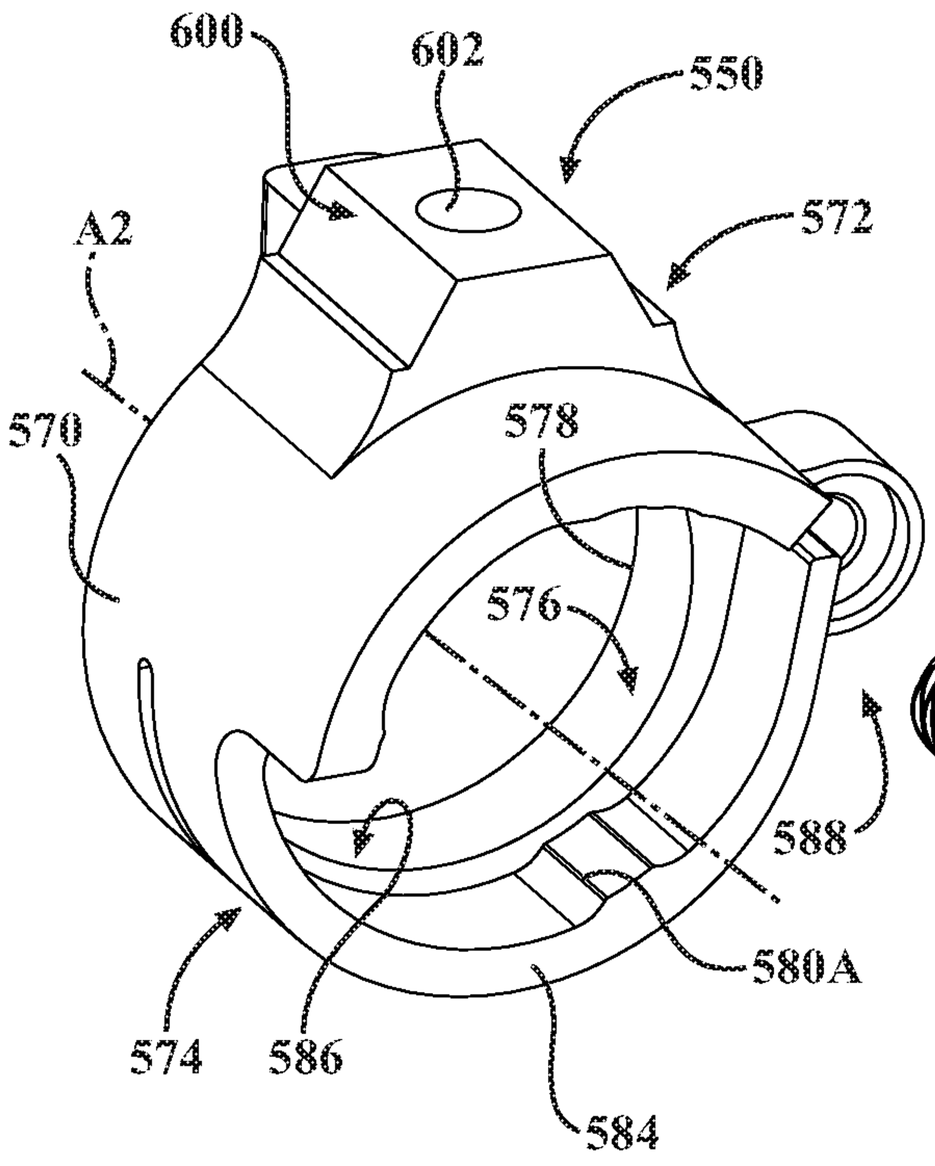
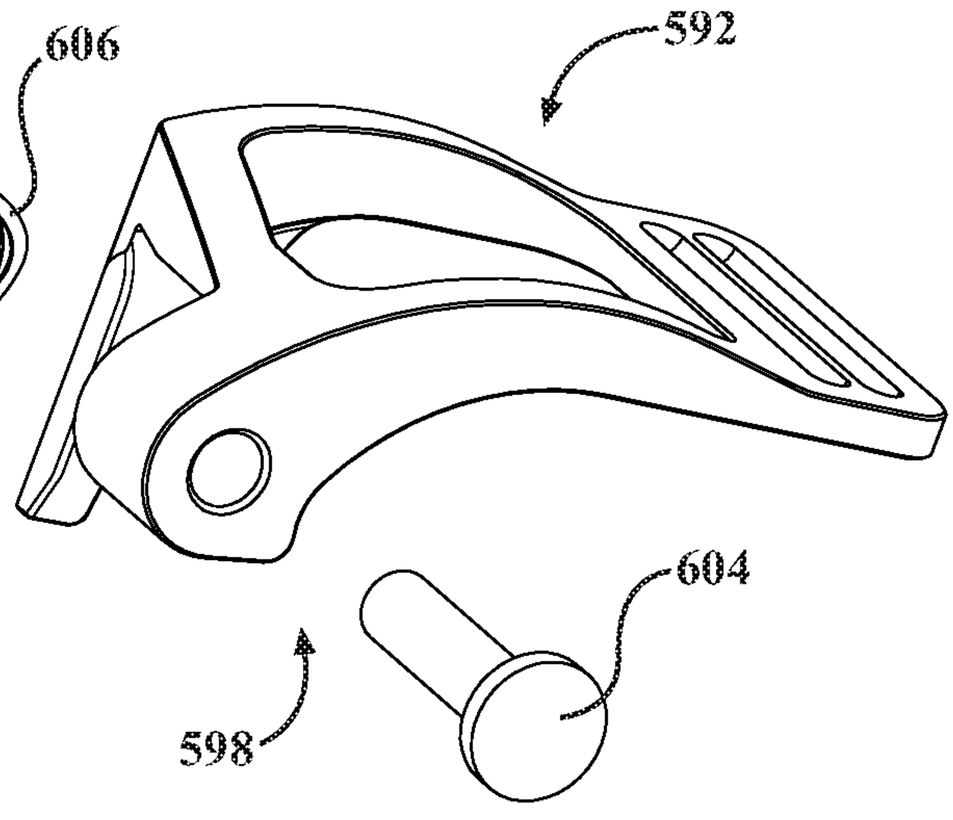

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FIG. 9


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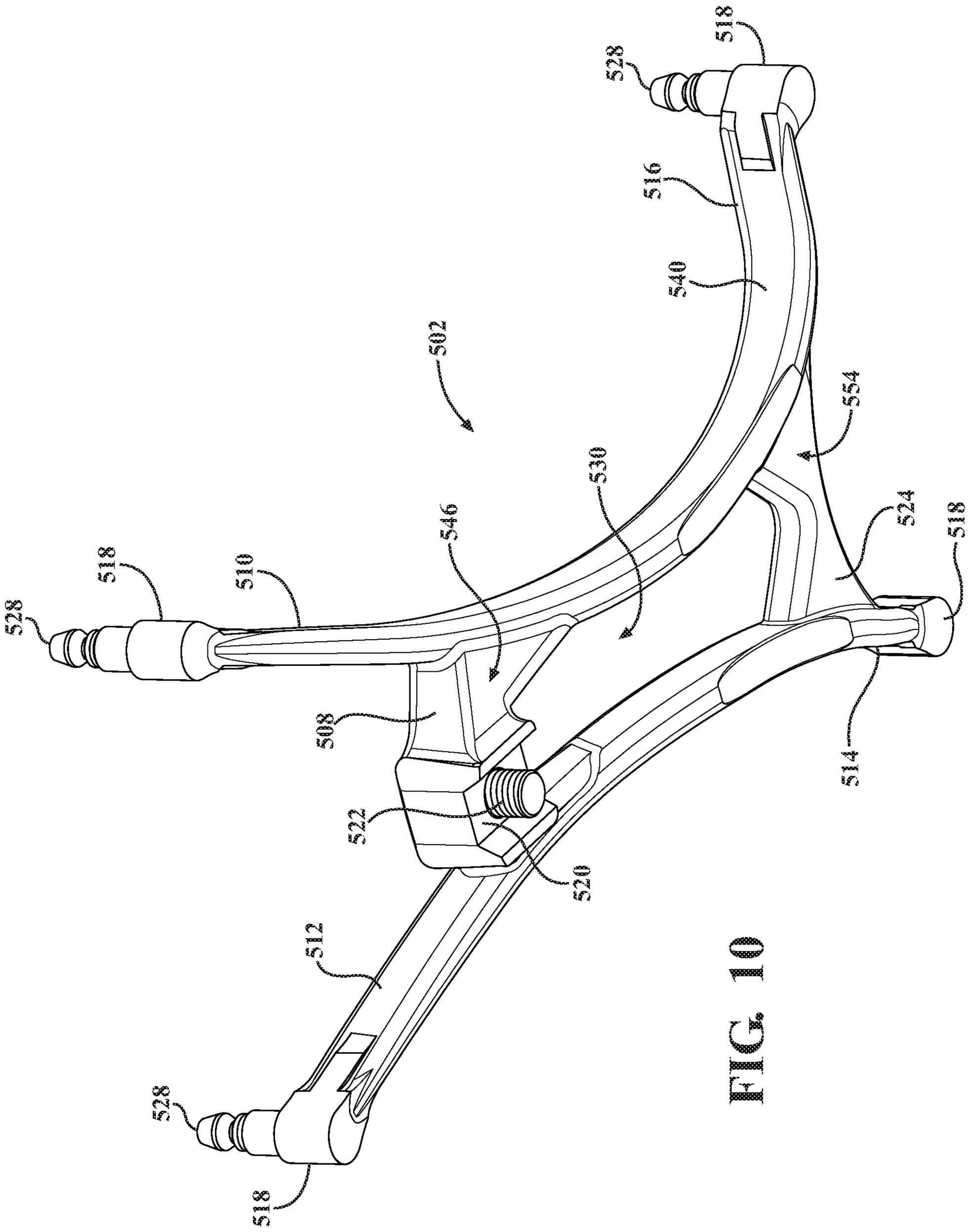

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FIG. 10

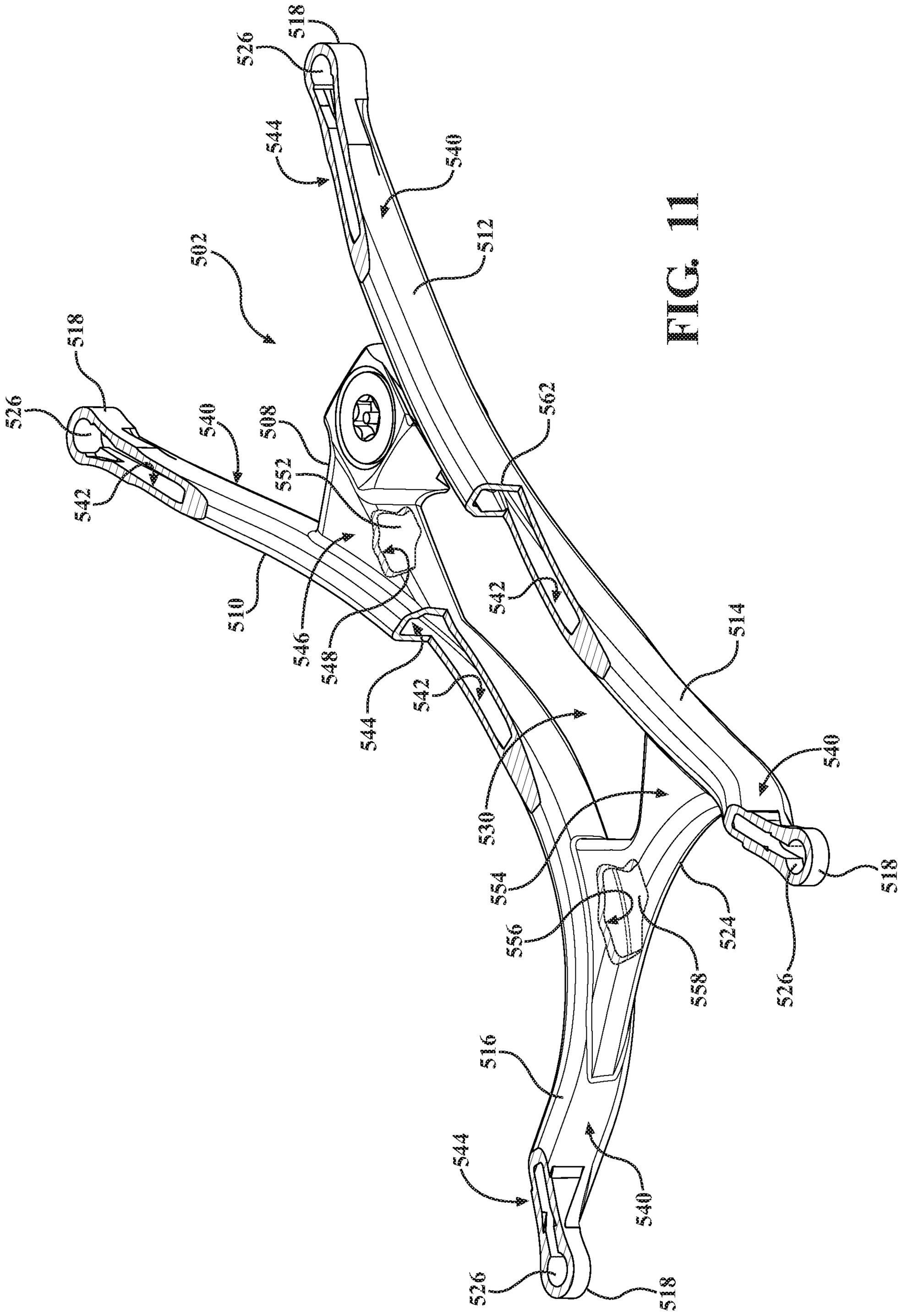

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FIG. 11

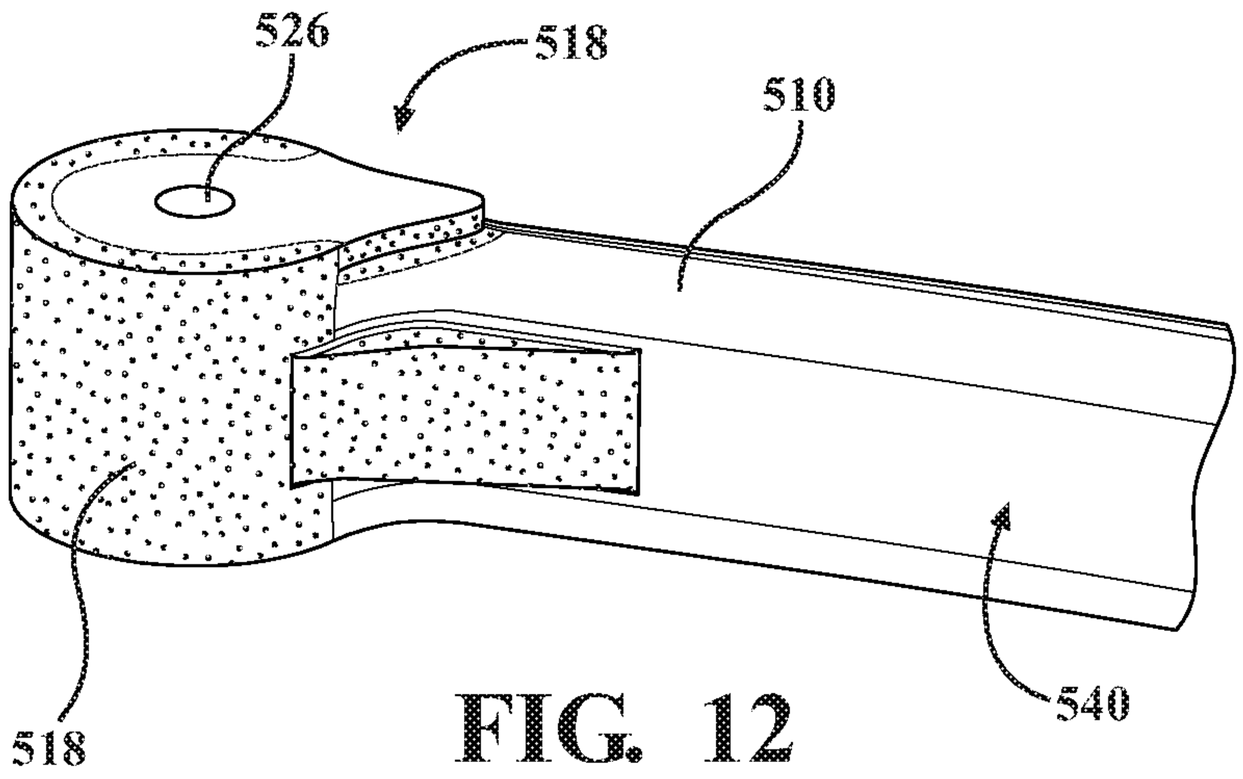
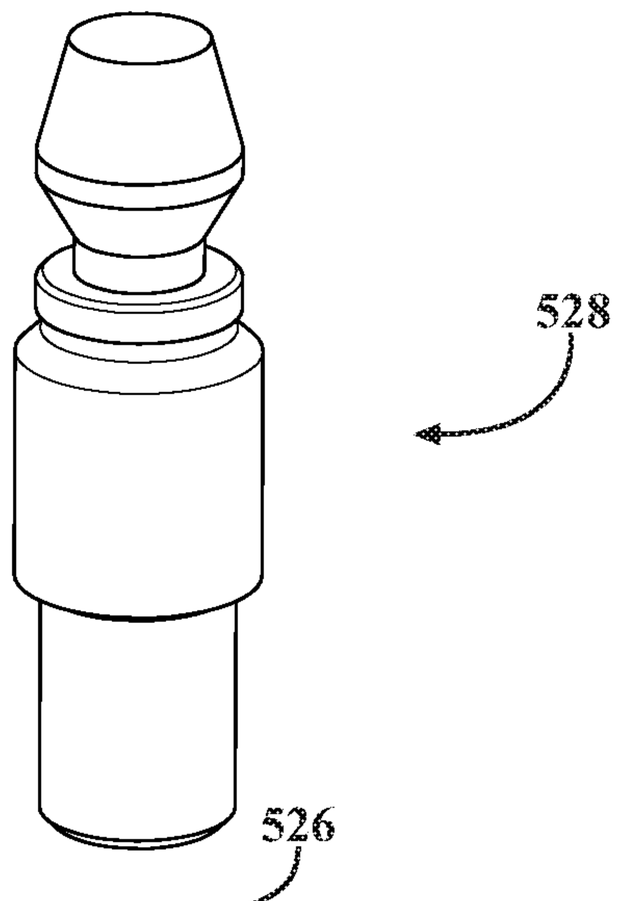


FIG. 12



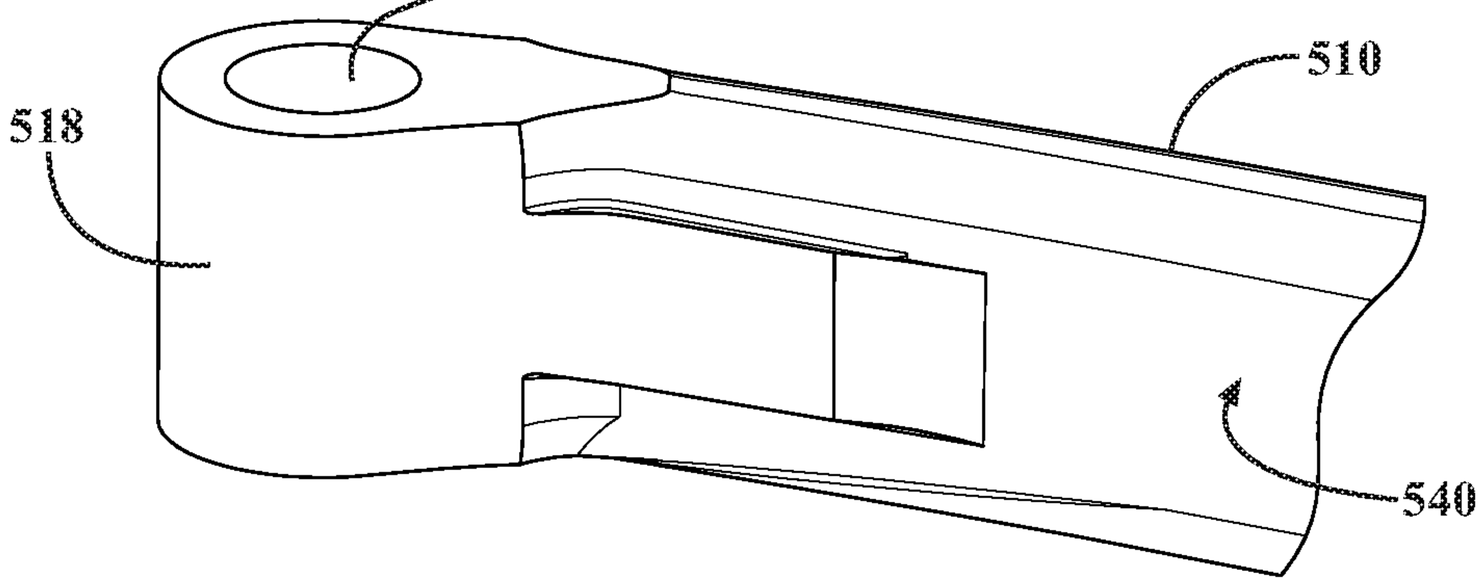


FIG. 13

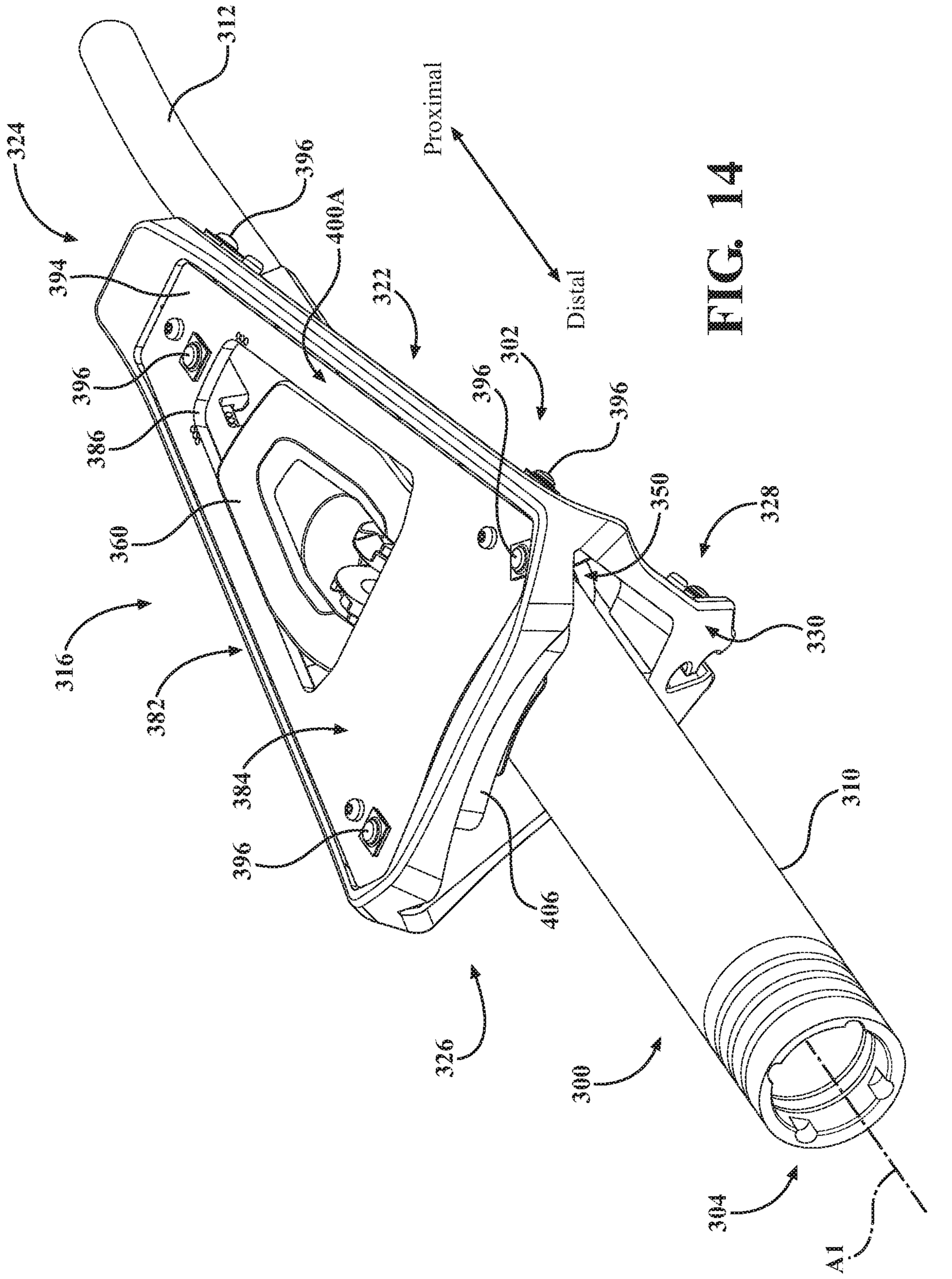

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FIG. 14

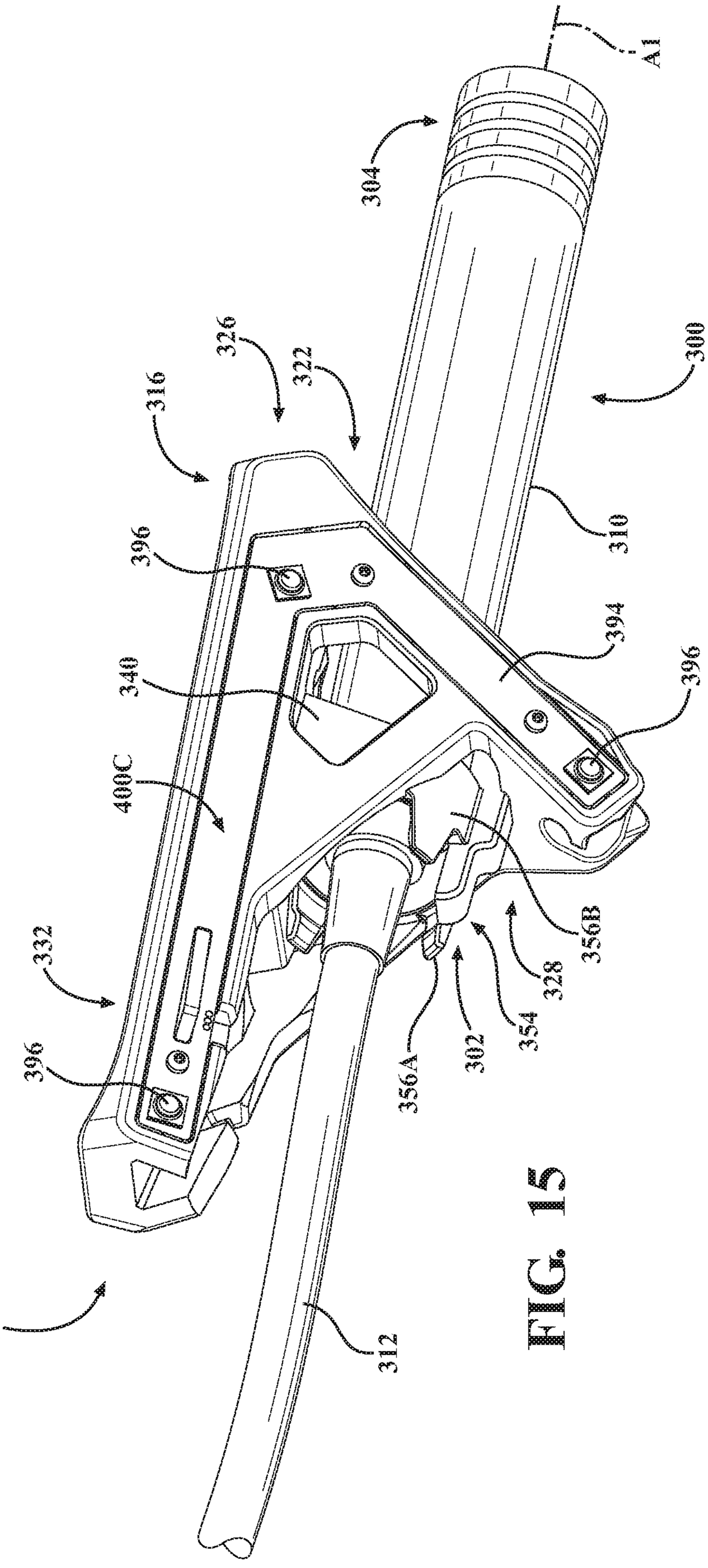

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FIG. 15

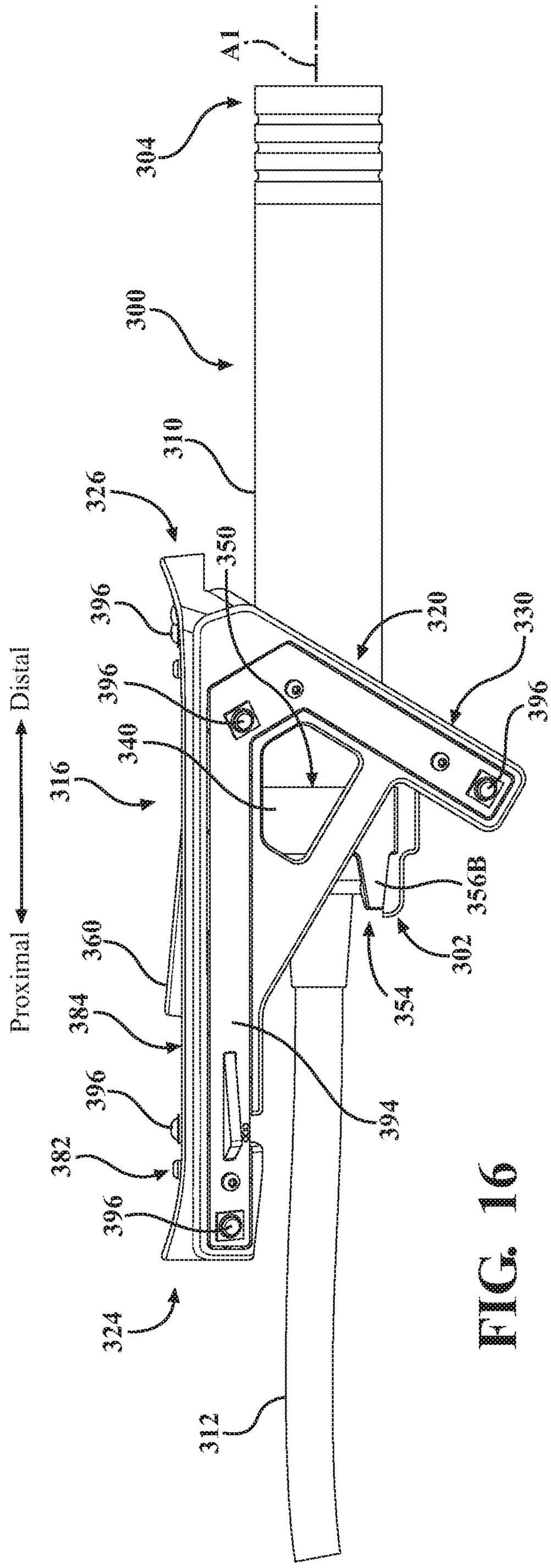

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FIG. 16

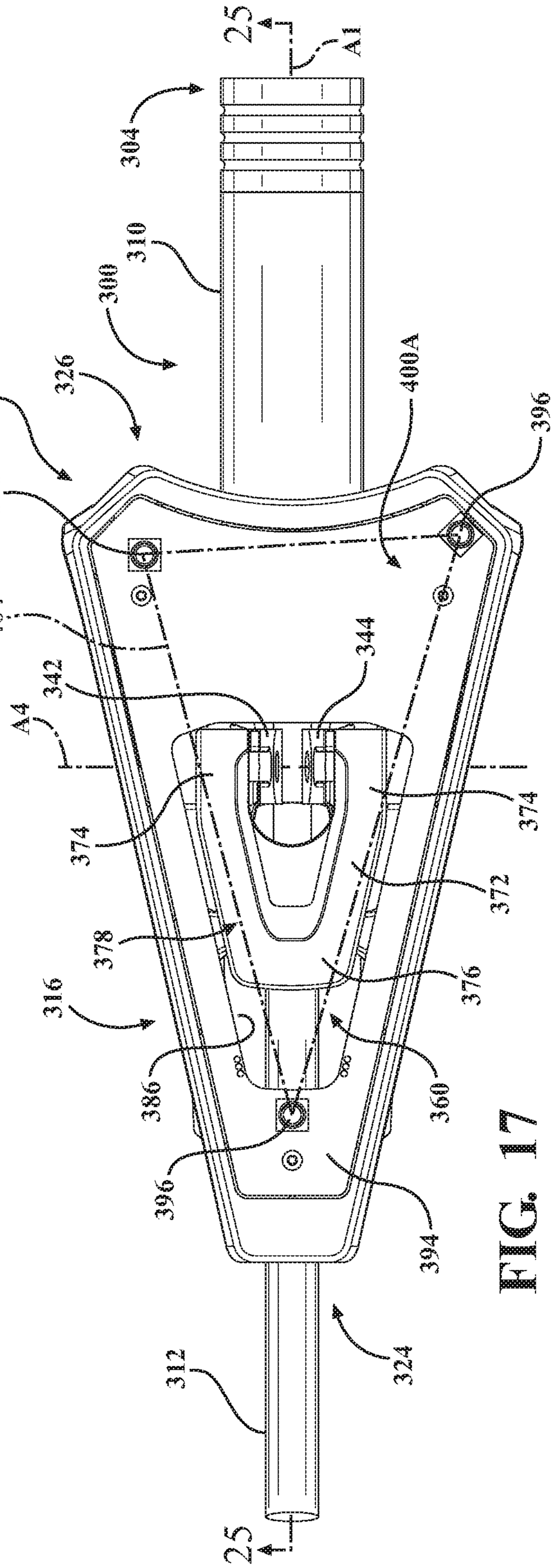

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FIG. 17

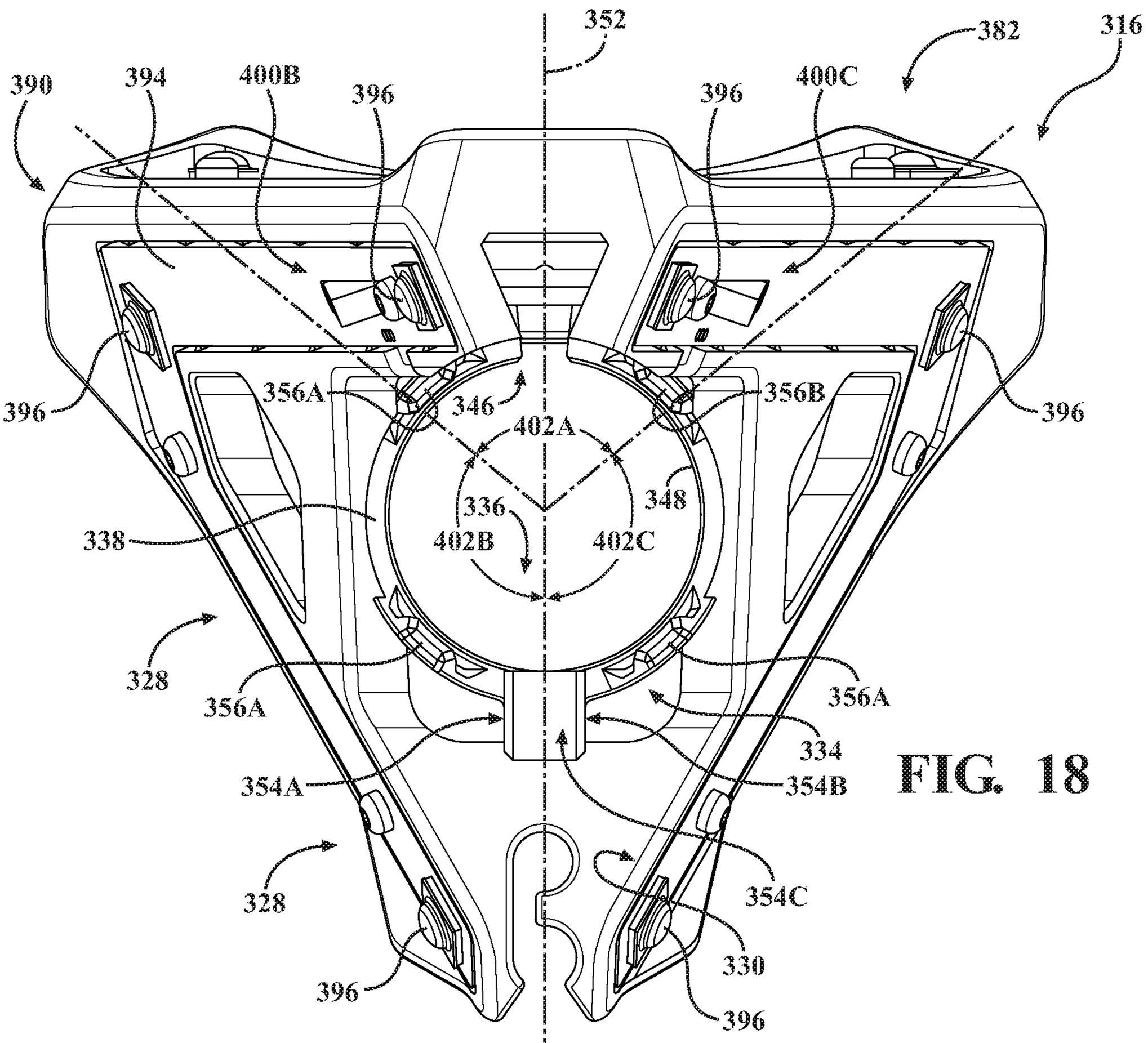

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FIG. 18

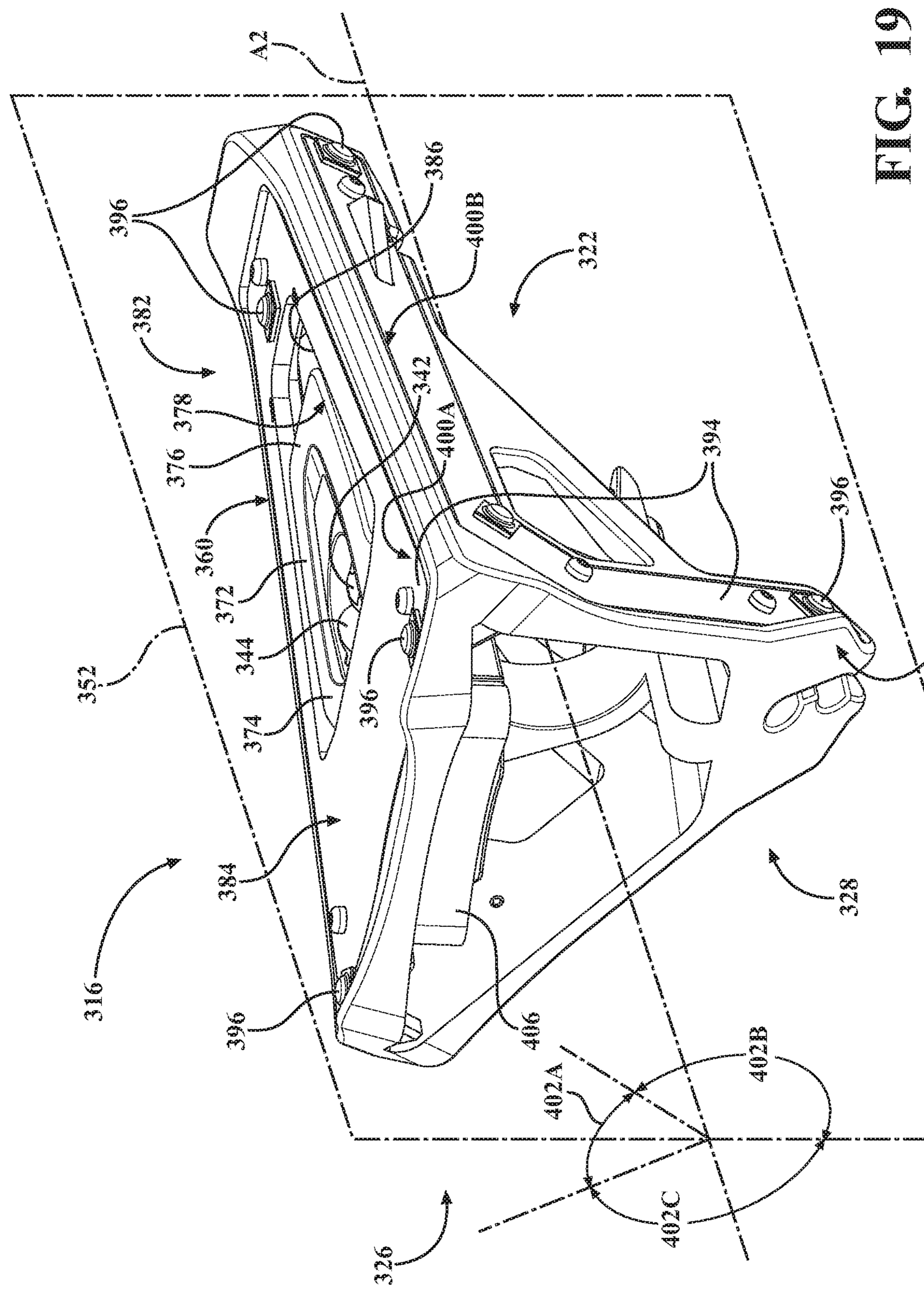

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FIG. 19

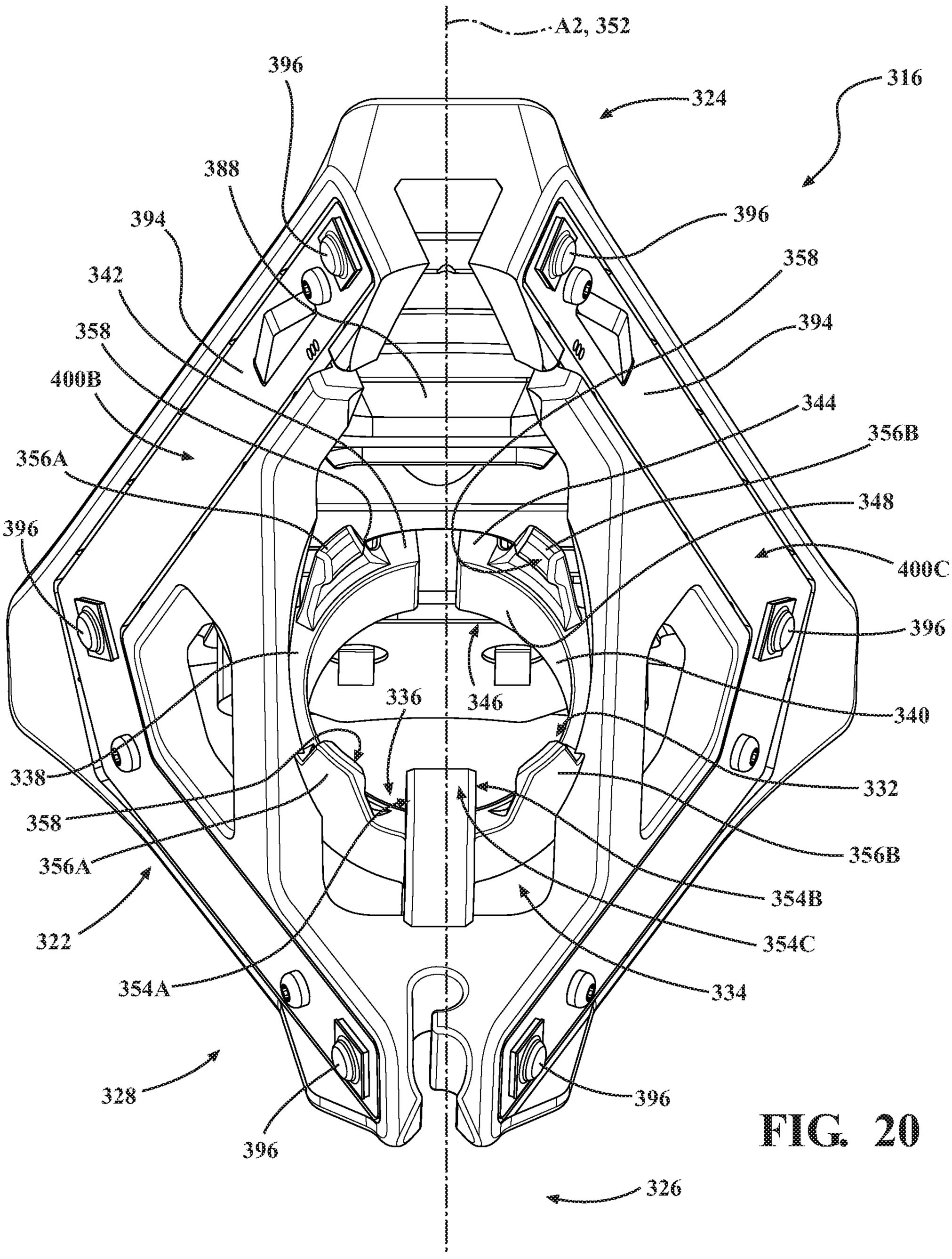

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FIG. 20

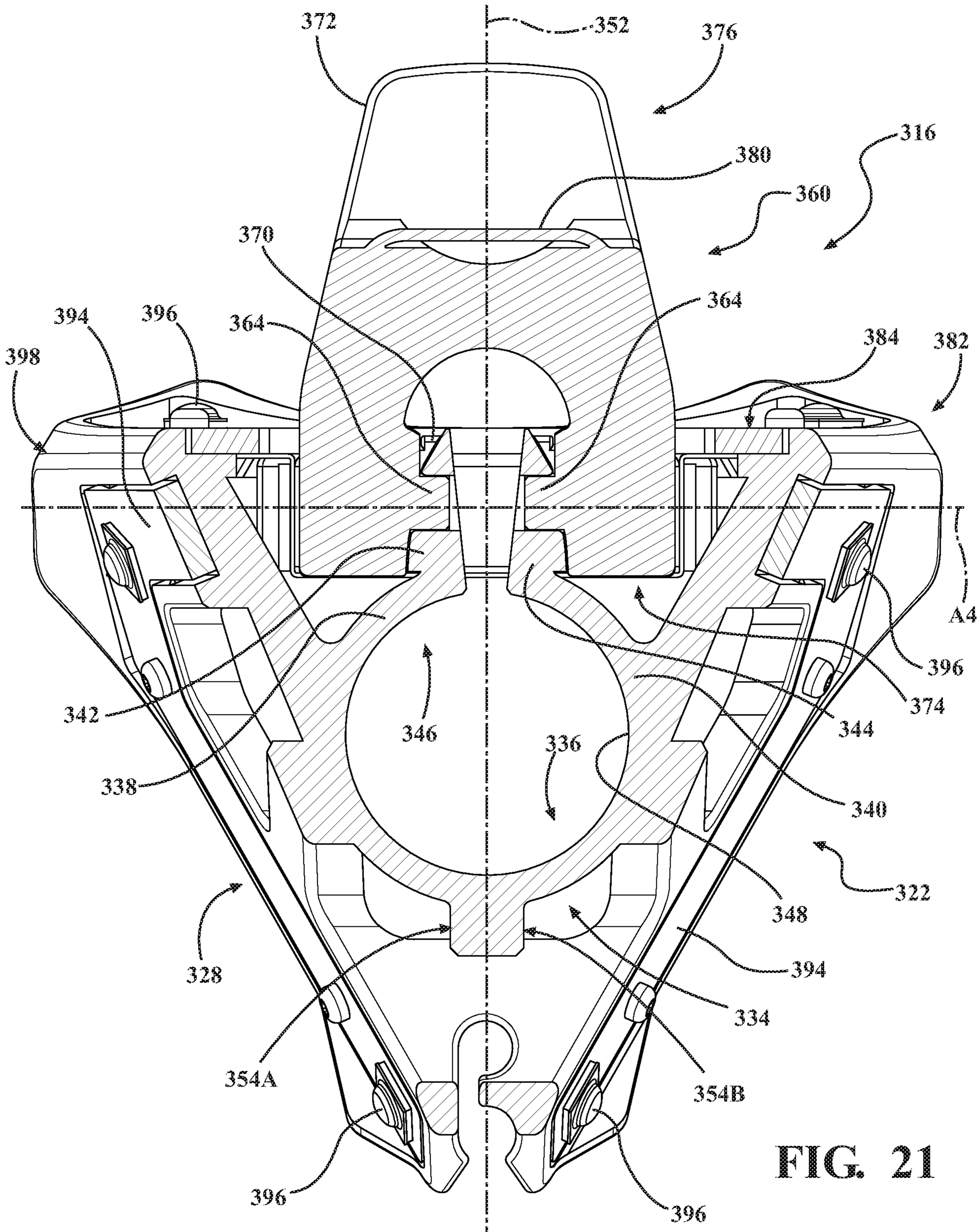

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FIG. 21

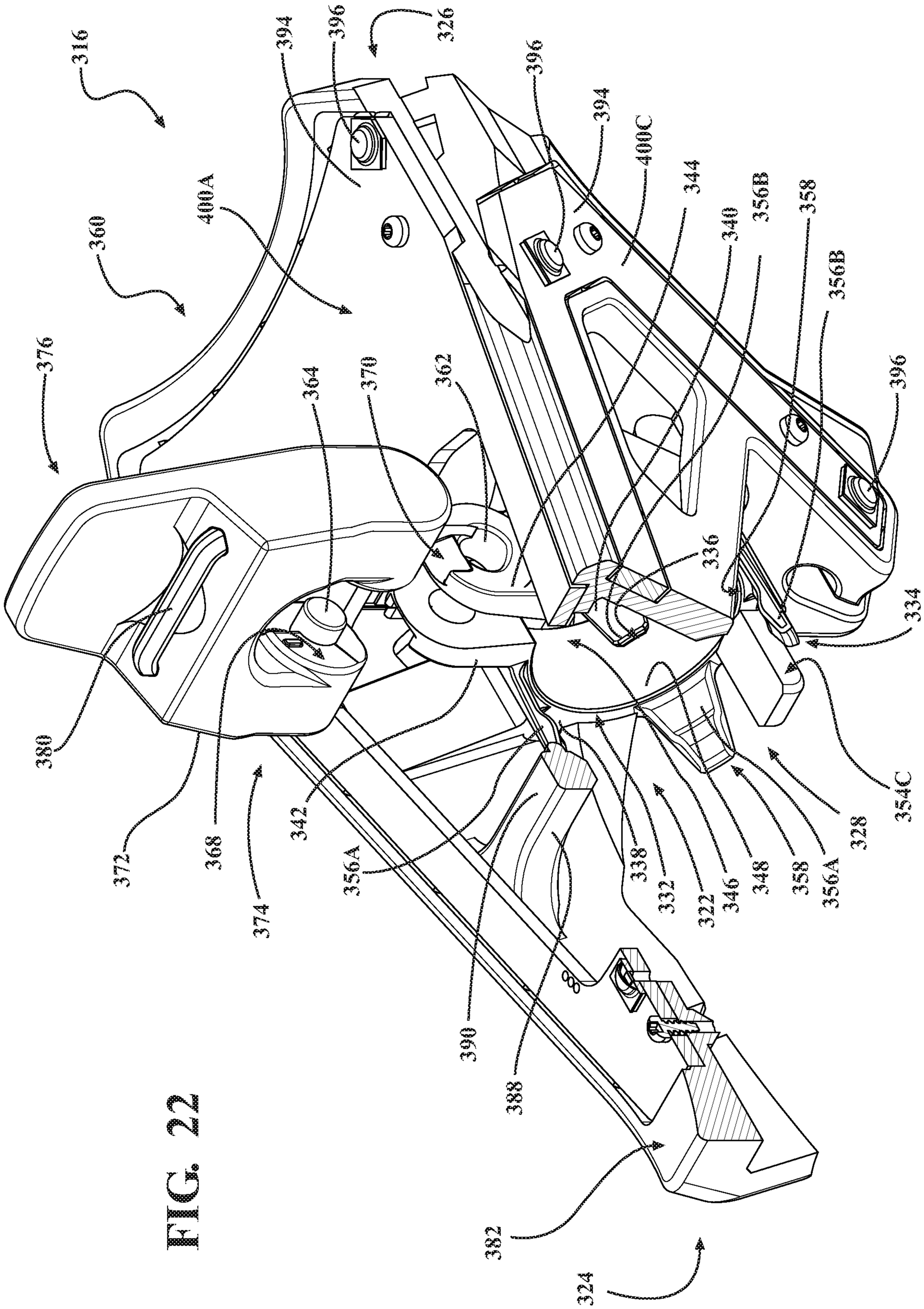

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FIG. 22

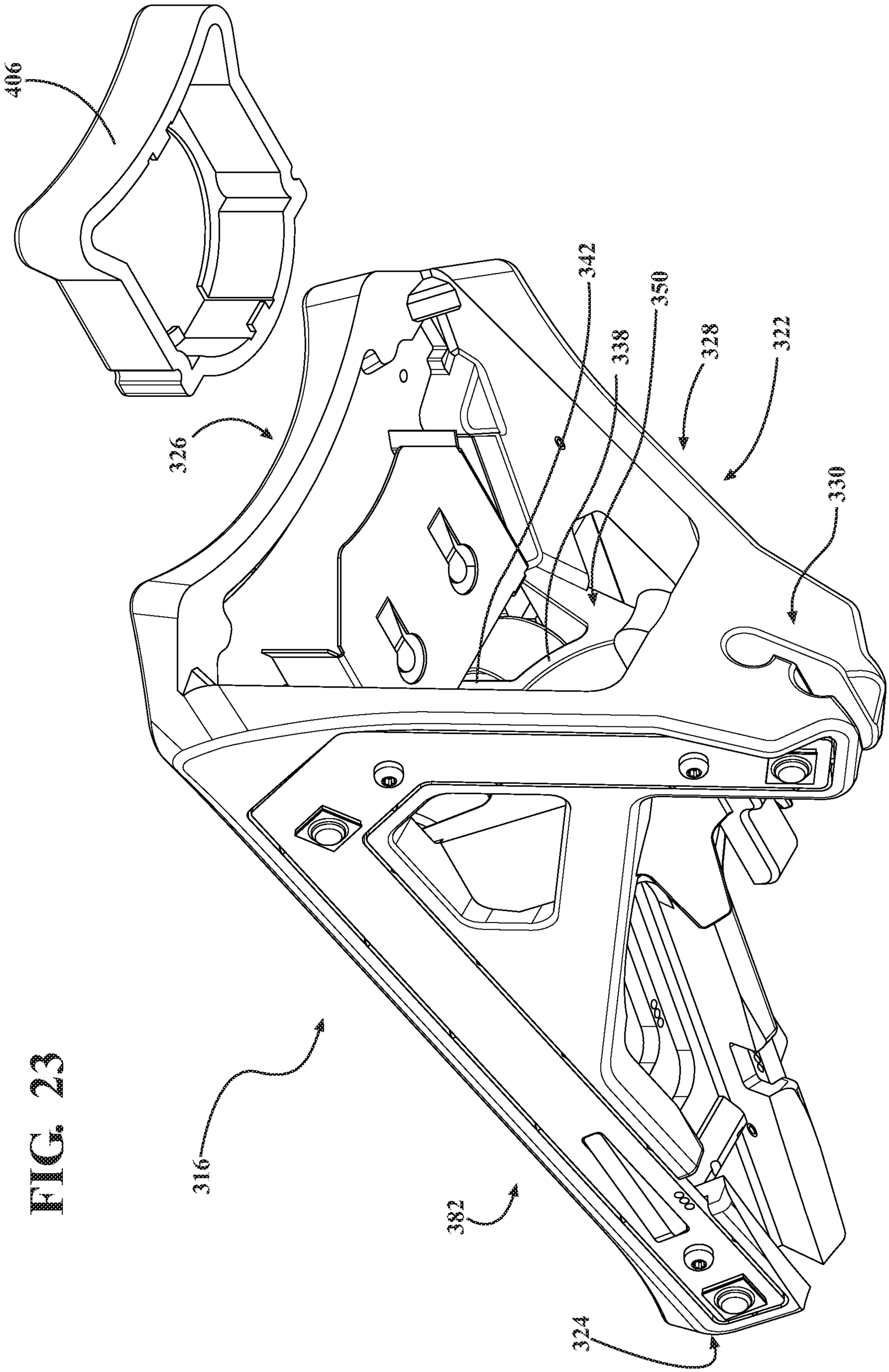


FIG. 23

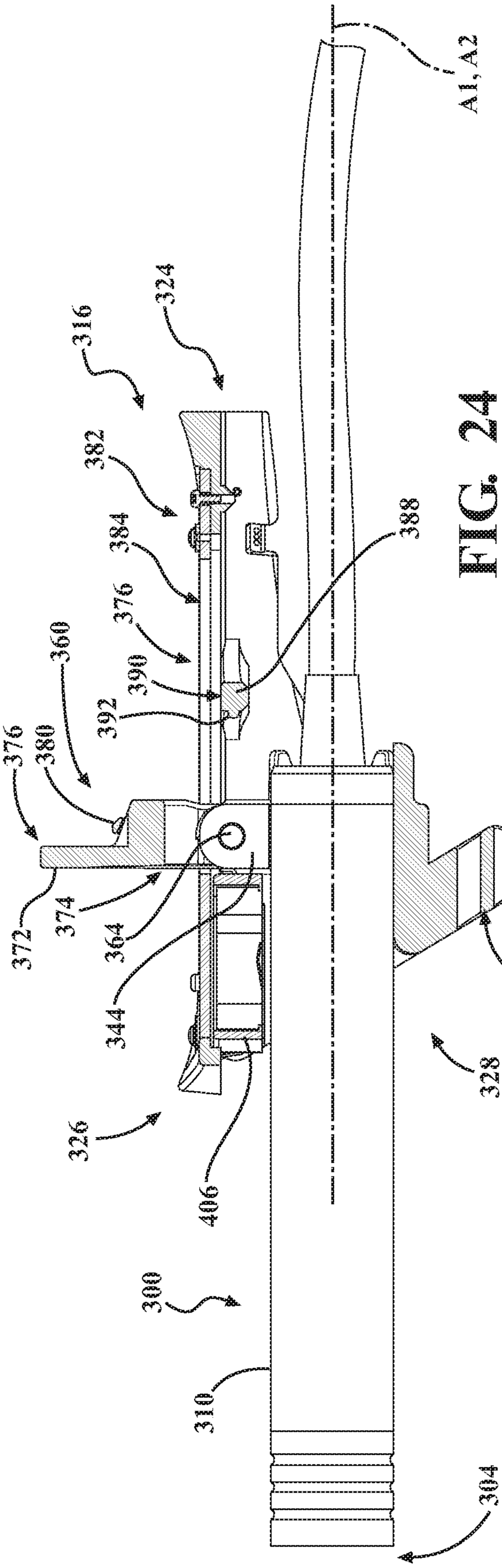

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FIG. 24

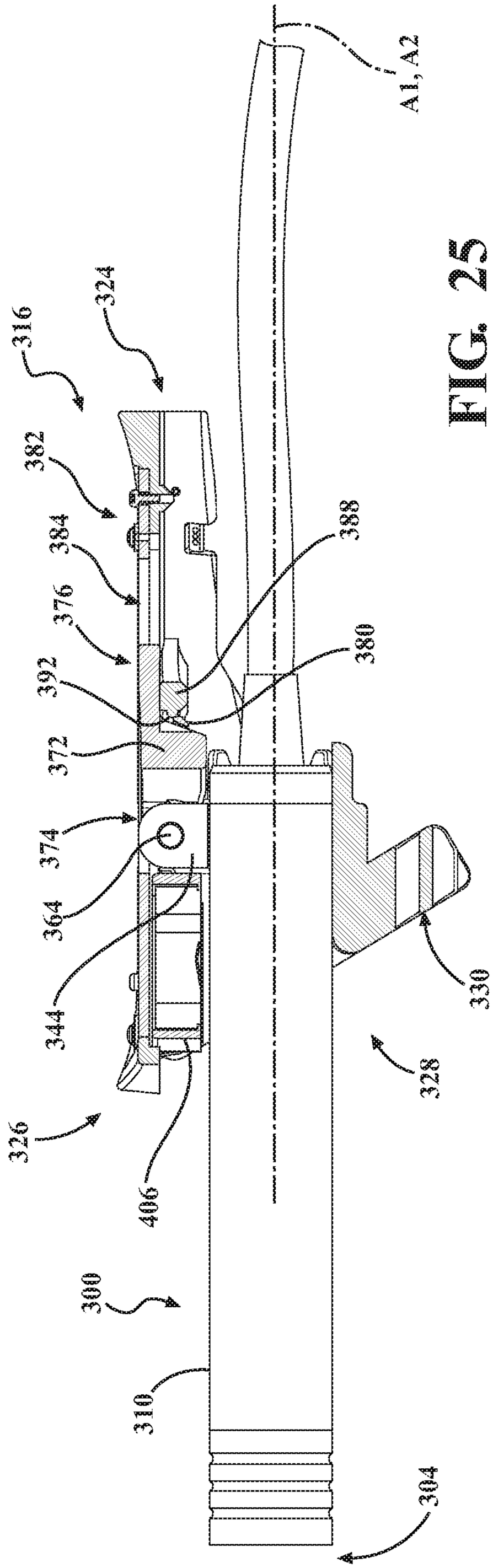

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FIG. 25

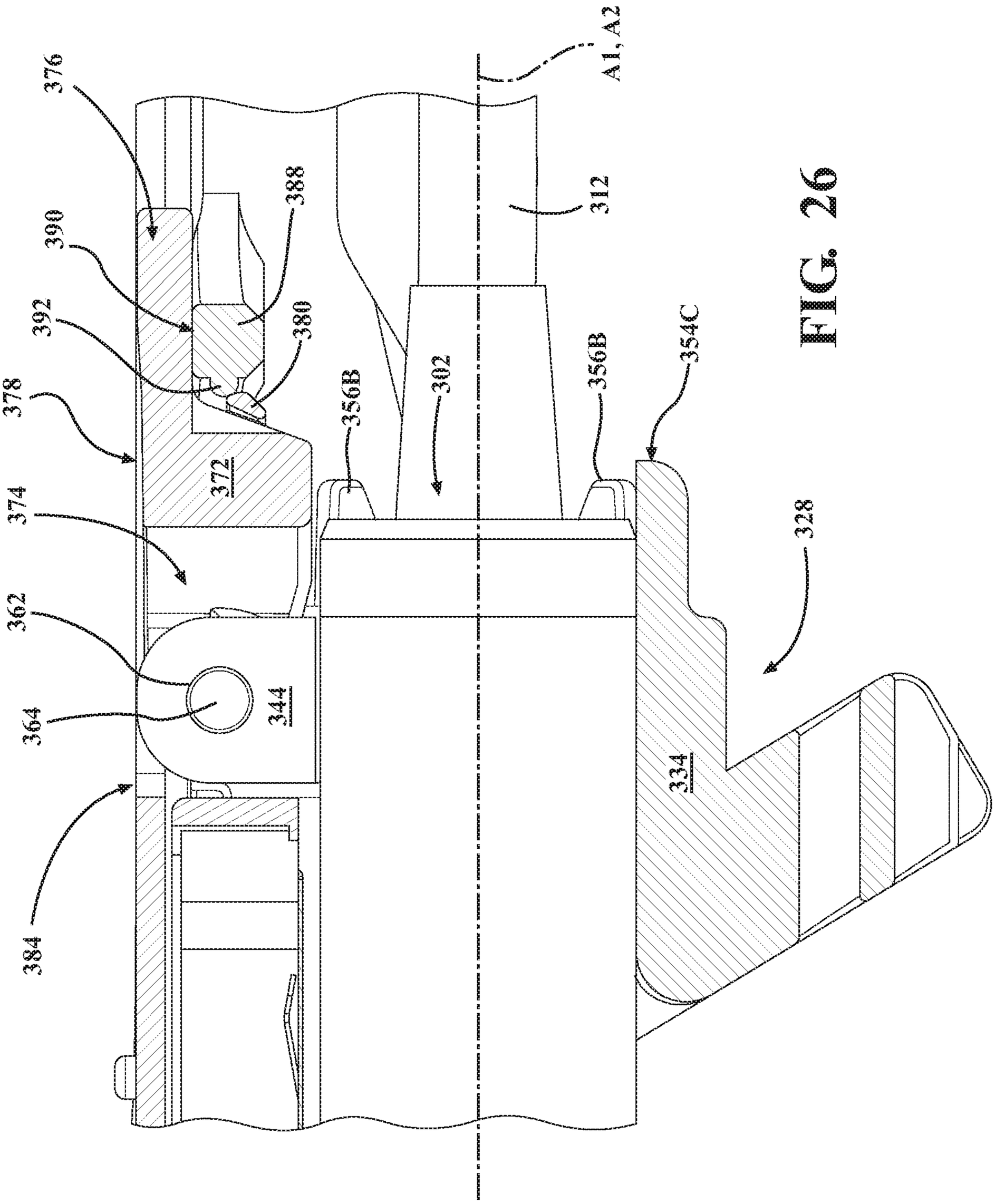

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FIG. 26

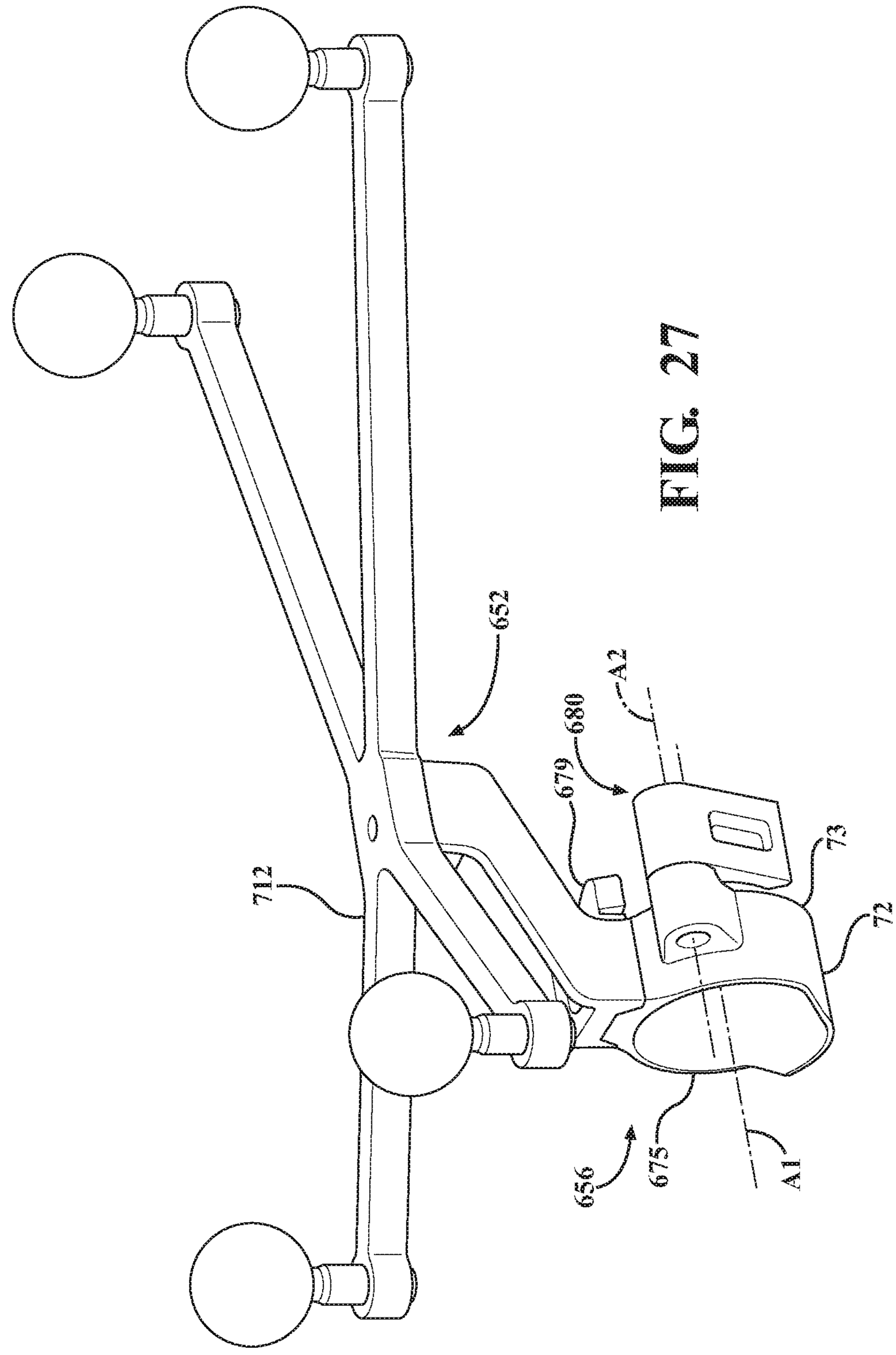


FIG. 27

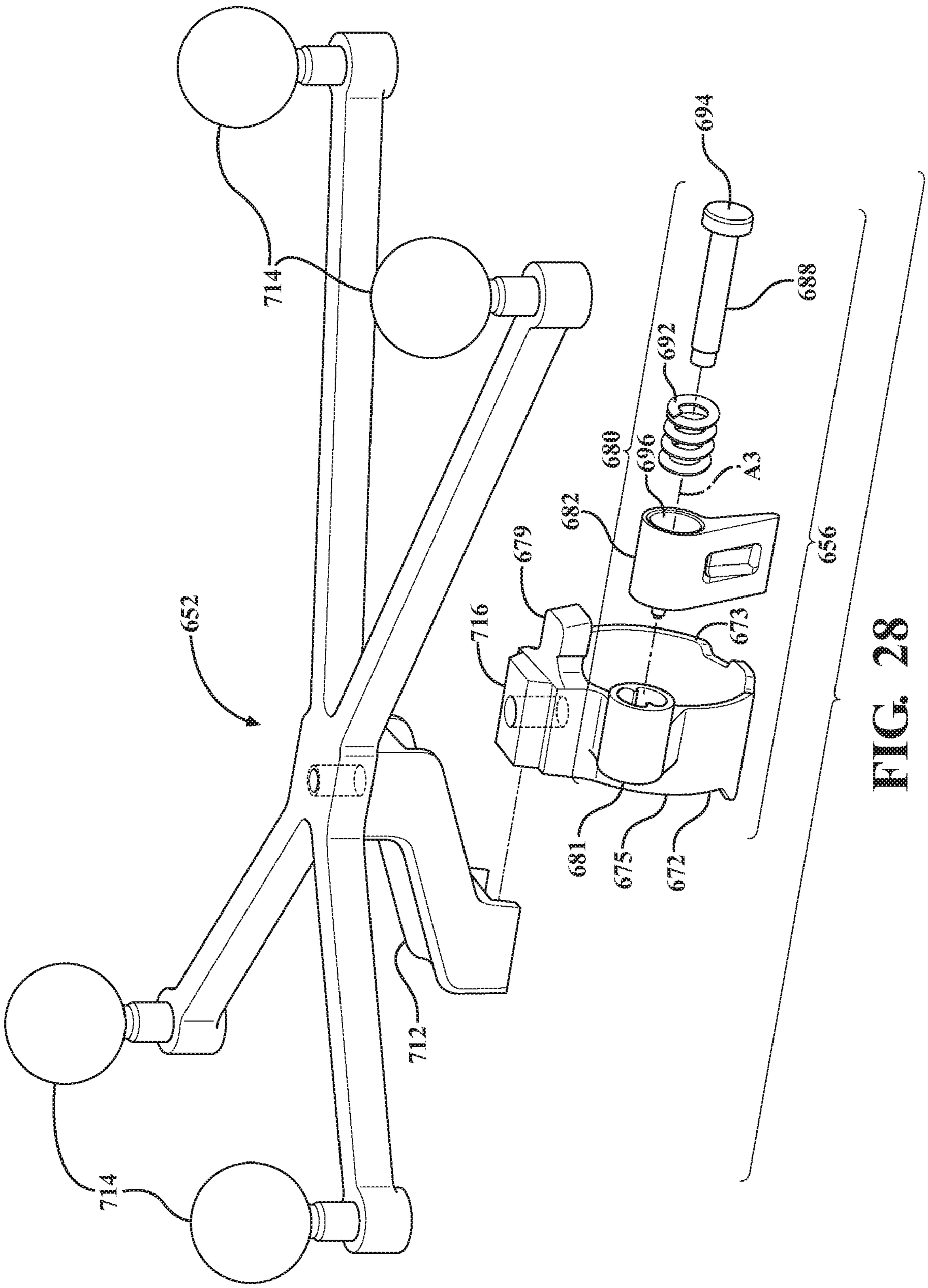

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FIG. 28

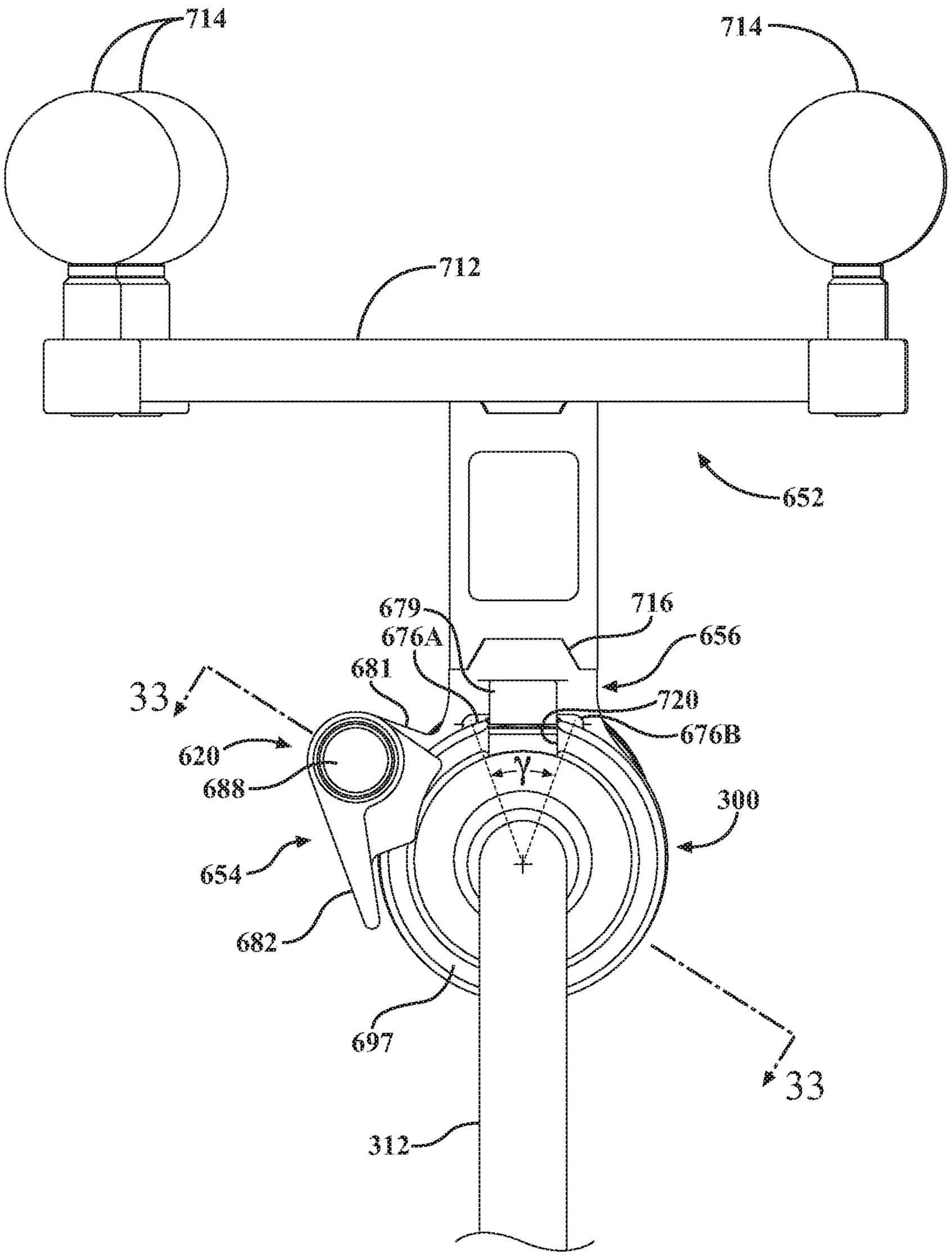

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FIG. 29

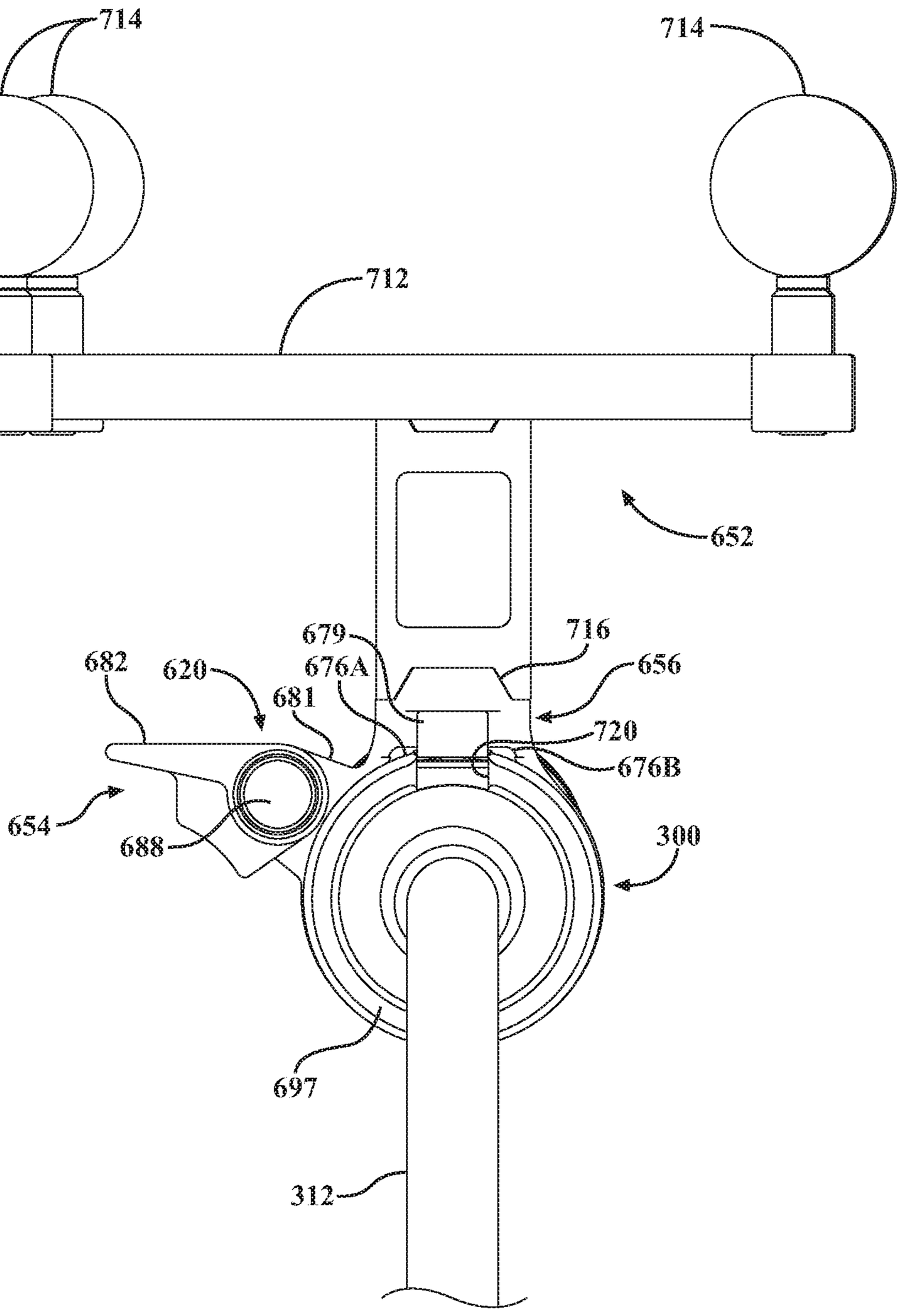

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FIG. 30

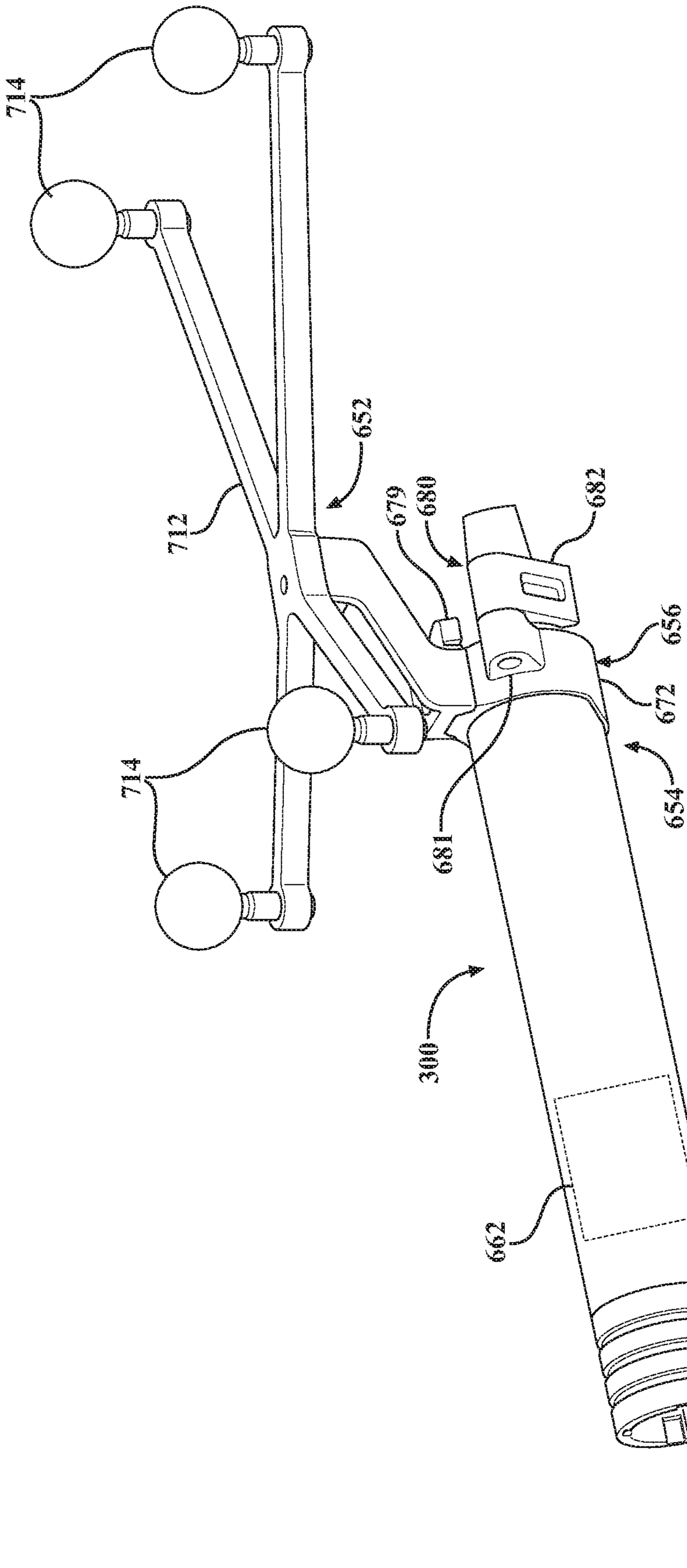


FIG. 31

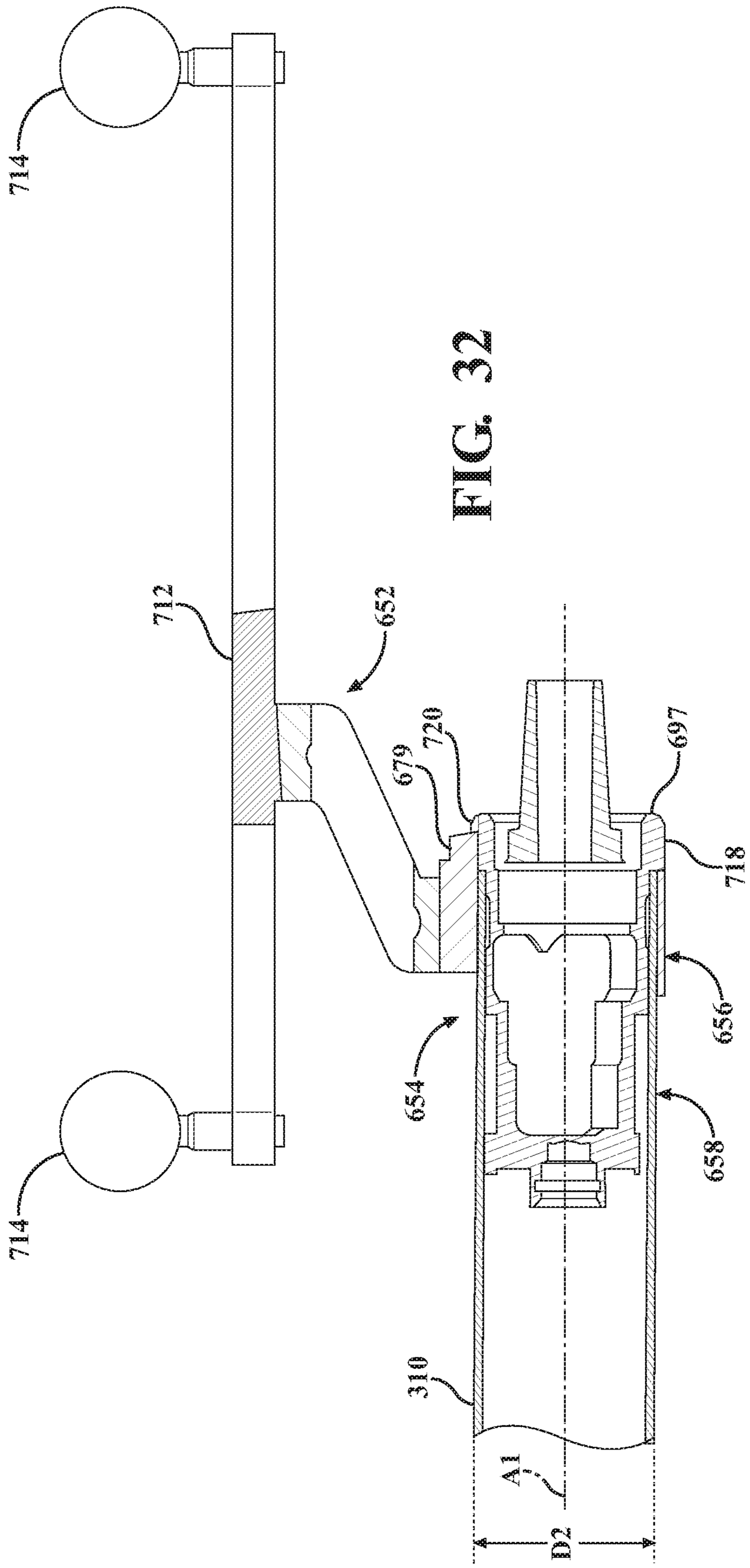


FIG. 32

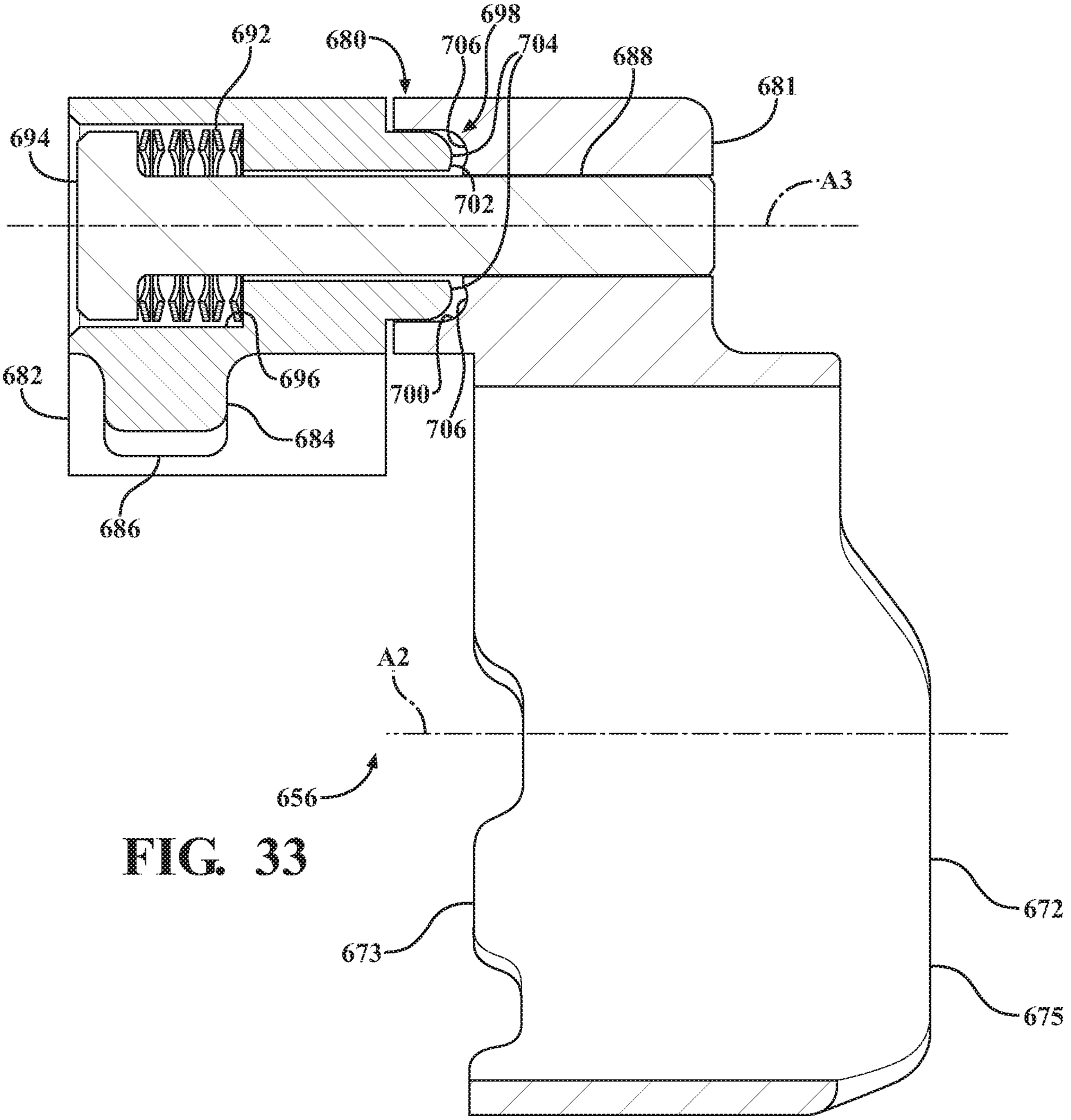

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FIG. 33

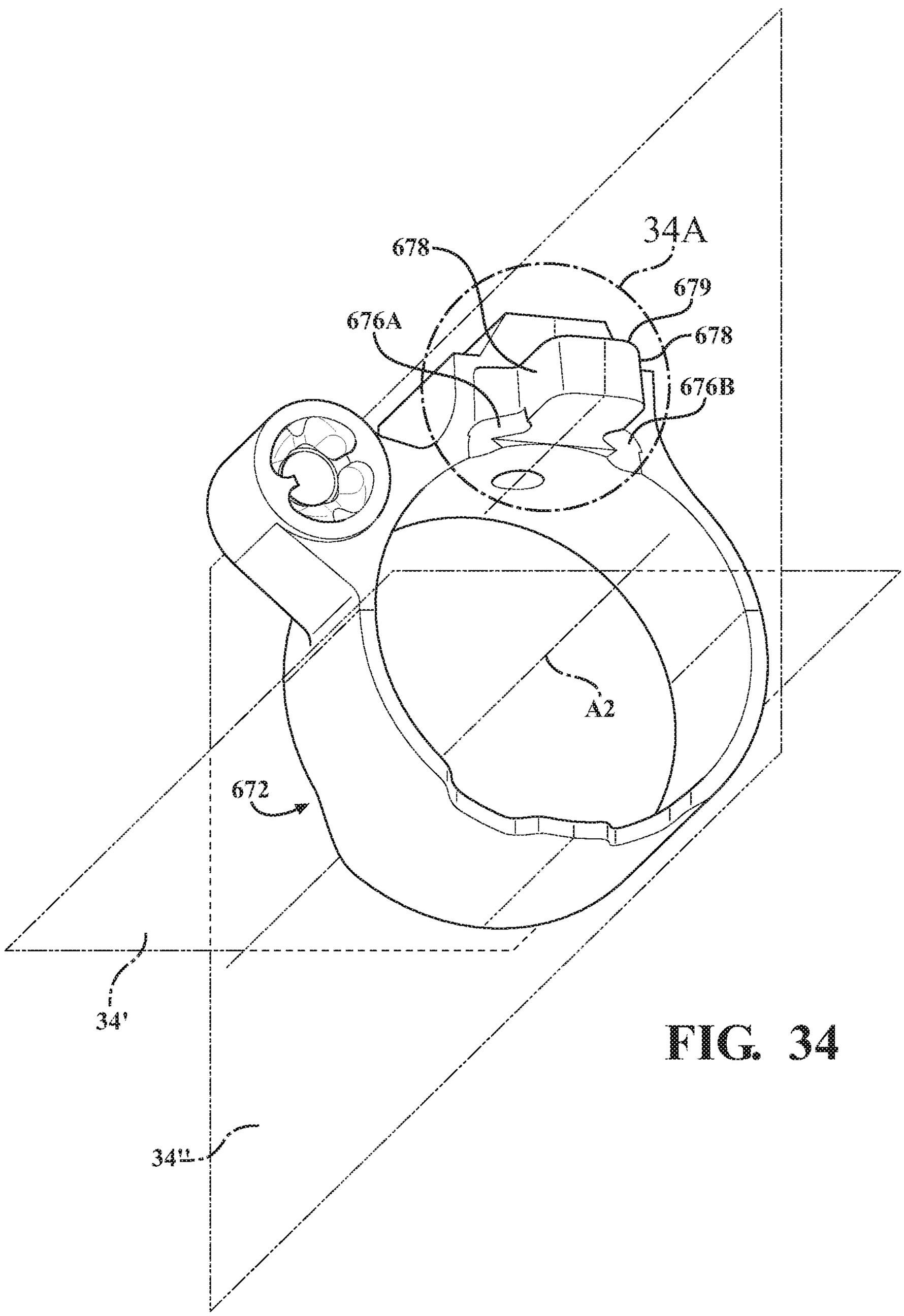


FIG. 34

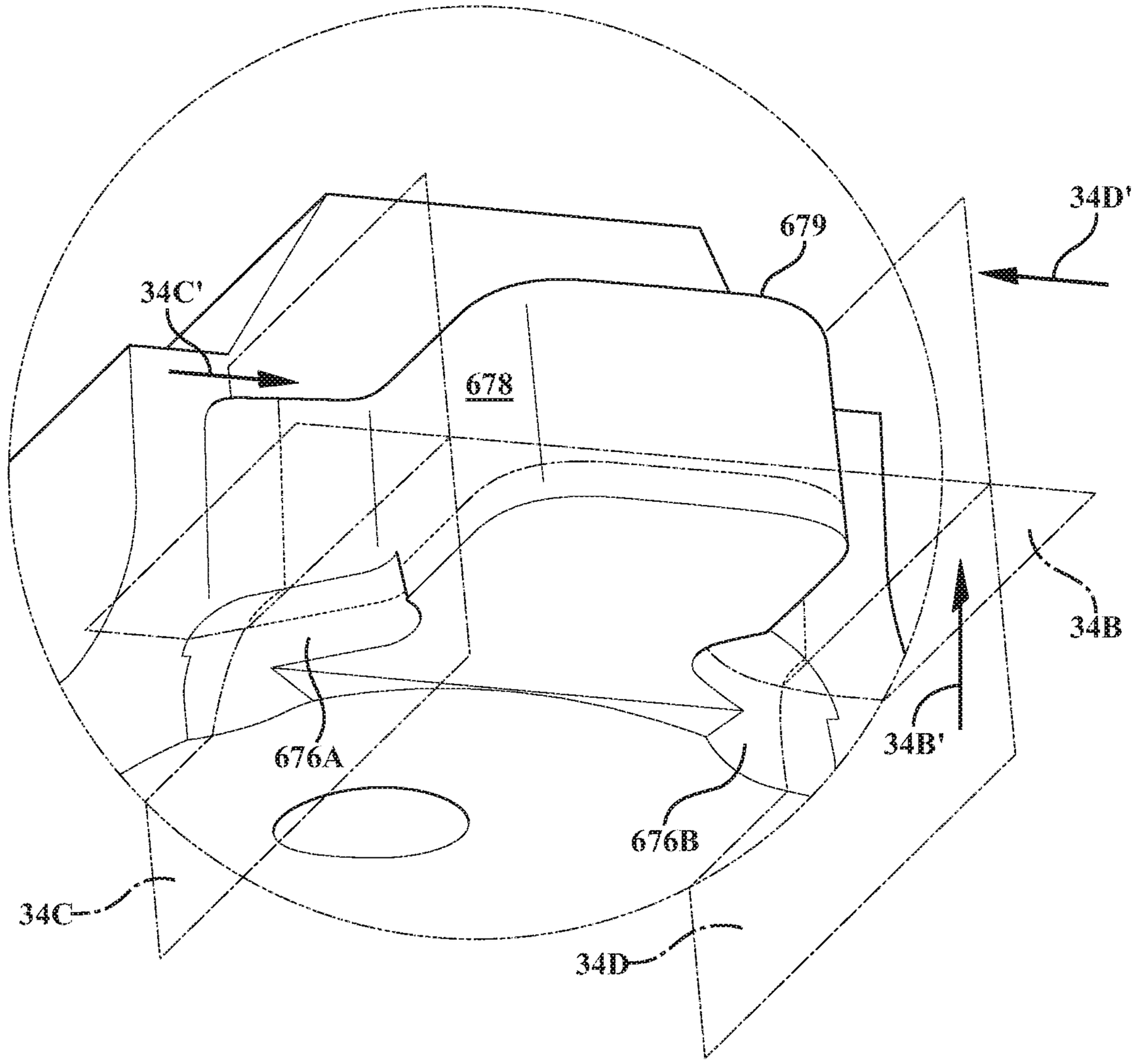


FIG. 34A

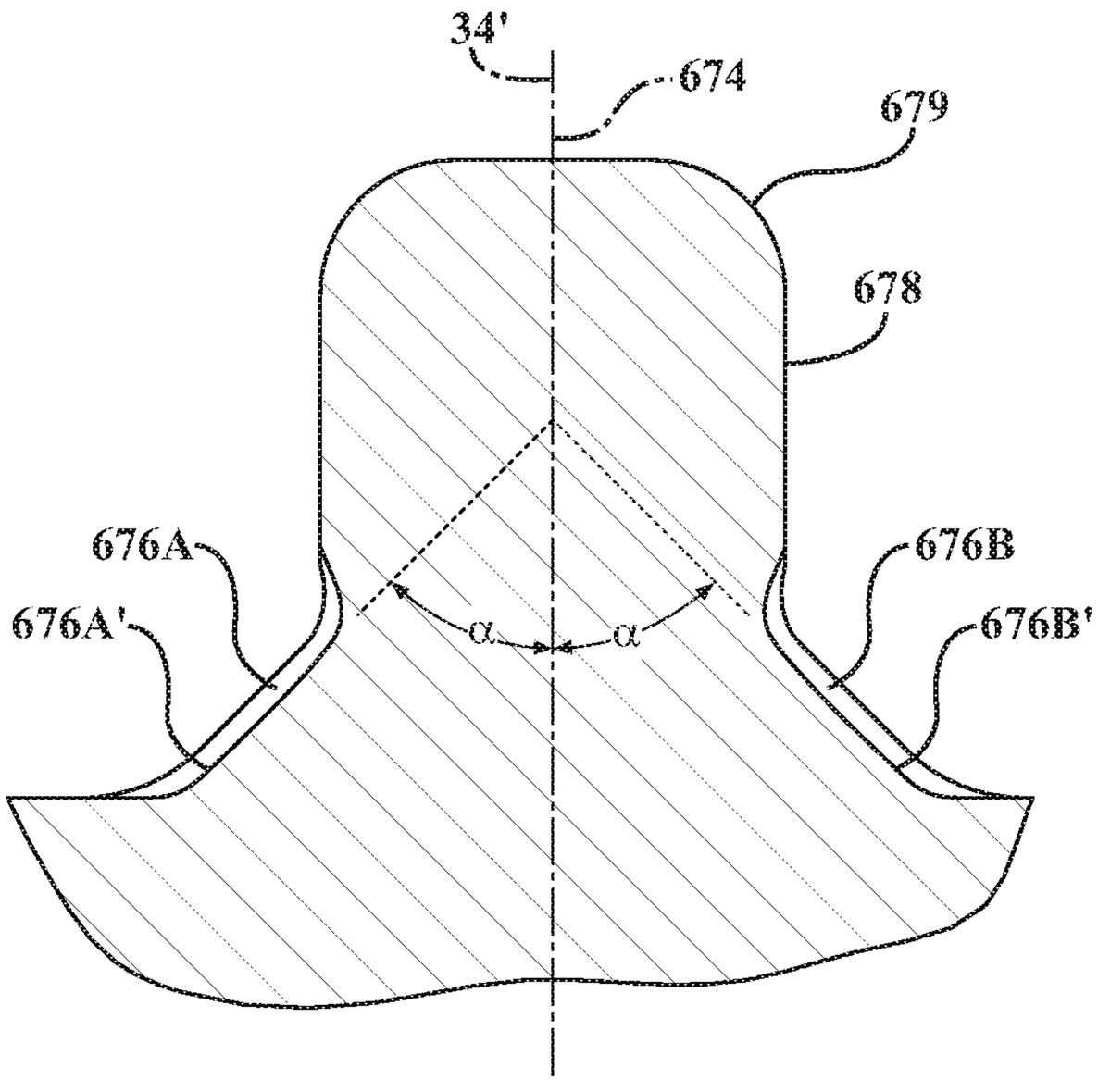


FIG. 34B

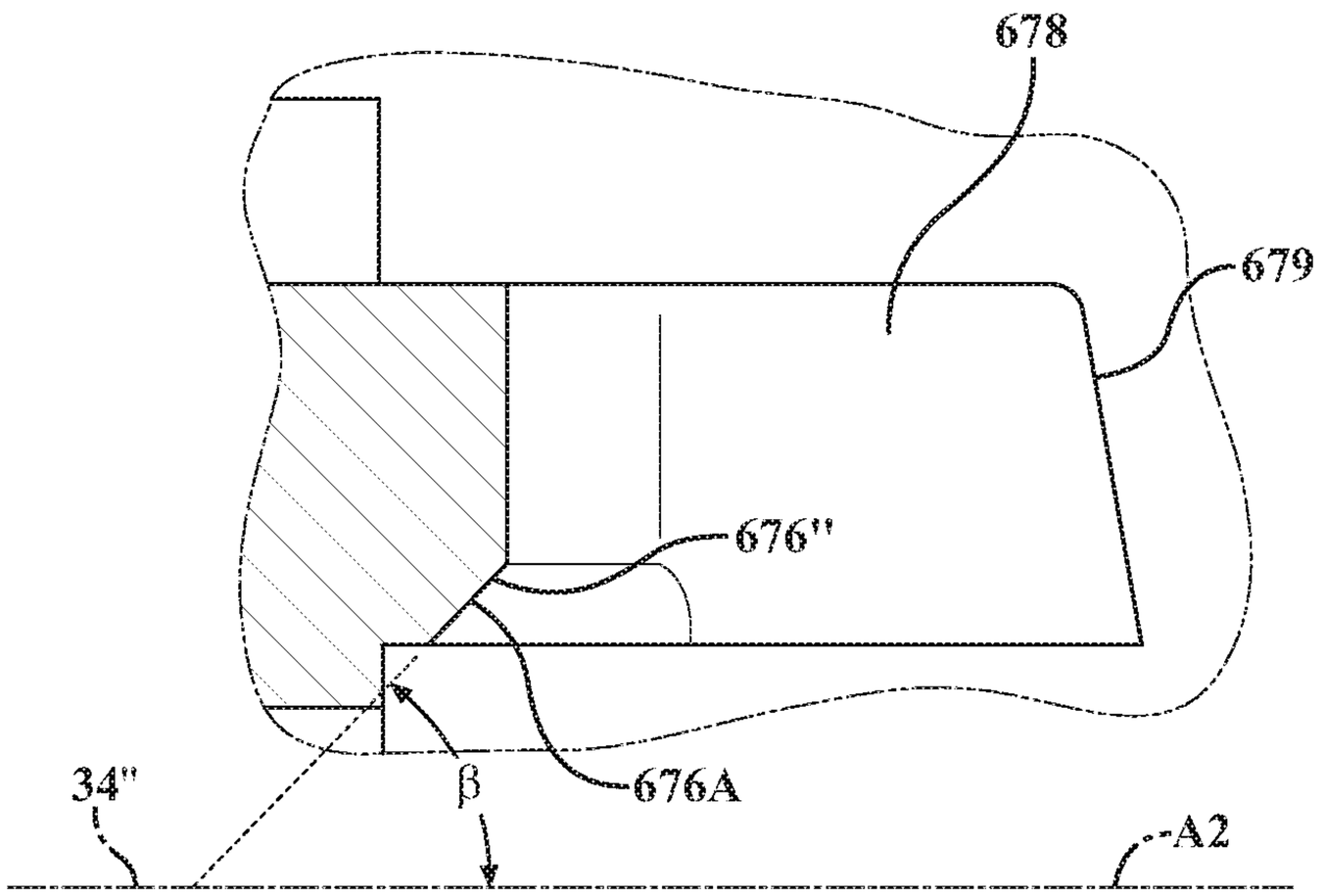


FIG. 34C

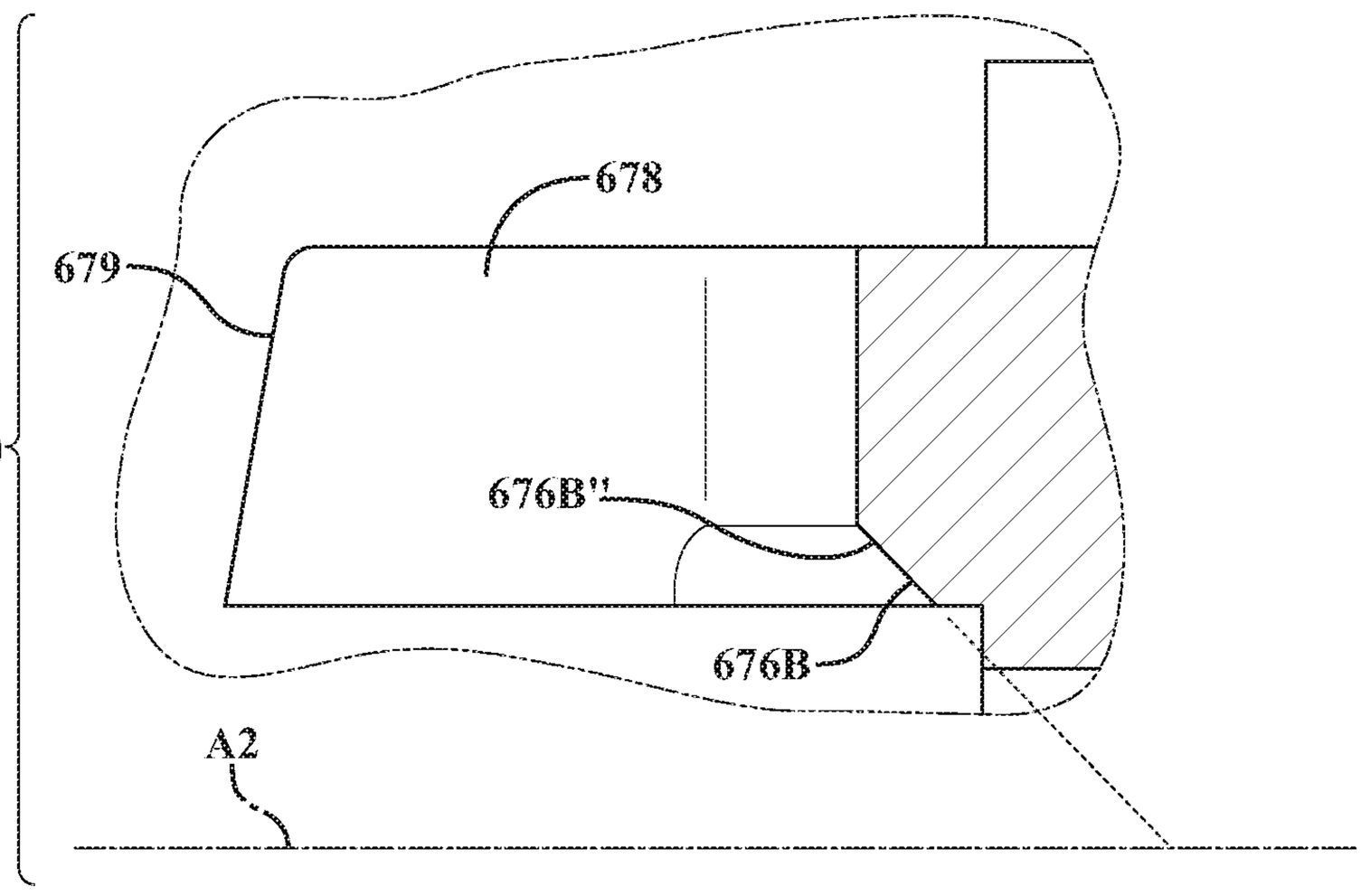


FIG. 34D

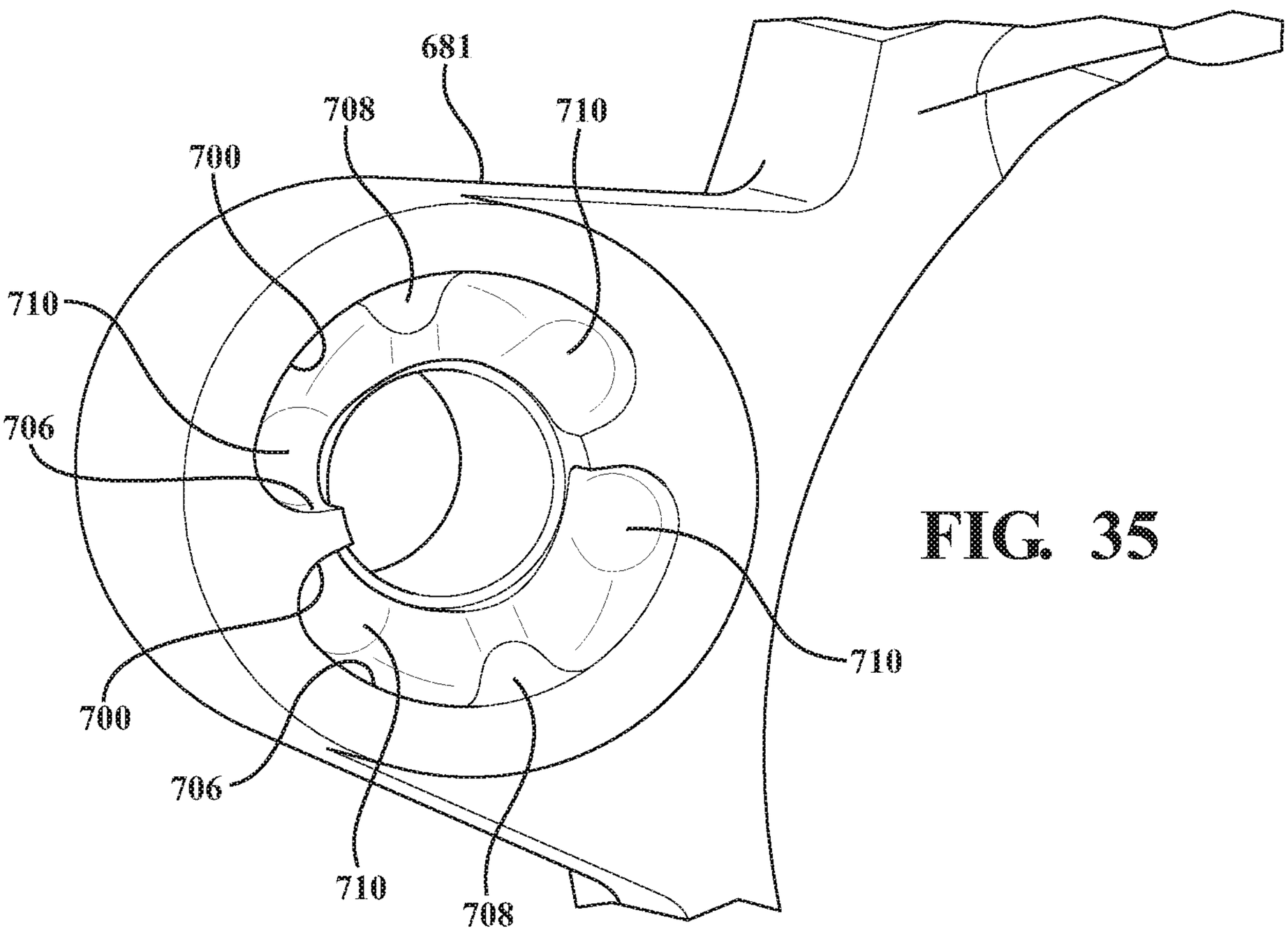


FIG. 35

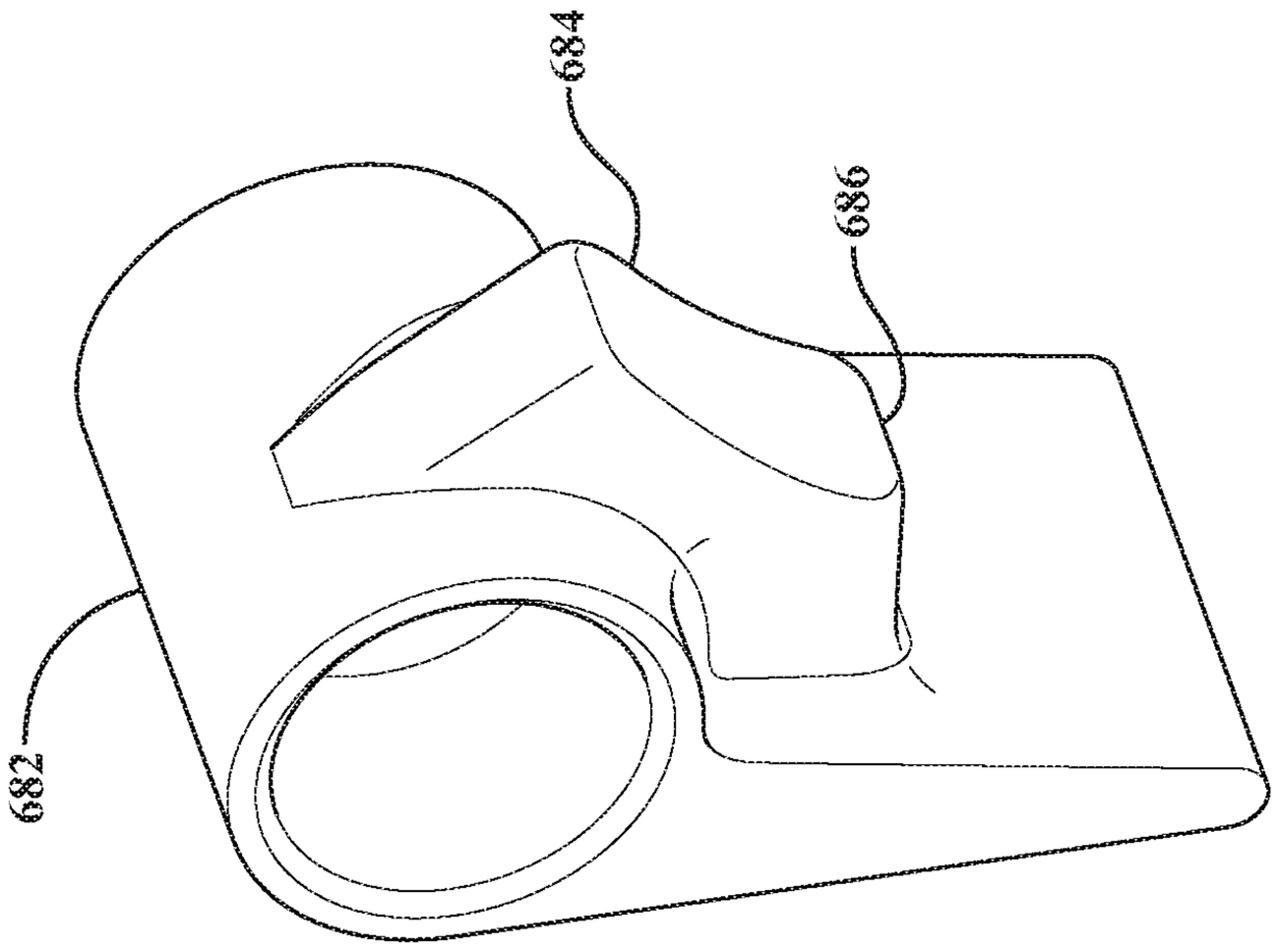


FIG. 37

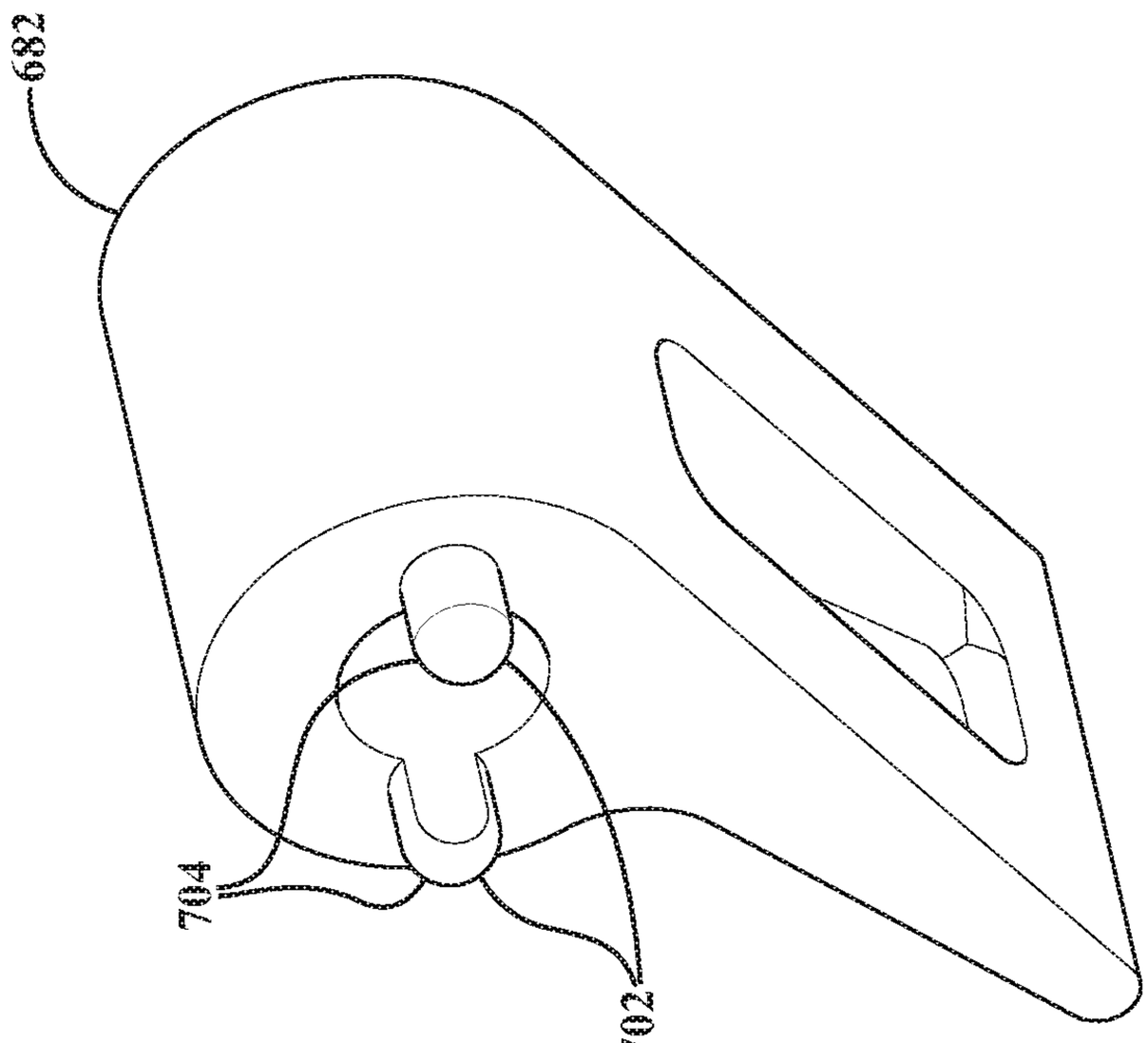


FIG. 36

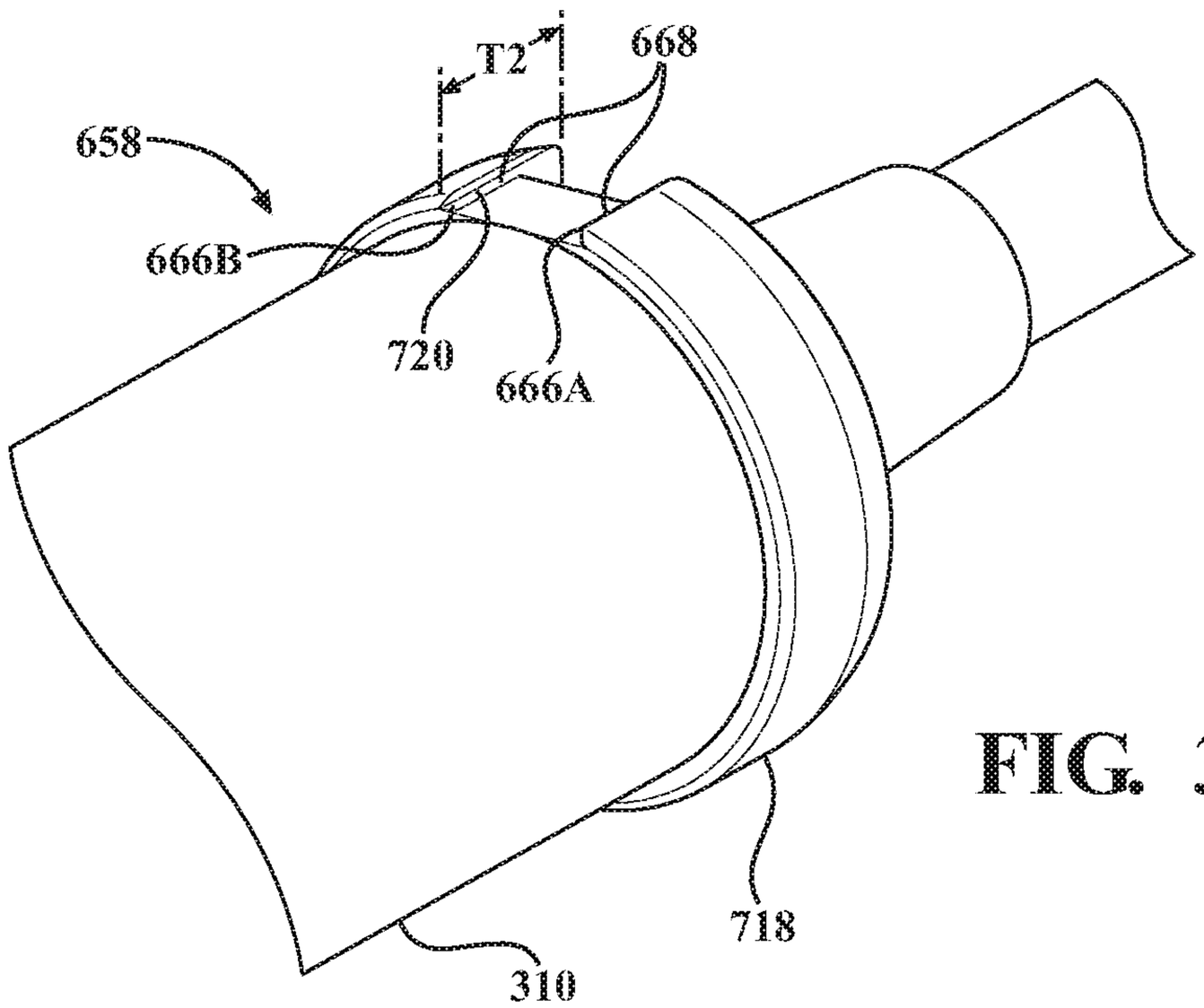


FIG. 38

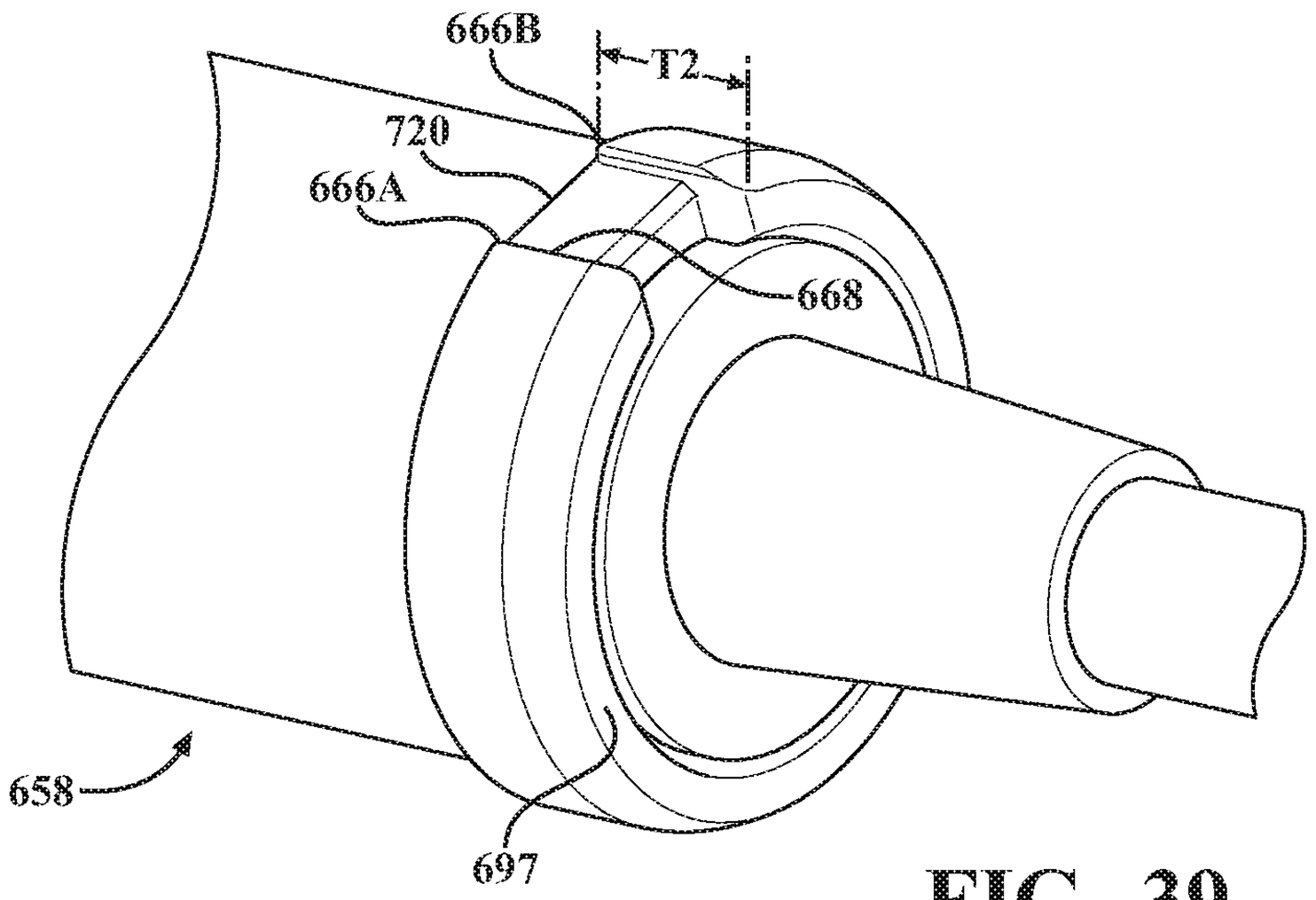


FIG. 39

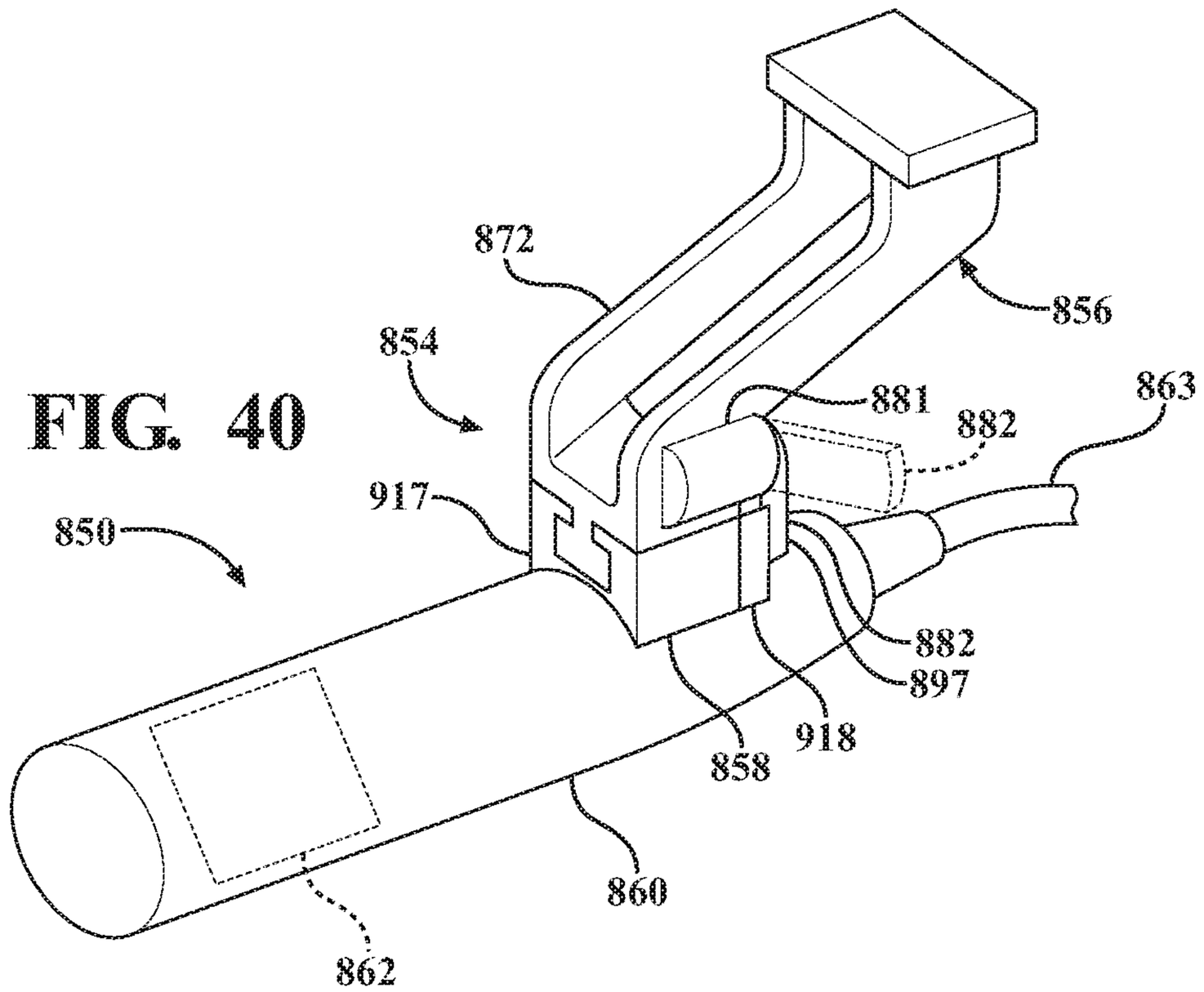

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FIG. 40

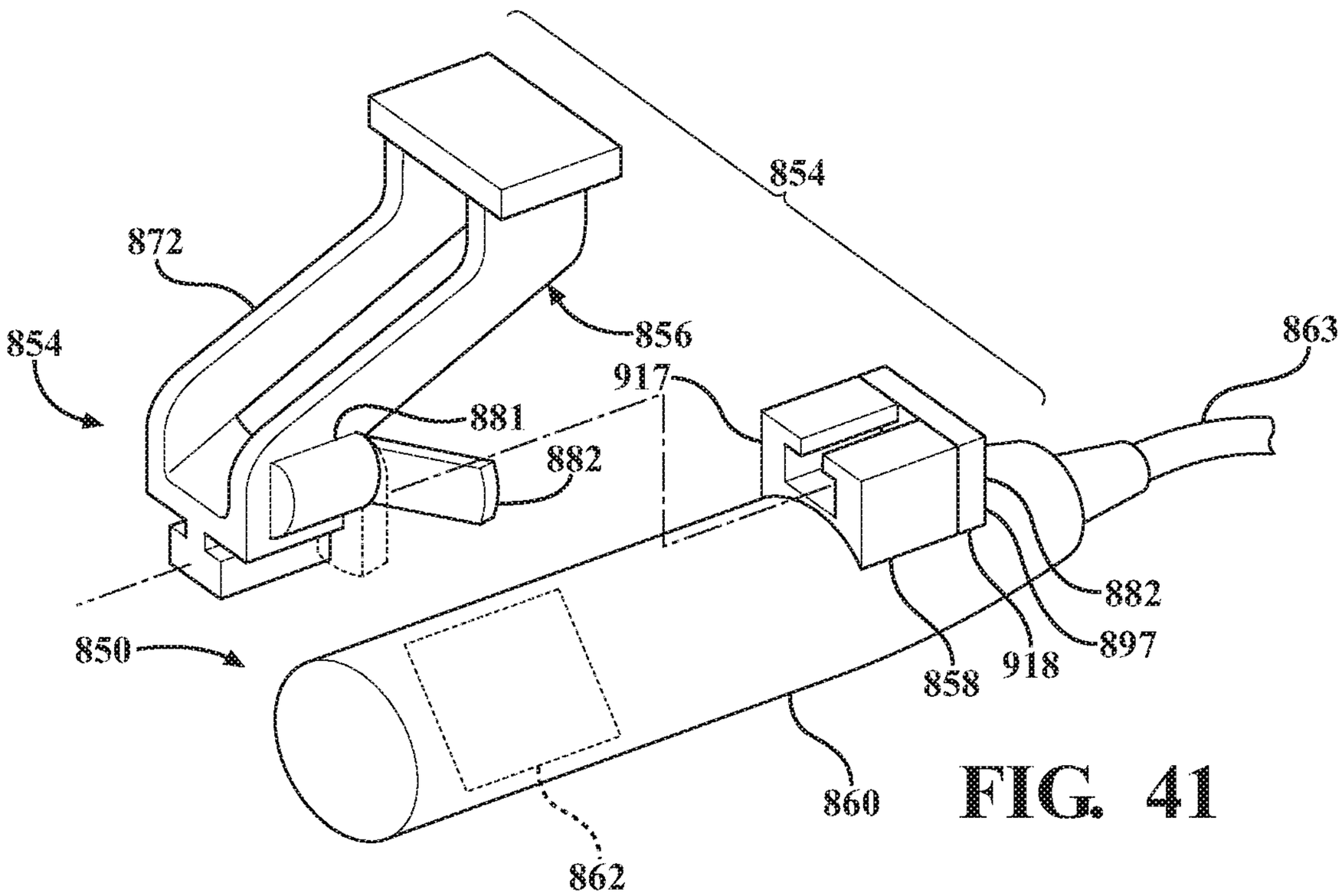

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FIG. 41

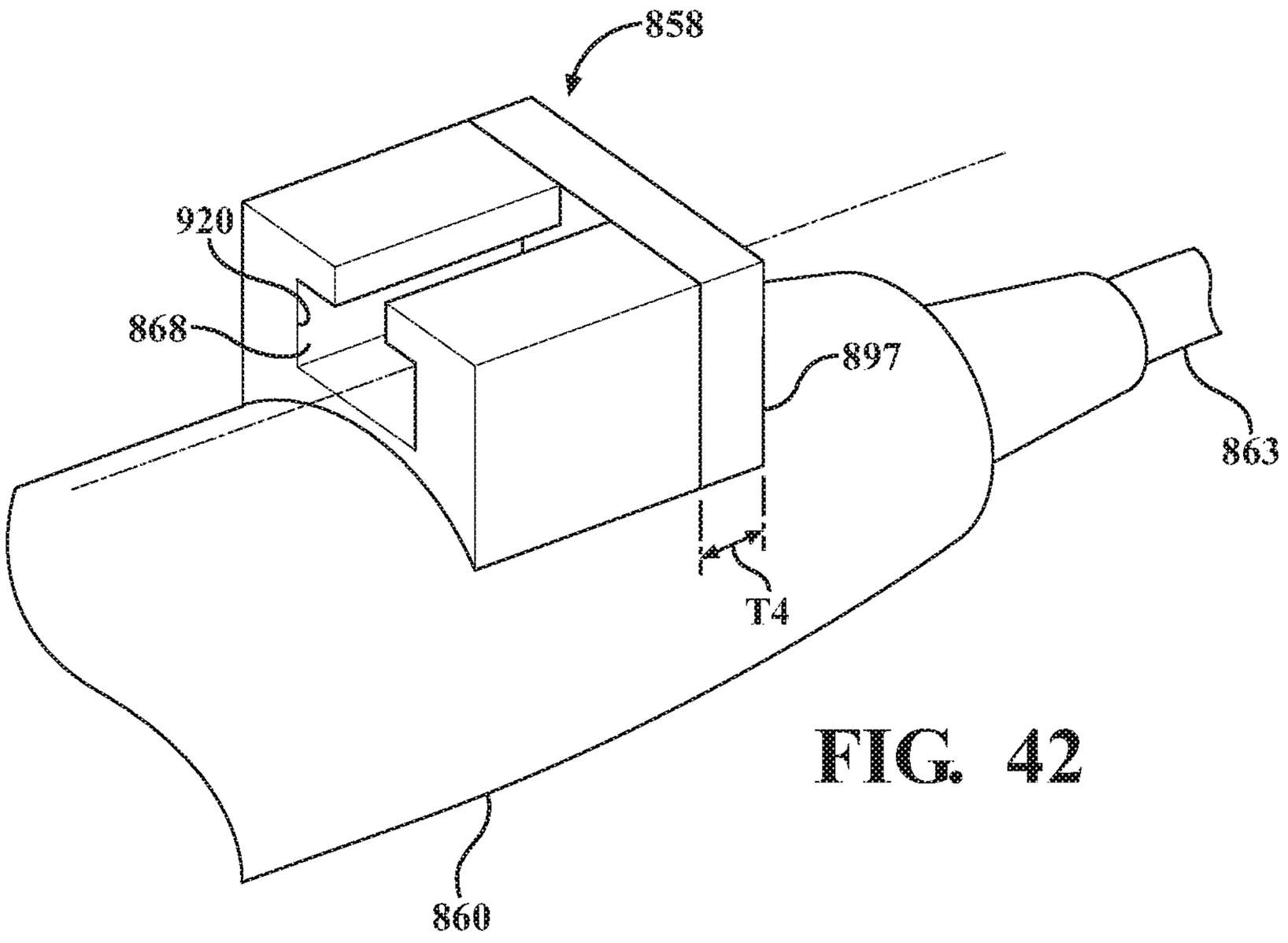


FIG. 42

FIG. 43

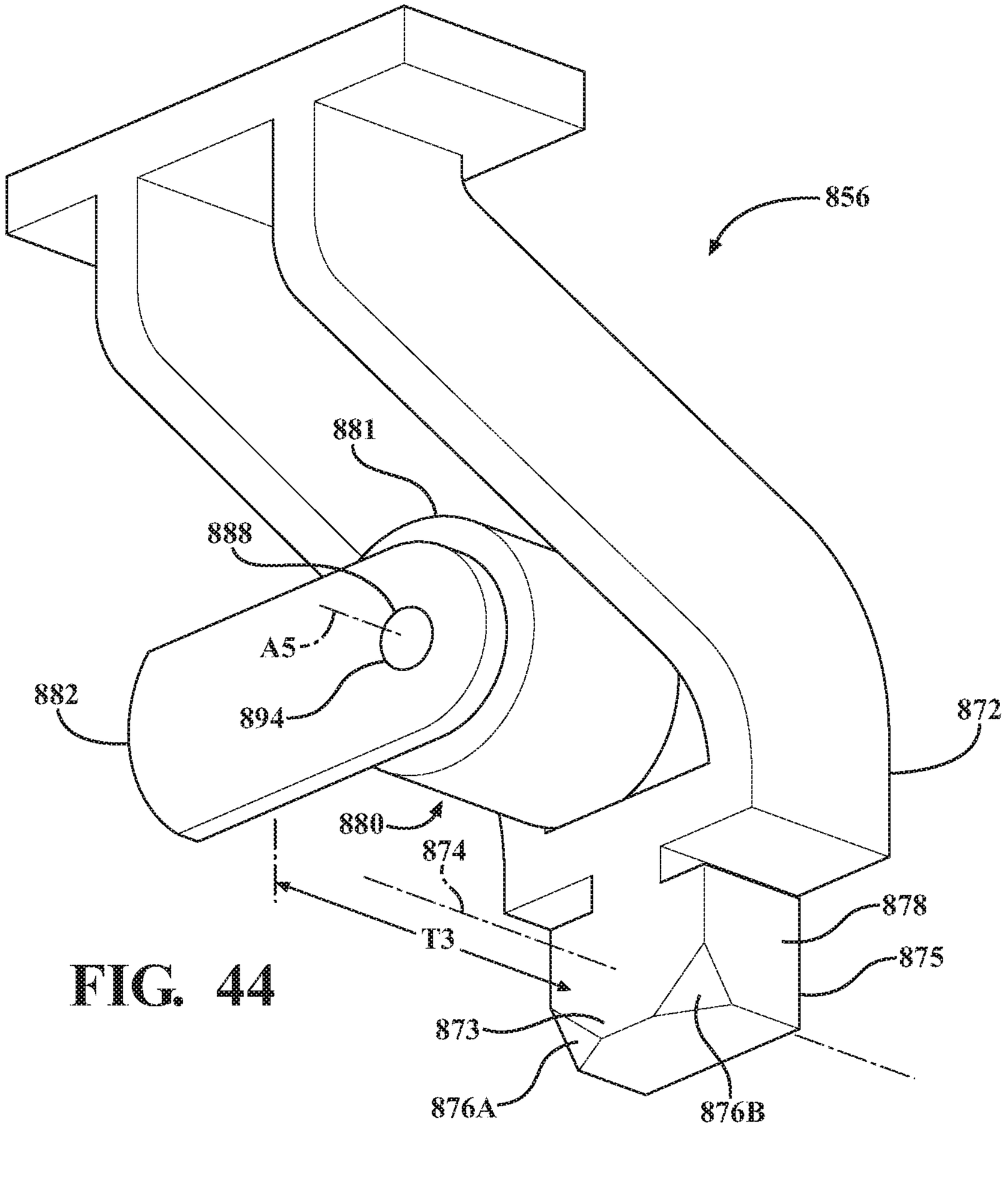


FIG. 44