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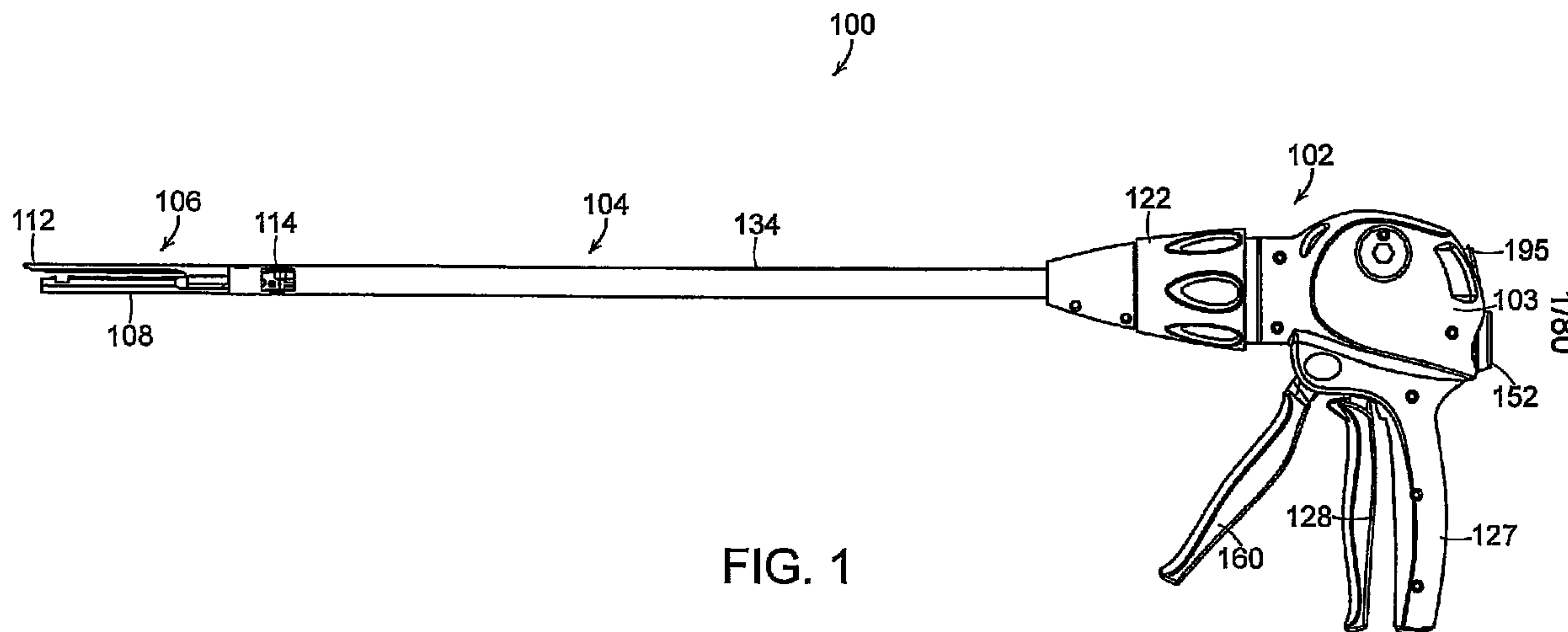


FIG. 1

(57) **Abrégé/Abstract:**

A surgical instrument including a shaft and an end effector. The end effector may comprise a first jaw and a second jaw. The first jaw may be movable relative to the second jaw between an open configuration and a closed configuration. The surgical instrument may comprise a closure assembly which may be operably engaged with the first jaw. The closure assembly may comprise a closure trigger and a dampening system. The closure trigger may be configured to be actuated from a first position to a second position to close the first jaw. The dampening system may be configured to retard the opening of the closure trigger. The dampening system may comprise an aperture configured to receive the projection at a first end of the aperture and a seal configured to form a fluid seal between said projection and said aperture sidewall.



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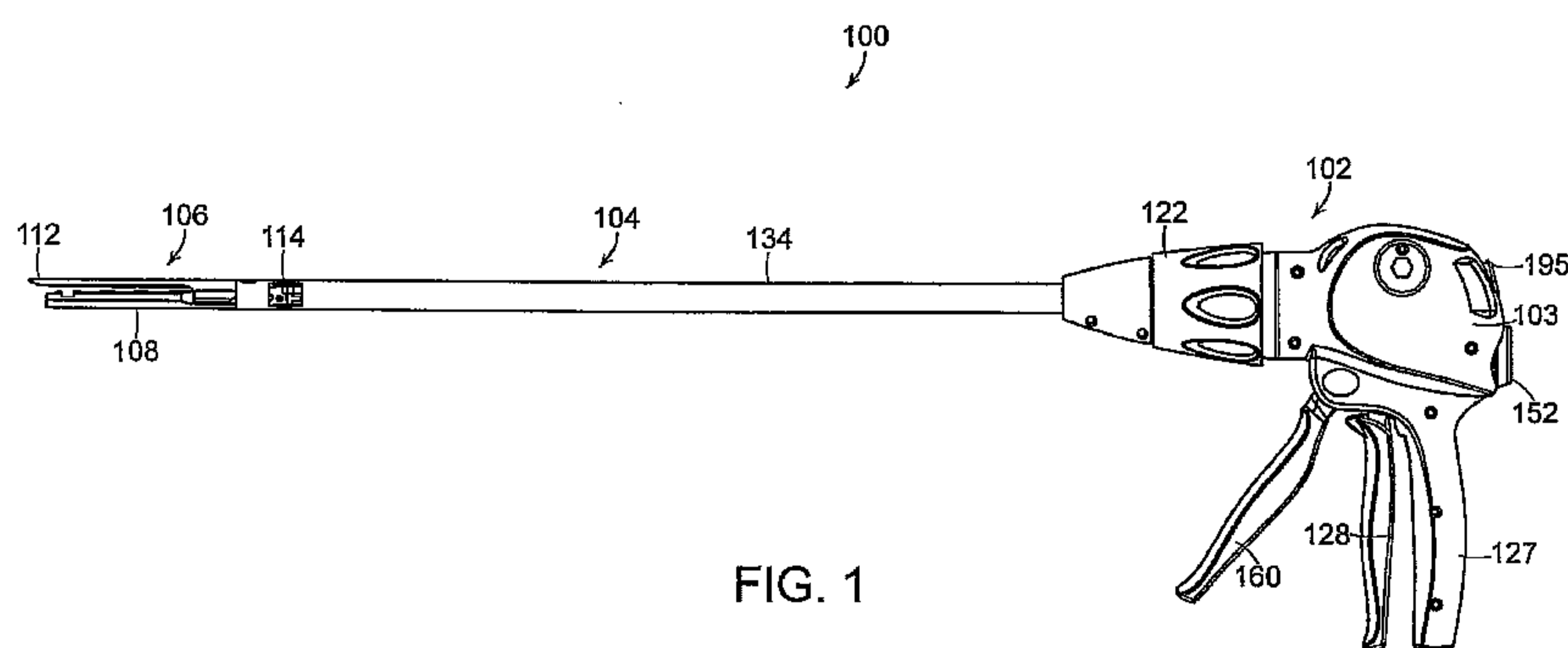


FIG. 1

(57) Abstract: A surgical instrument including a shaft and an end effector. The end effector may comprise a first jaw and a second jaw. The first jaw may be movable relative to the second jaw between an open configuration and a closed configuration. The surgical instrument may comprise a closure assembly which may be operably engaged with the first jaw. The closure assembly may comprise a closure trigger and a dampening system. The closure trigger may be configured to be actuated from a first position to a second position to close the first jaw. The dampening system may be configured to retard the opening of the closure trigger. The dampening system may comprise an aperture configured to receive the projection at a first end of the aperture and a seal configured to form a fluid seal between said projection and said aperture sidewall.

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DAMPENING DEVICE FOR ENDOSCOPIC SURGICAL STAPLER**BACKGROUND**

[0001] The present application is related to the following commonly-owned U.S. Patent Applications filed concurrently herewith, and which are hereby incorporated by reference in their entirety:

(1) U.S. Patent Application Serial No. 11/821,425, entitled END EFFECTOR CLOSURE SYSTEM FOR A SURGICAL STAPLING INSTRUMENT, Atty. Docket No. END6085USNP/070054;

(2) U.S. Patent Application Serial No. 11/821,426, entitled SURGICAL STAPLING INSTRUMENT WITH AN ANTI-BACK UP MECHANISM, Atty. Docket No. END6100USNP/070053;

(3) U.S. Patent Application Serial No. 11/821,347, entitled SURGICAL STAPLING INSTRUMENT WITH A RETURN MECHANISM, Atty. Docket No. END6091USNP/070061;

(4) U.S. Patent Application Serial No. 11/821,455, entitled SURGICAL STAPLING INSTRUMENT WITH AN ARTICULATING END EFFECTOR, Atty. Docket No. END6092USNP/070062; and.

(5) U.S. Patent Application Serial No. 11/821,277, entitled SURGICAL STAPLING INSTRUMENTS, Atty. Docket No. END6099USNP/070057.

1. Field of the Invention

[0002] The present invention generally relates to surgical stapling instruments and, more particularly, to surgical staplers having a closing system which allows for closing of an end effector and allows for an automatic controlled opening of the end effector.

2. Description of the Related Art

[0003] As known in the art, surgical staplers are often used to deploy staples into soft tissue in order to reduce or eliminate bleeding from the soft tissue, especially as the tissue is being transected, for example. Surgical staplers, such as an endocutter, for example, can comprise an end effector which can be moved, or articulated, with respect to an elongate shaft assembly. End

effectors are often configured to secure soft tissue between first and second jaw members where the first jaw member often includes a staple cartridge which is configured to removably store staples therein and the second jaw member often includes an anvil. Such surgical staplers can include a closing system for pivoting the anvil relative to the staple cartridge.

[0004] Staples are typically deployed from the staple cartridge by a driver which traverses a channel in the staple cartridge and causes the staples to be deformed against the anvil and secure layers of the soft tissue together. Often, as known in the art, the staples are deployed in several staple lines, or rows, in order to more reliably secure the layers of tissue together. The end effector may also include a cutting member, such as a knife, for example, which is advanced between two rows of the staples to resect the soft tissue after the layers of the soft tissue have been stapled together.

[0005] After the driver and the cutting member have been advanced within the end effector, it is often necessary to retract the driver and/or cutting member to their starting positions and release the first and second jaw members of the end effector. Often surgical staplers have included an opening spring which returns a closure trigger to the closure trigger's open position thus returning the first and second jaw members to their original positions after a release button or toggle switch on the surgical stapler has been actuated by the surgeon, for example. Such staplers, however, are often difficult to use as such opening springs often apply a biasing force to the closure trigger which can, in various circumstances, cause the closure trigger to open and thus the first and second jaws of the end effector to automatically spring open with excessive force which may damage tissue surrounding the end effector. What is needed is an improvement over the foregoing.

SUMMARY

[0006] In one embodiment, a surgical instrument can comprise an elongate shaft and an end effector. The end effector may comprise a first jaw and a second jaw. The first jaw may be movable relative to the second jaw between an open configuration and a closed configuration. The surgical instrument may further comprise a closure assembly. The closure assembly may be operably engaged with the first jaw. The closure assembly may comprise a closure trigger and a dampening system. The closure trigger may be configured to be actuated from a first position to

a second position to close the first jaw. The closure trigger may further comprise a projection. The dampening system may be configured to retard the opening of the closure trigger. The dampening system may comprise an aperture and a seal. The aperture may be configured to receive the projection at a first end of the aperture. The aperture may comprise a second end, wherein the second end is smaller than the first end. The aperture may be defined by an aperture sidewall. The seal may be configured to form a fluid seal between said projection and said aperture sidewall.

[0007] In one embodiment, a surgical instrument may comprise an elongate shaft and an end effector. The end effector may comprise a first jaw and a second jaw. The first jaw may be movable relative to the second jaw between an open configuration and a closed configuration. The surgical instrument may further comprise a closure assembly operably engaged with the first jaw. The closure assembly may comprise a closure trigger configured to be actuated from a first position to a second position to close the first jaw. The closure trigger may comprise a piston. The closure assembly may further comprise a cylinder configured to receive the piston at a first end of the cylinder. The piston may be configured to move within the cylinder. The closure assembly may also comprise a dampening device configured to slow a return of the closure trigger from the second position to the first position by slowing movement of the piston in the cylinder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

[0009] Fig. 1 is an elevational view of a surgical instrument in accordance with an embodiment of the present invention;

[0010] Fig. 2 is an elevational view of a handle portion of the surgical instrument of Fig. 1;

[0011] Fig. 3 is an elevational view of an end effector of the surgical instrument of Fig. 1;

[0012] Fig. 4 is a top view of the end effector of Fig. 3;

[0013] Fig. 5 is a perspective view of an articulation joint of the surgical instrument of Fig. 1 with some components of the surgical instrument removed;

[0014] Fig. 6 is a perspective view of an elongate shaft assembly and the articulation joint of the surgical instrument of Fig. 1 with some components of the surgical instrument removed;

[0015] Fig. 7 is a partial perspective view of the handle portion and the elongate shaft assembly of the surgical instrument of Fig. 1 with some components of the surgical instrument removed;

[0016] Fig. 8 is an elevational view of the handle portion of Fig. 2 with some components of the surgical instrument removed;

[0017] Fig. 9 is an elevational view of the handle portion of Fig. 2 with additional components of the surgical instrument removed;

[0018] Fig. 10 is an elevational view of an actuator of an articulation locking mechanism and an end effector closure system of a surgical instrument in accordance with an alternative embodiment of the present invention with some components of the surgical instrument removed;

[0019] Fig. 11 is an elevational view of the surgical instrument of Fig. 10 illustrating the articulation locking mechanism actuator in an unlocked position and the end effector closure system in an open configuration;

[0020] Fig. 12 is an elevational view of the surgical instrument of Fig. 10 illustrating the articulation locking mechanism actuator in an unlocked position and the end effector closure system in a partially closed configuration;

[0021] Fig. 13 is an elevational view of the surgical instrument of Fig. 10 illustrating the articulation locking mechanism actuator in a locked position and the end effector closure system in a closed configuration;

[0022] Fig. 14 is an elevational view of a closure trigger of an end effector closure system of the surgical instrument of Fig. 1;

[0023] Fig. 15 is a partial perspective view of the closure trigger of Fig. 15;

[0024] Fig. 16 is a partial elevational view of the closure trigger of Fig. 15;

[0025] Fig. 17 is a perspective view of a trigger lock of the surgical instrument of Fig. 1;

[0026] Fig. 18 is an elevational view of the trigger lock of Fig. 17;

[0027] Fig. 19 is a detail view of a firing drive of the surgical instrument of Fig. 1 with some components of the surgical instrument removed;

[0028] Fig. 20 is a perspective view of the firing drive of Fig. 19;

[0029] Fig. 21 is a partial detail view of a firing trigger, pawl, and tilter mechanism of the firing drive of Fig. 19;

- [0030] Fig. 22 is an elevational view of the pawl, tilter mechanism, and a pawl return spring of the firing drive of Fig. 19;
- [0031] Fig. 23 is an elevational view of the pawl of Fig. 22;
- [0032] Fig. 24 is a detail view of the firing drive of Fig. 19 illustrating the pawl pivoted into a position to engage a firing link of the firing drive;
- [0033] Fig. 25 is a perspective view of the tilter mechanism of Fig. 22;
- [0034] Fig. 26 is a perspective view of a frame of the surgical instrument of Fig. 1;
- [0035] Fig. 27 is a detail view of a firing drive of a surgical instrument in accordance with an alternative embodiment of the present invention with some components of the surgical instrument removed;
- [0036] Fig. 28 is a detail view of the firing drive of Fig. 27 illustrating a pawl of the firing drive disengaged from a firing link;
- [0037] Fig. 29 is a perspective view of a return mechanism of the surgical instrument of Claim 1 illustrating the firing trigger in an unactuated position with some components of the surgical instrument removed;
- [0038] Fig. 30 is a partial perspective view of the return mechanism of Fig. 29 illustrating the firing trigger in an actuated position with some components of the return mechanism removed;
- [0039] Fig. 31 is an elevational view of the return mechanism of Fig. 29 arranged in the configuration illustrated in Fig. 30;
- [0040] Fig. 32 is an elevational view of the return mechanism of Fig. 29 illustrating a return carriage of the return mechanism in an actuated position;
- [0041] Fig. 33 is a partial perspective view of the return mechanism of Fig. 29 with some components of the return mechanism removed;
- [0042] Fig. 34 is a perspective view of the pawl and firing pin of the firing drive of Fig. 19;
- [0043] Fig. 35 is a perspective view of the return mechanism of Fig. 29 illustrating the return carriage in an actuated position and the firing trigger returned to its unactuated position;
- [0044] Fig. 36 is a partial perspective view of the return mechanism of Fig. 29 arranged in the configuration illustrated in Fig. 35 illustrating a return pin of the return mechanism operably engaged with the firing trigger;
- [0045] Fig. 37 is a partial perspective view of the return mechanism of Fig. 29 illustrating the firing trigger in an actuated position after rotating the return pin;

[0046] Fig. 38 is an additional perspective view of the return mechanism of Fig. 29 arranged in the configuration illustrated in Fig. 37;

[0047] Fig. 39 is a partial perspective view of the return mechanism of Fig. 29 illustrating the firing trigger returned to its unactuated position;

[0048] Fig. 40 is a perspective view of the return mechanism of Fig. 29 illustrating the return carriage returned to its unactuated position;

[0049] Fig. 41 is a perspective view of the return mechanism of Fig. 29 arranged in the configuration of Fig. 40 illustrating the relative relationship between a biasing spring and the return pin of the return mechanism with some components of the return mechanism removed;

[0050] Fig. 42 is a perspective view of the return mechanism of Fig. 29 arranged in the configuration of Fig. 40 illustrating the return carriage operably engaged with the firing pin of the firing drive and the return pin of the return mechanism in order to reset the firing drive and the return mechanism to their initial configurations;

[0051] Fig. 43 is a detail view of a reel of the return mechanism of Fig. 29 illustrating the relative relationship between a return band of the return mechanism and the stapler frame of Fig. 26;

[0052] Fig. 44 is a detail view of the reel of Fig. 43 illustrating the relative relationship between the return band and an alternative embodiment of the stapler frame of Fig. 26;

[0053] Fig. 45 is a perspective view of a return mechanism of a surgical instrument in accordance with an alternative embodiment of the present invention having an anti-back-up ratchet mechanism;

[0054] Fig. 46 is an elevational view of the return mechanism of Fig. 45 having a return carriage in an unactuated position;

[0055] Fig. 47 is a perspective view of the return mechanism of Fig. 45 with some components of the surgical instrument removed;

[0056] Fig. 48 is a perspective view of a return gear, return pin, and anti-back-up pawl of the ratchet mechanism of Fig. 45;

[0057] Fig. 49 is another elevational view of the return mechanism of Fig. 45;

[0058] Fig. 50 is a perspective view of the articulation joint of Fig. 5;

[0059] Fig. 51 is a perspective view of the articulation joint of Fig. 5 with some components of the surgical instrument removed;

- [0060] Fig. 52 is a perspective view of the articulation joint of Fig. 5 with additional components of the surgical instrument removed;
- [0061] Fig. 53 is a perspective view of a lock member of the end effector of Fig. 3;
- [0062] Fig. 54 is another perspective view of the end effector lock member of Fig. 53;
- [0063] Fig. 55 is a bottom view of the end effector lock member of Fig. 53;
- [0064] Fig. 56 is an elevational view of the end effector lock member of Fig. 53;
- [0065] Fig. 57 is a partial perspective view of an articulation joint of a previous surgical instrument;
- [0066] Fig. 58 is a perspective view of the articulation joint of Fig. 5 with some components of the end effector and elongate shaft assembly removed;
- [0067] Fig. 59 is another perspective view of the articulation joint of Fig. 5 with some components of the end effector and elongate shaft assembly removed;
- [0068] Fig. 60 is a perspective view of the end effector lock member of Fig. 53 operably engaged with a lock member of the elongate shaft assembly;
- [0069] Fig. 61 is a perspective view of the shaft assembly lock member of Fig. 60;
- [0070] Fig. 62 is a bottom view of end effector lock member of Fig. 53 operably engaged with the shaft assembly lock member of Fig. 60;
- [0071] Fig. 63 is a perspective view of an articulation joint of a surgical instrument in accordance with an alternative embodiment of the present invention with some components of the surgical instrument removed;
- [0072] Fig. 64 is a top view of an end effector lock member operably engaged with a shaft assembly lock member of the surgical instrument of Fig. 63;
- [0073] Fig. 65 is a perspective view of the end effector lock member operably engaged with the shaft assembly lock member of Fig. 64;
- [0074] Fig. 66 is a perspective view of the end effector lock member of Fig. 64;
- [0075] Fig. 67 is an elevational view of the end effector lock member of Fig. 64.
- [0076] Fig. 68 an elevational view of another surgical instrument embodiment of the present invention;
- [0077] Fig. 69 is an elevational view of a handle portion of the surgical instrument of Fig. 68 with some components of the surgical instrument omitted for clarity;

[0078] Fig. 70 is a side elevational view of a closure trigger of the closure assembly of the surgical instrument of Fig. 68;

[0079] Fig. 71 is a partial perspective view of the closure trigger of Fig. 70;

[0080] Fig. 72 is a partial perspective view of the closure trigger of Figs. 70 and 71;

[0081] Fig. 73 is a partial elevational view of the handle portion of Fig. 69 with some components of the surgical instrument removed for clarity and illustrating a closure trigger of the surgical instrument in an open position;

[0082] Fig. 74 is another partial elevational view of the handle portion of Fig. 73 with some components of the surgical instrument removed for clarity and illustrating the closure trigger of the surgical instrument in a closed position;

[0083] Fig. 75 is a perspective view of a trigger lock of the surgical instrument of Fig. 68;

[0084] Fig. 76 is a perspective view of a trigger lock of the surgical instrument of Fig. 68;

[0085] Fig. 77 is an elevational view of a portion of the handle portion of Fig. 68 with some components of the surgical instrument removed for clarity;

[0086] Fig. 78 is another partial elevational view of the surgical instrument of FIG. 68 with some components omitted for clarity and illustrating a firing mechanism portion thereof;

[0087] Fig. 79A is a partial perspective view of a portion of the closure trigger and handle portion embodiment of the present invention illustrating the actuation of the closure trigger from the open position to the closed position;

[0088] Fig. 79B is another partial perspective view of a portion of the closure trigger and handle portion embodiment of the present invention illustrating the actuation of the closure trigger from the closed to open position;

[0089] Fig. 80 is a partial side elevational view of a handle portion of a surgical instrument with some components of the surgical instrument removed for clarity and illustrating another dampening system embodiment of the present invention;

[0090] Fig. 81 is a partial side elevational view of a handle portion of a surgical instrument with some components of the surgical instrument removed for clarity and illustrating another dampening system embodiment of the present invention; and

[0091] Fig. 82 is an elevational view of a portion of the handle portion of Fig. 68 with some components of the surgical instrument removed for clarity to illustrating portions of a firing mechanism embodiment of the present invention; and

[0092] Fig. 83 is a partial perspective view of the firing mechanism portion of FIG. 78 with some components omitted for clarity.

[0093] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate preferred embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION

[0094] Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

[0095] In various embodiments, a surgical instrument in accordance with the present invention can be configured to insert surgical staples into soft tissue, for example. In at least one embodiment, referring to Figs. 1-4, surgical instrument 100 can include handle portion 102, elongate shaft assembly 104, and end effector 106. In various embodiments, referring to Figs. 3 and 4, end effector 106 can include staple cartridge channel 108 and staple cartridge 110, where staple cartridge 110 can be configured to removably store staples therein. In at least one embodiment, end effector 106 can further include anvil 112 which can be pivotably connected to staple cartridge channel 108 and can be pivoted between open and closed positions by an end effector closure system. In order to deploy the staples from staple cartridge 110, surgical instrument 100 can further include a staple driver configured to traverse staple cartridge 110 and a firing drive configured to advance the staple driver within the staple cartridge. In various embodiments, anvil 112 can be configured to deform at least a portion of the staples as they are deployed from the staple cartridge. Although various embodiments of an end effector closure

system and a firing drive are described in further detail below, several embodiments of end effector closure systems and firing drives are disclosed in U.S. Patent No. 6,905,057, entitled SURGICAL STAPLING INSTRUMENT INCORPORATING A FIRING MECHANISM HAVING A LINKED RACK TRANSMISSION, which issued on June 14, 2005, and U.S. Patent No. 7,044,352, entitled SURGICAL STAPLING INSTRUMENT HAVING A SINGLE LOCKOUT MECHANISM FOR PREVENTION OF FIRING, which issued on May 16, 2006, the entire disclosures of which are hereby incorporated by reference herein.

[0096] In various embodiments, a surgical instrument in accordance with the present invention can include a system for moving, or articulating, an end effector relative to an elongate shaft assembly of the surgical instrument. In at least one embodiment, referring to Figs. 3-7, surgical instrument 100 can include articulation joint 114 which can movably connect end effector 106 and elongate shaft assembly 104. In various embodiments, articulation joint 114 can permit end effector 106 to be moved relative to shaft assembly 104 in a single plane or, alternatively, multiple planes. In either event, articulation joint 114 can include one or more pivot axes 116 (Fig. 5) about which end effector 106 can be articulated. In various embodiments, referring to Figs. 5 and 6, surgical instrument 100 can further include locking mechanism 118 which can fix, or lock, the relative relationship between end effector 106 and elongate shaft assembly 104. In at least one embodiment, locking mechanism 118 can include lock member 120 which can be slid relative to end effector 106 and engage end effector 106 in order to prevent, or at least partially inhibit, relative movement between end effector 106 and shaft assembly 104. In at least one embodiment, lock member 120 can be configured to engage at least one of teeth 312 (Figs. 5 and 6) of end effector 106 such that the interaction between lock member 120 and teeth 312 can prevent, or at least partially inhibit, end effector 106 from rotating about axis 116 as described in greater detail further below.

[0097] In various embodiments, referring to Figs. 7-9, locking mechanism 118 can further include actuator 122 which can be operably connected to lock member 120. In at least one embodiment, actuator 122 can include pin 124 which can be received within slot 121 in lock member 120 such that, when actuator 122 is slid relative to handle portion 102, pin 124 can abut a side wall of slot 121 and motivate lock member 120 relative to end effector 106. In at least one embodiment, actuator 122 can be pulled away from end effector 106, i.e., proximally, to disengage lock member 120 from end effector 106. Although not illustrated, other embodiments

are envisioned where actuator 122 can be moved distally, or even rotated, in order to disengage lock member 120 from end effector 106. In either event, locking mechanism 118 can further include return spring 126 (Fig. 6) which can be configured to move lock member 120 toward end effector 106, i.e., distally, to engage lock member 120 with end effector 106 after actuator 122 has been released. Other locking mechanisms are disclosed in U.S. Patent Application Serial No. 11/100,772, entitled SURGICAL INSTRUMENT WITH ARTICULATING SHAFT WITH SINGLE PIVOT CLOSURE AND DOUBLE PIVOT FRAME GROUND, which was filed on April 7, 2005, U.S. Patent Application Serial No. 11/238,358, entitled SURGICAL INSTRUMENT WITH ARTICULATING SHAFT WITH RIGID FIRING BAR SUPPORTS, which was filed on September 29, 2005, and U.S. Patent Application Serial No. 11/491,626, entitled SURGICAL STAPLING AND CUTTING DEVICE AND METHOD FOR USING THE DEVICE, which was filed on July 24, 2006, the entire disclosures of which are hereby incorporated by reference herein.

[0098] In various embodiments, referring to Figs. 1 and 2, actuator 122 can be contoured such that a surgeon can grasp the outer surface of actuator 122 and pull actuator 122 proximally as described above. To move actuator 122, in at least one embodiment, a surgeon may place one hand on handle grip 127, for example, and place their other hand on actuator 122 so that the surgeon can move actuator 122 relative to handle grip 127. In other various embodiments, referring to Figs. 10-13, actuator 122' can be configured such that a surgeon may only need one hand to operate the surgical instrument. More particularly, in at least one embodiment, actuator 122' can include hooks, or projections, 115 extending therefrom which can allow the surgeon to hold handle grip 127 with one hand and extend at least one finger from that hand distally to grip at least one projection 115 and pull actuator 122' proximally as described above. While actuator 122' is described herein as having projections 115, actuator 122, or any other suitable actuator, can also include projections 115 and/or any other suitable features that can assist a surgeon in operating surgical instrument 100 with one hand. In at least one embodiment, projections 115 can be at least partially comprised of and/or coated with an elastic or 'soft-touch' material which can improve the surgeon's grip on projections 115 and can provide other ergonomic benefits to the surgeon. In various embodiments, actuator 122', for example, can be operably engaged with shaft assembly 104 such that end effector 106 and shaft assembly 104 can be rotated about a longitudinal axis by actuator 122'. In such embodiments, a surgeon can orient end effector 106

in a surgical site by articulating end effector 106 as described above and/or rotating end effector 106 into position. In at least one embodiment, the surgeon can rotate actuator 122' by positioning a finger against one of projections 115 and applying a force thereto. In various embodiments, the surgeon can hold actuator 122' in position by placing a finger against a projection 115 and resisting any undesired motion of actuator 122' and, correspondingly, end effector 106.

[0099] In various embodiments, a surgical instrument in accordance with the present invention can include a system for closing, or clamping, an end effector onto soft tissue, for example. In at least one embodiment, referring to Figs. 2, 5, 8 and 9, surgical instrument 100 can include closure trigger 128, drive link 130, driver 132, and closure tube 134. In various embodiments, upon an actuation of closure trigger 128, closure trigger 128 can be configured to displace drive link 130, driver 132, and closure tube 134 distally. More particularly, in at least one embodiment, drive link 130 can include a first end pivotably connected to trigger 128 and a second end pivotably connected to driver 132 such that the rotation of trigger 128 toward handle grip 127 can drive link 130 forward and slide driver 132 along an axis defined by driver guide 136 (Fig. 8). In various embodiments, driver 132 can include projections 133 extending therefrom which can be slidably received within slots 135 in driver guide 136 such that slots 135 can define a path for driver 132 as it is moved. In various embodiments, closure tube 134 can be operably engaged with driver 132 such that, when driver 132 is moved distally as described above, closure tube 134 can engage anvil 112 and pivot anvil 112 downwardly. Referring primarily to Fig. 5, closure tube 134 can be configured to slide over articulation joint 114 and pivot anvil 112 relative to staple cartridge 110. In at least one embodiment, as illustrated in Fig. 9, closure tube 134 can include a proximal end having projection 135 extending therefrom which can be received in slot 131 in driver 132 such that the displacement of driver 132 is transmitted to closure tube 134.

[0100] In various embodiments, as described above, locking mechanism 118 can prevent, or at least partially inhibit, relative movement between end effector 106 and shaft assembly 104. In circumstances where soft tissue is clamped between anvil 112 and staple cartridge 110, for example, relative movement between end effector 106 and shaft assembly 104 can apply a shear force to the soft tissue clamped therebetween which may damage it. In various embodiments, referring to Figs. 10-13, in order to prevent, or at least reduce, relative movement between end

effector 106 and shaft assembly 104 when end effector 106 is closed, the end effector closure system can be configured to engage locking mechanism 118 to prevent actuator 122' from being moved into its unlocked position. In effect, in at least one embodiment, the actuation of closure trigger 128 can not only close end effector 106, but it can also prevent locking mechanism 118 from being unlocked. In various embodiments, referring to Figs. 10-13, surgical instrument 100' can include driver 132 which can be configured to abut, or be positioned closely adjacent to, actuator 122' when driver 132 is moved distally by trigger 128 and thereby prevent actuator 122' from being moved proximally as described above with respect to actuator 122. More particularly, before trigger 132 is actuated, as illustrated in Figs. 10 and 11, actuator 122' can be slid proximally in order to slide lock member 120 relative to end effector 106 and unlock articulation joint 114. Upon an actuation of trigger of 132, however, referring to Fig. 13, driver 132 can be configured to abut, or be positioned adjacent to, actuator 122' such that actuator 122' cannot be moved proximally to disengage lock member 120 from end effector 106. As a result, the end effector closure system can prevent end effector 106 from being articulated after it has been closed, thereby reducing the possibility that a shear force will be transmitted to the soft tissue clamped therein.

[0101] Further to the above, the end effector closure system can provide feedback to the surgeon that the end effector has been closed and, in order for the surgeon to unlock and articulate the end effector, the surgeon must first at least partially re-open the end effector before the end effector can be articulated. More particularly, owing to the interaction between driver 132 and actuator 122' when end effector 106 is closed, when a surgeon attempts to pull actuator 122' proximally to unlock articulation joint 114, driver 132 can substantially prevent actuator 122' from moving thereby signaling to the surgeon that end effector 106 is closed and end effector 106 must first be opened before actuator 122' can be moved and the articulation joint can be unlocked. In various embodiments, such an end effector closure system can prevent the surgeon from damaging the surgical instrument and/or tissue captured within, or surrounding, the end effector. More particularly, in at least one embodiment, when closure tube 134 has been advanced to close anvil 112 as described above, closure tube 134 may apply a force to anvil 112 to maintain anvil 112 in a closed position and, in various circumstances, this force can create friction forces within articulation joint 114 which can inhibit, if not prevent, end effector 106 from rotating about articulation joint 114. In embodiments without the end effector closure

system described above, if a surgeon attempts to overcome these friction forces without first at least partially opening the end effector, the surgeon may bend or break one or more components of the surgical instrument, for example. In various embodiments of the present invention, however, driver 132, for example, may prevent the surgeon from releasing articulation lock 120 as described above and, as a result, the surgeon may not be afforded the opportunity to unlock articulation joint 114 let alone articulate end effector 106.

[0102] In various embodiments, a surgical instrument in accordance with the present invention can include an end effector closure system which can position anvil 112, for example, in an open position, a closed position, and a partially closed position. In at least one embodiment, a surgeon can move an anvil 112 into a partially closed position and evaluate whether the end effector should be repositioned or articulated before anvil 112 is moved into its closed position. In such embodiments, anvil 112 can be moved relative to soft tissue positioned intermediate anvil 112 and staple cartridge 110 without applying a shear force, or at least a substantial shear force, to the soft tissue before anvil 112 is completely closed. In at least one embodiment, anvil 112 can be configured such that it does not clamp the soft tissue positioned between anvil 112 and staple cartridge 110 when it is in its partially closed position. Alternatively, anvil 112 can be configured to apply a light clamping force to the soft tissue when anvil 112 is in its partially closed position before applying a larger clamping force when it is moved into its closed position. In at least one such embodiment, the surgical instrument can include a trigger which can be moved between a first position (Fig. 11) which corresponds to the open position of anvil 112, a second position (Fig. 12) which corresponds with its partially closed position, and a third position (Fig. 13) which corresponds with its closed position. In various embodiments, referring to Figs. 8 and 9, trigger 128 can be pivotably mounted to housing 103 of handle portion 102 such that trigger 128 can be rotated about pin 129 between its first, second, and third positions. In various embodiments, referring to Figs. 8, 9, 17 and 18, surgical instrument 100 can further include trigger lock 148 which can be configured to engage trigger 128 and selectively lock trigger 128 in at least one of its first, second, and third positions described above. In at least one embodiment, trigger 128 can include pivot end 138 comprising cam surface 140, first notch 142, and second notch 144 where trigger lock 148 can be configured to engage first notch 142 and second notch 144. More particularly, surgical instrument 100 can further include, referring to Figs. 8 and 9, trigger lock spring 150 which can be configured to bias follower portion 149 of

trigger lock 148 against cam surface 140 such that when either first notch 142 or second notch 144 is aligned with follower portion 149, trigger lock spring 150 can push follower portion 149 into first notch 142 or second notch 144, respectively. In at least one embodiment, referring primarily to Figs. 8 and 9, trigger lock 148 can be pivotably mounted to housing 103 of handle portion 102 via pin 151. In various embodiments, trigger lock spring 150 can be compressed intermediate button portion 152 of trigger lock 148 and housing 103 such that trigger lock spring 150 can rotate trigger lock 148 about pin 151 and bias trigger lock 148 downwardly against cam surface 140 of trigger 128.

[0103] Further to the above, in at least one embodiment, first notch 142 can be aligned with follower portion 149 when trigger 132 is moved into its second position and anvil 112 is moved into its partially closed position. In various embodiments, follower portion 149 can be securely retained within first notch 142 such that trigger lock 148 may need to be manually disengaged from trigger 132 before trigger 132 can be moved into its third position and/or returned to its first position. In at least one embodiment, referring to Figs. 8 and 9, a surgeon can depress button portion 152 of lock member 148 such that lock member 148 is rotated about pin 151 and follower portion 149 is lifted upwardly and out of engagement with trigger 128. In other various embodiments, first notch 142 can be configured such that follower portion 149 can slide out of first notch 142 upon an application of force to trigger 132. In either event, after follower portion 149 has been disengaged from first notch 142, a surgeon can selectively move trigger 132 into its third position or release trigger 132 and allow a trigger spring, for example, to return trigger 132 to its first position. In at least one alternative embodiment, first notch 142 and follower portion 149 can be configured such that, after trigger 132 has been moved into its second position, trigger 132 must be moved into its third position before it can be returned into its first position. In either event, in at least one embodiment, second notch 144 of trigger 132 can be aligned with follower portion 149 when trigger 132 is moved into its third position and anvil 112 is moved into its closed position. Similar to first notch 142, second notch 144 can be configured to retain follower portion 149 therein until lock member 148 is disengaged from trigger 132 and/or a sufficient force is applied to trigger 132 to dislodge follower portion 149 from second notch 144. Thereafter, in various embodiments, a trigger spring can move trigger 132 from its third position into its second position where the surgeon may be required to, similar to the above, disengage follower portion 149 from first notch 142. In at least one alternative embodiment, first notch 142

can be configured such that follower portion 149 can slide past first notch 142 and allow trigger 132 to be moved from its third position to its first position without requiring the surgeon to dislodge follower portion 149 from first notch 142.

[0104] Further to the above, although not illustrated, button portion 152 of lock member 148 can be recessed, for example, within surgical instrument housing 103 when closure trigger 128 is in its first position. In alternative embodiments, button portion 152 can be positioned flushly with housing 103 or it can extend slightly from housing 103. In either event, in at least one embodiment, button portion 152 can move outwardly relative to housing 103 when closure trigger 128 is moved into its second position. Such movement can provide visual feedback to the surgeon that the anvil of the surgical instrument is in its partially closed position. In addition, the movement of button portion 152 can also be accompanied by audio and/or tactile feedback. In either event, a surgeon can access button portion 152 after it has been moved outwardly such that lock member 148 can be disengaged from trigger 128 as described above. In various embodiments, button portion 152 can move outwardly even further when trigger 128 is moved from its second position to its third position. Similar to the above, such movement can provide a visual cue to the surgeon that the anvil is now in its closed position and can be accompanied by audio and/or tactile feedback, as described above. Although button 152 is described above as moving outwardly as trigger 128 is progressed between its first and third positions, the invention is not so limited. On the contrary, button 152, or any other suitable indicator, can be provide feedback to the surgeon in any suitable manner.

[0105] In alternative embodiments, although not illustrated, anvil 112 can be held, or retained, in more than the three positions described above, i.e., its open, closed, and partially-closed positions. In at least one embodiment, anvil 112 can be retained in open, closed, and two or more intermediate positions. In such embodiments, anvil 112 could be progressed through these intermediate positions and apply an increasingly greater force to the soft tissue captured in end effector 106 as anvil 112 is moved toward its closed position. In at least one embodiment, similar to the above, trigger 132 could include a plurality of notches which could correspond with the various intermediate positions of anvil 112. In various alternative embodiments, although not illustrated, the end effector closure system could include a ratchet assembly which could allow trigger 132 and, correspondingly, anvil 112 to be held in a plurality of positions. In

such embodiments, anvil 112 and trigger 132 could be held in place by a pawl pivotably engaged with a ratchet wheel operably engaged with trigger 132.

[0106] In various embodiments, referring to Figs. 10-13, the relative movement between actuator 122' and handle portion 102', as described above, can be limited in order to control the range through which lock member 120 can be displaced. More particularly, referring to Figs. 10 and 11, the distal portion of actuator 122' can include projection 123 extending therefrom which can be received in cavity 125 where the displacement of actuator 122' can be limited by proximal wall 117 and distal wall 119 of cavity 125. In at least one embodiment, when trigger 128 is in its first position, as illustrated in Figs. 10 and 11, actuator 122 can be moved from a distal position in which projection 123 can abut distal wall 119, as illustrated in Fig. 10, into a more proximal position in which projection 123 does not abut distal wall 119, as illustrated in Fig. 11. In this more distal position, as described above, lock member 120 can be disengaged from end effector 106 and end effector 106 can be rotated relative to shaft assembly 104. When trigger 128 is in its second position, referring to Fig. 12, driver 132 can limit the range of motion of actuator 122' such that projection 123 cannot be positioned against proximal wall 117. In at least one embodiment, however, actuator 122' can be moved proximally a sufficient distance to disengage lock member 120 from end effector 106. In these circumstances, a surgeon can reposition end effector 106 although anvil 112 may be partially closed onto the soft tissue, for example. When trigger 128 is in its third position, as illustrated in Fig. 13, driver 132 can force actuator 122' distally such that projection 132 abuts, or is positioned adjacent to, distal wall 119 and actuator 122' cannot be moved sufficiently to unlock articulation joint 114.

[0107] In various embodiments, a surgical instrument in accordance with the present invention can include a firing drive configured to advance a cutting member and/or staple driver within an end effector as described above. In at least one embodiment, referring to Figs. 8, 9 and 19-25, the firing drive of surgical instrument 100 can include firing trigger 160, first firing link 162, second firing link 164, and firing member 166. In various embodiments, firing trigger 160 can be operably engaged with at least one of firing member 166 and firing links 162 and 164 in order to advance knife bar 168 within elongate shaft assembly 104. In at least one embodiment, knife bar 168 can be operably engaged with a cutting member (not illustrated) and a staple driver (not illustrated) in end effector 106 where the cutting member can be configured to incise tissue, for example, and the staple driver can be configured to deploy staples from staple cartridge 110.

Cutting members and staple drivers are well disclosed in U.S. Patent Nos. 6,905,057 and 7,044,352, which have been previously incorporated by reference into the present application, and, as a result, these devices are not described in greater detail herein. Other cutting members and staple drivers are disclosed in U.S. Patent Application Serial No. 11/541,123, entitled SURGICAL STAPLES HAVING COMPRESSIBLE OR CRUSHABLE MEMBERS FOR SECURING TISSUE THEREIN AND STAPLING INSTRUMENTS FOR DEPLOYING THE SAME, which was filed on September 29, 2006, and U.S. Patent Application Serial No. 11/652,169, entitled SURGICAL STAPLING DEVICE WITH A CURVED CUTTING MEMBER, which was filed on January 11, 2007, the entire disclosures of which are hereby incorporated by reference herein.

[0108] In various embodiments, referring primarily to Figs. 19 and 20, firing trigger 160 can be pivotably connected to surgical instrument housing 103 (Figs. 8 and 9) by pin 161. In use, in at least one embodiment, firing trigger 160 can be pivoted about pin 161 in order to advance firing member 166 and firing links 162 and 164 distally. In various embodiments, firing trigger 160 can include slots 159, where slots 159 can be configured to receive firing pin 172. In various embodiments, when firing trigger 160 is actuated, or rotated, from its position illustrated in Fig. 2 to a position adjacent handle grip 127, the side walls of slots 159 can be configured to engage and advance firing pin 172 distally. In at least one embodiment, referring to Fig. 23, the firing drive can further include pawl 170, where pawl 170 can include aperture 171. In various embodiments, aperture 171 can be configured to receive at least a portion of firing pin 172 such that, when firing pin 172 is advanced distally by trigger 160, firing pin 172 can advance pawl 170 distally as well. In various embodiments, referring to Fig. 24, pawl 170 can include tooth 174 and firing member 166 can include recess 167, where recess 167 can be configured to receive tooth 174. In use, when pawl 170 is advanced distally by firing pin 172 and tooth 174 is engaged with a side wall of recess 167, pawl 170 can advance firing member 166 distally as well. In various embodiments, pawl 170 can be advanced distally by firing pin 172 along a substantially linear path. In such embodiments, slots 159 can include arcuate profiles which can, in cooperation with firing pin 172, convert the rotational motion of firing trigger 160 into translational motion of pawl 170. In at least one embodiment, the force applied to pawl 170 can be substantially, if not entirely, directed in the distal direction. In such embodiments, as a result, the possibility of pawl 170 becoming bound or stuck against stapler frame 184 can be reduced.

[0109] In various embodiments, pawl 170 can be pivoted between a first position in which pawl 170 is operably disengaged from firing member 166 and a second position, referring to Figs. 19 and 20, in which pawl 170 is operably engaged with firing member 166. Referring primarily to Figs. 21-25, the firing drive can further include tilter mechanism 178 which can be configured to pivot pawl 170 between its first and second positions. In use, when firing trigger 160 is actuated, pawl 170 can be moved, at least initially, relative to tilter mechanism 178 such that at least a portion of pawl 170 can abut tilter mechanism 178 and pivot pawl 170 upwardly and into operative engagement with firing member 166. In at least one embodiment, pawl 170 can include, referring primarily to Fig. 23, groove 175 which can be configured to receive projection 179 (Fig. 25) extending from the center portion of tilter mechanism 178. In at least one embodiment, as pawl 170 is advanced distally, proximal wall 176 of groove 175 can contact a cam surface on projection 179 and, owing to the force applied to pawl 170 by pivot pin 172, pawl 170 can be pivoted, or rotated, upwardly such that tooth 174 can be positioned in recess 167 of firing member 166 as described above. After pawl 170 has been pivoted, pawl 170 can drag tilter mechanism 178 distally as pawl 170 is advanced toward end effector 106. More particularly, in at least one embodiment, tilter mechanism 178 can include deformable members 180 which can be received within slots 182 in stapler frame 184 such that the interaction between deformable members 180 and stapler frame 184 at least partially inhibits the movement of tilter mechanism 178 relative to stapler frame 184. Stated another way, owing to static friction forces between deformable members 180 and the side walls of slots 182, a force sufficient to overcome these friction forces must be applied to tilter mechanism 178 before tilter mechanism 178 can be 'dragged' relative to stapler frame 184.

[0110] After firing trigger 160 has been actuated and firing member 166 has been advanced, trigger 160 can be released and returned to its unactuated position illustrated in Fig. 2 and pawl 170 can be disengaged from firing member 166 and retracted to its starting position illustrated in Fig. 19. More particularly, in at least one embodiment, surgical instrument 100 can further include a trigger spring (not illustrated) operably engaged with trigger 160 and housing 103, for example, where the trigger spring can be configured to rotate trigger 160 about pin 161 and drive firing pin 172 proximally after pawl 170 has been disengaged from firing member 166. In various embodiments, pawl 170 can be disengaged from firing member 166 when it is pivoted from its second position, as illustrated in Fig. 24, into its first position, as described above, by

tilter mechanism 178. In such embodiments, pawl 170 can be moved, at least initially, relative to tilter mechanism 178 such that distal wall 177 of groove 175 can contact a second cam surface on projection 179 and can, owing to a force applied to firing pin 172 by trigger 160 or return spring 186, rotate pawl 170 downwardly such that tooth 174 of pawl 170 can be disengaged from recess 167 in firing member 166. Thereafter, trigger 160 and/or return spring 186 can pull, or retract, pawl 170 relative to firing member 166. In various embodiments, similar to the above, pawl 170 can be configured to drag tilter mechanism 178 proximally within slot 182. As a result of the above, pawl 170 does not need to be biased into its first or second positions. In various circumstances, pawl 170 can be rotated freely between its first and second positions without having to overcome a force applied thereto by a biasing spring. In effect, in various embodiments, the force to move pawl 170 between its first and second positions need only overcome the gravitational weight of pawl 170 and any frictional forces between pawl 170 and the surrounding components of the surgical instrument.

[0111] Once pawl 170 has been returned to its original position, in at least one embodiment, tooth 174 of pawl 170 may no longer be aligned with recess 167 in firing member 166. On the contrary, referring generally to Figs. 19 and 20, tooth 174 of pawl 170 can be aligned with recess 163 in first firing link 162. More particularly, first firing link 162 can be pivotably connected to firing member 166 such that, when firing member 166 is advanced distally, as described above, firing member 166 can pull first firing link 162 into the position that firing member 166 previously occupied. As a result, upon a second actuation firing trigger 160, pawl 170 can be pivoted from its first position into its second position such that tooth 174 is operably engaged with recess 163 and pawl 170 can advance firing link 162 distally. In at least one embodiment, firing link 162 can push firing member 166 and knife bar 168 distally and, correspondingly, advance the cutting member and the staple driver distally within end effector 106. Thereafter, pawl 170 can once again be pivoted from its second position to its first position and can be retracted relative to first firing link 162. Once pawl 170 is returned to its original position for the second time, tooth 174 of pawl 170 may no longer be aligned with recess 163 of first firing link 162. On the contrary, similar to the above, tooth 174 can be aligned with recess 165 in second firing link 164 and the process described above can be repeated.

[0112] Although not illustrated, a surgical instrument in accordance with the present invention can include more than two, or less than two, firing links in order to advance the cutting member

and staple driver to their desired positions within end effector 106. In various embodiments, although not illustrated, firing member 166 can include more than one recess 167 such that pawl 170 can directly advance firing member 166 toward end effector 106 more than once. In at least one such embodiment, pawl 170 can be retracted after advancing firing member 166 distally, as described above, such that, when pawl 170 is once again tilted upwardly, pawl 170 can engage another recess 167 in firing member 166 and advance firing member 166 toward end effector 106 once again. As a result, in at least one embodiment, firing links 162 and 164 may not be required.

[0113] In various embodiments, a surgical instrument can include one or more spring members configured to move pawl 170 into at least one of its first and second positions. In at least one embodiment, referring to Figs. 27 and 28, the firing drive can include pawl 170', firing pin 172, and tilter mechanism 178' where, similar to the above, tilter mechanism 178' can be configured to pivot pawl 170' upwardly when pawl 170' is advanced distally. The firing drive can further include pivot spring 188 which can be operably connected to pawl 170' such that, when pawl 170' is pivoted upwardly into its second position as illustrated in Fig. 27, pawl 170' can flex, or resiliently bend, pivot spring 188. After pawl 170' has been advanced, pawl 170' can be pivoted downwardly into its first position by pivot spring 188 as illustrated in Fig. 28. More particularly, owing to potential energy stored in pivot spring 188 when it is flexed, spring 188 can move pawl 170' downwardly once pawl 170' is no longer held in its second position by tilter mechanism 178' and firing pin 172. Thereafter, as described above, pawl 170' can be retracted relative to firing member 166 and/or firing links 162 and 164. In various embodiments, tilter mechanism 178' may not include a second cam surface for pivoting pawl 170 into its first position. In such embodiments, pawl 170' can be retracted by a force applied to firing pin 172 as described above. In various alternative embodiments, although not illustrated, tilter mechanism 178' and pawl 170' can also include co-operating features for pivoting pawl 170' downwardly into its first position.

[0114] In various embodiments, referring to Figs. 19 and 20, surgical instrument 100 can further include band 190 which can be configured to move firing member 166 and firing links 162 and 164 relative to end effector 106. In at least one embodiment, a first end of band 190 can be connected to firing member 166, for example, such that, when firing member 166 is advanced distally, band 190 can be pulled distally as well. In various alternative embodiments, band 190

can be connected to first firing link 162 and/or second firing link 164. In at least one embodiment, band 190 can be positioned around at least a portion of reel, or spool, 192 such that when band 190 is pulled by firing member 166, band 190 can be deployed, or unwound, from reel 192. In at least one embodiment, a second end of band 190 can be connected to reel 192 such that band 190 cannot be readily disengaged from reel 192 under the normal operating conditions of surgical instrument 100. In either event, when band 190 is pulled by firing member 166, reel 192 can be rotated in one of a clockwise or counter-clockwise direction, depending on the manner in which band 190 is positioned around reel 192. In order to retract firing member 166, reel 192 can be rotated in an opposite direction to move firing member 166, and firing links 162 and 164, proximally and wind band 190 around reel 192.

[0115] In various embodiments, band 190 can be wound around reel 192 such that band 190 is wrapped around a substantially cylindrical surface on reel 192. In at least one embodiment, the distance between an axis of rotation of reel 192 and the cylindrical surface can be substantially equidistant around the perimeter of reel 192. In these embodiments, the mechanical advantage of reel 192 can remain substantially constant as band 190 is pulled proximally as described above and the capacity for reel 192 to apply a pulling force to band 190 can remain substantially the same. In alternative embodiments, however, reel 192 can be configured to provide a variable mechanical advantage. In at least one embodiment, reel 192 can include a non-cylindrical surface on which band 190 can be wrapped such that the distance between the axis of rotation of reel 192 and the non-cylindrical surface is not equidistant around the perimeter of reel 192. In these embodiments, as a result, the capacity for reel 192 to apply a pulling force to band 190 can change as band 190 is wound around reel 192. In at least one embodiment, reel 192 can act as a cam and can include a shape which can be optimized to provide additional force to band 190 when it is initially retracted, i.e., when the force to retract the cutting member, for example, can be at its highest.

[0116] In various embodiments, referring to Figs. 29-42, firing trigger 160 can be selectively engaged with a return mechanism of surgical instrument 100. In at least one embodiment, when firing trigger 160 is operably engaged with firing member 166 via pawl 170, as described above, an actuation of firing trigger 160 can advance firing member 166 distally and, when firing trigger 160 is operably engaged with firing member 166 via band 190, an actuation of firing trigger 160 can retract firing member 166 proximally. In various embodiments, the return mechanism can be

manually actuated to disengage firing trigger 160 from firing member 166 and to operably engage firing trigger 160 with reel 192. In at least one embodiment, the return mechanism can include return carriage 194 which can be pivotably mounted in surgical instrument housing 103 such that return carriage 194 can be pivoted between a first, or unactuated, position as illustrated in Fig. 29 and a second, or actuated, position as illustrated in Fig. 32. In at least one such embodiment, return carriage 194 can include push button portion 195 which, when a force is applied thereto, can be configured to move return carriage 194 from its unactuated position to its actuated position.

[0117] When return carriage 194 is positioned in its unactuated position illustrated in Figs. 29-31, firing trigger 160 can be configured to advance firing member 166 as described above and gear portion 158 of trigger 160 can be operatively engaged with trigger gear 196. In various embodiments, gear portion 158 and trigger gear 196 can be operably engaged such that a rotation of trigger 160 about pin 161 can drive trigger gear 196 about an axis defined by return pin 198. In at least one embodiment, when return carriage 194 is in its unactuated position, trigger gear 196 can be configured to rotate freely about return pin 198 such that the rotation of trigger gear 196 is not transmitted, or at least not substantially transmitted, to return pin 198. More particularly, referring to Fig. 30, key 199 of return pin 198 can be biased out of engagement with trigger gear 196 such that the rotation of trigger gear 196 is not transmitted to key gear 206 and reel 192. As a result, an actuation of trigger gear 160 does not rotate, or at least substantially rotate, reel 192 when return carriage 194 is in its unactuated position.

[0118] After the cutting member and the staple driver have been advanced within end effector 106, return carriage 194 can be moved into its actuated position. In various embodiments, referring to Fig. 30, reel 192 can include cam member 202 extending therefrom which can contact return carriage 194 and rotate return carriage 194 downwardly. In at least one embodiment, cam member 202 can contact return carriage 194 during the final actuation of trigger 160 which advances the cutting member and staple driver within end effector 106. In at least one such embodiment, cam member 202 can contact return carriage 194 after the third actuation of firing trigger 160. In various embodiments, referring to Figs. 32-35, when gear carriage 194 is moved into its actuated position, return carriage 194 can be configured to operably engage trigger gear 196 with reel 192. In at least one embodiment, referring to Figs. 33 and 35, return carriage 194 can include biasing spring 200 where, when return carriage 194 is in

its unactuated position, spring 200 can be located in the position illustrated in Fig. 33 and, when return carriage 194 is moved into its actuated position illustrated in Fig. 35, spring 200 can contact return pin 198 and bias return pin 198 toward trigger gear 196. In at least one embodiment, referring to Fig. 31, trigger gear 196 can include D-shaped cavity 197 therein which can, under certain circumstances explained below, receive key 199 extending from return pin 198 and operably engage trigger gear 196 with key gear 206 and reel 192. In various embodiments, the movement of return carriage 194 into its actuated position can be accompanied by an audio and/or tactile feedback to inform the surgeon that the return mechanism of the surgical instrument has been engaged with trigger 160.

[0119] Further to the above, when return pin 198 is slid toward trigger gear 196, D-shaped cavity 197 can be positioned such that key 199 does not immediately enter cavity 197. On the contrary, referring to Fig. 31, spring 200 can bias return pin 198 such that key 199 initially abuts face 204 of trigger gear 196. After trigger 160 is released and is returned to its unactuated position, however, D-shaped cavity 197 can be rotated and aligned with key 199 such that spring 200 can bias key 199 into cavity 197 as illustrated in Fig. 36. In at least one embodiment, referring to Fig. 31, when return pin 198 is slid toward trigger gear 196, an end of return pin 198 can be received in slot 193 in return carriage 194 as illustrated in Fig. 32. After key 199 has been inserted into cavity 197, a subsequent actuation of trigger 160 can cause drive surface 210 of D-shaped cavity 197 to abut key 199 and rotate return pin 198 to a position illustrated in Figs. 37 and 38. In effect, an actuation of trigger 160, in at least one embodiment, can rotate key 199 approximately half a revolution such that key 199, which is initially extending substantially downwardly (Fig. 36), can be rotated such that key 199 is extending substantially upwardly (Fig. 37). Thereafter, trigger 160 can be released and trigger gear 194 can be rotated relative to key 199 where key 199 can remain oriented in a substantially upward direction as illustrated in Figs. 39-41.

[0120] In various embodiments, referring primarily to Fig. 38, key gear 206 can be operably engaged with return pin 198 such that the rotation of return pin 198 can be transmitted to key gear 206. In at least one embodiment, key gear 206 can include key-shaped aperture 212 which can be configured to slidably receive key 199 of return pin 198. In at least one such embodiment, key 199 can be operably engaged with both recess 197 of trigger gear 196 and aperture 212 of key gear 206 when return pin 198 is engaged with trigger gear 196. In various

alternative embodiments, key gear 206 can be fixedly mounted to return pin 198. In such embodiments, when return pin 198 is slid relative to trigger gear 196, key gear 206 can also be slid relative to trigger gear 196. In various embodiments, referring generally to Fig. 38, reel 192 can include spur gear 216 mounted thereto, where spur gear 216 can be operatively engaged with key gear 206 such that the rotation of key gear 206 can be transmitted to reel 192. In at least one embodiment, key gear 206, when it is slid toward trigger gear 196 as described above, can be slid into operative engagement with reel 192. In alternative embodiments, spur gear 216 can be configured such that key gear 206 is in operative engagement therewith regardless of whether key gear 206 has been biased toward trigger gear 196.

[0121] As a result of the above, when return carriage 194 is positioned in its actuated position illustrated in Fig. 32, an actuation of trigger 160 can rotate reel 192 and wind band 190 around at least a portion thereof. In the event that key 199 cannot be operably engaged with trigger gear 196 when return carriage 194 is actuated, reel 192 can be rotated manually to retract band 190. In at least one such embodiment, referring to Figs. 33 and 37, bolt, or fastener, 218 can be operatively engaged with reel 192 such that the rotation of bolt 218 can effect rotation of reel 192. In various embodiments, a surgeon can insert bolt 218 through an opening in surgical instrument housing 103 and engage bolt 218 with reel 192. In at least one embodiment, surgical instrument 100 can further include a counting mechanism (not illustrated) which can count the actuations of trigger 160 and, in at least one such embodiment, bolt 218, for example, can be operably engaged with the counting mechanism to rotate reel 192. In various embodiments, as a result, the surgical instrument can include a first, or primary, actuator for winding reel 192 and a second actuator which can be configured to wind reel 192 in lieu of the first actuator.

[0122] In various embodiments, as described above, reel 192 can be configured to pull band 190 and retract firing member 166 and firing links 162 and 164 proximally. More particularly, as described above, firing member 166 and firing links 162 and 164 can be retracted relative to pawl 170 in order to reposition firing member 166 and firing links 162 and 164 in their starting positions. In such embodiments, especially in embodiments where pawl 170 is pivotable as described above, the return mechanism of surgical instrument 100 can be further configured to hold pawl 170 out of operative engagement with firing member 166 and firing links 162 and 164 while they are moved relative to pawl 170. More particularly, when return carriage 194 is moved into its actuated position illustrated in Fig. 35, return carriage 194 can be configured to

contact an end of firing pin 172 and slide firing pin 172 toward pawl 170 such that firing pin 172 engages pawl 170 and prevents pawl 170 from pivoting upwardly. More particularly, referring to Fig. 34, firing pin 172 can include first end 220 which can include a beveled and/or rounded surface, for example, where, when return carriage 194 contacts first end 220, return carriage 194 can push firing pin 172 toward pawl 170. In at least one embodiment, pawl 170 can include recess 173 which can be configured to receive key 222 extending from firing pin 172 when firing pin 172 is moved toward pawl 170. When key 222 and recess 173 are operatively engaged, firing pin 172 can prevent pawl 170 from pivoting upwardly into engagement with firing member 166 and firing links 162 and 164.

[0123] After firing member 166 and firing links 162 and 164 have been retracted, a new staple cartridge 110 can be secured in end effector 106 and surgical instrument 100 can be reset such that it can be used to incise and staple soft tissue once again. In various embodiments, referring to Figs. 39-42, return carriage 194 can be moved from its actuated position illustrated in Fig. 32 to its unactuated position illustrated in Fig. 40. In at least one embodiment, return carriage 194 can be rotated, or pivoted, upwardly when a force is applied to button portion 195. Alternatively, return carriage 194 can be moved upwardly when, referring to Fig. 29, trigger lock 148 is rotated upwardly to disengage follower portion 149 from closure trigger 128 in order to reopen end effector 106 as described above. More particularly, when a force is applied to button portion 152 of trigger lock 148, trigger lock 148 can be rotated upwardly such that projection 147 extending therefrom can contact return carriage 194 and move return carriage 194 upwardly as well. In either event, referring to Fig. 42, when return carriage 194 is moved upwardly into its unactuated position, return carriage 194 can disengage firing pin 172 from pawl 170 and, in addition, disengage return pin 198 from trigger gear 196. More particularly, return carriage 194 can be configured to abut beveled, or rounded, end 221 of firing pin 172 such that, when return carriage 194 is rotated upwardly, return carriage 194 can slide return pin 172 away from pawl 170 and disengage key 222 from recess 173. Similarly, when return carriage 194 is moved upwardly, a side wall of slot 193 can be configured to contact an end of return pin 198 and slide return pin 198 away from trigger gear 196 to disengage key 199 from D-shaped recess 197. In short, in at least the illustrated embodiment, when button portion 152 of lock member 148 is depressed and return carriage 194 is moved upwardly, the surgical instrument can be reset and can be reused once again.

[0124] Although the surgical instruments described above can be reset after the cutting member and staple driver have been completely advanced within end effector 106, button portion 195 of return carriage 194, for example, can be depressed after the cutting member and staple driver have been only partially advanced within end effector 106. In various embodiments, return carriage 194 can further include guide pin 191 extending between opposite sides of return carriage 194. In at least one such embodiment, guide pin 191 can be slidably received within guide slot 185 (Fig. 31) in frame 184 such that slot 185 and pin 191 can define a path for return carriage 194. In various embodiments, guide pin 191 and guide slot 185 can be configured to assure that return carriage 194 engages firing pin 172 and return pin 198 and resets the surgical instrument when return carriage 194 is moved from its actuated position to its unactuated position as described above.

[0125] In various embodiments, surgical instrument 100 can further include a brake for preventing, or at least partially inhibiting, the firing drive from advancing and/or retracting the cutting member and staple driver, for example, within end effector 106. In at least one embodiment, referring to Fig. 43, frame 184 can include brake surface 187 where brake surface 187 can be configured to apply a braking force to band 190. More particularly, when band 190 is pulled proximally and/or distally as described above, frame 184 can be configured such that band 190 slides over brake surface 187 and a friction force is created therebetween. In various embodiments, referring to Fig. 44, brake surface 187' can be configured such that the path of band 190 between firing member 166 and reel 192 is interrupted by brake surface 187' and a significant normal force can be applied to band 190.

[0126] In at least one embodiment, band 190 can be engaged with brake surface 187' when band 190 is at rest such that a static friction force between band 190 and brake surface 187' can prevent, at least initially, band 190 from moving relative to brake surface 187' when a pulling force is applied to band 190. When the pulling force applied to band 190 exceeds the static friction force, band 190 can be moved relative to brake surface 187'. Such embodiments may be particularly useful when trigger 160 is actuated more than one time to advance the cutting member and/or staple driver within end effector 106. More particularly, after an actuation of trigger 160, pawl 170 can be retracted relative to firing member 166 as described above and, in various embodiments, the friction force between band 190 and brake surface 187' can prevent, or at least partially inhibit, firing member 166 and/or firing links 162 and 164 from moving

proximally, and/or distally, as pawl 170 is retracted. As a result of the above, the alignment between tooth 174 of pawl 170 and the recesses in firing member 166 and firing links 162 and 164 can be maintained when pawl 170 is moved relative thereto.

[0127] Similarly, in at least one embodiment, the stiffness of band 190 can also assist in holding firing member 166 and firing links 162 and 164 in position. More particularly, in order for firing member 166 to 'back up', or move proximally, firing member 166 would have to push band 190 proximally and, in effect, wind band 190 around reel 192. In various embodiments, the stiffness of band 190 can be such that a significant force to wind band 190 around reel 192 is required and, as a result, firing member 166 can be held in place. To further increase the force required to wind band 190 around reel 192, referring to Fig. 44, the path of band 190 can be controlled such that it is not wound onto reel 192 in a tangential direction. More particularly, if the path of band 190 is such that it is wound onto reel 192 in a non-tangential direction, a portion of the force transmitted through band 190 will be lost thus resulting in a poor mechanical advantage for winding reel 192.

[0128] In various embodiments, surgical instrument 100 can include a brake which can be engaged with reel 192, or any other suitable component of the firing drive, to prevent firing member 166 and/or firing links 162 and 164 from being retracted unintentionally, for example. In at least one embodiment, although not illustrated, the brake can be moved between a first position and a second position, where, when the brake is in the first position, the brake can apply a first braking force to band 190, for example. In at least one such embodiment, the brake can apply, when it is in the second position, a second braking force to band 190, for example, which can be greater than or less than the first braking force. In various alternative embodiments, the brake may not be engaged with band 190 or any other portion of the firing drive when the brake is in the second position. In various embodiments, although not illustrated, surgical instrument 100 can include a detent mechanism which can apply a braking force to reel 192 and/or band 190. In at least one such embodiment, the detent mechanism can include a ball detent and a spring member for biasingly engaging the ball detent against reel 192 and/or band 190.

[0129] In various embodiments, surgical instrument 100 can include a ratchet which can allow reel 192 to turn in a first direction but can, in various circumstances, prevent reel 192 from turning in a direction opposite the first direction. In at least one embodiment, referring to Figs. 45-49, surgical instrument 100 can include ratchet assembly 230, where ratchet assembly 230

can include ratchet wheel 232 and ratchet pawl 234. In various embodiments, ratchet wheel 232 can operate in substantially the same way as key gear 206 described above except that, referring primarily to Figs. 47 and 48, ratchet wheel 232 can include ratchet teeth 236 which can, owing to a ratcheting engagement with ratchet pawl 234, prevent ratchet wheel 232 from being turned in a clockwise direction, for example, when return carriage 194' is in its unactuated position (Fig. 47). More particularly, each ratchet tooth 236 can include a flat surface 240 where, referring to Fig. 48, at least one of flat surfaces 240 can abut edge 235 of pawl 234 and thereby prevent ratchet wheel 232 from being rotated in a clockwise direction.

[0130] Each ratchet tooth 236 can further include an inclined surface 238, where inclined surfaces 238 can be configured to slide underneath pawl 234 when ratchet wheel 232 is turned in a counter-clockwise direction. As a result of the above, ratchet assembly 230 can allow band 190 to be pulled distally by firing member 166, for example, but prevent, or at least substantially inhibit, band 190 from being moved proximally, at least when return carriage 194 is in its unactuated position. When return carriage 194' is pivoted downwardly into its actuated position, as described above with regard to return carriage 194, ratchet wheel 232 can be slid toward trigger gear 196' and out of operative engagement with ratchet pawl 234. Thereafter, as a result, ratchet wheel 232 can be rotated in either a clockwise or counter-clockwise direction without interference, or at least substantial interference, from ratchet pawl 234. In various alternative embodiments where ratchet wheel 232 is not slid toward trigger gear 196', ratchet pawl 234 can be moved downwardly and out of operative engagement with ratchet teeth 236 when return carriage 194' is moved into its actuated position. In either event, when return carriage 194' is in its actuated position, trigger gear 196' and return pin 198' can rotate ratchet wheel 232 and cam 192' to retract band 190 and firing member 166.

[0131] In various embodiments, referring to Fig. 50, surgical instrument 100 can include end effector 106 and elongate shaft assembly 104, where end effector 106 and shaft assembly 104 can be pivotably connected by articulation joint 114. As outlined above, articulation joint 114 can allow end effector 106 to be moved, or articulated, relative to shaft assembly 106 about axis 116. In various circumstances, a surgeon can articulate end effector 106 to more easily access a surgical site within a patient's body. More particularly, a surgeon may insert end effector 106 and shaft assembly 104 through a cannula at least partially inserted into the patient's body and, once end effector 106 has passed through the cannula, end effector 106 can be pivoted, or

articulated, in order to position end effector 106 relative to soft tissue, for example, in the surgical site that is to be stapled and/or incised. Once end effector 106 has been positioned, the relative relationship between end effector 106 and shaft assembly 104 can be fixed, or locked, by a locking mechanism as described in greater detail further below.

[0132] In at least one embodiment, referring to Figs. 51 and 52, articulation joint 114 can include end effector lock member 300 and pivot 302. In various embodiments, referring to Figs. 53-56, end effector lock member 300 can include connector portion 320 which can secure lock member 300 to end effector 106 and, referring to Fig. 52, shaft assembly 104 can include pivot connector 342, where pivot connector 342 can include pivot 302 extending therefrom. In various embodiments, lock member 300 can include aperture 301 which can be sized and configured to receive at least a portion of pivot 302 therein. In at least one embodiment, pivot 302 and aperture 301 can be configured such that end effector 106 can rotate freely about axis 116. In other various embodiments, pivot 302 and aperture 301 can be configured such that friction between pivot 302 and aperture 301 can resist, although permit, relative movement between end effector 106 and shaft assembly 104. Although not illustrated, articulation joint 114 can include more than one axis, or pivot, about which end effector 106 can be rotated.

[0133] In various embodiments, a surgeon can articulate end effector 106 relative to shaft assembly 104 by pushing end effector 106 against a cavity side wall surrounding a surgical site, for example, and applying a force to shaft assembly 104 such that end effector 106 pivots about axis 116. Thereafter, if the surgeon desires to re-center end effector 106, i.e., orient end effector 106 and shaft assembly 104 along a line, the surgeon can place end effector 106 against a cavity side wall once again, for example, and apply a force to shaft assembly 104 as described above. In various embodiments, referring to Figs. 51 and 52, surgical instrument 100 can include a re-centering mechanism which can automatically re-center, or at least substantially re-center, end effector 106 relative to shaft assembly 104. In various embodiments, end effector lock member 300 can include centering surfaces 316 and elongate shaft assembly 104 can include centering shafts 328 and biasing members 330, where biasing members 330 can be configured to bias centering shafts 328 against centering surfaces 316. In at least one such embodiment, centering surfaces 316 can be disposed on substantially opposite sides of axis 116 such that centering shafts 328 can apply a substantially equal torque, or moment, to lock member 300 and, absent an additional motivating force, hold end effector 106 in a substantially centered position. When end

effector 106 is articulated by such a motivating force, as described above, lock member 300 can be configured to displace one of centering shafts 328 proximally and compress the biasing member 330 operably engaged therewith. More particularly, the biasing member 330 can be positioned between a guide 331 and at least one projection 329 extending from centering shaft 328 such that, when projection 329 is moved proximally by shaft 328, biasing member 330 is compressed therebetween. After the motivating force is removed, the compressed biasing member 330 can expand and rotate lock member 300 to its center position via centering shaft 328, or to a position where the torque applied by biasing members 330 is substantially balanced. Although biasing member 330 is illustrated as a coil spring, biasing member 330 can include any suitable elastic member.

[0134] In various embodiments, a locking mechanism can be used to hold end effector 106 in its articulated position even after the motivating force has been removed. In at least one embodiment, referring to Figs. 53-56, end effector lock member 300 can include a first portion having first surface 308, a second portion having second surface 304, teeth 312, and recesses 314 defined between teeth 312 where, as described in greater detail further below, teeth 312 and recesses 314 can be configured to be operably engaged with a shaft assembly locking member in order to fix, or lock, the relative relationship between end effector 106 and shaft assembly 104. In various embodiments, teeth 312 and recesses 314 can be positioned intermediate first surface 308 and second surface 304. In at least one embodiment, first surface 308 can extend from aperture 301 to first perimeter 310, and second surface 304 can extend from aperture 301 to second perimeter 306. In various embodiments, first perimeter 310 can define a first plane and second perimeter 306 can define a second plane where teeth 312 and recesses 314 can be positioned intermediate the first and second planes. In embodiments where first perimeter 310 is different than second perimeter 306, teeth 312 can extend at an angle, or bevel, therebetween. In various embodiments, a tooth 312 can intersect first perimeter 310 at a point further away from axis 116 than a point at which the tooth 312 intersects second perimeter 306. In at least one embodiment, at least one of the teeth 312 can define a first axis 313 which can extend between first surface 308 and second surface 304 in a direction which is not perpendicular to first surface 308 and/or axis of rotation 116. In such embodiments, teeth 312 can slide over soft tissue, for example, which is positioned adjacent to articulation joint 114. Stated another way, owing to the angled, or beveled, surfaces of teeth 112, the probability of teeth 112 catching on, or impinging

upon, the soft tissue surrounding articulation joint 114 when end effector 106 is articulated can be reduced. In at least one embodiment, teeth 312 may not extend beyond first perimeter 310 such that, in the event that at least a portion of first perimeter 310 is in contact with soft tissue, for example, first perimeter 310 and teeth 312 can, as above, easily slide relative to the soft tissue.

[0135] Further to the above, embodiments of the present invention can provide significant advantages over previous surgical instruments. More particularly, referring to Fig. 57, the articulation joints of previous end effectors have included lock members, such as lock member 299, for example, which include teeth 298 that extend outwardly from the perimeter of the lock member. As a result, when the end effector is articulated relative to the shaft assembly of the surgical instrument, teeth 298 can catch on, or impinge upon, the surrounding soft tissue and potentially cause trauma thereto. In various circumstances, tissue can be caught between adjacent teeth 298 such that, when the end effector is articulated, the soft tissue can be pulled into the articulation joint and can be pinched by the relatively moving components of the joint. In embodiments of the present invention in which the teeth of the lock member are angled, or beveled, as outlined above and illustrated in Fig. 58, the soft tissue can more easily flow over the teeth and reduce the possibility that the soft tissue can be pulled into the articulation joint.

[0136] As outlined above, referring to Figs. 59-62, surgical instrument 100 can further include locking member 120 which can be slid relative to end effector 106 and can be operably engaged with end effector 106 to prevent, or at least limit, relative movement between shaft assembly 104 and end effector 106. In at least one embodiment, lock member 120 can be configured to engage at least one of teeth 312 such that end effector 106 is prevented from moving relative to lock member 120. More particularly, lock member 120 can include end portion 338 and shaft portion 340, where end portion 338 can include recess 336 which can be configured to receive a tooth 312 of lock member 300 in a close-fit, or even interference-fit, relationship. In various alternative embodiments, locking portion 338 can be received within at least one of recesses 314 in a close-fit, or interference-fit, relationship similar to the above. In either event, surgical instrument 100 can further include spring 126 which can be configured to bias lock member 120 into engagement with end effector lock member 300. In the event that recess 336 is not aligned with a tooth 312, in at least one embodiment, the biasing force applied to lock member 120 by spring 126 can cause lock member 120 to contact and rotate end effector lock member 300 about

axis 116 until one of teeth 312 is aligned with recess 336. In various embodiments, spring 126 can comprise any suitable biasing member including a helical spring, leaf spring, or other biasing material.

[0137] In various alternative embodiments, referring to Figs. 63-67, a surgical instrument can include end effector lock member 350 comprising aperture 301, a first portion including first surface 358, a second portion including second surface 354 (Fig. 67), and connector portion 320. End effector lock member 350 can also comprise teeth 362 and recesses 364 defined between teeth 362 where, in at least one embodiment, teeth 362 and recesses 364 can be positioned intermediate first surface 358 and second surface 354. In various embodiments, referring to Figs. 65-67, teeth 362 may not extend beyond first perimeter 357 of first surface 358 and/or second perimeter 353 of second surface 354. In at least one such embodiment, teeth 362 may be completely positioned, or contained, between first surface 358 and second surface 354. In at least one alternative embodiment, teeth 362 may partially extend from first perimeter 357 and/or second perimeter 353. In various embodiments, first perimeter 357 and second perimeter 353 can define an outer surface therebetween where recesses 364 can be defined in the outer surface. As a result of the above-described features, end effector lock member 350 can slide relative to soft tissue positioned adjacent to the articulation joint without impinging on the soft tissue. In various embodiments, teeth 362 may be blunted or rounded to further facilitate the relative sliding described above. In at least one embodiment, referring to Figs. 63-65, a locking mechanism can be configured to engage at least one of teeth 362 and recesses 364 and can include lock member 382 comprising end portion 388 and shaft portion 390. In at least one embodiment, similar to the above, end portion 388 can include recess 394 which can be configured to engage at least one of teeth 362, for example.

[0138] Various embodiments of the present invention may further comprise a surgical instrument 400 that can be configured to insert surgical staples into soft tissue, for example. The surgical instrument 400 may comprise many of the components employed in the various embodiments described hereinabove. Thus, the specific details regarding the operation and construction of such components will not be further discussed herein beyond that which is needed to explain the additional unique and novel features employed by surgical instrument 400.

[0139] Referring to Figs. 68-69, the surgical instrument 400 can include a handle portion 402, an elongate shaft assembly 404, and an end effector 406. In one embodiment, the end effector

406 may further include an anvil 412, or first jaw, which can be pivotably connected to a staple cartridge channel 408, or a second jaw, that may be pivoted between open and closed positions, or configurations, by an end effector closure system, or a closure assembly. The closure system may comprise, for example, a drive link 430, a driver 432, and closure tube 434 and, except for the differences discussed below, may operate in the various manners described above. The closure tube 434 may be configured to interact with the anvil 412 in a known manner such that, as the closure tube 434 is moved distally, a closure motion is applied to the anvil 412.

[0140] In various embodiments of the present invention, movement of the closure tube 434 may be controlled by means of a closure trigger 428 that is operably mounted to the handle portion 402. More particularly and with reference to FIG. 69, the closure trigger 428 may be pivotally coupled to the handle assembly 402 by a pin 429 and be movable between a “first” open position and a “second” closed position. As can also be seen in FIG. 70, the closure trigger 428 may further have a drive notch 500 formed therein that is adjacent to a pivot hole 502 to facilitate attachment of the drive link 430 thereto by a pivot pin 506 that is received in pivot hole 502. See FIG. 73. The drive link 430 may also be pivotably connected to driver 432 such that the rotation of closure trigger 428 from the first position to the second position drives the drive link 430 distally which also slides driver 432 distally. In various embodiments, closure tube 434 is operably engaged with driver 432 such that, when driver 432 is moved distally, closure tube 434 applies closure motions to anvil 412. Likewise, when the closure trigger 428 is moved from the second position to the first position, the drive link 430 is moved proximally which causes driver 432 to slide proximally as well. As driver 432 slides proximally, it causes the closure tube 434 to apply an opening motion to the anvil 412.

[0141] In various embodiments, the closure trigger 428 is normally biased to the open position (FIGS. 69 and 73) by an opening spring 486. In at least one embodiment, the opening spring 486 interacts with the driver 432 to bias the driver 432 in the proximal direction and, in doing so, moves the closure trigger 428 to the “first” or open position. Movement of the closure trigger 428 to the “second” or closed position compresses the opening spring 486 such that when the surgeon releases the trigger 428 (unless it has been otherwise locked in position) the opening spring 428 will bias the driver 432 and closure trigger 428 to the open position.

[0142] The surgical instrument 400 may also include a trigger lock 448 for locking the closure trigger 428 in at least one of its first and second positions. More particularly and with reference

to FIGS. 74 and 75, the trigger lock 448 may include an arcuate neck portion 449 that terminates in a locking tip portion 600. The trigger lock 448 may be pivotally coupled to the housing 403 of the handle portion 402 via pin 451. See FIG. 74. When mounted as shown in FIGS. 73 and 74, a trigger lock spring 450 is employed to apply a biasing force to the trigger lock 448 such that the arcuate neck portion 449 is biased into sliding engagement with a cam surface 440 formed on a pivot end 438 of the closure trigger 428. See FIGS. 70-73. In various embodiments, at least one notch 442 is provided on the pivot end 438 of the closure trigger 428 that interrupts the cam surface 440. In the illustrated embodiment, the notch 442 corresponds to the fully closed (“second”) position of the closure trigger 428 as illustrated in FIG. 74. In alternative embodiments, additional notches 442 may be provided wherein each notch corresponds to a particular position of the closure trigger 428 (and anvil 412).

[0143] In use, as the closure trigger 428 is pivoted toward the handle grip 427, the cam surface 440 rides along the arcuate neck portion 449 of the trigger lock 448 until the locking tip portion 600 of the trigger lock 448 engages one of the notches 442 therein. Once the locking tip portion 600 engages a notch 442, the closure trigger 428 is retained in that corresponding position. Thus, in the embodiment depicted in FIG. 74, for example, the closure trigger 428 is retained in the closed position by the trigger lock 448. This is because the opening spring 428 is biasing the closure trigger 428 in such a manner as to force the notch 442 into engagement with the locking tip portion 600. In one embodiment, the locking tip portion 600 can be securely retained within notch 442 such that trigger lock 448 may need to be manually disengaged from trigger 428 before trigger 428 can be moved into an alternative position and/or returned to its first position by the force exerted by opening spring 486. For example, a surgeon can depress a button portion 452 of trigger lock 448 such that trigger lock 448 is pivoted about pin 451 and the locking tip portion 600 is moved out of engagement with notch 442 in the opening trigger 428. In other various embodiments, notch 442 can be configured such that locking tip portion 600 can slide out of notch 442 upon an application of force to closure trigger 428. In either event, after locking tip portion 600 has been disengaged from notch 442, a surgeon can selectively move the closure trigger 428 into an alternative position or release closure trigger 428 and allow opening spring 486, for example, to return the closure trigger 428 to its first position.

[0144] In certain applications, it may be desirable to control the speed at which the closure trigger 428 and anvil 412 /and or staple cartridge channel 408 are returned to their respective

open positions when the surgeon releases the closure trigger 428 or pivots the locking member to an unlocked position. This slowing of the opening of closure trigger 428 and anvil 412 and/or staple cartridge channel 408 may reduce and/or eliminate damage to tissue surrounding the effector 406 caused by the rapid opening of the anvil 412 and/or staple cartridge channel 408. Thus, various embodiments of the present invention may employ a unique and novel dampening system.

[0145] Referring again to FIGS. 69-73, one dampening system embodiment of the present invention may comprise a projection 441 that extends from the pivot end 438 of the closure trigger 428. The projection 441 may have any suitable cross-sectional shape. However, in the illustrated embodiment, the projection comprises a cylindrical piston that has an arcuate shape that is sized and shaped to extend into a passage 437 that is provided in the handle portion 402 of surgical instrument. In one embodiment wherein the handle portion 402 is formed from two housing portions 403, 453, one half of the passage 437 may be formed in housing 403 (Fig. 77) and the other half of the passage 437 may be formed in housing 453 (Fig. 78). Thus, passage 437 is formed when the two housing portions 403, 453 are coupled together by screws, snap features, etc. A gasket 456, or any other suitable fluid sealing device, may be provided between the housing portions 403, 453 to form a substantially fluid-tight sealed passage 437.

[0146] In one embodiment, the projection 441 is sized to protrude into the passage 437 through a first open end 455. The passage 437 may further have a closed second end 457 that is configured to restrict fluid expelled from the passage 437 when the projection 441 is forced therein as a result of the closure trigger 428 being biased or otherwise moved to an open position. In one embodiment, an opening may be provided through the second end 457 of passage 437 to allow fluid to flow from passage 437 to a fluid passage 405 formed in the handle housing 403 that vents to atmosphere. The fluid may be any suitable fluid for slowing the inward movement of the projection 441 into the passage 437 to thereby slow the corresponding movements of the closure trigger 428 and anvil 412 and/or staple cartridge channel 408. In one embodiment, the fluid may be air or any other suitable gas, for example. In other embodiments, the fluid may be hydraulic fluid or any other suitable fluid, for example. The opening of second end 457 may be smaller than an opening at first end 455 of the passage 437. The opening may be formed in second end 457 or may be formed in a portion inserted in the second end 457.

[0147] In various embodiments, the projection 441 may be sized and shaped relative to the passage 437 such that a substantially fluid-tight sliding seal is established between the projection 441 and the sidewall 483 of the passage 437. In one embodiment, for example, at least one O-ring may 481 be provided on the projection 441 or in the wall of the passage 437 to achieve such a fluid tight seal while still facilitating the sliding travel of the protrusion 441 within the passage 437. See FIG. 73.

[0148] Referring to Figs. 79A-79B, an embodiment of the dampening system may include a valve 401 that is located adjacent the second end 457 of passage 437. In one embodiment, valve 401 may comprise a flapper valve that is sized to cover a first opening 407 in the passage 437. See Fig. 79A. In various embodiments, valve 401 may comprise a valve body 418 and a hinge 411. The valve 401 may further have a second opening 409 that is smaller than the first opening 407. The valve 401 is movable between an open position (Fig. 79A) and a closed position (Fig. 79B). For example, when the closure trigger 428 is actuated to close anvil 412 and/or staple cartridge channel 408, the valve 401 is drawn to the open position. As the projection 441 is withdrawn in the upward direction "UD", air is drawn up through fluid passage 405 and opening 407 into passage 437 (represented by arrows d_o). Such movement of the valve 401 to an open position allows the closure trigger 428 to be actuated with minimal or little drag from the dampening system. When the closure trigger 428 is moved to an open position and the protrusion 441 is moved downward into the passage 437 (represented by arrow "DD" in Fig. 79B), the valve 401 is forced to the closed position by the air located between the protrusion 441 and the bottom of the passage 437. When the valve 401 is moved to the closed position as shown in Fig. 79B, at least some of the remaining air may exit the passage 437 through the second opening 409 in the valve 401 (represented by arrow d_c). Various embodiments of the dampening system may also include a valve stop projection 413 that extends inwardly from sidewall 483 of the passage 437 for limiting the opening travel of the valve body 418. See Fig. 79A.

[0149] Fig. 80 illustrates an alternative dampening system embodiment. As can be seen in that Figure, a dampening spring may be positioned within the passage to bias projection 441 in the upward direction "UD" which corresponds to the closed position of trigger 428. The force of dampening spring 494 may be less than the force provided by the opening spring 486 of the surgical instrument such that the trigger 428 is not normally biased to the closed position. Thus,

when the surgeon releases the closure trigger 428 from the closed position, the opening spring 486 biases the closure trigger 428 to the open position. However, the dampening spring 494 resists such movement and thereby slows the opening of the closure trigger 428 and the anvil 412.

[0150] Fig. 81 illustrates yet another dampening system embodiment of the present invention. 86, projection 441 may be configured to be operably engaged with an alternative dampening system. In this embodiment, a bladder 495 is provided within the passage 437. The bladder 495 may bias the projection 441 in the upward direction “UD” which corresponds to the closed position of trigger 428. The biasing force generated by the bladder 495 may be less than the force provided by the opening spring 486 of the surgical instrument such that the trigger 428 is not normally biased to the closed position. Thus, when the surgeon releases the closure trigger 428 from the closed position, the opening spring 486 biases the closure trigger 428 to the open position. However, the bladder 495 resists such movement and thereby slows the opening of the closure trigger 428 and the anvil 412. The bladder 495 may contain any suitable fluid such as air or hydraulic fluid, for example.

[0151] Surgical instrument 400 may also include a firing drive that is configured to advance a cutting member and/or staple driver within an end effector as described above. In at least one embodiment, the firing drive may include, for example, a firing trigger 460 that may meshingly engage, a first firing gear 462 that meshingly interfaces with a firing member 466. See Figs. 82 and 83. Firing gear 462 may comprise two sets of gear teeth 470, 471. In one embodiment, firing trigger 460 may have a series of teeth 469 thereon that may be configured to operably engage a first set of teeth 470 on firing gear 462 and rotate firing gear 462 in direction d_1 when firing trigger 460 is pivoted from a first position to a second position about pin 461. As the first gear 462 is rotated, the second set of gear teeth 471 which are in meshing engagement with the firing member 466 cause the firing member 466 to be driven distally which ultimately drives a knife bar (not shown) or other implement provided within the end effector 406 (Fig. 69). When the firing trigger 460 is pivoted in an opposite direction to return it to the first position, the firing gear 462 rotates in direction d_2 by virtue of the engagement between gear teeth 469 and 470 which also drives the firing member in the proximal direction to retract the knife bar.

[0152] Various embodiments of the present invention may further include a firing trigger locking system that prevents the instrument 400 from being fired unless the closure trigger is

locked in a closed position. Thus, the anvil of the instrument must be retained in the closed position, before the knife bar can be fired. For example, in one embodiment, referring to Figure 78, firing gear 462 may include a notch 498. Notch 498 may be integrally formed in second gear 468. In one embodiment, notch 498 may be formed in a separate portion which may be attached to second gear 468 through welding, soldering, or any other suitable attachment methods. The firing trigger locking system may further include a movable locking bar 497 that has a distal end 490 and a proximal end 491. See Fig. 83. The distal end 490 of locking bar 497 may include a first notch 492 that is sized to permit the locking bar 497 to clear teeth 471 of second gear 468. The proximal end 491 of locking bar 497 may include a second notch 499 which may be configured to engage follower portion 650 of trigger lock 448. When the locking bar 497 is in engagement with notch 498 in firing gear 462, the firing gear 462 cannot rotate and hence the instrument cannot be fired. When the closure trigger 428 has been closed, the trigger lock 448 is pivoted to a position wherein follower portion 650 disengages the proximal notch 499 in the locking bar 497. When locking bar 497 and follower portion 650 have been disengaged, locking bar 497 is free to move proximally to allow the firing trigger 460 to close and thereby cause rotation of the firing gear 462 which results in the firing of the instrument in the manner described above. When the firing trigger 460 is returned to its open position, and the button portion 452 of the trigger lock 448 has been released to allow the closure trigger 428 to return to its open position, the follower portion 650 may re-engage the locking member 497 to thereby prevent the device from being fired unless the closure trigger 428 has once again been moved and locked in the closed position.

[0153] The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly,

cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[0154] Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

[0155] While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of the disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

WHAT IS CLAIMED IS:

1. A surgical instrument having a handle portion that is operably coupled to an end effector that has an end effector portion that is selectively movable between an open position and a closed position, said surgical instrument comprising:

a closure system operably interfacing with said end effector portion to selectively transmit opening and closing motions thereto;

a closure trigger movably coupled to said handle portion and being selectively movable between first and second positions, said closure trigger interacting with said closure system such that movement of said closure trigger from said first position to said second position causes said closure system to apply said closing motions to said movable end effector portion and wherein movement of said closure trigger from said second position to said first position causes said closure system to apply said opening motion to said movable end effector portion; and

a dampening system supported by said handle portion and interacting with said closure trigger to retard movement of said closure trigger from said second position to said first position upon application of an actuation force thereto.

2. The surgical instrument of claim 1 wherein said dampening system comprises:

a passage formed in said handle portion and having a first end with a first opening therein and a closed second end;

a protrusion on said closure trigger extending into said passage through said opening in said first end, said protrusion sized relative to said passage to establish a substantially fluid tight sliding seal therewith as said closure trigger is moved from said first position to said second position; and

a second opening through said closed second end of said passage, said second opening sized to enable fluid between said protrusion and said closed second end of said passage to pass therethrough at a predetermined controlled rate as said closure trigger is moved from said first position to said second position.

3. The surgical instrument of claim 1 wherein said dampening system comprises:

a passage formed in said handle portion and having a first end with a first opening therein and a second end with a second opening therein;

a protrusion on said closure trigger extending into said passage through said opening in said first end, said protrusion sized relative to said passage to establish a substantially fluid tight sliding seal therewith as said closure trigger is moved from said first position to said second position; and

a movable valve member mounted within said passage and movable between a first valve position wherein said movable valve member blocks said second opening when said closure trigger moves from said second position to said first position and a second valve position exposing said second opening when said closure trigger is moved from said first position to said second position; and

a third opening in said valve member that is smaller than said second opening.

4. The surgical instrument of claim 1 further comprising a first biasing member in said housing for applying a first biasing force to said closure trigger to bias said closure trigger from said second position to said first position upon discontinuing said application of said actuation force thereto and wherein said dampening system further comprises:

a passage formed in said handle portion and having a first end with a first opening therein and a closed second end;

a protrusion on said closure trigger extending into said passage through said opening in said first end; and

a second biasing member in said passage between said protrusion and said closed second end, said second biasing member applying a second biasing force to said protrusion wherein said second biasing force is less than said first biasing force.

5. The surgical instrument of claim 4 wherein said second biasing member comprises a spring.

6. The surgical instrument of claim 4 wherein said second biasing member comprises a bladder.

7. The surgical instrument of claim 1 further comprising a trigger lock on said handle portion for selectively locking said closure trigger in at least one of said first and second positions.

8. The surgical instrument of claim 1 wherein said surgical instrument further comprises:

a firing member movably supported within said end effector;

a firing system supported by said handle portion and interacting with said firing member to supply a firing motion thereto;

a firing trigger movably supported by said handle portion between a fired position and an unfired position and interacting with said firing system to cause said firing system to supply said firing motion to said firing member upon application of another actuation motion to said firing trigger; and

a trigger lock operably supported on said handle portion and interacting with said closure trigger and said firing trigger to retain said firing trigger in said unfired position when said closure trigger is not retained in said second position.

9. The surgical instrument of claim 8 wherein said trigger lock is configured to selectively retain said closure trigger in said second position.

10. A surgical instrument, comprising:

a handle portion;

an elongate shaft coupled to said handle portion;

an end effector coupled to said elongate shaft, said end effector comprising:

a first jaw; and

a second jaw, wherein the first jaw is movable relative to said second jaw between an open position and a closed position upon application of opening and closing motions thereto by a closure tube portion of said elongate shaft, said surgical instrument further comprising:

a closure system supported by said handle portion and operably interfacing with said closure tube portion to selectively transmit opening and closing motions thereto;

a closure trigger movably coupled to said handle portion and being selectively movable between first and second positions, said closure trigger interacting with said closure system such that movement of said closure trigger from said first position to said second position causes said closure trigger to apply said closing motions to said closure tube portion and wherein movement of said closure trigger from said second position to said first position causes said closure system to apply said opening motion to said closure tube portion; and

a dampening system supported by said handle portion and interacting with said closure trigger to retard movement of said closure trigger from said second position to said first position upon application of an actuation force thereto.

11. The surgical instrument of claim 10 wherein said dampening system comprises:
a passage formed in said handle portion and having a first end with a first opening therein and a closed second end;

a protrusion on said closure trigger extending into said passage through said opening in said first end, said protrusion sized relative to said passage to establish a substantially fluid tight sliding seal therewith as said closure trigger is moved from said first position to said second position; and

a second opening through said closed second end of said passage, said second opening sized to enable fluid between said protrusion and said closed second end of said passage to pass therethrough at a predetermined controlled rate as said closure trigger is moved from said first position to said second position.

12. The surgical instrument of claim 10 wherein said dampening system comprises:
a passage formed in said handle portion and having a first end with a first opening therein and a second end with a second opening therein;

a protrusion on said closure trigger extending into said passage through said opening in said first end, said protrusion sized relative to said passage to establish a substantially fluid tight sliding seal therewith as said closure trigger is moved from said first position to said second position; and

a movable valve member mounted within said passage and movable between a first valve position wherein said movable valve member blocks said second opening when said closure

trigger moves from said second position to said first position and a second valve position exposing said second opening when said closure trigger is moved from said first position to said second position; and

a third opening in said valve member that is smaller than said second opening.

13. The surgical instrument of claim 10 further comprising a first biasing member in said housing for applying a first biasing force to said closure trigger to bias said closure trigger from said second position to said first position upon discontinuing said application of said actuation force thereto and wherein said dampening system further comprises:

a passage formed in said handle portion and having a first end with a first opening therein and a closed second end;

a protrusion on said closure trigger extending into said passage through said opening in said first end; and

a second biasing member in said passage between said protrusion and said closed second end, said second biasing member applying a second biasing force to said protrusion wherein said second biasing force is less than said first biasing force.

14. The surgical instrument of claim 13 wherein said second biasing member comprises a spring.

15. The surgical instrument of claim 13 wherein said second biasing member comprises a bladder.

16. The surgical instrument of claim 10 further comprising a trigger lock on said handle portion for selectively locking said closure trigger in at least one of said first and second positions.

17. The surgical instrument of claim 10 wherein said surgical instrument further comprises:

a firing member movably supported within said end effector;

a firing system supported by said handle portion and interacting with said firing member to supply a firing motion thereto;

a firing trigger movably supported by said handle portion between a fired position and an unfired position and interacting with said firing system to cause said firing system to supply said firing motion to said firing member upon application of another actuation motion to said firing trigger; and

a trigger lock operably supported on said handle portion and interacting with said closure trigger and said firing trigger to retain said firing trigger in said unfired position when said closure trigger is not retained in said second position.

18. A surgical instrument, comprising:

a handle portion;

an elongate shaft coupled to said handle portion;

an end effector coupled to said elongate shaft, said end effector comprising:

a first jaw; and

a second jaw, wherein the first jaw is movable relative to said second jaw between an open position and a closed position upon application of opening and closing motions thereto by a closure tube portion of said elongate shaft, said surgical instrument further comprising:

a closure system supported by said handle portion and operably interfacing with said closure tube portion to selectively transmit opening and closing motions thereto;

a closure trigger movably coupled to said handle portion and being selectively movable between first and second positions, said closure trigger interacting with said closure system such that movement of said closure trigger from said first position to said second position causes said closure trigger to apply said closing motions to said closure tube portion and wherein movement of said closure trigger from said second position to said first position causes said closure system to apply said opening motion to said closure tube portion; and

a dampening system supported by said handle portion and interacting with said closure trigger to retard movement of said closure trigger from said second position to said first position upon application of an actuation force thereto, said dampening system comprising a passage formed in said handle portion having a first end with a first opening therein and a second end,

said dampening system comprising a projection on said closure trigger extending into said passage through said opening in said first end.

19. The surgical instrument of claim 18 wherein said dampening system comprises:
said second end of said passage having a second opening therein;
said projection sized relative to said passage to establish a substantially fluid tight sliding seal therewith as said closure trigger is moved from said first position to said second position;
and
a movable valve member mounted within said passage and moveable between a first valve position wherein said moveable valve member blocks said second opening when said closure trigger moves from said second position to said first position and a second valve position exposing said second opening when said closure trigger is moved from said first position to said second position; and
a third opening in said valve member that is smaller than said second opening.

20. The surgical instrument of claim 18 further comprising a first biasing member in said housing for applying a first biasing force to said closure trigger to bias said closure trigger from said second position to said first position upon discontinuing said application of said actuation force thereto and wherein said dampening system further comprises:
a second biasing member in said passage between said projection and said second end, said second biasing member applying a second biasing force to said projection wherein said second biasing force is less than said first biasing force.

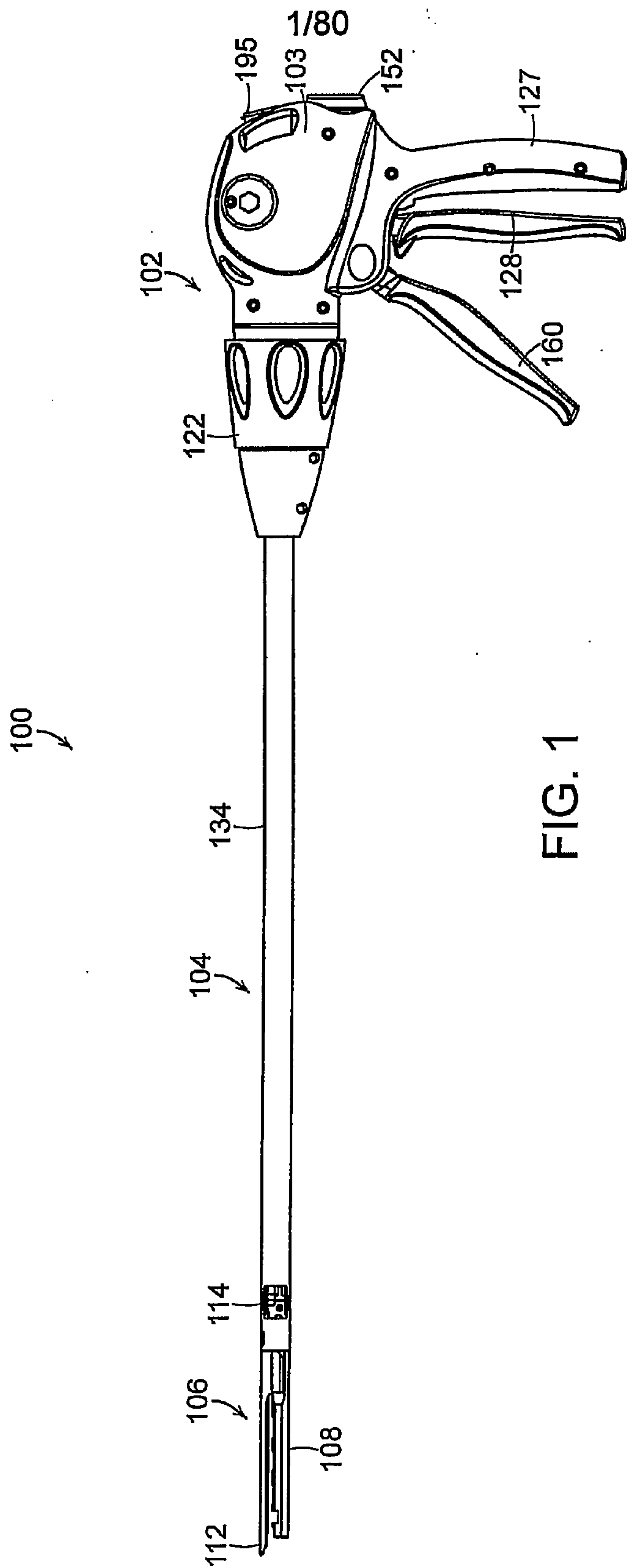


FIG. 1

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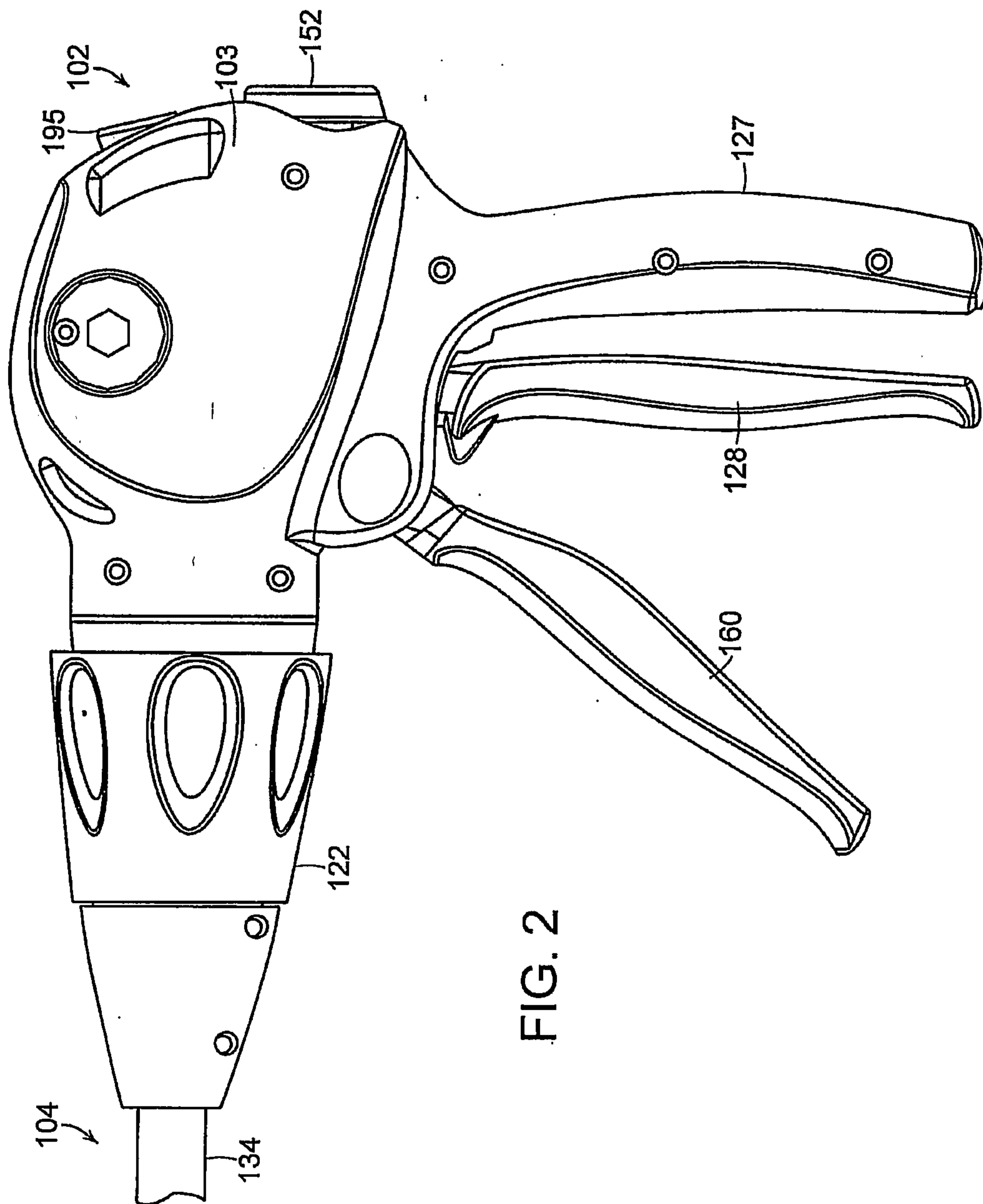


FIG. 2

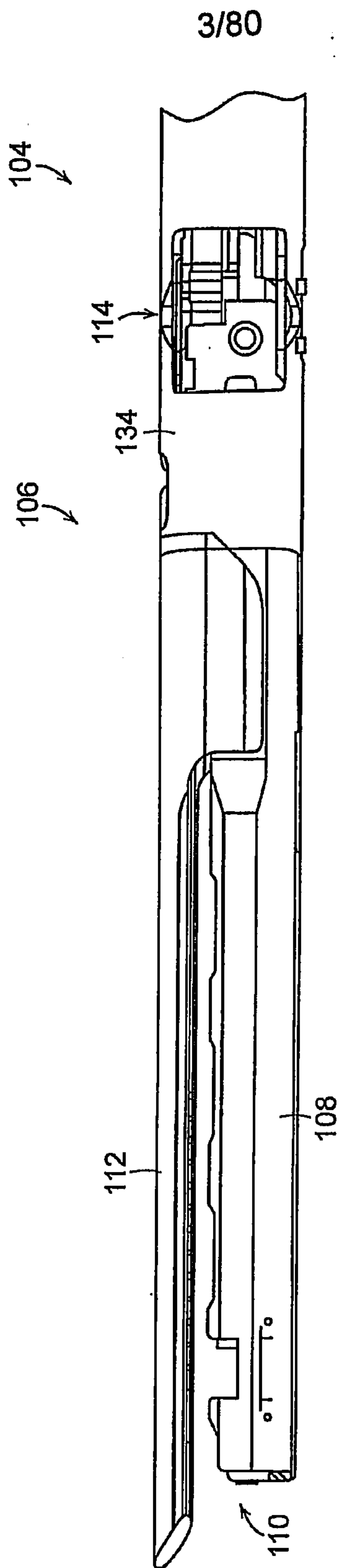
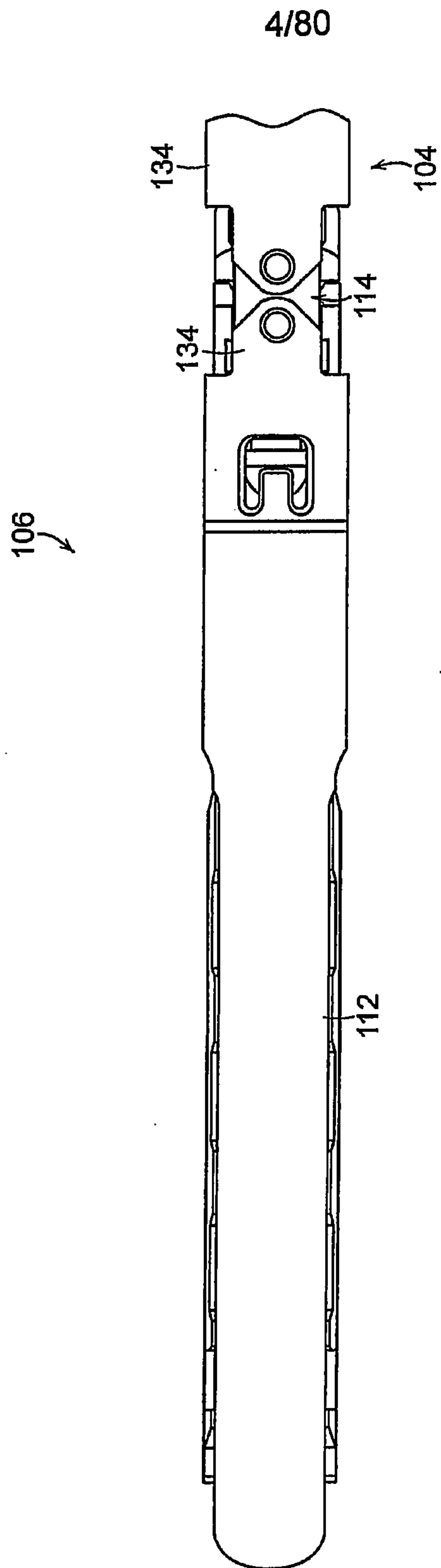


FIG. 3



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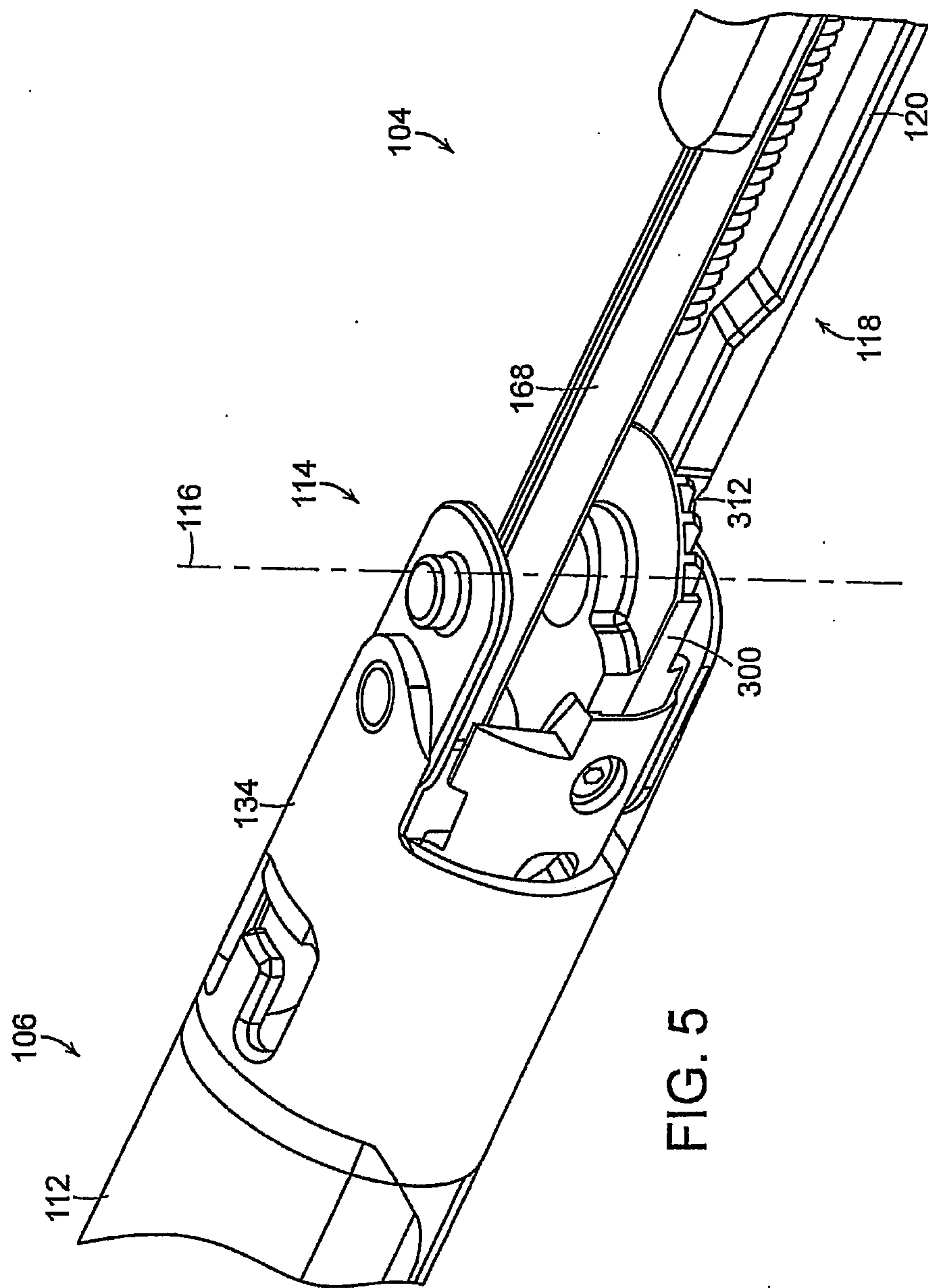


FIG. 5

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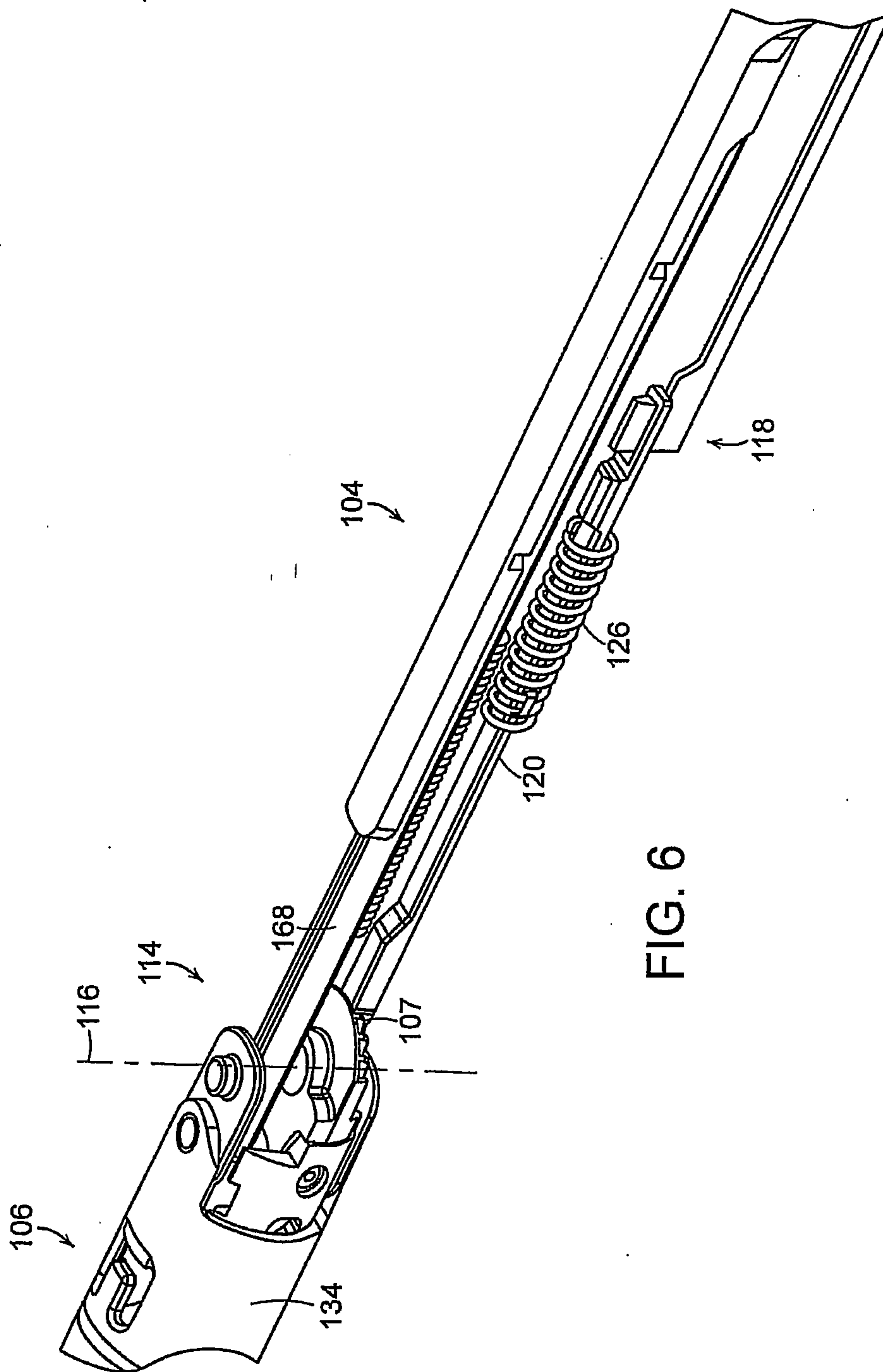


FIG. 6

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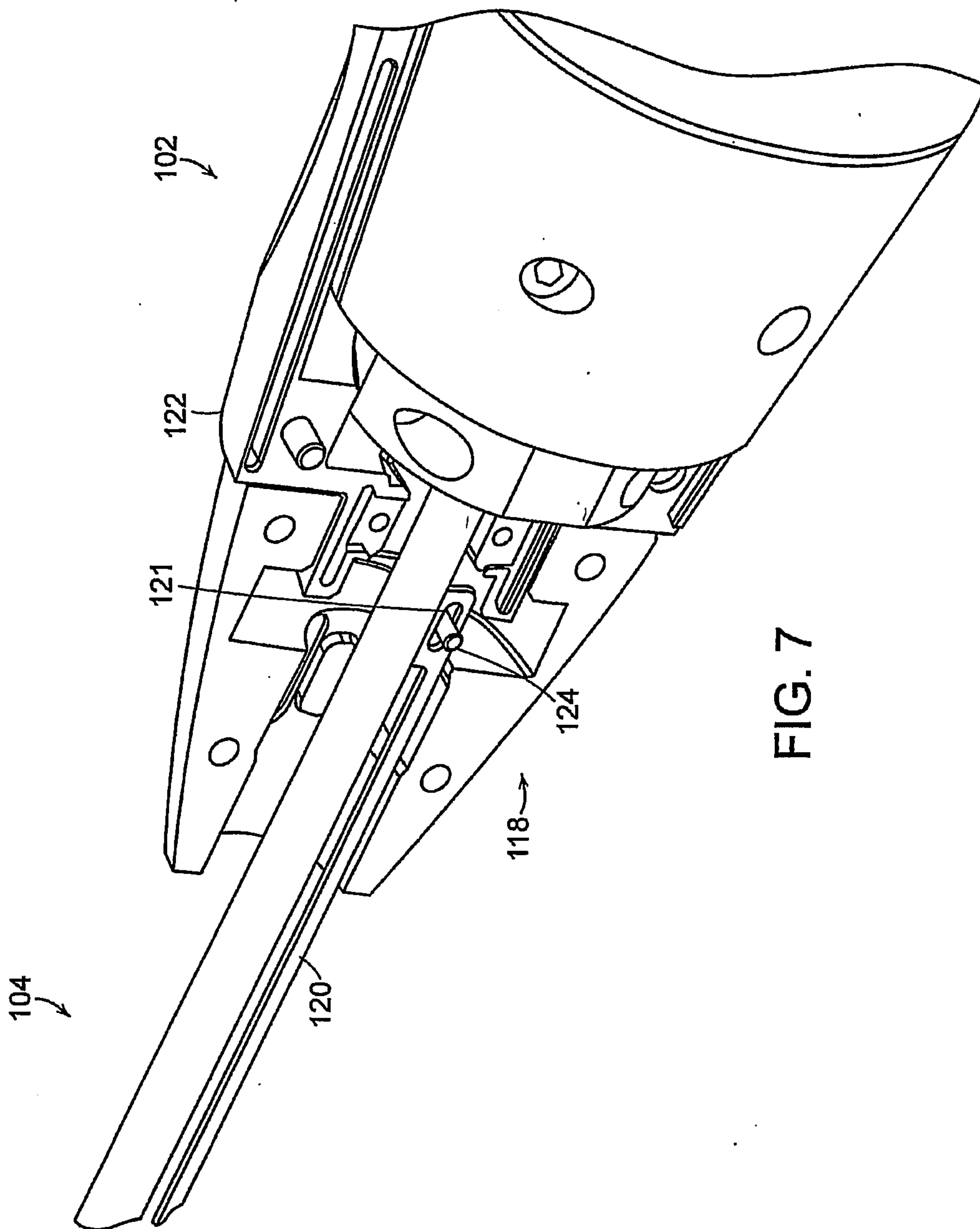


FIG. 7

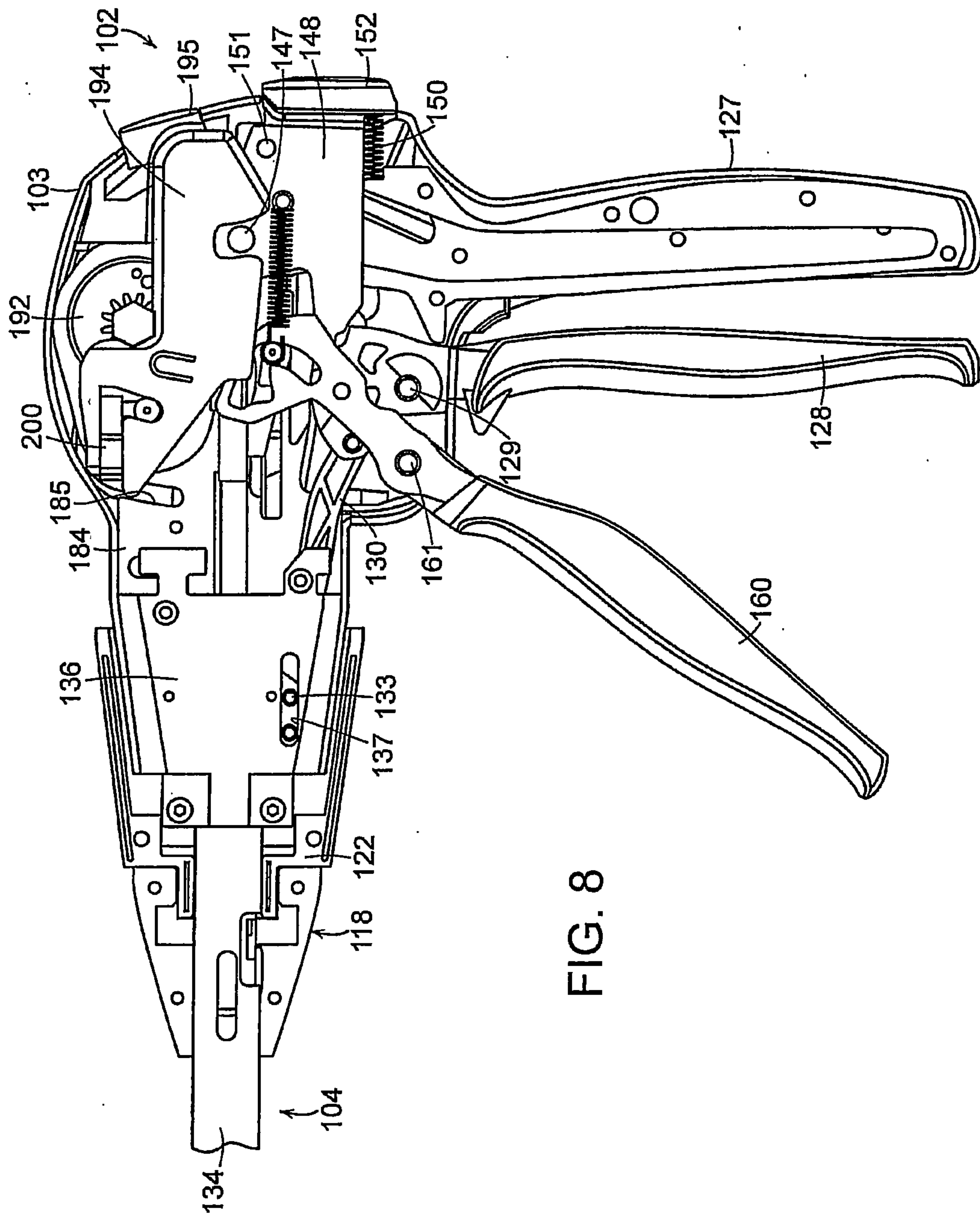


FIG. 8

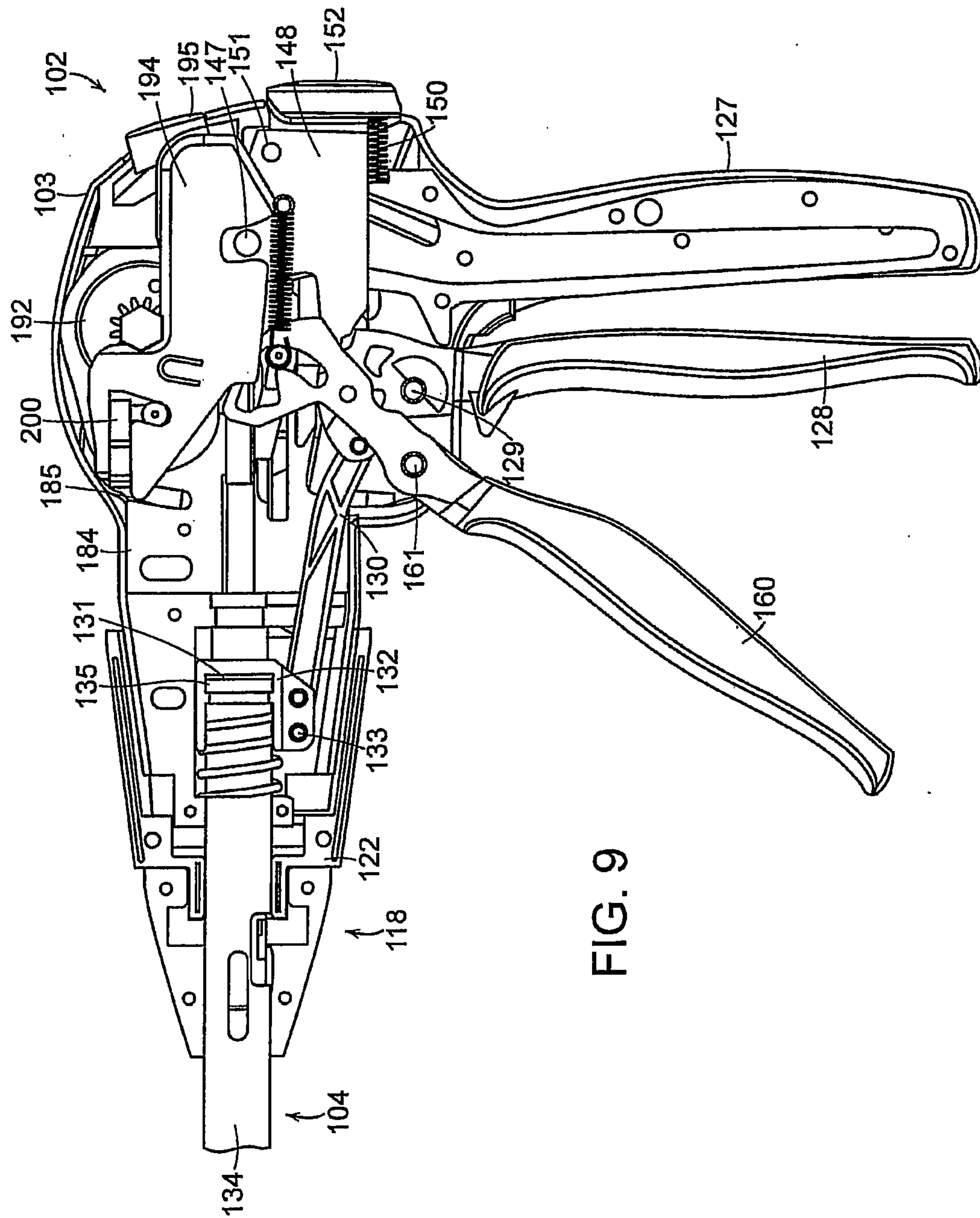


FIG. 9

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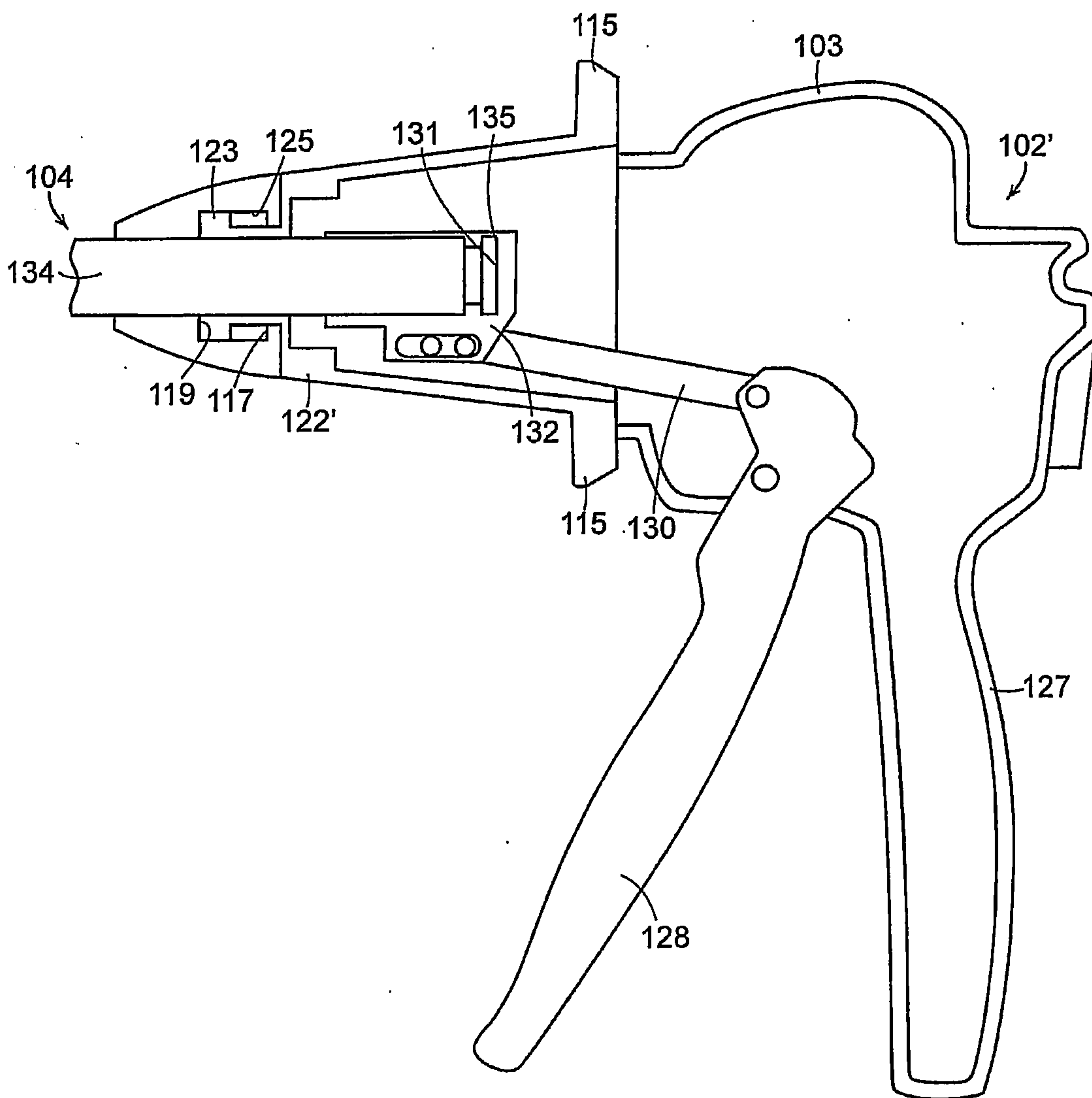


FIG. 10

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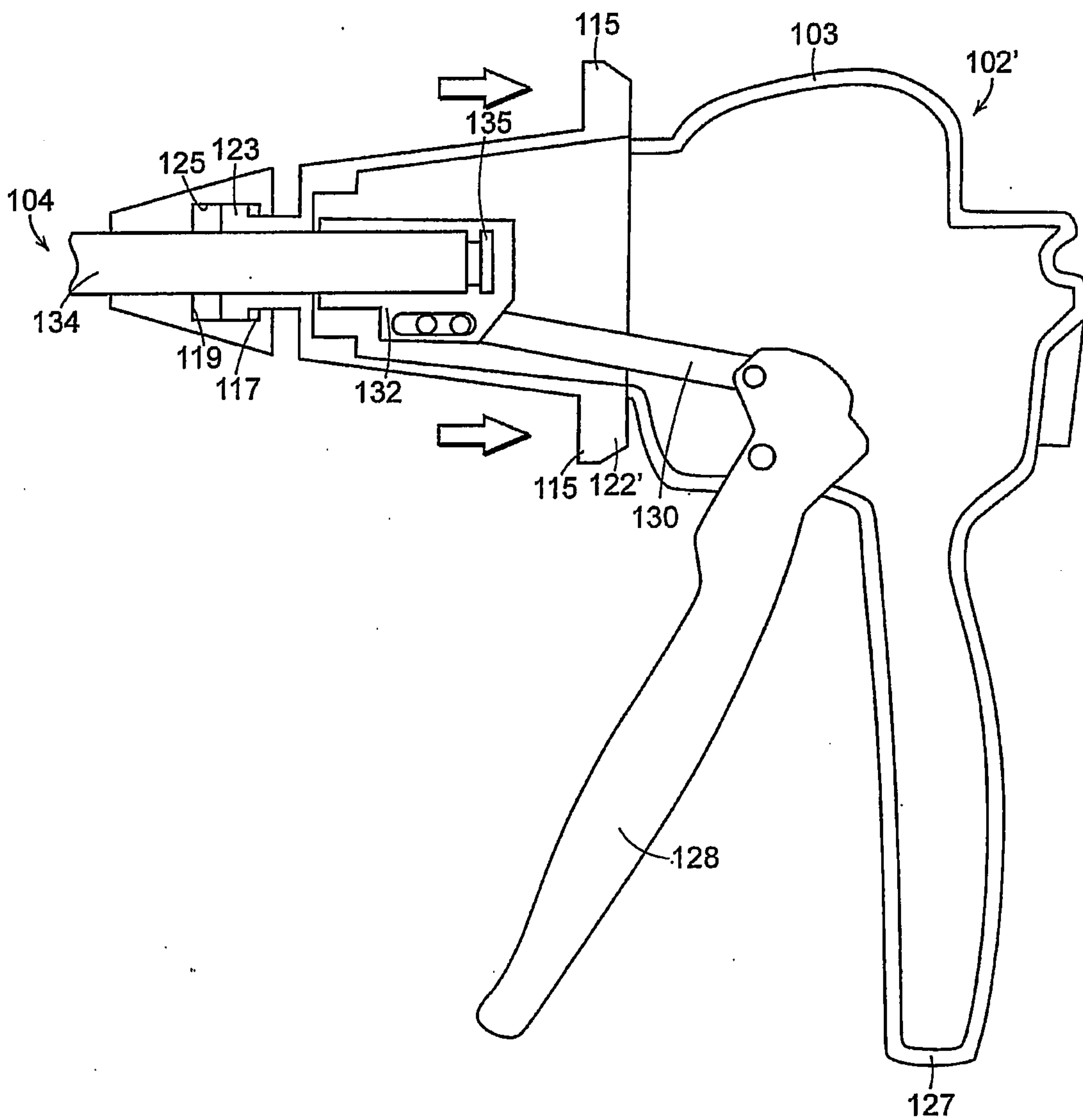


FIG. 11

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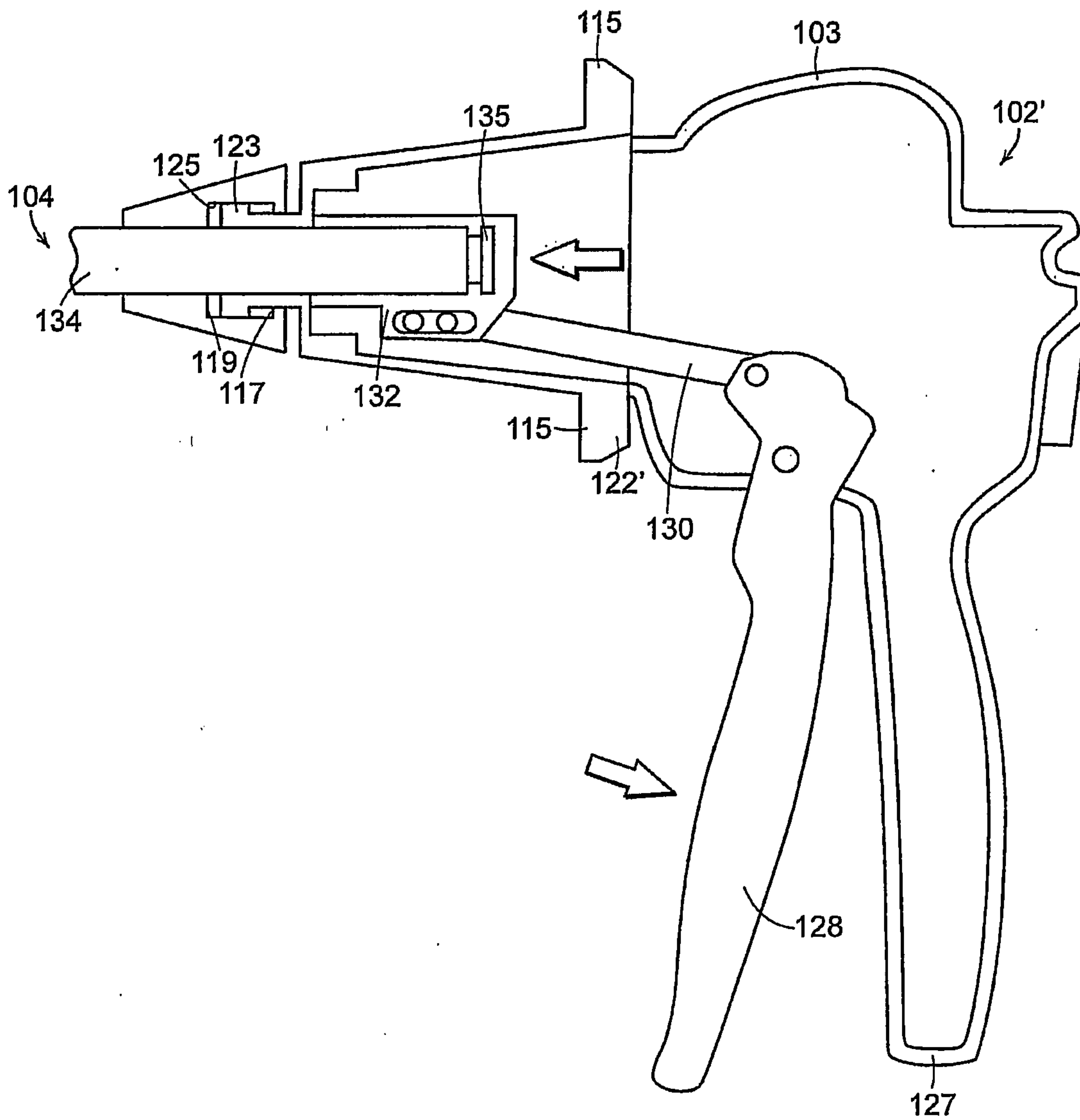


FIG. 12

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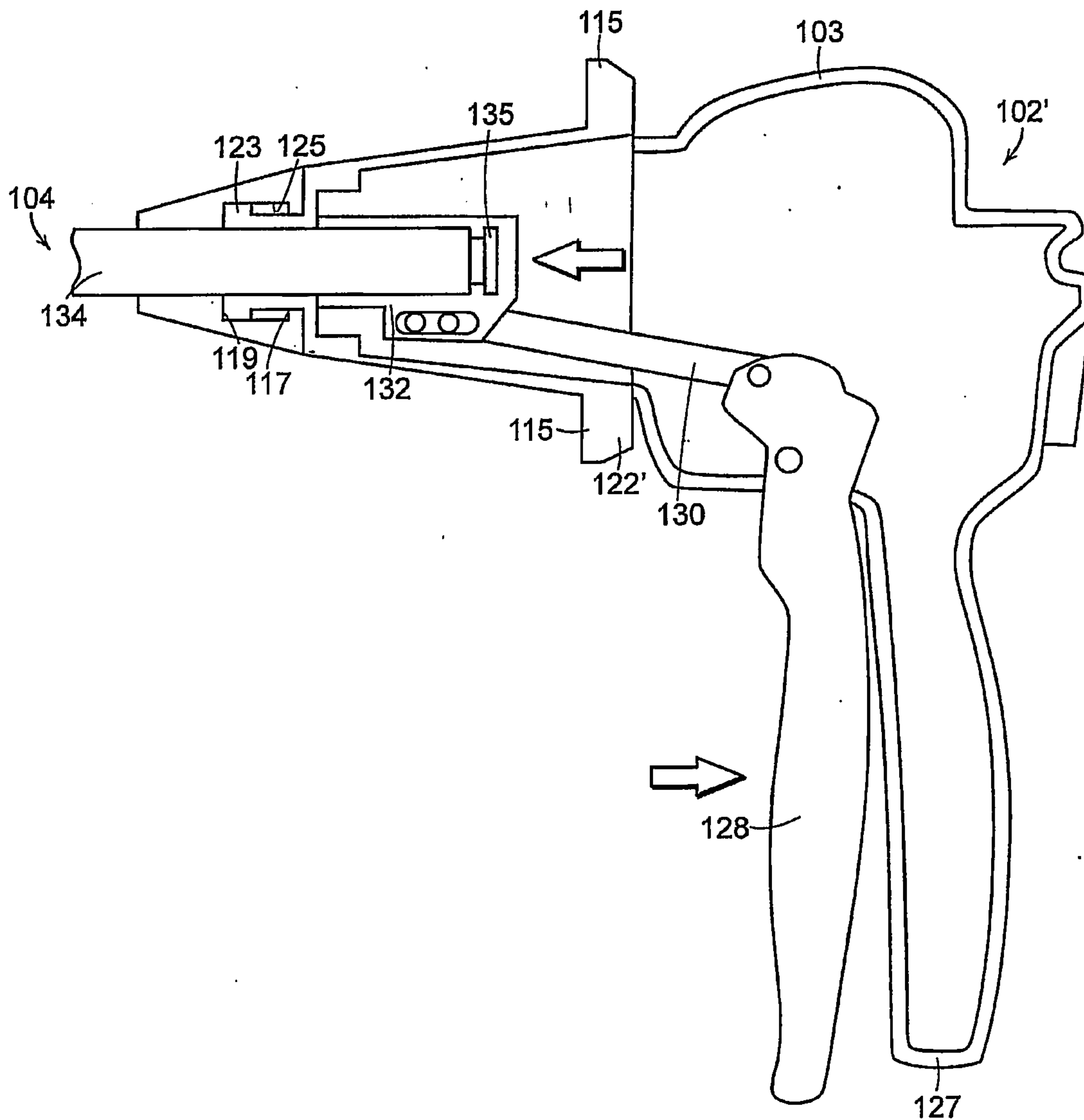


FIG. 13

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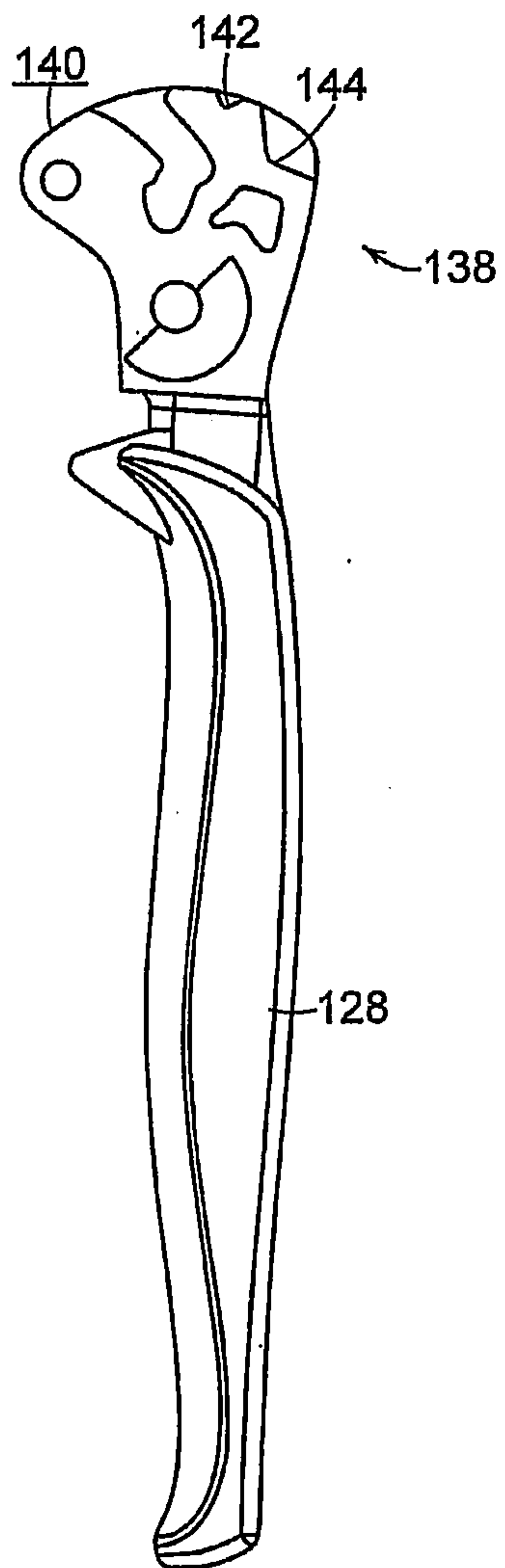


FIG. 14

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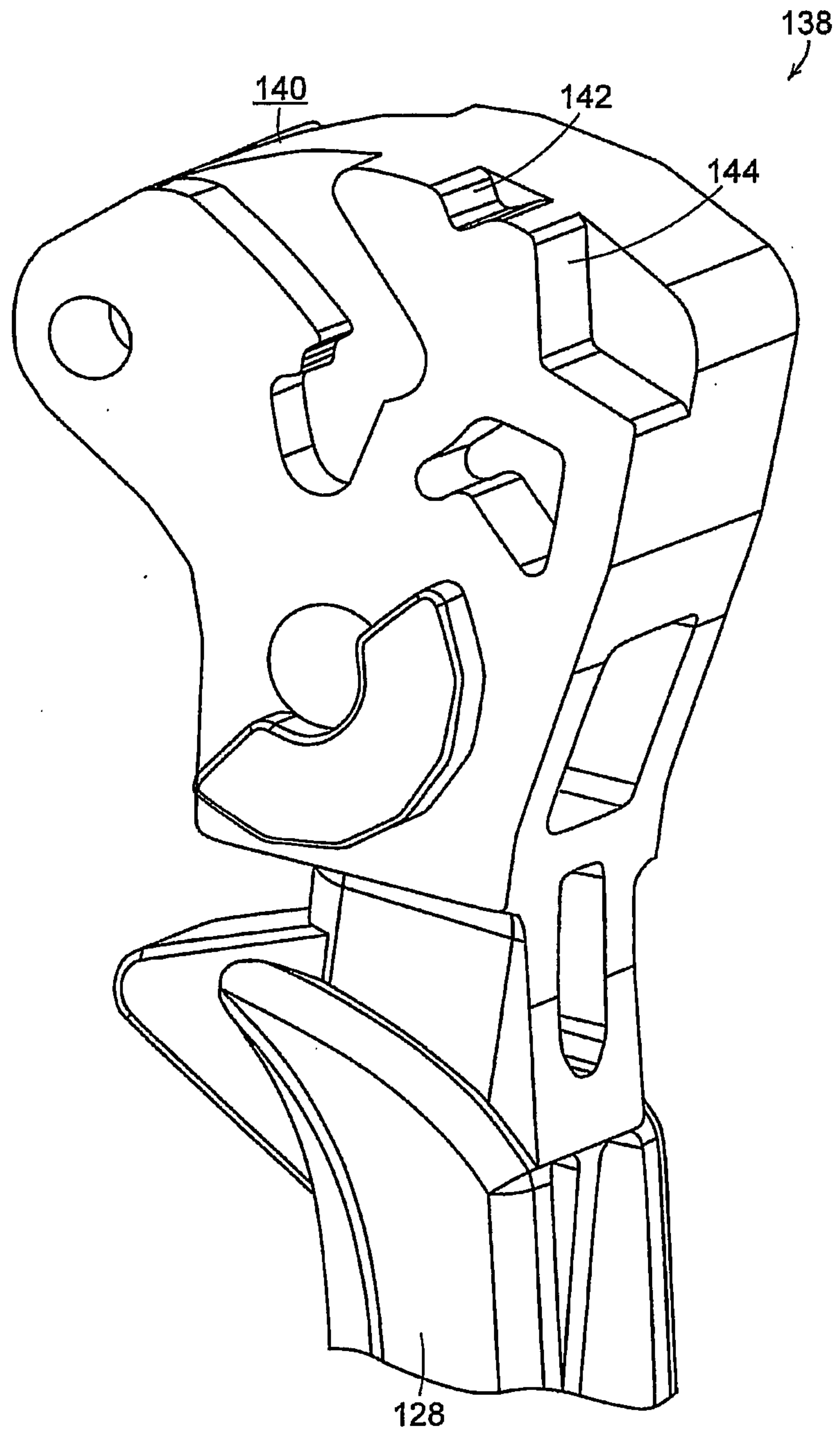


FIG. 15

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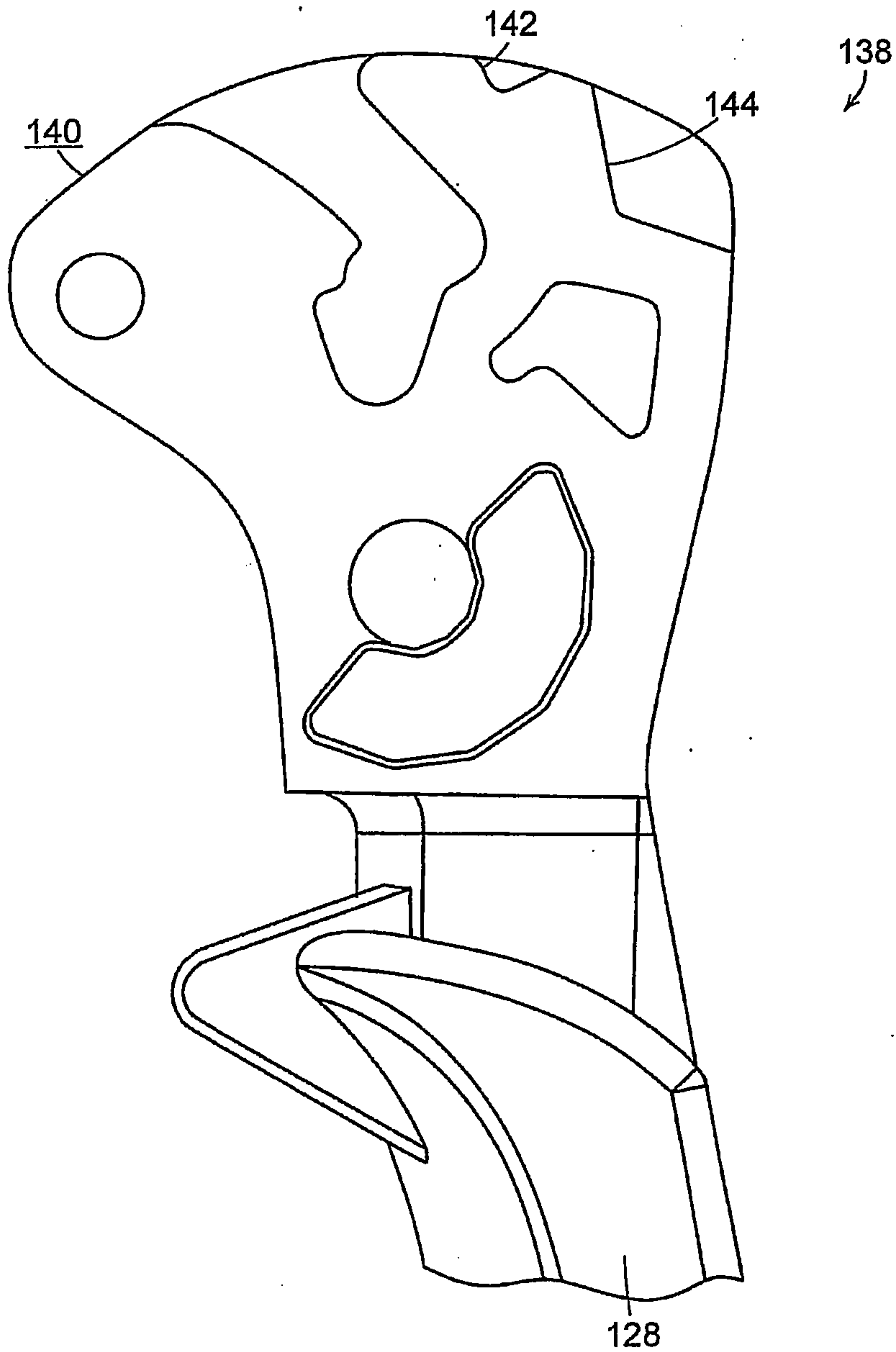


FIG. 16

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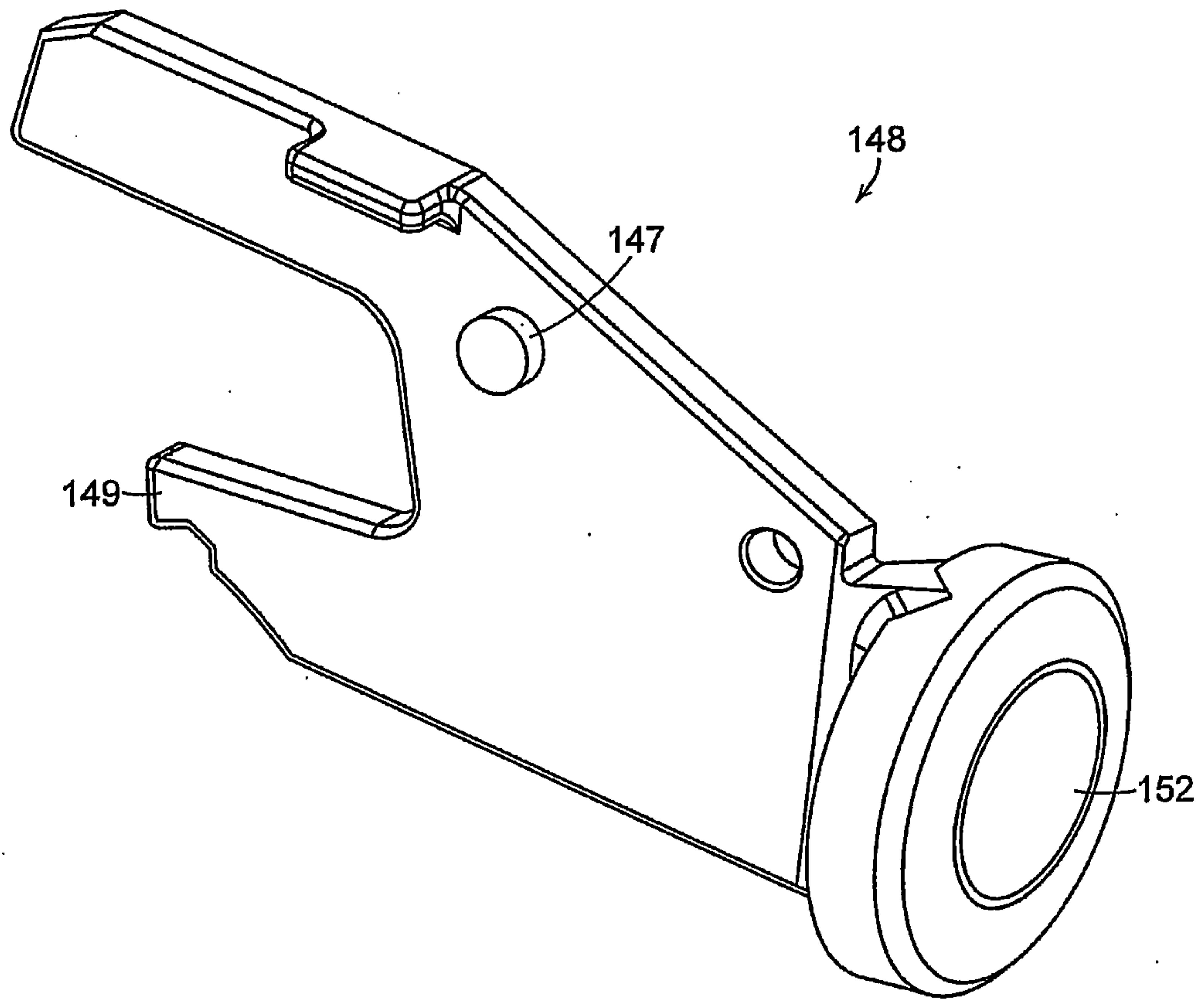


FIG. 17

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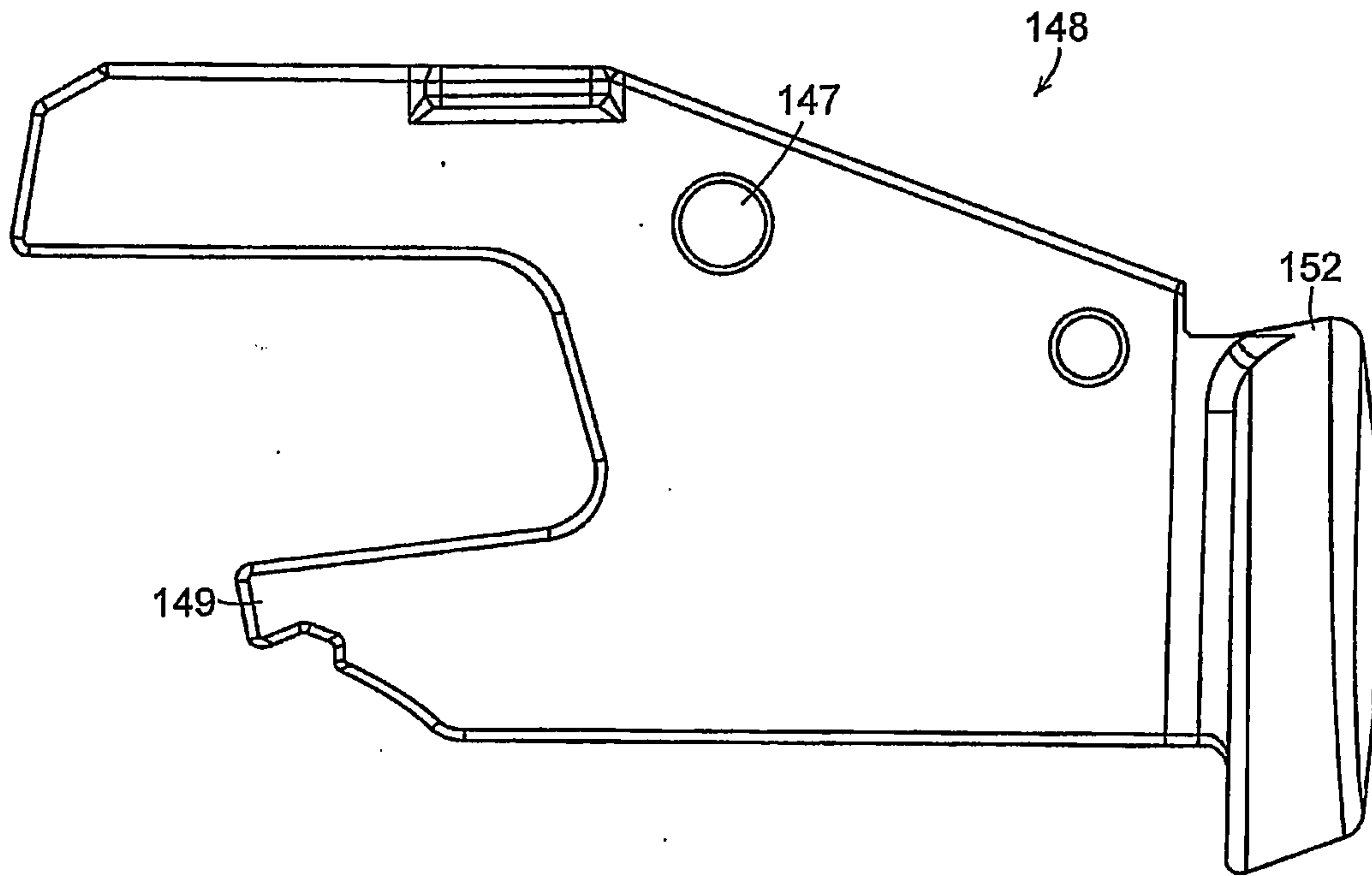
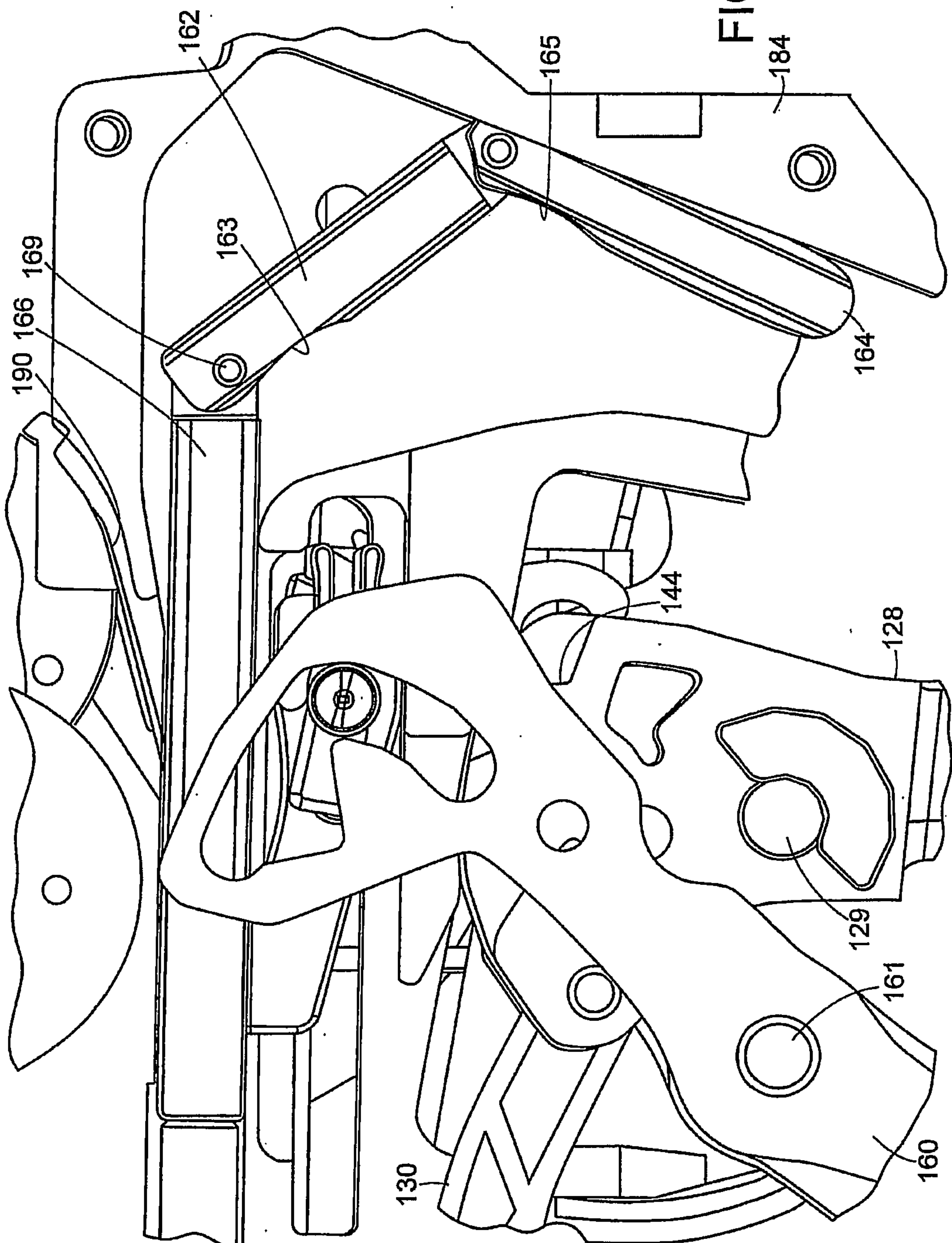


FIG. 18

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FIG. 19



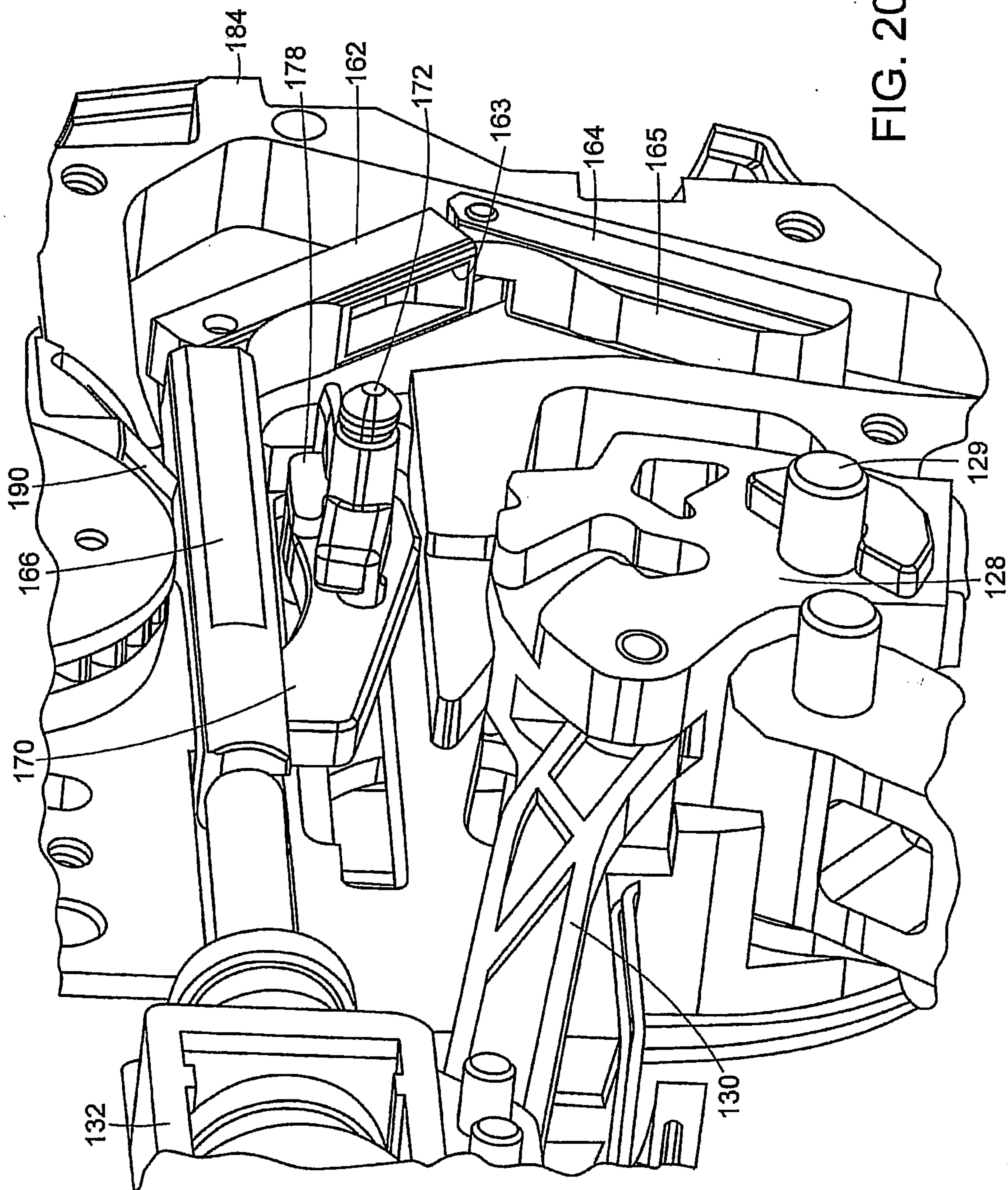


FIG. 20

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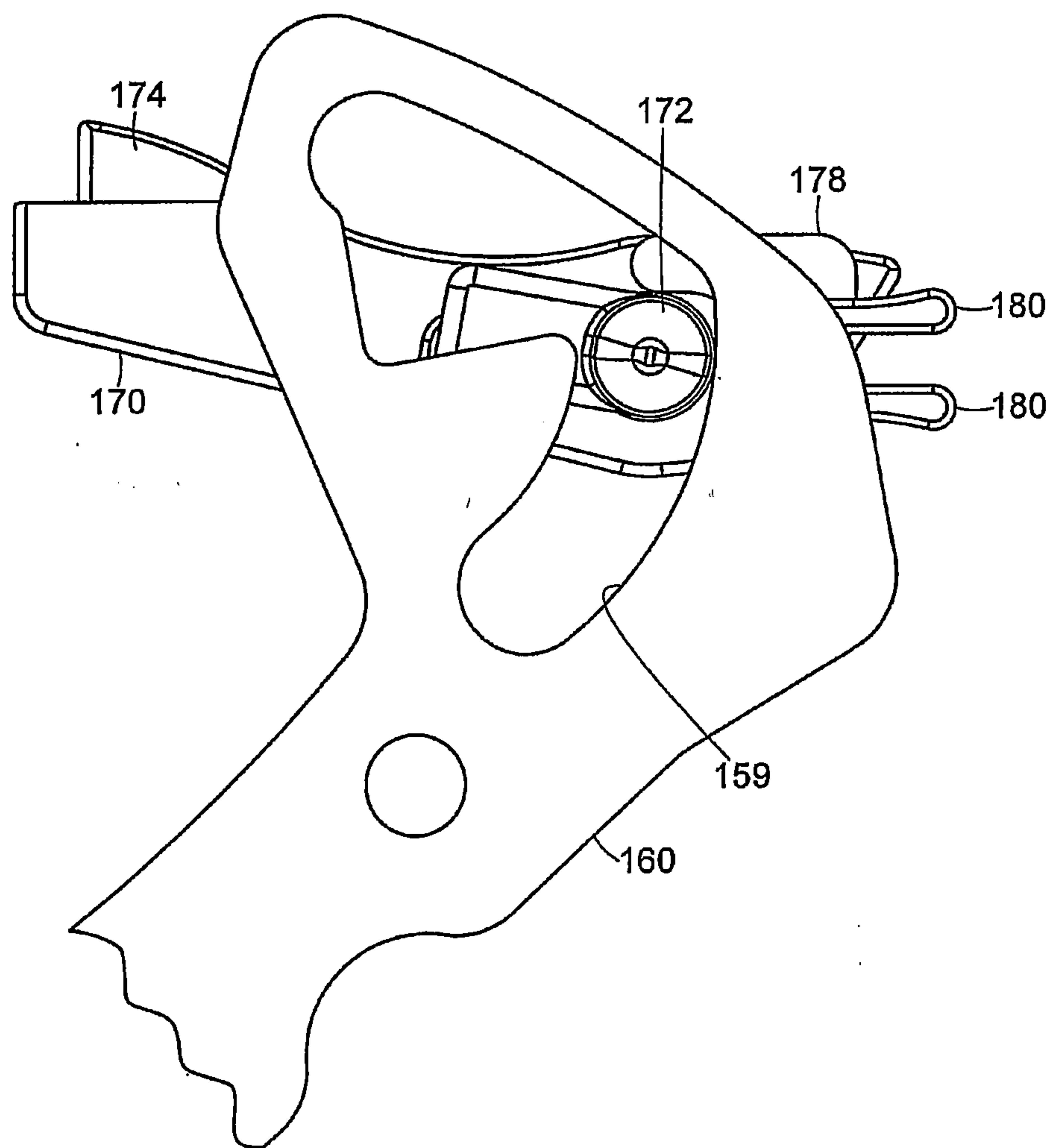


FIG. 21

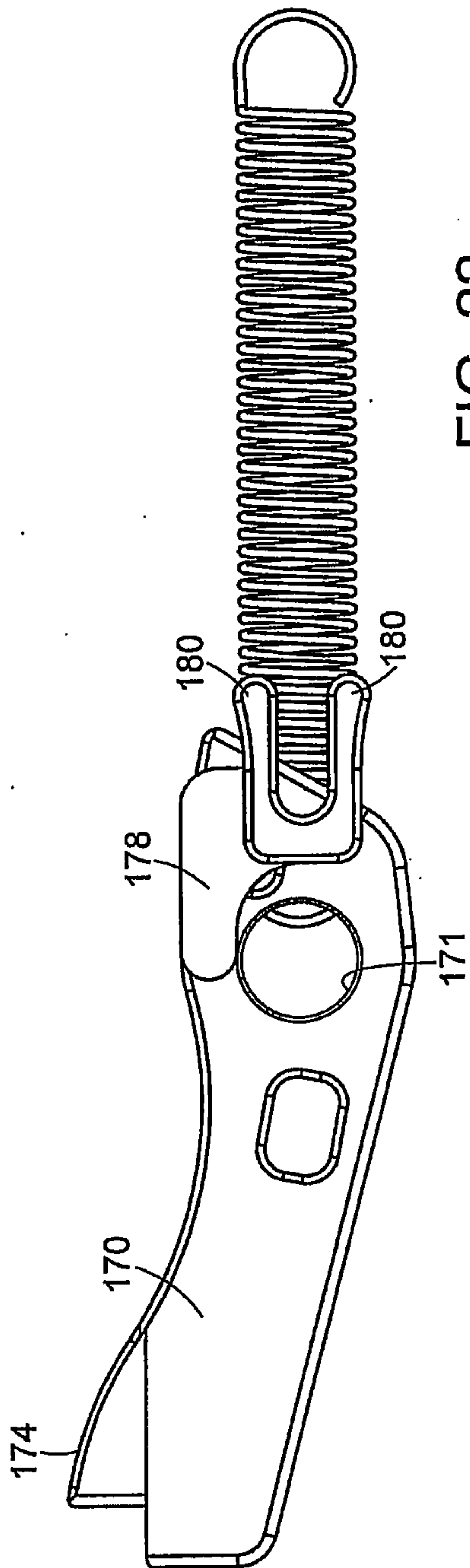


FIG. 22

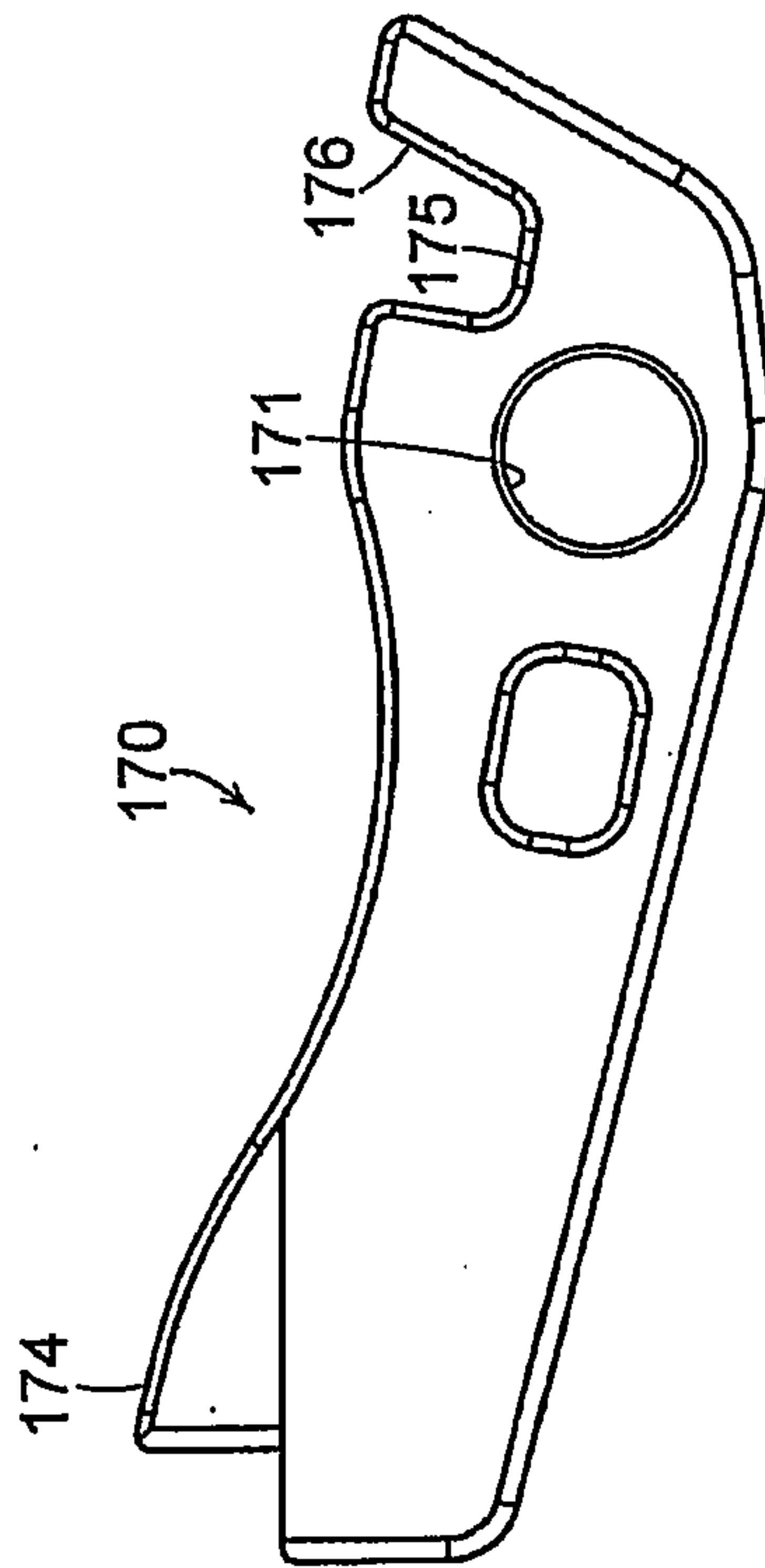


FIG. 23

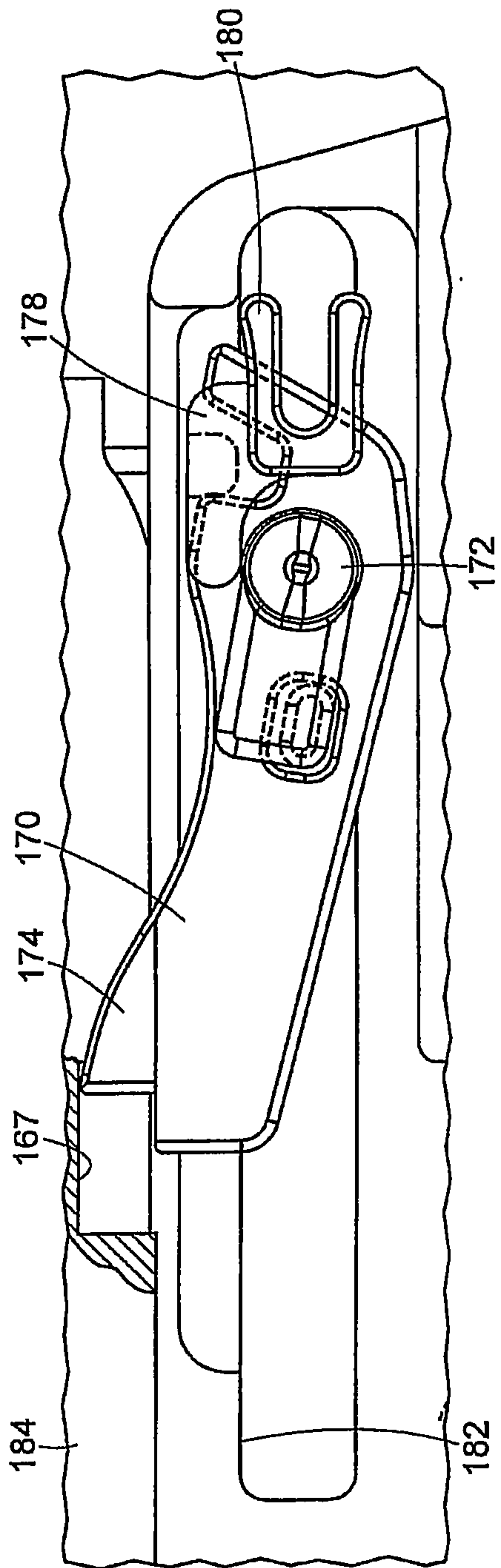


FIG. 24

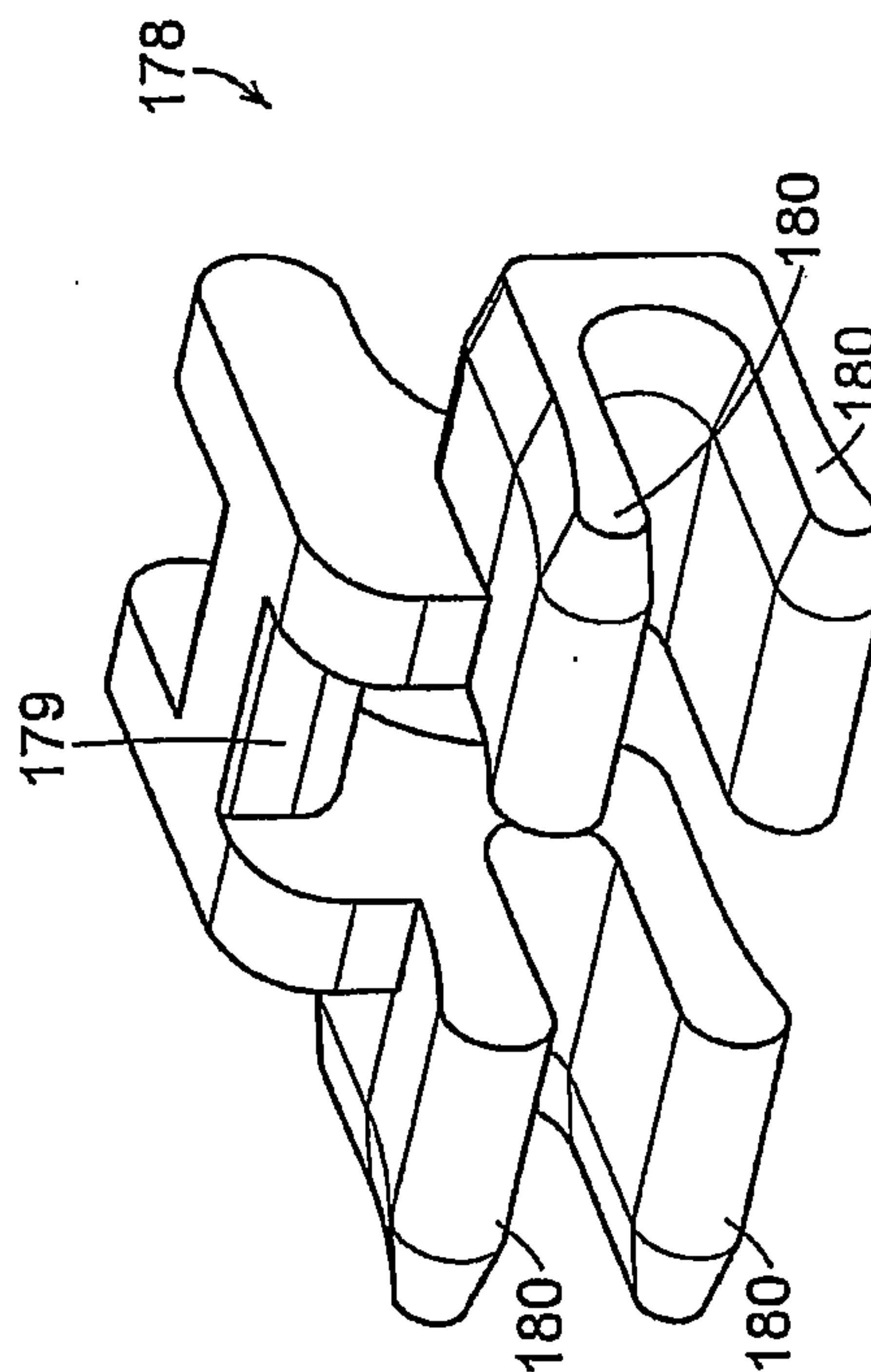


FIG. 25

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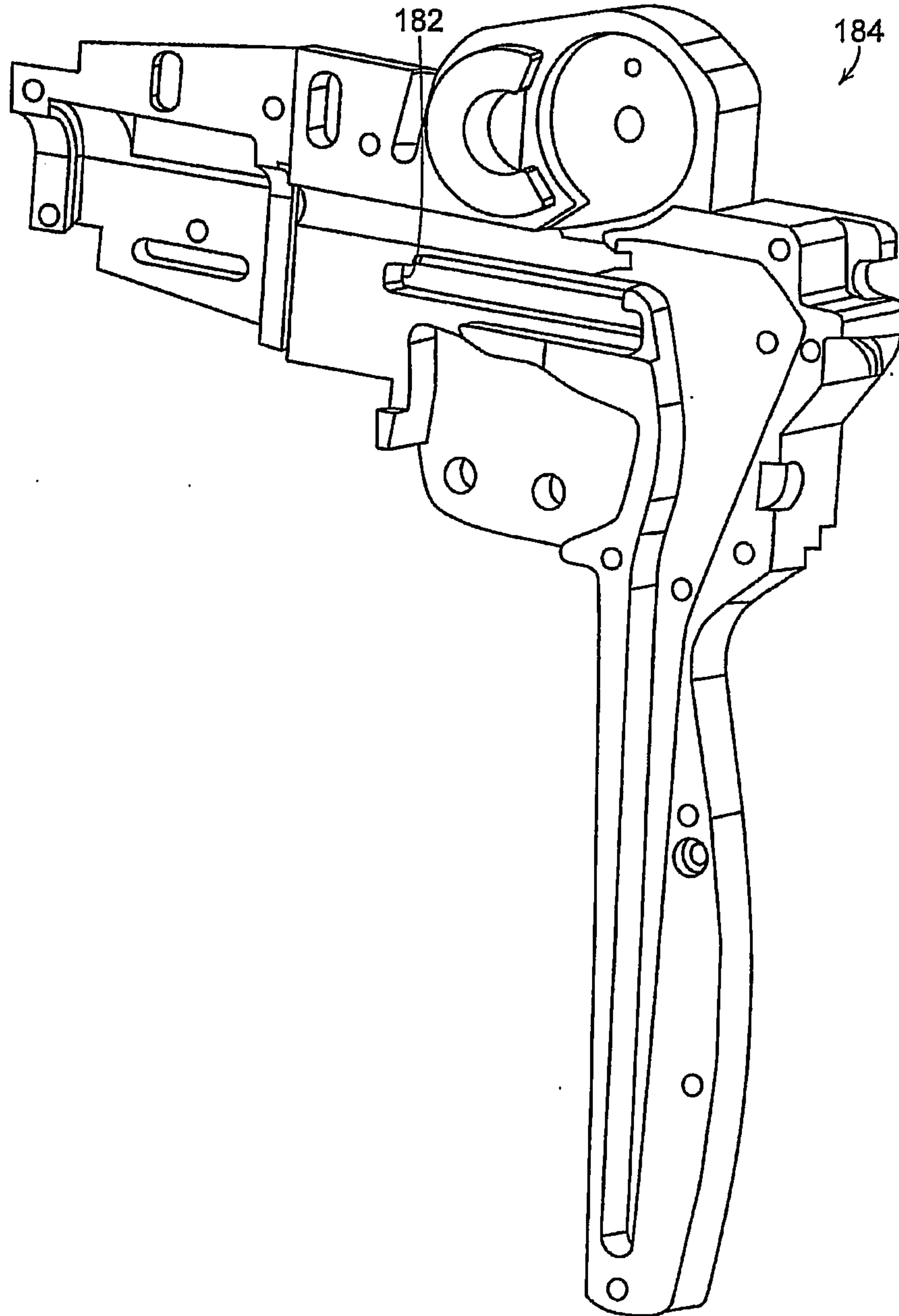


FIG. 26

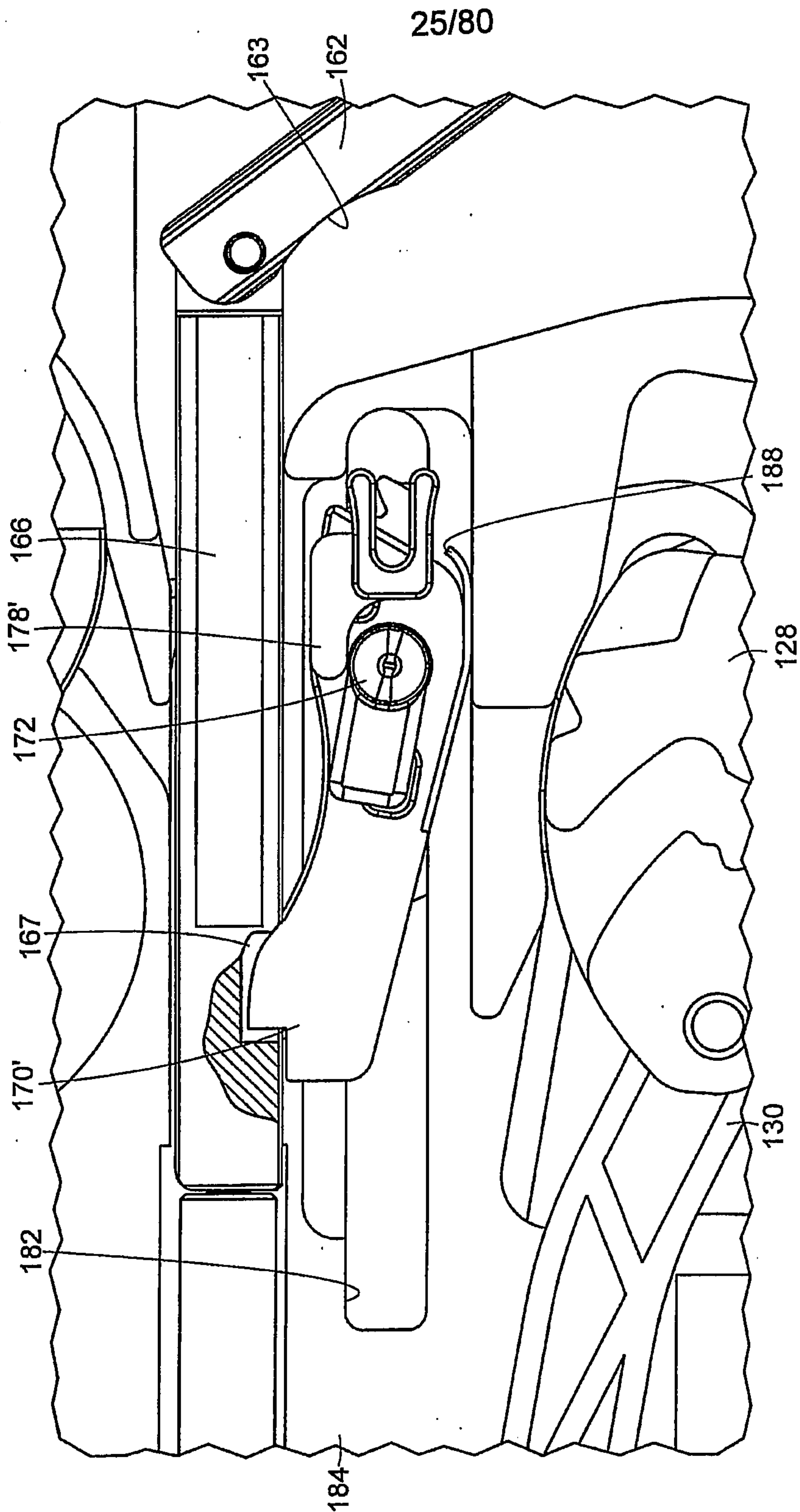


FIG. 27

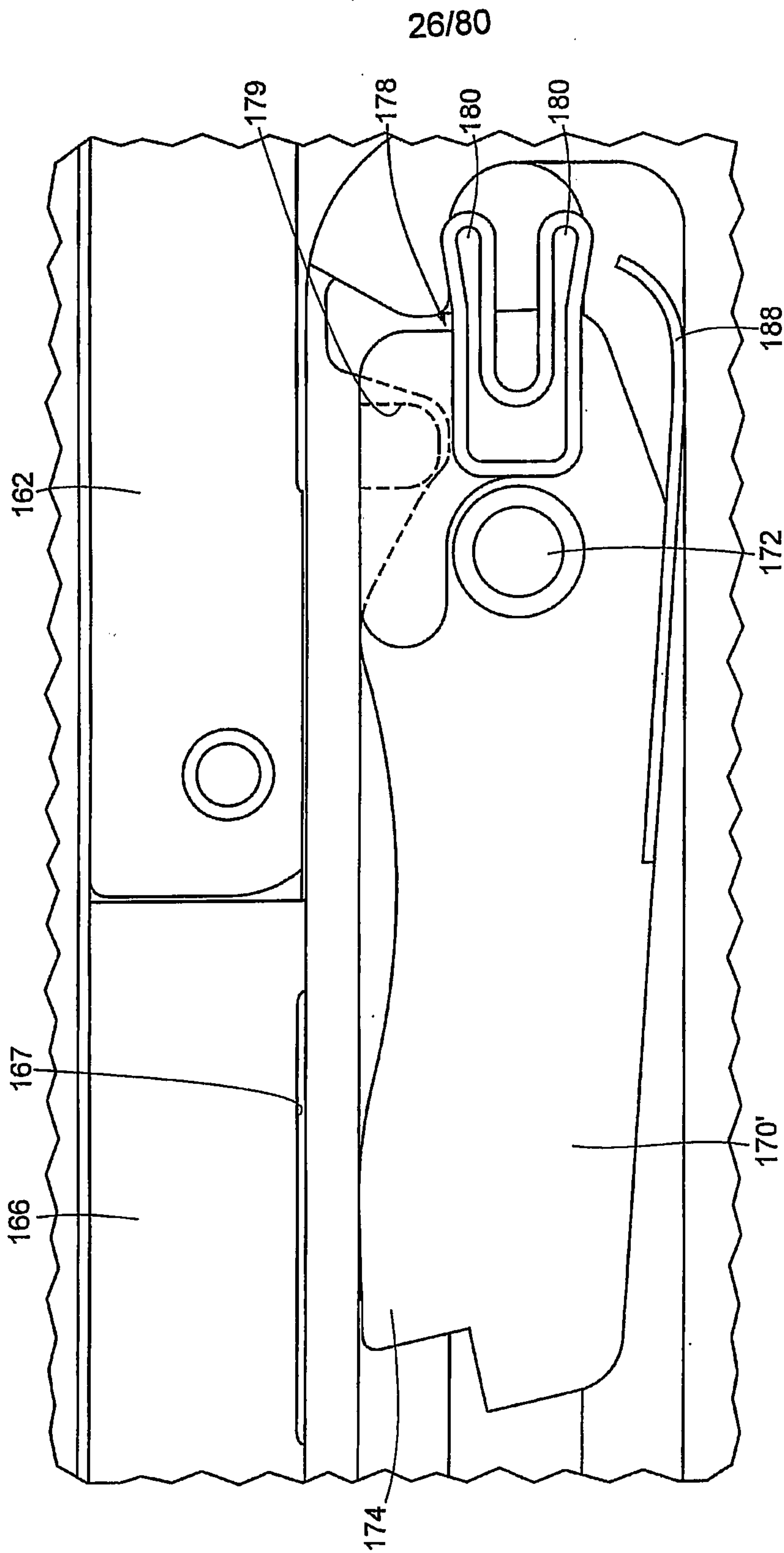


FIG. 28

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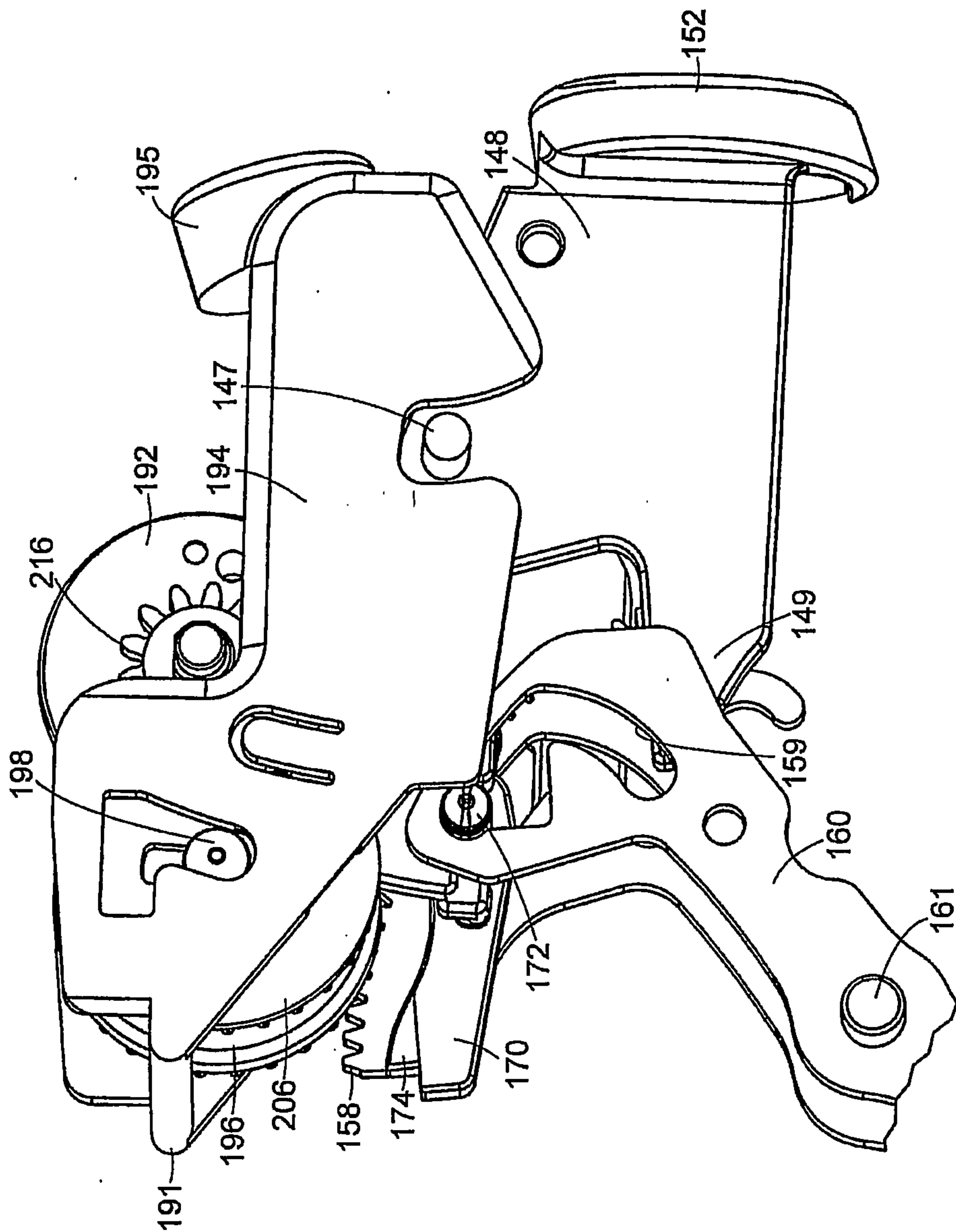


FIG. 29

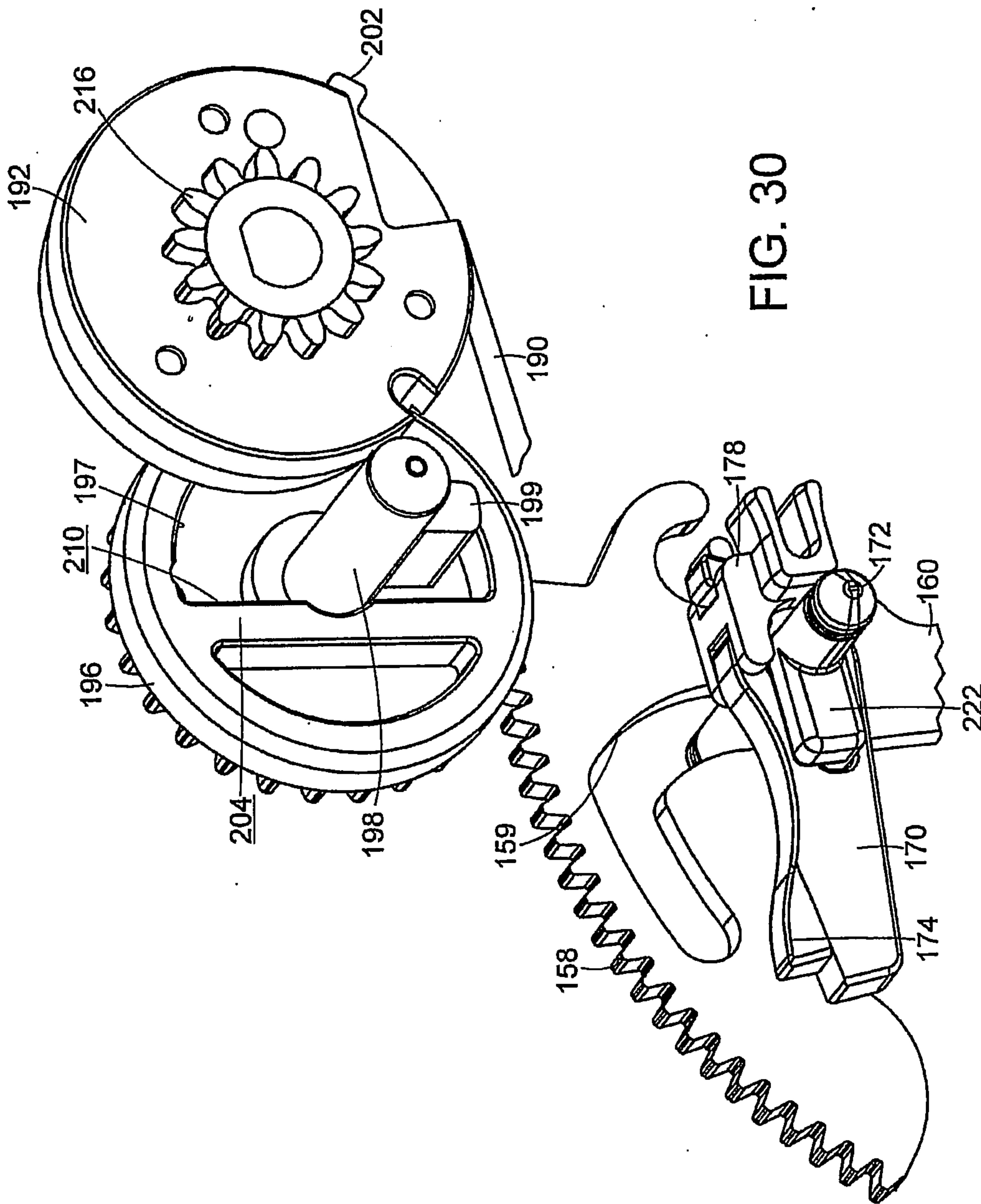


FIG. 30

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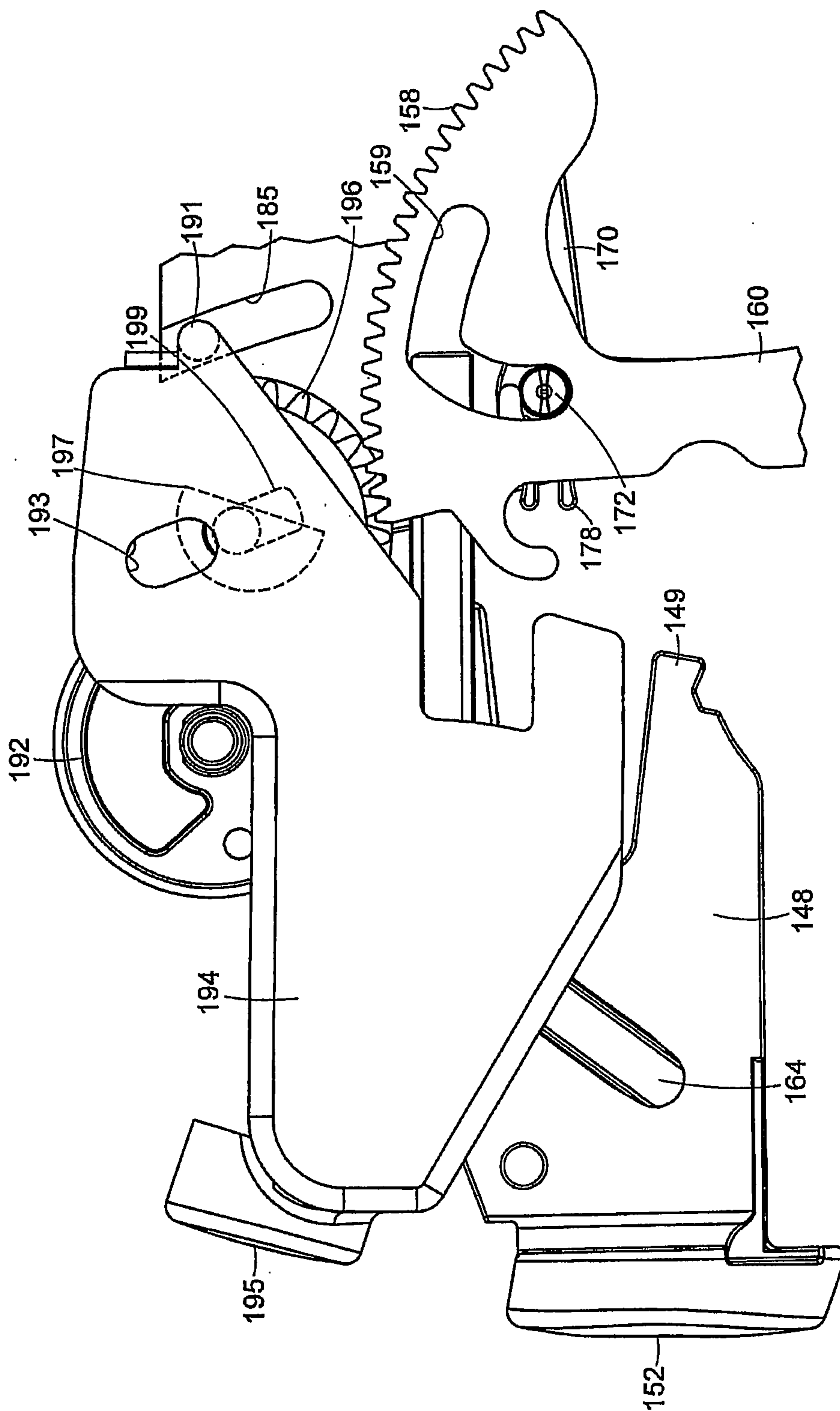


FIG. 31

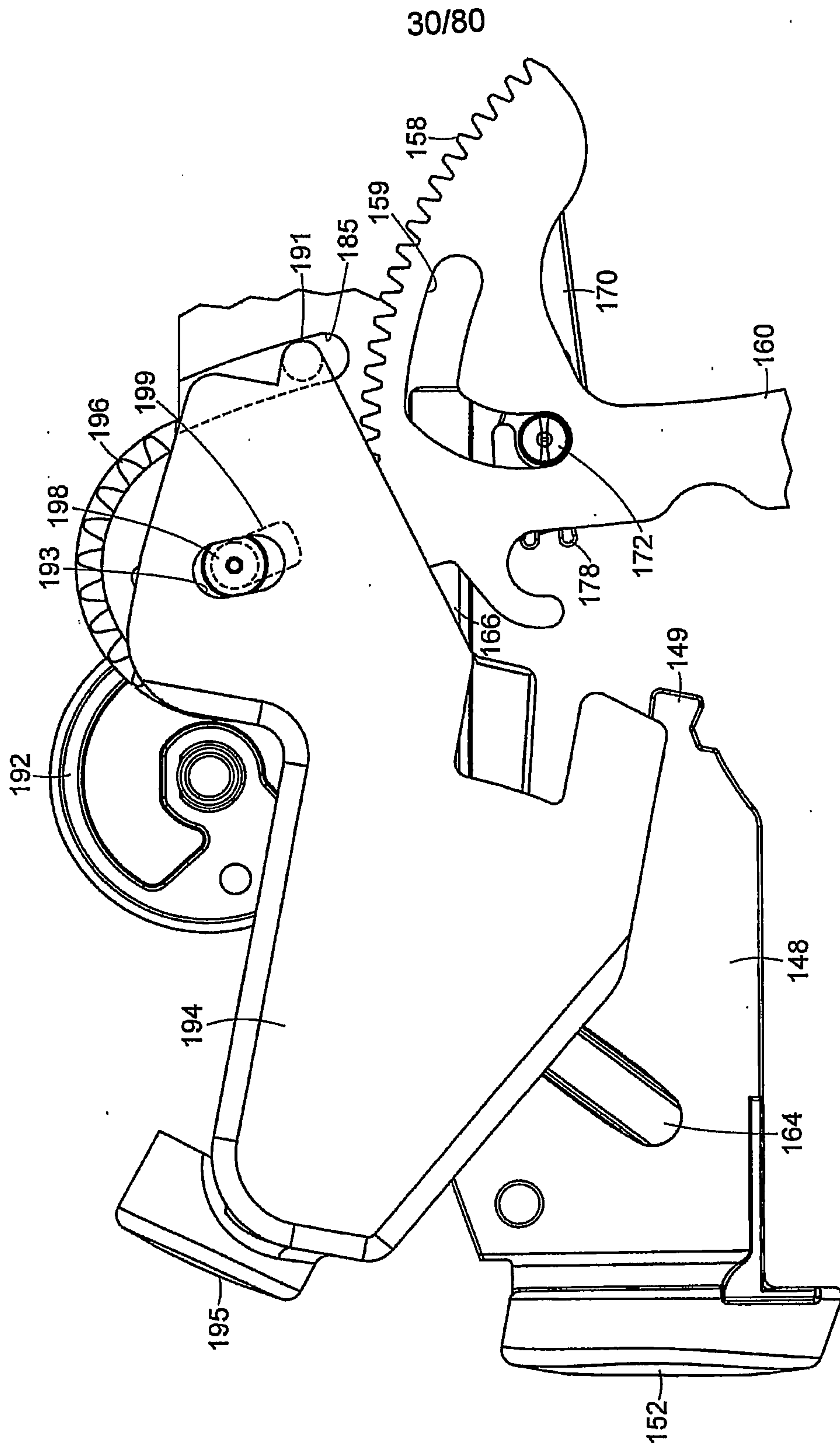


FIG. 32

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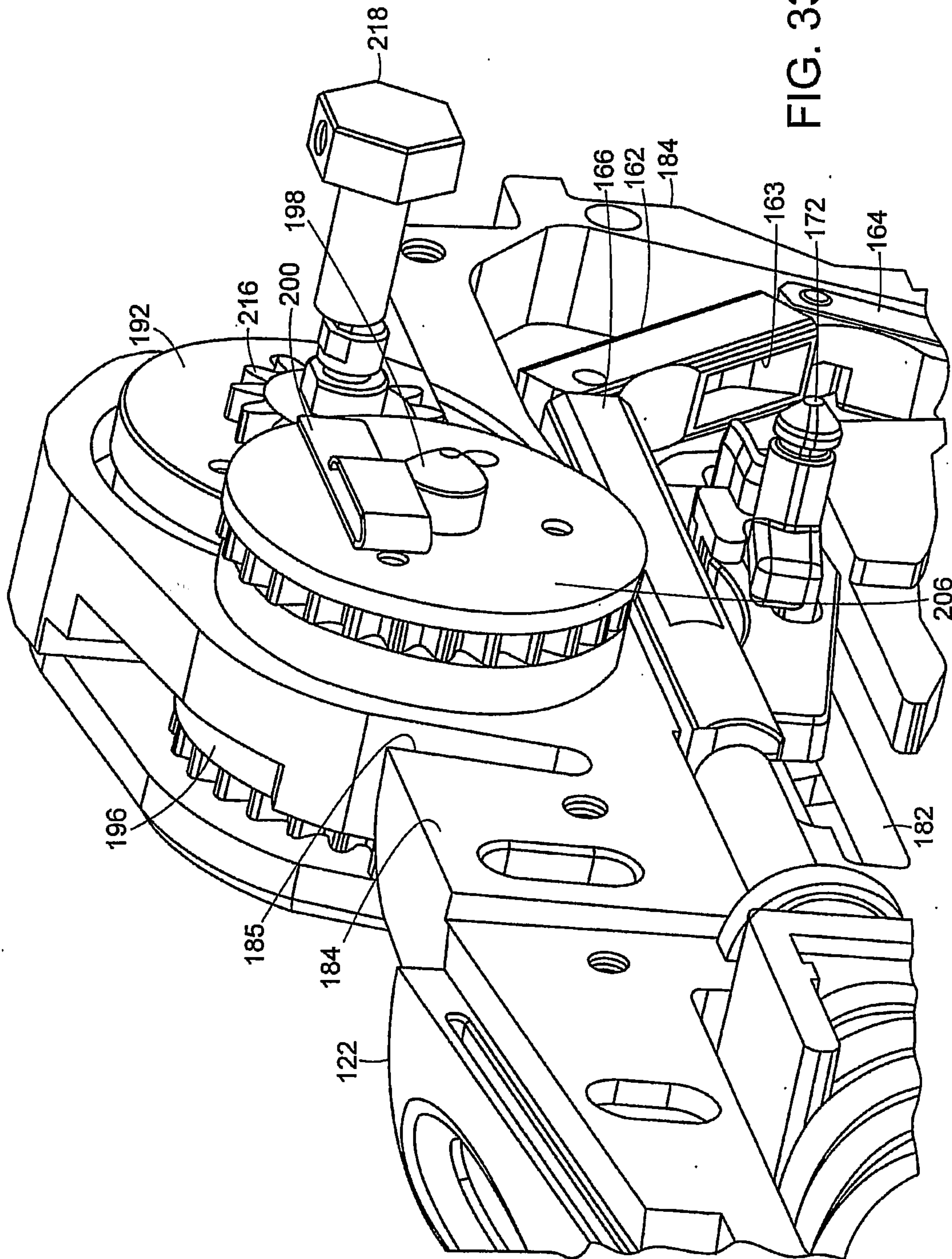


FIG. 33

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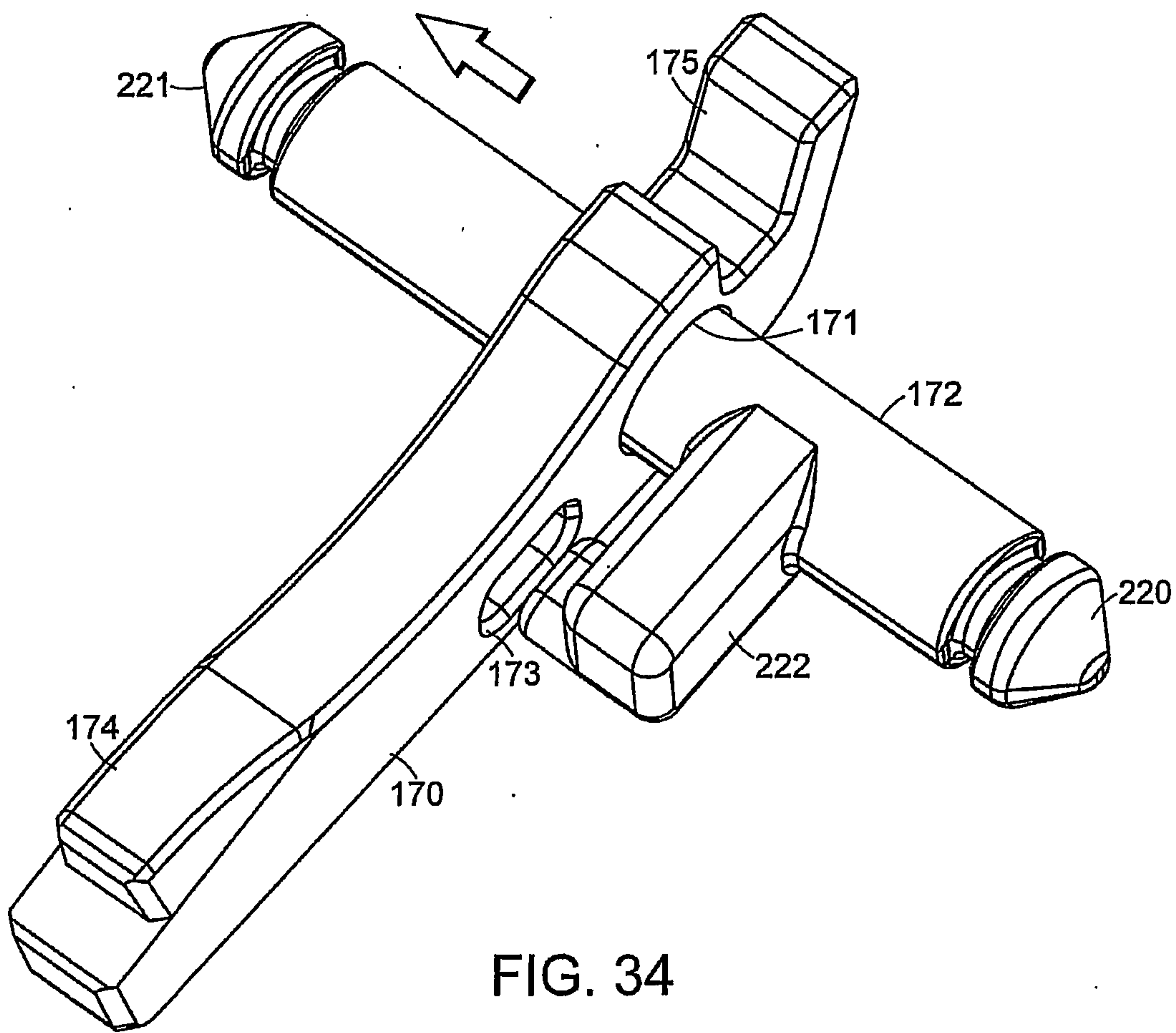


FIG. 34

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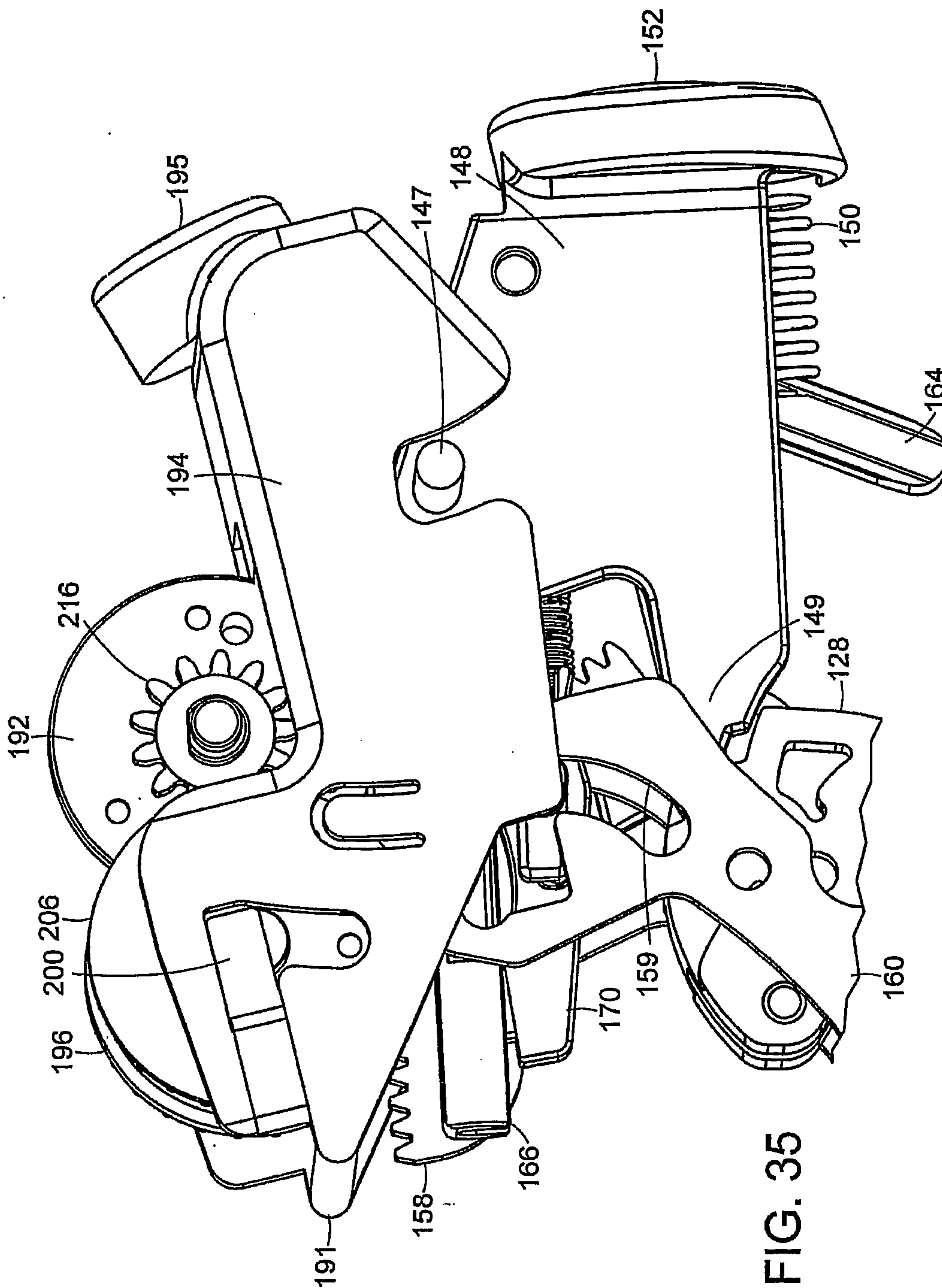


FIG. 35

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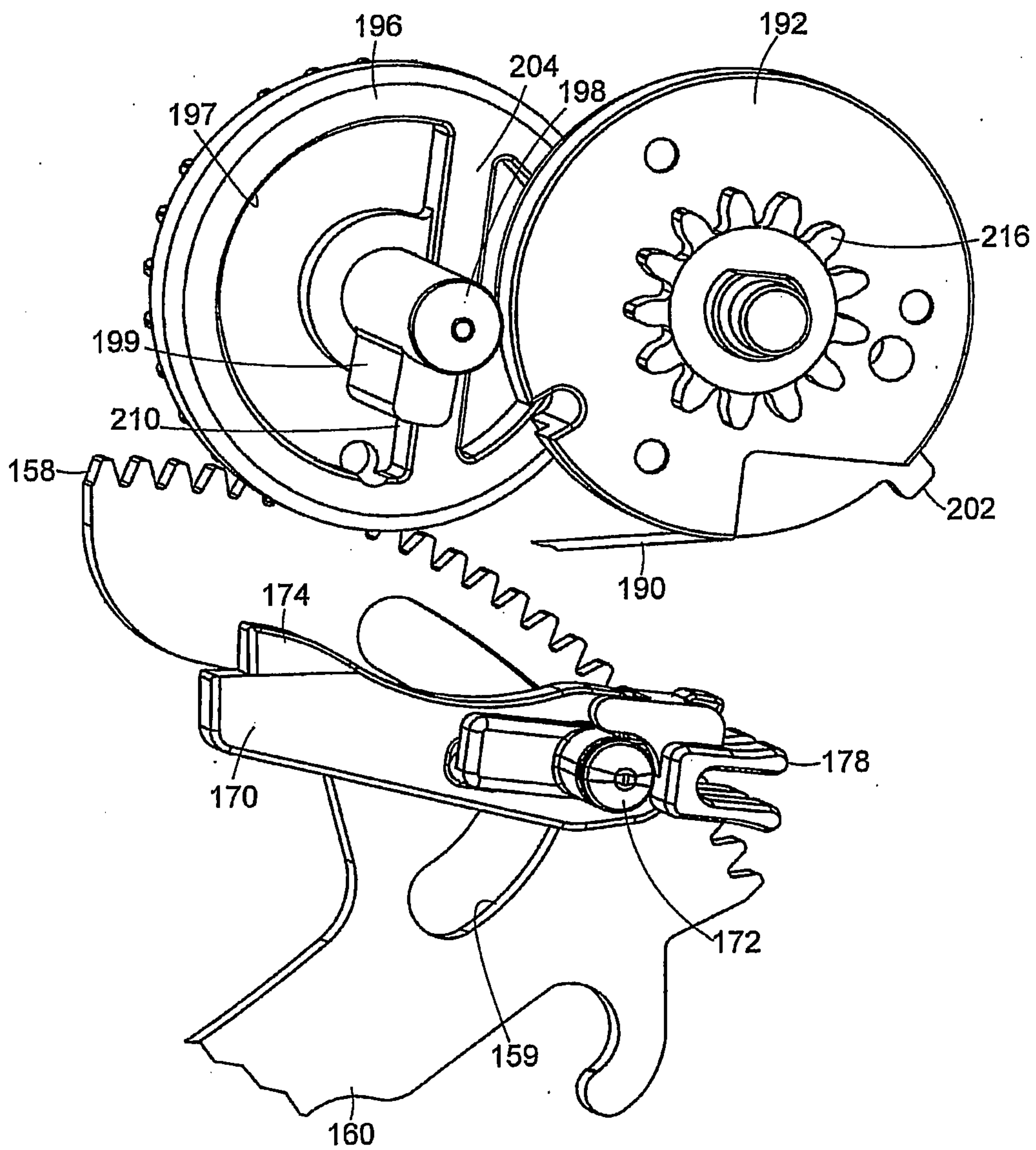


FIG. 36

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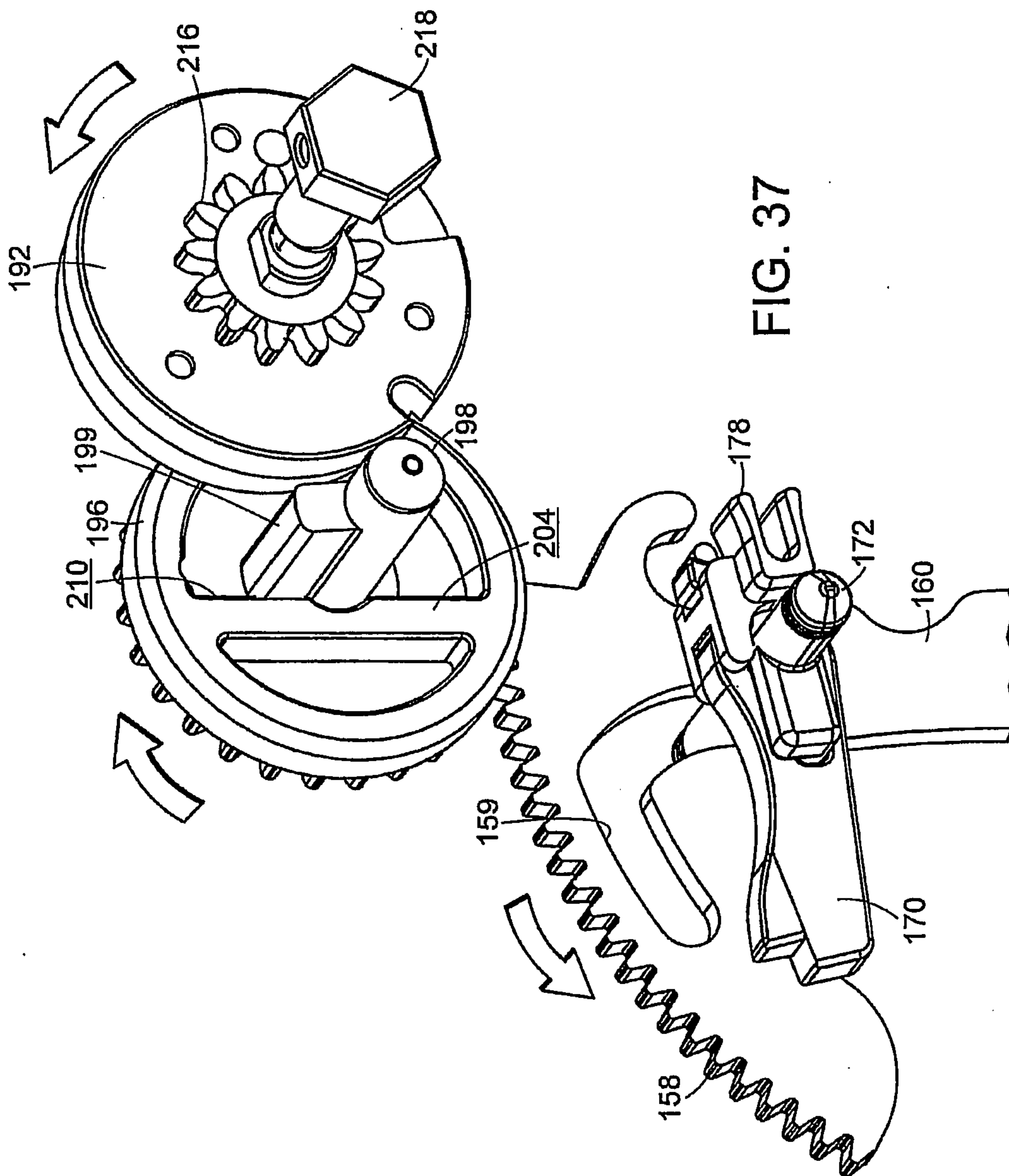


FIG. 37

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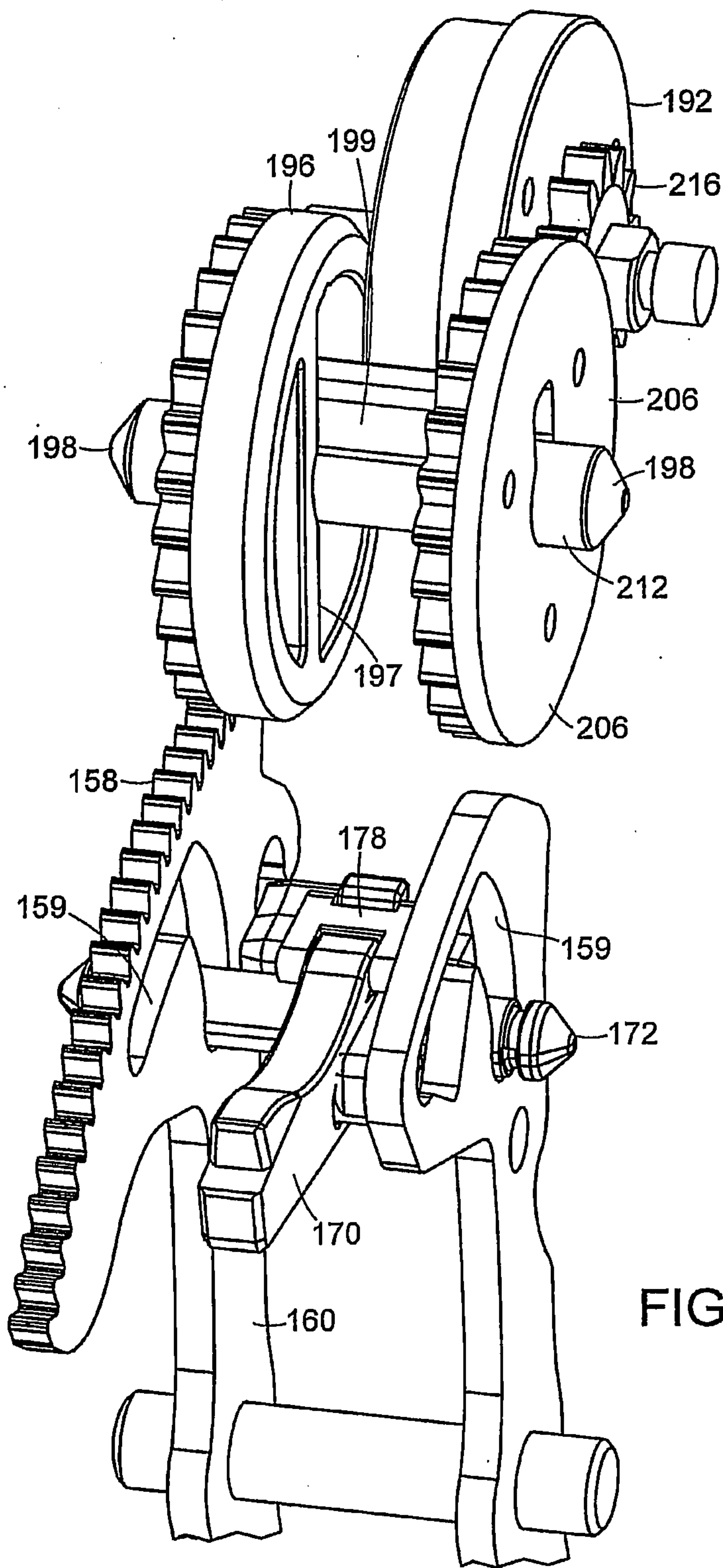
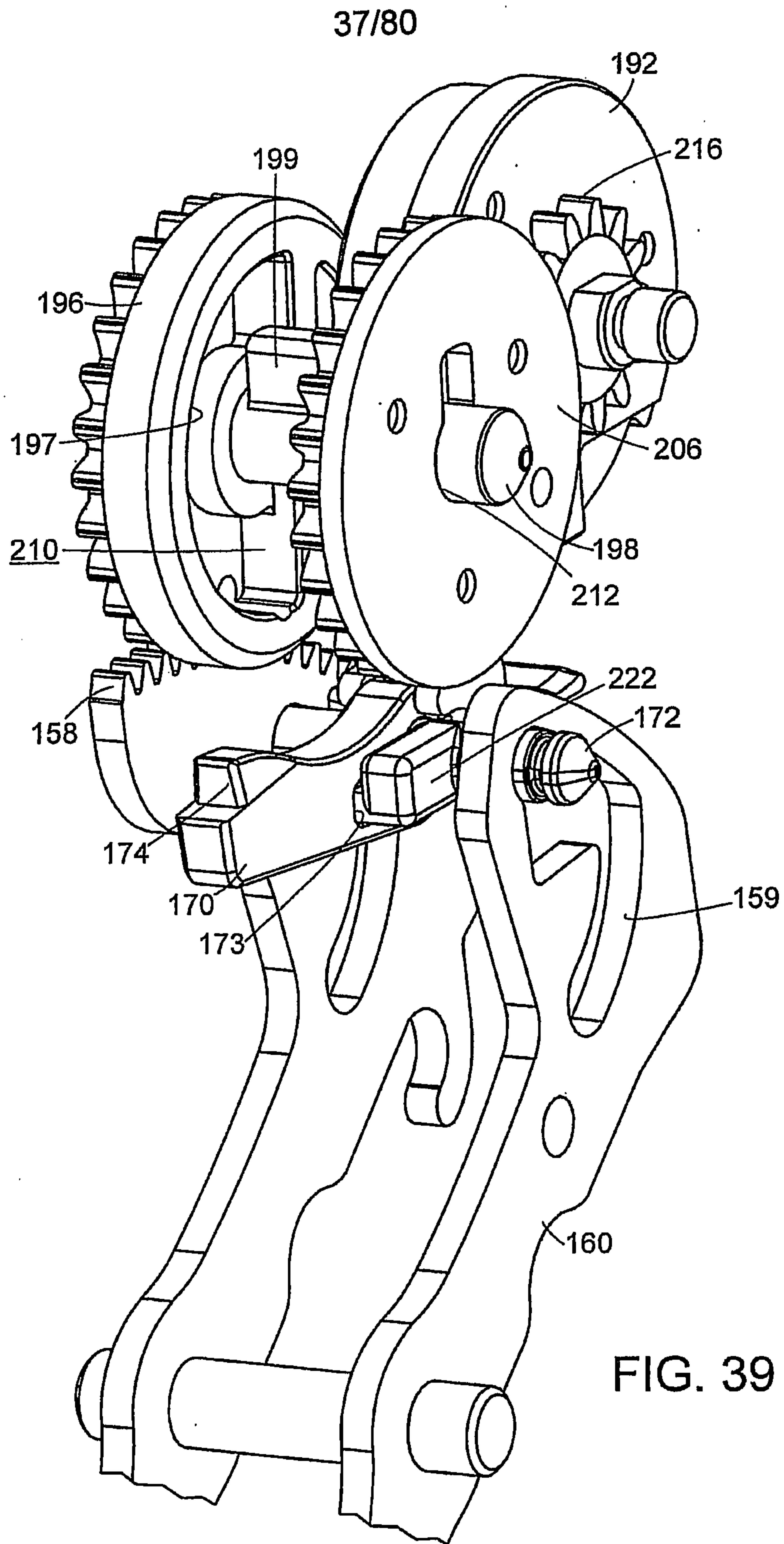
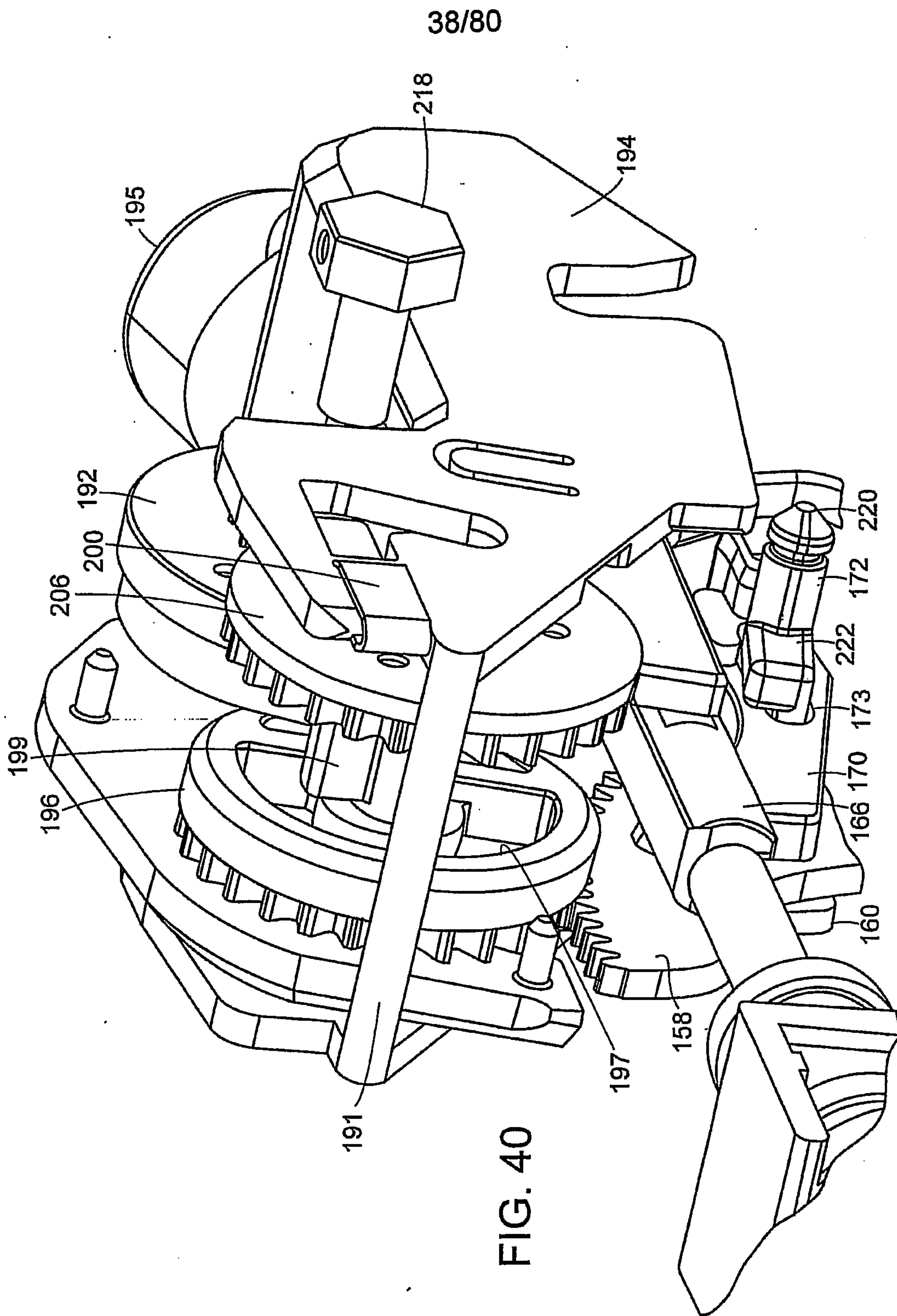


FIG. 38





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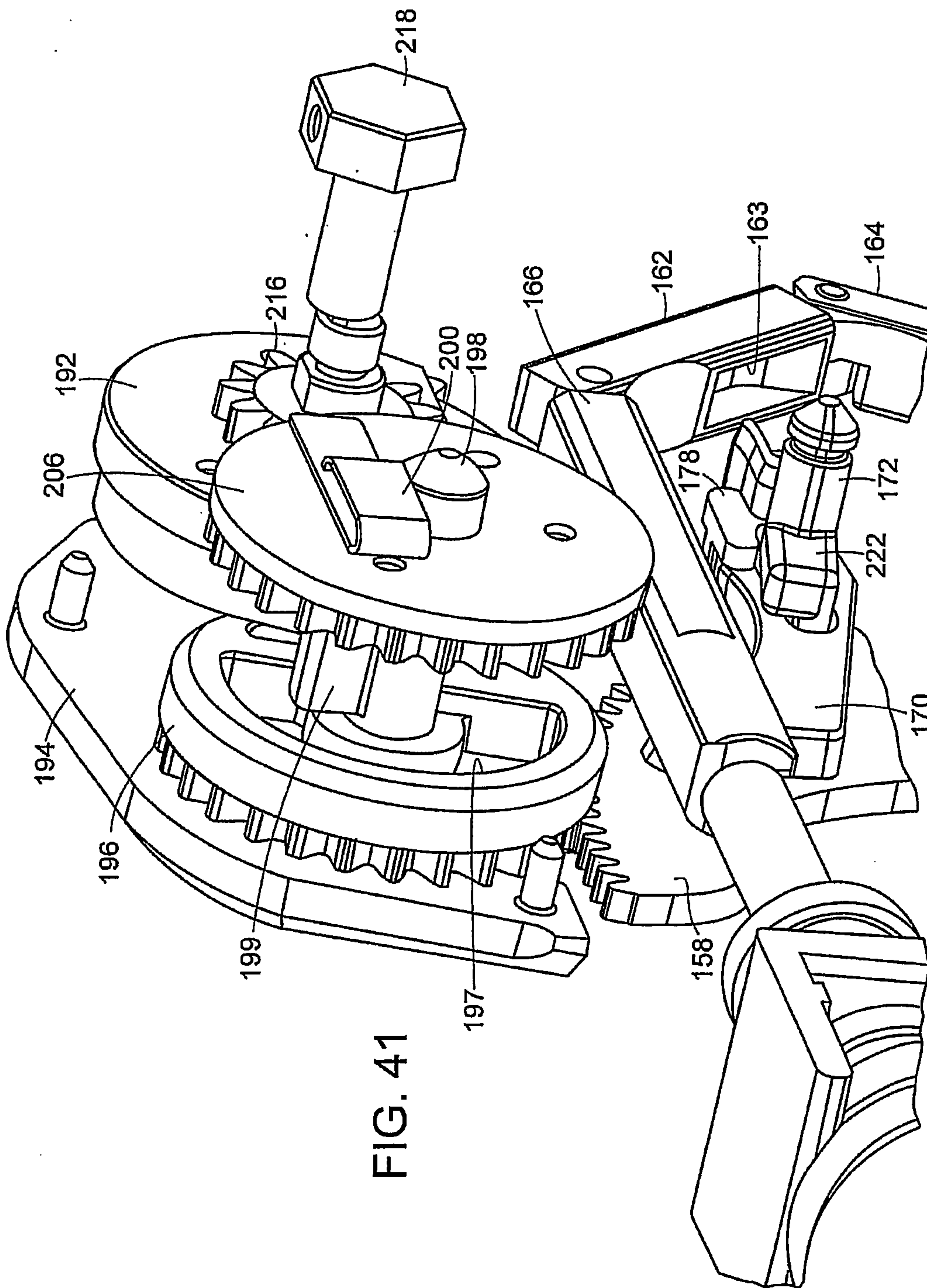


FIG. 41

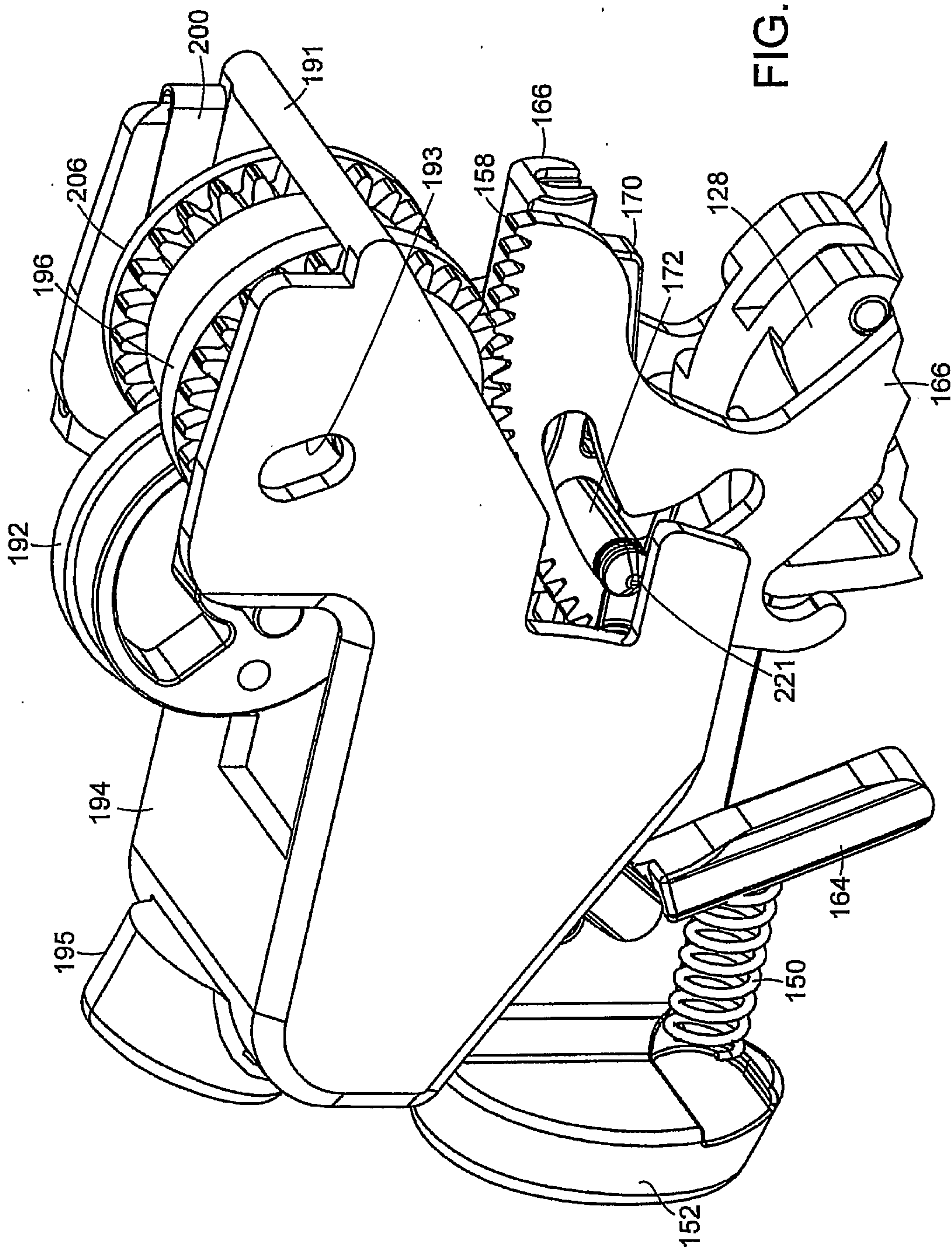


FIG. 42

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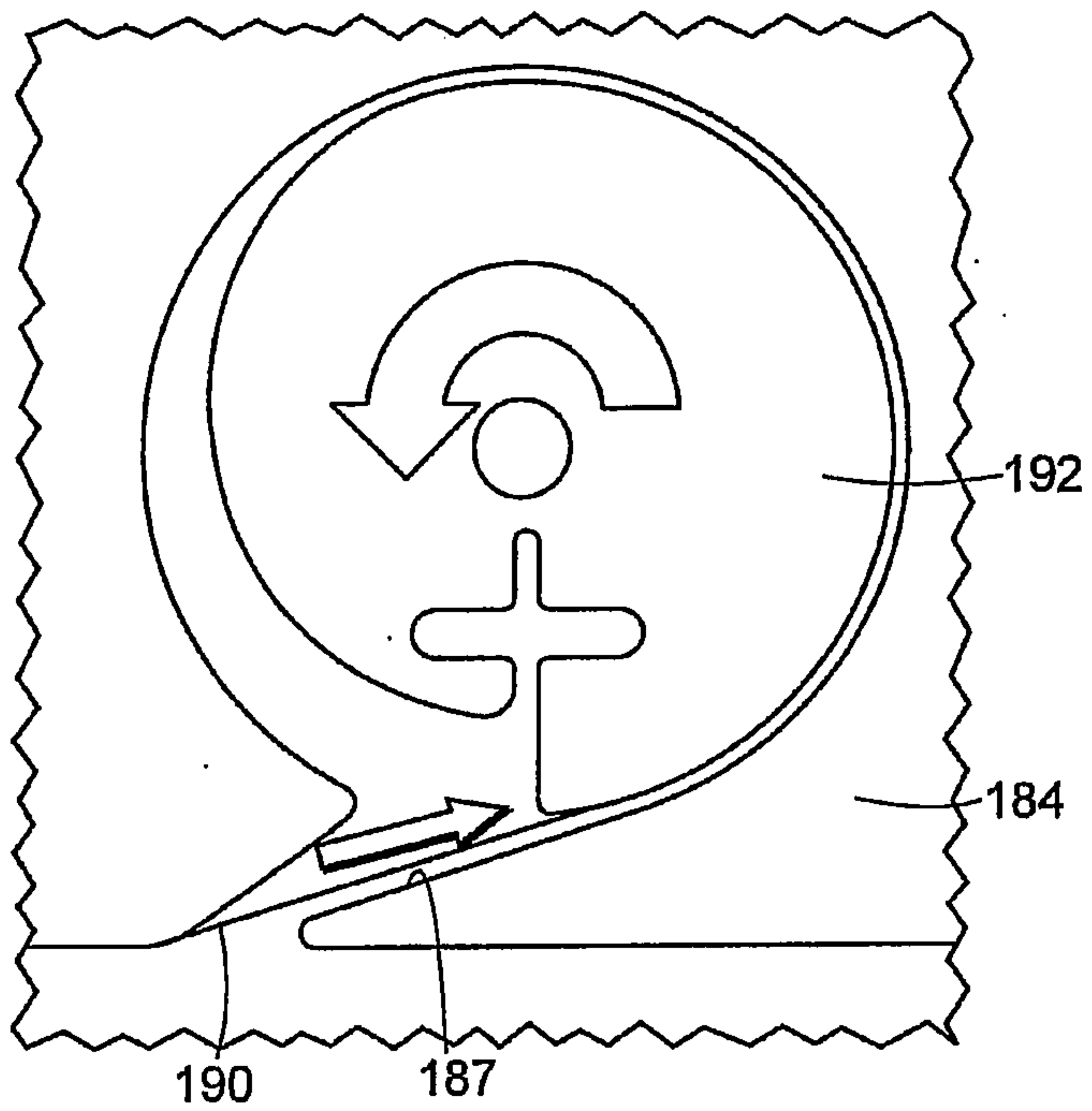


FIG. 43

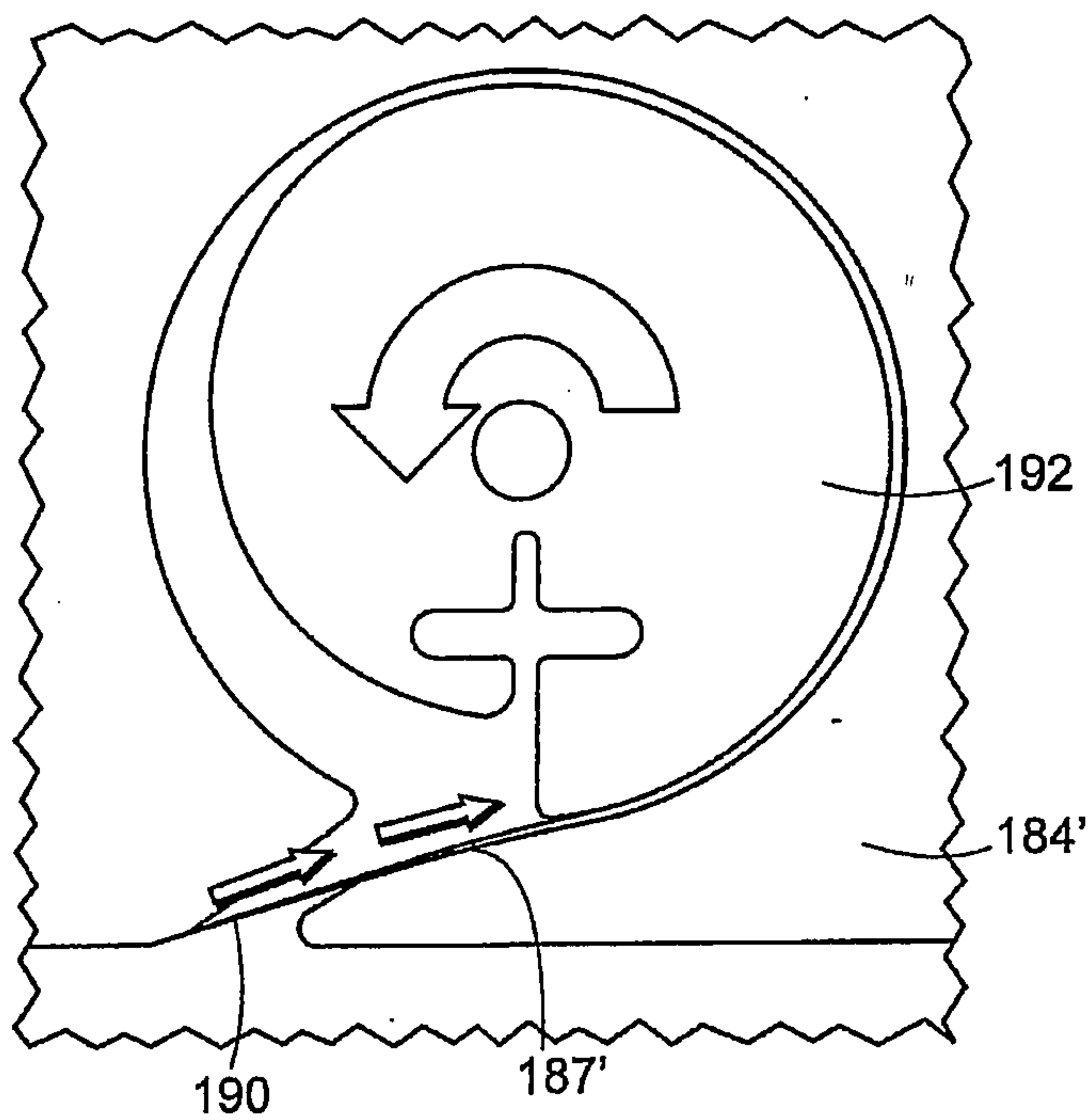


FIG. 44

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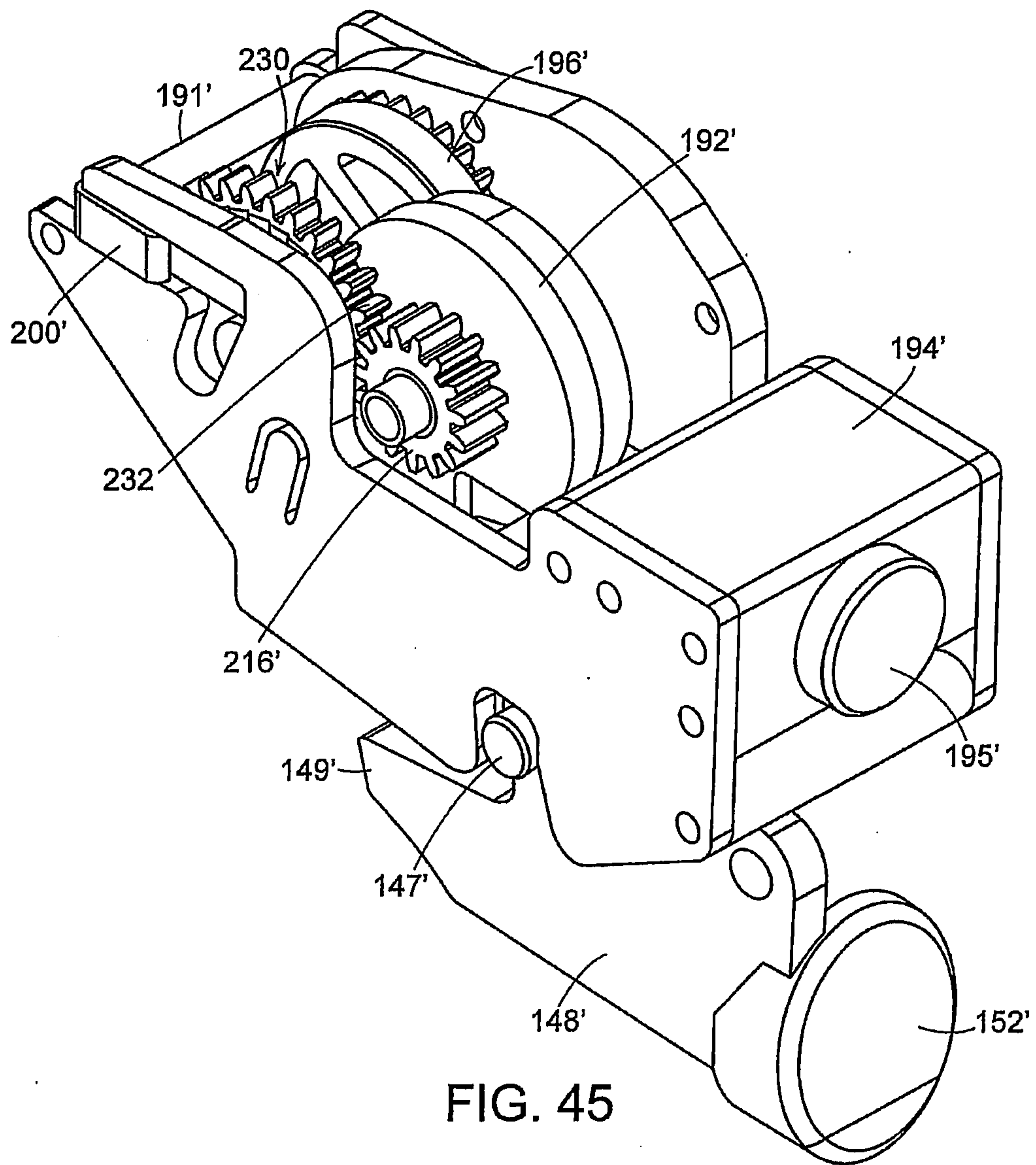


FIG. 45

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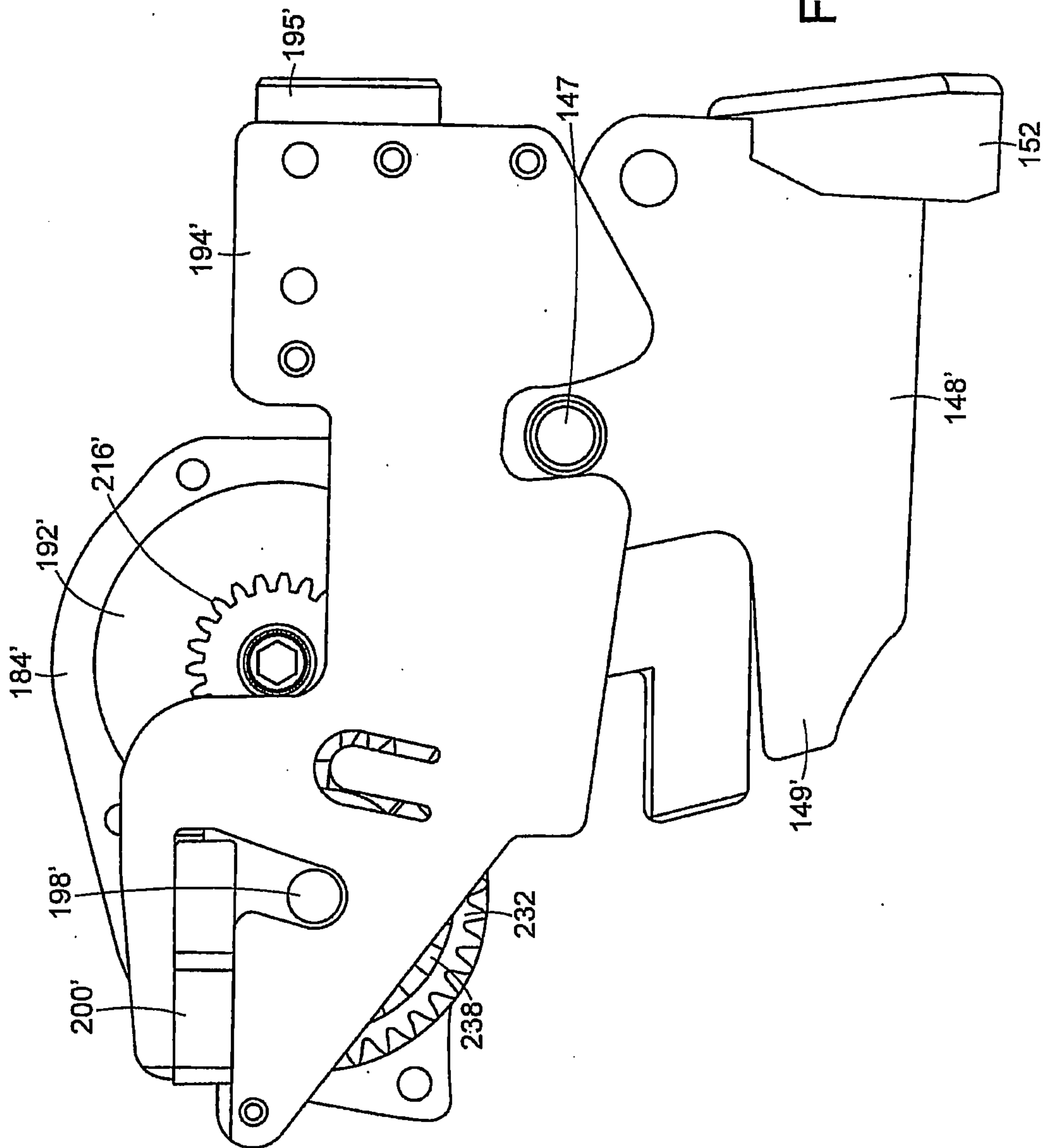


FIG. 46

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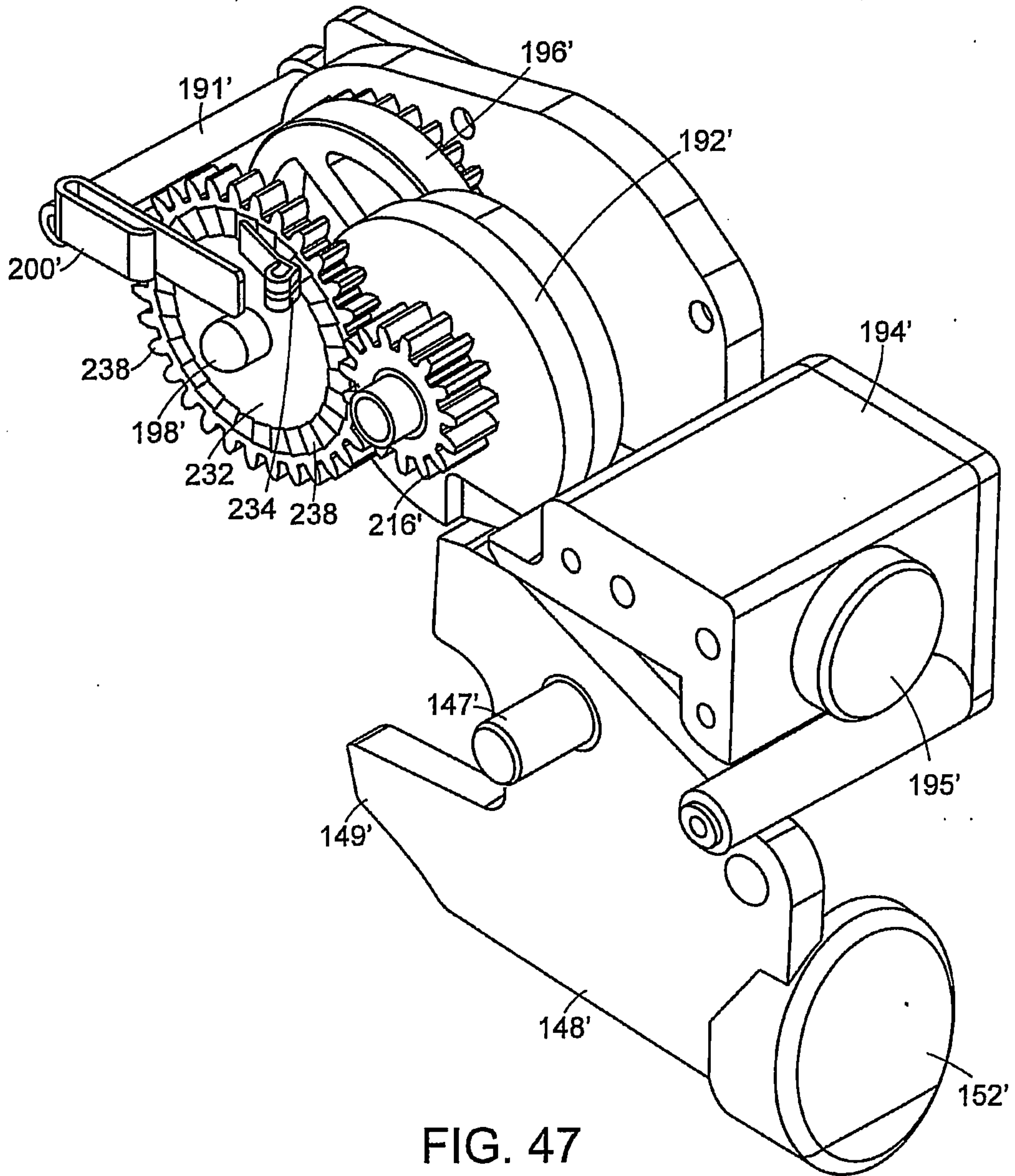


FIG. 47

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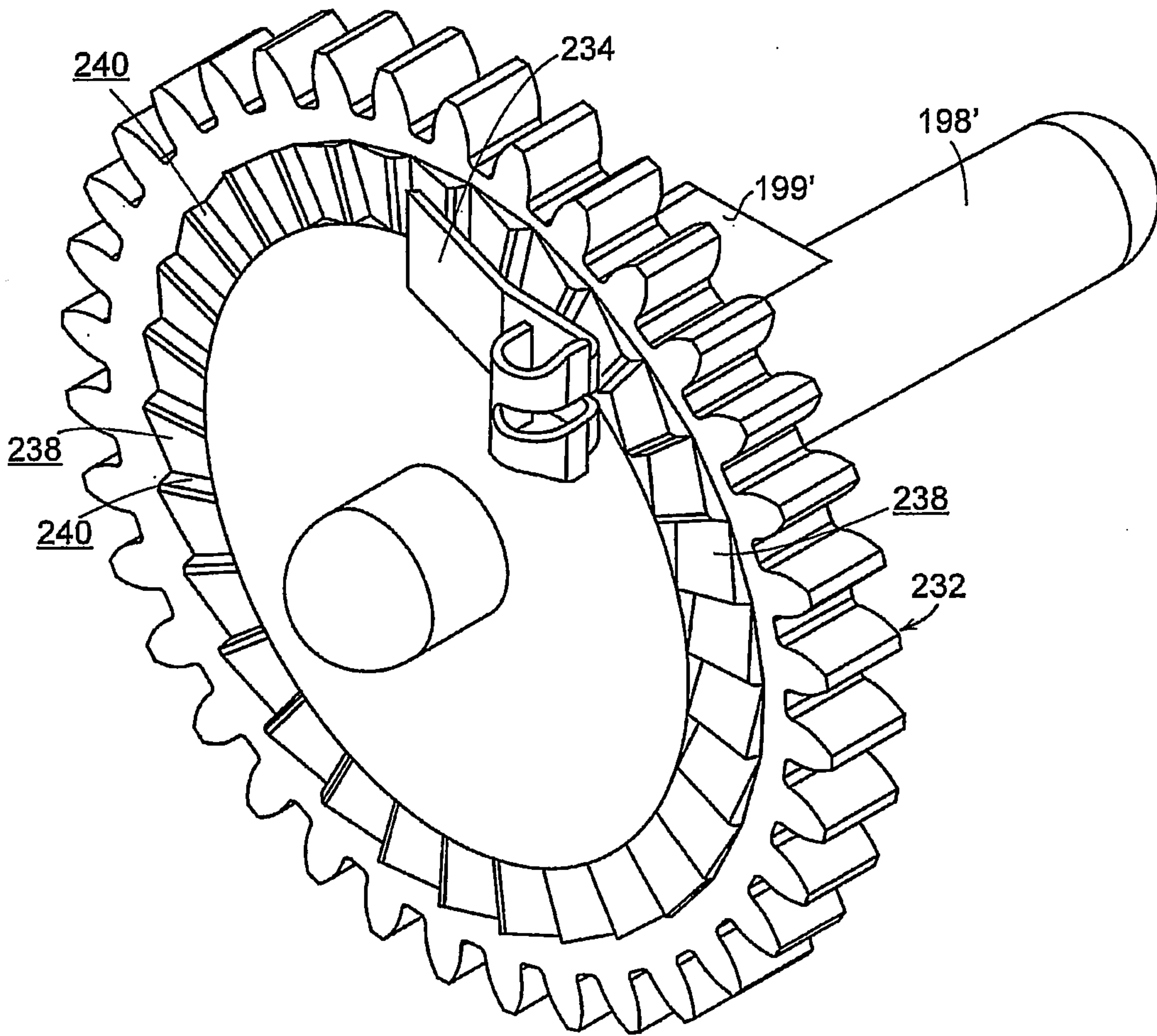


FIG. 48

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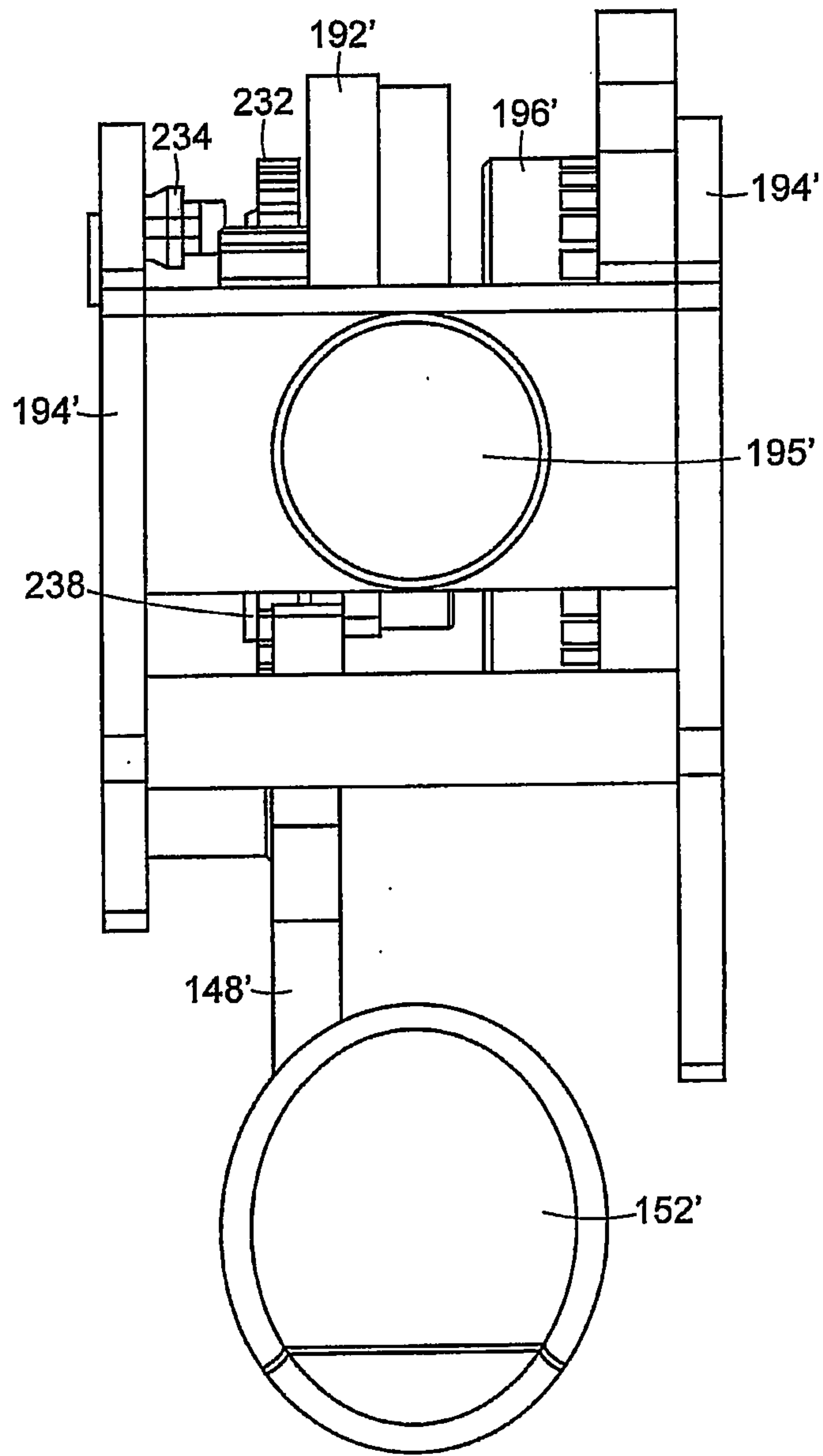
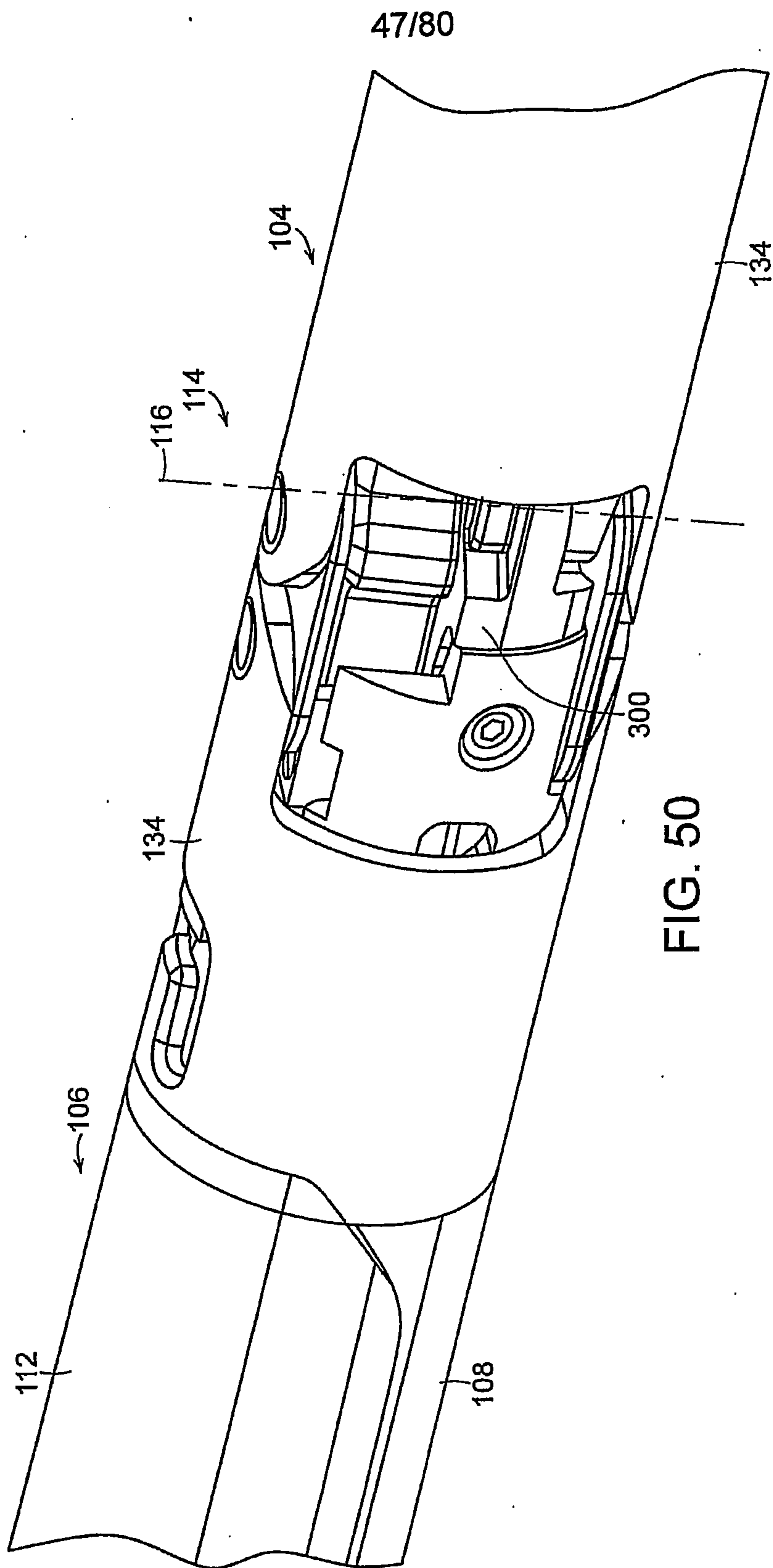


FIG. 49



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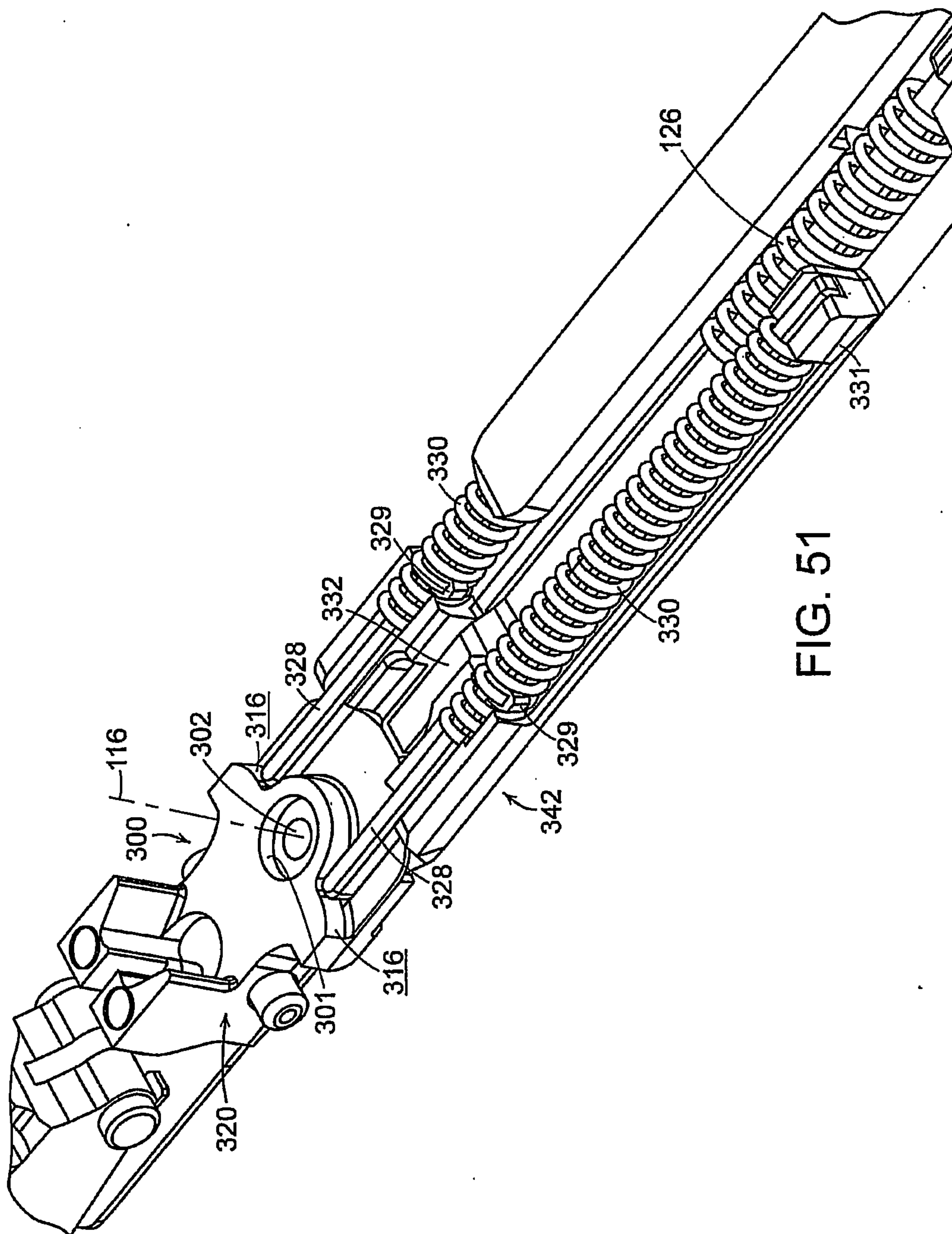


FIG. 51

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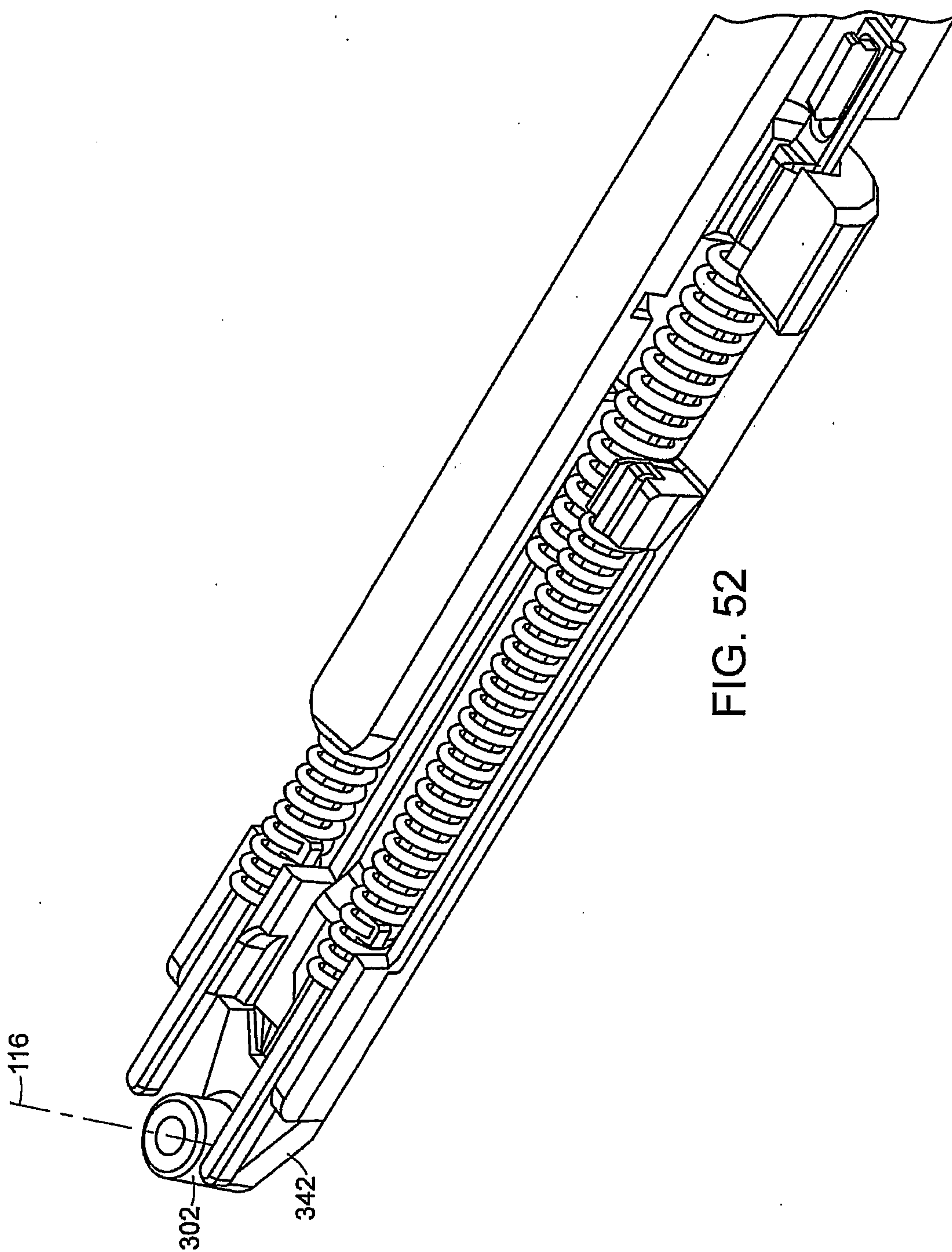


FIG. 52

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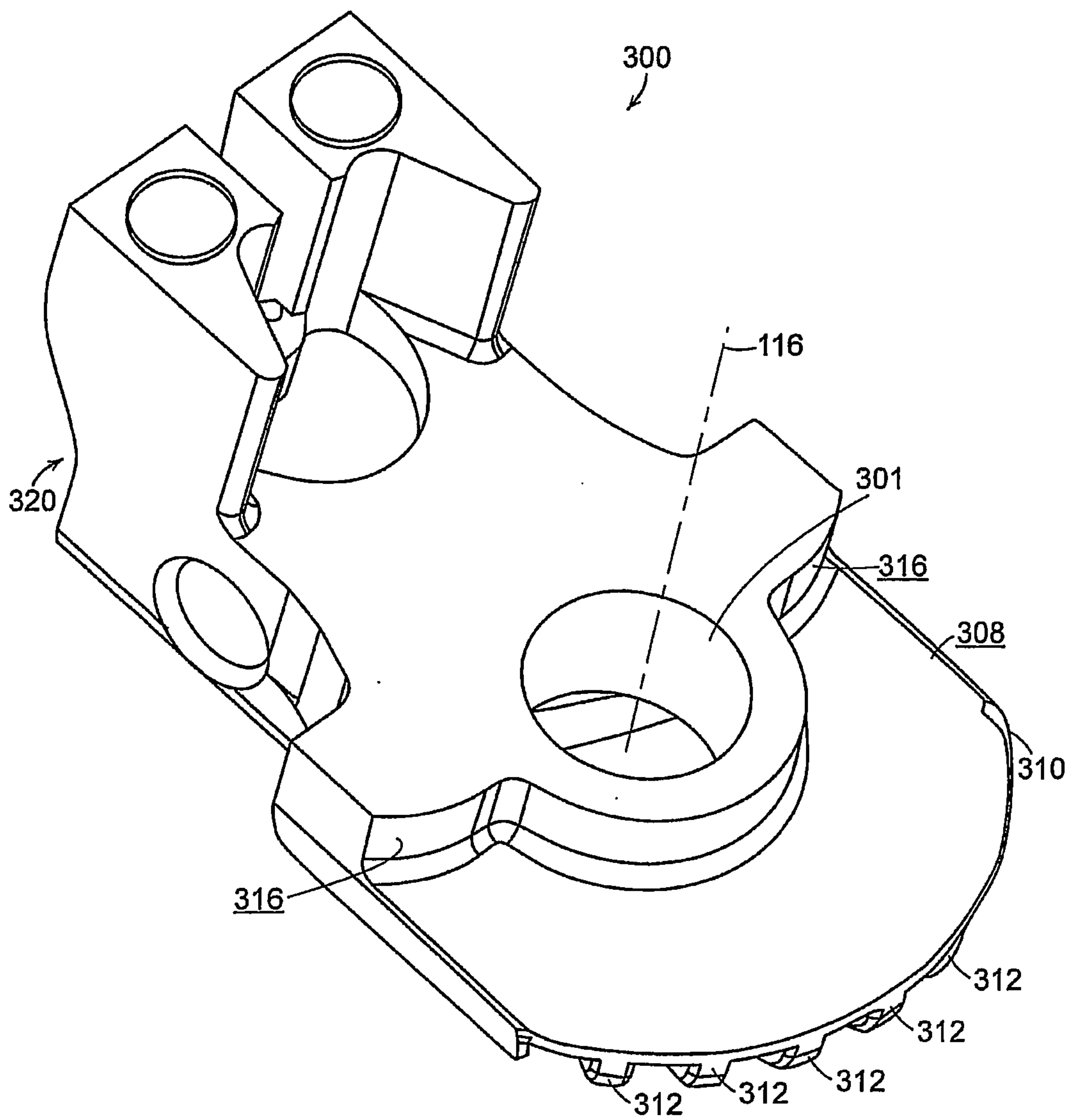
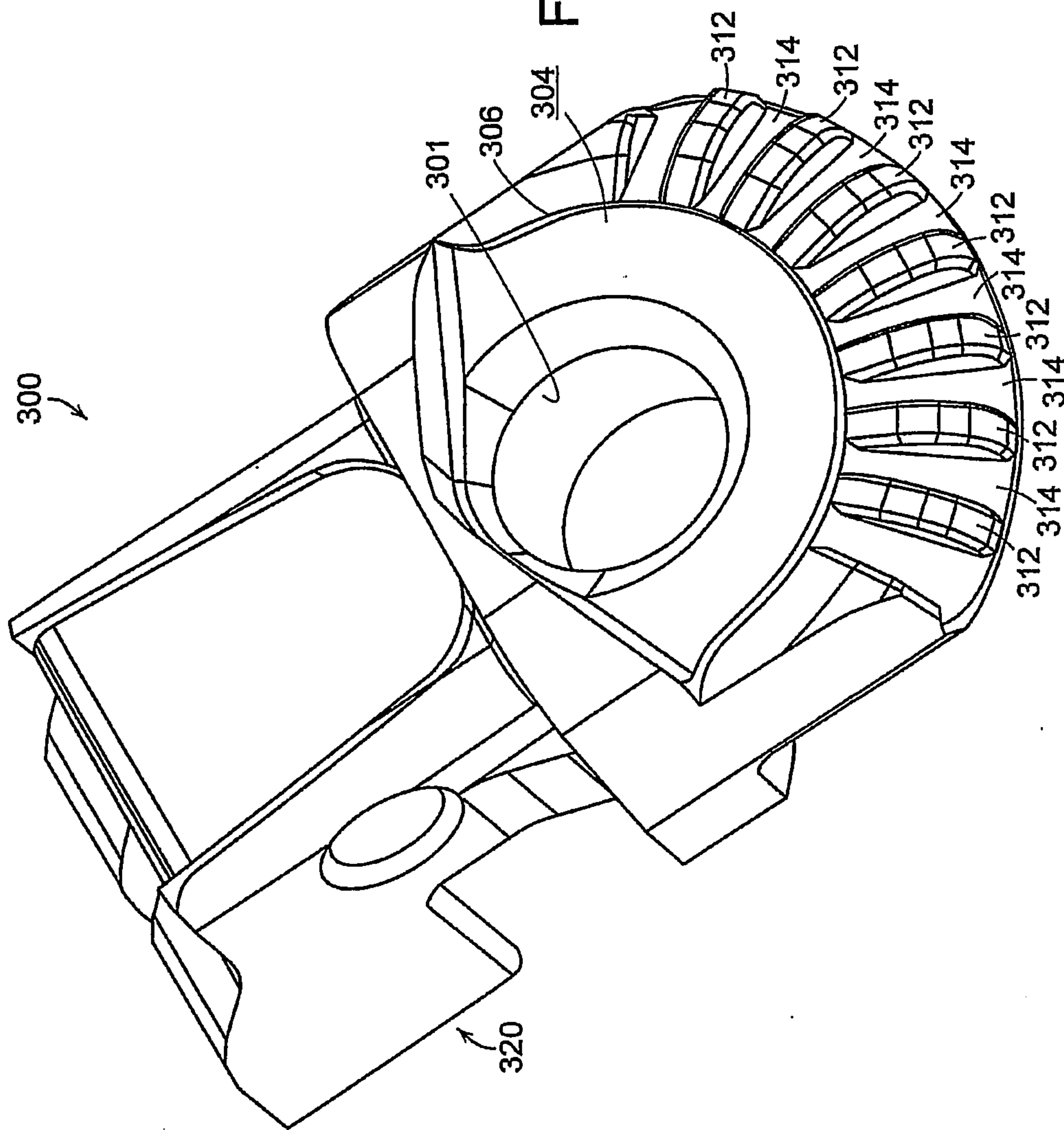
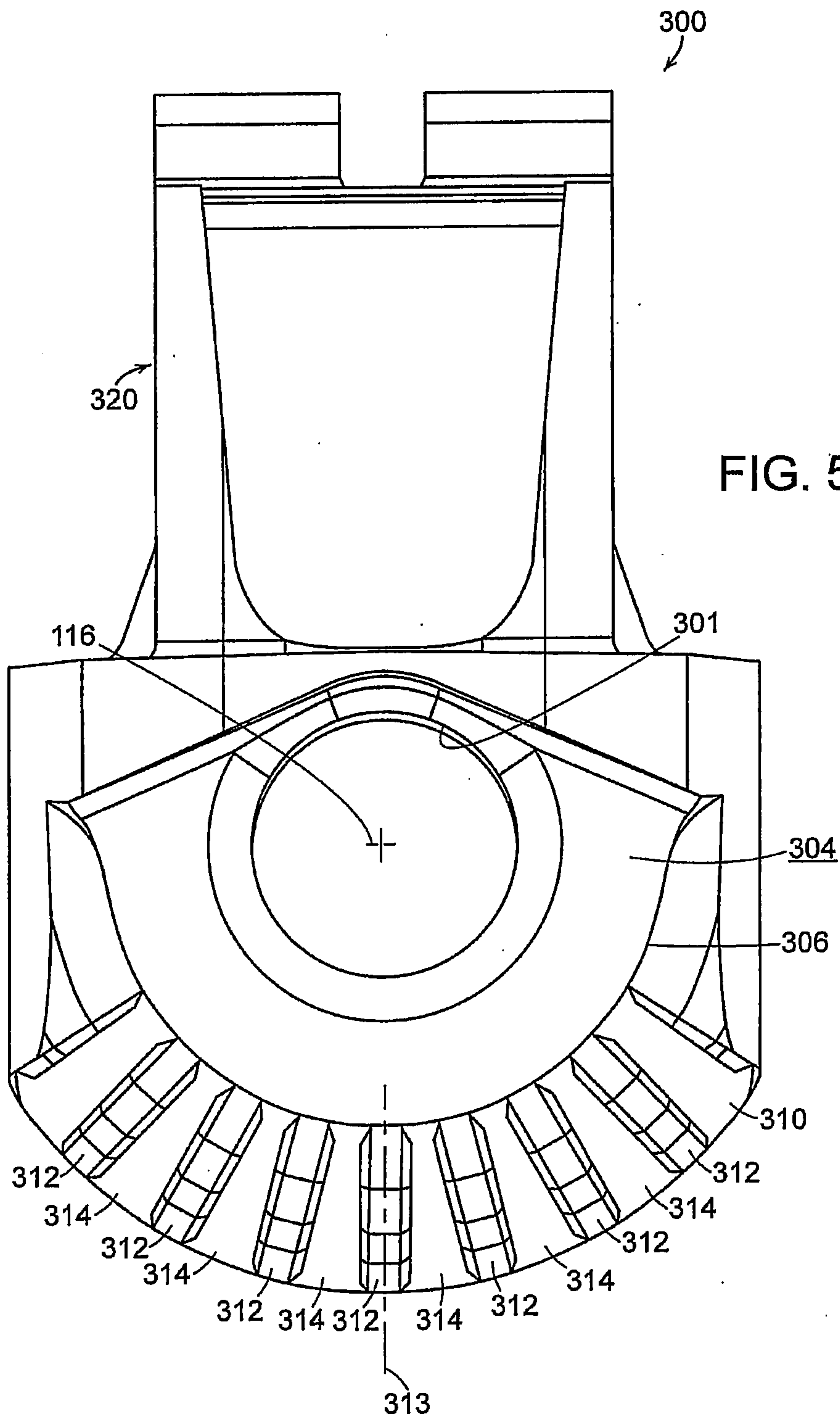


FIG. 53

FIG. 54



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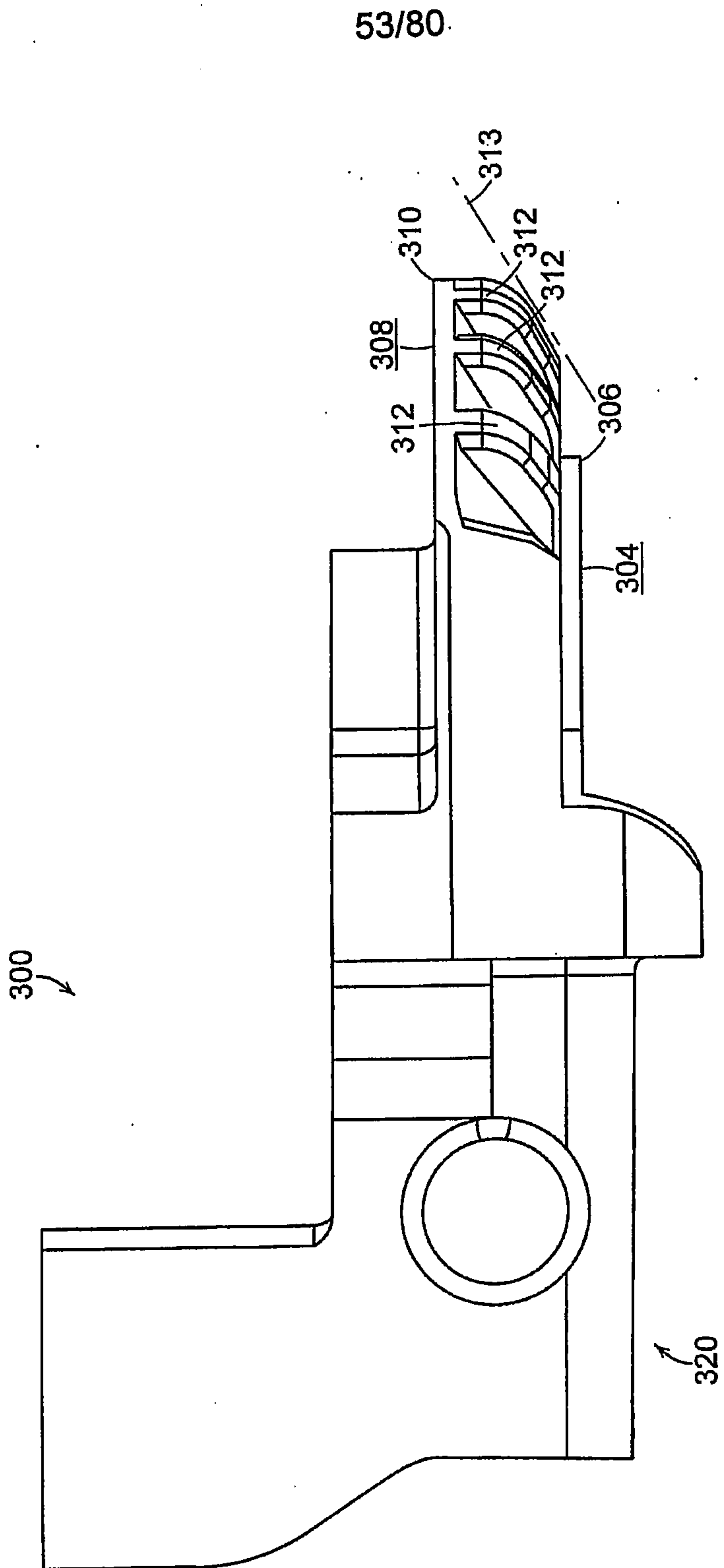


FIG. 56

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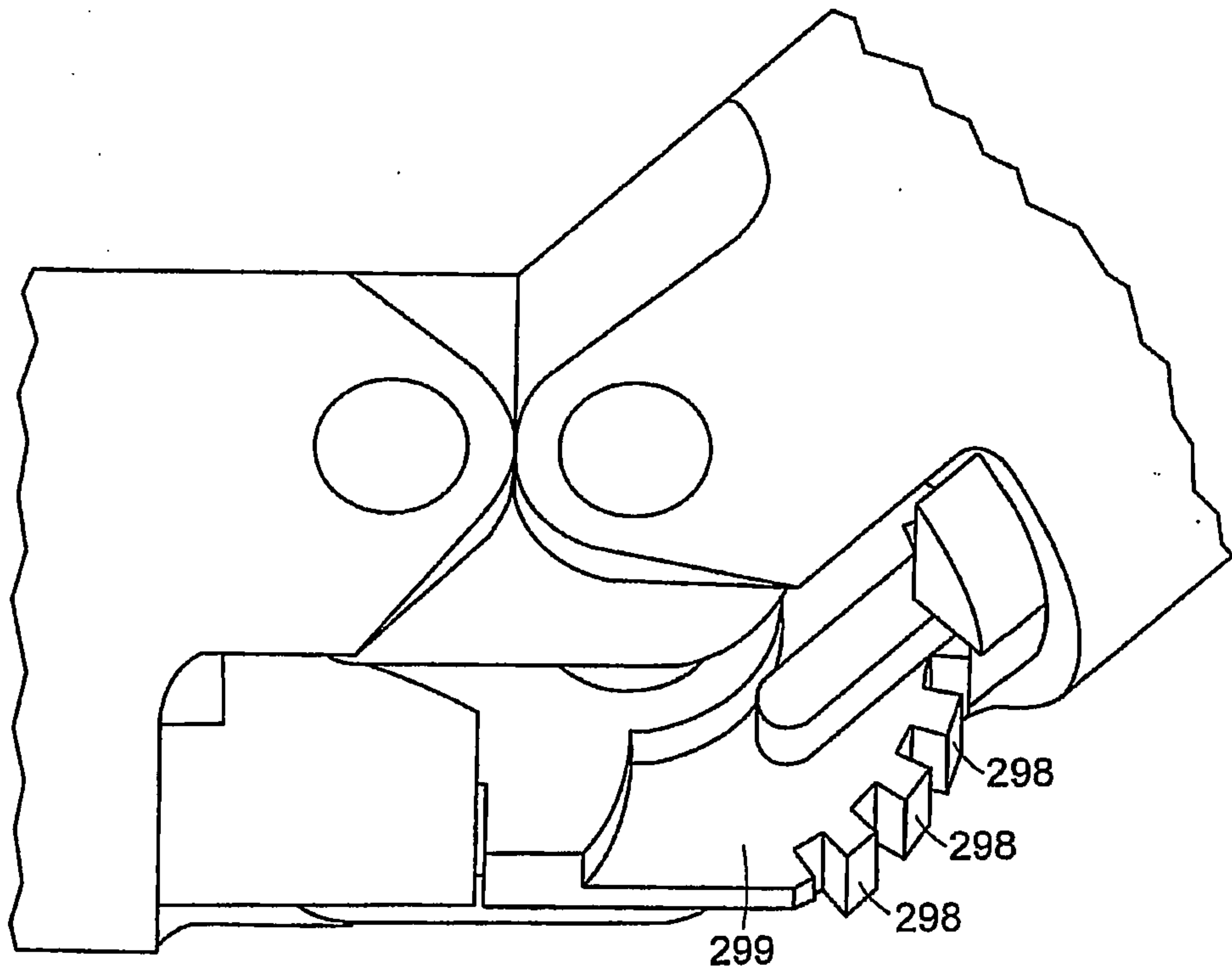


FIG. 57

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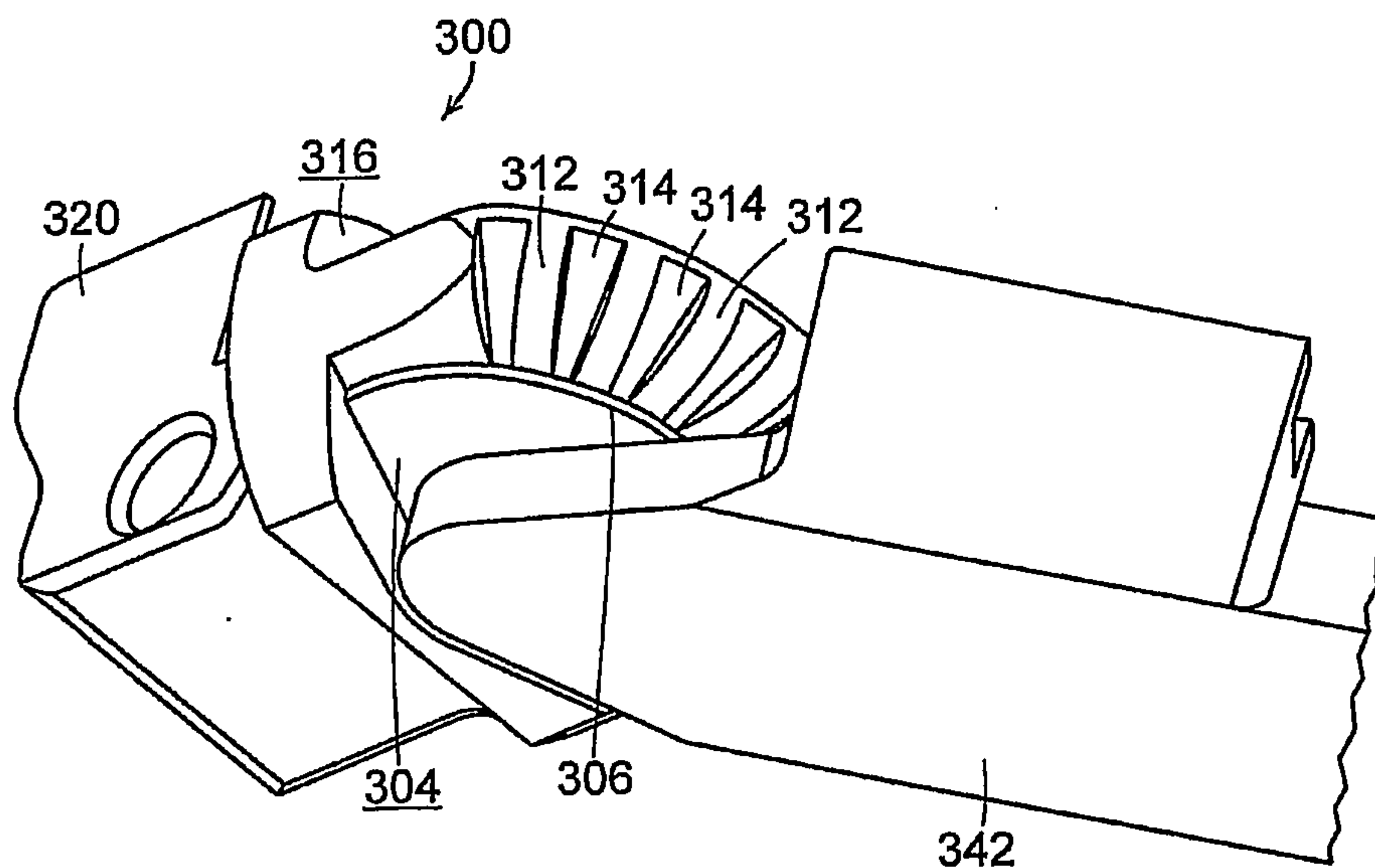


FIG. 58

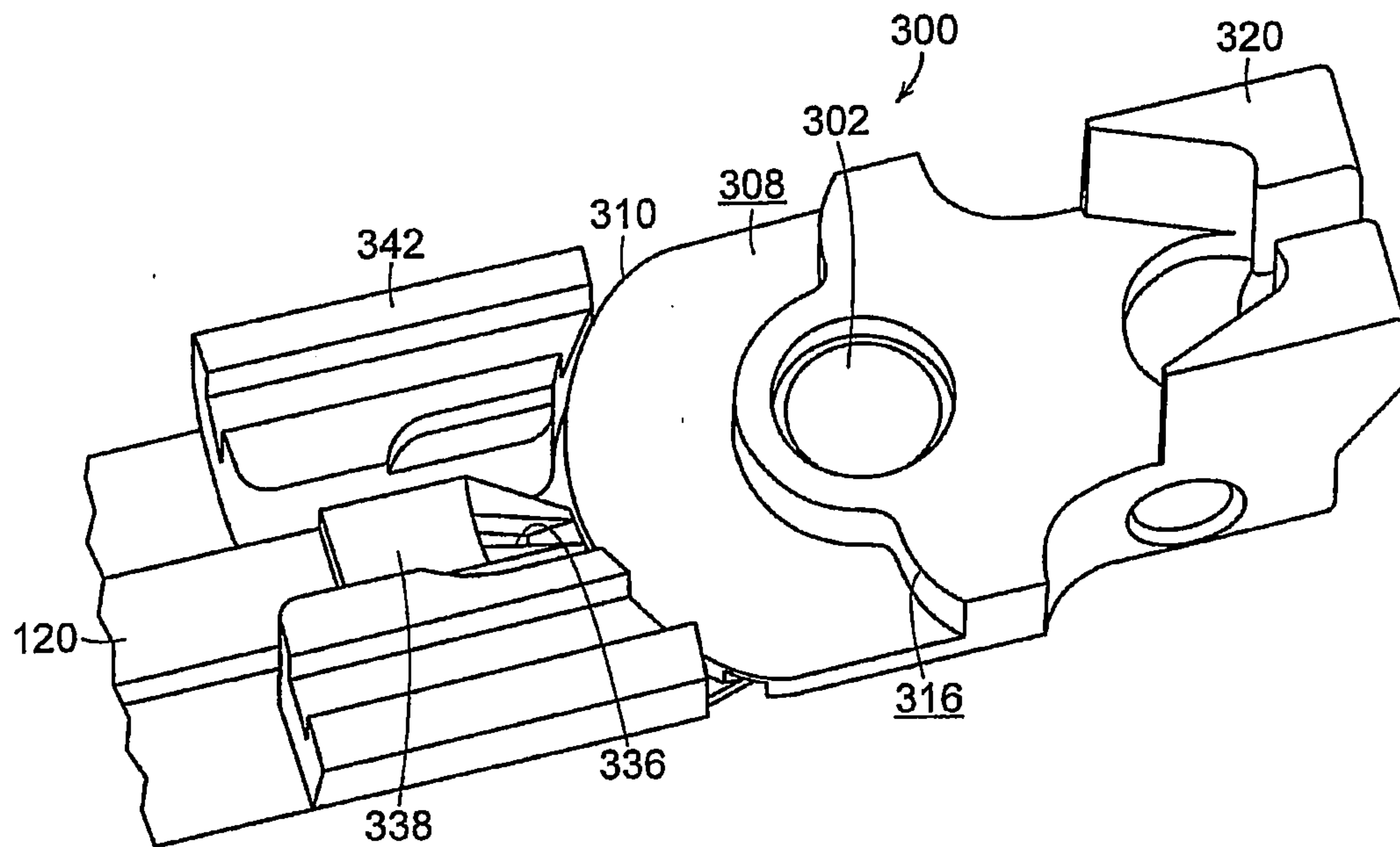
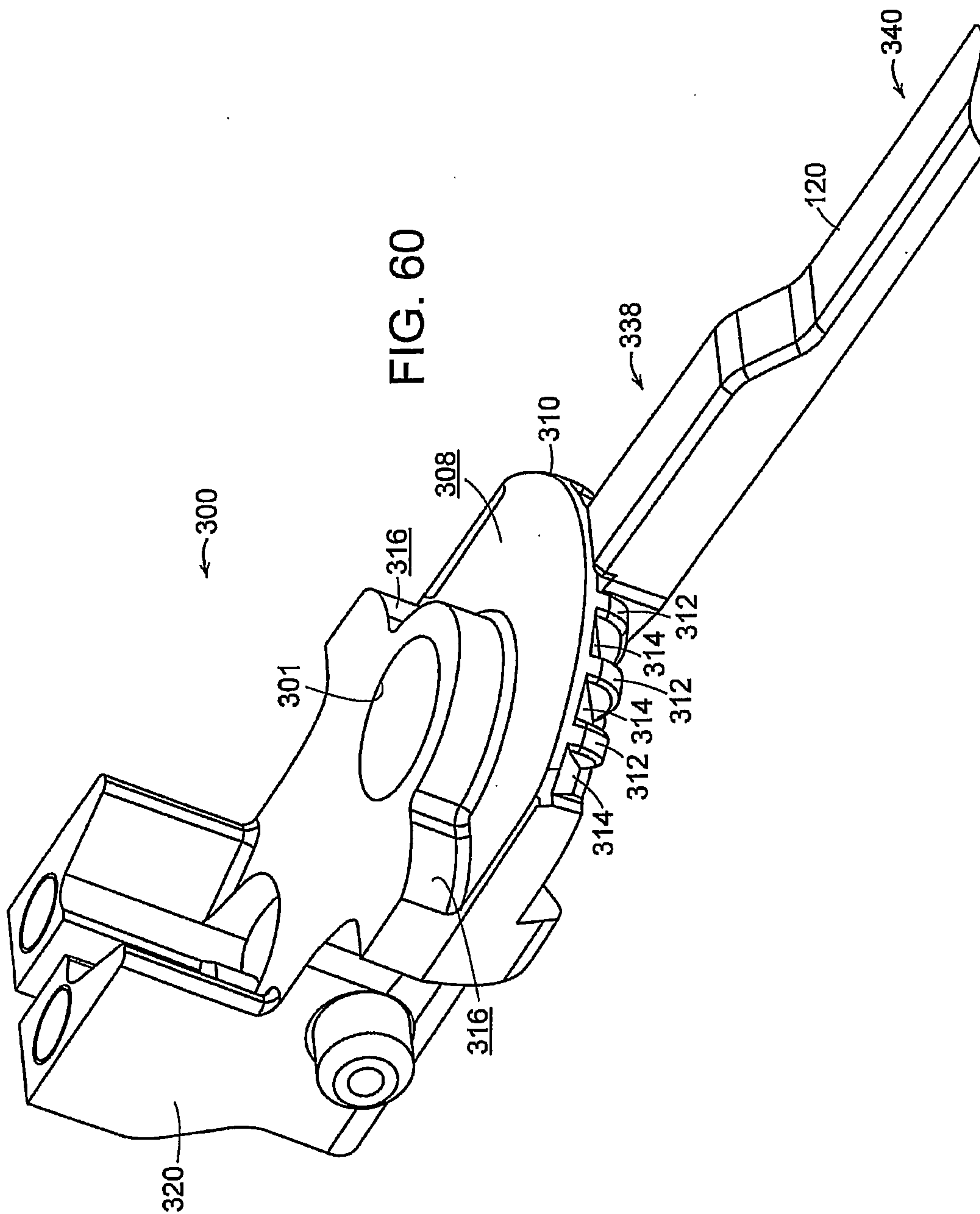


FIG. 59

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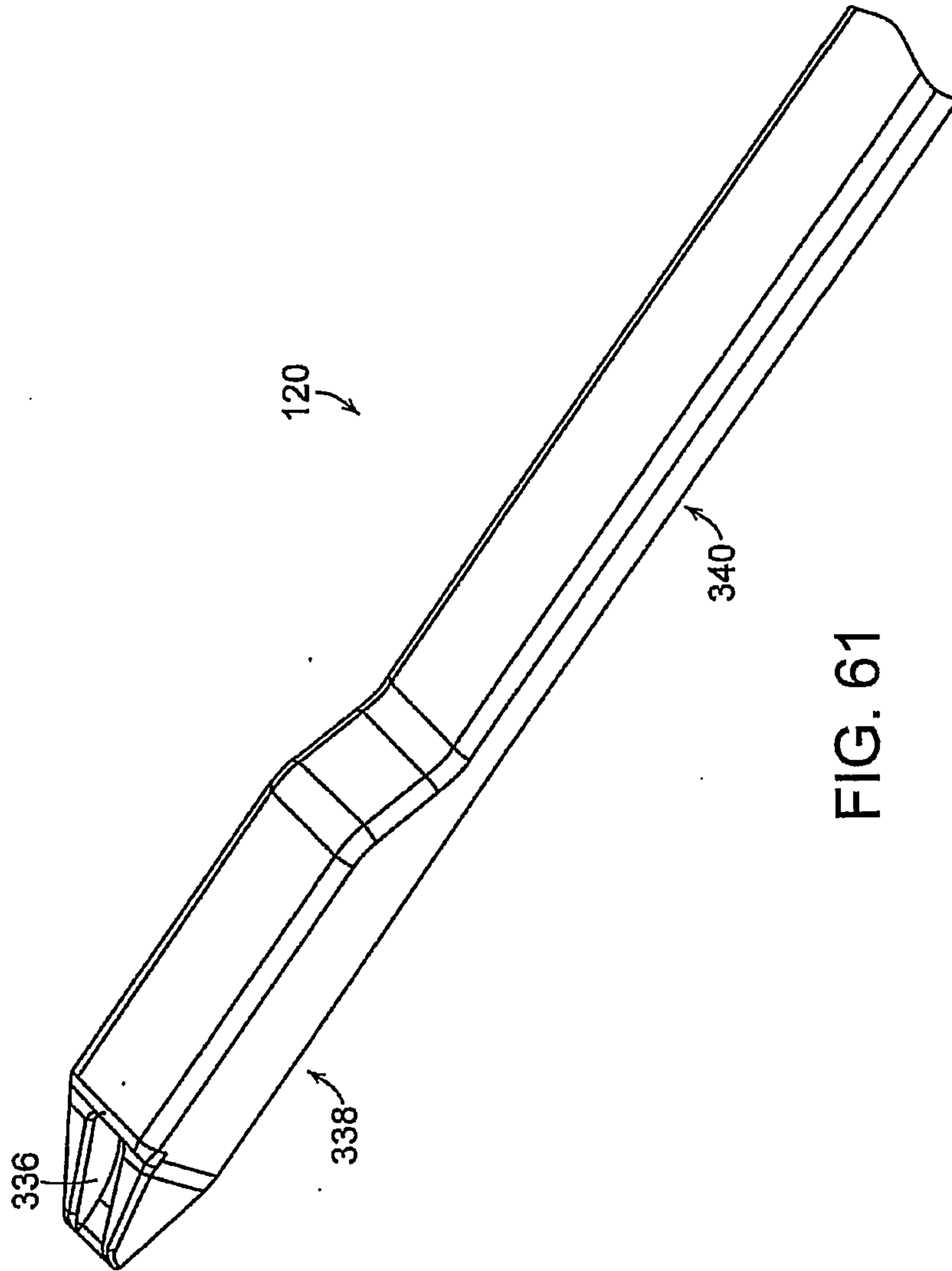


FIG. 61

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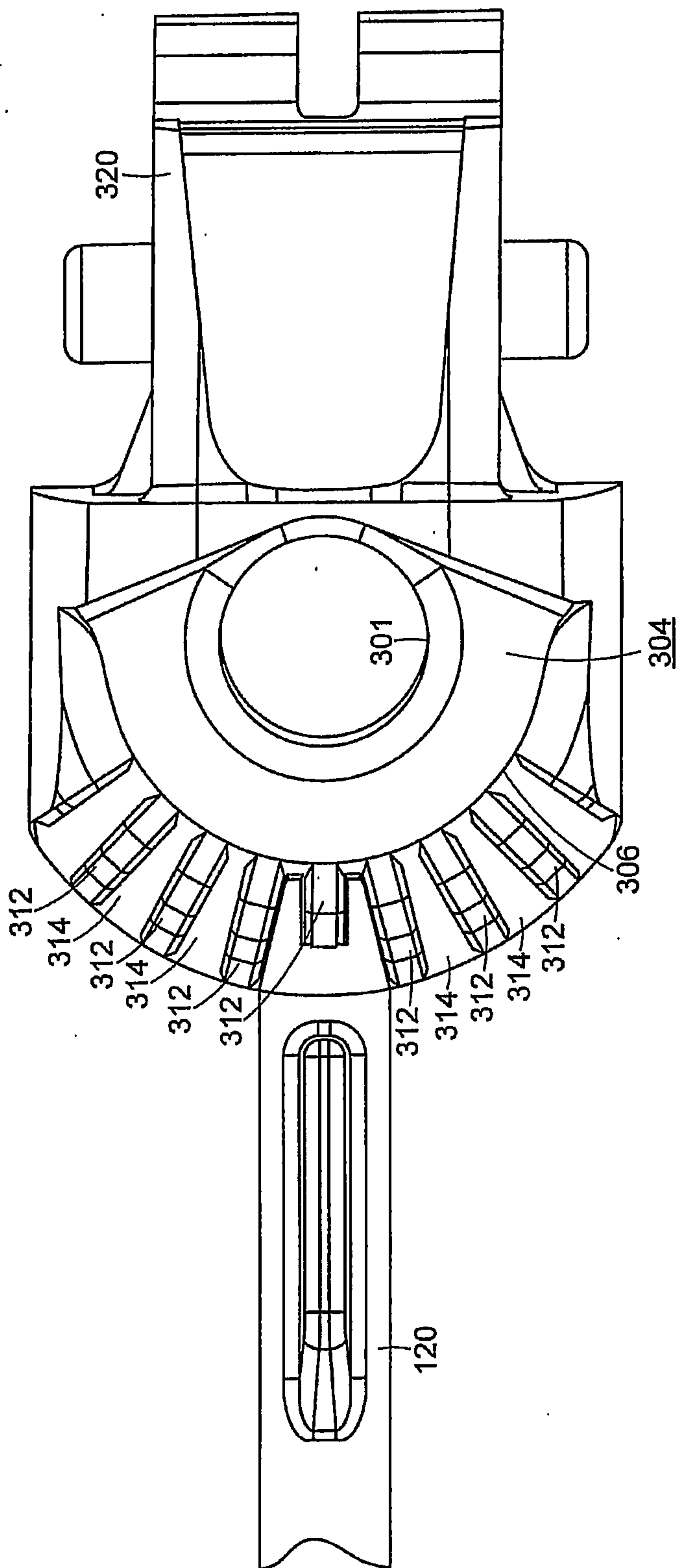


FIG. 62

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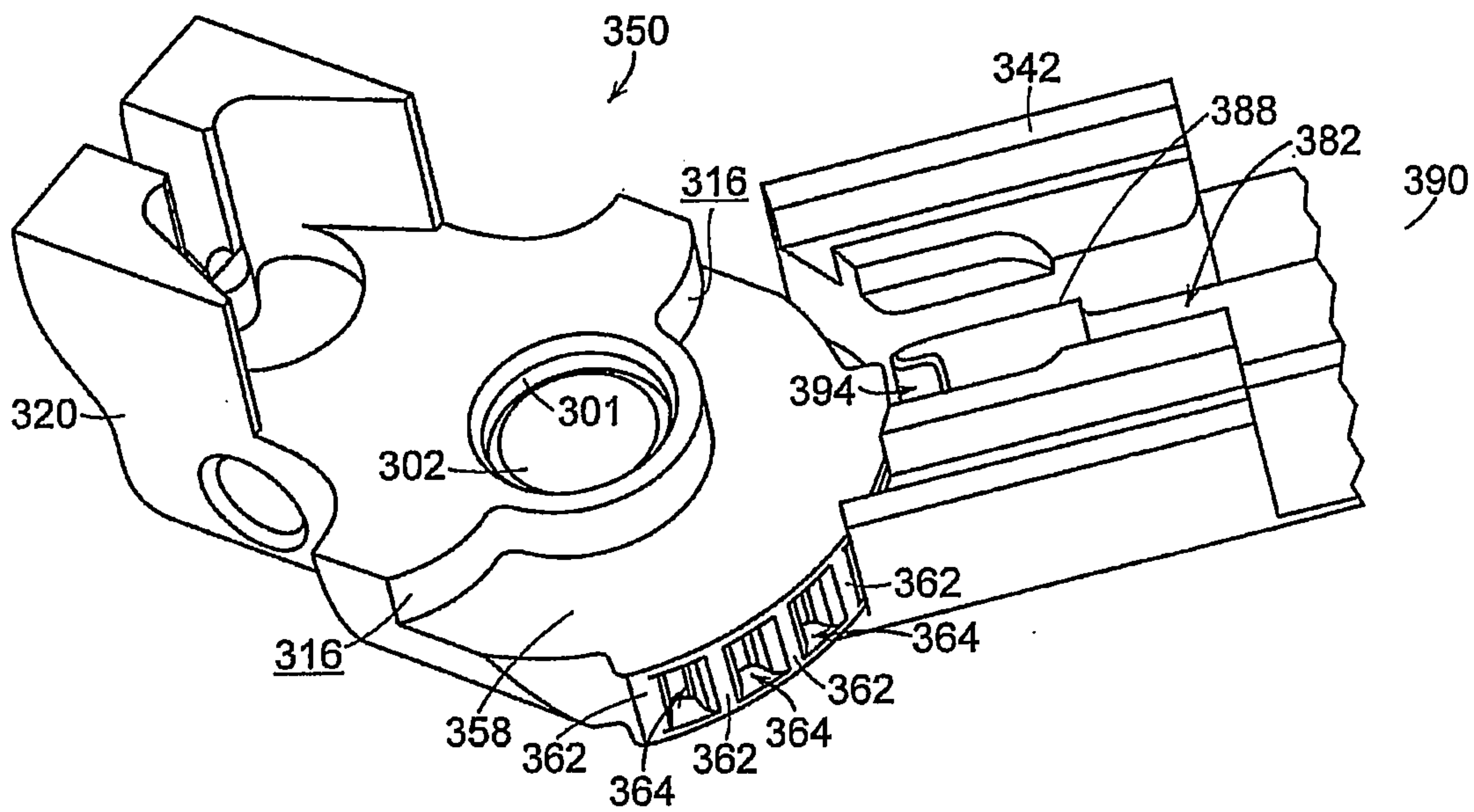


FIG. 63

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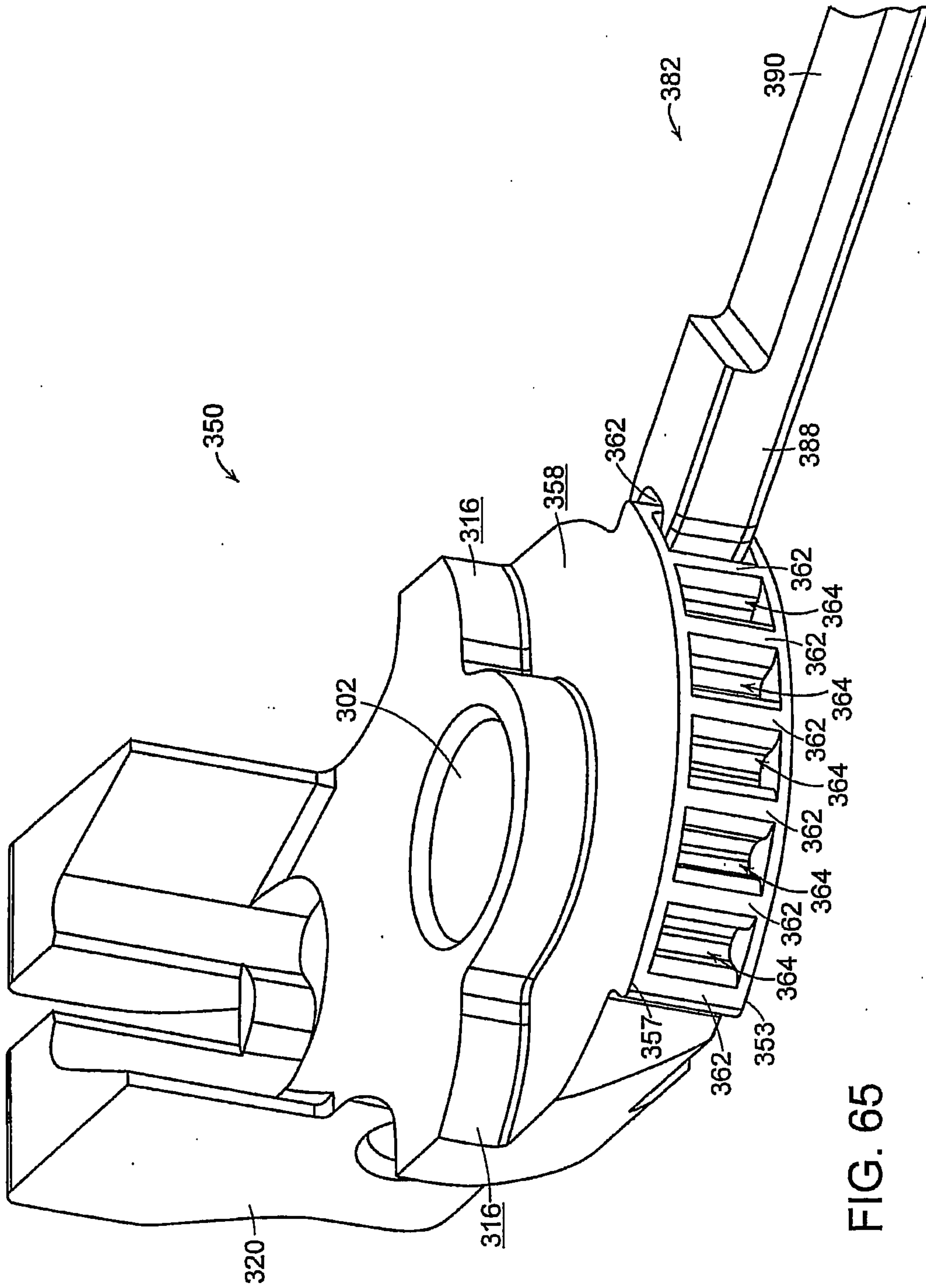


FIG. 65

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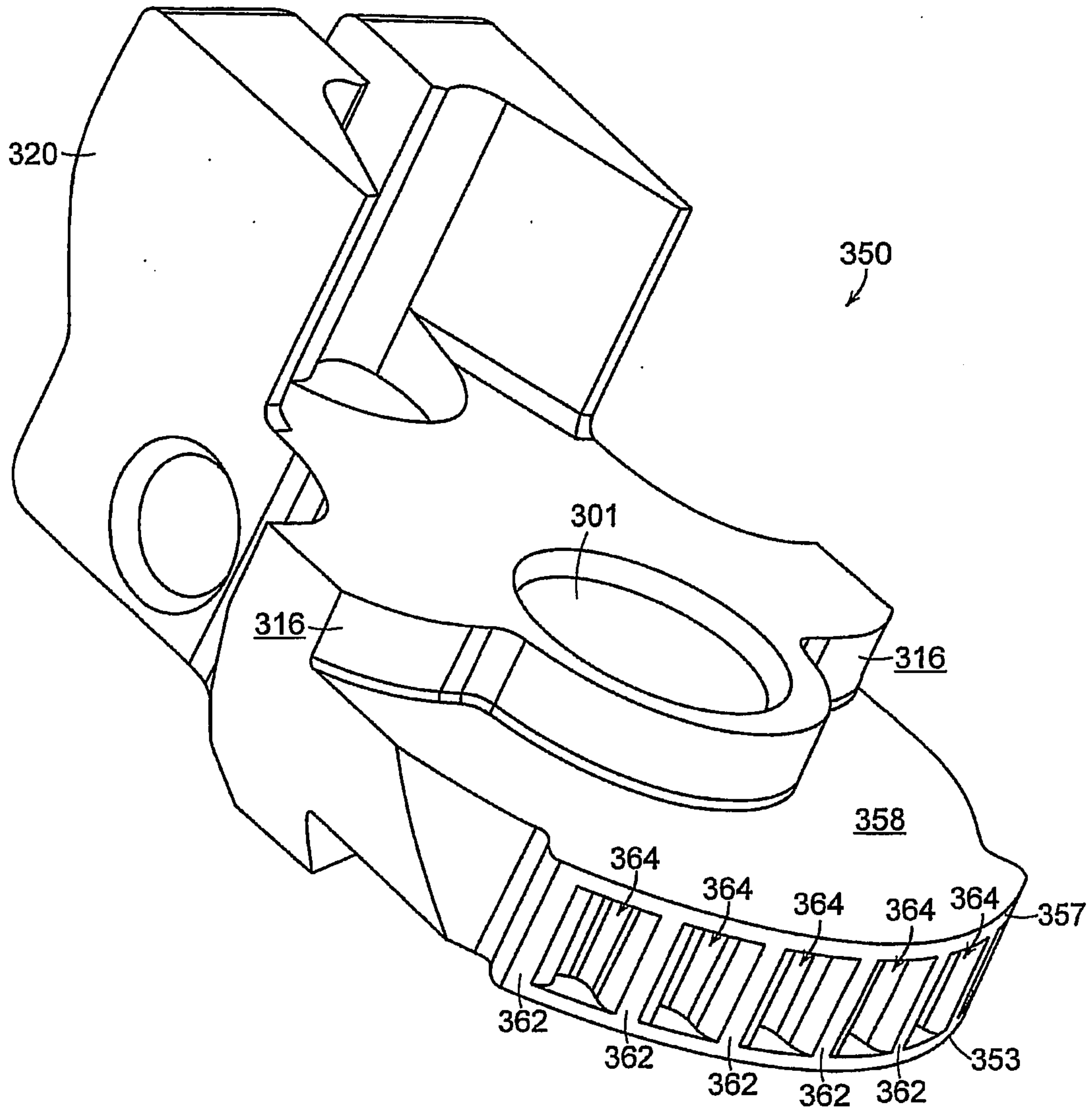


FIG. 66

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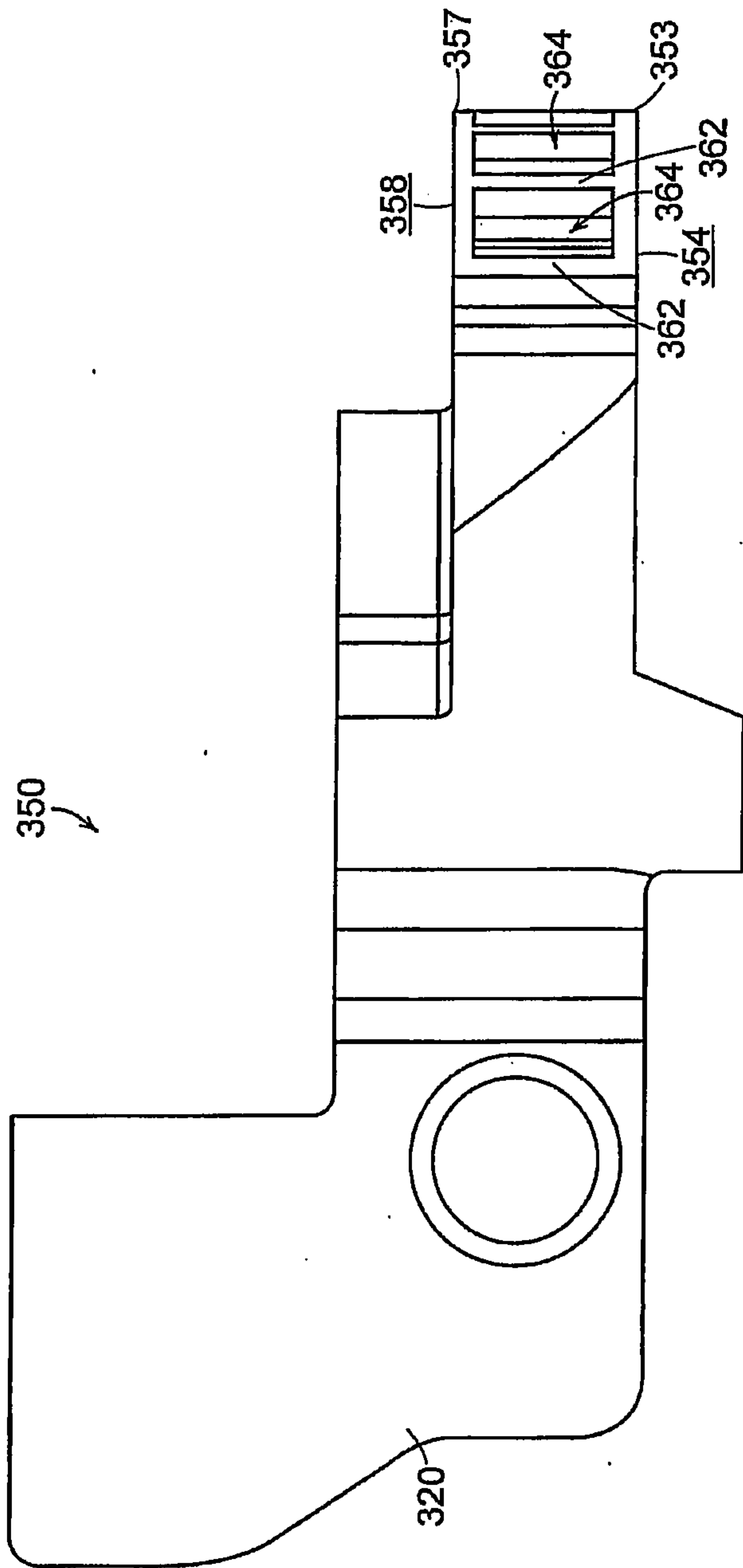


FIG. 67

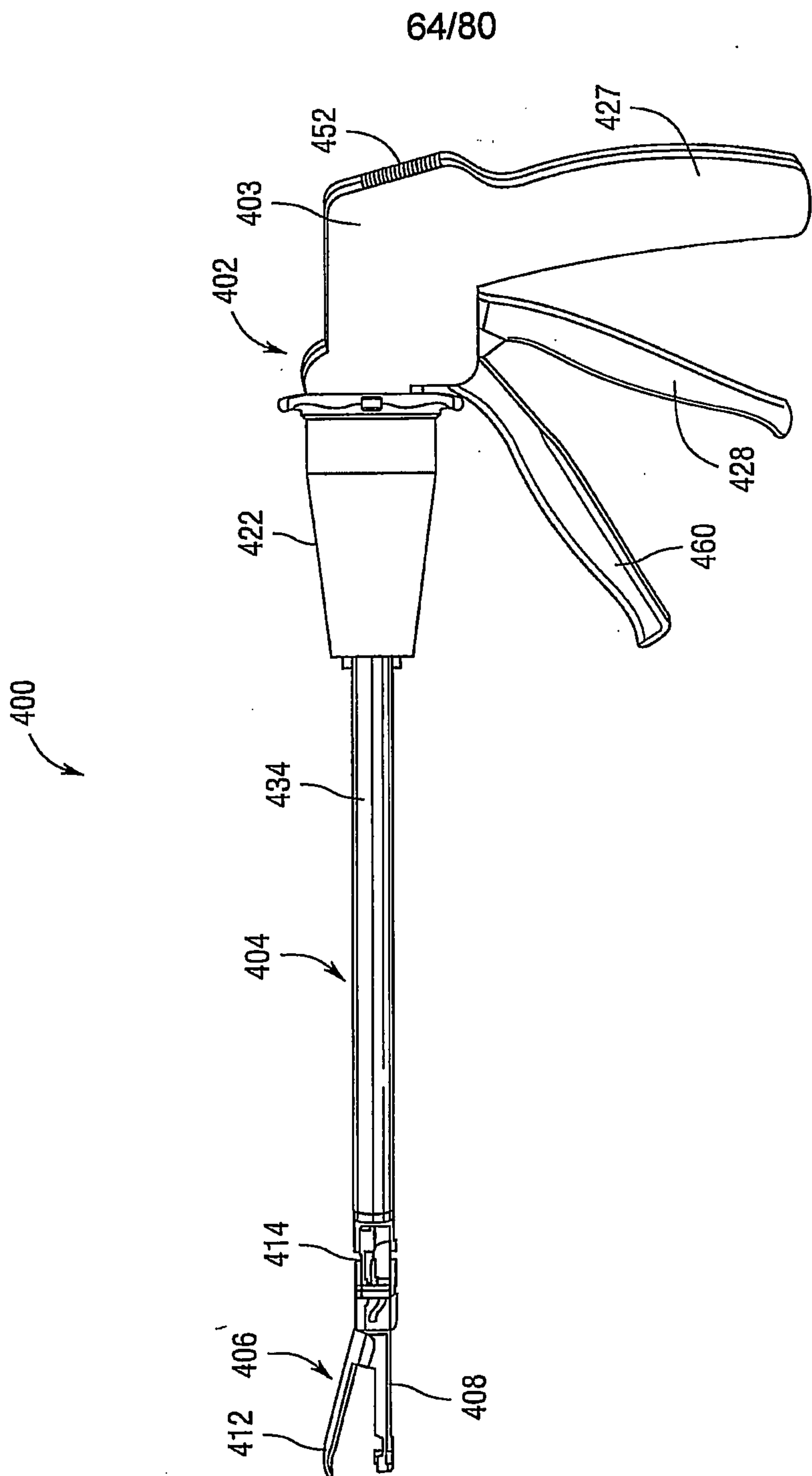


Fig. 68

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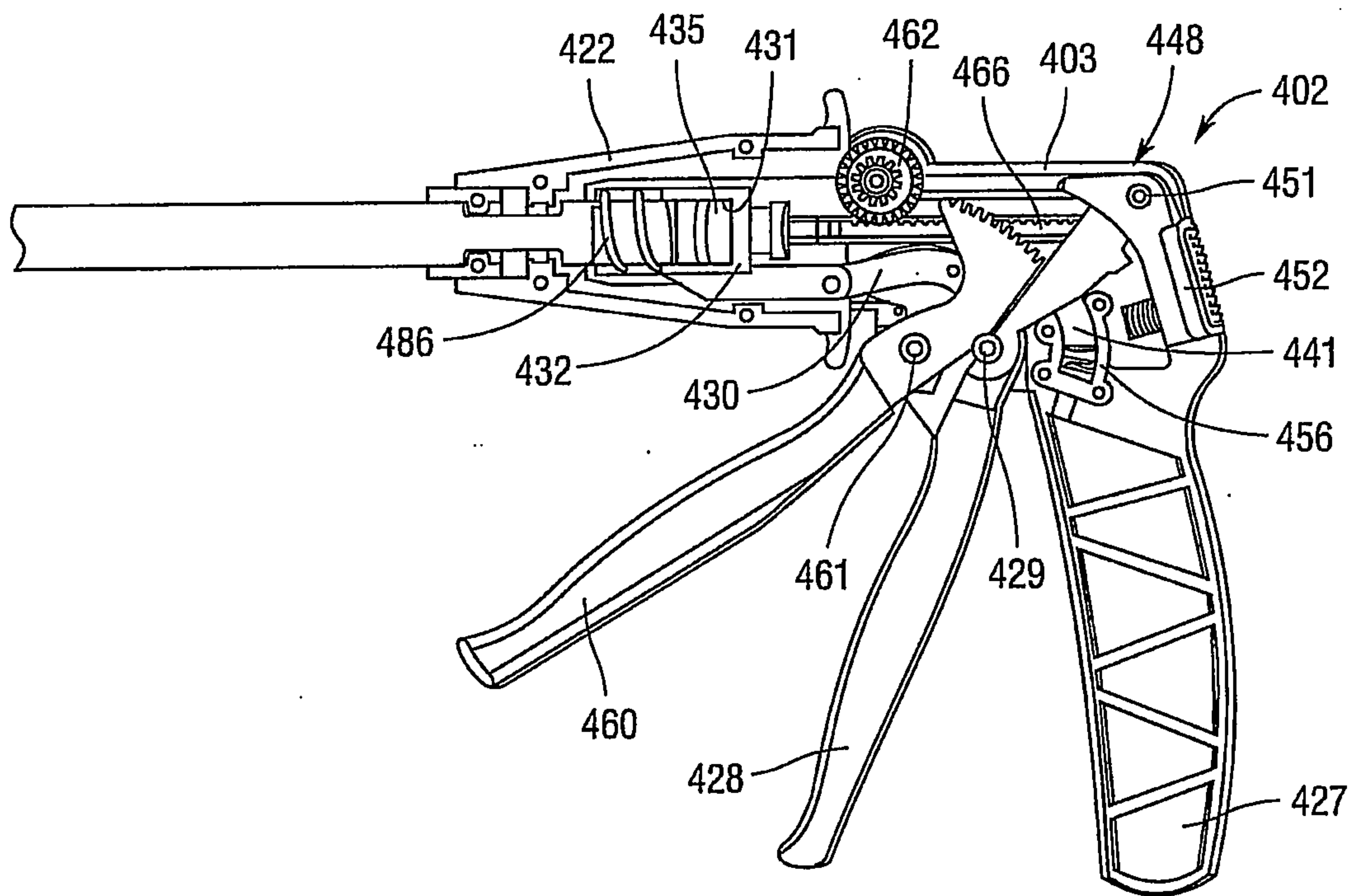


Fig.69

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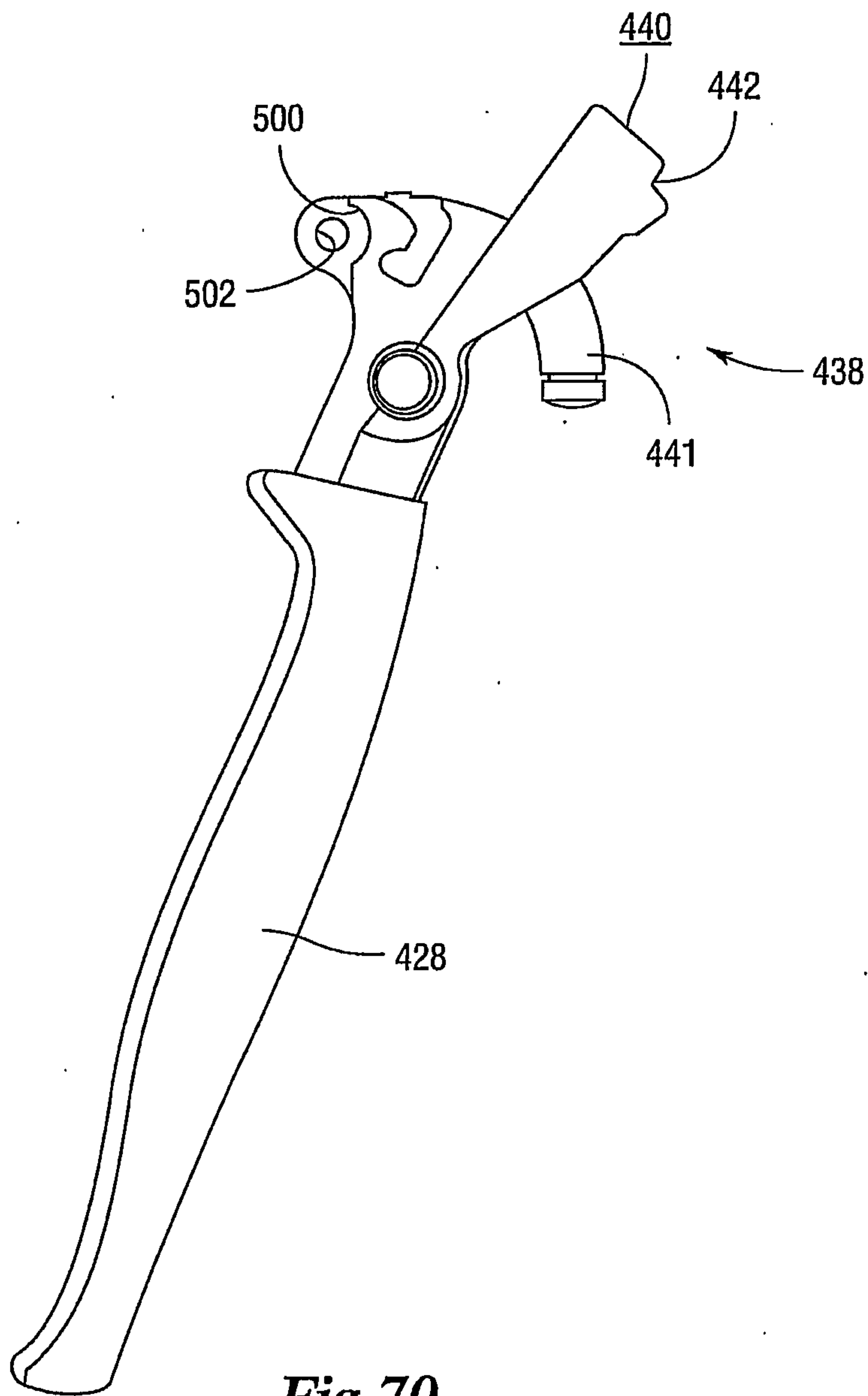


Fig. 70

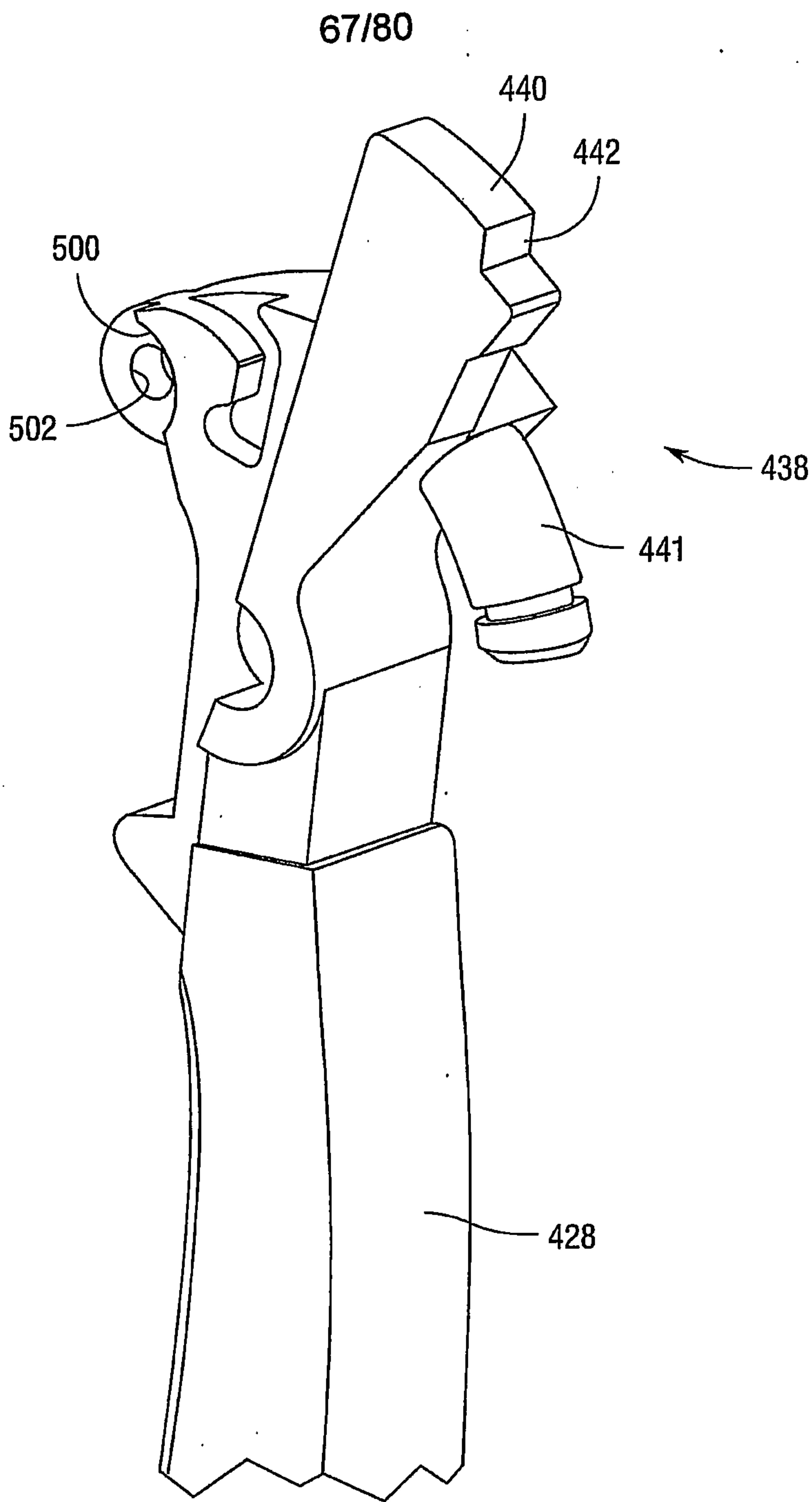


Fig. 71

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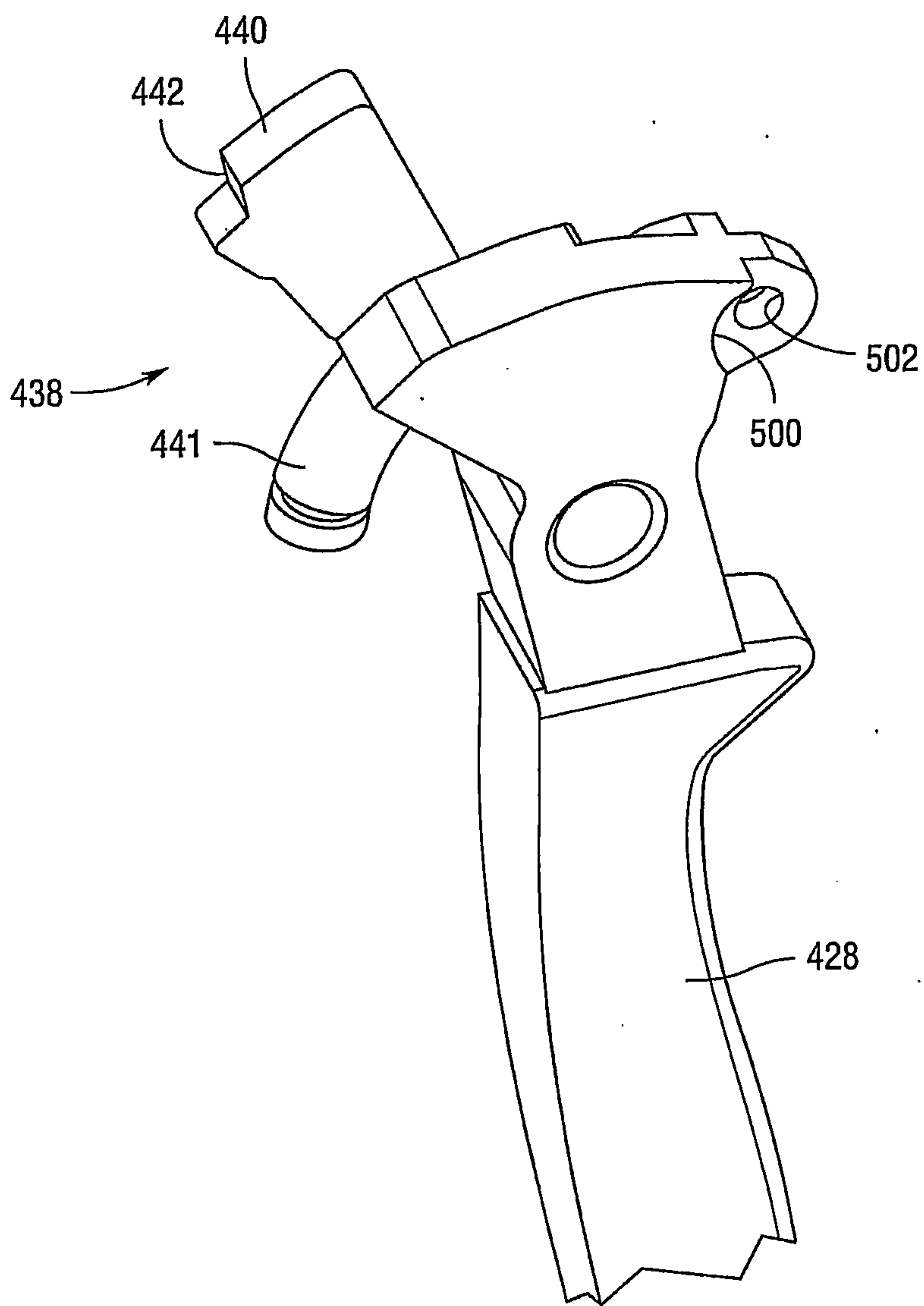


Fig. 72

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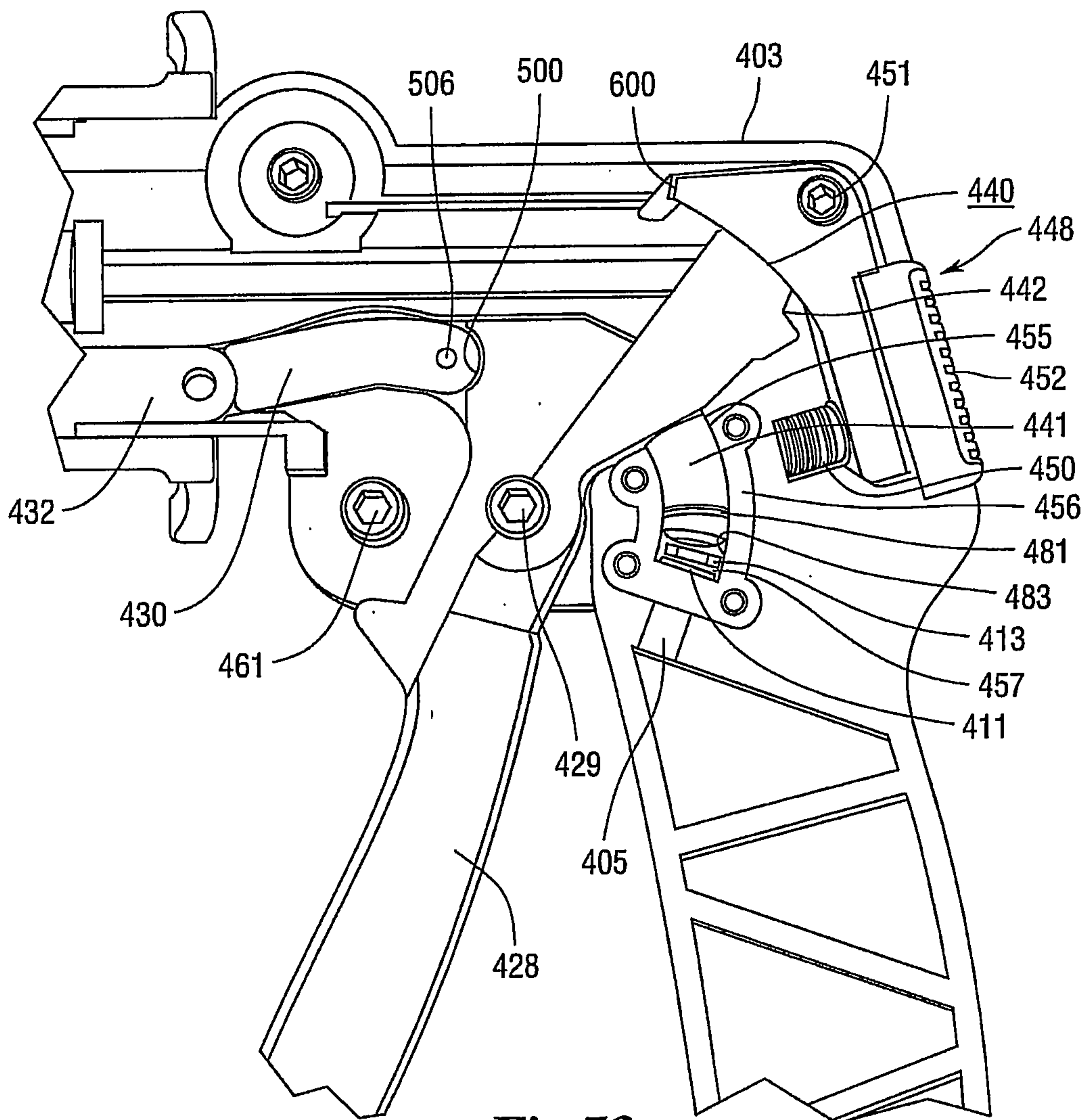


Fig. 73

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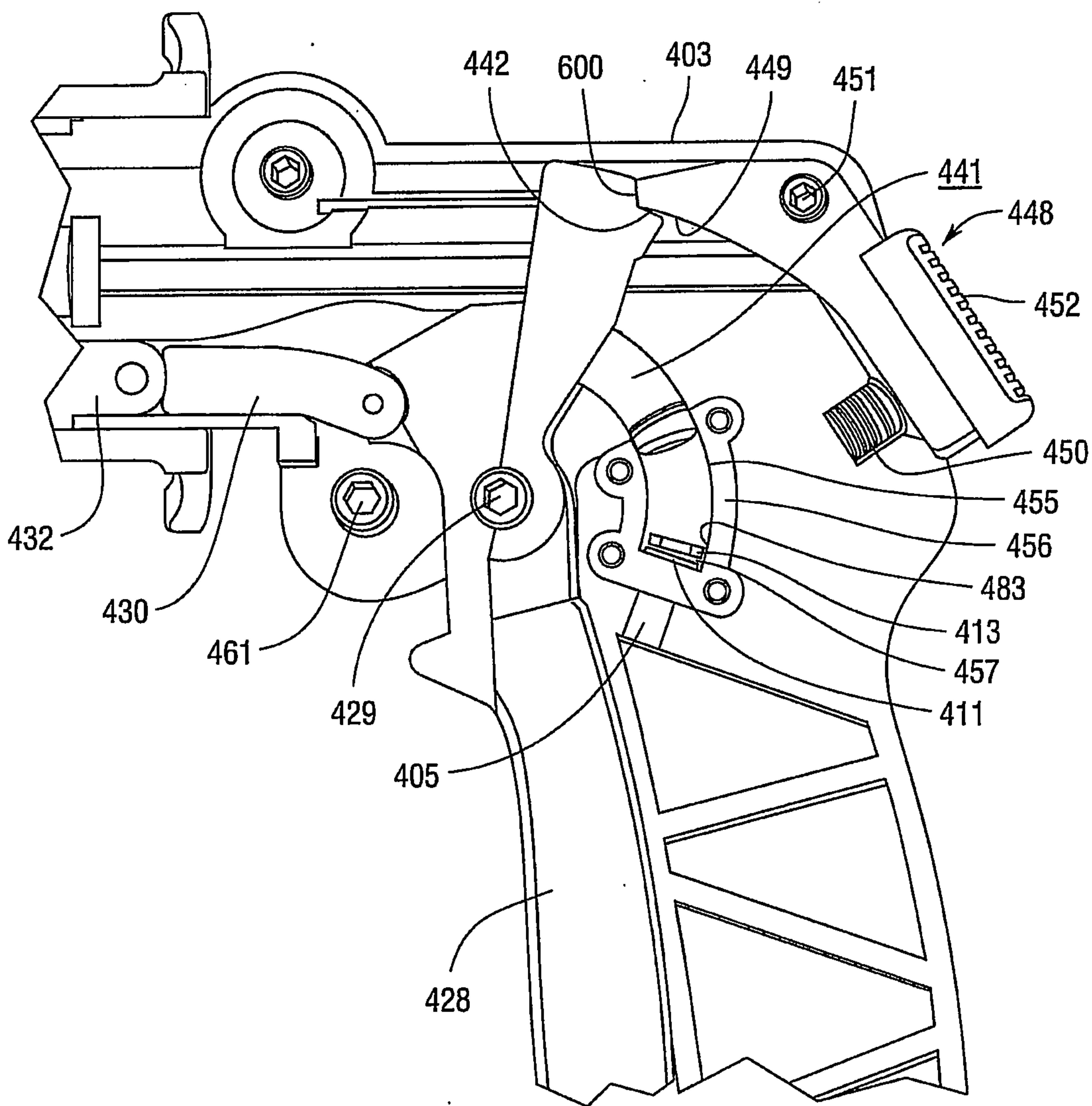


Fig. 74

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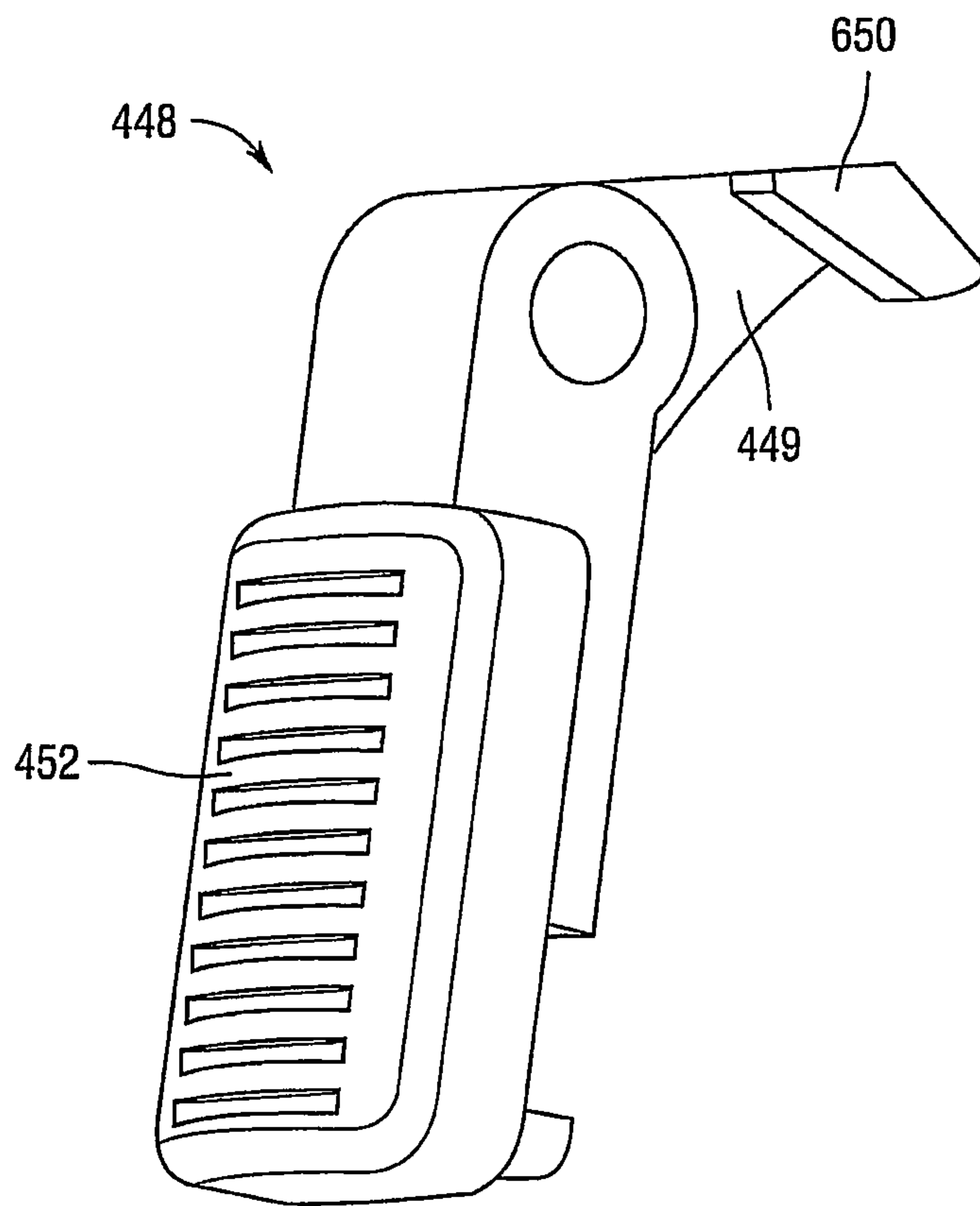


Fig. 75

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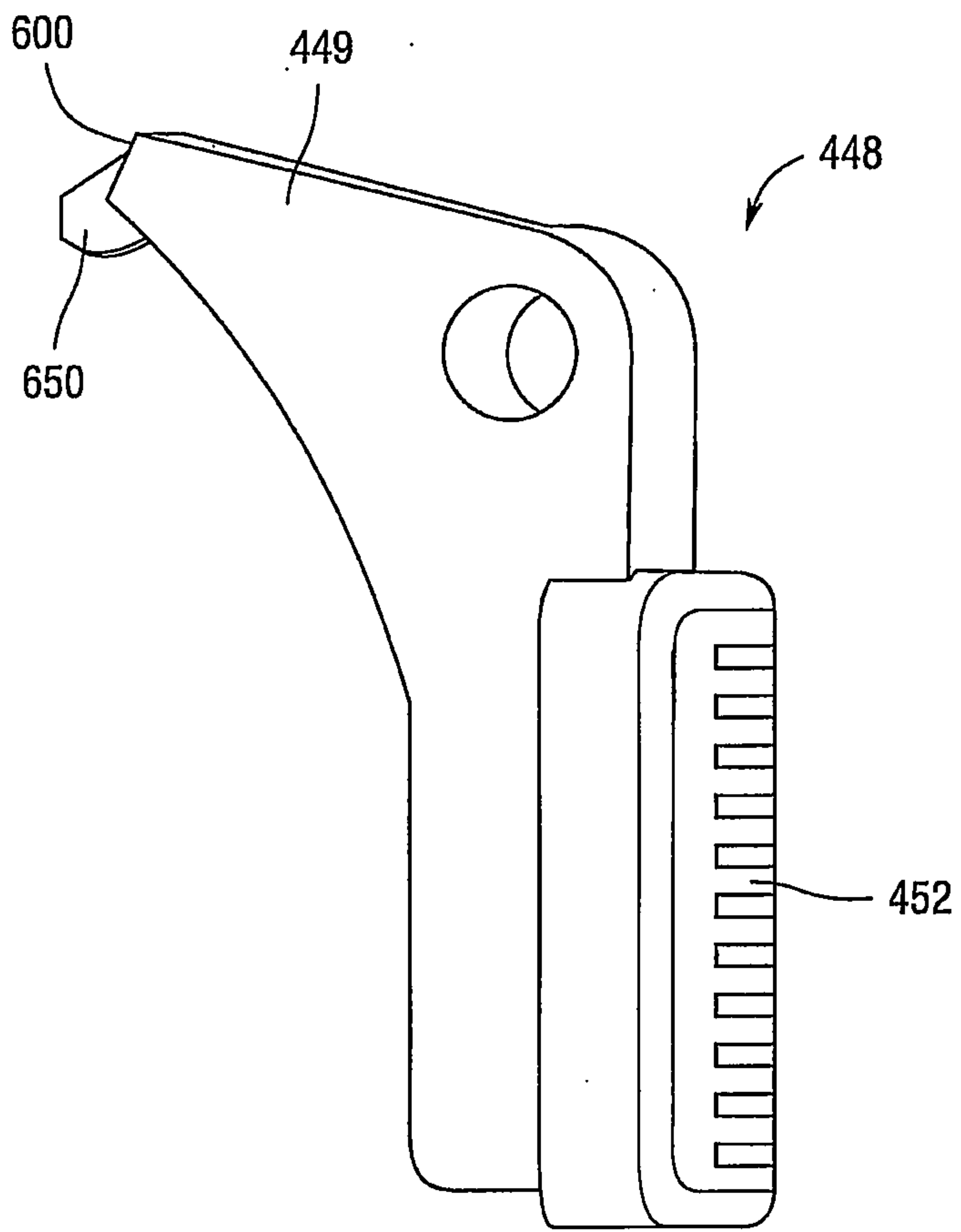


Fig. 76

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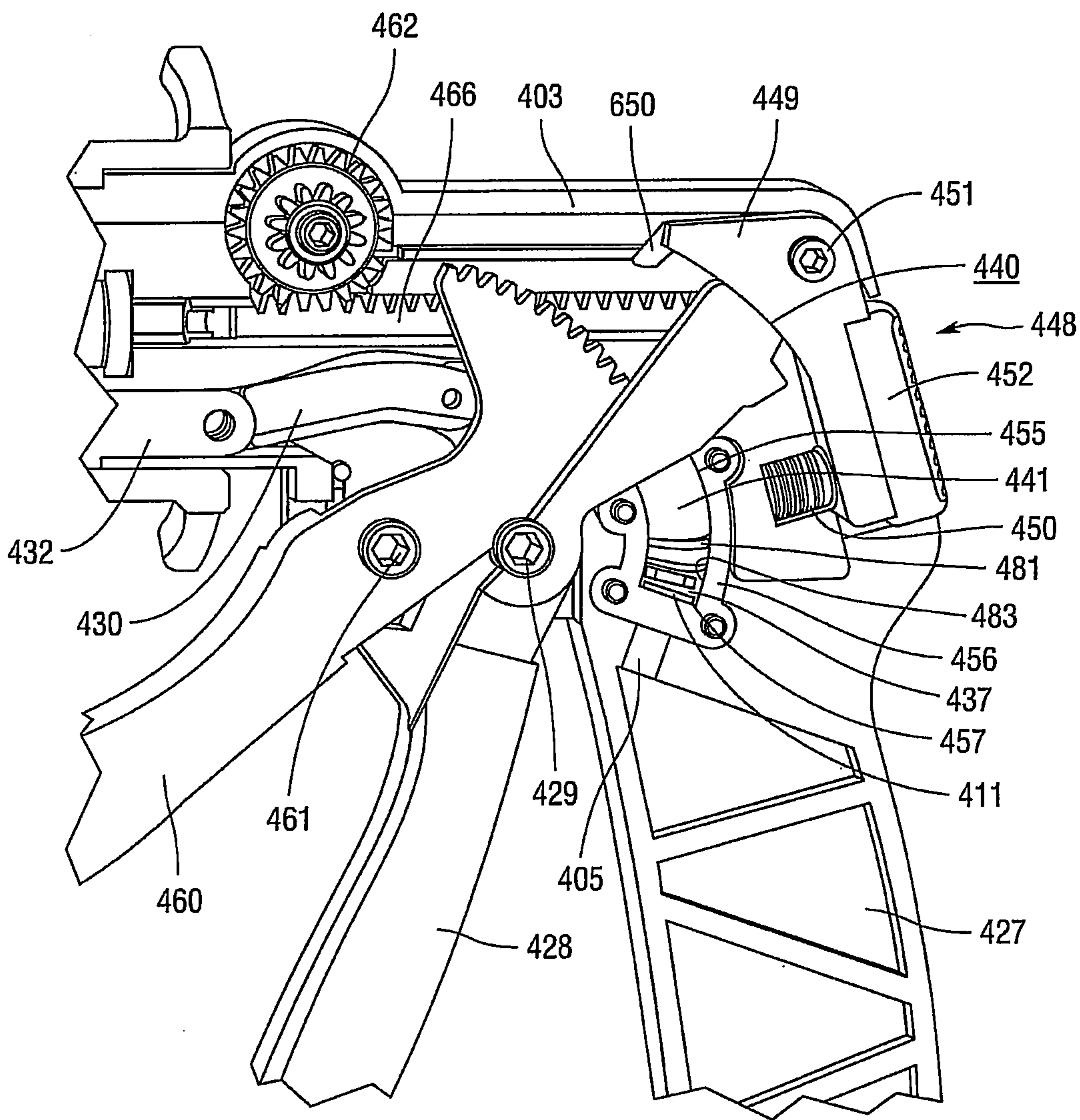


Fig. 77

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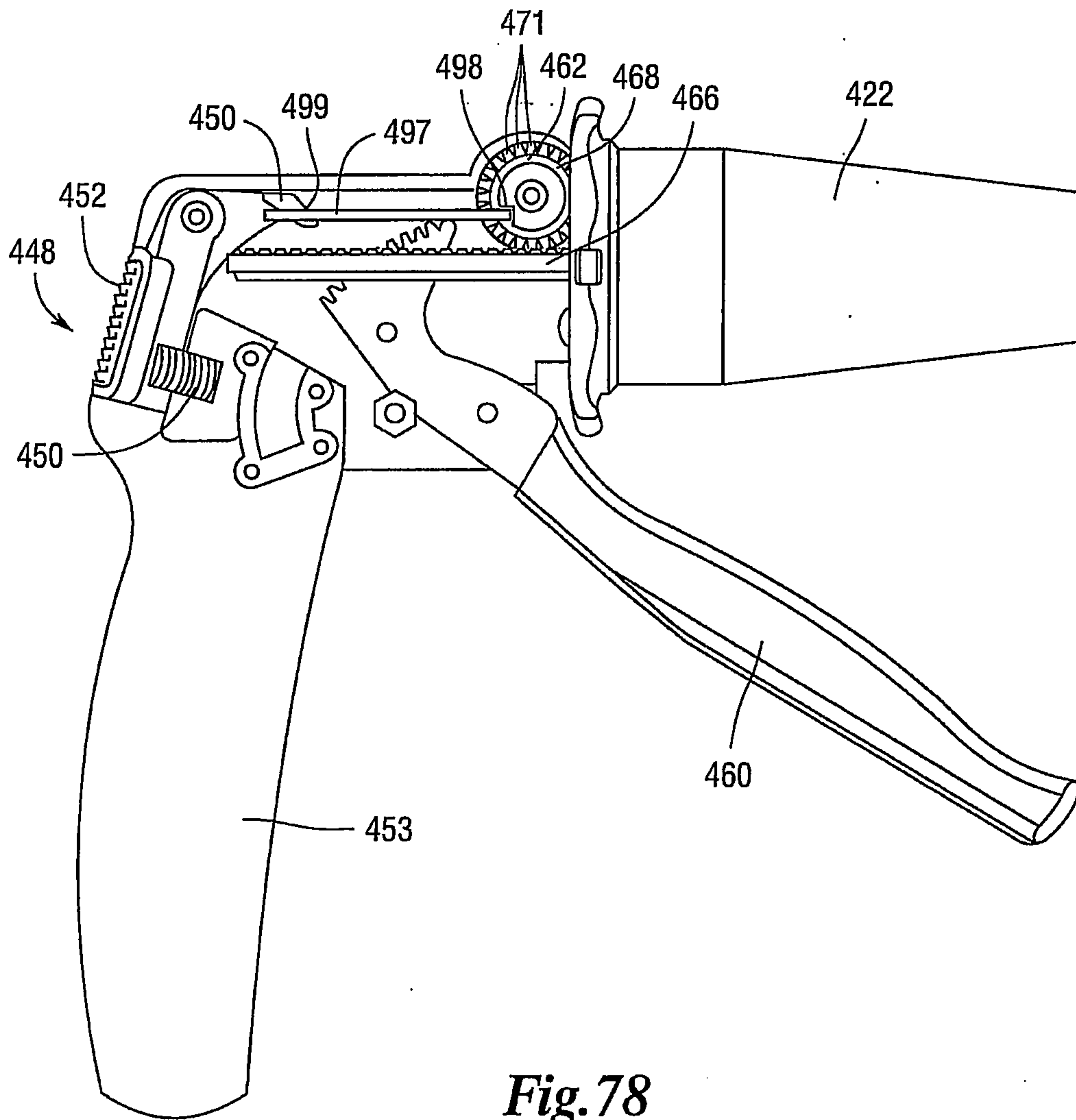


Fig. 78

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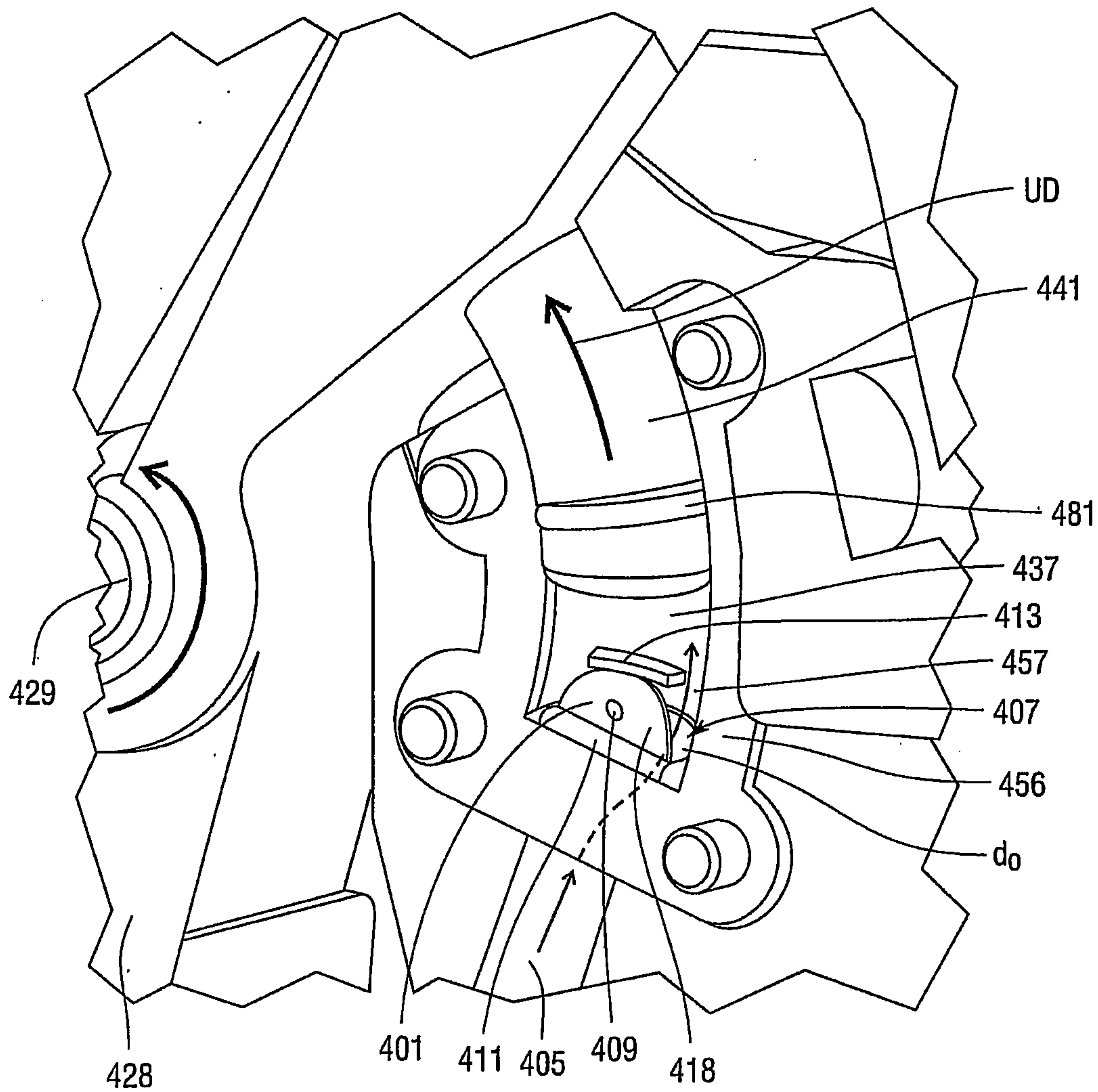


Fig. 79A

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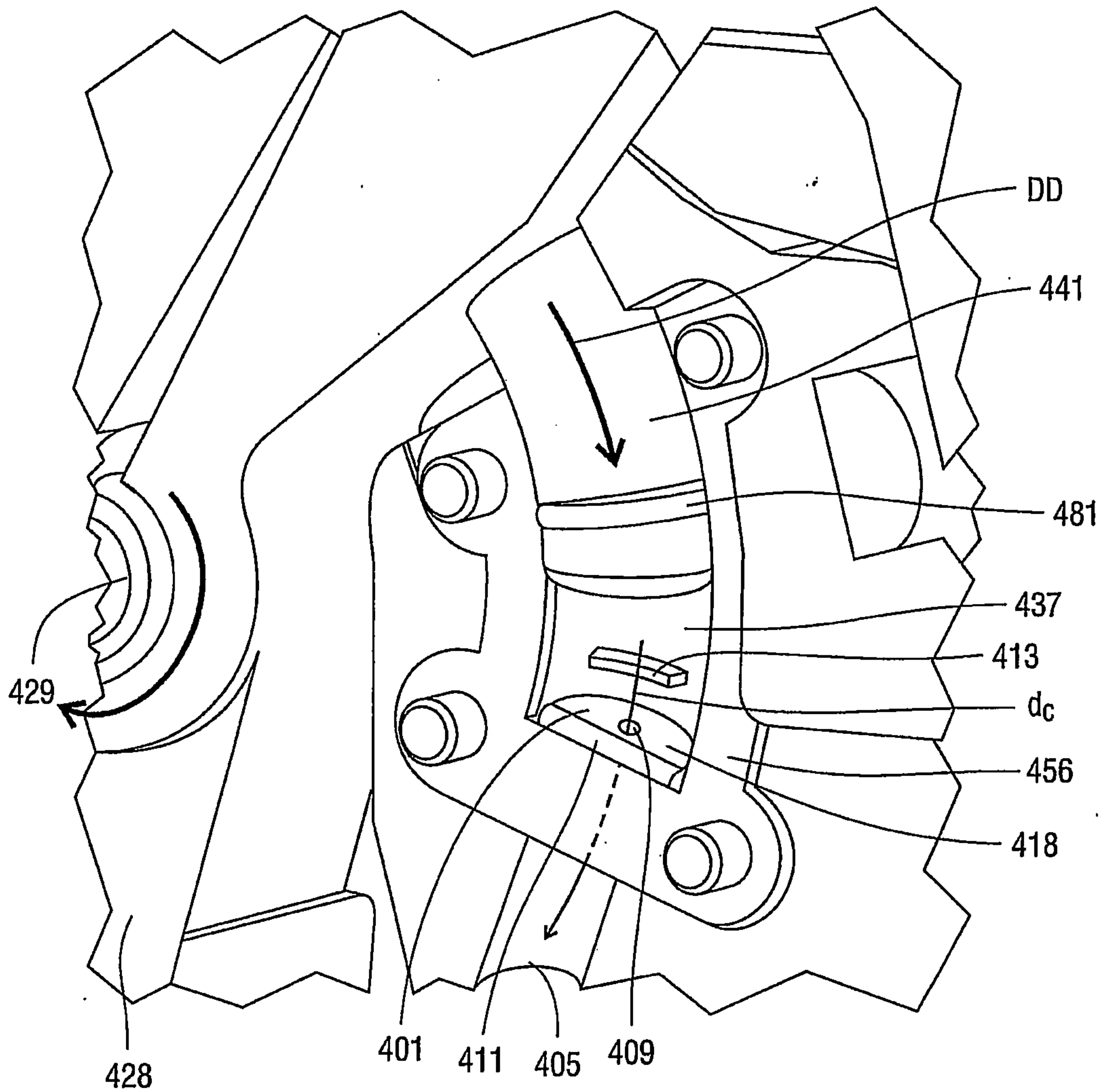


Fig. 79B

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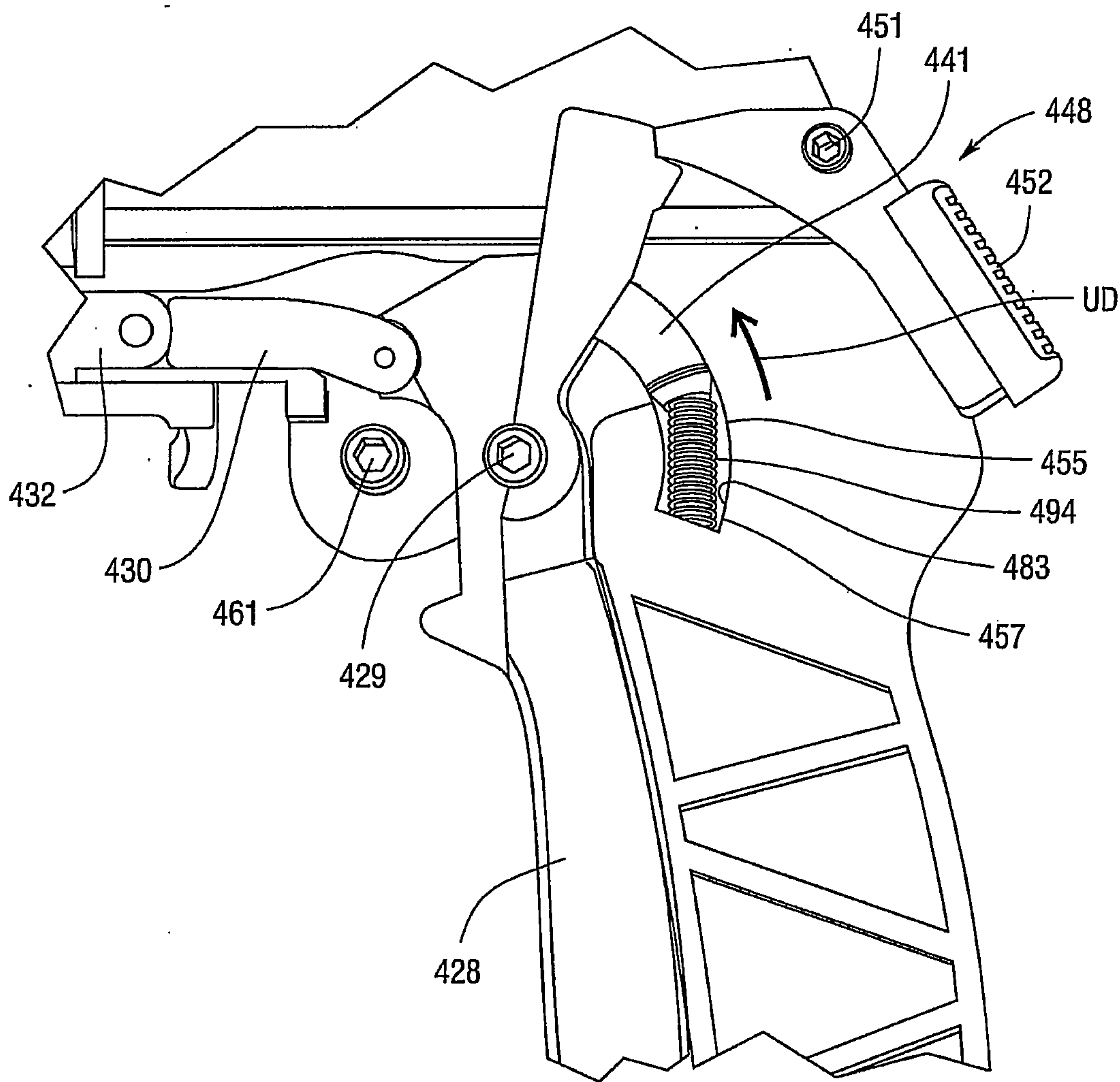


Fig.80

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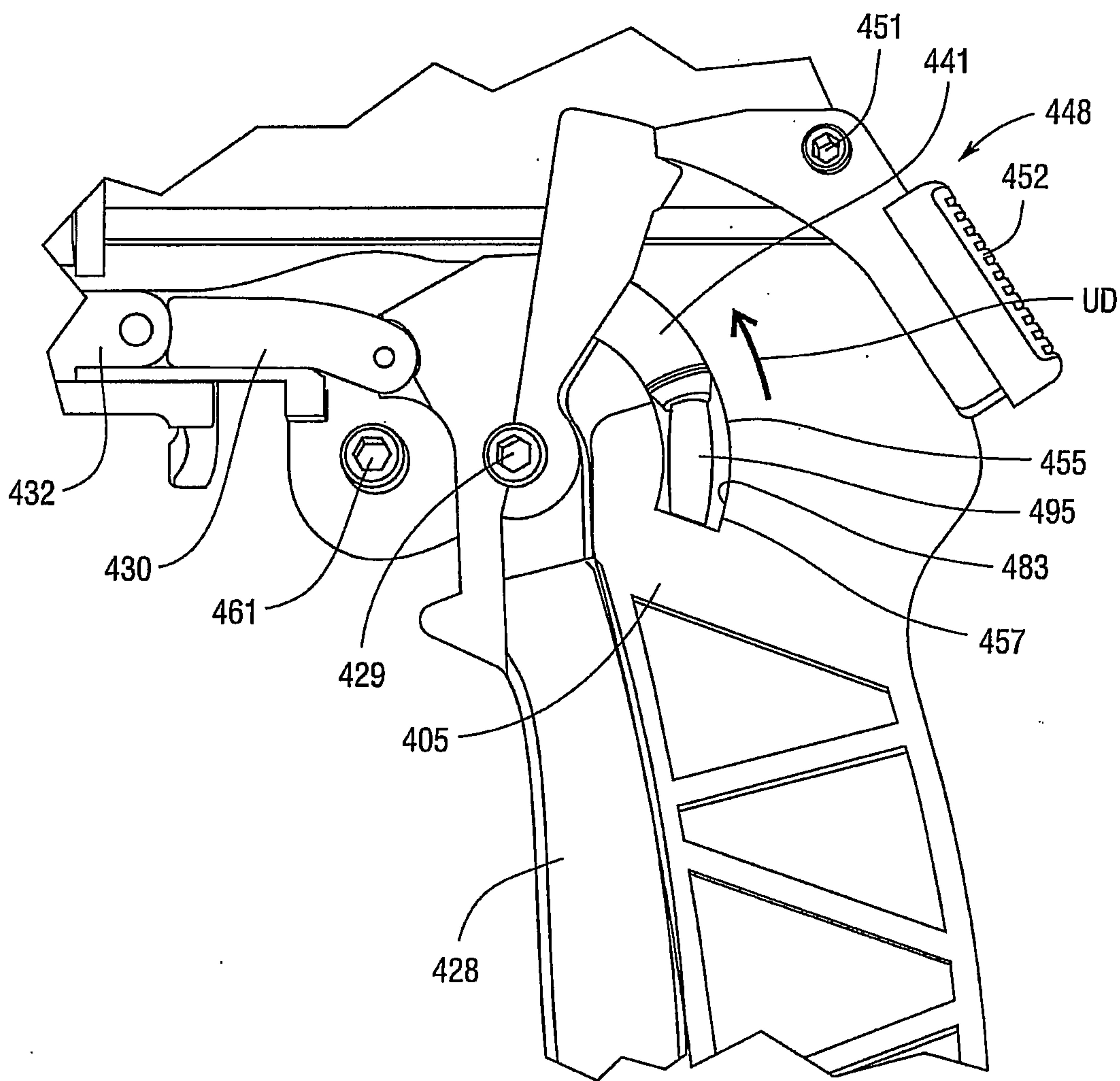


Fig.81

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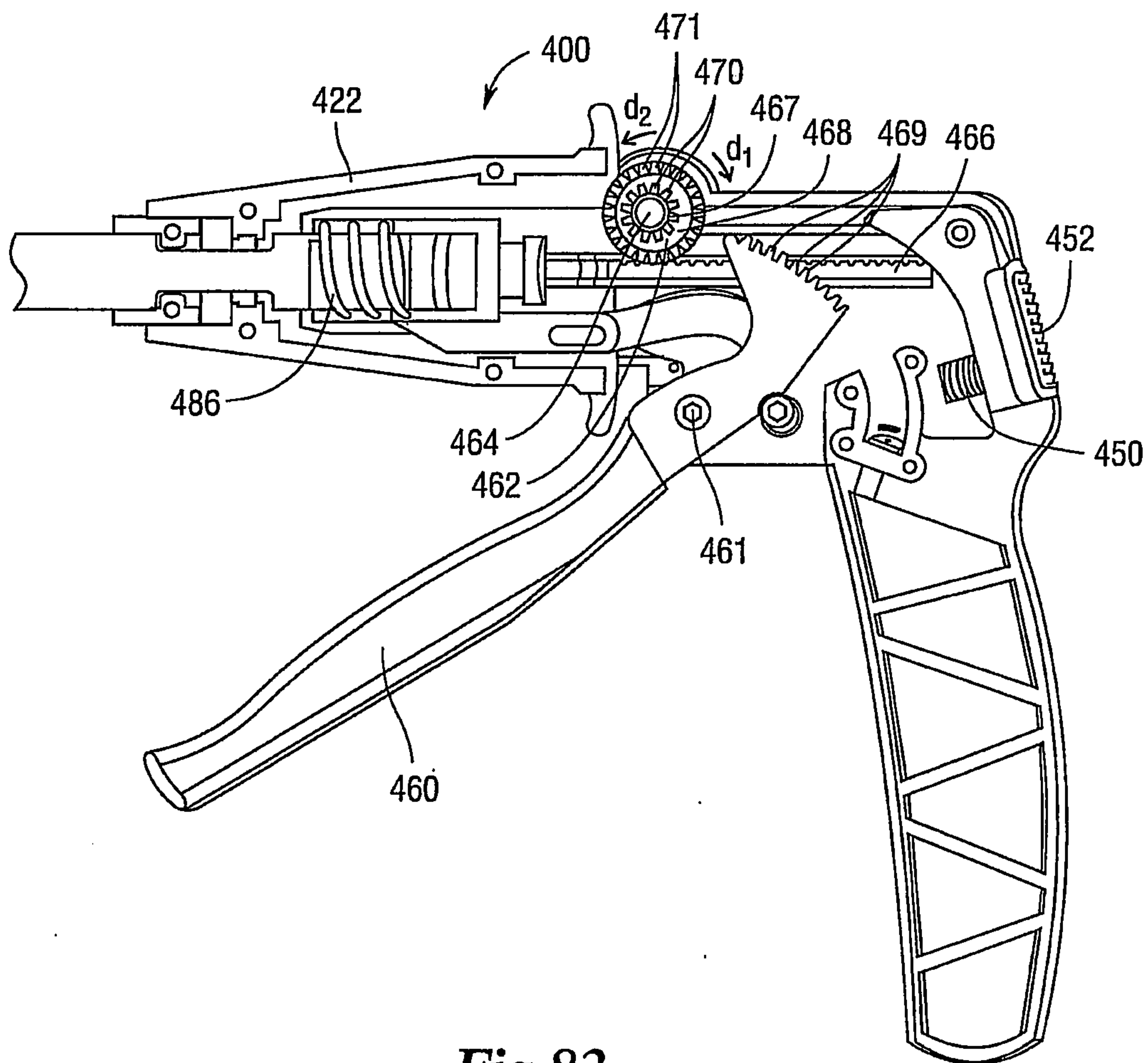


Fig.82

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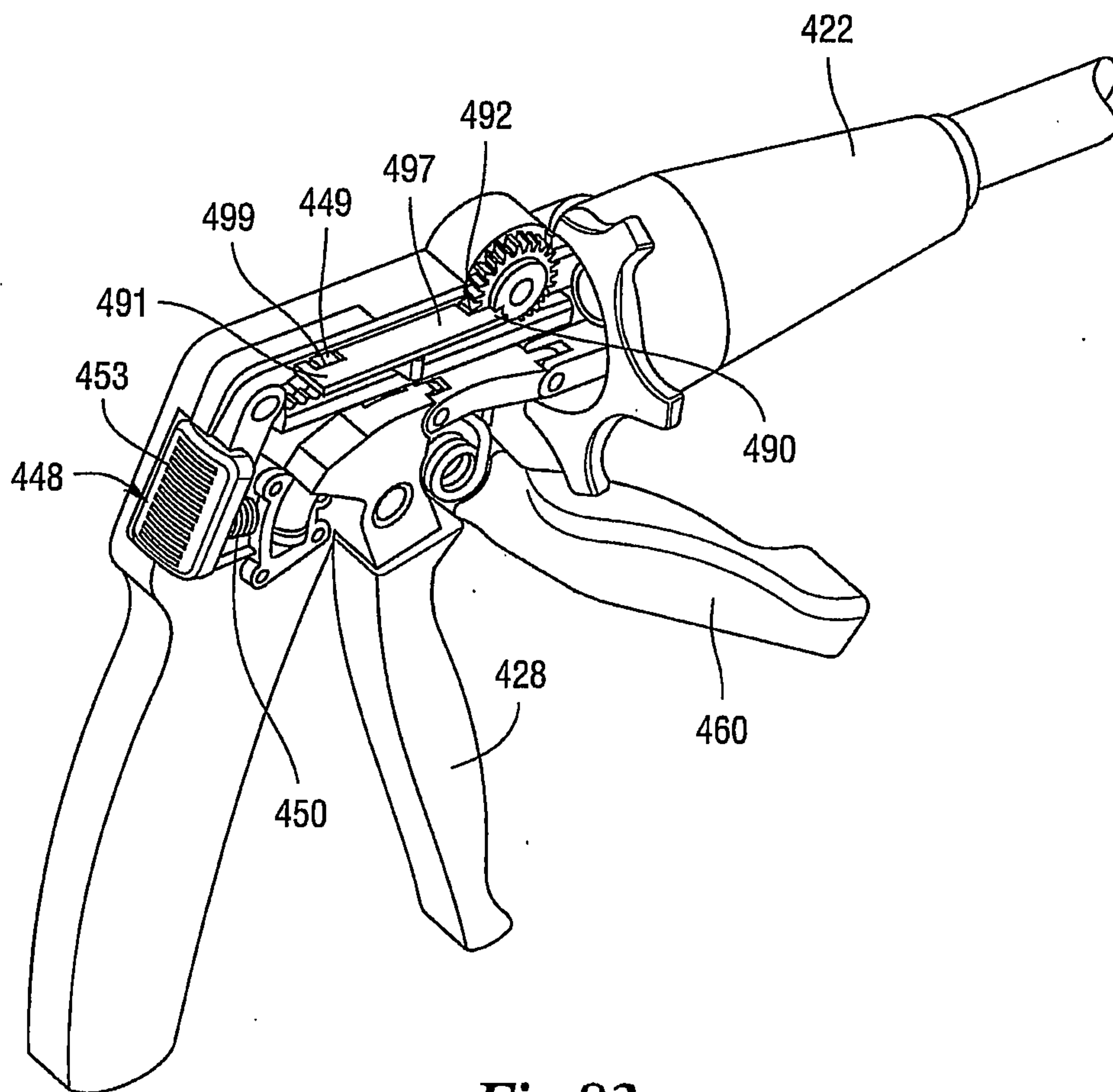


Fig.83