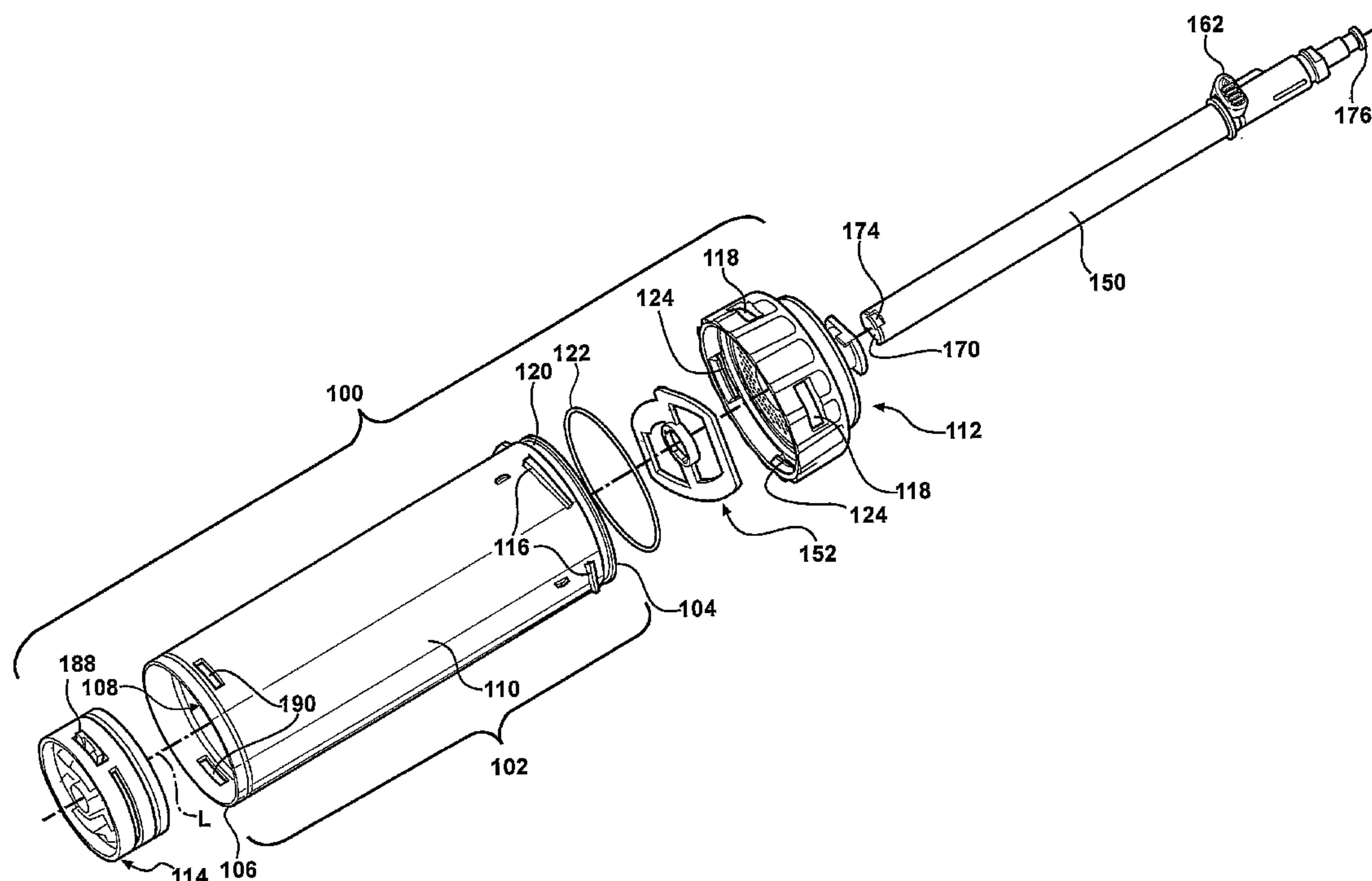




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(57) Abrégé/Abstract:

A bone cement mixing and delivery system is provided. The system includes a mixing cartridge (100) for receiving liquid and powder components of bone cement, a mixing device (152) for mixing the components, and a delivery gun (500) for discharging the bone cement from the mixing cartridge. The mixing cartridge comprises a cylinder having proximal and distal ends with a cylinder wall extending between the ends. A piston (144) is locked at the distal end by a locking member that includes a pair of locking tabs (188) protruding into slots in the cylinder wall. With the piston in the locked position, the mixing device, e.g., a mixing shaft and blade, mixes the components. After mixing, the cartridge is placed in the delivery gun and release buttons on the locking member are engaged by a release mechanism on the delivery gun to release the piston from the locked position.



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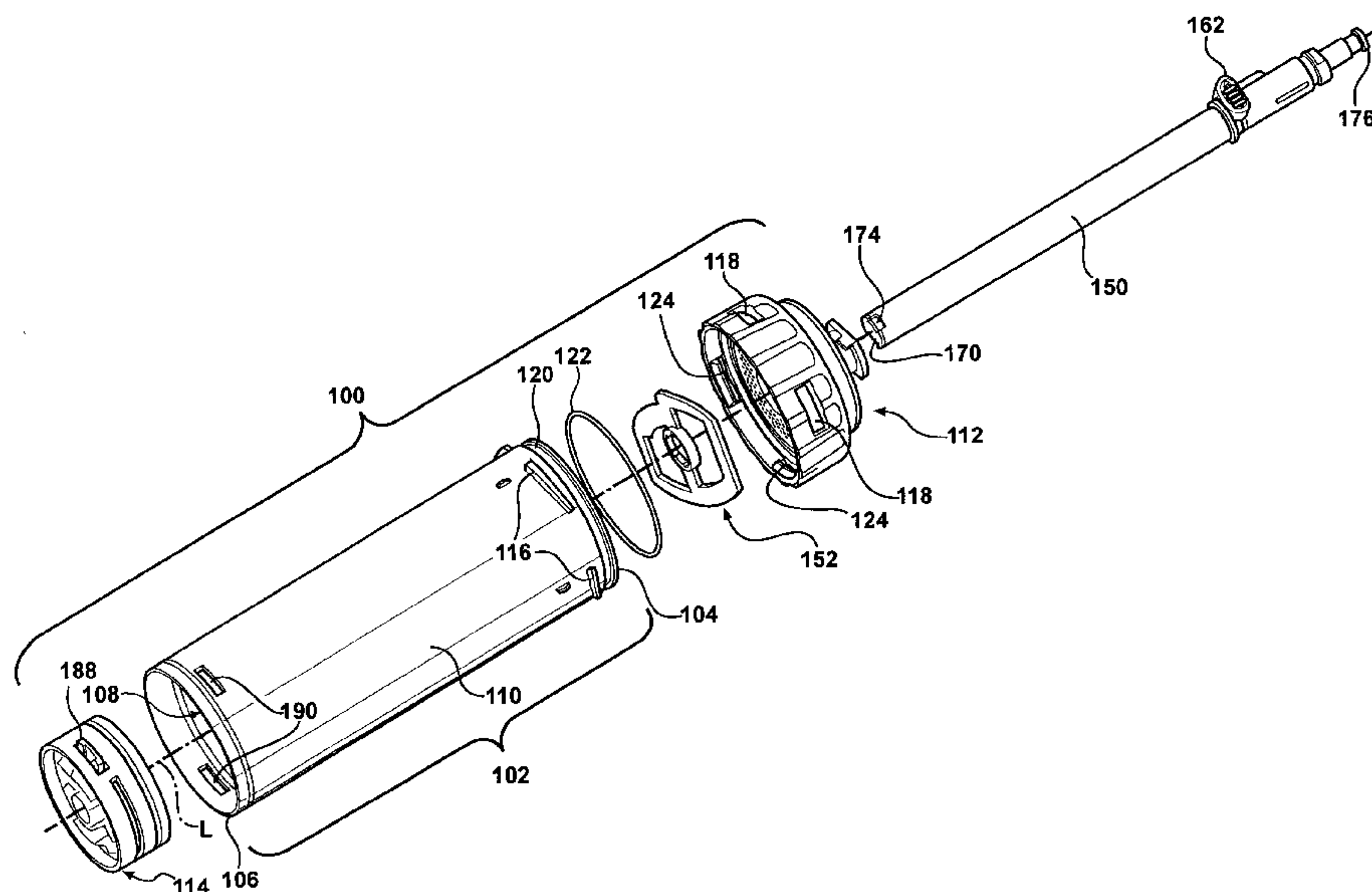
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(54) Title: BONE CEMENT MIXING AND DELIVERY SYSTEM



(57) Abstract: A bone cement mixing and delivery system is provided. The system includes a mixing cartridge (100) for receiving liquid and powder components of bone cement, a mixing device (152) for mixing the components, and a delivery gun (500) for discharging the bone cement from the mixing cartridge. The mixing cartridge comprises a cylinder having proximal and distal ends with a cylinder wall extending between the ends. A piston (144) is locked at the distal end by a locking member that includes a pair of locking tabs (188) protruding into slots in the cylinder wall. With the piston in the locked position, the mixing device, e.g., a mixing shaft and blade, mixes the components. After mixing, the cartridge is placed in the delivery gun and release buttons on the locking member are engaged by a release mechanism on the delivery gun to release the piston from the locked position.

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BONE CEMENT MIXING AND DELIVERY SYSTEM

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application Serial No. 60/469,651, filed May 12, 2003 and U.S. provisional patent application Serial No. 60/520,877, filed November 18, 2003, the advantages and disclosures of which are herein incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention generally relates to a bone cement mixing and delivery system. More specifically, the present invention relates to a mixing cartridge for receiving liquid and powder components of bone cement to be mixed, a mixing device for mixing the components, and a delivery gun for discharging the bone cement from the mixing cartridge into an anatomical site of a patient.

BACKGROUND OF THE INVENTION

[0003] Bone cement mixing and delivery systems are well known for mixing liquid and powder components of bone cement and delivering the prepared bone cement to an anatomical site during various surgical procedures. Bone cement is particularly useful in orthopedic procedures in which a prosthetic device is fixed to a bone or joint structure to improve the strength, rigidity, and movement of the structure. In a total hip arthroplasty (THA) procedure, in which a hip joint is replaced with a prosthetic device, bone cement is used to fix the prosthetic device in place in a medullary canal of a femur.

[0004] Typically, the bone cement is prepared in a mixing cartridge. The mixing cartridge includes a cylinder having proximal and distal ends with a mixing chamber defined between the ends. The mixing cartridge further includes a cap covering the proximal end of the cylinder and a piston disposed in the distal end of the cylinder such that the mixing chamber is further defined between the cap and the piston. The piston may be releasably secured in a locked position in the cylinder by a cotter pin. The cap supports a mixing device, i.e., a mixing shaft and blade, for mixing the liquid and powder components of the bone cement in the mixing chamber.

[0005] Once the bone cement is mixed, the mixing cartridge is prepared for inserting into a delivery gun to discharge the bone cement. This may include disengaging

the mixing shaft and coupling a nozzle to the cap to provide a discharge point for the bone cement. At the same time, the piston is released from the locked position in the distal end of the cylinder by pulling the cotter pin. This allows the piston to be driven by the delivery gun through the mixing chamber to discharge the bone cement from the nozzle. An alternative solution for securing and releasing the piston is shown in United States Patent No. 5,328,262 to Lidgren et al.

[0006] In Lidgren et al., the piston is releasably secured in the locked position in the distal end of the cylinder by a gripping portion in the form of a flange, which extends along only a portion of an inner periphery of the cylinder. The piston in Lidgren et al. has a corresponding gripping portion in the form of an outwardly directed lip that protrudes behind the flange. The lip defines a groove with an outer surface of the piston to receive the flange. To release the piston from the locked position, the flange is rotated through the groove until the flange has been rotated past the lip. Lidgren et al. discloses a base that is used to secure the piston from rotation while a user rotates the cylinder relative to the piston to release the piston from the locked position. This method of releasing the piston from the locked position, much like pulling the cotter pin, requires additional manipulation by a user.

[0007] Once the piston is released from the locked position, the mixing cartridge is inserted into the delivery gun. A typical delivery gun includes a ram disk that engages the piston and drives the piston through the mixing chamber to discharge the bone cement from the nozzle. The delivery gun includes a cradle for supporting the mixing cartridge and a casing for supporting a drive rod that engages the ram disk and advances the ram disk to drive the piston. The drive rod includes a plurality of teeth and a pawl member engages the teeth to advance the drive rod. A trigger supports the pawl member and the casing rotatably supports the trigger. Actuation of the trigger relative to the casing urges the pawl member against the teeth to advance the drive rod.

[0008] An example of such a delivery gun is illustrated in United States Patent No. 5,431,654 to Nic. In the '654 patent to Nic, two pawl members are used to independently advance the drive rod and the ram disk. The pawl members provide high speed/low force and low speed/high force advancement of the drive rod. A switch is used to select between the speeds. When high speed is selected, both pawl members engage the drive rod, while only the high-speed pawl member actually advances the drive rod. When low speed is selected, the high-speed pawl member is isolated from the teeth such that only

the low speed pawl member engages the teeth to advance the drive rod. However, in Nic, the trigger directly supports each of the pawl members which results in a low mechanical advantage to advance the drive rod and ram disk.

BRIEF SUMMARY OF THE INVENTION

[0009] A mixing cartridge for receiving liquid and powder components of bone cement to be mixed for medical use. The mixing cartridge comprises a cylinder having proximal and distal ends with a mixing chamber defined therebetween. The cylinder includes a cylinder wall extending between the ends about a longitudinal axis of the cylinder. A piston is disposed in the cylinder at the distal end such that the mixing chamber is further defined between the proximal end and the piston. A locking member is coupled to the piston to lock the piston in the distal end. The locking member includes a male portion engaging a female portion in the cylinder wall to place the piston in a locked position at the distal end of the cylinder. The locking member includes a resilient portion for biasing the male portion into mating engagement with the female portion. The piston remains in the locked position at the distal end of the cylinder while mixing the liquid and powder components.

[0010] One advantage of the mixing cartridge is the conveniently positioned locking member used to lock the piston in the distal end. By using the resilient portion to bias the male portion into mating engagement with the female portion, a user can easily release the piston from the locked position by either manually or mechanically acting against the bias of the resilient portion to disengage the male and female portions.

[0011] A delivery gun is also provided for discharging the bone cement from the cartridge once the bone cement is prepared. The delivery gun comprises a casing for supporting the cartridge. A drive mechanism is supported by the casing and advanceable relative to the casing to force the bone cement from the cartridge. The casing pivotally supports a trigger operatively connected to the drive mechanism to advance the drive mechanism upon actuation of the trigger to force the bone cement from the cartridge. A linkage system works in conjunction with the trigger to advance the drive mechanism. The linkage system comprises a first link pivotally connected to the casing and a second link interconnecting the first link and the trigger such that actuating the trigger moves the second link and the first link to advance the drive mechanism.

[0012] An advantage of the delivery gun is the use of the linkage system to

increase the mechanical advantage needed to successfully advance the drive mechanism and force the bone cement from the cartridge while minimizing fatigue to a user of the delivery gun.

[0013] In one aspect of the delivery gun, the drive mechanism includes a drive rod and gripper plates to advance the drive rod. The gripper plates frictionally engage the drive rod to advance the drive rod when the trigger is actuated. In one embodiment, the gripper plates include mating pegs and notches to align adjacent gripper plates. In another embodiment, the gripper plates are coated to increase lubricity and corrosion resistance thereof.

[0014] In another aspect of the delivery gun, the drive mechanism includes a drive rod and first and second pawl members to advance the drive rod. In one embodiment, the second pawl member is movable into engagement with teeth on the drive rod for high-speed advancement of the drive rod and out from engagement with the teeth for low-speed advancement. During low-speed advancement, only the first pawl member engages the teeth to advance the drive rod. During high-speed advancement, both pawl members engage the teeth, but only the second pawl member works to advance the drive rod.

[0015] A bone cement mixing and delivery system is also provided. The mixing and delivery system includes the cartridge and the delivery gun. In this aspect of the invention, the locking member includes a release button to release the piston from the locked position. At the same time, the delivery gun includes a release mechanism integrated into the drive mechanism to engage the release button. When the cartridge is placed into the cradle of the delivery gun, the drive mechanism is advanced and the release mechanism engages the release button to release the piston from the locked position. This configuration reduces the number of steps typically associated with releasing the piston. By incorporating the release mechanism into the drive mechanism, when the drive mechanism is advanced, the piston is automatically released.

[0016] A bone cement loading system for receiving the liquid and powder components of the bone cement is also provided. The loading system includes the cylinder with the piston locked in the distal end. A base defining a cavity is provided for receiving and securing the distal end of the cylinder. A funnel is provided for coupling to the proximal end of the cylinder to channel the powder component of the bone cement into the mixing chamber. The funnel has a proximal end with an oblong oval-shaped periphery to

facilitate loading of the powder component of the bone cement into the mixing chamber and a distal end with a circular periphery for snugly fitting into the proximal end of the cylinder. One particular advantage to this loading system is the use of the oblong oval-shaped funnel. The shape of the funnel reduces any mess typically associated with filling the mixing chamber with powder.

[0017] A bone cement mixing system comprising the mixing cartridge and a mixing shaft and blade is also provided. The blade is coupled to the mixing shaft and disposed in the mixing chamber for rotating with the mixing shaft about the longitudinal axis to mix the liquid and powder components of the bone cement. The blade includes a center hub coupled to the mixing shaft and an outer ring extending from the center hub. The outer ring forms an acute angle with the longitudinal axis of between twenty and seventy degrees to ensure adequate mixing of the bone cement in the mixing chamber.

[0018] A method of mixing the liquid and powder components of the bone cement in the mixing chamber is also provided. The method includes using a rotary power tool connected to a portion of the mixing shaft extending outside of the mixing chamber to mix the liquid and powder components of the bone cement. The blade is disposed in the mixing chamber while being operatively connected to the portion of the mixing shaft extending outside of the mixing chamber. In the method, the rotary power tool is first connected to the portion of the mixing shaft extending outside of the mixing chamber. Then the rotary power tool is actuated to rotate the blade and mix the liquid and powder components of the bone cement. At the same time, the rotary power tool is axially displaced relative to the mixing cartridge to completely mix the liquid and powder components of the bone cement. Once mixing is complete, the operative connection between the blade and the portion of the mixing shaft extending outside of the mixing chamber is removed.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0019] Advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0020] Figure 1 is an exploded perspective view of a mixing cartridge of the present invention in combination with a mixing shaft and blade;

[0021] Figure 2 is an assembled perspective view of the mixing cartridge

with the mixing shaft and blade supported therein;

[0022] Figure 3 is an exploded perspective view of a cap of the mixing cartridge;

[0023] Figure 4 is a cross-sectional view of the cap of Figure 3 and a partial cross-sectional view of a cylinder of the mixing cartridge to illustrate fitting of the cap to the cylinder;

[0024] Figure 5 is an exploded perspective view of the cap and the mixing shaft and blade;

[0025] Figure 6 is an assembled perspective view of the cap with the mixing shaft and blade supported therein;

[0026] Figure 7 is a perspective view of the blade;

[0027] Figure 7A is a side elevational view of the blade of Fig. 7;

[0028] Figures 8-8A and 9 are perspective views of alternative blades;

[0029] Figure 10 is a an exploded perspective view of the mixing shaft and a latch rod;

[0030] Figure 11 is an elevational end view of the mixing shaft and latch rod of Fig. 10;

[0031] Figure 12 is a cross-sectional view of the mixing shaft and latch rod of Figs. 10 and 11;

[0032] Figure 13 is an exploded perspective view of a release latch coupling the mixing shaft and latch rod;

[0033] Figures 14A-14C illustrate the release of the blade from the mixing shaft;

[0034] Figure 15 is an exploded perspective view of a piston of the mixing cartridge;

[0035] Figure 16 is a cross-sectional view of the piston of Fig. 15;

[0036] Figure 17 is a perspective view of an alternative piston of the mixing cartridge;

[0037] Figure 18 is a top view of the alternative piston of Fig. 17;

[0038] Figure 19 is an exploded perspective view of the cap and a nozzle;

[0039] Figure 20 is an assembled perspective view of the cap and nozzle;

[0040] Figure 21 is a blown-up view of a locking mechanism of the cap and nozzle;

- [0041] Figures 22-23 are perspective views of the nozzle;
- [0042] Figure 24 is a perspective view of a delivery gun of the present invention illustrating a linkage system of the delivery gun;
- [0043] Figures 24A-24B illustrate alternative linkage systems of the present invention;
- [0044] Figure 25 is an elevational view illustrating release of a locking member securing the piston;
- [0045] Figure 26 is a partial perspective view of an alternative linkage system and drive mechanism of the delivery gun;
- [0046] Figure 27 is a partial perspective view of the alternative linkage system and drive mechanism of Fig. 26 employing a striker to prevent freeze-up of the drive mechanism;
- [0047] Figures 28 is an elevational view of a second alternative embodiment of the linkage system and drive mechanism of the delivery gun in a low-speed position;
- [0048] Figure 29 is a perspective view of the second alternative embodiment of the linkage system and drive mechanism in the low-speed position;
- [0049] Figure 30 is an elevational view of the second alternative embodiment of the linkage system and drive mechanism in a high-speed position;
- [0050] Figure 31 is a perspective view of the second alternative embodiment of the linkage system and drive mechanism in the high-speed position;
- [0051] Figure 32 is an exploded view of a cylinder of the mixing cartridge and a base and funnel used to fill the cylinder with components of bone cement; and
- [0052] Figures 33-42 illustrate various steps associated with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0053] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a bone cement mixing and delivery system is generally shown. The bone cement mixing and delivery system comprises a mixing cartridge **100** for receiving liquid monomer and powdered copolymer components of bone cement to be mixed, a mixing device (mixing shaft **150** and blade **152**) for mixing the components, and a delivery device, e.g., a delivery gun **500**, for discharging the bone

cement from the mixing cartridge **100** into an anatomical site (not shown). An exemplary use for the bone cement is to secure a prosthetic device used to replace a joint structure such as in a total hip arthroplasty (THA) procedure.

[0054] Referring to FIGS. 1 and 2, the bone cement mixing system comprises the mixing cartridge **100** in combination with the mixing shaft **150** and blade **152** used to mix the components of the bone cement in the mixing cartridge **100**. The mixing cartridge **100** includes a cylinder **102** having proximal **104** and distal **106** ends. A mixing chamber **108** is defined between the ends **104**, **106**. The cylinder **102** includes a cylinder wall **110** extending between the ends **104**, **106**, about a longitudinal axis **L**. A cap **112** is coupled to the cylinder **102** at the proximal end **104** and a piston **114** is disposed in the cylinder **102** at the distal end **106** such that the mixing chamber **108** is further defined between the cap **112** and the piston **114**. The components of the bone cement are placed in the mixing chamber **108** and mixed by the mixing shaft **150** and blade **152**, as will be described further below.

[0055] In the preferred embodiment, the cylinder **102** has locking strips **116** disposed on the cylinder wall **110** at the proximal end **104** to insert into locking slots **118** on the cap **112**. Each of the locking strips **116** include a straight portion lying perpendicular relative to the longitudinal axis **L** and an angled portion lying at an angle relative to the straight portion. As should be appreciated, the locking strips **116** and locking slots **118** could be reversed, i.e., the locking strips **116** positioned on the cap **112** and the locking slots **118** defined in the cylinder wall **110**. The locking strips **116** and locking slots **118** are configured to provide quick locking of the cap **112** onto the cylinder **102** with a one-quarter turn of the cap **112**. Those of ordinary skill in the art will appreciate that numerous methods are available for connecting the cap **112** to the cylinder **102**, such as mating threads, snap-fit connections, etc. A groove **120** is formed in the cylinder **102** at the proximal end **104** to seat an o-ring seal **122**. The o-ring seal **122** assists in sealing the cap **112** to the cylinder **102**.

[0056] Referring to FIGS. 3-4, the cap **112** includes radially inwardly protruding ramps **124** that lead into the locking slots **118** to facilitate the fit with the locking strips **116** on the cylinder wall **110**. When first placing the cap **112** on the cylinder **102**, the locking strips **116** are positioned between the ramps **124**. As the cap **112** is rotated, the ramps **124** cam the locking strips **116** proximally to urge the proximal end **104** of the cylinder **102** into a sealed relationship with the cap **112**, as shown in FIG. 4 (only a portion

of the cylinder wall **110** with two locking strips **116** is shown in FIG. 4 for illustrative purposes). In the preferred embodiment, there are four locking strips **116** and four locking slots **118** to facilitate the sealed relationship between the cap **112** and the cylinder **102**.

[0057] Referring specifically to FIG. 4, an o-ring seal **126** and dynamic seal **128** operate together within an orifice **130** in the cap **112** to movably support and seal to the mixing shaft **150**. The mixing shaft **150** slides through the orifice **130** and the dynamic seal **128** and is movably supported therein. The dynamic seal **128** allows nearly frictionless rotational, as well as axial movement of the mixing shaft **150** within the mixing chamber **108** to mix the liquid and powder components of the bone cement, while maintaining a snug fit within the orifice **130**. A filter **132** and liner **134** are positioned on an interior of the cap **112** to allow a vacuum to be drawn in the mixing chamber **108** by way of a vacuum port **136**. The vacuum port **136** is isolated from the mixing chamber **108** by the filter **132** and liner **134** to prevent fouling of a vacuum pump (not shown). Referring to FIGS. 5-6, a vacuum tube **138** is shown attached to the vacuum port **136** to draw the vacuum in the mixing chamber **108** during mixing.

[0058] Referring to FIG. 7, the preferred blade **152** used to mix the bone cement is shown. The blade **152** is integrally formed from plastic in one piece and has an outer ring **154** connected to a center hub **156** by vanes **158**. Ears **160** protrude radially inwardly from the center hub **156** to facilitate a releasable connection to the mixing shaft **150**. The releasable connection is described further below. Referring to FIG. 7A, the outer ring **154** forms an acute angle α with the longitudinal axis **L** of the cylinder **102** (which is also a rotational mixing axis of the blade **152**). The acute angle α is important for efficient mixing of the bone cement. The acute angle α is preferably between twenty and seventy degrees, and more preferably sixty degrees. The blade **152** has an effective height **H** that is greater than one quarter inch to ensure adequate mixing. Preferably, the effective height **H** of the blade **152** is approximately one half inch.

[0059] Referring back to FIG. 7, two radially inwardly protruding fingers **157** are attached to the outer ring **154**. One of the fingers **157** protrudes radially inwardly in a first plane and the other finger **157** protrudes radially inwardly in a second plane spaced from and parallel to the first plane. The center hub **156** is positioned between the planes. The fingers **157** are used to scrape proximal and distal regions of the mixing chamber **108** to ensure complete mixing. A protruding node **159** is also attached to the outer ring **154**. The node **159** protrudes radially outwardly to control spacing between the blade **152** and an

inner periphery of the cylinder wall **110** by scraping along the inner periphery of the cylinder wall **110** in the mixing chamber **108**.

[0060] FIGS. 8 and 8A illustrate alternative blades **252**, **352** that could also be used to mix the bone cement. Each of the blades **152**, **252**, **352** is designed to flatten at the proximal end **104** of the cylinder **102** adjacent to the cap **112** after the blade **152**, **252**, **352** is released from the mixing shaft **150** in the mixing chamber **108**. This ensures that the maximum possible amount of bone cement can be discharged from the mixing cartridge **100**. In the case of the preferred blade **152**, the blade **152** is flexible and the outer wall **154** flattens into a plane perpendicular to the longitudinal axis **L** and occupied by the center hub **156**, as illustrated by hidden lines in FIG. 7A. Thus, the effective height **H** is reduced and the acute angle α becomes close to ninety degrees. This is accomplished by twisting at the vanes **158**. Spaces **155**, **255**, **355** formed in the center hub **156**, **256**, **356** ensure that once the blade **152**, **252**, **352** is flattened, the bone cement can pass through the blade **152**, **252**, **352** when discharged from the mixing cartridge **100**. To further facilitate the discharge of the bone cement past the blades **152**, **252**, **352**, each of the center hubs **156**, **256**, **356** are sized to partially fit within the aperture **130** defined in the cap **112**.

[0061] Another alternative blade **452** is shown in FIG. 9. This blade **452** is a relatively thick disk **452** with chamfered ends **453** forming an acute chamfer angle with a sidewall **457**. The chamfer angle is preferably sixty degrees. In the preferred embodiment, the disk is about one half inch thick and about one eighth inch less in diameter than the inner periphery of the cylinder wall **110**. In one embodiment, the inner periphery of the cylinder wall **110** is about two and one quarter inches in diameter. As should be appreciated, the slight distance between the side wall **457** of the disk **452** and the inner periphery of the cylinder wall **110** creates a shear force on the bone cement as the disk **452** is rotated and moved axially in the mixing chamber **108**. The shear force is the force applied to the bone cement to mix the bone cement. This blade **452** also includes a space **455** formed in a center of the disk **452** and ears **460** for releasably attaching to the mixing shaft **150**.

[0062] Referring to FIGS. 10-13 the mixing shaft **150** has a release latch **162** for releasing the blade **152** from the mixing shaft **150** once mixing of the bone cement is complete. The release latch **162** moves between a holding position and a releasing position. In the holding position, the blade **152** is secured to the mixing shaft **150** to mix the bone cement in the mixing chamber **108**. In the releasing position, the blade **152** is released

from the mixing shaft **150** to remain in the mixing chamber **108** while the mixing shaft **150** is removed from the cap **112** to make way for a nozzle **204**, as will be described further below. The release latch **162** is operatively connected to a latch rod **164**, which latches the blade **152** to the mixing shaft **150** in the holding position. The latch rod **164** defines a split cavity **166** for receiving split legs **168** of the release latch **162** in a snap-fit manner. The latch rod **164** is rotatably supported within the mixing shaft **150**.

[0063] Referring to FIGS. 14A-14C, the transition of the release latch **162** between the holding position and the releasing position is illustrated. Referring first to FIG. 14C, the exposed end **170** of the latch rod **164** is generally "T" shaped. The corresponding end **172** of the mixing shaft **150** has opposed notches **174** that are adapted to receive the ears **160** on the center hub **156** of the blade **152**. Initially, the ears **160** are positioned in the notches **174** and the exposed end **170** is positioned over the ears **160** to hold the blade **152** to the mixing shaft **150**. See FIG. 14A. To release the blade **152**, the release latch **162** is depressed and rotated. Rotating the release latch **162** rotates the latch rod **164** with respect to the mixing shaft **150** thus rotating the exposed end **170** away from the ears **160** to release the blade **152**. See FIG. 14B. With the blade **152** released, the mixing shaft **150** is withdrawn from the cap **112** while the blade **152** remains in the mixing chamber **108**.

[0064] A proximal end **176** of the mixing shaft **150**, which represents a portion of the mixing shaft **150** extending outside of the mixing chamber **108** during mixing, is adapted to engage a rotary power tool **177** (see FIG. 37), such as a reamer drill, used to rotate the mixing shaft **150** and blade **152** and mix the bone cement. The proximal end **176** of the mixing shaft **150** is operatively connected to the blade **152** to transfer the rotation of the rotary power tool **177** to the blade **152**. When the blade **152** is released from the mixing shaft **150**, the operative connection is removed. The operative connection is also removed if the portion of the mixing shaft **150** extending outside of the mixing chamber **108** is severed from the rest of the mixing shaft **150** in the mixing chamber **108**, as in alternative embodiments. A manually operated mixing handle (not shown) could engage the mixing shaft **150** at the proximal end **176** to mix the bone cement in other embodiments.

[0065] Referring to FIGS. 15-16, the piston **114** is positioned within the distal end **106** of the cylinder **102** to further seal the mixing chamber **108**. The piston **114** has a skirt **178** extending about the inner periphery of the cylinder wall **110**. The piston **114** also includes a proximal end **180** and a distal end **182** defining a cavity **184**.

[0066] Referring specifically to FIG. 16, the piston **114** is releasably

secured in a locked position in the distal end **106** of the cylinder **102** by a locking member **186**. The locking member **186** is disposed in the cavity **184** and includes diametrically opposed locking tabs **188** protruding into diametrically opposed slots **190** defined in the cylinder wall **110** to secure the piston **114** to the cylinder **102**. It should be appreciated that the slots **190** could be in the form of any suitable female portion, e.g., slot, groove, channel, etc., used for interlocking with a corresponding male portion such as the locking tabs **188**. Furthermore, while the embodiment of FIG. 16 illustrates two-way locking, i.e., the piston **114** being locked from moving proximally and distally, the locking member **186** could also be used for one-way locking, i.e., for preventing only proximal movement of the piston **114**.

[0067] The locking member **186** is integrally formed from plastic and a resilient portion **192** of the locking member **186** biases the locking tabs **188** radially outwardly from the longitudinal axis **L** into the slots **190**. The resilient portion **192** is in the form of a thin resilient ribbon **192** acting like a spring and extending in a winding shape between the locking tabs **188**. The locking tabs **188** couple the locking member **186** to the piston **114** by protruding through carrier slots **194** formed in the skirt **178**. In the preferred embodiment, a step **196** protrudes into each of the carrier slots **194** to define a guide for sliding engagement within a channel **198** partially defined in each of the locking tabs **188**. In the locked position, the carrier slots **194** are axially and radially aligned with the slots **190** formed in the cylinder wall **110**.

[0068] The piston **114** is locked at the distal end **106** of the cylinder **102** while the liquid and powder components are added and mixed in the mixing cartridge **100**. The piston **114** is released from the locked position after mixing of the bone cement is complete. Release buttons **200**, integrally formed with the locking tabs **188**, are used to release the piston **114** from the locked position. The release buttons **200** are disposed on the locking tabs **188** and protrude distally therefrom. Each of the release buttons **200** includes a cam surface **202** forming an acute angle with the longitudinal axis **L**. The piston **114** is released from the locked position by squeezing the release buttons **200** radially inwardly against the bias of the resilient portion **192** to withdraw the locking tabs **188** from the slots **190**. This action can be performed either manually or mechanically, as will be described further below. After release from the slots **190**, the locking tabs **188** remain coupled to the piston **114** in the carrier slots **194**.

[0069] Referring to FIGS. 17-18, an alternative locking member **386** is shown. The alternative locking member **386** includes locking tabs **388** that are biased

radially outwardly from the longitudinal axis **L** of the cylinder **302** to engage the slots **390** in the cylinder wall **310**. In this embodiment, four slots **390** are defined in the cylinder wall **310** to receive the locking tabs **388**. The resilient portion **392** is further defined as a resilient base **392** resiliently supporting each of the locking tabs **388** on the piston **314** with each of the locking tabs **388** being radially biased outwardly from the skirt **378** of the piston **314** to engage the slots **390** in the cylinder wall **310**. The release buttons **400** are further defined as fingers **400** extending radially inwardly toward the longitudinal axis **L** of the cylinder **302** with the fingers **400** being engageable to urge the locking tabs **388** radially inwardly and withdraw the locking tabs **388** from the slots **390** in the cylinder wall **310** to release the piston **314** from the locked position.

[0070] Referring to FIGS. 19-23, once the bone cement is mixed, and the mixing shaft **150** is withdrawn from the cap **112**, the nozzle **204** is positioned on the cap **112**. In the disclosed embodiment, the nozzle **204** is set in place by pushing a hollow shaft **205** of the nozzle **204** down into the orifice **130** of the cap **112** and then twisting the nozzle **204** slightly, about one-quarter turn. The nozzle **204** is attached to the cap **112** to prepare the mixing cartridge **100** for placement into the delivery gun **500**.

[0071] The cap **112** has a nipple **206** protruding from an outer surface **208** thereof. The nipple **206** has tabs **210**, which engage detent members **212** in the nozzle **204**. After the nozzle **204** is fully rotated into position, the tabs **210** fully engage the detent members **212** while being positioned proximal to the detent members **212** to secure the nozzle **204** in place. A stop **214** on the cap **112**, best shown in FIG. 19, prevents the nozzle **204** from rotating freely in the clockwise direction after the tabs **210** have engaged the detent members **212**. The stop **214** extends downwardly from one of the tabs **210** to abut a side surface **216** of one of the detent members **212** to prevent further clockwise rotation.

[0072] The nozzle **204** and cap **112** have first **218** and second **220** locking protrusions. The first locking protrusion **218** acts as a detent and slides over the second locking protrusion **220** to a locked position as illustrated in FIG. 21. In this position, rear flat surfaces **222**, **224** of the locking protrusions **218**, **220**, abut one another to prevent the nozzle **204** from being turned in the opposite direction, thereby preventing removal of the nozzle **204** from the cap **112**. The nozzle **204** can be removed by deflecting an outer skirt **226** of the nozzle **204** and rotating the nozzle **204** counterclockwise thereby disengaging the locking protrusions **218**, **220**. Both the nozzle **204** and cap **112** are formed from plastic, which facilitates the detent-like locking and unlocking of the nozzle **204** to the cap **112**.

[0073] With the nozzle 204 in place, the mixing cartridge 100 is ready to be placed within the delivery gun 500. Referring to FIG. 24, the delivery gun 500 of the present invention includes a cradle 502 for supporting the mixing cartridge 100 and a casing 504 fixed to the cradle 502 for supporting a drive mechanism 506, a linkage system 508, and corresponding components. The cradle 502 includes an endplate 510, which has an opening 512 for receipt of the nozzle 204. The endplate 510 holds the mixing cartridge 100 in position in the cradle 502. In the preferred embodiment, the casing 504 and the endplate 510 are connected by two connecting bars 514 (one on each side of the mixing cartridge 100) to reduce the weight of the delivery gun 500. A handle 516 is integrally formed with the casing 504 to maneuver the delivery gun 500 during use.

[0074] To dispense the bone cement from the mixing cartridge 100, the piston 114 must first be released from the locked position. Referring to FIG. 25, this is accomplished using a release mechanism 518 integrated into the delivery gun 500. Once the mixing cartridge 100 is in place in the cradle 502, a ram disk 520 protrudes into the cavity 184 in the distal end 182 of the piston 114. The release mechanism 518 is integrated into the ram disk 520. The release mechanism 518 includes a bearing surface 522 forming an acute angle with the longitudinal axis L for catching the release buttons 200 to cam the release buttons 200 radially inwardly. More specifically, the cam surfaces 202 of the release buttons 200 slide along the bearing surface 522, while being cammed radially inwardly. This action pulls the locking tabs 188 radially inwardly to withdraw the locking tabs 188 from the slots 190 in the cylinder wall 110 and release the piston 114 from the locked position (when the alternative piston 314 is used, the ram disk has a flat bearing surface that axially presses the fingers 400 proximally to bend each resilient base 392 inwardly and urge the locking tabs 388 radially inward). A centering pin 800 can be used to center the ram disk 520 in a centering cavity 802 of the piston 114 to facilitate the release of the piston 114 from the locked position.

[0075] Referring back to FIG. 24, once the piston 114 is released, the piston 114 can be driven through the mixing chamber 108 by the drive mechanism 506 to force the bone cement from the nozzle 204. The drive mechanism 506 includes a drive rod 524 movably supported by bushings 526 in the casing 504. The ram disk 520 is fixed to the drive rod 524. The drive mechanism 506 further includes a first gripper plate 528 responsive to movement of the linkage system 508 upon actuation of a trigger 530. The first gripper plate 528 defines an aperture surrounding the drive rod 524. The first gripper

plate 528 frictionally engages the drive rod 524 to advance the drive rod 524. The first gripper plate 528 is urged forward while in frictional contact with the drive rod 524 by the linkage system 508 when the trigger 530 is actuated. The first gripper plate 528 thereby advances the drive rod 524 and ram disk 520 relative to the casing 504 to drive the piston 114 and force the bone cement from the mixing cartridge 100. The trigger 530 is pivotally supported by the casing 504 and operatively connected to the drive mechanism 506 to advance the drive mechanism 506 upon actuation of the trigger 530.

[0076] The linkage system 508 includes a first link 532, which is pivotally mounted to the casing 504 about a pivot axis A adjacent to the first gripper plate 528. The first link 532 is adapted to engage the first gripper plate 528 when the first link 532 pivots about the pivot axis A. A second link 536 pivotally interconnects the trigger 530 to the first link 532 via support pins 538, 540. The links 532, 536 and trigger 530 are interconnected to move in unison upon rotation of the trigger 530 about a second pivot axis B. When the trigger 530 is pulled, the second link 536 rotates the first link 532 about the pivot axis A, which engages the first gripper plate 528 and urges the first gripper plate 528 forward while the first gripper plate 528 is in frictional engagement with the drive rod 524 thereby advancing the drive rod 524. A return spring 542 returns the links 532, 536 and the trigger 530 to an initial position upon release of the trigger 530. At the same time, a first spring 534 momentarily disengages the first gripper plate 528 from the drive rod 524 to slide the first gripper plate 528 back to an initial position to await the next pull of the trigger 530. The casing 504 pivotally supports the first link 532 and the trigger 530 about the pivot axes A and B via support pins 544, 546.

[0077] A speed-changing link 548 is pivotally connected to the second link 536 about a support pin 549. The speed-changing link 548 selectively pivots into and out from engagement with the first gripper plate 528 by way of a switch 550. The speed-changing link 548 pivots between a high-speed position and a low-speed position about the support pin 549 (the low-speed position is shown in FIG. 24). The high-speed position corresponds to faster advancement of the drive rod 524 at a lower force. This allows the user to quickly advance the drive rod 524 to drive the piston 114 and dispense high volumes of bone cement at low pressure. The low-speed position corresponds to slower advancement of the drive rod 524 at a higher force, which exerts more force on the piston 114 to pressurize the bone cement.

[0078] The first gripper plate 528 and the speed-changing link 548 have

complementary first and second coupling devices **552**, **554** used to couple the first gripper plate **528** with the speed-changing link **548** in the high-speed position. More specifically, in the embodiment of FIG. 24, the first gripper plate **528** has a shoulder **552** that is received within a channel **554** on the speed-changing link **548**. The speed-changing link **548** engages the shoulder **552** in the high-speed position. In the high-speed position, a user's gripping force is transmitted through the trigger **530** to the second link **536** and the speed-changing link **548** to engage the first gripper plate **528** and advance the drive rod **524**. The speed-changing link **548** is isolated from the first gripper plate **528** in the low-speed position. The low-speed position corresponds to the speed-changing link **548** being switched or disconnected from the shoulder **552**. In the low-speed position, the user's gripping force is transmitted through the trigger **530** to both the first **532** and second **536** links to engage the first gripper plate **528** and advance the drive rod **524**. This results in slower advancement of the drive rod **524**, but at a much higher mechanical advantage than the high-speed position. As a result, the user can better pressurize the bone cement during injection.

[0079] The pivot axes **A** and **B** and the links **532**, **536**, **548** are positioned above the drive rod **524**, while the trigger **530** extends below the drive rod **524**. A channel **556** defined in the trigger **530** facilitates this configuration. There are several advantages to this configuration. Moving the second pivot axis **B** away from a user's hand results in better usage of the stronger index and ring fingers by allowing those fingers more travel distance as the trigger **530** is actuated. This configuration also allows the handle **516** to be closer to the drive rod **524**, which is believed to reduce wrist strain when the user pushes the delivery gun **500** forward during cement pressurization. Another benefit is that it allows for a more streamlined casing design and better weight distribution.

[0080] In one embodiment, shown in FIG. 24, a secondary gripper plate **562** is mounted about the drive rod **524** adjacent to the first gripper plate **528**. The addition of one or more secondary gripper plates **562** to the first gripper plate **528** adds strength to the delivery gun **500** while still permitting proper operation. By using two or more gripper plates **528**, **562**, increased frictional contact with the drive rod **524** is obtained without adversely affecting performance.

[0081] A release pin **558** disengages the gripper plates **528**, **562** to allow a user to freely move the drive rod **524** by hand. The release pin **558** is connected to a retainer plate **560** and is adapted to engage the first gripper plate **528**. When the retainer

plate 560 is pushed by the user, the release pin 558 engages the first gripper plate 528 which forces the first gripper plate 528 to tilt back against the bias of the first spring 534 thus releasing the drive rod 524. Any secondary gripper plates 562 follow. As should be appreciated, pushing the retainer plate 560 also pivots the retainer plate 560 releasing its engagement with the drive rod 524. With both the retainer plate 560 and the gripper plates 528, 562 released, the drive rod 524 is free to move. This allows the user to manually move the drive rod 524 with respect to the casing 504.

[0082] The delivery gun 500 is unique among bone cement guns with a friction-plate mechanism in the way that it handles wear and deformation of the gripper plates 528, 562. In the disclosed embodiments, the gripper plates 528, 562 are tilted by the first spring 534 into frictional contact with the drive rod 524. Regardless of the amount of wear or deformation of the gripper plates 528, 562 or the drive rod 524, the gripper plates 528, 562 require no further tilting to engage the drive rod 524 upon actuation of the trigger 530. Thus, advancement of the drive rod 524 is produced over the entire actuation of the trigger 530 and efficiency is maintained throughout the life of the delivery gun 500.

[0083] Referring to FIGS. 24A and 24B, alternatives of the linkage system 508' and 508'' are shown. These alternatives are represented with similar numerals to the embodiment of FIG. 24 to indicate like parts. FIG. 24A illustrates a configuration of the linkage system 508' in which the linkage system 508' lies beneath the drive rod 524'. Furthermore, the speed-changing link 548' in this embodiment is pivotally connected to the first gripper plate 528' and includes a hook-shaped end to engage the support pin 538' in the high-speed position and disengage the support pin 538' in the low-speed position. FIG. 24B illustrates a configuration of the linkage system 508'' in which the first gripper plate 528'' is pushed by the linkage system 508'', as opposed to being pulled by the linkage system 508 and 508' in FIGS. 24 and 24A. Here, the speed-changing link 548'' is pivotally connected to the first gripper plate 528'' to pivot into engagement with a notch 555'' defined in the trigger 530'' in the high-speed position and out from engagement with the notch 555'' in the low-speed position. These alternatives of the linkage system 508' and 508'' illustrate the flexibility of design, e.g., the selection of mechanical advantage, provided by the linkage system of the present invention.

[0084] Referring to FIGS. 26-27, an alternative embodiment of the drive mechanism 606 and linkage system 608 is shown (only a portion of the drive mechanism 606 and linkage system 608 is shown for illustrative purposes). In this embodiment, the

linkage system 608 comprises the same components as previously described with an improved first link 632 and gripper plates 628, 662. In this embodiment, a plurality of secondary gripper plates 662 are aligned along the drive rod 624 next to the first gripper plate 628. The first link 632 defines a female recess 664 and the first gripper plate 628 includes a male member 668 for mating engagement with the female recess 664. The secondary gripper plates 662 are aligned relative to the first gripper plate 628 via mating notches 670 and pegs 672 formed therein. The notches 670 and pegs 672 assume the same shape to mate with one another and maintain alignment. This arrangement minimizes alignment changes that may cause slipping or uneven wear. The arrangement also reduces contact between the gripper plates 628, 662 and an interior wall of the casing 504. The gripper plates 628, 662 are shown spaced in FIG. 26 for illustration only. In practice, the gripper plates 628, 662 abut one another, as shown in FIG. 27.

[0085] In this embodiment, each of the gripper plates 628, 662 also defines a pair of semi-spherical grooves 674. In FIG. 26, only the first of the pair of grooves 674 are shown in each of the gripper plates 628, 662. The other of the pair of grooves 674 is located in a rear surface of each of the gripper plates 628, 662, cater-cornered from the first of the pair of grooves 674. These grooves 674 increase the frictional contact with the drive rod 624. When the gripper plates 628, 662 are urged forward while in frictional engagement with the drive rod 624 by the first link 632, a substantial portion of a rim 676 defined by each of the grooves 674 frictionally contacts the drive rod 624.

[0086] Referring to FIG. 27, autoclave sterilization of the delivery gun 500 can create a tendency for the gripper plates 628, 662 to adhere to the drive rod 624 beyond their initial positions when the trigger 630 is released. In this situation the first spring 634 cannot produce enough force to disengage the gripper plates 628, 662 from the drive rod 624, and the gripper plates 628, 662 do not return to their initial positions. FIG. 27 shows a way to prevent this condition. A striker 678, in the form of a downwardly protruding portion of the second link 636, closely follows one of the gripper plates 628, 662 during actuation of the trigger 630. In the event that any of the gripper plates 628, 662 do not properly disengage the drive rod 624 upon release of the trigger 630, the striker 678 will contact the notch 670 in the closest gripper plate 628, 662 and dislodge the gripper plate 628, 662 from the drive rod 624. The first spring 634 can then properly return the gripper plates 628, 662 to their initial positions.

[0087] A coating has been added to an exterior of each of the gripper plates

528, 562, 628, 662 in FIGS. 24 and 26-27. The coating increases lubricity and corrosion resistance. This facilitates sliding between the gripper plates 528, 562, 628, 662 as they engage the drive rod 524, 624. The coating also reduces corrosion due to autoclave sterilization that may cause the gripper plates 528, 562, 628, 662 to adhere to one another and prevent proper engagement with the drive rod 524, 624. The coating used may be Electroless-Nickel with polytetrafluoroethylene (PTFE) or other like coatings possessing the same or similar properties.

[0088] Referring to FIGS. 28-31, another alternative embodiment of the drive mechanism 706 and linkage system 708 is shown. This embodiment also provides selective high-speed and low-speed advancement of the drive rod 724. This alternative drive mechanism 706 eliminates the gripper plate by providing teeth 780 on the drive rod 724. A cross-section of the drive rod 724 shows the teeth 780 on a flat upper surface 782, while a lower surface 784 is smooth and round. The first link 732, which in previous embodiments urged the first gripper plate 528, 628 forward with the drive rod 524, 624, now pivotally supports a first pawl member 786. The first pawl member 786 is spring-biased into engagement with the teeth 780.

[0089] A second pawl member 788 is pivotally supported by the second link 736. The second pawl member 788 is pivotable between a high-speed position in which the second pawl member 788 is spring-biased into engagement with the teeth 780 to advance the drive rod 724, and a low-speed position in which the second pawl member 788 is disengaged and isolated from the teeth 780. In the low-speed position, the first pawl member 786 advances the drive rod 724. The low-speed position is illustrated in FIGS. 28-29. In the high-speed position, with the second pawl member 788 engaging the teeth 780, the first pawl member 786 remains in engagement with the teeth 780, but only ratchets along the teeth 780 as the second pawl member 788 advances the drive rod 724. The high-speed position is illustrated in FIGS. 30-31. The principle of increasing mechanical advantage in the low-speed position relative to the high-speed position also applies in this embodiment.

[0090] The switch 750 is used to pivot the second pawl member 788 out from engagement with the teeth 780 of the drive rod 724 in the low-speed position (see FIGS. 28-29) and into engagement with the teeth 780 in the high-speed position (see FIGS. 30-31). A switch similar to that shown in United States Patent No. 5,431,654 to Nic, herein incorporated by reference, can be used for this purpose. The switch 750 extends through

the casing **704** and terminates in a button that is manipulated by a user to move the second pawl member **788** between the high-speed and low-speed positions (see briefly FIGS. 41-42). This also applies to the switch **550** used to move the speed-changing link **548** in previous embodiments.

[0091] In this embodiment, the retainer plate **560** can be removed. In its place, a spring-biased non-return pawl member **790** retains the drive rod **724** in position upon advancement. The drive rod **724** can be freely moved in the casing **704** by rotating the drive rod **724** one hundred and eighty degrees such that the pawl members **786**, **788**, **790** are out of engagement with the teeth **780**. Upon such rotation, the pawl members **786**, **788**, **790** ride on the smooth lower surface **784** of the drive rod **724** allowing the user to freely pull the drive rod **724** relative to the casing **704**. This is generally disclosed in the '654 patent to Nic.

[0092] Each of the pawl members **786**, **788**, **790** are pivotally supported by pins. Springs, such as those shown in the '654 patent to Nic, bias the pawl members into engagement with the teeth **780** on the drive rod **724** (except when the switch **750** acts against the bias of the spring in the low-speed position to disengage the second pawl member **788** from the teeth **780**).

[0093] Mixing and delivery of the bone cement will now be described with reference to FIGS. 32-42. Referring first to FIG. 32, a bone cement loading system is shown. The bone cement loading system comprises a base **900** supporting the cylinder **102** while loading the liquid and powder components of the bone cement into the mixing chamber **108**. The base includes a cavity for receiving the distal end **106** of the cylinder **102**. Detents **903** are formed in the cavity. A groove **905** is defined in an outer surface of the cylinder **102** to receive the detents **903** and facilitate a snug fit between the base **900** and the cylinder **102**. It should be appreciated that the detents **903** could be formed on the cylinder **102** with the groove **905** defined in the base **900**. The distal end **106** of the cylinder **102** may also be press fit into the base **900**. The base **900** is oblong and oval in shape to fully support the cylinder **102** on a work surface, while the cavity is circular in shape to fit the circular shaped cylinder **102**. A funnel **902** couples to the cylinder **102** to channel the powder into the cylinder **102** during loading. The funnel **902** includes a proximal end **911** having an oblong oval-shaped periphery to facilitate the loading of the powder into the mixing chamber **108** and a distal end **909** having a circular periphery to snugly fit inside the proximal end **104** of the cylinder **102**.

[0094] FIGS 33-42 illustrate ten steps for preparing and injecting the bone cement. The mixing cartridge **100**, delivery gun **500**, and other components are generically shown in each step for illustrative purposes only.

[0095] In STEP 1, shown in FIG. 33, the funnel **902** is coupled to the cylinder **102** and the powder is poured into the mixing chamber **108**.

[0096] In STEP 2, shown in FIG. 34, after the powder is poured into the mixing chamber **108**, the funnel **902** is removed, and the liquid component, e.g., liquid monomer, of the bone cement is added. In this manner, the present invention avoids wetting of the funnel **902** and the associated clean-up.

[0097] In STEP 3, shown in FIG. 35, the cap **112** with the mixing shaft **150** and blade **152** supported therein is attached to the cylinder **102**.

[0098] In STEP 4, shown in FIG. 36, the vacuum line **138** is attached to the vacuum port **136** and a vacuum is drawn in the mixing chamber **108** with the liquid and powder components therein.

[0099] In STEP 5, shown in FIG. 37, with the vacuum drawn, the power tool (reamer) is then connected to the mixing shaft **150**.

[00100] In STEP 6, shown in FIG. 38, with the vacuum still drawn, the mixing shaft **150** is moved axially with respect to the mixing cartridge **100** and rotated by the power tool. The blade **152** (not shown in FIG. 38) is moved axially the entire extent of the mixing cartridge **100** while rotating to ensure that the liquid and powder components are fully mixed.

[00101] In STEP 7, shown in FIG. 39, once mixed, the release latch **162** is moved to release the blade **152** (not shown in FIG. 39). The blade **152** remains in the mixing chamber **108** once released. The mixing shaft **150** is then removed from the mixing cartridge **100**. Mixing is now complete.

[00102] In STEP 8, shown in FIG. 40, the nozzle **204** is pushed down on the cap **112** and rotated into place.

[00103] In STEP 9, shown in FIG. 41, the mixing cartridge **100** is positioned in the cradle **502**.

[00104] In STEP, shown in FIG. 42, the piston **114** is released from the distal end **106** of the cylinder **102** and the delivery gun **500** is primed and ready to discharge the bone cement from the mixing cartridge **100**.

[00105] It will be appreciated that the above description relates to the

disclosed embodiments by way of example only. Many apparent variations of the disclosed invention will be known to those of skill in this area and are considered to be within the scope of this invention and are considered to be within the scope of the following claims. Obviously, many modifications and variations of the present invention are possible in light of the above teachings.

CLAIMS

What is claimed is:

1. A mixing cartridge for receiving liquid and powder components of bone cement to be mixed for medical use, said mixing cartridge comprising:

a cylinder having proximal and distal ends and defining a mixing chamber therebetween for receiving the liquid and powder components of the bone cement, said cylinder including a cylinder wall extending between said ends about a longitudinal axis thereof and said cylinder wall defining at least one female portion at said distal end;

a piston disposed in said cylinder at said distal end;

a locking member coupled to said piston and including at least one male portion for mating with said at least one female portion in said cylinder wall to place said piston in a locked position in said distal end of said cylinder; and

said locking member including a resilient portion for biasing said at least one male portion into mating engagement with said at least one female portion in said cylinder wall whereby said piston remains in said locked position while mixing the liquid and powder components of the bone cement.

2. A mixing cartridge as set forth in claim 1 wherein said female portion is further defined as at least one slot and said male portion is further defined as at least one locking tab protruding radially outwardly from said longitudinal axis into said at least one slot in said locked position.

3. A mixing cartridge as set forth in claim 2 wherein said piston includes a proximal end and a distal end with a cavity defined in said distal end and said locking member is disposed in said cavity.

4. A mixing cartridge as set forth in claim 2 wherein said at least one slot is further defined as a pair of diametrically opposed slots and said at least one locking tab is further defined as a pair of diametrically opposed locking tabs protruding radially outwardly into said slots in said cylinder wall under the bias of said resilient portion.

5. A mixing cartridge as set forth in claim 4 wherein said resilient portion extends between said locking tabs to bias said locking tabs radially outwardly from said

longitudinal axis of said cylinder.

6. A mixing cartridge as set forth in claim 5 wherein said resilient portion is integral with said locking tabs and extends in a thin resilient ribbon between said locking tabs.

7. A mixing cartridge as set forth in claim 6 wherein said piston defines a pair of carrier slots for receiving and axially securing said locking tabs when said piston is in said locked position and after said piston is released from said locked position.

8. A mixing cartridge as set forth in claim 7 wherein said piston includes a step extending partially into each of said carrier slots and each of said locking tabs defines a channel partially extending therein for receiving said step when said piston is in said locked position and after said piston is released from said locked position.

9. A mixing cartridge as set forth in claim 4 wherein said locking member includes a pair of release buttons for releasing said piston from said locked position.

10. A mixing cartridge as set forth claim 9 wherein said release buttons are integrally formed with said locking tabs and said release buttons extend distally from said locking tabs to protrude distally from said piston.

11. A mixing cartridge as set forth in claim 10 wherein each of said release buttons include a cam surface extending at an acute angle to said longitudinal axis of said cylinder with said cam surfaces being engageable to cam said release buttons radially inwardly toward said longitudinal axis to withdraw said locking tabs from said slots in said cylinder wall and release said piston from said locked position.

12. A mixing cartridge as set forth in claim 2 wherein said at least one slot is further defined as a plurality of slots and said at least one locking tab is further defined as a plurality of locking tabs protruding into said slots in said locked position.

13. A mixing cartridge as set forth in claim 12 wherein said resilient portion is

further defined as a resilient base resiliently supporting each of said plurality of locking tabs on said piston with each of said locking tabs being radially biased outwardly from said piston to engage said slots in said cylinder wall.

14. A mixing cartridge as set forth in claim 13 wherein said locking member includes a plurality of release buttons for releasing said piston from said locked position.

15. A mixing cartridge as set forth in claim 14 wherein said release buttons are integrally formed with said tabs.

16. A mixing cartridge as set forth in claim 15 wherein said release buttons are further defined as fingers extending radially inwardly toward said longitudinal axis of said cylinder with said fingers being engageable to urge said locking tabs radially inwardly and withdraw said locking tabs from said slots in said cylinder wall to release said piston from said locked position.

17. A mixing cartridge as set forth in claim 1 including a cap sealed to said cylinder at said proximal end.

18. A mixing cartridge for use with a delivery device having a release mechanism to discharge bone cement from the mixing cartridge, said mixing cartridge comprising:

a cylinder having proximal and distal ends and defining a mixing chamber therebetween for receiving liquid and powder components of the bone cement, said cylinder including a cylinder wall extending between said ends about a longitudinal axis thereof and said cylinder wall including one of a male portion or a female portion at said distal end;

a piston disposed in said cylinder at said distal end;

a locking member coupled to said piston and including the other of said male portion or said female portion for engaging said male portion or said female portion of said cylinder wall to place said piston in a locked position in said distal end of said cylinder; and

said locking member including at least one release button for being engaged by the release mechanism of the delivery device to disengage said male and female portions and release said piston from said locked position.

19. A mixing cartridge as set forth in claim 18 wherein said cylinder wall includes said female portion and said female portion is further defined as at least one slot and said locking member includes said male portion with said male portion being further defined as at least one locking tab protruding radially outwardly from said longitudinal axis into said at least one slot in said locked position.

20. A mixing cartridge as set forth in claim 19 wherein said at least one slot is further defined as a pair of diametrically opposed slots and said at least one locking tab is further defined as a pair of diametrically opposed locking tabs protruding radially outwardly into said slots in said cylinder wall under the bias of said resilient portion.

21. A mixing cartridge as set forth in claim 20 wherein said locking member includes a resilient portion extending between said locking tabs to bias said locking tabs radially outwardly from said longitudinal axis.

22. A mixing cartridge as set forth in claim 20 wherein said at least one release button is further defined as a pair of release buttons for being engaged by the release mechanism of the delivery device to release said piston from said locked position.

23. A mixing cartridge as set forth claim 22 wherein said release buttons are integrally formed with said locking tabs and said release buttons extend distally from said locking tabs to protrude distally from said piston.

24. A mixing cartridge as set forth in claim 23 wherein each of said release buttons include a cam surface extending at an acute angle to said longitudinal axis of said cylinder with said cam surfaces being engageable to cam said release buttons radially inwardly toward said longitudinal axis to withdraw said locking tabs from said slots in said cylinder wall and release said piston from said locked position.

25. A delivery gun for receiving a cartridge containing bone cement to deliver the bone cement to an anatomical site by discharging the bone cement from the cartridge, said delivery gun comprising:

a casing;

a drive mechanism supported by said casing and advanceable relative to said casing to discharge the bone cement from the cartridge;

a trigger pivotally supported by said casing and operatively connected to said drive mechanism to actuate said drive mechanism upon actuation of said trigger; and

a linkage system operatively interconnecting said trigger with said drive mechanism to actuate said drive mechanism, said linkage system comprising a first link pivotally connected to said casing and a second link pivotally interconnecting said first link and said trigger such that actuating said trigger moves said second link and said first link to actuate said drive mechanism and advance said drive mechanism to discharge the bone cement from the cartridge.

26. A delivery gun as set forth in claim 25 wherein said drive mechanism includes a drive rod supported by said casing.

27. A delivery gun as set forth in claim 26 wherein said drive mechanism further includes a first gripper plate responsive to movement of said linkage system upon actuation of said trigger wherein said first gripper plate defines an aperture surrounding said drive rod and said first gripper plate frictionally engages said drive rod to advance said drive rod when said trigger is actuated.

28. A delivery gun as set forth in claim 27 including a speed-changing link pivotally supported by one of said drive mechanism or said linkage system for pivoting between a high-speed position and a low-speed position.

29. A delivery gun as set forth in claim 28 wherein said first gripper plate includes a first coupling device and said speed-changing link defines a second coupling device for coupling with said first coupling device in said high-speed position with said speed-changing link being isolated from said first gripper plate in said low-speed position.

30. A delivery gun as set forth in claim 29 wherein said first coupling device is a shoulder and said second coupling device is a channel for engaging said shoulder in said high-speed position.

31. A delivery gun as set forth in claim 27 including a second gripper plate aligned with said first gripper plate to increase frictional contact with said drive rod to advance said drive rod.

32. A delivery gun as set forth in claim 31 wherein said second gripper plate includes a peg engaging a notch in said first gripper plate to align said second gripper plate with said first gripper plate.

33. A delivery gun as set forth in claim 32 including a spring positioned over said drive rod between said casing and said gripper plates to bias said gripper plates into frictional engagement with said drive rod.

34. A delivery gun as set forth in claim 26 wherein said drive rod includes a plurality of teeth along a length thereof.

35. A delivery gun as set forth in claim 34 wherein said drive mechanism includes at least one pawl member for engaging said teeth to advance said drive rod.

36. A delivery gun as set forth in claim 34 wherein said drive mechanism includes a pair of pawl members for engaging said teeth to advance said drive rod.

37. A delivery gun as set forth in claim 36 wherein said pawl members are further defined as a first pawl member and a second pawl member with said first pawl member being pivotally supported by said linkage system and said second pawl member being pivotally supported by said linkage system for moving between a high-speed position in which the second pawl member engages said teeth and a low-speed position in which said second pawl member is isolated from said teeth.

38. A delivery gun as set forth in claim 37 including biasing devices for biasing

each of said pawl members into engagement with said teeth on said drive rod.

39. A delivery gun as set forth in claim 38 including a switch engaging said second pawl member to move said second pawl member between said high speed and said low speed positions.

40. A delivery gun as set forth in claim 39 wherein said trigger is pivotally supported by said casing about a pivot axis and said pivot axis is positioned above said drive rod while said trigger extends downwardly below said drive rod with said trigger defining a channel therethrough for receiving said drive rod.

41. A delivery gun as set forth in claim 40 wherein said first and second links are positioned above said drive rod.

42. A delivery gun as set forth in claim 26 wherein said drive mechanism includes a ram disk fixed to said drive rod to discharge the bone cement from the cartridge and said ram disk includes a release mechanism for releasing a piston of the cartridge from a locked position.

43. A delivery gun as set forth in claim 42 wherein said release mechanism includes a bearing surface for engaging release buttons on the piston to cam the release buttons radially inwardly and release the piston from the locked position.

44. A delivery gun for receiving a cartridge containing bone cement to deliver the bone cement to an anatomical site by discharging the bone cement from the cartridge, said delivery gun comprising:

a casing;

a drive rod supported by said casing and advanceable relative to said casing to discharge the bone cement from the cartridge;

a trigger pivotally supported by said casing; and

a first gripper plate responsive to actuation of said trigger wherein said first gripper plate surrounds said drive rod and frictionally engages said drive rod to advance said drive rod when said trigger is actuated.

45. A delivery gun as set forth in claim 44 including at least one second gripper plate aligned with said first gripper plate about said drive rod to increase frictional contact with said drive rod when advancing said drive rod upon actuation of said trigger.

46. A delivery gun as set forth in claim 45 wherein said at least one second gripper plate includes a peg and said first gripper plate defines a notch for receiving said peg to align said at least one second gripper plate with said first gripper plate.

47. A delivery gun as set forth in claim 44 including a linkage system operatively interconnecting said trigger with said first gripper plate, said linkage system comprising a first link pivotally connected to said casing and a second link interconnecting said first link and said trigger whereby actuating said trigger moves said second link and said first link to engage said first link with said first gripper plate and advance said drive rod to discharge the bone cement from the cartridge.

48. A delivery gun as set forth in claim 47 wherein said second link includes a striker extending downwardly therefrom for engaging said first gripper plate to dislodge said first gripper plate from said drive rod when said first gripper plate does not return to an initial position upon release of said trigger.

49. A delivery gun as set forth in claim 44 including a spring positioned over said drive rod between said casing and first gripper plate to bias said first gripper plate into frictional engagement with said drive rod.

50. A delivery gun as set forth in claim 45 including a coating applied to each of said gripper plates to increase lubricity and corrosion resistance.

51. A delivery gun as set forth in claim 50 wherein said coating is electroless-nickel with polytetrafluoroethylene.

52. A bone cement mixing and delivery system for combining liquid and powder components of bone cement and delivering the bone cement to an anatomical site of a patient, said system comprising:

a cartridge comprising;

a cylinder having proximal and distal ends and defining a mixing chamber therebetween with said cylinder including a cylinder wall extending between said ends about a longitudinal axis thereof,

a piston releasably secured in said cylinder at said distal end, and

a locking member for releasably securing said piston in a locked position at said distal end with said locking member including at least one release button for releasing said piston from said locked position,

in combination with a delivery device adapted to hold said cartridge comprising;

a casing, and

a drive mechanism supported by said casing and advanceable relative to said casing to discharge the bone cement from said cartridge wherein said drive mechanism includes a release mechanism for engaging said at least one release button to release said piston from said locked position.

53. A bone cement mixing and delivery system as set forth in claim 52 wherein said cylinder wall defines a plurality of slots at said distal end and said locking member includes a plurality of locking tabs radially protruding outwardly into said slots in said locked position.

54. A bone cement mixing and delivery system as set forth in claim 53 wherein said at least one release button is further defined as a plurality of release buttons for releasing said piston from said locked position.

55. A bone cement mixing and delivery system as set forth in claim 54 wherein each of said release buttons include a cam surface extending at an acute angle to said longitudinal axis of said cylinder with said cam surfaces being engagable by said release mechanism to cam said buttons radially inwardly to withdraw said locking tabs from said slots in said cylinder wall and release said piston from said locked position.

56. A bone cement mixing and delivery system as set forth in claim 55 wherein said release mechanism includes a bearing surface for engaging said cam surfaces of said release buttons to cam said release buttons radially inwardly and release said piston from said locked position.

57. A bone cement mixing and delivery system as set forth in claim 54 wherein said plurality of release buttons are further defined as fingers extending radially inwardly toward said longitudinal axis of said cylinder with said fingers being engagable by said release mechanism to urge said locking tabs radially inwardly and withdraw said locking tabs from said slots in said cylinder wall to release said piston from said locked position.

58. A bone cement loading system for receiving liquid and powder components of bone cement to be mixed for medical use, comprising:

- a cylinder having an open proximal end and a closed distal end and defining a mixing chamber between said ends;

- a piston locked in said cylinder to define said closed distal end;

- a base defining a cavity for receiving and securing said closed distal end of said cylinder to support said cylinder while loading the liquid and powder components therein;

- a funnel for coupling to said open proximal end of said cylinder to channel the powder component of the bone cement into said mixing chamber, said funnel having a proximal end and a distal end wherein said distal end has a circular periphery for snugly fitting into said open proximal end of said cylinder and said proximal end has an oblong oval-shaped periphery to facilitate the transfer of the powder component of the bone cement into said mixing chamber.

59. A bone cement loading system as set forth in claim 58 wherein said base is oblong in shape and said cavity is circular in shape.

60. A bone cement loading system as set forth in claim 59 wherein one of said base and said cylinder includes a plurality of detents and the other of said base and said cylinder defines a groove in a surface thereof for releasably receiving said detents to facilitate a snug fit between said base and said cylinder.

61. A bone cement mixing system for mixing liquid and powder components of bone cement for medical use, comprising:

a cartridge including a cylinder having proximal and distal ends and defining a mixing chamber between said ends;

a mixing shaft rotatably supported by said cartridge for rotation about an axis and including a portion extending outside of said mixing chamber; and

a blade operatively connected to said portion and disposed in said mixing chamber for rotating with said mixing shaft about said axis to mix the liquid and powder components of the bone cement, said blade including a center hub coupled to said mixing shaft and an outer ring extending from said center hub wherein said outer ring forms an acute angle with said axis and said acute angle is between twenty and seventy degrees to ensure adequate mixing of the bone cement.

62. A bone cement mixing system as set forth in claim 61 wherein said blade is adapted to remain in said mixing chamber after mixing is complete and said portion of said mixing shaft extending outside of said mixing chamber is adapted to be removed from said operative connection with said blade after mixing.

63. A bone cement mixing system as set forth in claim 61 wherein said blade has an effective height that is greater than one quarter inch to further ensure adequate mixing of the bone cement.

64. A bone cement mixing system as set forth in claim 63 wherein said blade is flexible and adapted to flatten in said mixing chamber such that said effective height of said blade is reduced and said acute angle is increased to approximately ninety degrees to minimize axial space occupied by said blade in said mixing chamber.

65. A bone cement mixing system as set forth in claim 61 wherein said blade has an effective height that is approximately one half inch and said acute angle is approximately sixty degrees to ensure adequate mixing of the bone cement.

66. A bone cement mixing system as set forth in claim 61 including a plurality of radially inwardly protruding fingers attached to said outer ring wherein one of said

plurality of fingers protrudes radially inwardly in a first plane and another of said plurality of fingers protrudes radially inwardly in a second plane spaced from and parallel to said first plane.

67. A bone cement mixing system as set forth in claim 61 including a protruding node attached to said outer ring and protruding radially outwardly to control spacing between said blade and an inner periphery of said cylinder by scraping along said inner periphery of said cylinder.

68. A method of mixing liquid and powder components of bone cement in a mixing chamber of a mixing cartridge using a rotary power tool with a portion of a mixing shaft extending outside of the mixing chamber to connect to the rotary power tool and a blade being operatively connected to the portion and disposed within the mixing chamber to mix the liquid and powder components of the bone cement, said method comprising the steps of:

connecting the rotary power tool to the portion of the mixing shaft extending outside of the mixing chamber;

actuating the rotary power tool once connected to the portion of the mixing shaft to rotate the blade and mix the liquid and powder components of the bone cement;

displacing the rotary power tool during actuation relative to the mixing cartridge to completely mix the liquid and powder components of the bone cement; and

removing the operative connection between the blade and the portion of the mixing shaft extending outside of the mixing chamber once mixing is complete.

69. A method as set forth in claim 68 wherein removing the operative connection between the blade and the portion of the mixing shaft extending outside of the mixing chamber is further defined as releasing the blade from the mixing shaft.

70. A method as set forth in claim 69 wherein axially displacing the rotary power tool during actuation includes moving the rotary power tool both proximally and distally during actuation to completely mix the liquid and powder components of the bone cement.

71. A method as set forth in claim 68 wherein removing the operative connection between the blade and the portion of the mixing shaft extending outside of the mixing chamber is further defined as severing the portion of the mixing shaft extending outside of the mixing chamber.

72. A method as set forth in claim 68 wherein displacing the rotary power tool during actuation relative to the mixing cartridge is further defined as axially displacing the rotary power tool during actuation relative to the mixing cartridge.

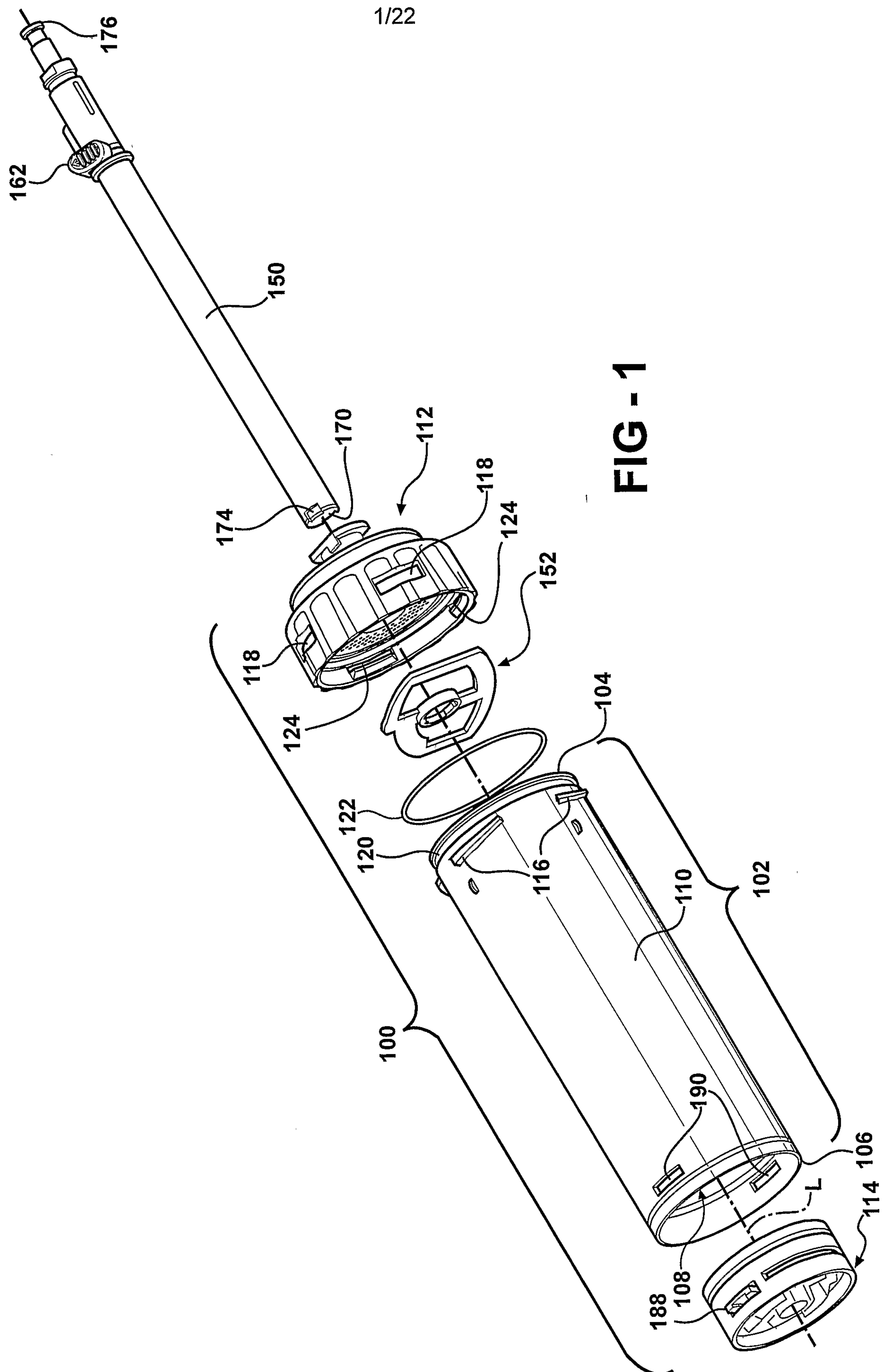


FIG - 1

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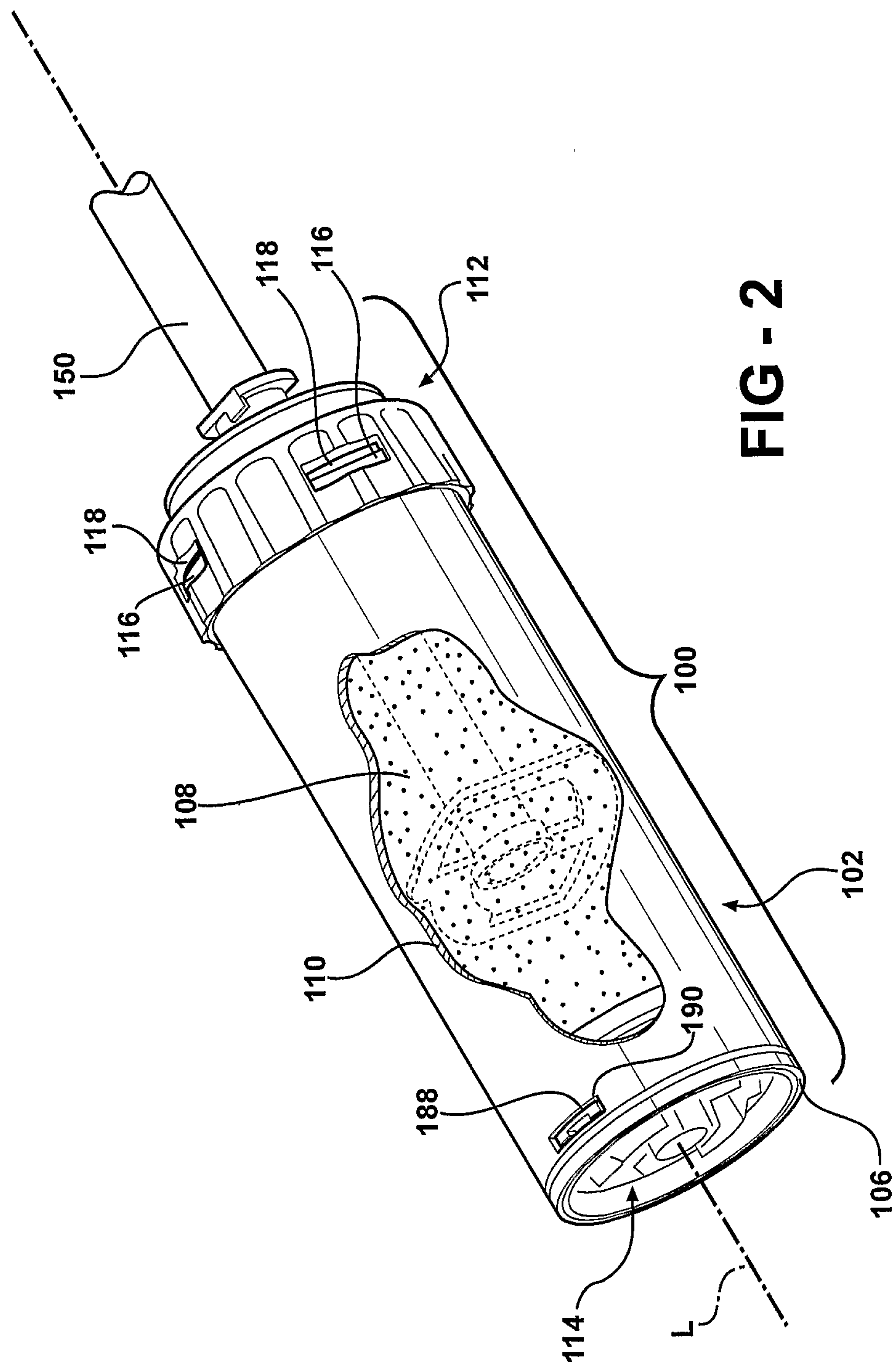
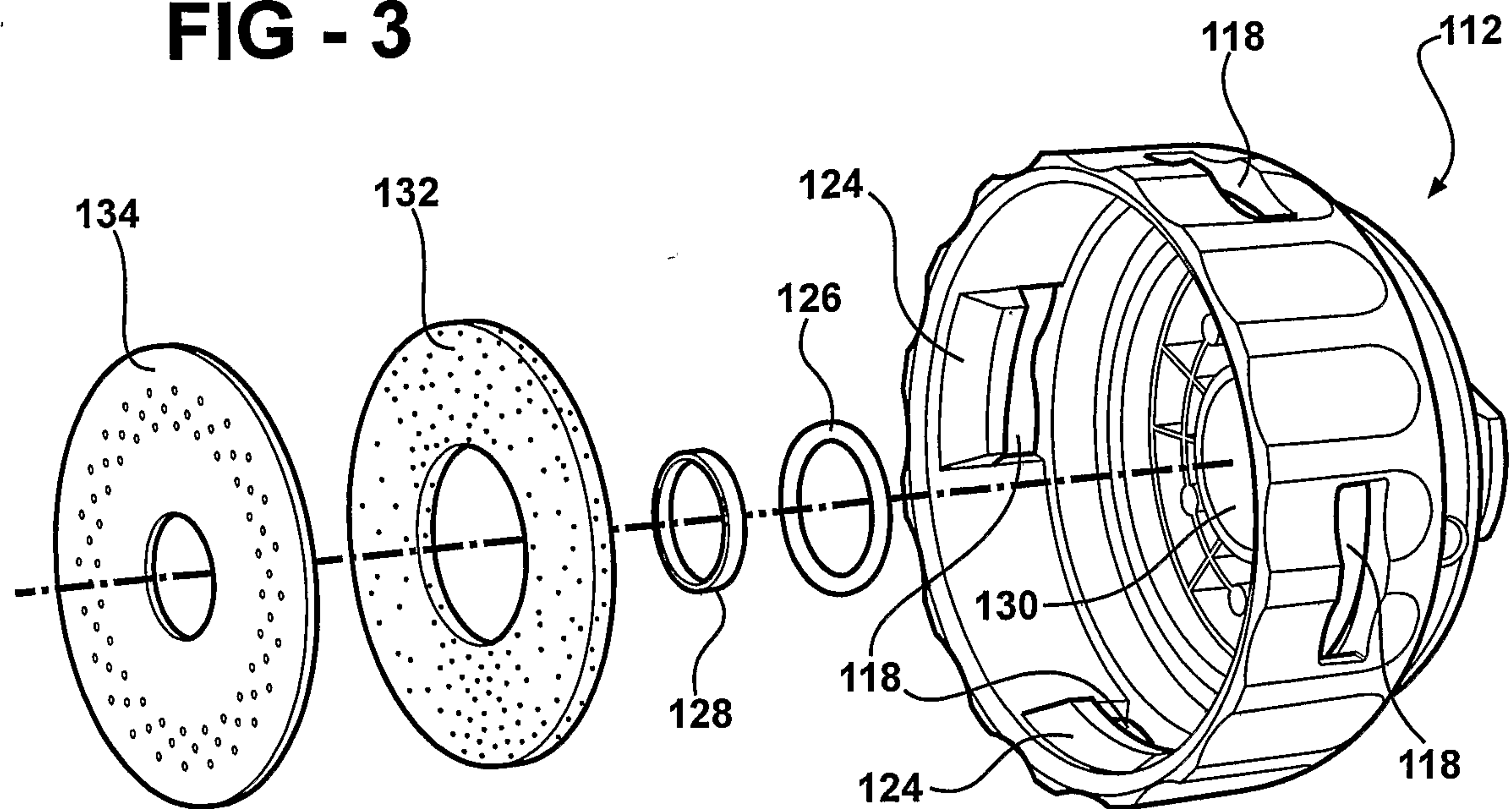
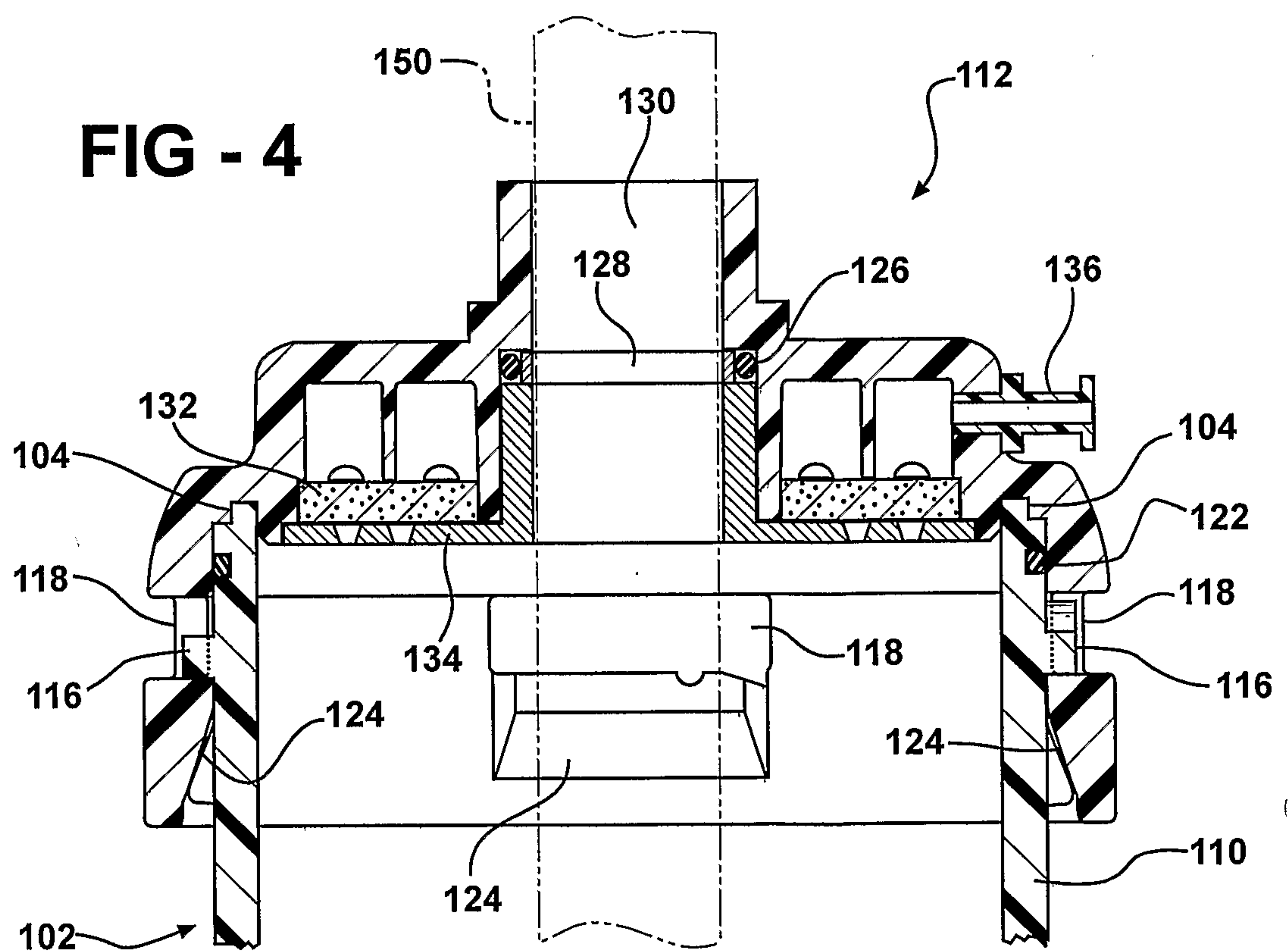
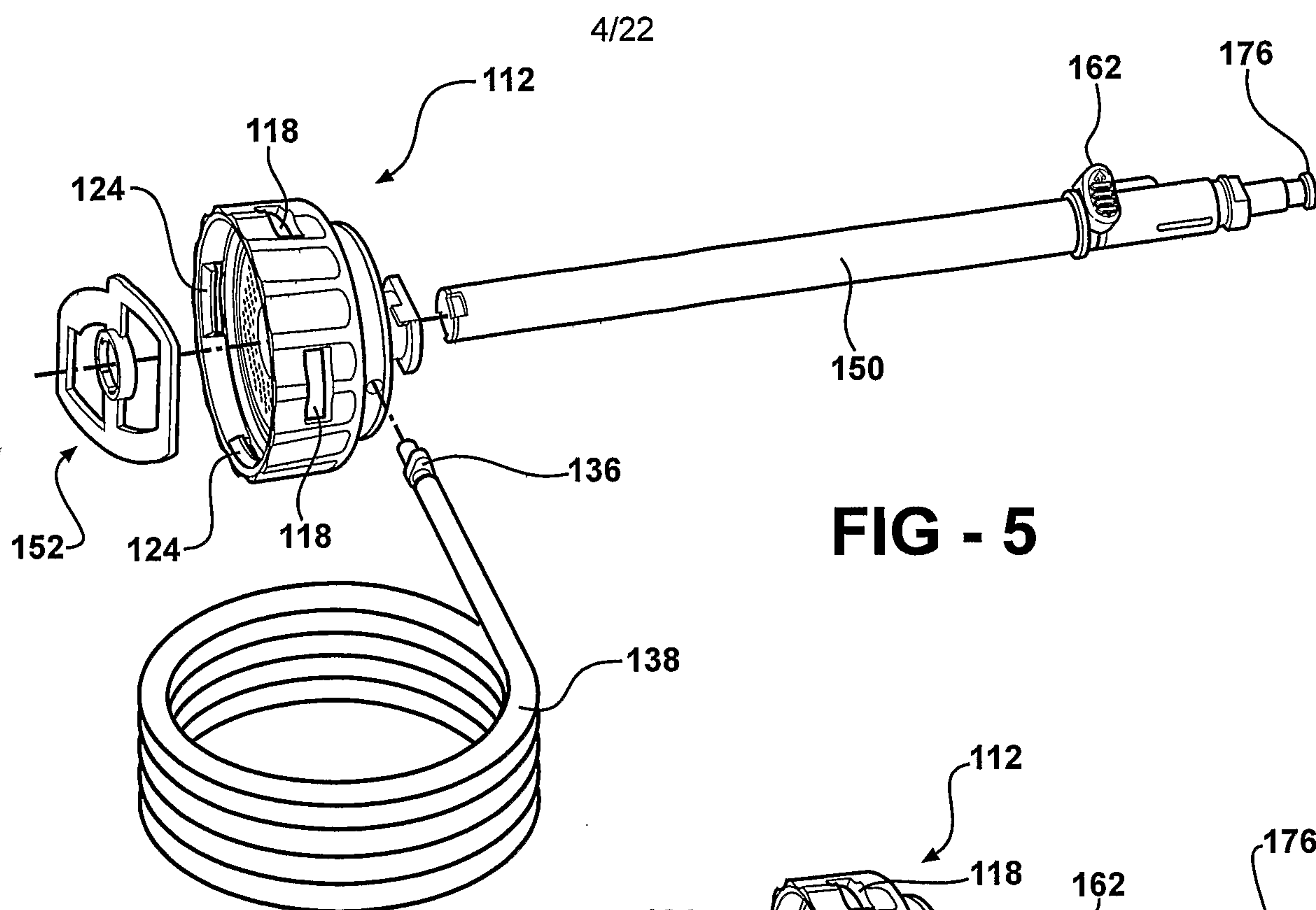
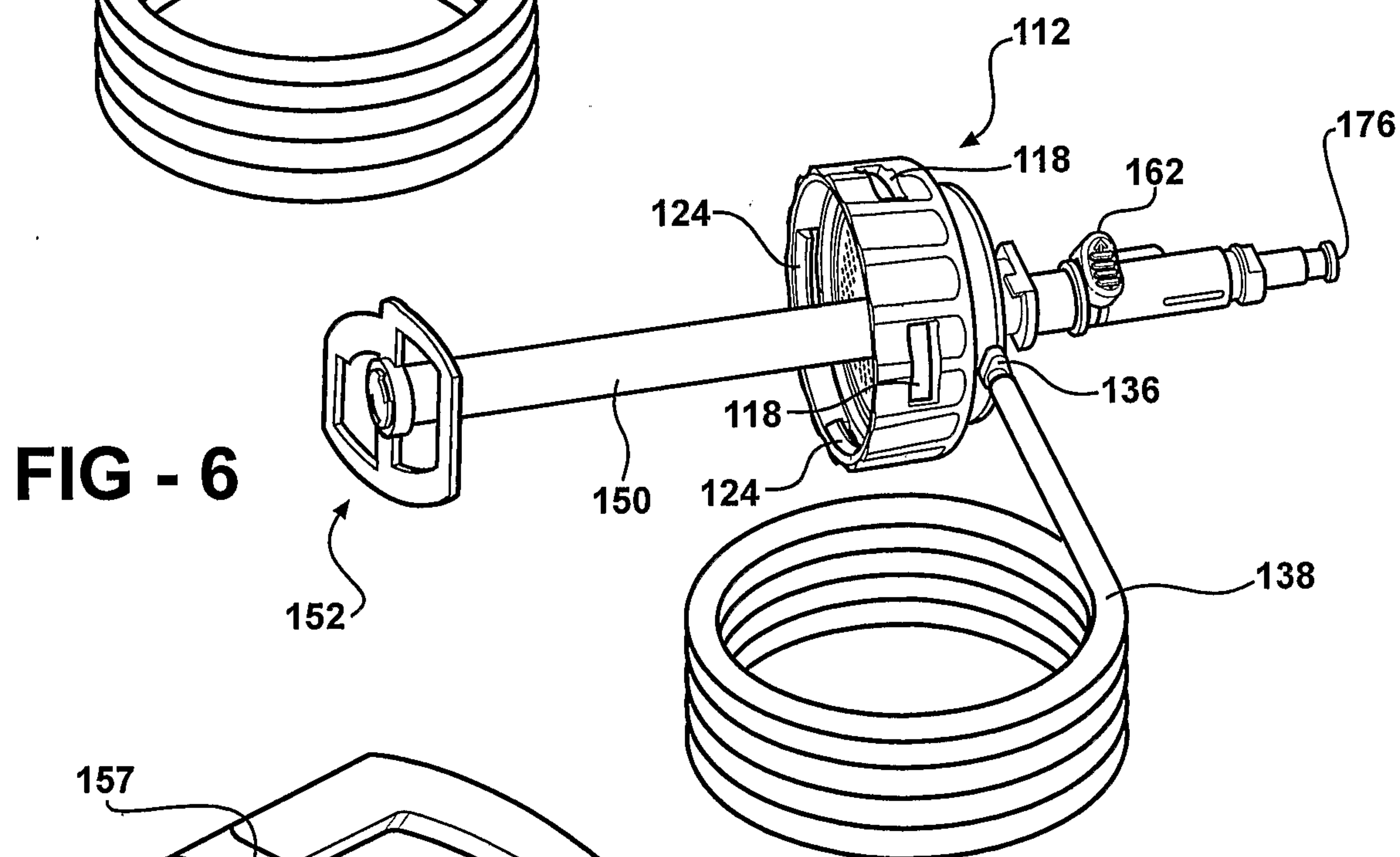
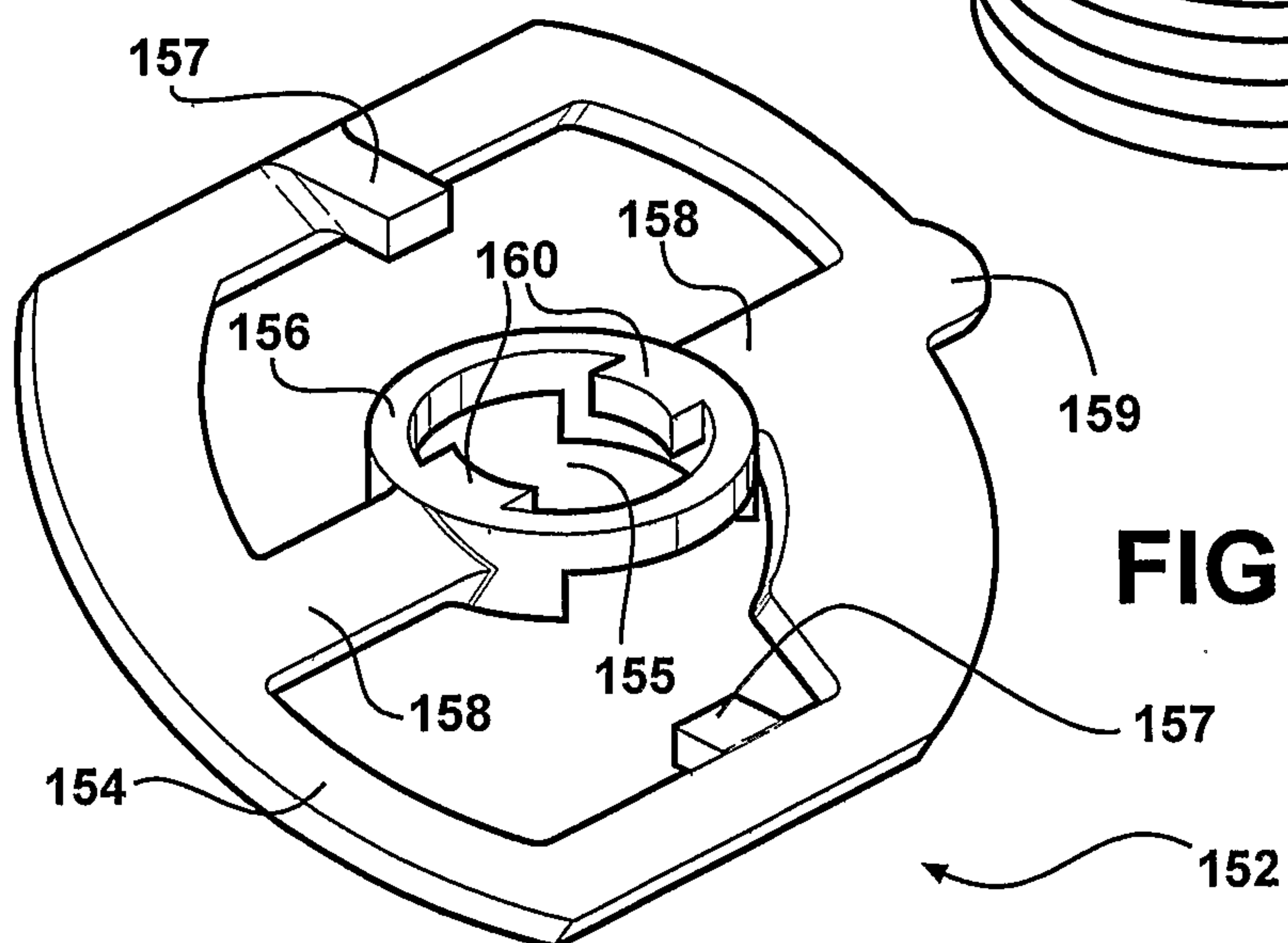


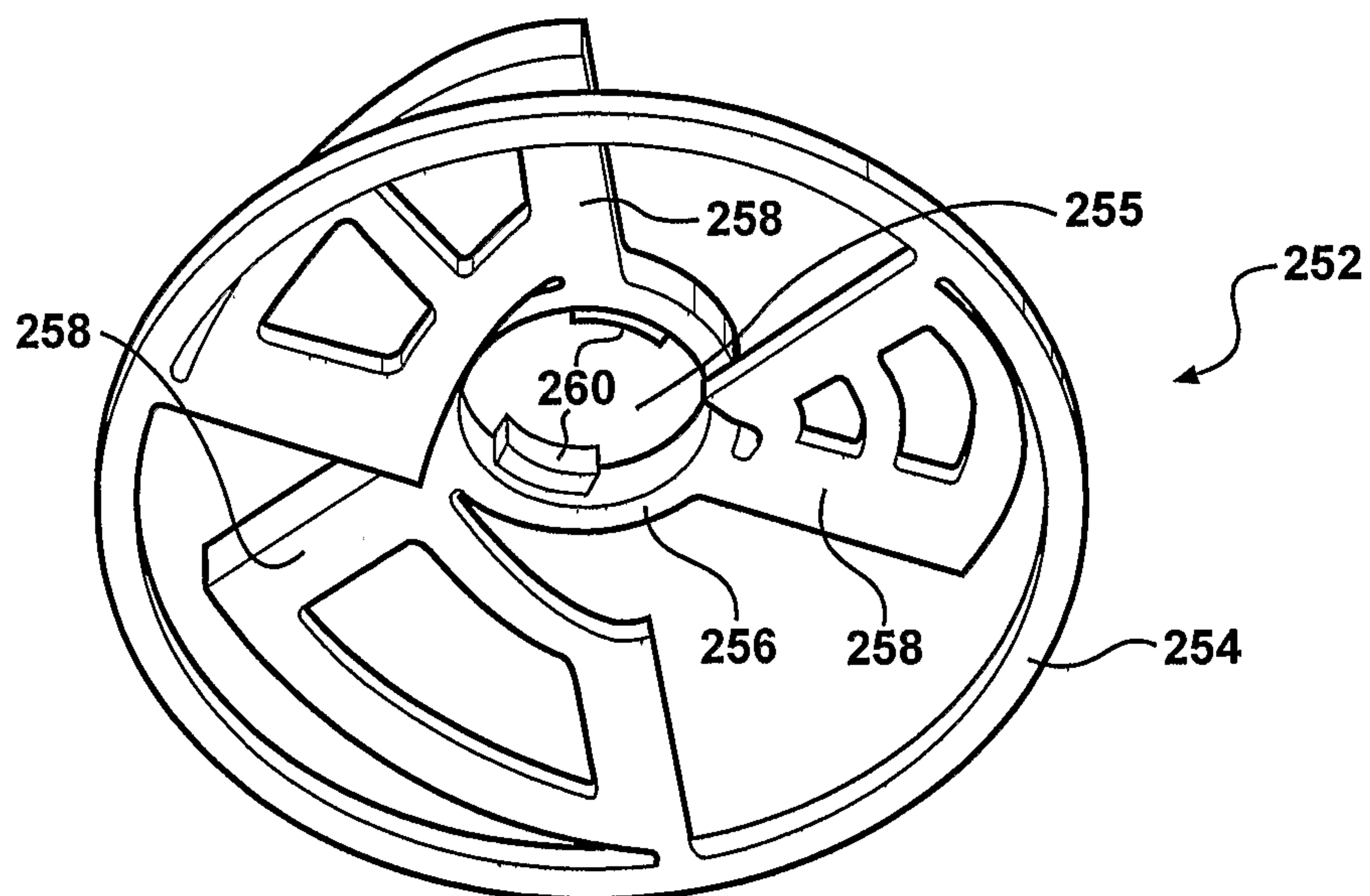
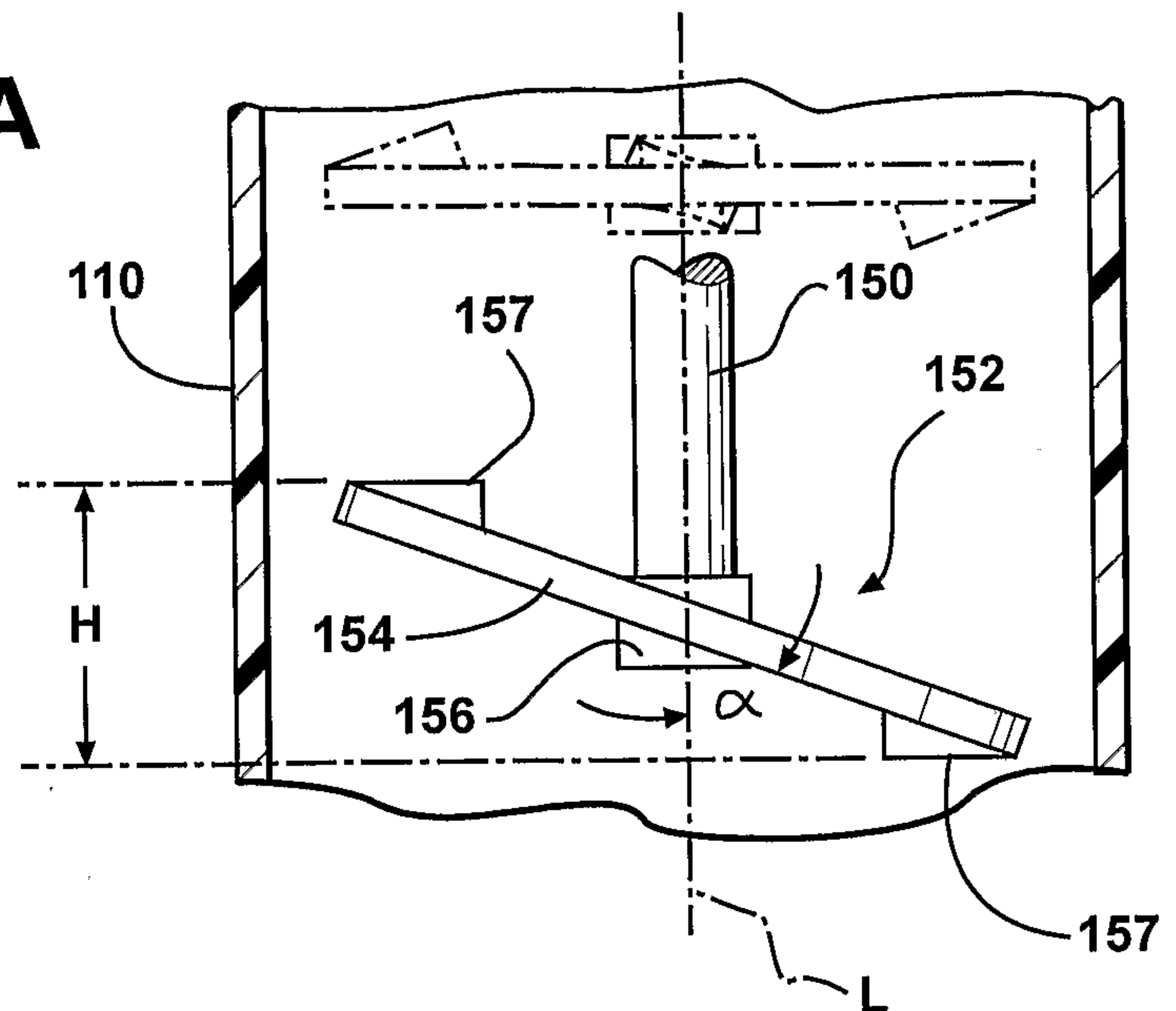
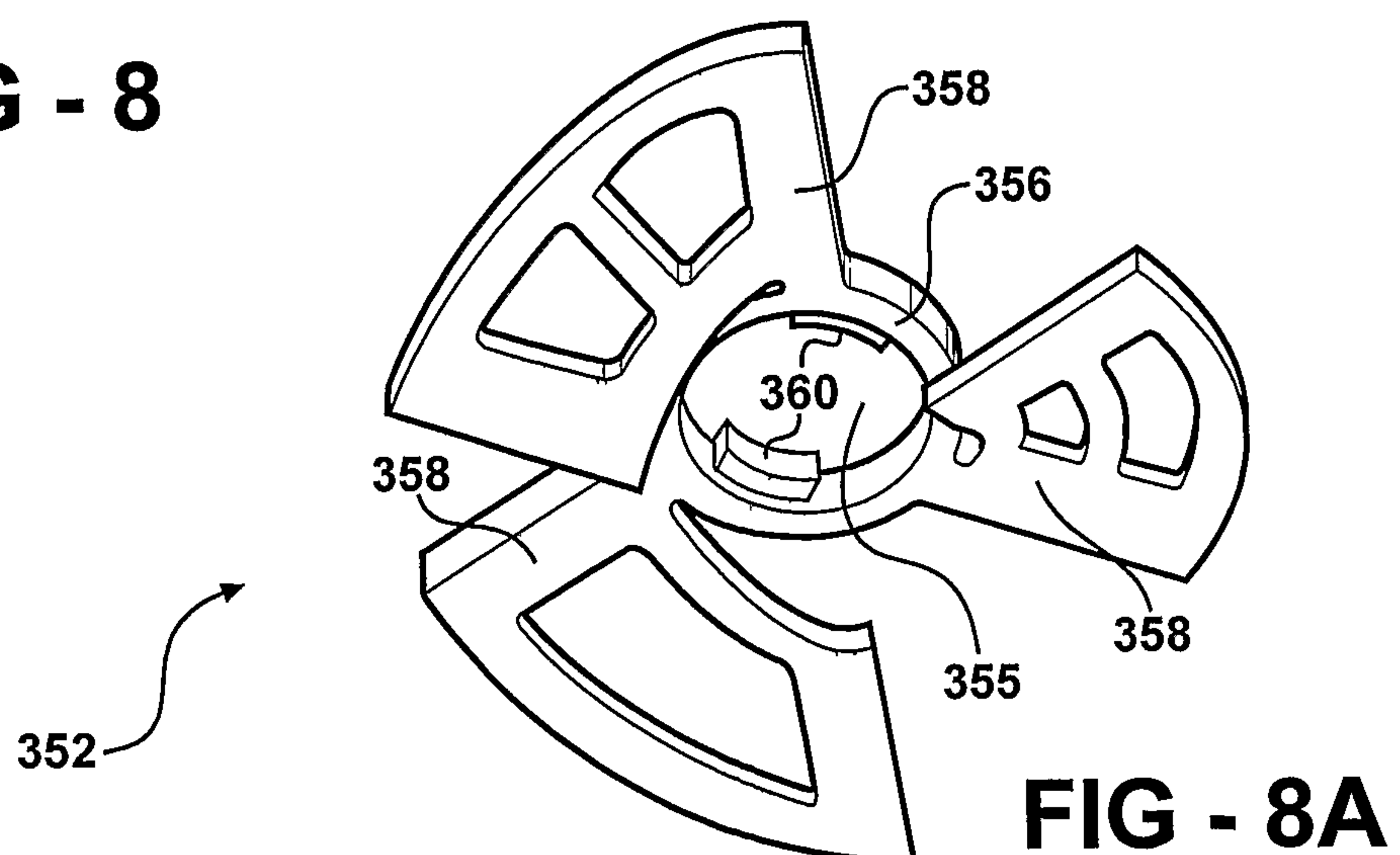
FIG - 2

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FIG - 3**FIG - 4**

**FIG - 5****FIG - 6****FIG - 7**

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FIG - 7A**FIG - 8****FIG - 8A**

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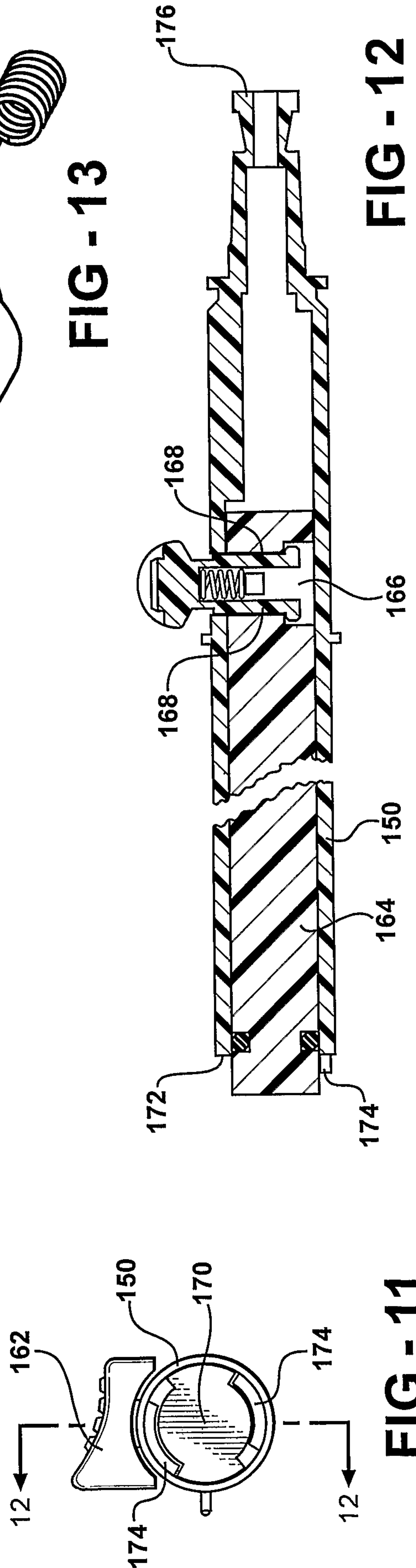
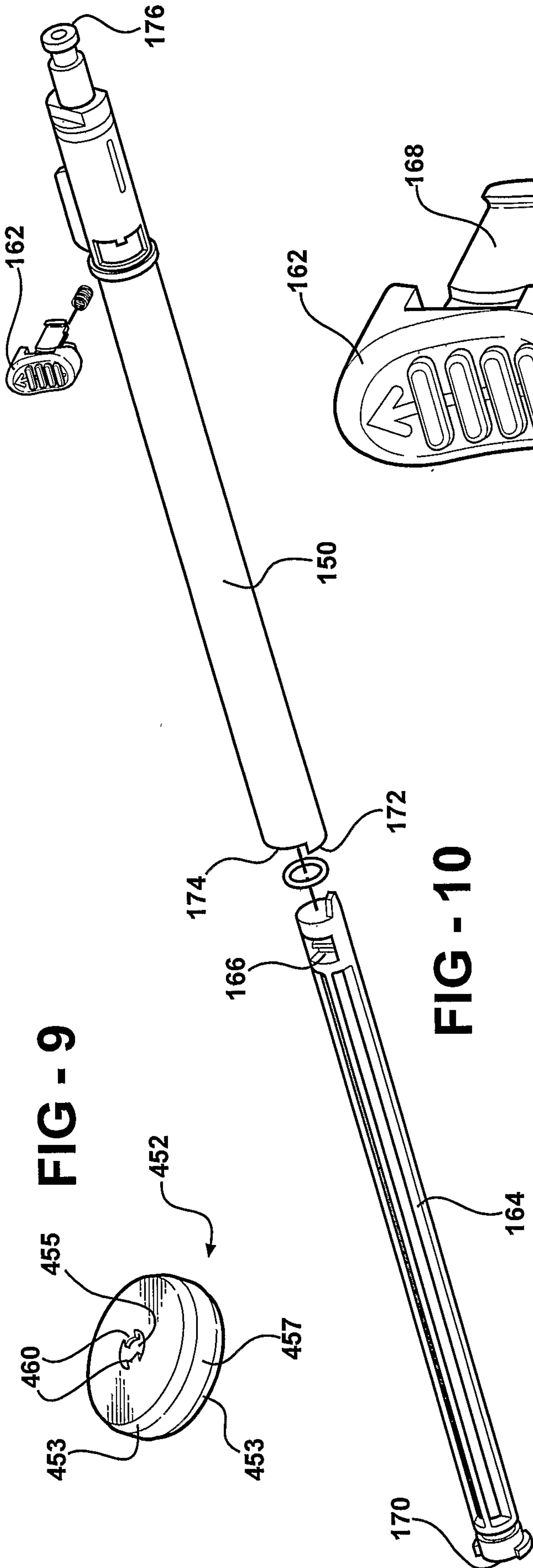
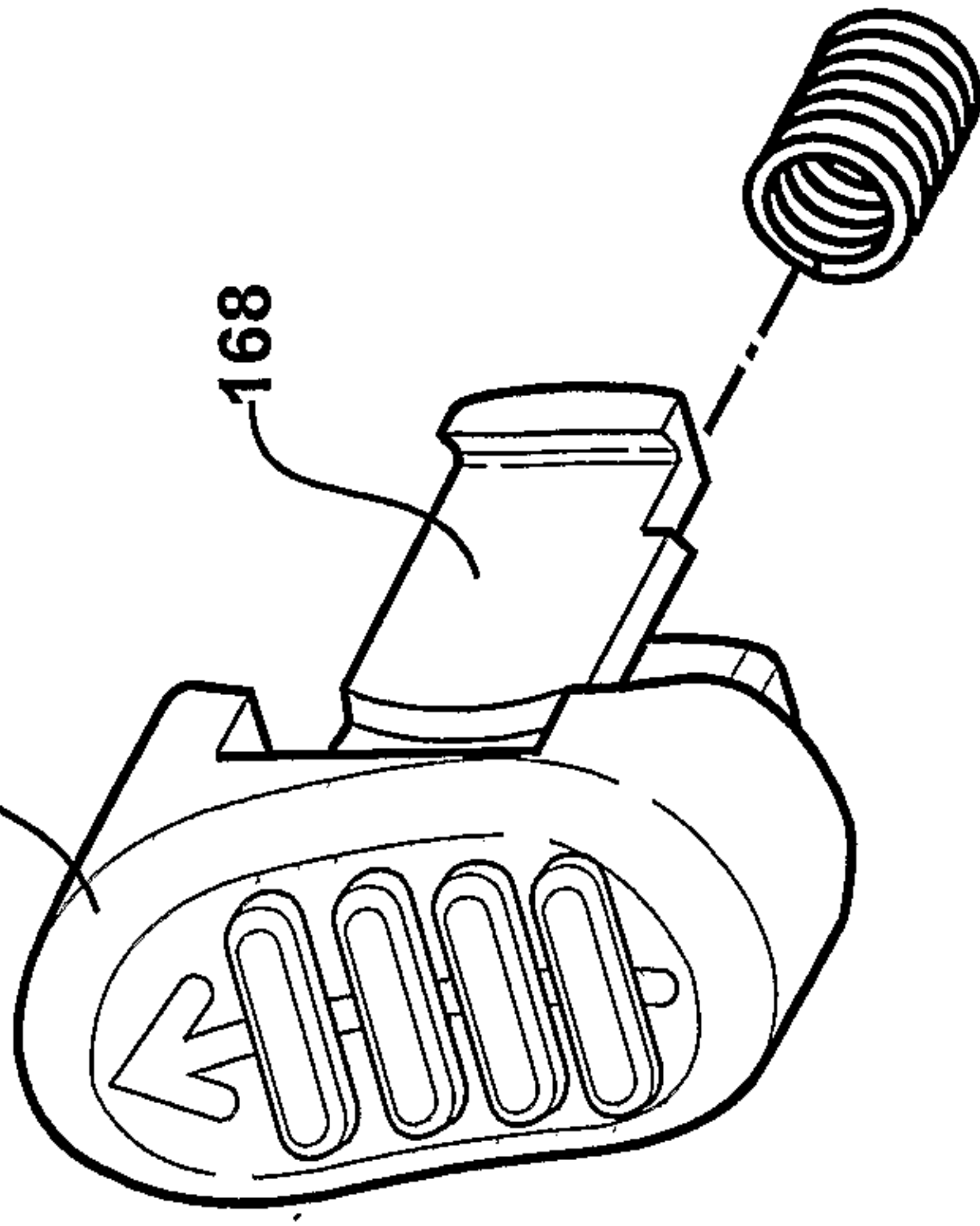
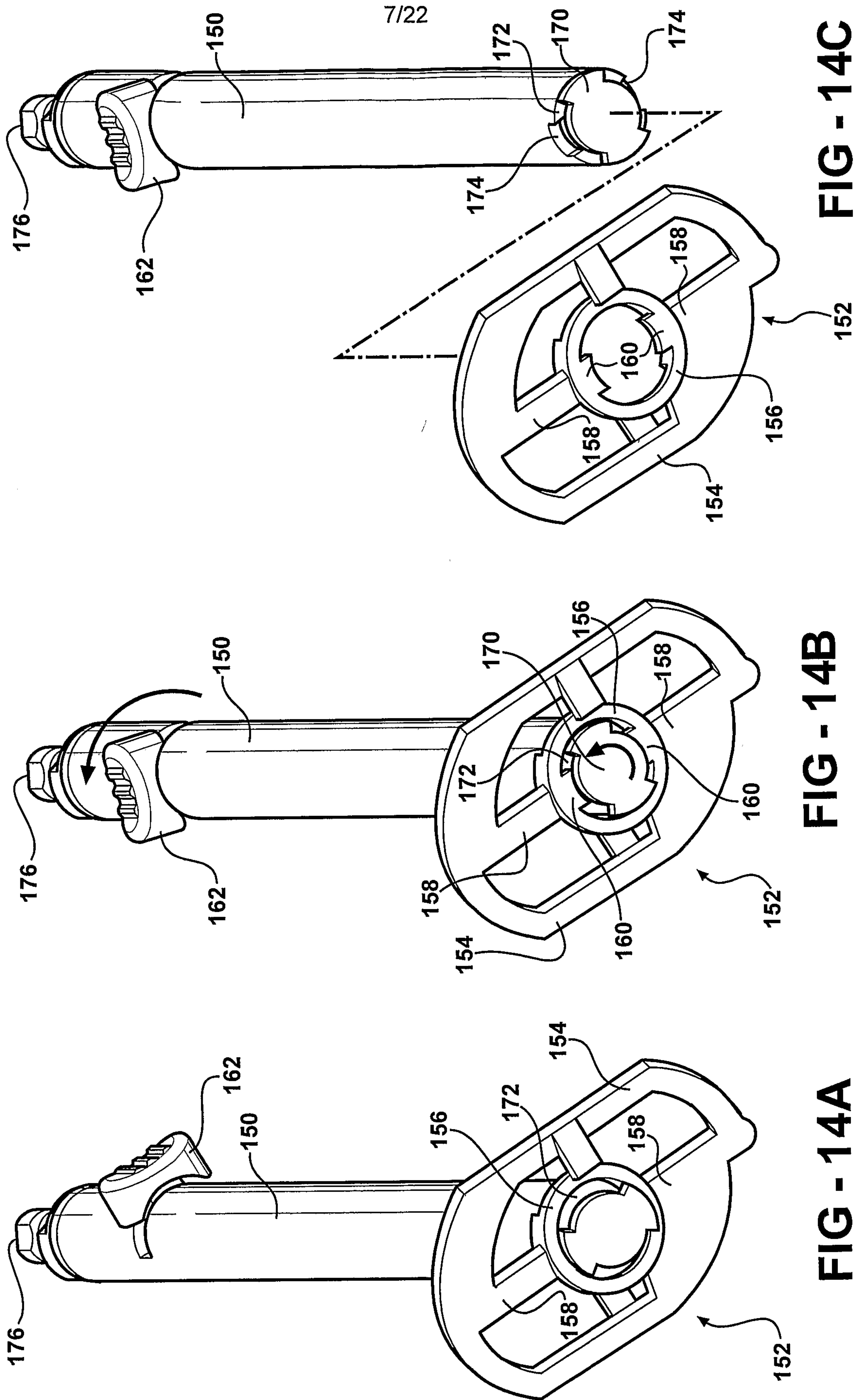
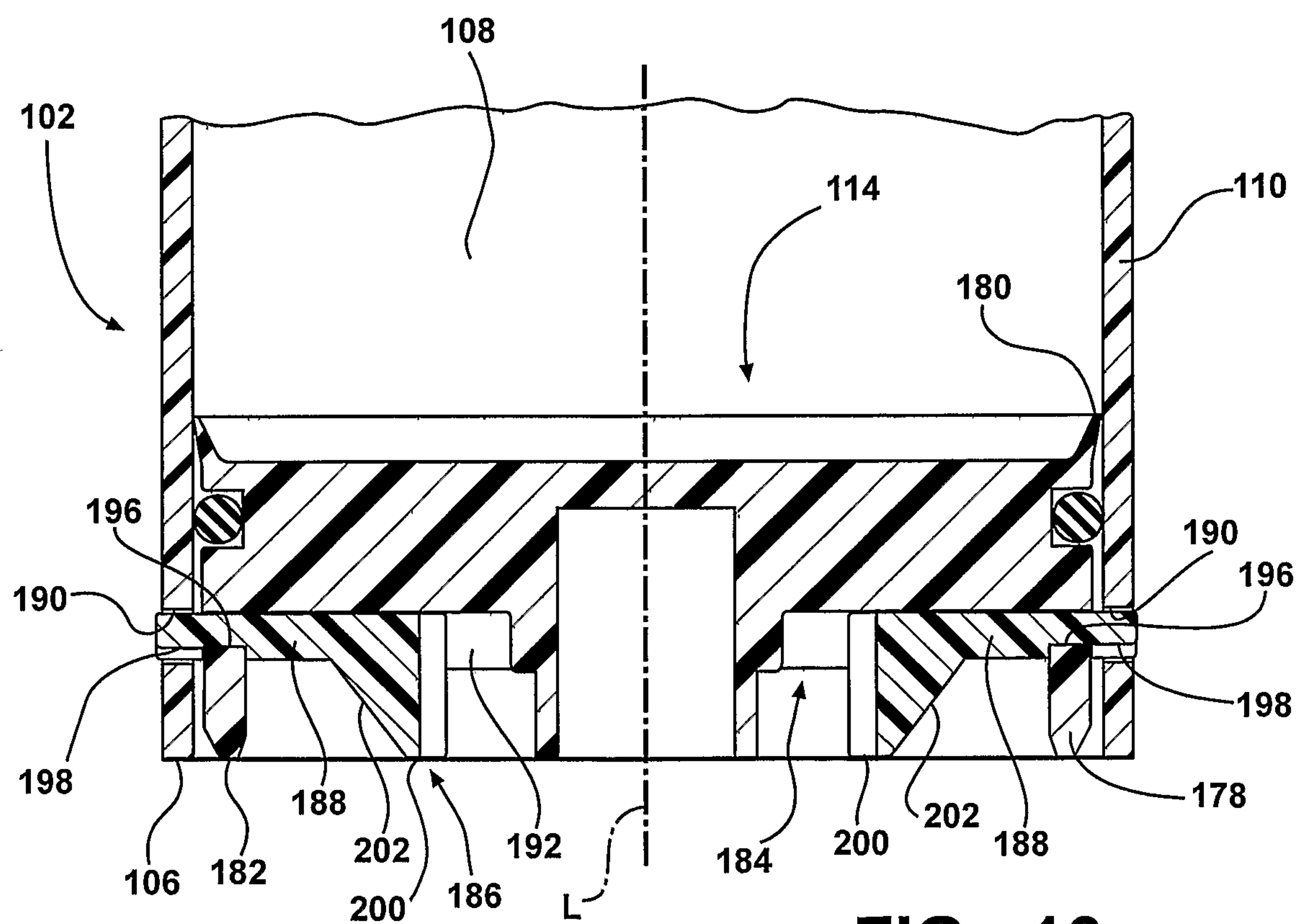
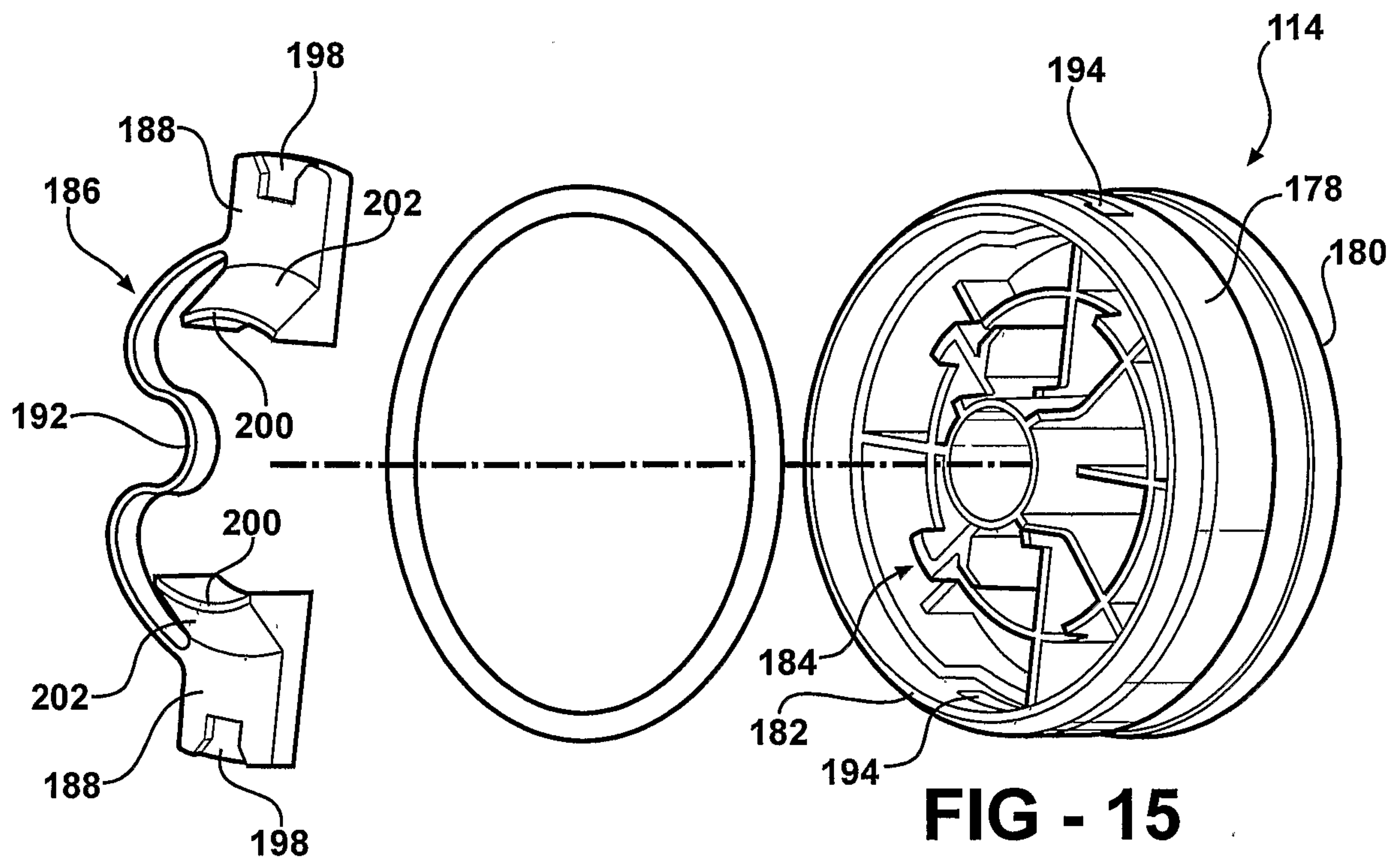


FIG - 13

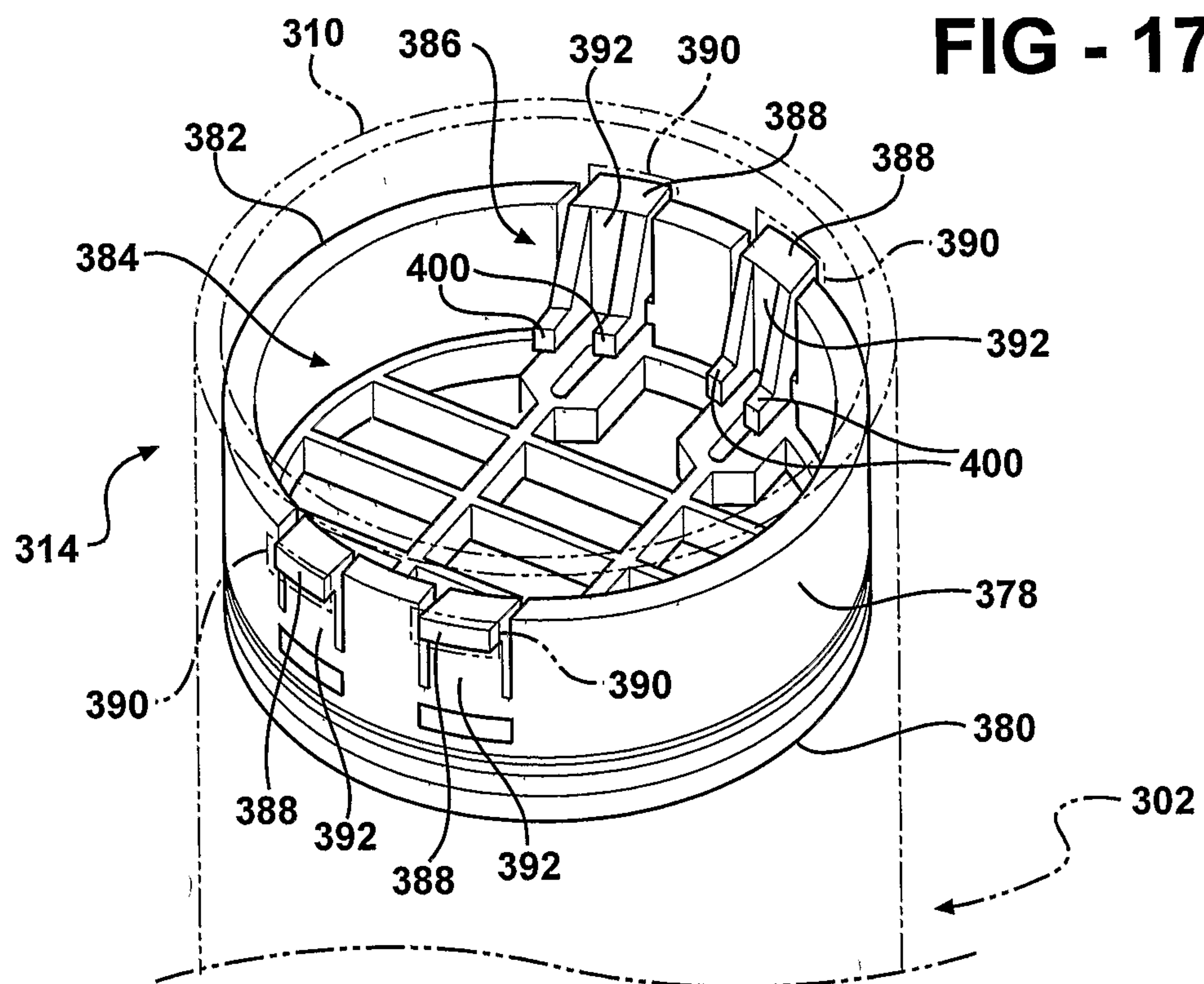
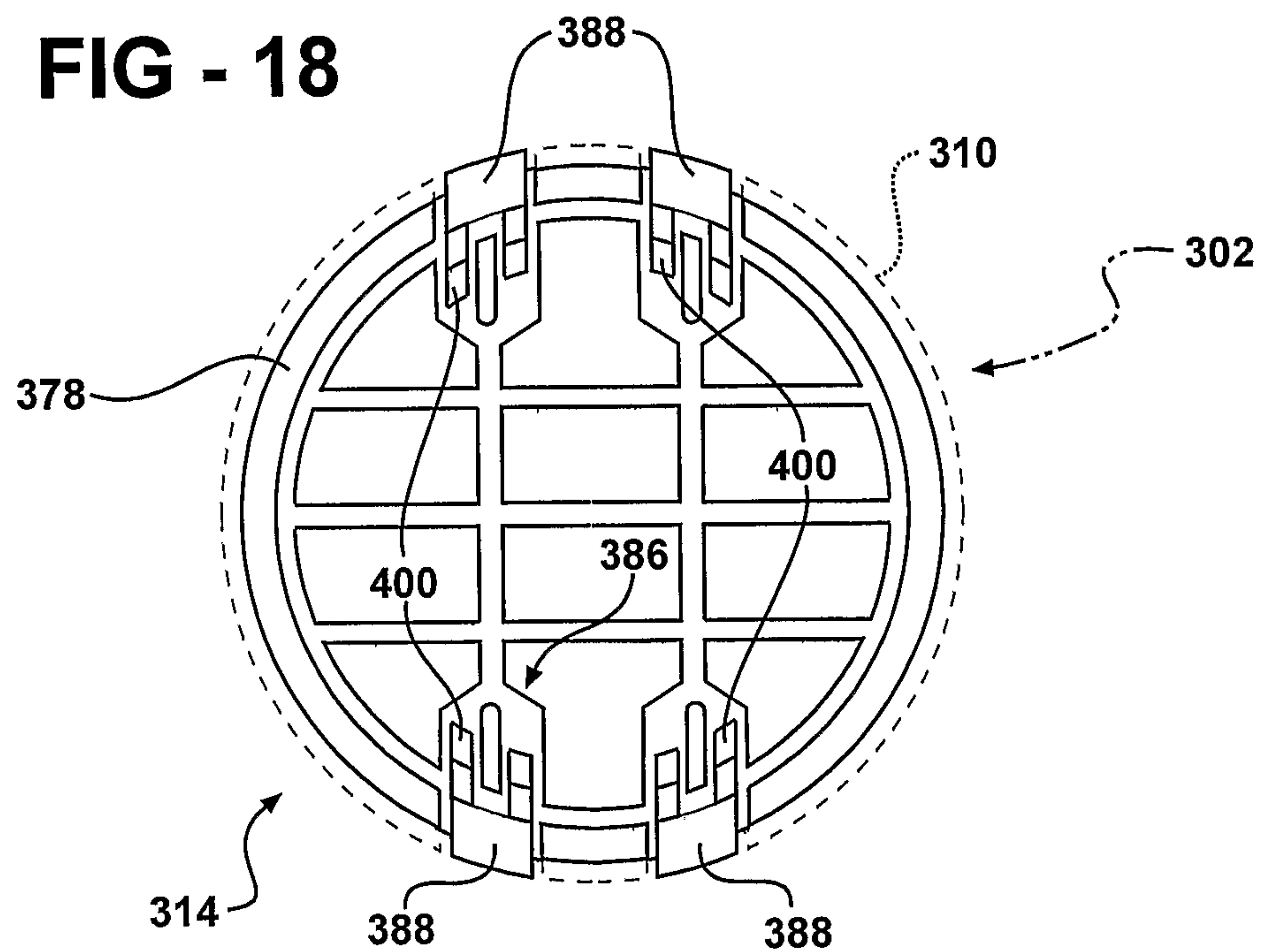




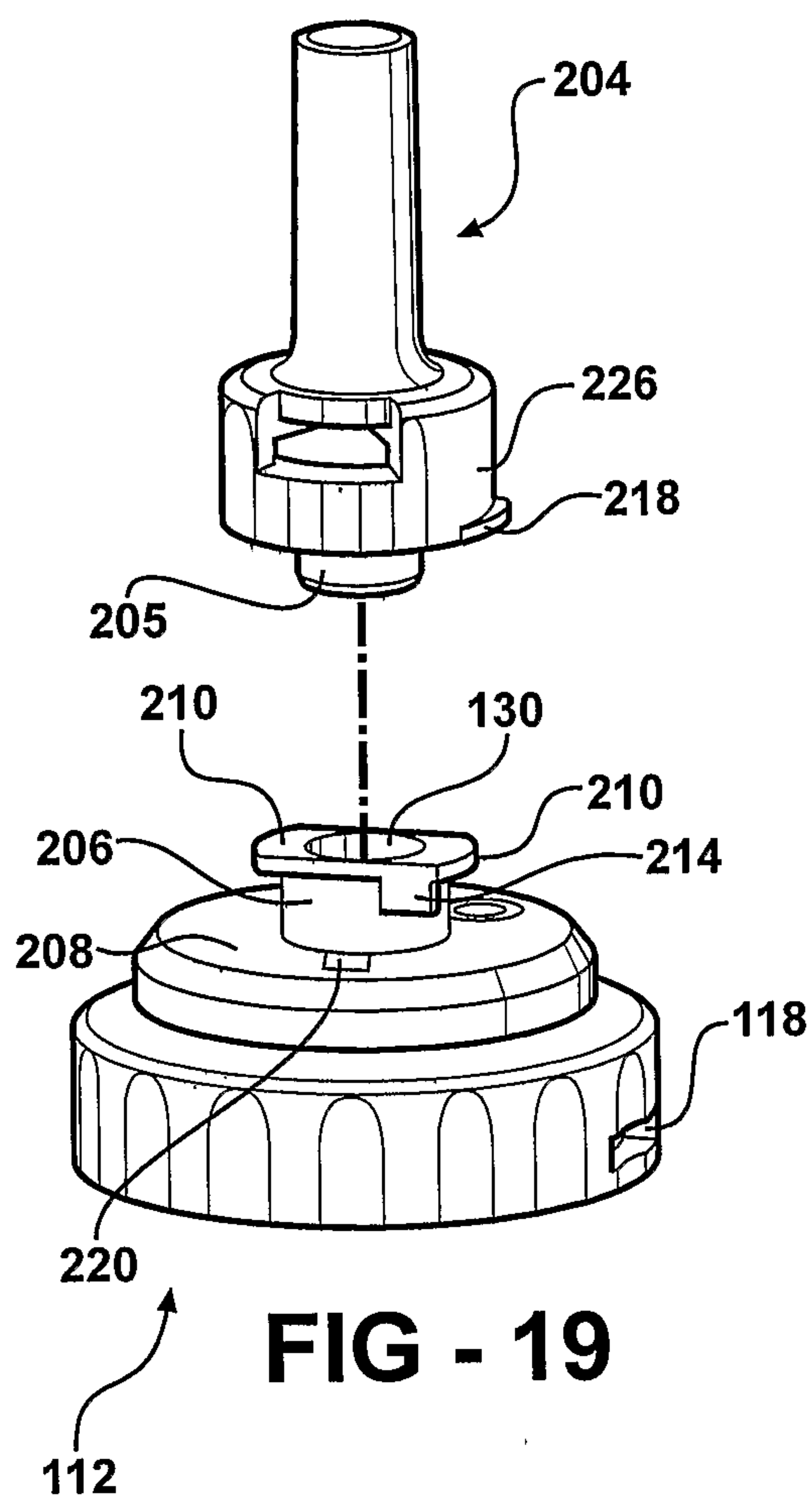
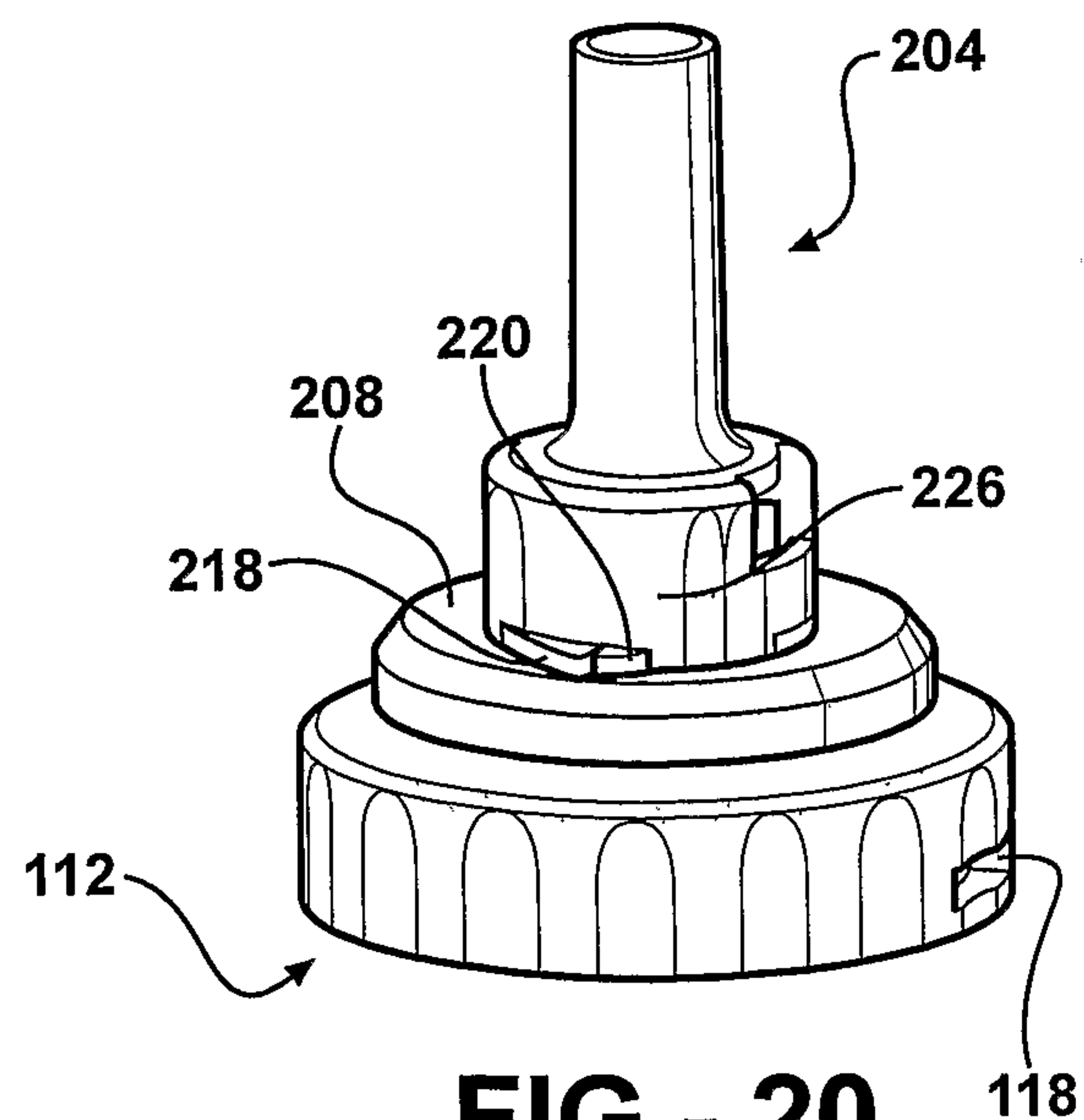
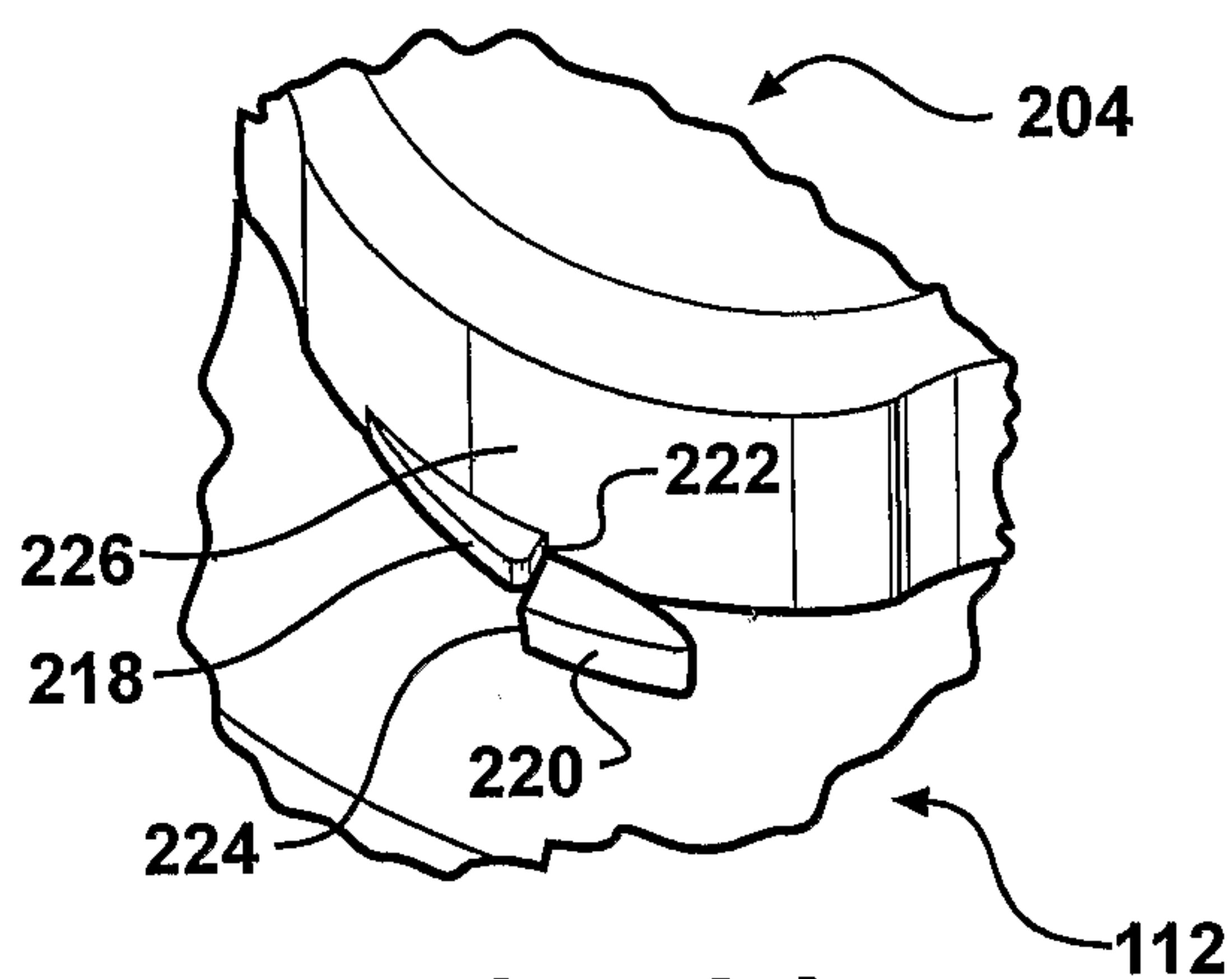
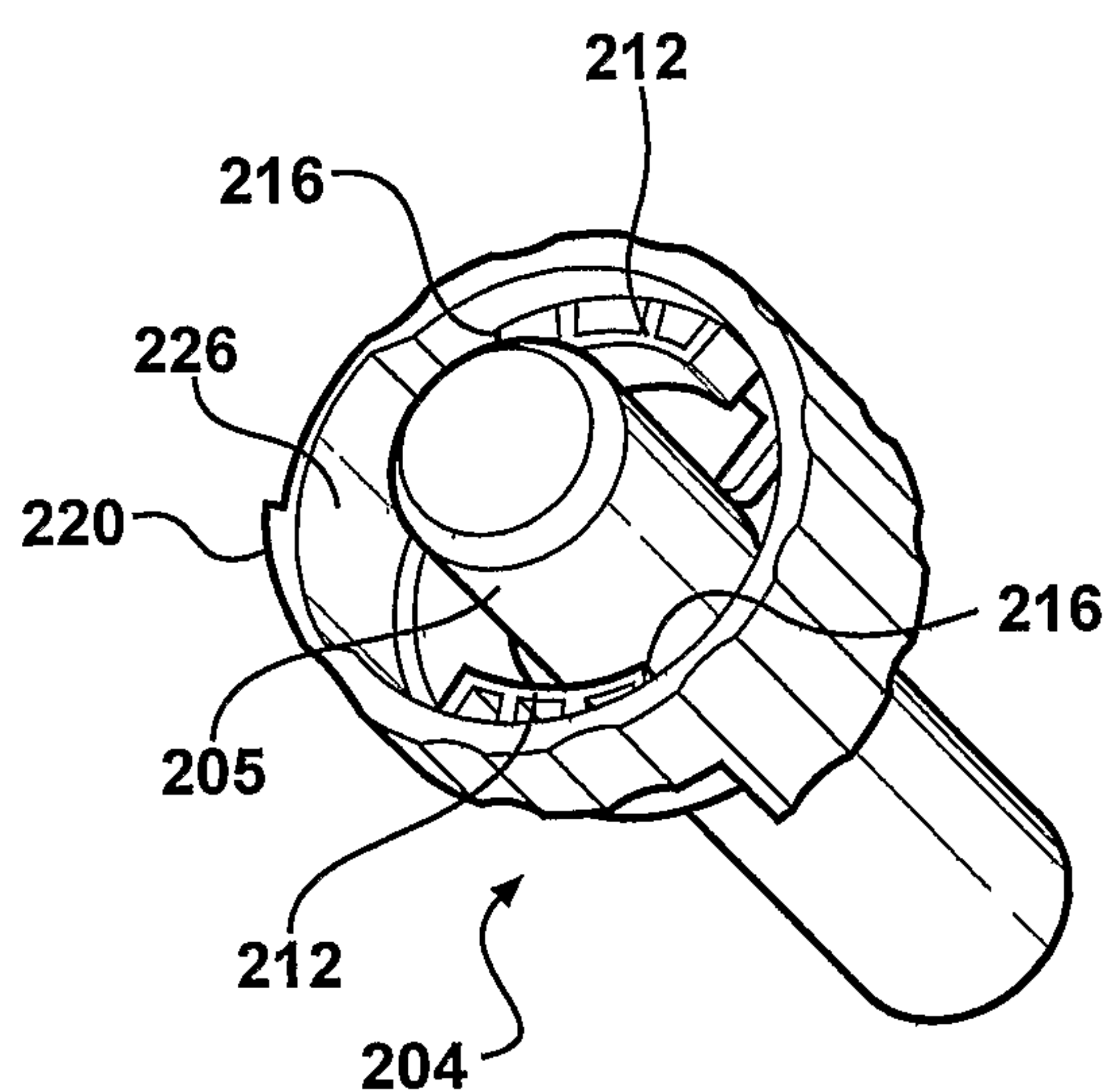
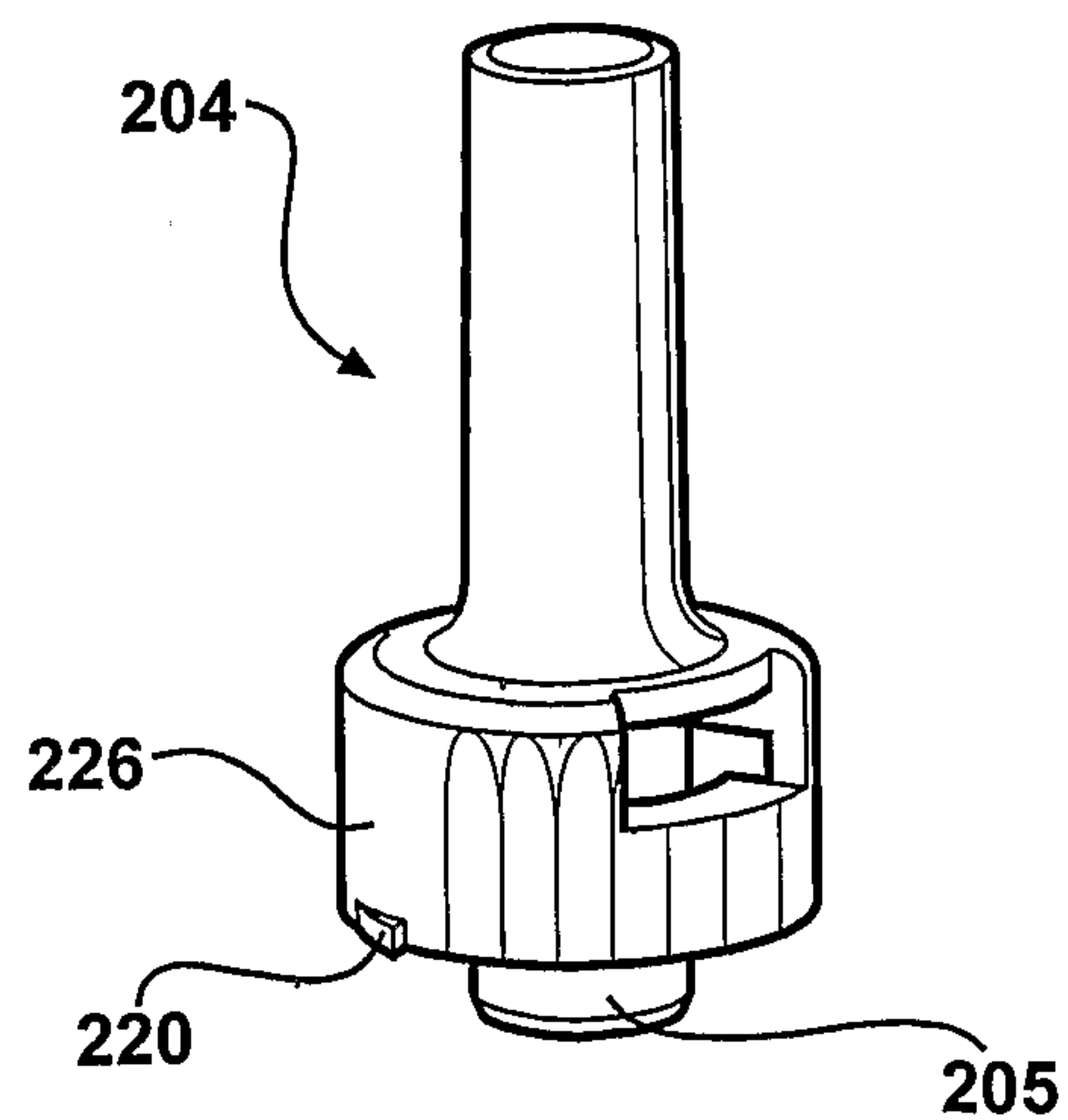
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FIG - 17**FIG - 18**

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**FIG - 19****FIG - 20****FIG - 21****FIG - 22****FIG - 23**

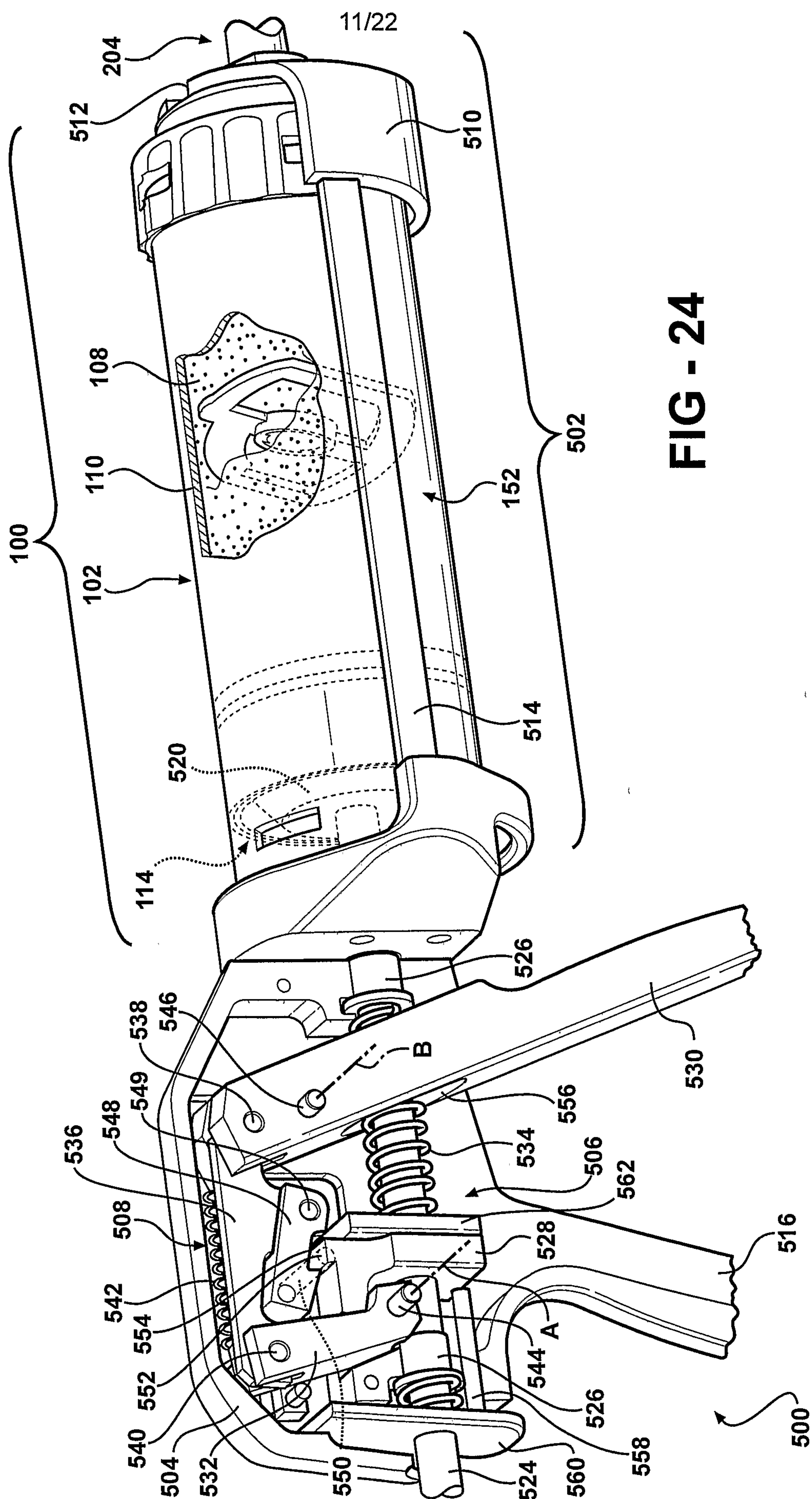


FIG - 24

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FIG - 24B

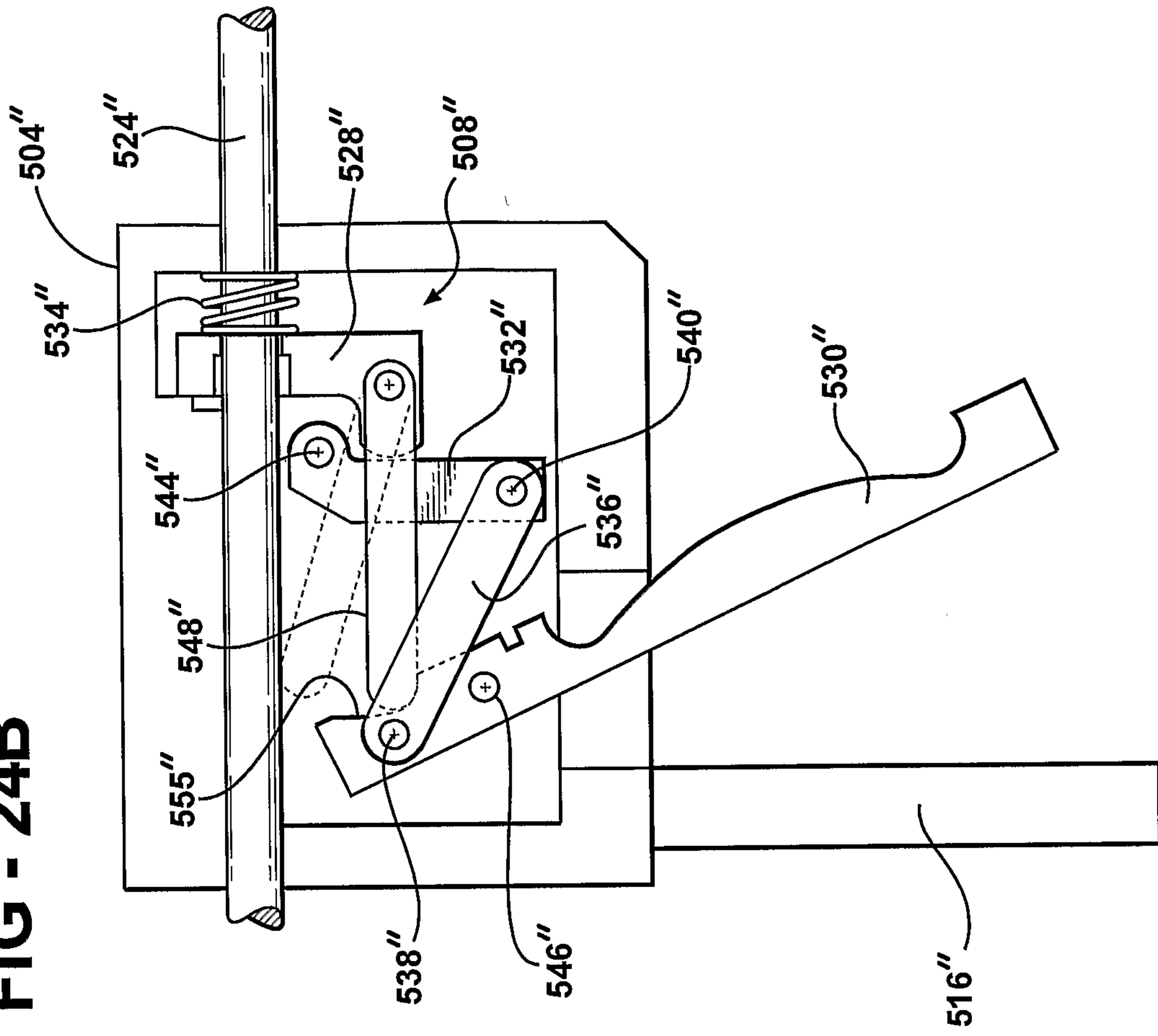
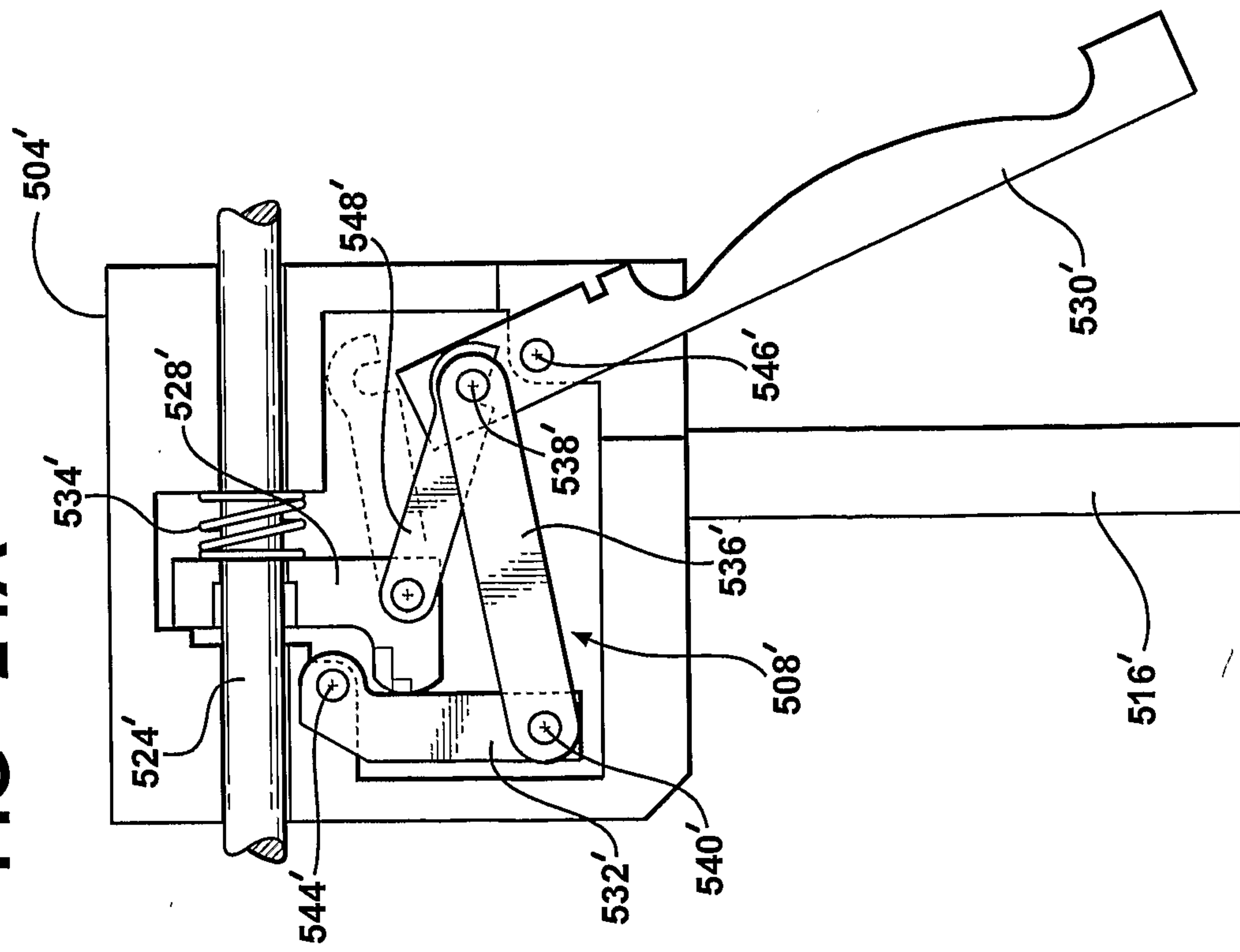
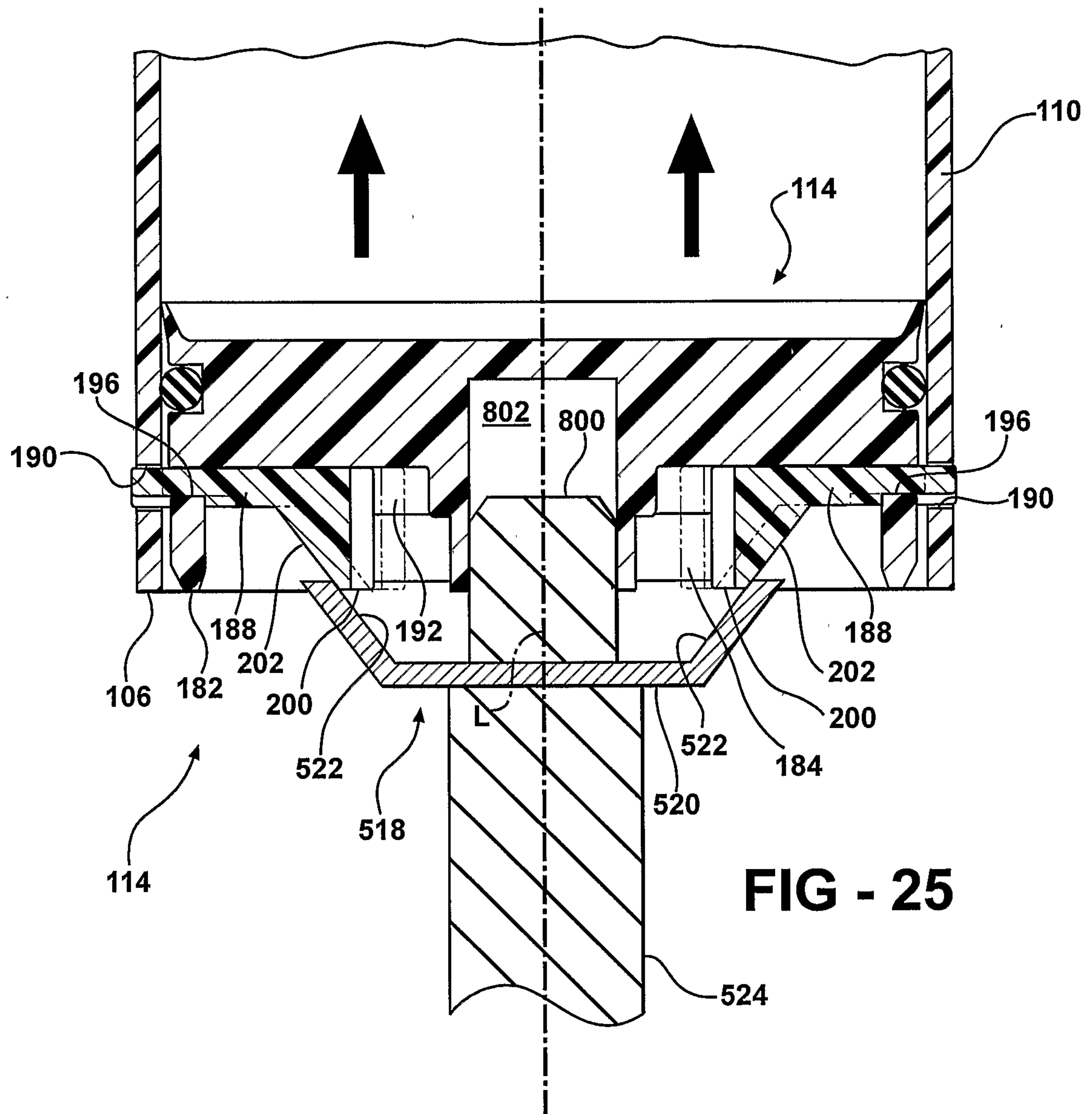
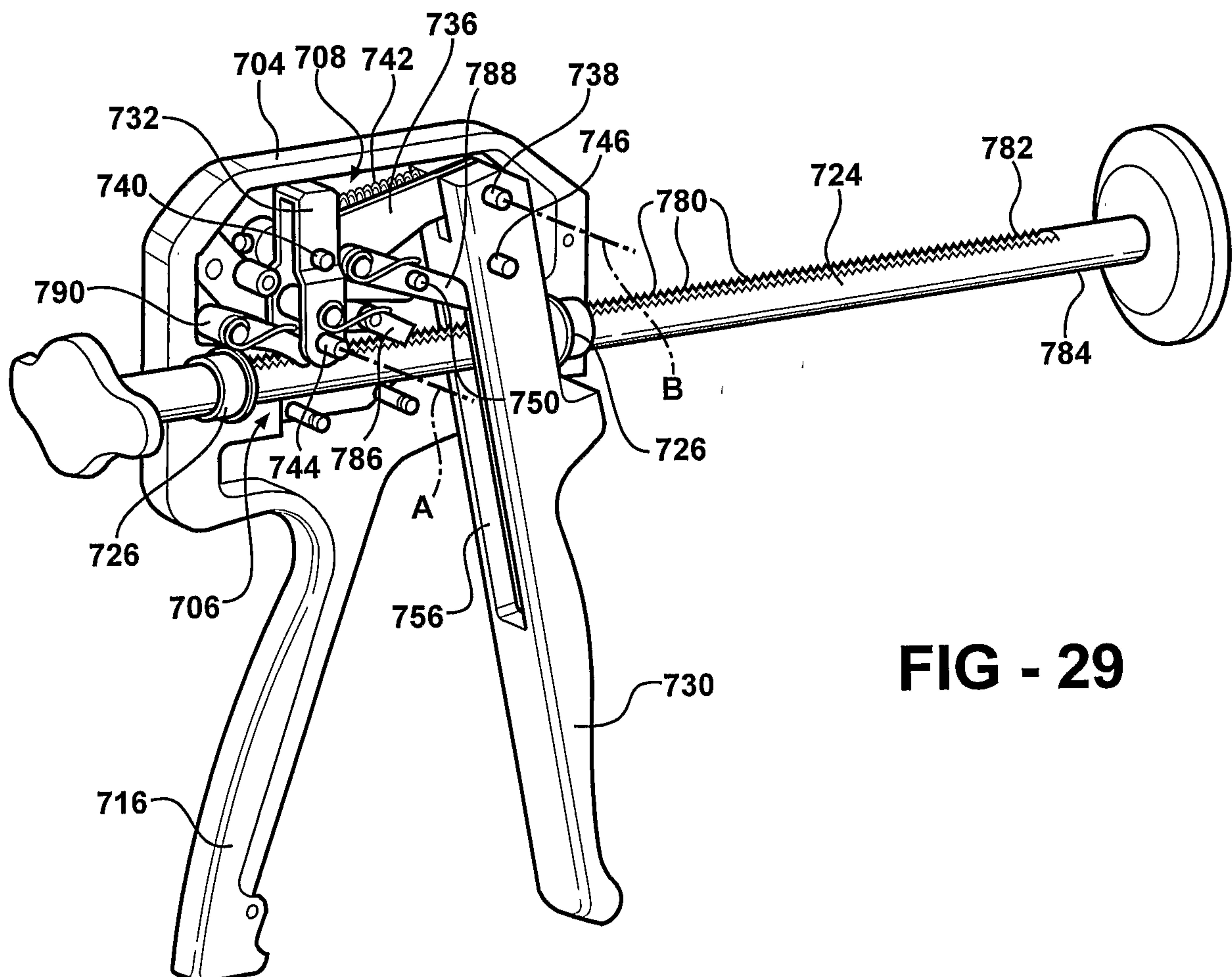
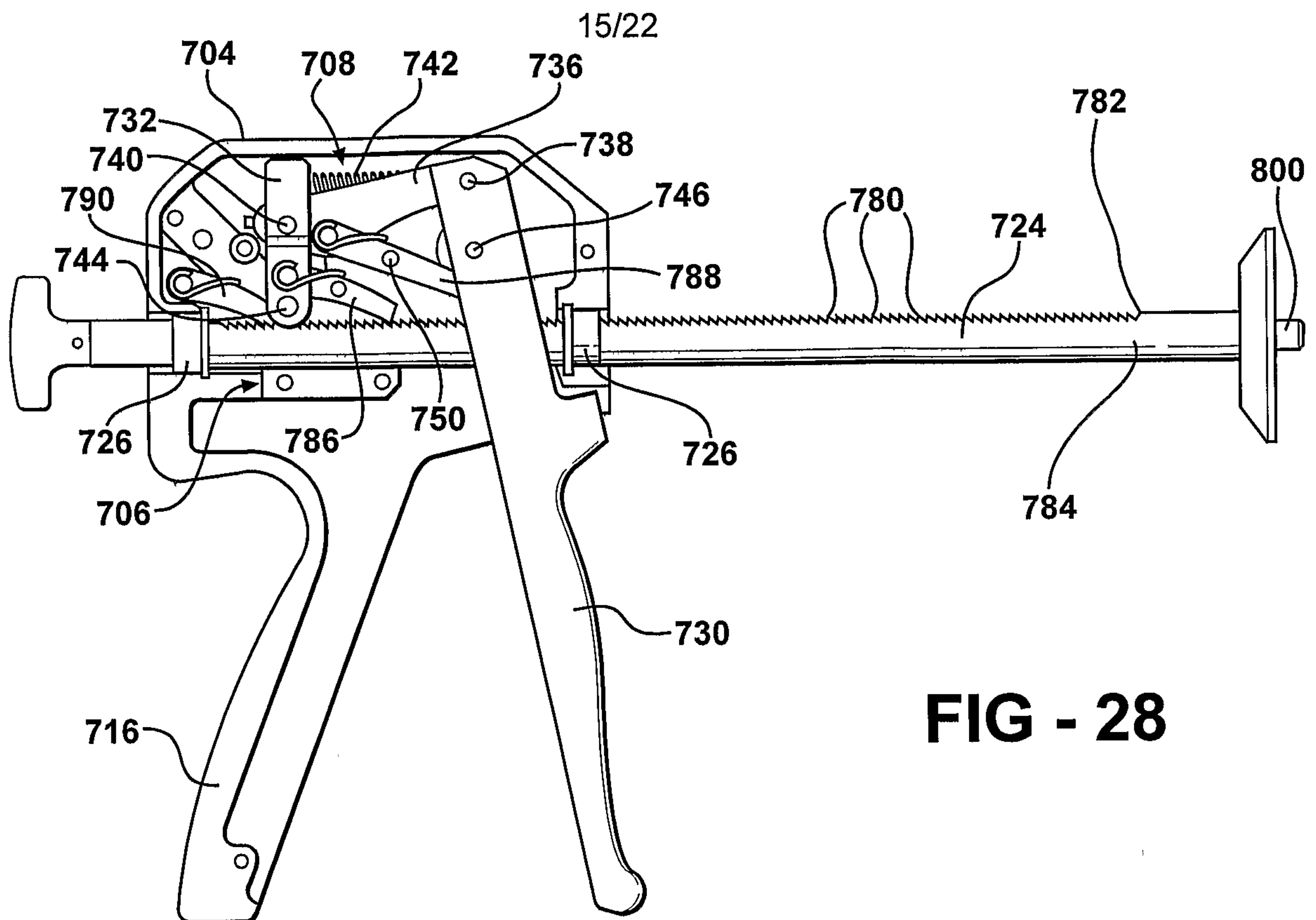


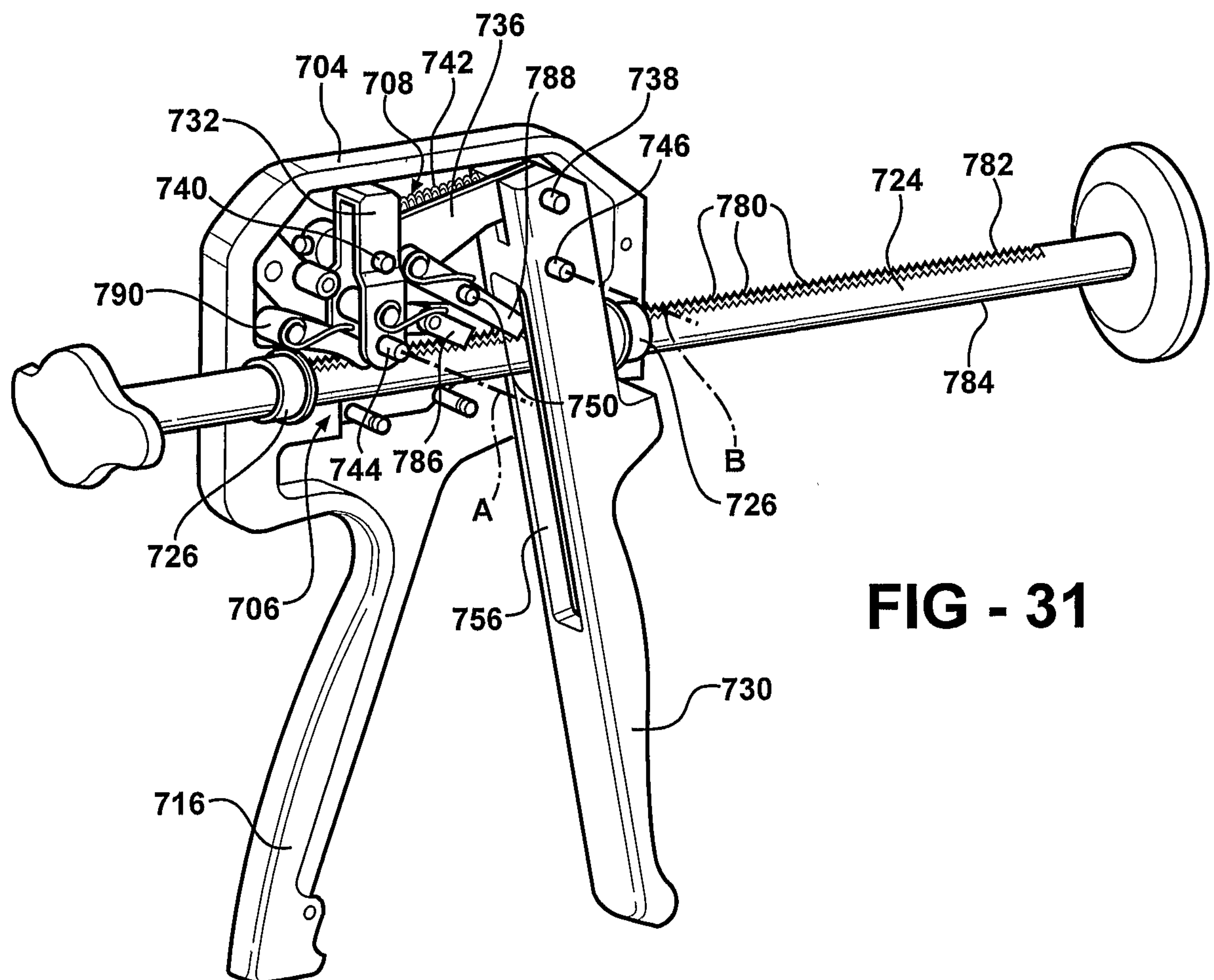
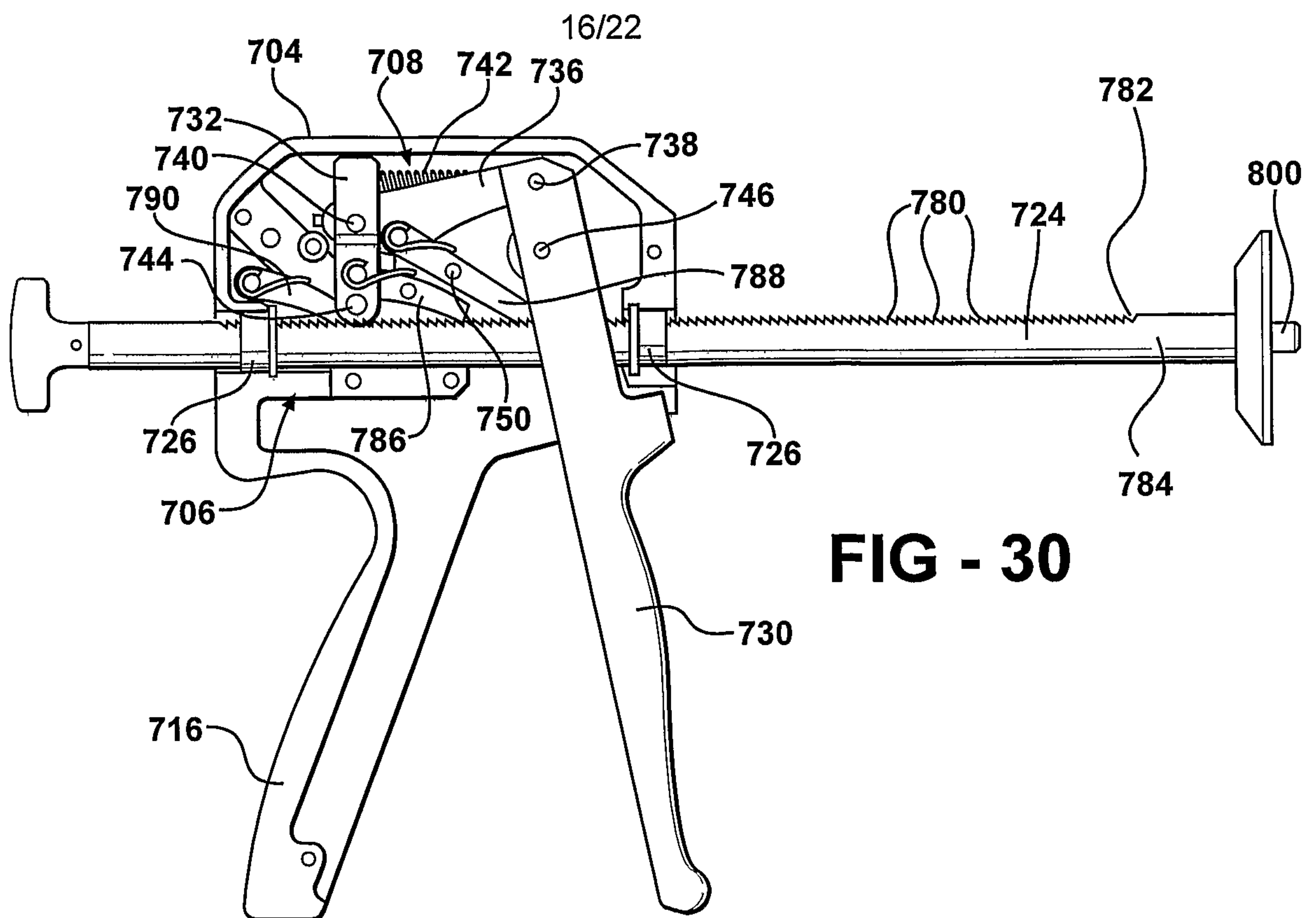
FIG - 24A



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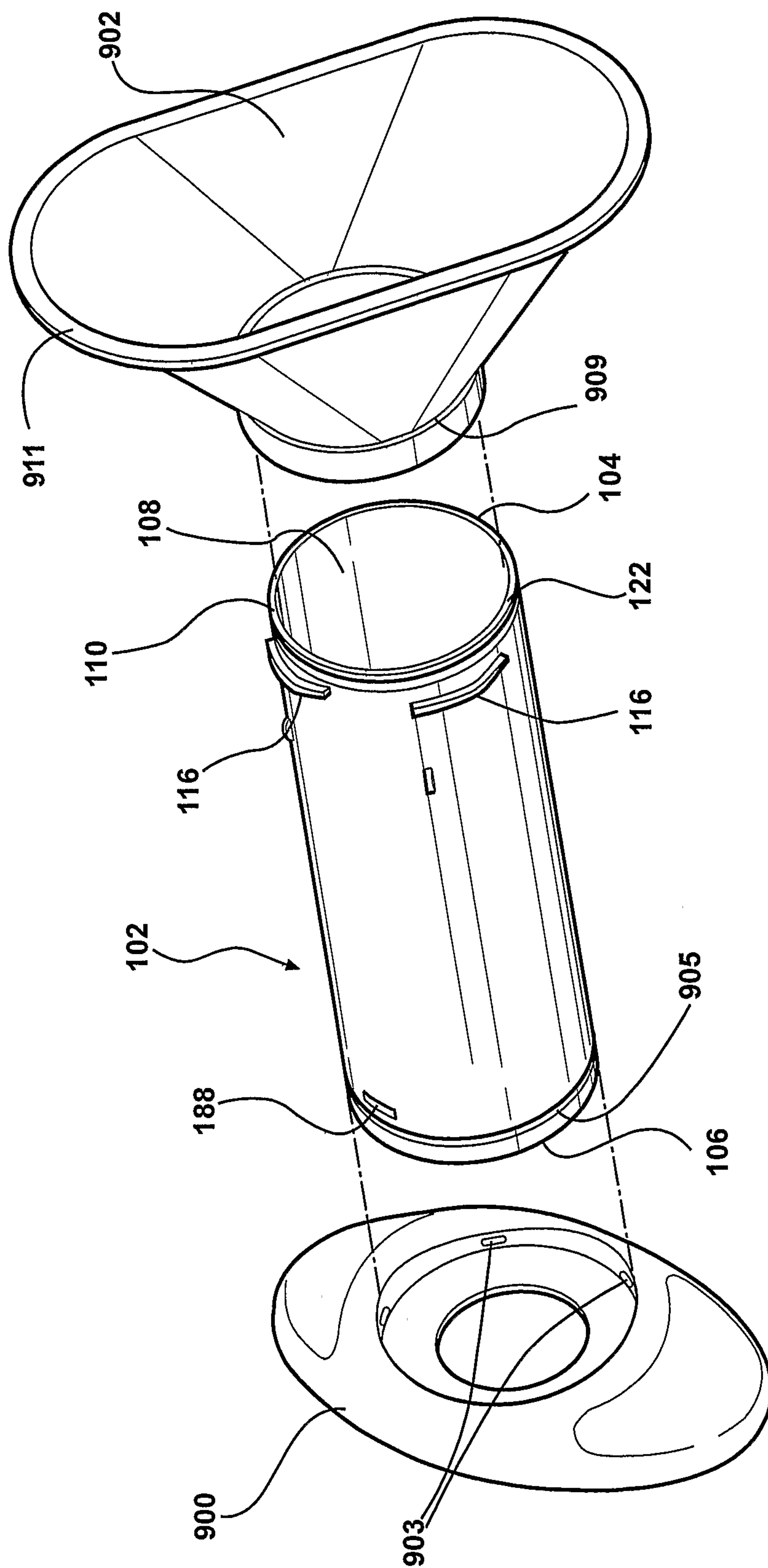
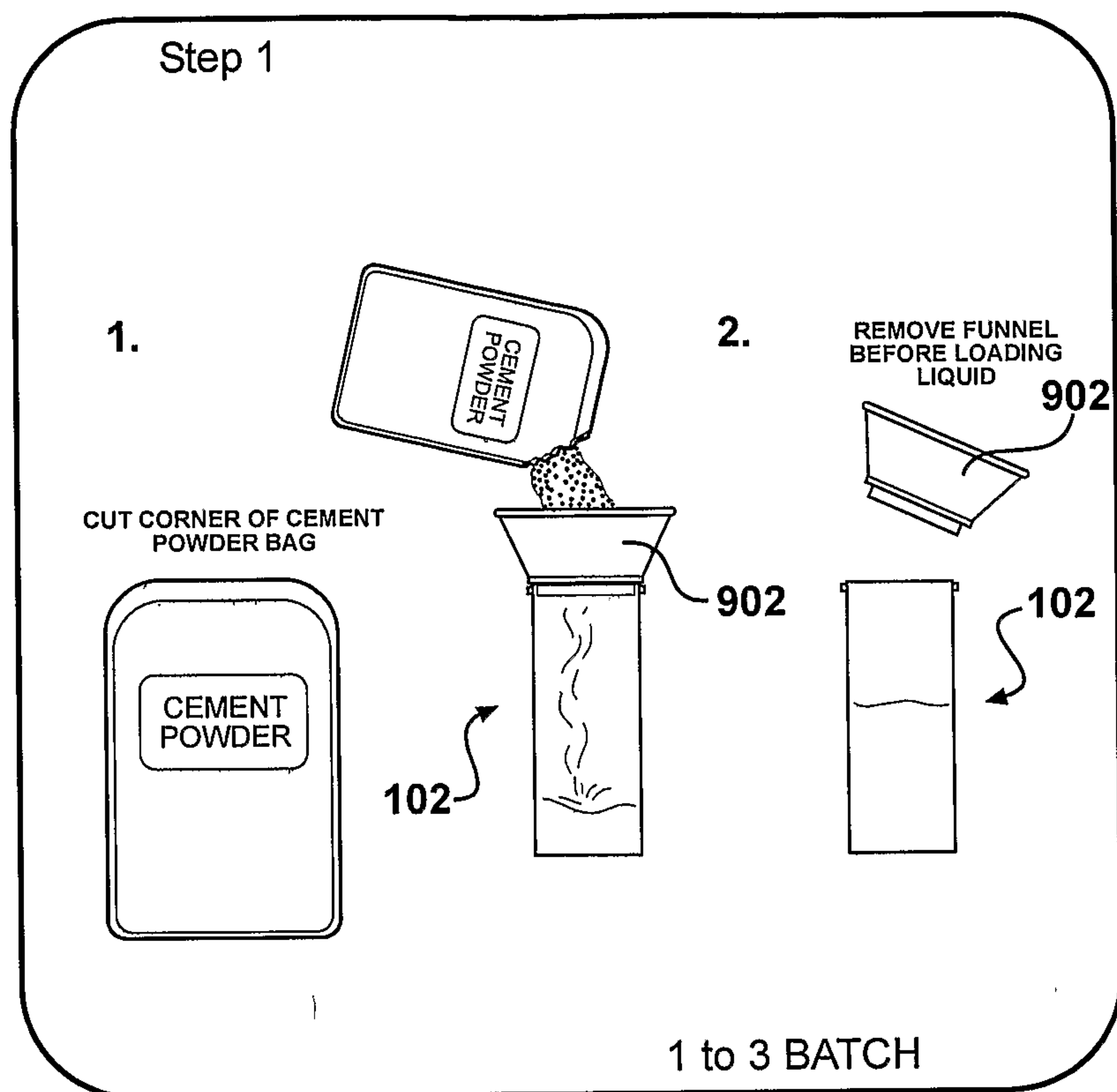
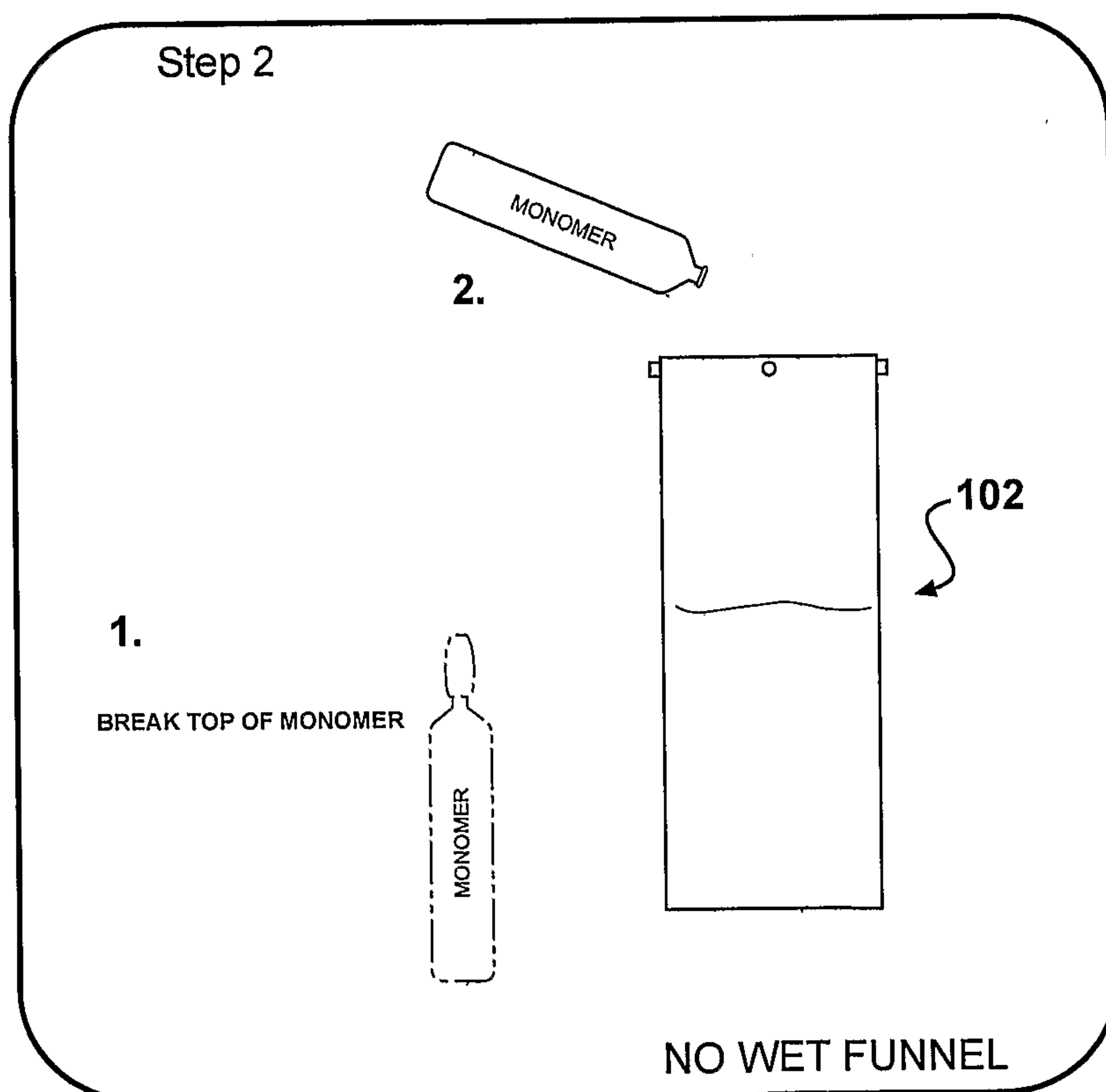


FIG - 32

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**FIG - 33****FIG - 34**

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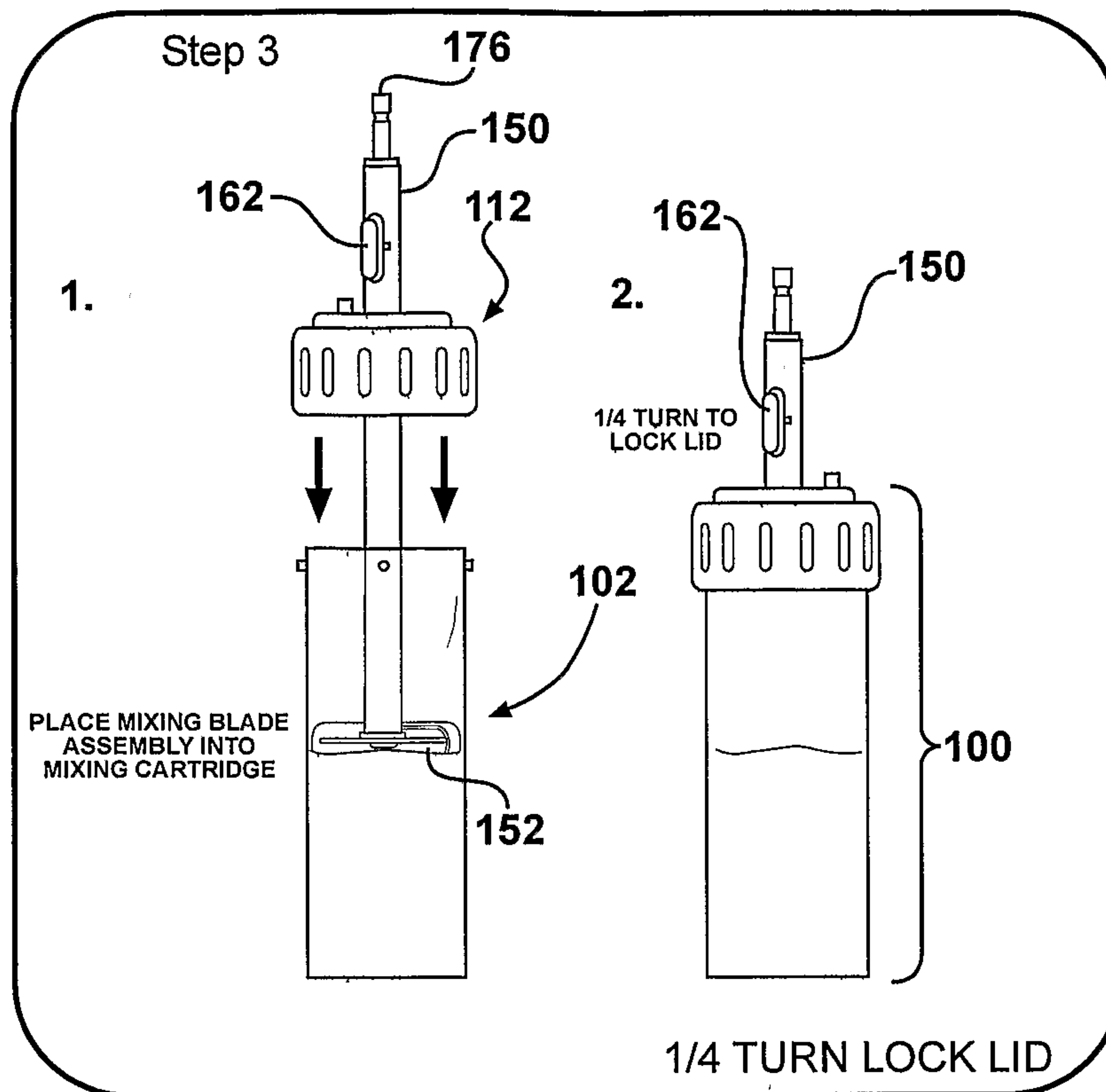


FIG - 35

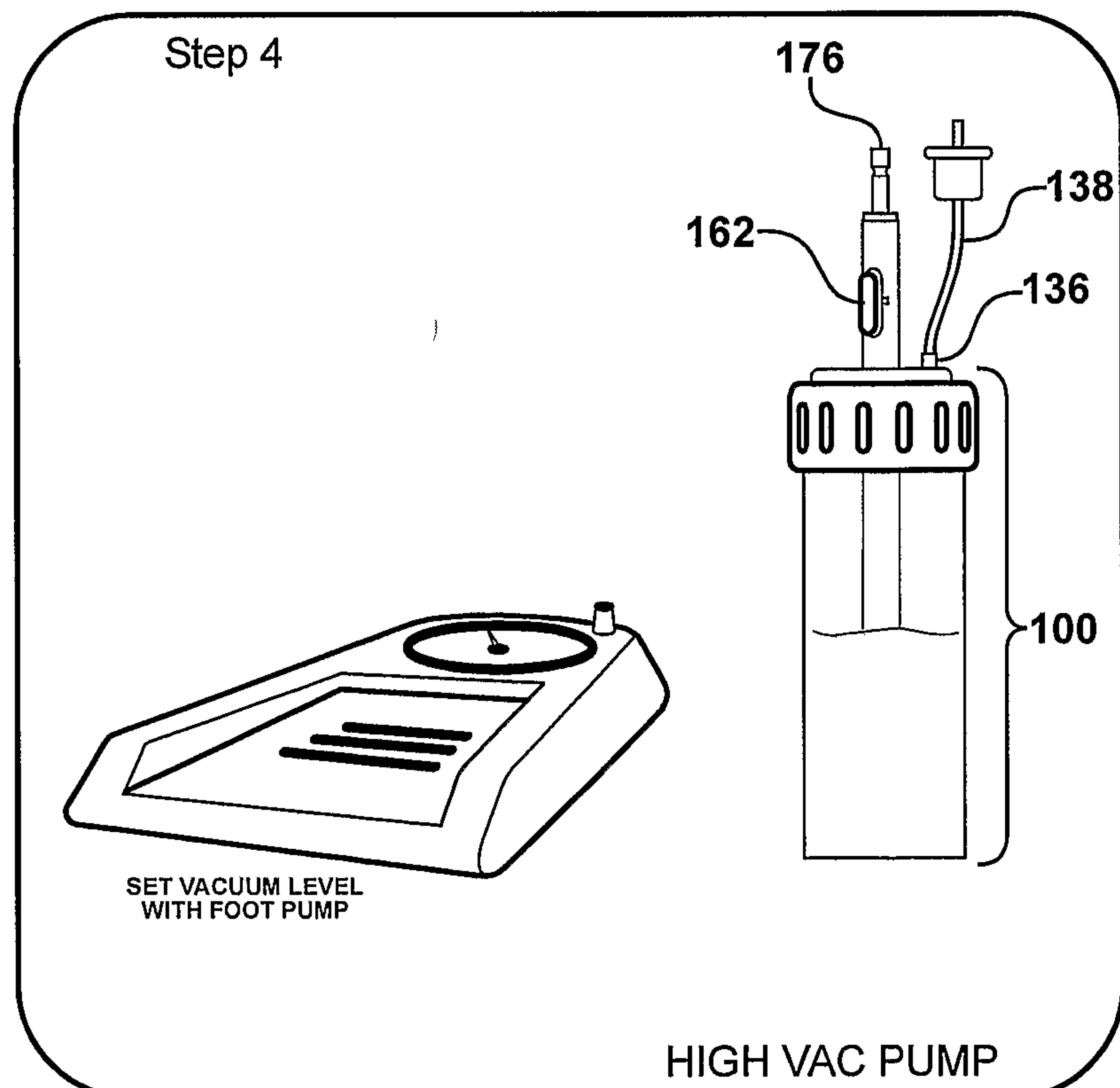
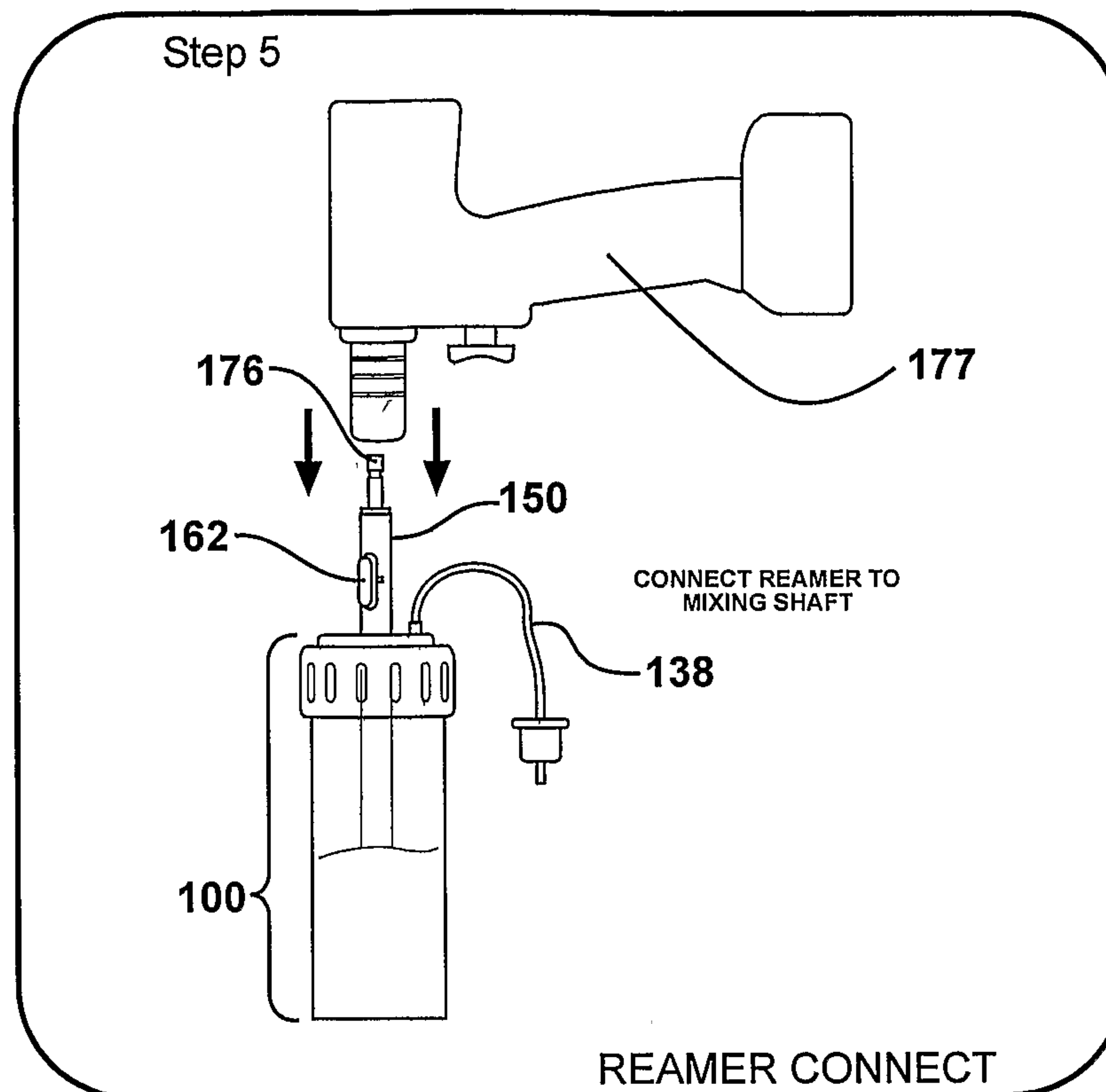
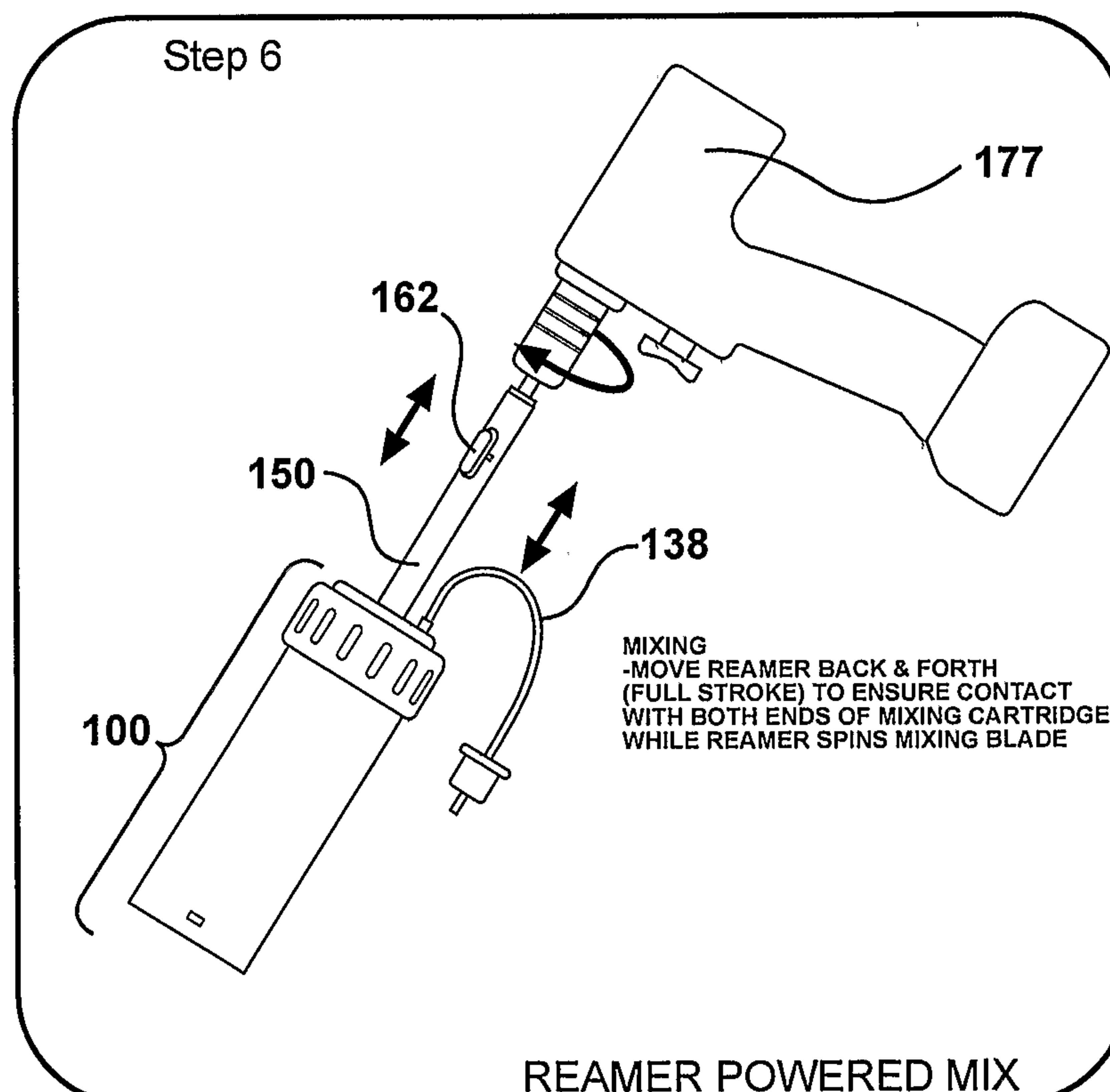
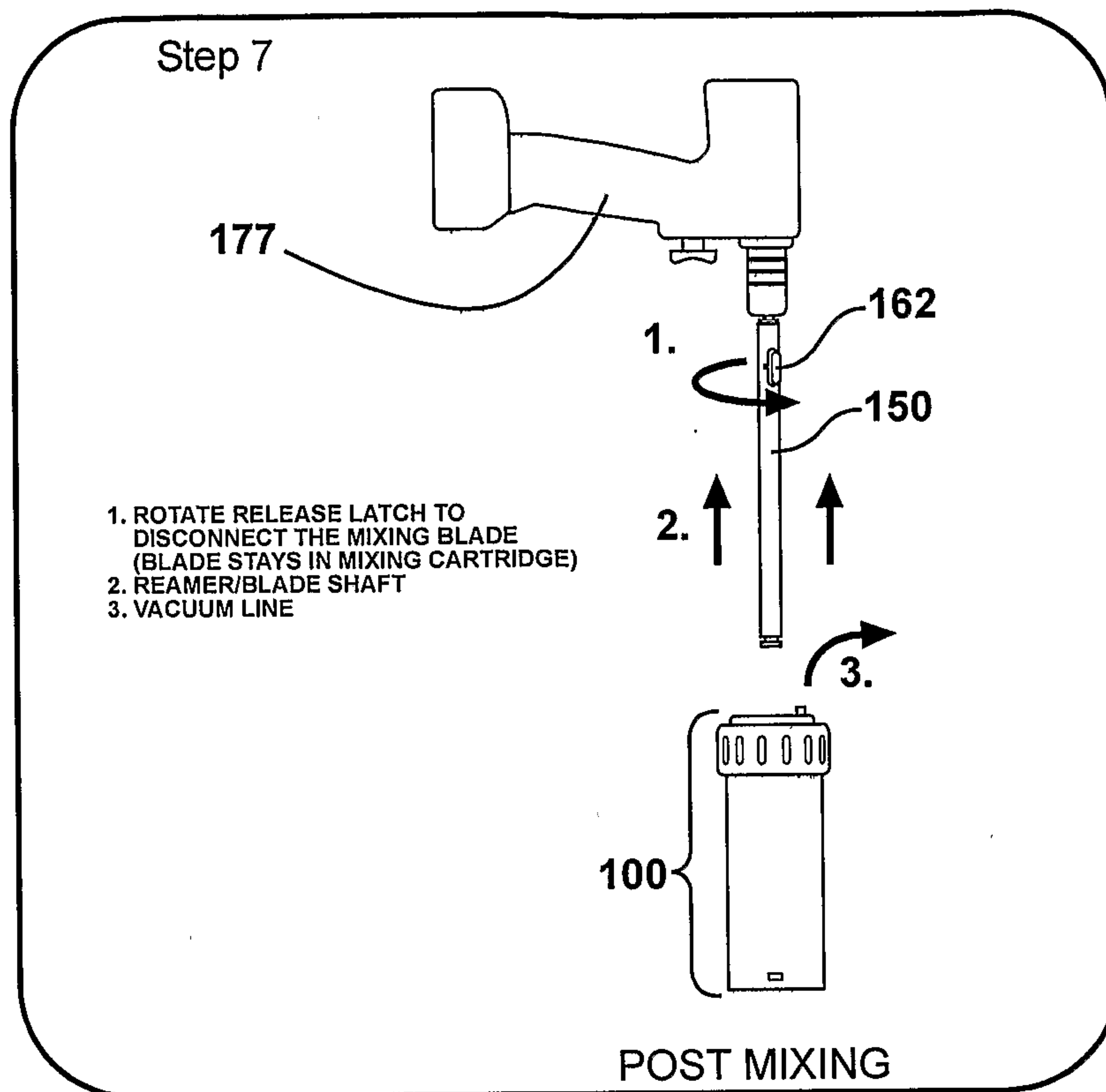
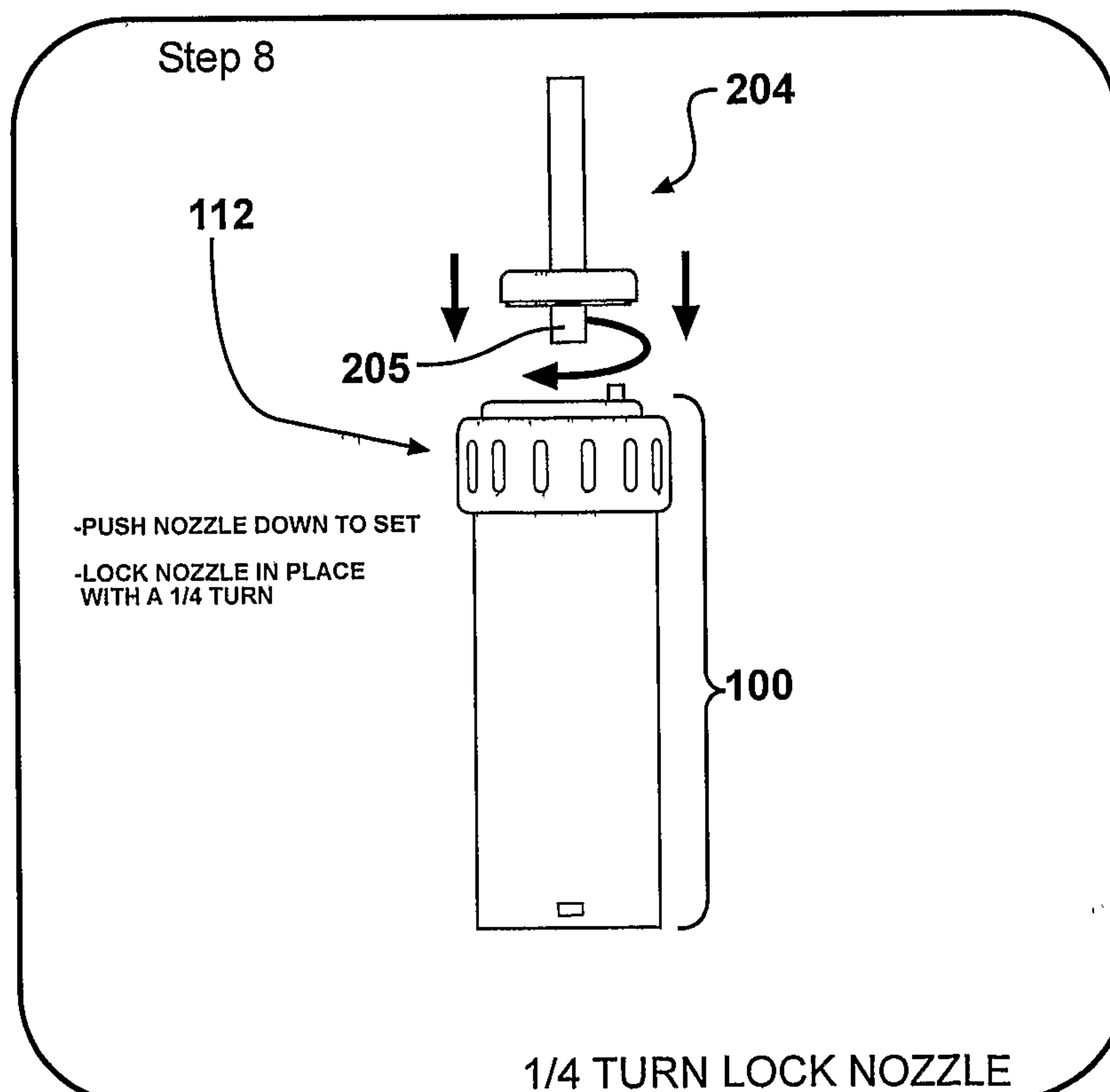


FIG - 36

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**FIG - 37****FIG - 38**

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**FIG - 39****FIG - 40**

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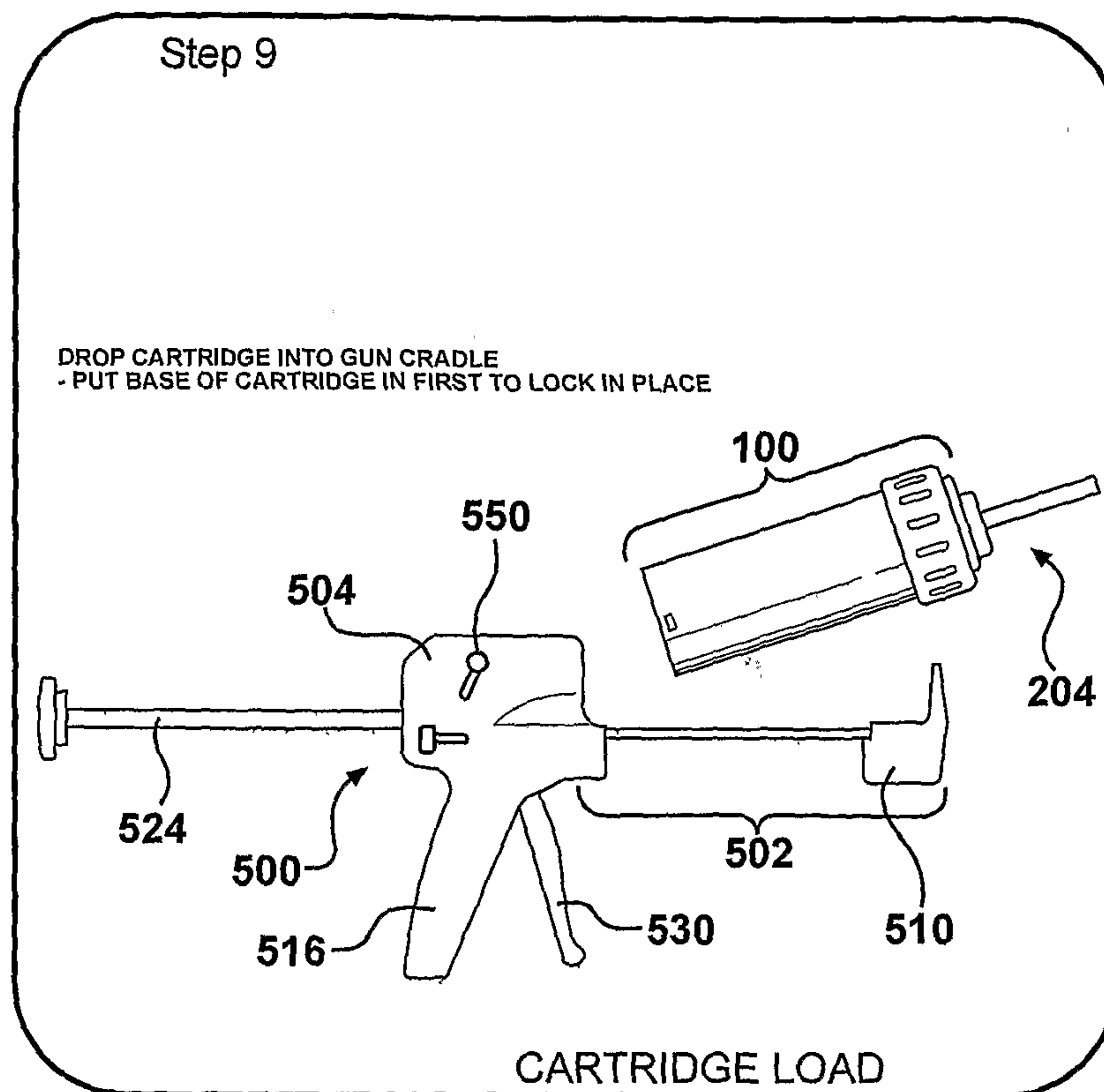


FIG - 41

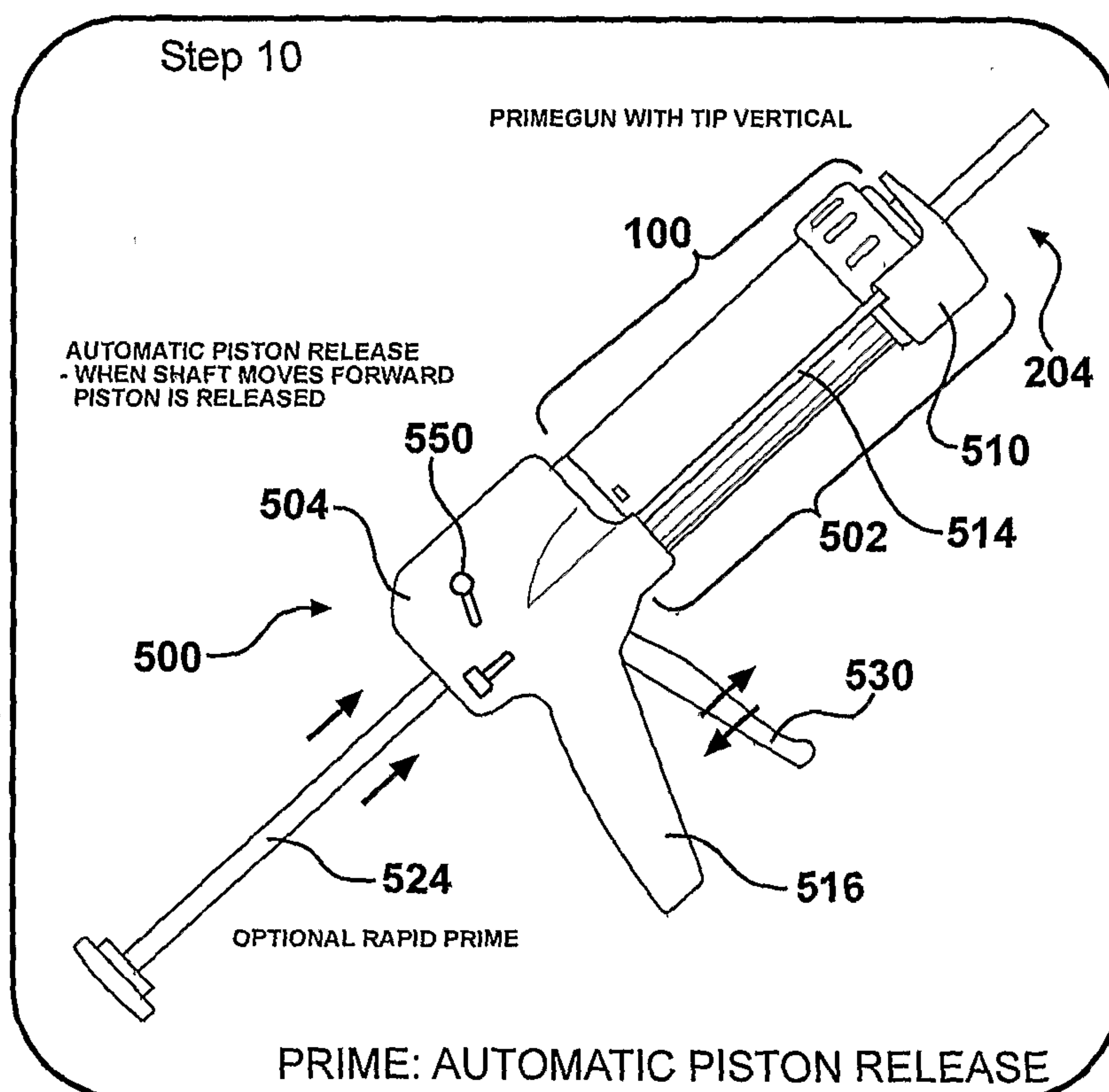


FIG - 42

