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Su

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(54) **FLUID DRIVEN DRILLING MOTOR**

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(22) Filed: **Feb. 27, 2014**

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(51) **Int. Cl.**

E21B 4/14	(2006.01)
E21B 1/02	(2006.01)
E21B 4/02	(2006.01)

(52) **U.S. Cl.**
CPC ***E21B 4/14*** (2013.01); ***E21B 1/02*** (2013.01); ***E21B 4/02*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 4/14; E21B 1/02; E21B 4/02; E21B 4/06
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,287,956	A	9/1981	Mauer	
6,561,777	B2	5/2003	Grupping	
7,331,404	B2	2/2008	Pusateri	
7,510,023	B1	3/2009	Cheng	
2002/0166700	A1 *	11/2002	Gillis	E21B 4/10 175/57
2005/0092525	A1 *	5/2005	Teale	E21B 4/02 175/57

OTHER PUBLICATIONS

PCT/US2014/019012 International Search Report and Written Opinion dated Jun. 20, 2014.

* cited by examiner

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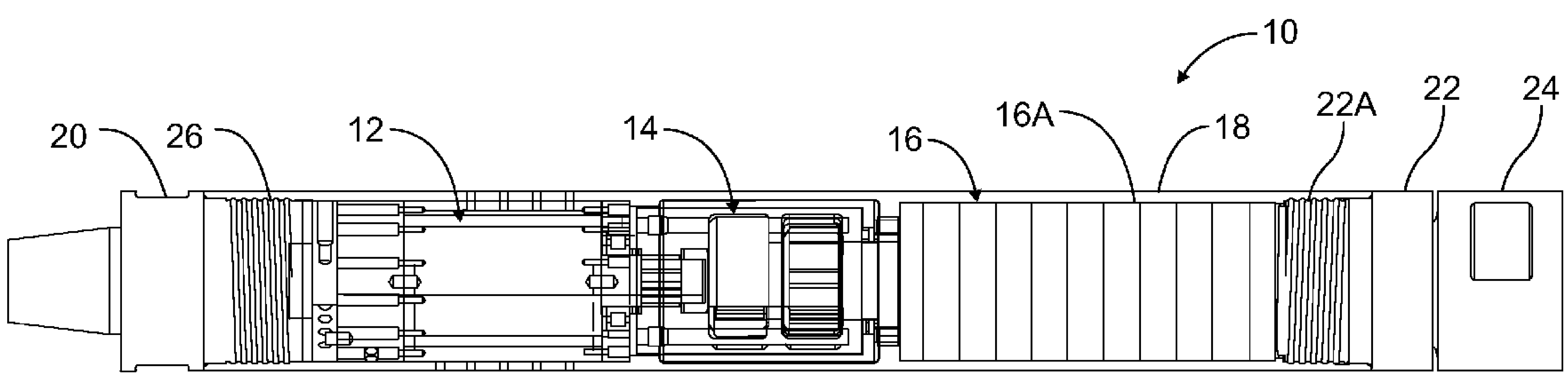
(57) **ABSTRACT**

A motor assembly is disclosed that includes a vane motor coupled to an output shaft by a drive section. The drive section includes hammers that engage the output shaft to provide improved torque.

14 Claims, 10 Drawing Sheets



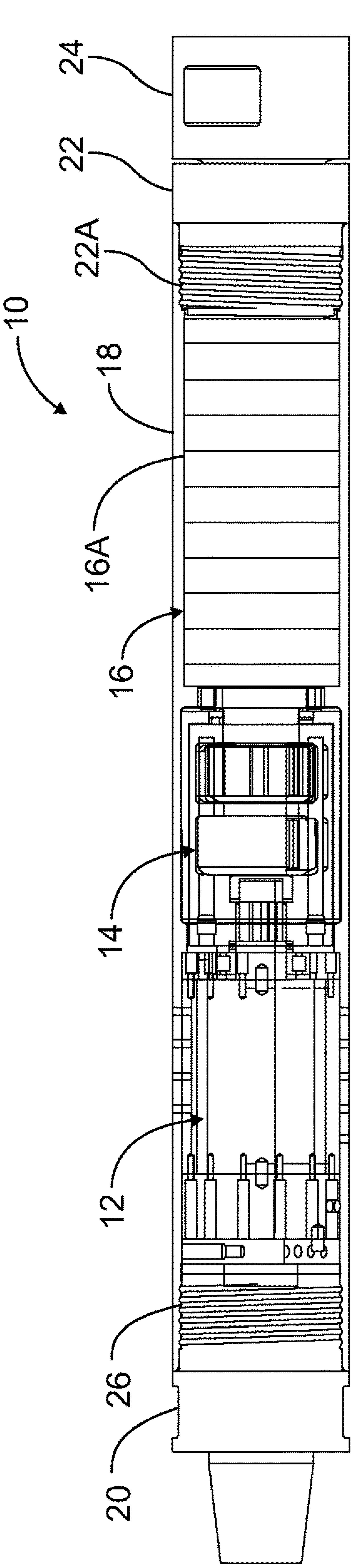
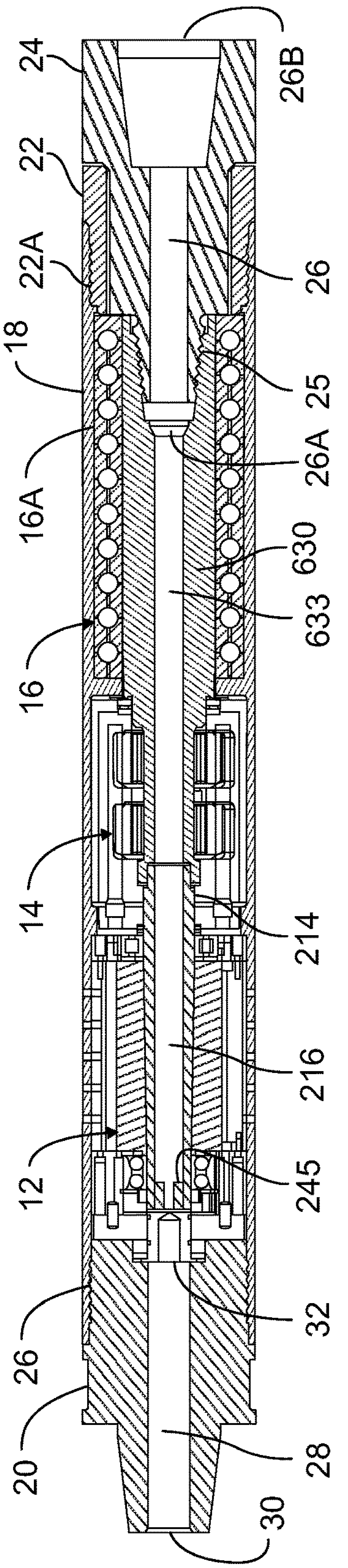


Figure 1



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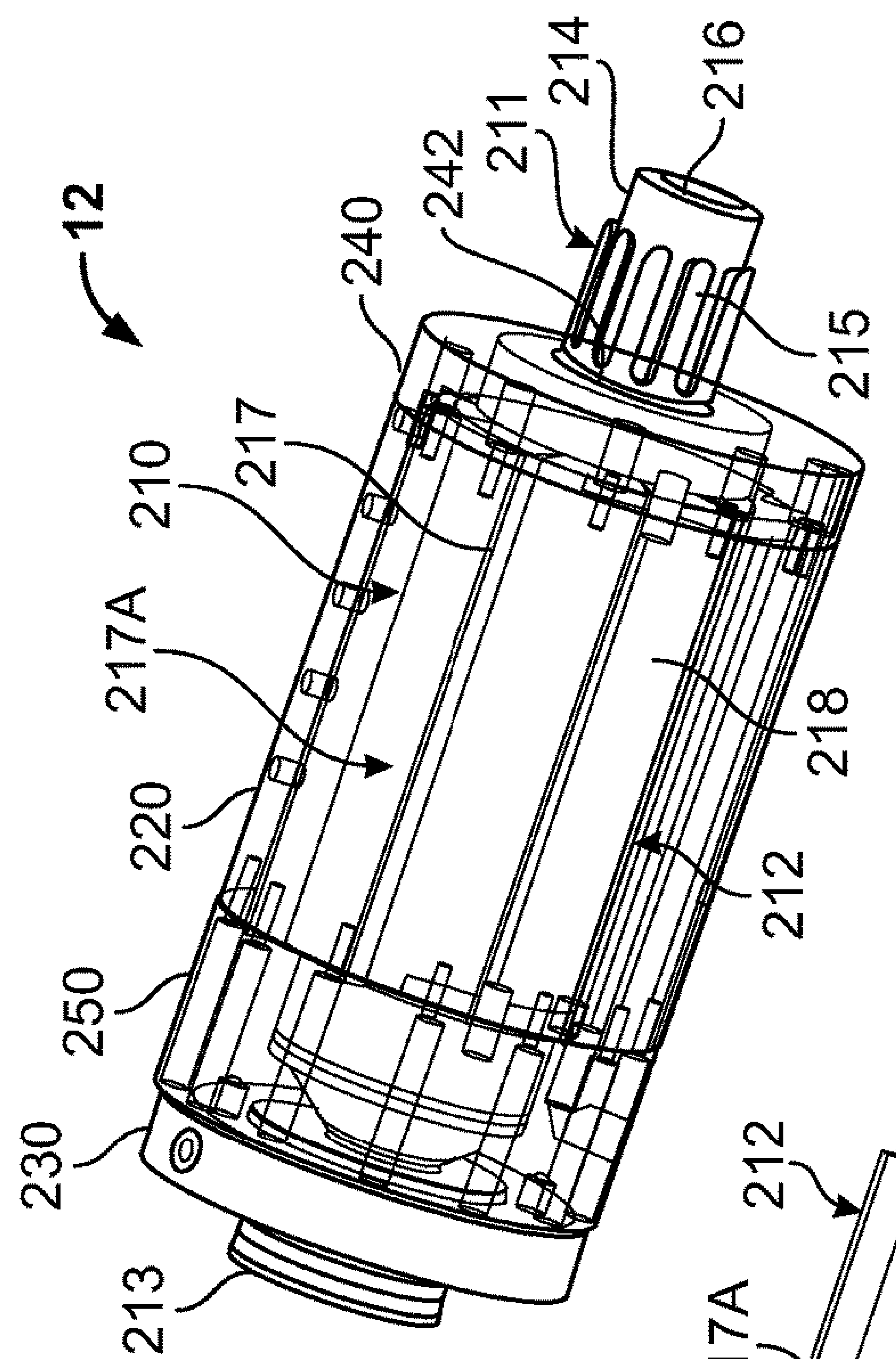


Figure 3

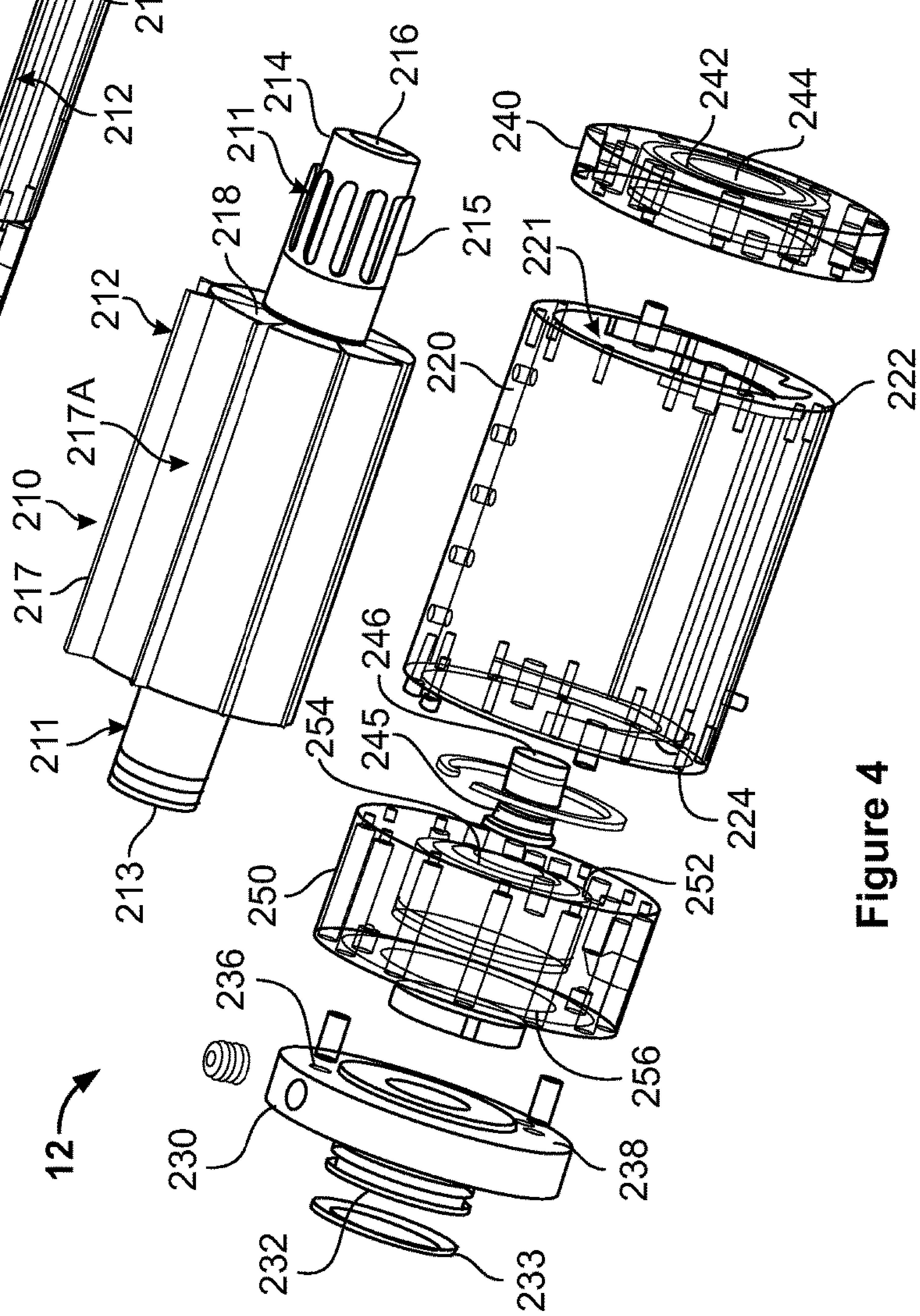
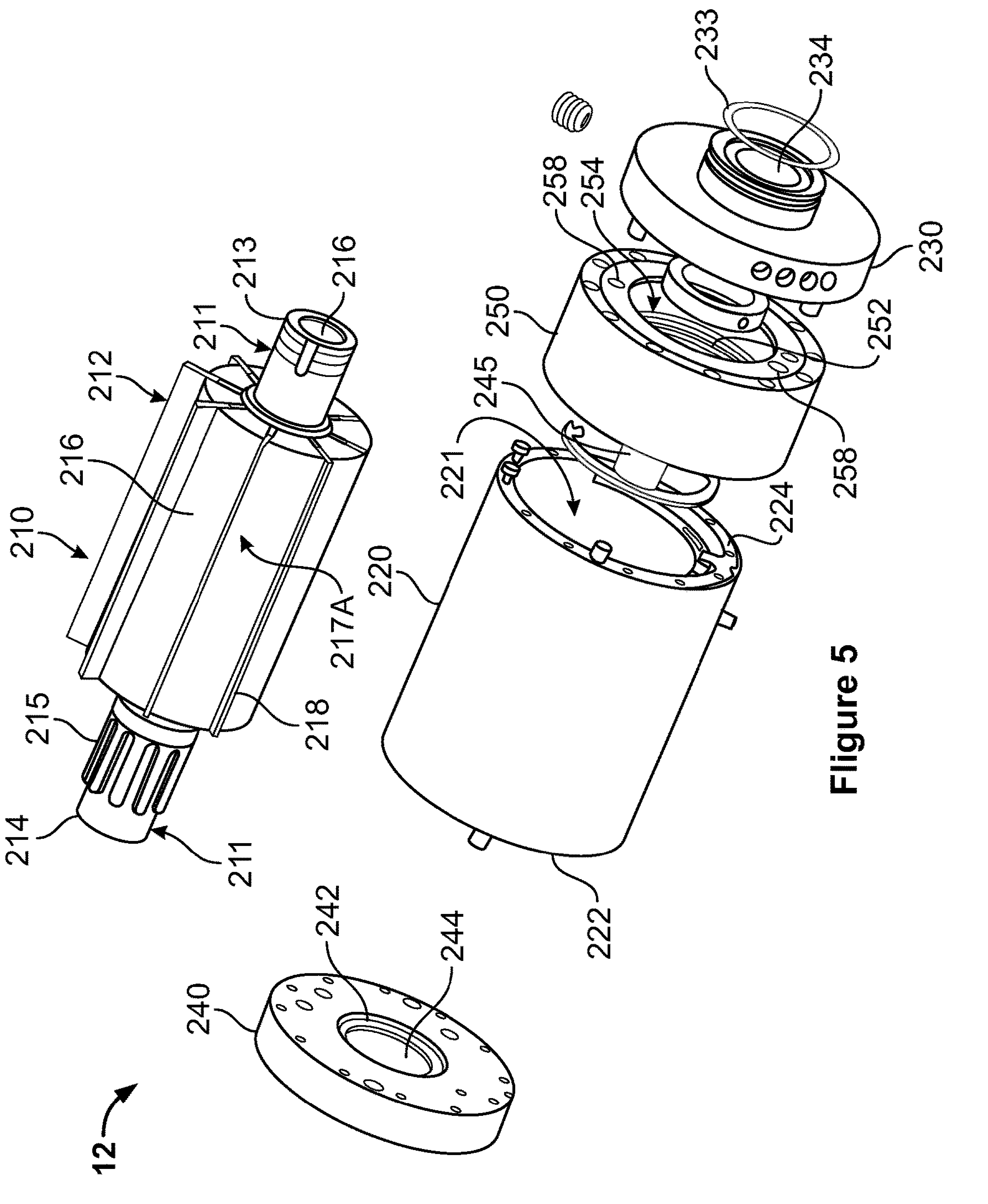


Figure 4


12
210
211
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217A
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211
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242
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252
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234

Figure 5

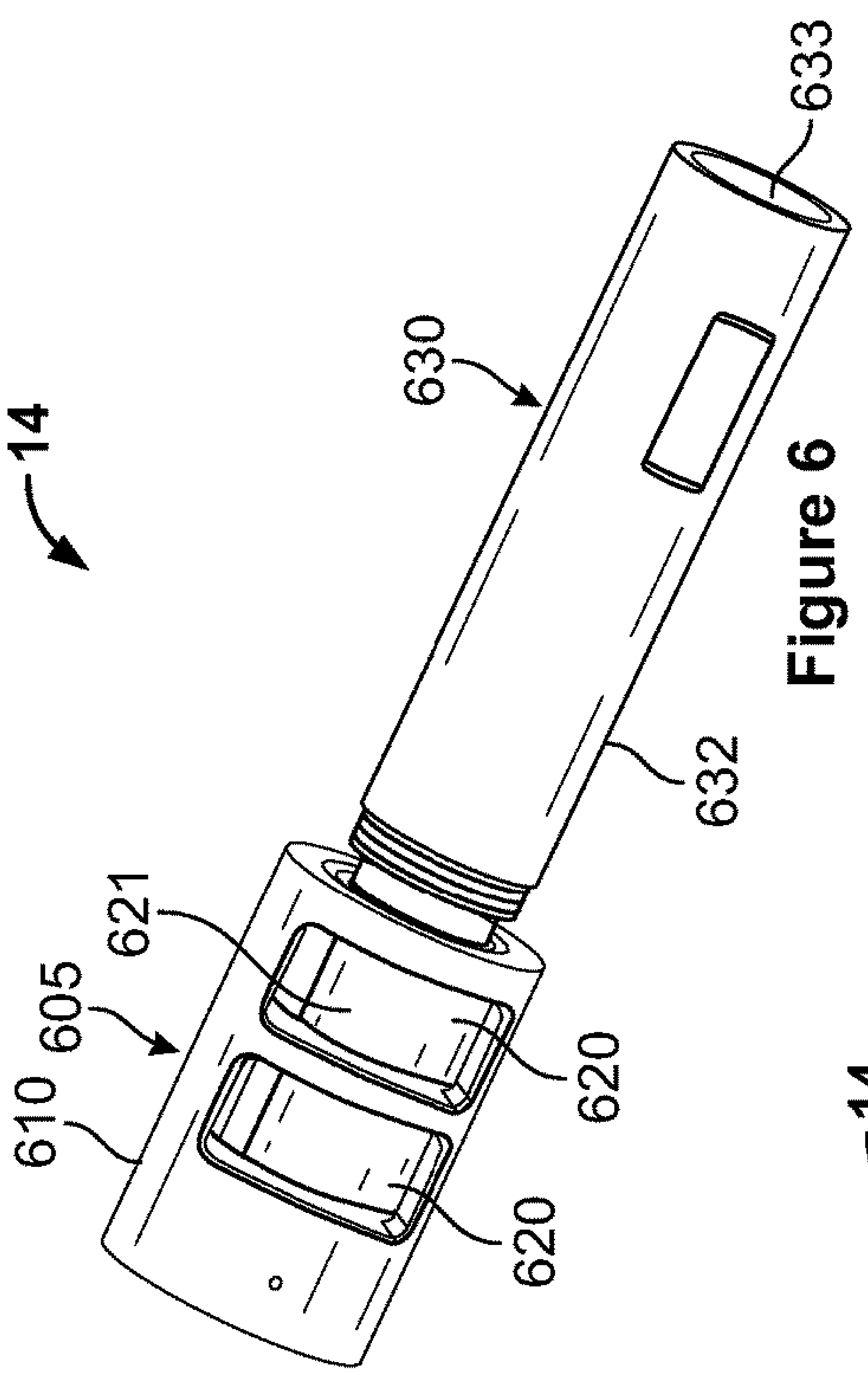

Figure 6

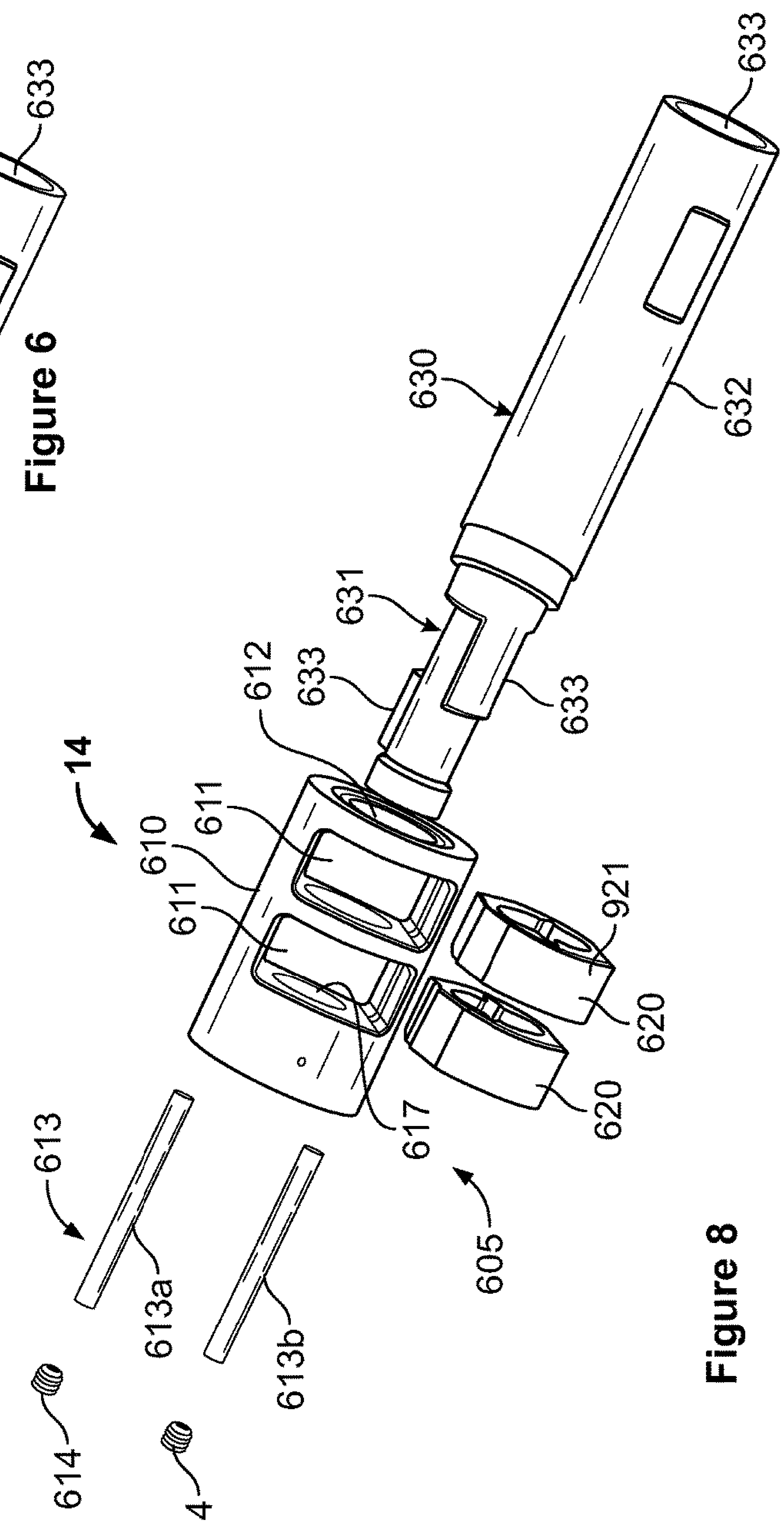

Figure 8

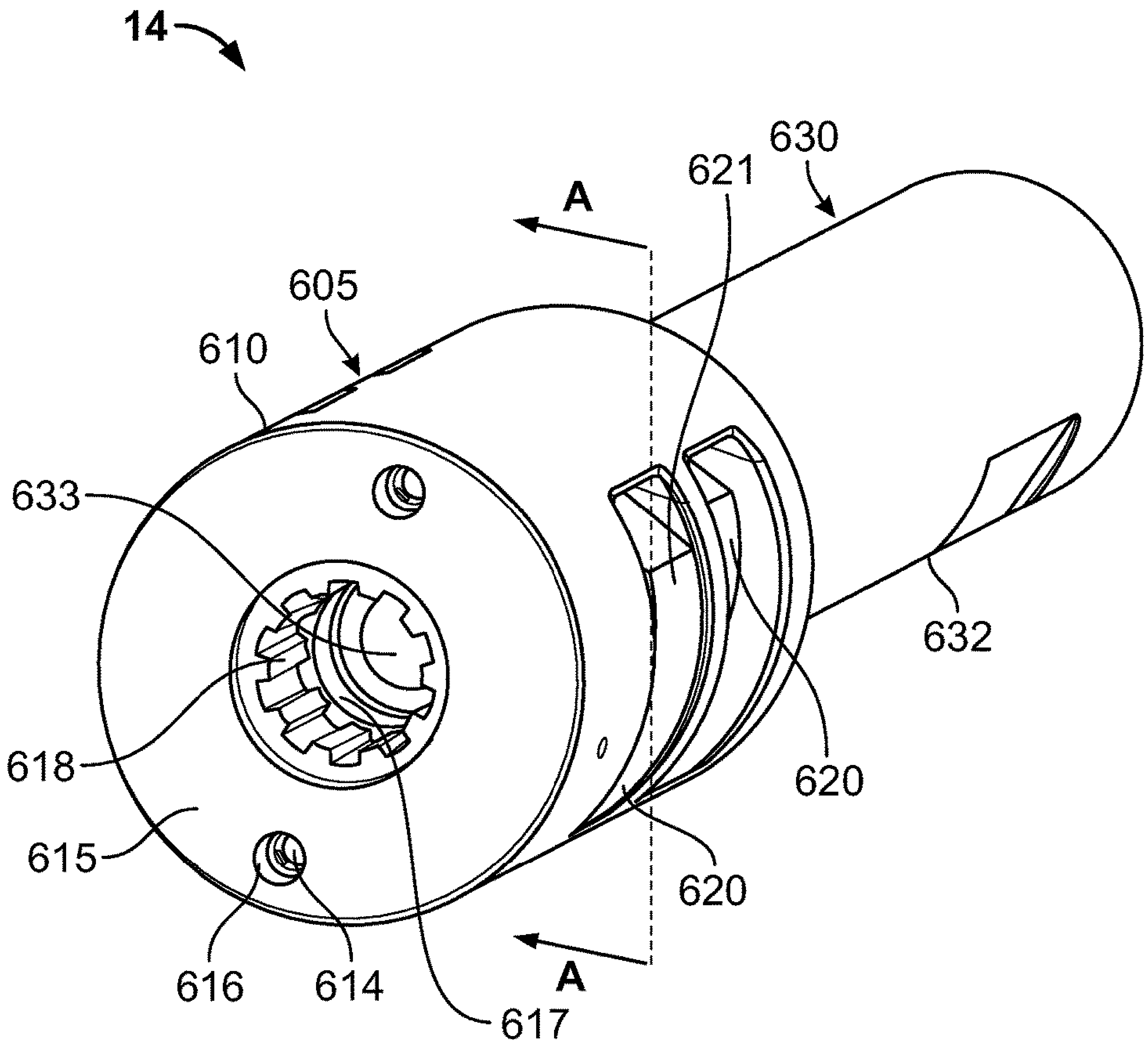

Figure 7

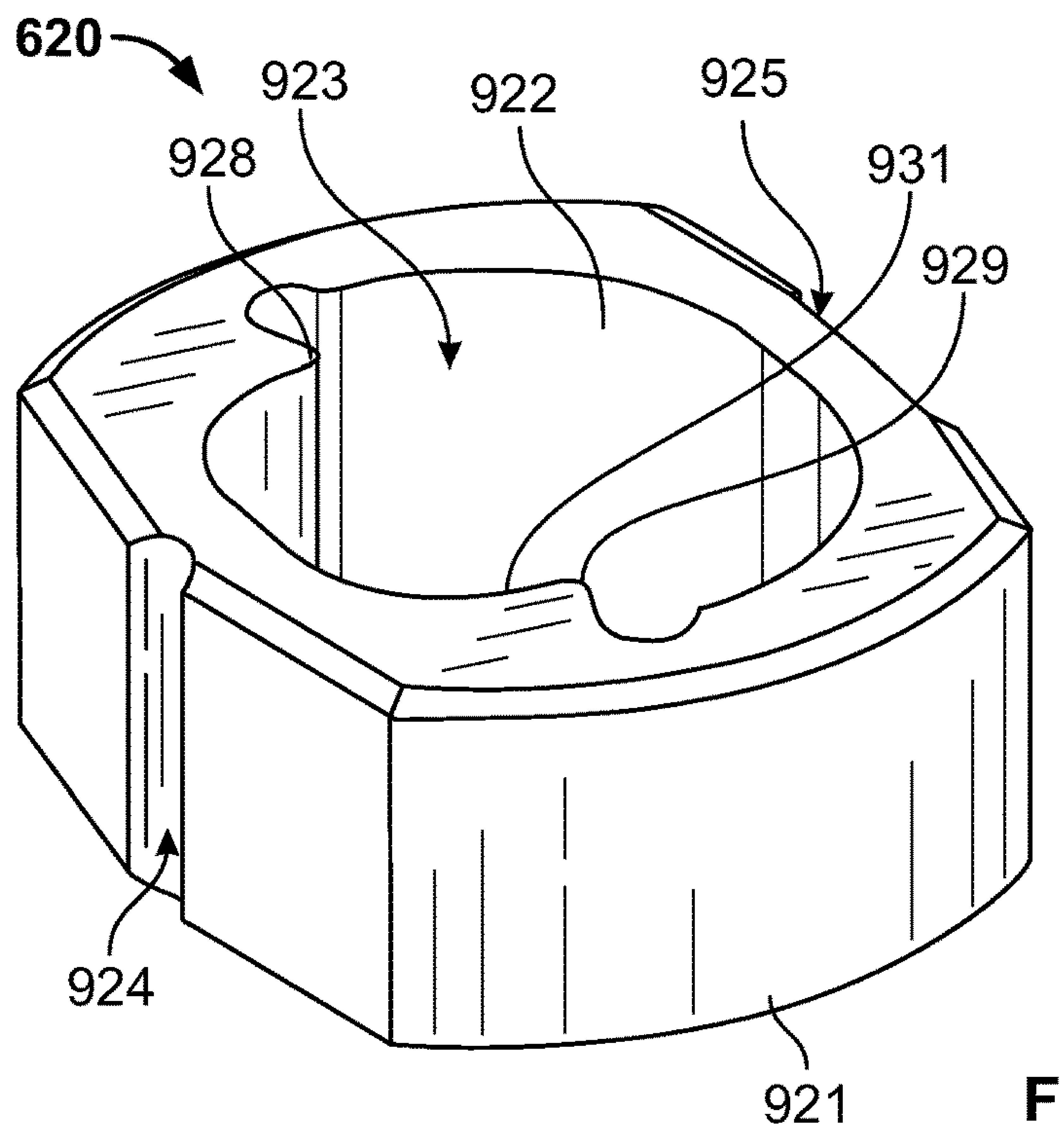

Figure 9

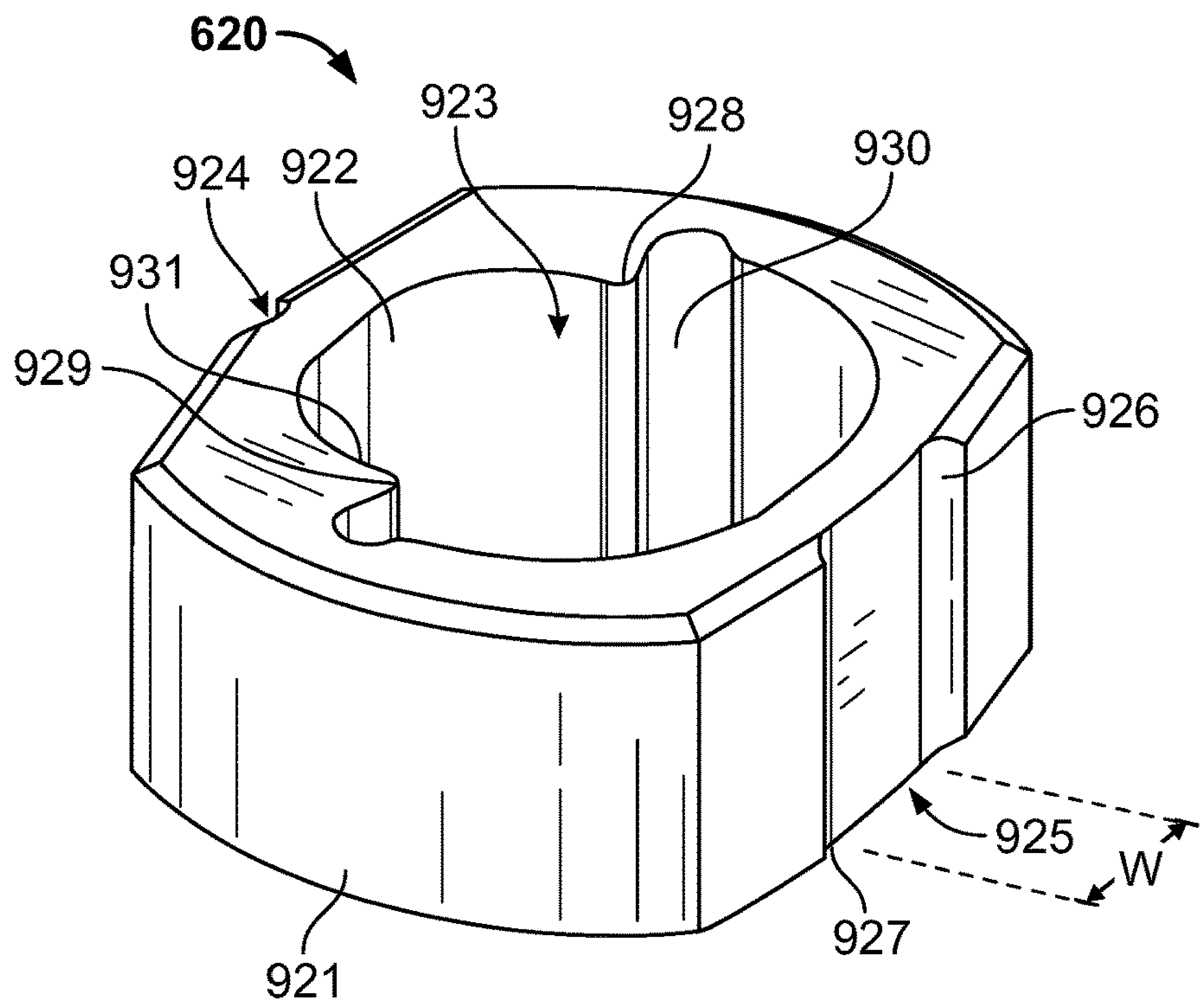

Figure 10

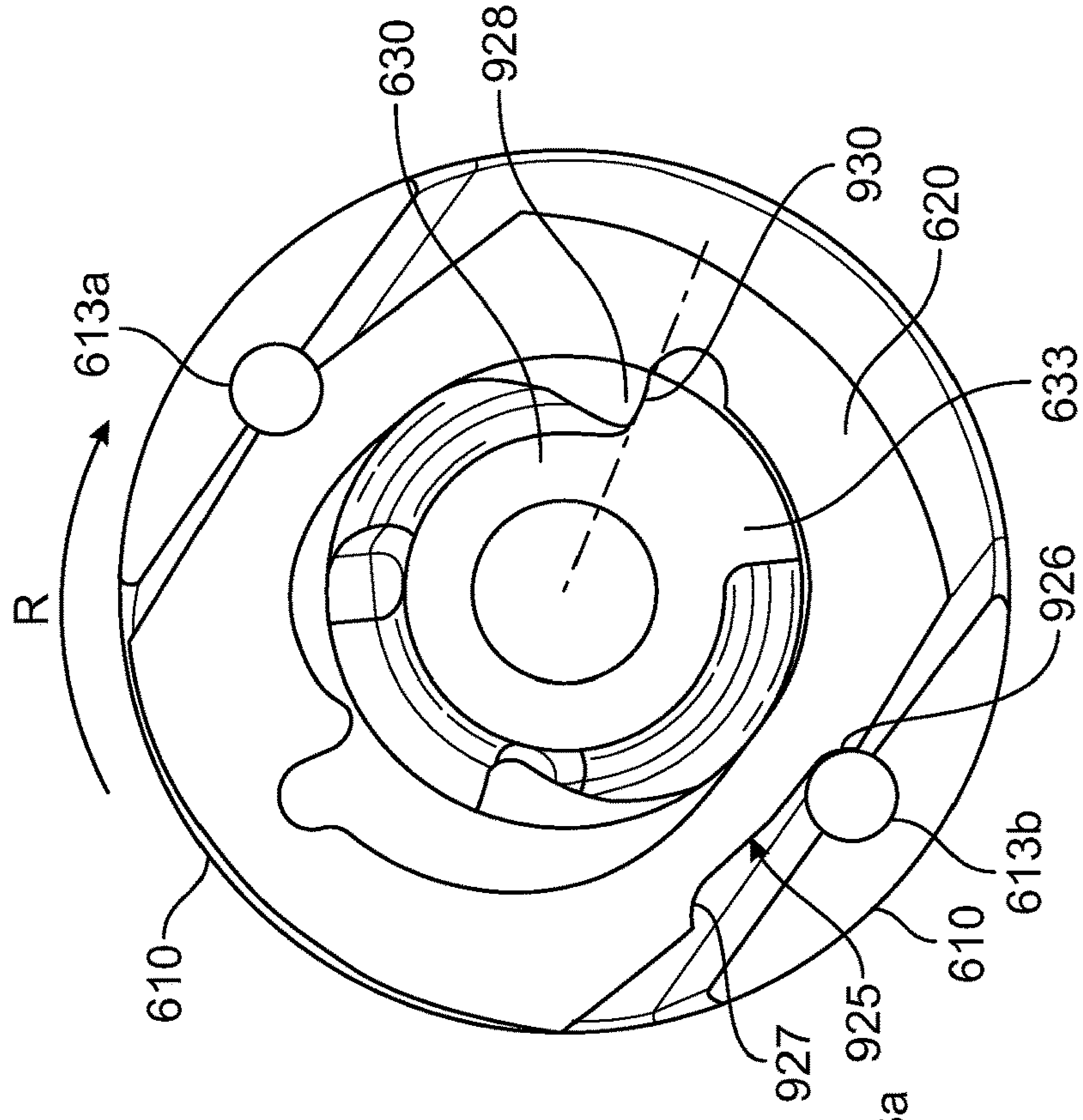

Figure 12

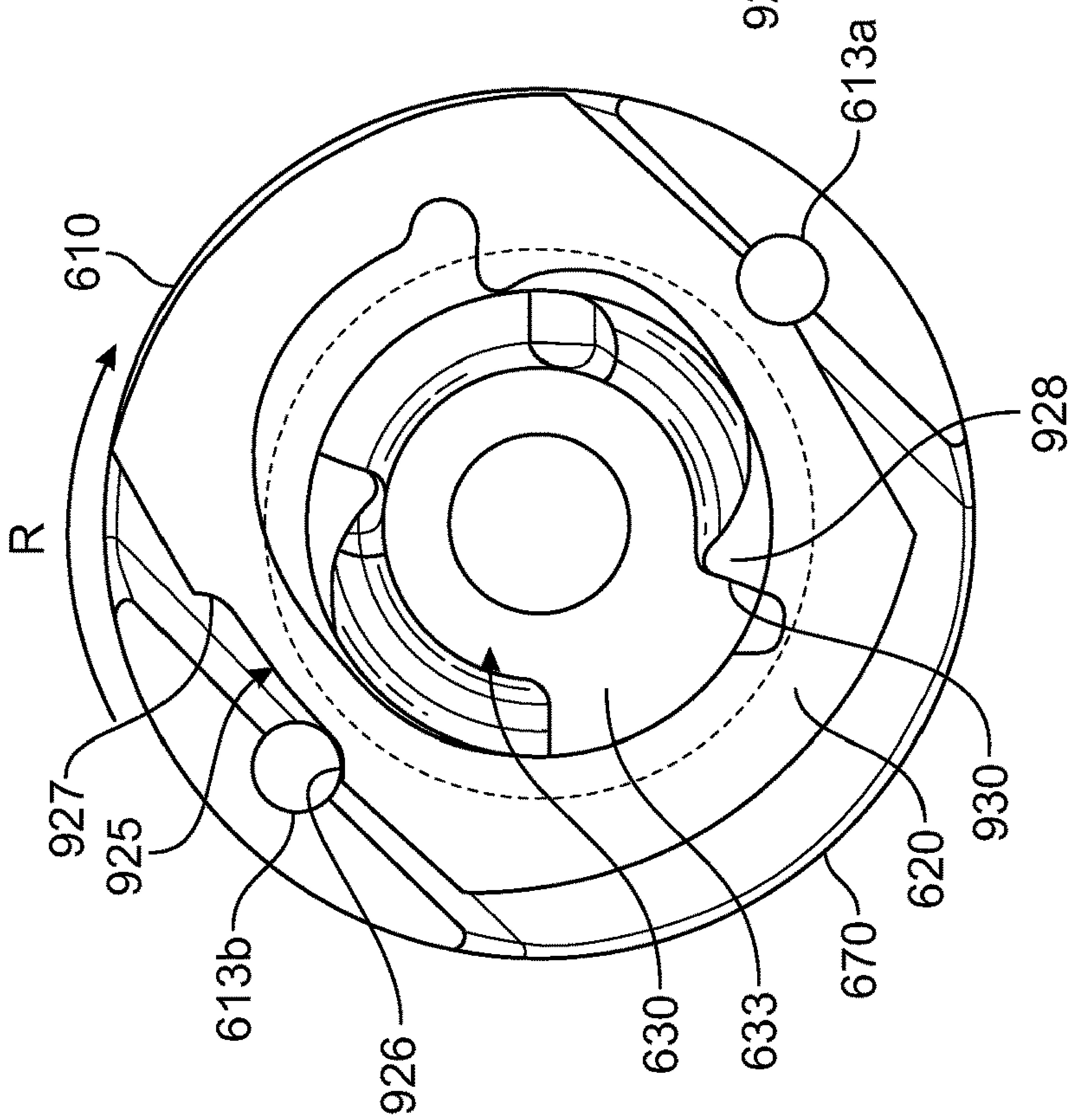

Figure 11

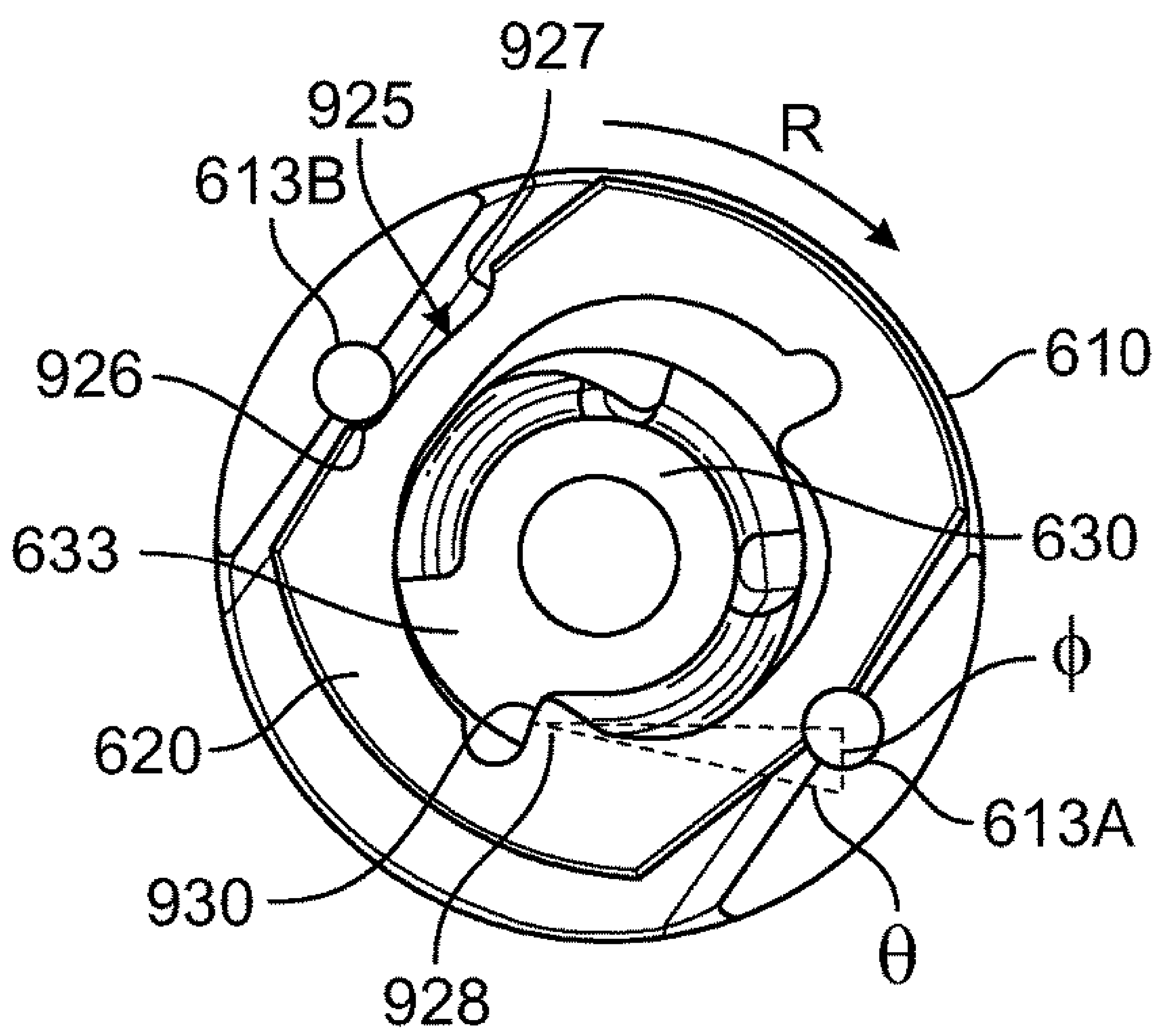

Figure 13

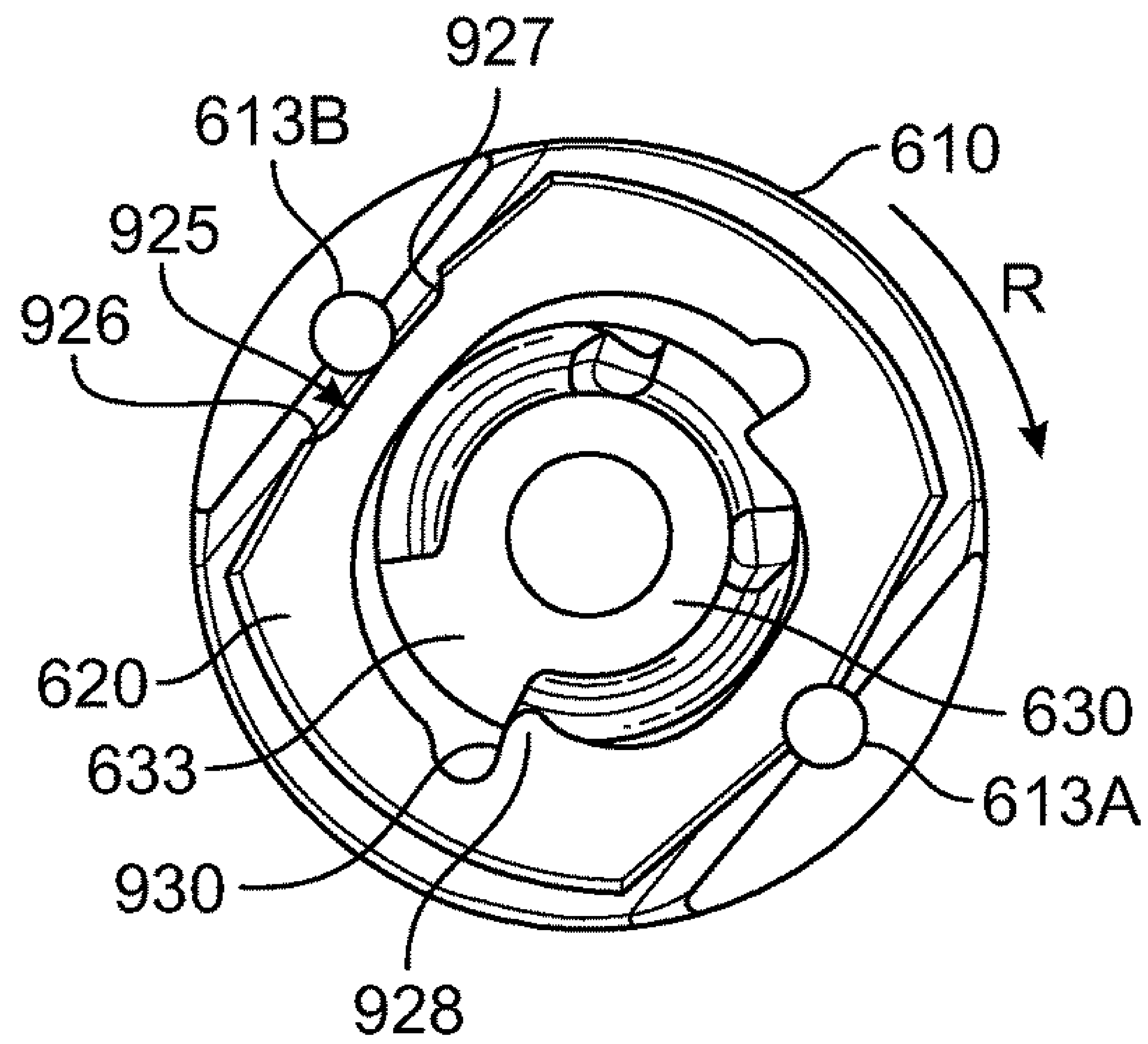

Figure 14

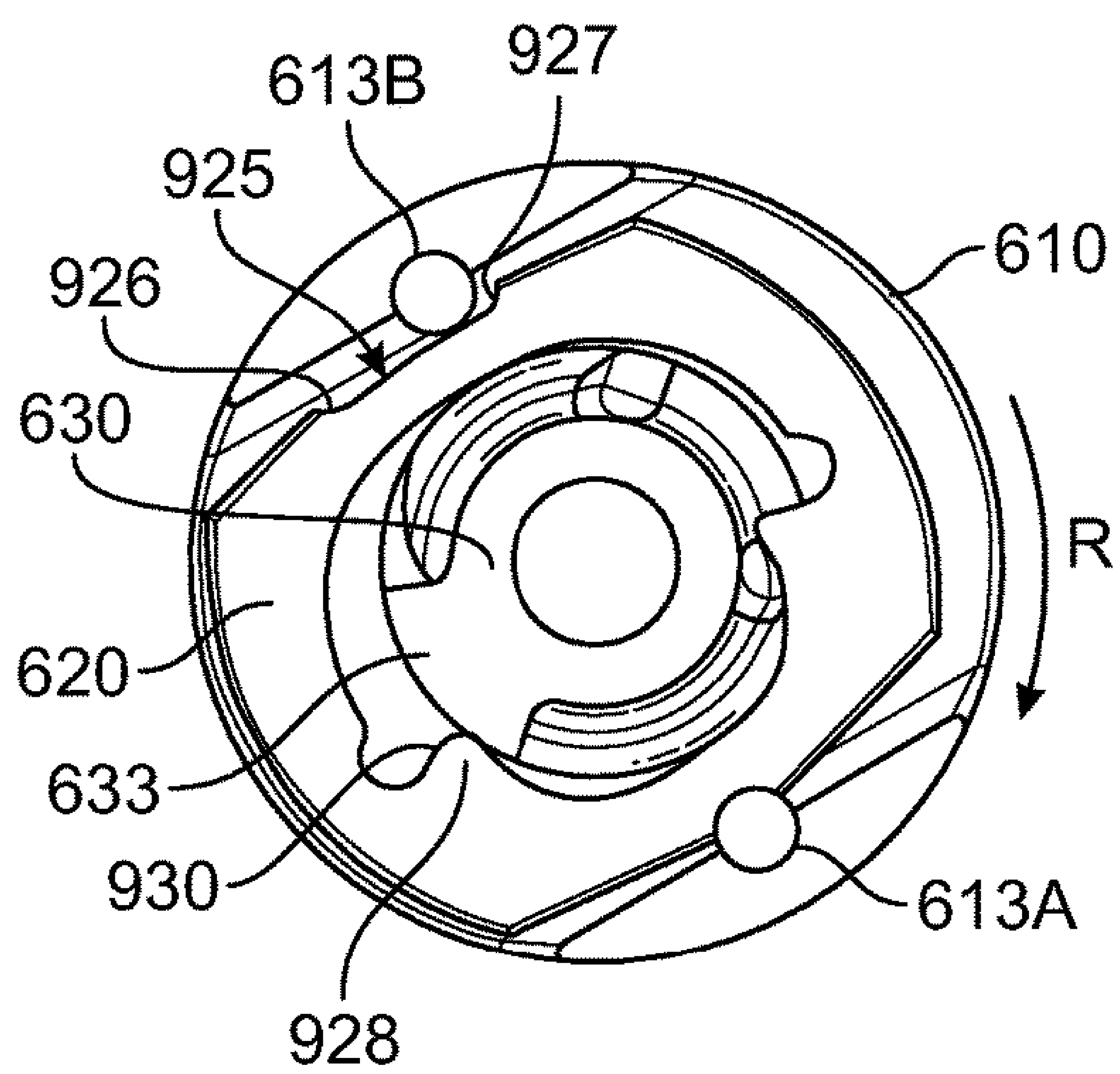

Figure 15

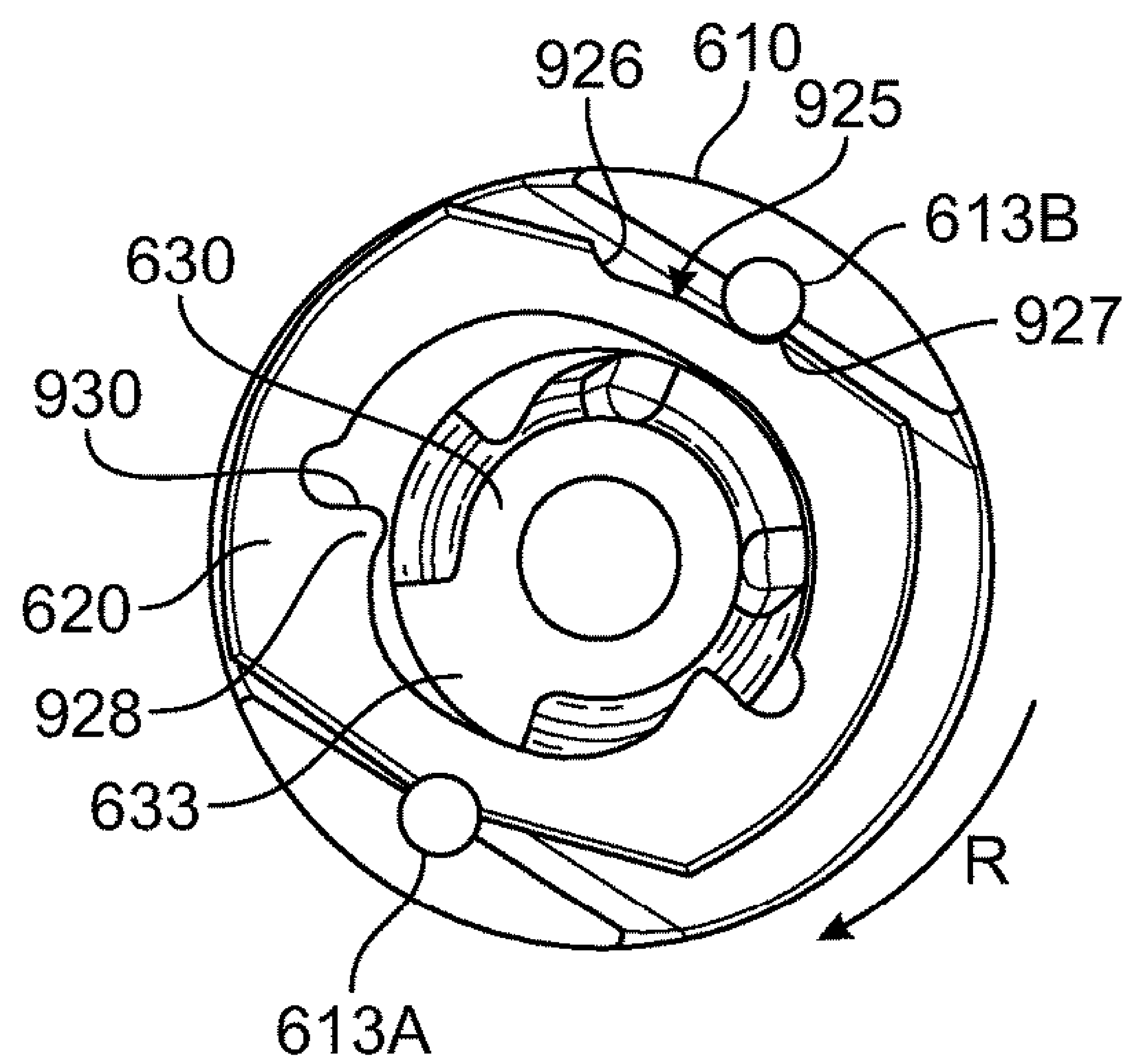

Figure 16

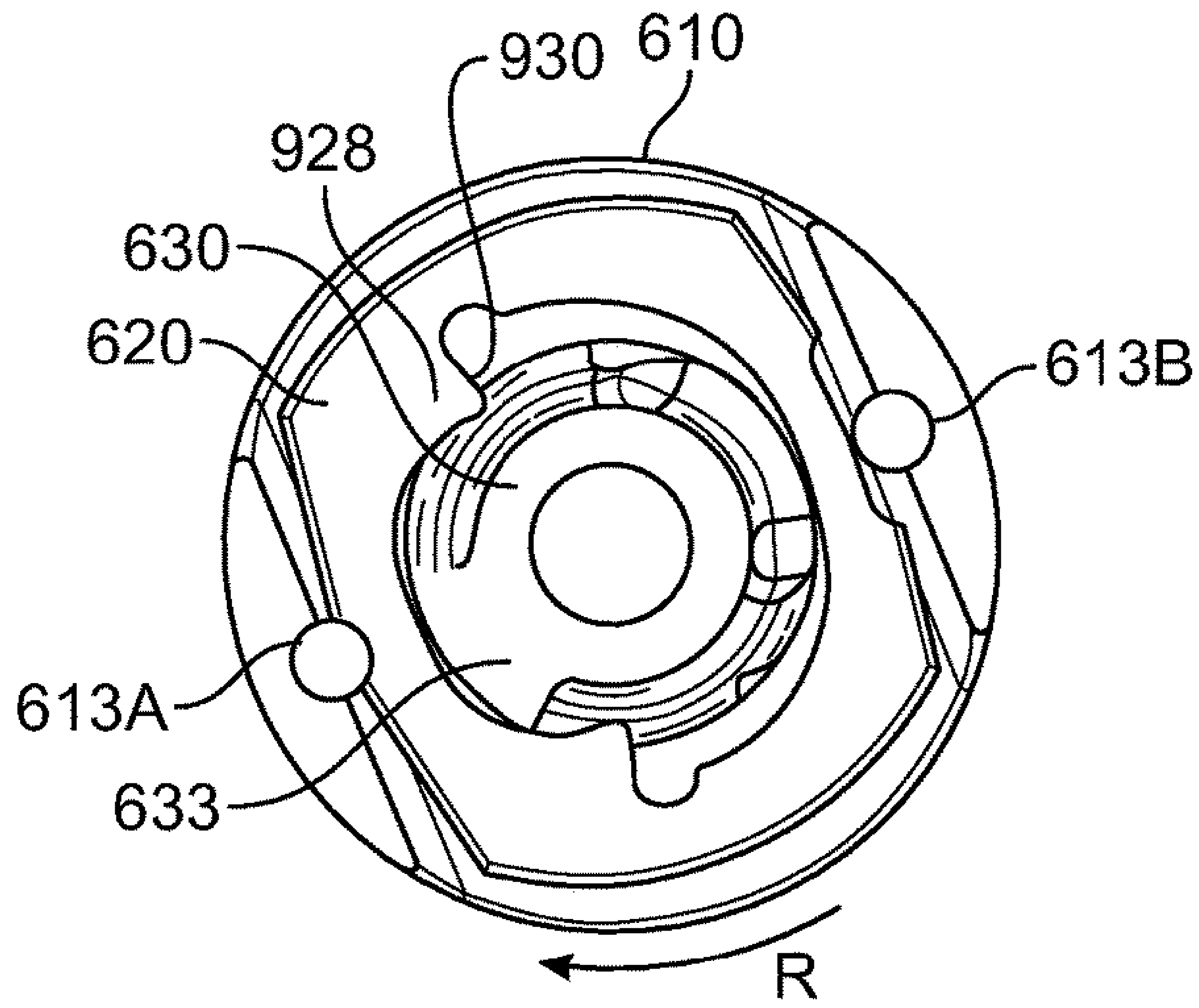

Figure 17

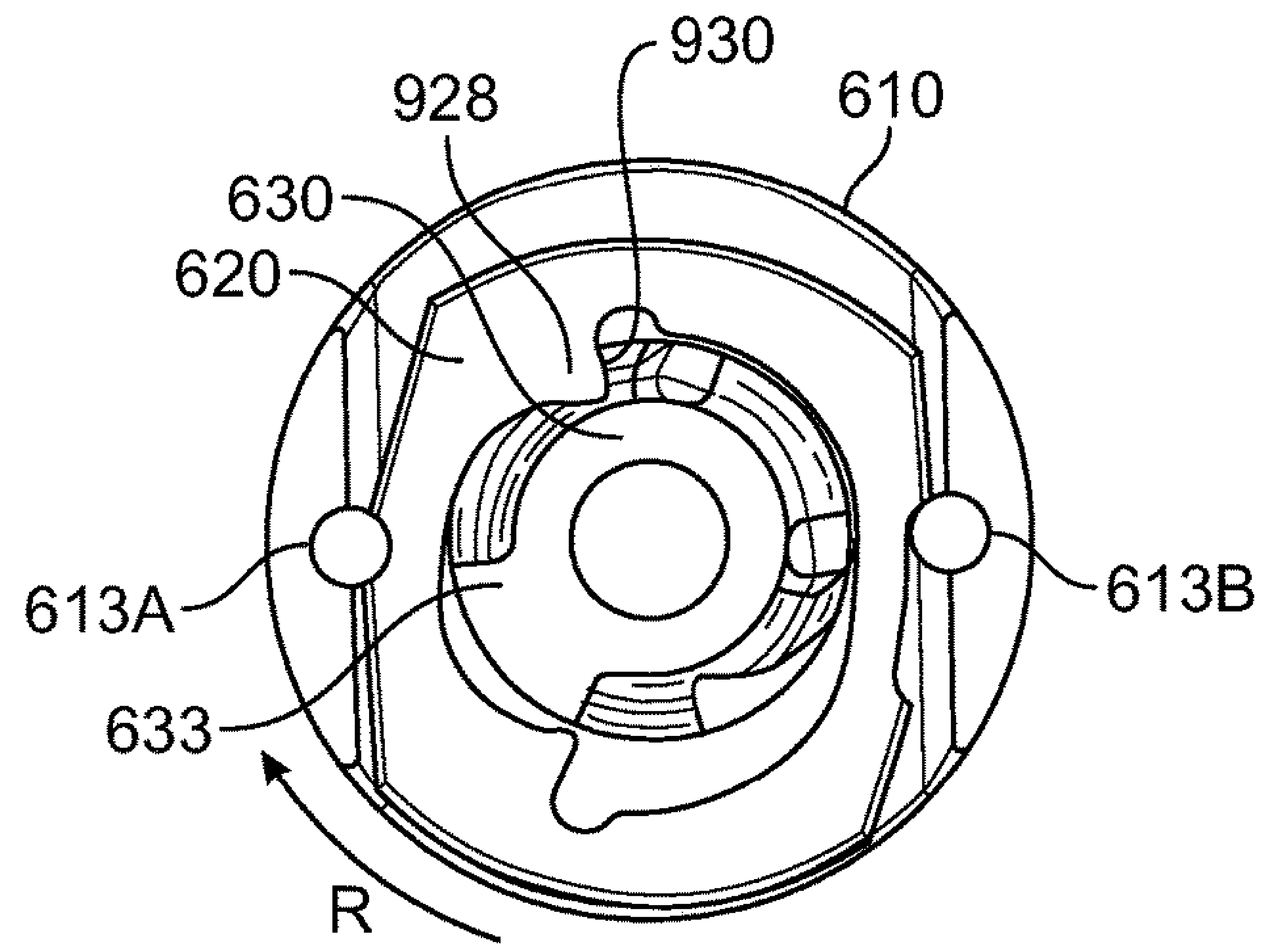

Figure 18

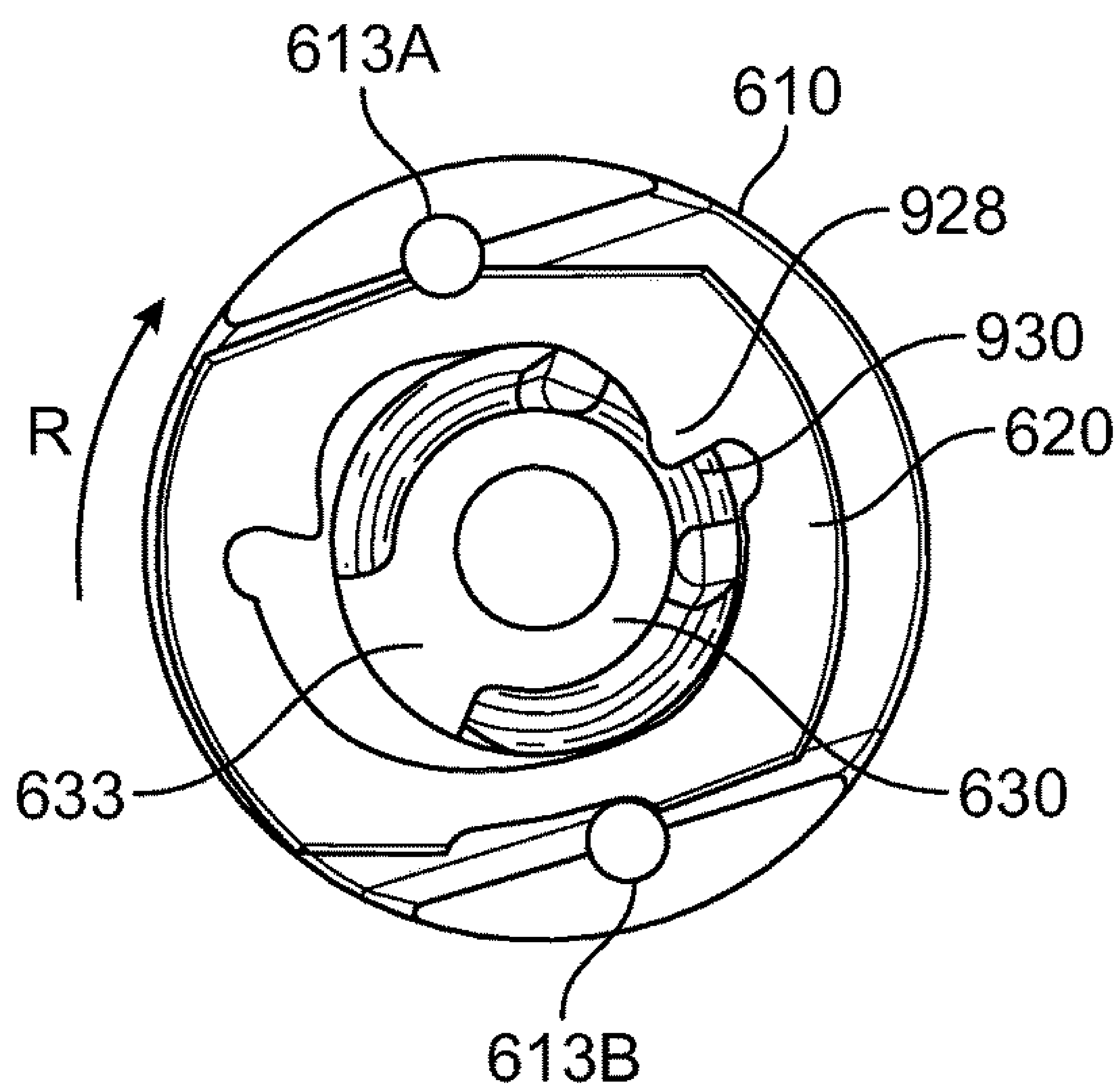

Figure 19

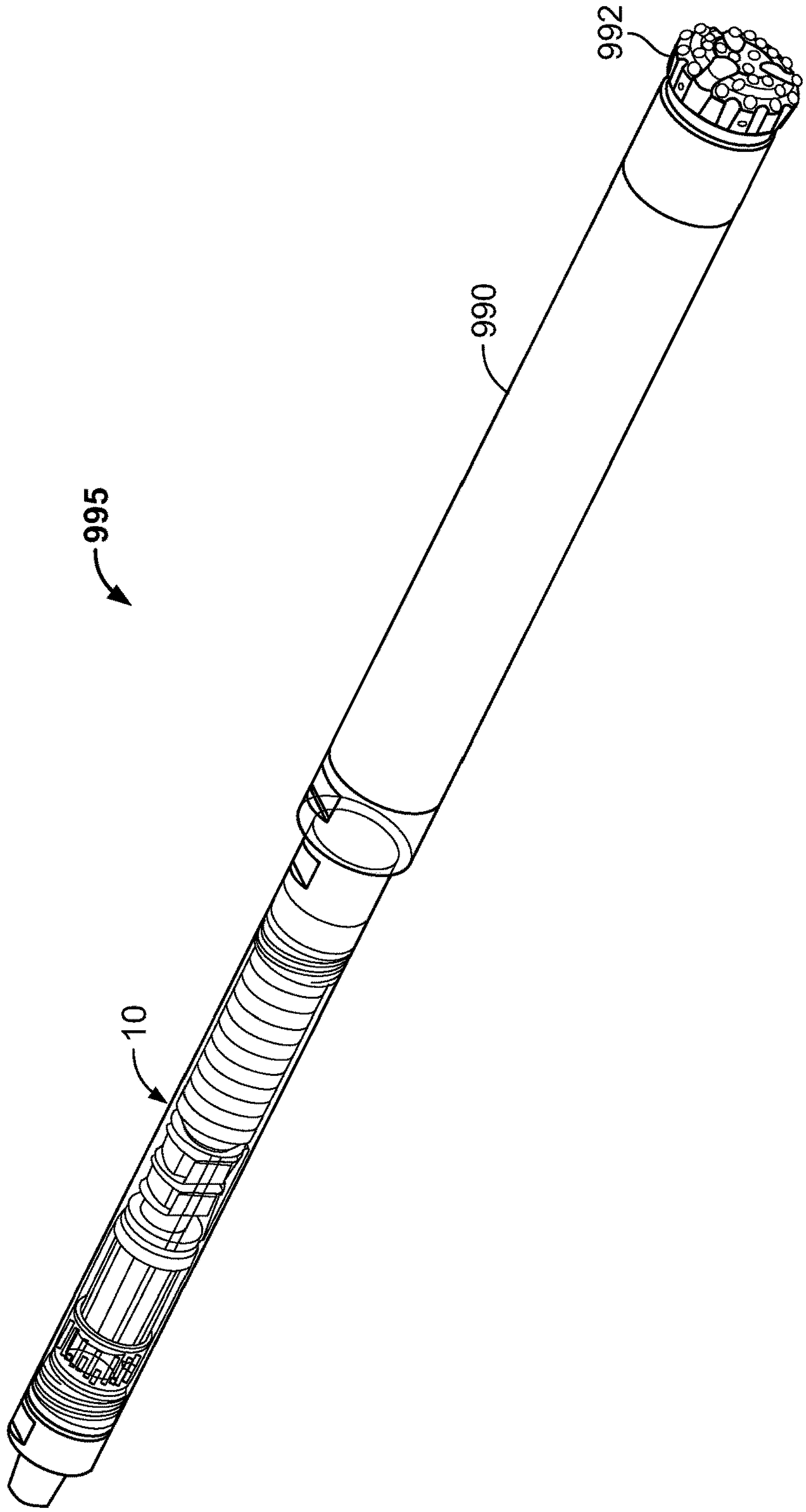

Figure 20

FLUID DRIVEN DRILLING MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. Provisional Patent Application No. 61/785,431, "AIR DRIVEN DOWNHOLE DRILLING MOTOR", filed Mar. 14, 2013, which is incorporated by reference herein in its entirety.

STATEMENT OF GOVERNMENT INTEREST

The United States Government has rights in this invention pursuant to Contract No. DE-AC04-94AL85000 between the United States Department of Energy and Sandia Corporation, for the operation of the Sandia National Laboratories.

FIELD

The present invention relates to the field of motors, and specifically to using a pressurized fluid to drive a rotary, indexing motor for a drill assembly.

BACKGROUND

Down-the-hole (DTH) drills are used for oil drilling, geothermal drilling, and other deep earth penetration applications. For nearly any drilling method, rotational energy must be transferred downhole in order to promote rock reduction. The drill bit may be rotated by an electric motor or fluid/hydraulic system. The rotating action can be produced either at the surface or near the drill bit. In additional to rotational cutting, drills may also be pressurized or mechanically actuated to force the drill bit to hammer against the rock/earth. Prior art rotation systems and methods are complex, require large form factors to create sufficient torque, and require a high degree of maintenance.

The most common method of downhole energy transfer is rigid drill pipe. The drill pipe is rotated from the surface, with 30 ft drilling joints added for tripping (moving in and out of the hole). For this type of system, the entire drill string rotates. Typically a rotary table system or a top drive is used to drive the drill string. Although it is well suited for vertical drilling, it has limited applications in directional drilling because the drill string curvature and thrust loads generate additional torque that the surface based motor must overcome and drill pipe survive.

Downhole techniques used to generate rotation such as positive displacement motors (PDMs) are limited in their temperature range due to the use of elastomers. Energy resources like geothermal and deep oil and gas wells lie in hot (160° C.-300° C.), and often hard rock. The high-temperatures limit the use of PDM's in those environments.

What is needed is a drill rotation system and method that overcomes the limitations of the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial cut away view of a motor assembly according to an embodiment of the disclosure.

FIG. **2** is a cut away view of the motor assembly of FIG. **1** taken along the center axis of the motor assembly

FIG. **3** is a first end perspective, partial see-through view of a vane motor according to an embodiment of the disclosure.

FIG. **4** is a first end perspective, exploded, partial see-through view of the vane motor of FIG. **3**.

FIG. **5** is a second end perspective, exploded view of the vane motor of FIG. **3**.

FIG. **6** is a perspective view of a drive section according to an embodiment of the disclosure.

FIG. **7** is another perspective view of the drive section of FIG. **6**.

FIG. **8** is an exploded view of the drive section of FIG. **6**.

FIG. **9** is a perspective view of a hammer according to an embodiment of the invention.

FIG. **10** is another perspective view of the hammer of FIG. **9**.

FIG. **11** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at a first, initial position.

FIG. **12** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at a later position in time position when the hammer **620** has rotated the drive section **14** for a partial complete rotation.

FIG. **13** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at a later position in time position when the hammer **620** has rotated the drive section **14** for a complete rotation and has now stalled in the rotation.

FIG. **14** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **15** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **16** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **17** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **18** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **19** is a cross-sectional view taken along line A-A of FIG. **7** showing the hammer **620** engaging the drive section **14** at another later position in time position.

FIG. **20** is an embodiment of a drilling assembly according to the present disclosure.

Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

SUMMARY

According to an embodiment of the disclosure, a motor assembly is disclosed that includes an engagement mechanism that provides improved peak torque to an output shaft in a compact form factor. The motor includes a vane motor coupled to a drive section. The drive section includes cam lobes releasably coupled to an output shaft.

According to another embodiment of the disclosure, a motor assembly is disclosed that includes a casing, a vane motor disposed within the casing, a drive section coupled to the vane motor; and an output shaft coupled to the drive section. The drive section includes a drive hammer coupled to the vane motor that engages the output shaft to provide rotation thereto.

According to another embodiment of the disclosure, a drill assembly is disclosed that includes a motor assembly a drill bit assembly coupled to the output shaft of the motor assembly. The motor assembly includes a casing, a vane motor disposed within the casing, a drive section coupled to the vane motor; and an output shaft coupled to the drive section. The drive section includes a drive hammer coupled to the vane motor that engages the output shaft to provide rotation thereto.

An advantage of the disclosed motor assembly is improved peak torque to an output shaft in a compact form factor.

Another advantage of the disclosed motor assembly is that the motor assembly is capable of generating rotation during drilling in extreme conditions such as high-temperature. This is due to the fact that it does not require elastomeric components, unlike conventional drilling motors.

Another advantage of the disclosed motor assembly is that the power delivery does not require a gear set to transmit power. The design allows high torque generation in a compact package.

Another advantage of the disclosed motor assembly is the compact packaging can allow directional control using down-the-hole hammer (DTHH).

Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. **1** and **2** shows an embodiment of a motor assembly **10** according to the present disclosure. The motor assembly **10** includes a vane motor **12**, a drive section **14** and a bearing/shaft section **16** disposed within an outer casing **18**. The motor assembly **10** further includes an input end cap **20** and an output end cap **22**. The motor assembly **10** is coupled to a coupler **24**.

The input end cap **20** is coupled to the outer casing **18** via threads **26**. In another embodiment, the input end cap **20** may be welded, brazed or fastened to the outer casing **18**. The input end cap **20** includes an internal fluid passage **28** having an inlet **30** and an outlet **32** for receiving and exiting a fluid, respectively.

FIGS. **3** to **5** show various perspective and exploded views of the vane motor **12**. As can be seen, the vane motor **12** includes a rotor or motor body **210**, a stator or housing **220**, an air distributor, **230**, a first bearing plate **240**, and orifice **245**, and a second bearing plate **250**.

The motor body **210** includes a motor shaft **211** and a vane section **212**. The motor shaft **211** includes a first end **213** for centrally positioning the motor body **210** in the second bearing plate **250**, which allows the motor body **210** to freely rotate adjacent the second bearing plate **250**. The motor shaft **211** also includes a second end **214** for centrally positioning the motor body in the first bearing plate **240** and for coupling the vane motor **12** to the drive section **14** (see FIG. **2**). The second end **214** includes tabs or protrusions **215** for engaging the drive section **14** thereby transferring rotation from the vane motor **12** to the drive section **14**. In another embodiment, the second end **214** may include protrusions, slots, pins or other engagement devices for coupling the vane motor **12** to the drive section **14**. The motor shaft **211** further includes a through passage **216** extending from the first end **213** to the second end **214**.

The vane section **212** includes vane section body **218** attached to the motor shaft **211**. The vane body section **218** may be attached to the motor shaft **211** by welding, brazing or other suitable joining method. In another embodiment, the vane body section **218** may be integral to the shaft **211**. The vane section **212** further includes vanes **217** attached to the vane section body **218**. The areas between the vanes **217** are referred to as chambers **217**A. As is appreciated by one of ordinary skill in the art, the vane section body **218** is eccentric with respect to the housing **220**. In this manner, the vanes **217** are mounted to the vane body section **218** at offset depths in the vane section body **218** as shown in FIGS. **3**-**5**.

The motor body **210** is disposed or fits within the housing **220** in such a manner that the motor body **210** may freely rotate within the housing **220**. The housing **220** includes a cavity **221** and has a first end **222** and a second end **224**. The cavity **221** is configured to circumferentially surround the vane section **212**.

The first bearing plate **240** is attached to the first end **224** of the housing **220** by screw fasteners (not shown). In another embodiment, the first bearing plate **240** may be attached to the housing **220** by welding, brazing, fasteners or other joining method. The first bearing plate **240** includes a bearing **242** and a passage **244** for receiving the motor shaft **211** and allowing the motor shaft **211** to rotate, respectively.

The second bearing plate **250** is attached to the second end **224** of the housing **220** by screw fasteners (not shown). In another embodiment, the second bearing plate **250** may be attached to the housing **220** by welding, brazing, fasteners or other joining method. The second bearing plate **250** includes a bearing **252** and a passage **254** for receiving the motor shaft **211** and allowing the motor shaft **211** to rotate. The second bearing plate **250** also includes channels **258** for distributing a fluid provided by the air distributor **230** to the motor body **210**.

The air distributor **230** is attached to the second bearing plate **250** by screw fasteners (not shown). In another embodiment, the air distributor **230** may be attached to the housing **220** by welding, brazing, fasteners or other joining method. The air distributor **230** includes an inlet **232** for receiving a fluid from the fluid passage **28** of the input end cap **20** (see FIG. **2**). The air distributor **230** may include one or more seals **233** for fluidly sealing the air distributor **230** to the input end cap **20**. The air distributor **230** further includes a passage **234** for allowing a fluid to travel from the input end cap **20** to the passage **254** of the second bearing plate **250**. The air distributor **230** further includes one or more channels **236** between the passage **234** and a first surface **238** of the air distributor.

In such a manner, fluid may flow from the passage **234** of the air distributor **230** to the second bearing plate passage **254**, or fluid may flow from the passage **234** into the channels **236** and then into channels **258** of the second bearing plate **250**. The amount of fluid that flows through the second bearing plate passage **254** is controlled by orifice **245**.

Orifice **245** is disposed within the first end **213** of the motor shaft **211**. In another embodiment, the orifice **245** may be disposed within the motor shaft **211**, the passage **254** of the second bearing **250**, or both. The orifice **245** includes a passage **246** that allows a predetermined amount of fluid to pass through the orifice **245** from the passage **254** of the second bearing to the through passage **216** of the shaft **211**. In another embodiment, the orifice **245** may have no passage **246** and functions as a plug to prevent any fluid from entering the through passage **216**.

During operation, fluid enters the inlet **30** of inlet section **20**, passes through fluid passage **28** and exits the outlet **32** into the inlet **232** of the passage **234** of the air distributor **230**. The fluid then enters the channels **236** of the air distributor **230** to be distributed to the channels **258** of the second bearing plate **250** to be directed to the chambers

217A of the motor body **210** or passes through the orifice **245** to enter the through passage **216** of the motor shaft **211**, or both. As the fluid travels through the chambers **217**A, the vane motor **12** rotates due to pressure differences in the chambers **217**A. As discussed above, the vane body section **218** is mounted with an eccentricity E_V with respect to the housing **220**. The eccentricity creates a variable volume between neighboring chambers **217**A. The differential pressure between neighboring chambers **217**A results in a non-zero net force. The seal between the vanes **217** and the housing **220** is created by either spring forces or air pressure.

The fluid may be a gas or liquid. In an embodiment, the fluid may be a pressurized gas such as, but not limited to air, nitrogen, or drilling foam. In an embodiment, the pressurized gas may be at a pressure between about 200 psi to about 500 psi. In another embodiment, the fluid may be a pressurized liquid, such as, but not limited to water, hydraulic fluid, or oil.

FIGS. **6**-**8** show an embodiment of the drive section **14** according to an embodiment of the disclosure. The drive section **14** includes a hammer assembly **605** including a hammer housing **610**, hammers **620**, and an output shaft **630**. In this exemplary embodiment, the drive section **14** includes 2 hammers **620**. In another embodiment, the drive section **14** may include one or more hammers **620**. The hammer housing **610** includes openings **611** for receiving the hammers **620**. The hammer housing **610** also includes a passage **612** for allowing the output shaft **630** to extend through the openings **611**. The hammer housing **610** also includes pins **613** for positioning the hammers **620** within the openings **611**, and set screws **614** for securing the pins **613** in the housing **610**. In another embodiment, the pins **613** may be secured within the housing **610** by welding, brazing, or other faster device.

As can be seen in FIG. **7**, the housing **610** has a first end surface **615** having openings **616** for receiving the pins **613** (not shown) and set screws **614**. The first end surface **615** also has a through passage **617** extending into the openings **611**. The through passage **617** has splines **618** configured to mate and engage with protrusions **215** of motor shaft **211** such that rotation of the motor shaft **211** rotates the drive section **14**.

Referring again to FIGS. **6**-**8**, the output shaft **630** includes a hammer engagement portion **631** and a shaft portion **632**. The hammer engagement portion **631** includes protrusions or tabs **633** extending radially therefrom for engaging hammers **620**. The number of tabs **633** corresponds to the number of hammers **620**. The hammer engagement portion **631** of the output shaft **630** extends through the through the hammer housing passage **612**, through passages **623** of the hammers **620**, and into through passage **617**. The output shaft **630** has a through passage **633** extending through the axial length of the output shaft **630** for receiving fluid from the through passage **617**.

FIGS. **9** and **10** show perspective views of a hammer **620**. As can be seen in FIGS. **9** and **10**, a hammer **620** includes an outer perimeter surface **921**, and an inner perimeter surface **922** defining a through passage **923**. The outer surface **921** includes a recess or slot **924** for engaging a pin **613***a* (see FIG. **8**) in such a manner that the pin **613***a* can rotate in the slot **924**. The outer surface **921** further includes a trough **925** that allows another pin **613***b* (see FIG. **8**) to move within in a confined manner. The movement of pin **613***b* is limited to the width W of trough **925** defined by a first ridge **926** and a second ridge **927**.

As can be further seen in FIGS. **9** and **10**, the inner perimeter surface **922** includes a first protrusion **928** and a second protrusion **929**. The first protrusion **928** includes an engagement surface **930**. The second protrusion **929** includes a sliding surface **931**.

The rotation of the output shaft **630** by the vane motor **12** will now be described by referring to FIGS. **11**-**19** discussed in the following paragraphs.

FIG. **11** shows a cross-sectional view of FIG. **7** taken along line A-A showing a hammer **620** engaging the output shaft **630** at a first, initial position. As can be seen in FIG. **11**, the hammer **610** has been rotated in a direction R by the vane motor **12** (FIGS. **1** and **2**) such that the engagement surface **930** of the first protrusion **928** is in contact and engaging tab **633** of output shaft **630**. Also, first pin **613***a* is in rotational contact within slot **924** and the second pin **613***b* is in the trough **925** and in contact with first ridge **926**. At this time, the hammer **610** has enough rotational energy to provide sufficient torque to rotate the output shaft **630** to the position shown in FIG. **12**. It should be noted that the first pin **613***a* is in the trough (not shown) of the second hammer, positioned behind the shown hammer in this figure, and that the second pin **613***b* is in the slot of the second hammer.

An analysis of the energy transfer during rotation is as follows. The rotational hammer is used to generate rotation in the output shaft through the transfer of angular momentum. The rotating hammer is driven to a specified angular velocity before impacting the output shaft. Upon impact, energy is transferred from the rotating hammer to the output shaft, resulting in rotational advancement.

Analysis of the rotating hammer system begins with the vane motor. Given an input pressure P_1 and outlet pressure P_2, the moment delivered by the motor is given by Equation (1). In the equation, C_M is a geometric parameter, L_V is the length of the motor, Z_V is the number of vanes.

$$M_M = \frac{C_M \cdot R_R^2 \cdot L_V \cdot Z_V}{2\pi}(P_1 - P_2) \tag{1}$$

The geometric parameter C_M is given by

$$C_M = \frac{1}{a_m}\left[\begin{array}{c} \varphi_V\left(a_m + \frac{1}{2}\right) - 2(a_m+1)\cos\left(\varphi_1 + \frac{\varphi_V}{2}\right)\sin\left(\frac{\varphi_V}{2}\right) + \\ \frac{1}{2}\cos\left(2\varphi_1 + \frac{\varphi_V}{2}\right)\sin(\beta_m) \end{array}\right] \tag{2}$$

where $a_m = R_R/H_V$, φ_V is the angle between vanes, and ω_1 is the angle at the end of the charging process.

If the moment is known, then the equation of motion for the rotational hammer is given by Equation (3). In the equation, I_1 is the mass moment of inertia of the body, and M_{impact} is the torque rebound due to impact. The equation shows that the applied moment from the vane motor is resisted by the impact between the rotational hammer and the output shaft.

$$I_1\ddot{\theta}_1 = M_M - M_{impact}(t) \tag{3}$$

The impact moment M_{impact} is estimated from the angular impulse imparted to the output shaft. Treating the rotating hammer and the output shaft as a system, the conservation of momentum for the system is given by Equation (4).

$$I_1\omega_1 + I_2\omega_2 = I_1\omega_1' + I_2\omega_2' \tag{4}$$

The relationship between the rotational speeds before and after impact is given by the coefficient of restitution e.

$$e = \frac{\omega_2' - \omega_1'}{\omega_1 - \omega_2} \quad (5)$$

Looking at the components individually, the moment impulse imparted on the output shaft to cause rotation is given by

$$I_2\omega_2 + M_{impact}\Delta t = I_2\omega_2' \quad (6)$$

The equation of motion for the output shaft takes a similar form. Assuming the impact moment accelerates the output shaft from rest, then the equation of motion is given by

$$I_2\ddot{\theta}_2 = M_{impact}(t) - M_{WOB} \quad (7)$$

The estimated torque load from the weight on output shaft is given by

$$M_{WOB} = \frac{\mu \cdot d \cdot WOB}{3 \cdot C_{area}} \quad (8)$$

where μ is the coefficient of friction, d is the output shaft diameter, WOB is the weight on the output shaft, and C_{area} is the ratio of the button area (the button area being the surface area of the cutting inserts contacting the cutting surface) to the output shaft face.

FIG. **13** shows a point in time when the hammer **620** and output shaft **630** has continued to rotate in direction R from the position shown in FIG. **12** with the engagement surface **930** of the first protrusion **928** in contact and engaging tab **633** of output shaft **630**. Also, first pin **613**A is in rotational contact within slot **924** and the second pin **613**B is in the trough **925** and in contact with first ridge **925**. At this time, the hammer **610** does not have enough rotational energy to provide sufficient torque to rotate the output shaft **630**. For example, the output shaft **630** may be coupled to a drill bit (not shown) that has engaged a surface that requires more torque to rotate the drill bit than is being provided by the hammer **610**.

An analysis of the applied force between the hammer and output shaft at the position shown in FIG. **13** is as follows. A force vector due to the torque applied by the vane motor exists between the driving pin **613**A and the impact face **930**. The force vector has a component normal ϕ to the impact face and parallel θ to the impact face. The normal force creates a friction force between the lobe or protrusion **928** of the hammer **620** and the protrusion or tab **633** of the output shaft **630**. If the friction force exceeds the force component parallel to the impact face, the hammer **620** will not release from the output shaft **630**. The hammer protrusion **928** will begin to release from the tab **633** when the parallel force component exceeds the normal force. This releasing force can be designed into the system by adjusting the contact angle between the hammer protrusion **928** and drive shaft tab **633**.

FIG. **14** shows a point in time when the first protrusion **928** is about to disengage from the tab **633**. As can be seen in FIG. **13**, the second pin **613***b* has begun to move across the trough **925** towards the second ridge **927**. As can be further seen in FIG. **14**, the hammer **610** has begun to reposition in the housing **610**.

FIG. **15** shows a point in time when the first protrusion **928** has moved past the tab **633** and the hammer **610** has continued to rotate R as the output shaft **630** remains stationary. As can be seen in FIG. **15**, the first protrusion **928** is no longer engaged with the tab **928**, but is in sliding contact with the tab **633**, allowing the hammer **610** to rotate. The second pin **613***b* continues to move across the trough **925** towards the second ridge **927**. As can be further seen in FIG. **15**, the hammer **610** has continued to reposition in the housing **610**.

FIG. **16** shows a point in time when the hammer **610** has continued to rotate R as the output shaft **630** remains stationary, As can be seen in FIG. **16**, the second pin **613***b* has moved across the trough **925** and is in contact with second ridge **927**. As can be further seen in FIG. **16**, the hammer **610** has repositioned in the housing **610**.

FIG. **17** shows a point in time when the hammer **610** has continued to rotate R as the output shaft **630** remains stationary. As can be seen in FIG. **17**, the hammer **610** is in contact with the tab **928** and the second pin **613***b* has started to move back towards the first ledge **926**.

FIG. **18** shows a point in time when the hammer **610** has continued to rotate R as the output shaft **630** remains stationary. As can be seen in FIG. **18**, the hammer **610** is not in contact the tab **633** or any part of the output shaft **630** and the second pin **613**B has moved back into contact with the first ledge **926**.

FIG. **19** shows a point in time when the hammer **610** has continued to rotate R as the output shaft **630** remains stationary. As can be seen in FIG. **19**, the hammer **610** is free to rotate until striking and contacting the tab **633** in the position shown in FIG. **11**. At that time, energy is transferred from the hammer **610** to the tab **633**, and ultimately to the output shaft **630**, to rotate the output shaft **630** if enough torque can be transferred from the hammer **610** to the tab **633**. If sufficient torque exists, the hammer **610** will continue to rotate the output shaft **630**. When insufficient torque exits to rotate the output shaft **630**, such as for example when the output shaft **630** is connected to a drill bit that has engaged a restrictive surface, the tab **633** begins to slip from the tab **633** as described above. The impulsive force generated between the hammer lobe and the drive shaft protrusion produces the output torque. This action repeats as long as the vane motor continues to receive input from the external fluid supply. The repeated impulsive force transfer creates the characteristic indexing action of the tool. The amount of rotation seen at the bit for each impulse depends on the reacting torque from the external load.

Referring again to FIGS. **1** and **2**, the output shaft **630** is supported in the bearing/shaft section **16** of the casing **18** by bearings **16**A. In this exemplary embodiment, the motor assembly **10** includes 10 bearings **16**A, however, in another embodiment, none, one, or more bearings may be used. Bearings **16**A may be roller bearings, angular contact or any type of bearing used to support shaft rotation.

The bearing/shaft section **16** is held in place in the casing **18** by output end cap **22**. Output end cap **22** is assembled to the casing **18** by threads **22**A. In another embodiment, the output end cap **22** may be welded, brazed or fastened to the casing **18**.

The coupler **24** is attached to the output shaft **30** by threads **25**. In another embodiment, the coupler **24** may be welded, brazed or fastened to the output shaft **30**. The coupler **24** includes an internal fluid passage **26** having an inlet **26**A and an outlet **26**B. The inlet **26**A is in fluid connectivity with the passage **633** of the outlet shaft **630** so as to receive fluid therefrom and discharge fluid via the outlet **26**B. The coupler **24** may be attached to a shaft, drill bit, or other extension for providing rotation to a tool or device.

FIG. **20** shows the motor assembly **10** shown in FIG. **1** attached to a drilling shaft **990** and bit **992** to form a drilling assembly **995**. As will be appreciated by one of ordinary skill in the art, this configuration is exemplary, and other shaft and bit configurations, including, but not limited to flexible shaft and rotary hammer assemblies, may be used.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A motor assembly, comprising:

a casing;

a vane motor disposed within the casing;

wherein the vane motor comprises:

a shaft having a shaft passage therethrough;

a motor assembly comprising a plurality of vanes defining a plurality of chambers, the motor assembly disposed around the shaft;

an orifice component disposed in the shaft passage and in fluid connectivity with the shaft passage that regulates fluid distribution between the shaft passage and the plurality of chambers;

a drive section coupled to the vane motor; and

an output shaft coupled to the drive section;

wherein the drive section comprises:

a drive hammer coupled to the vane motor that engages the output shaft to provide rotation thereto; and

wherein the drive hammer comprises two lobes that strike two corresponding tabs on the output shaft sequentially per revolution to provide two impulses per revolution to generate the provided rotation thereto;

wherein the output shaft comprises an output shaft passage therethrough in fluid connectivity with the shaft passage; and

wherein the orifice component comprises a body comprising a passage within the orifice component that regulates fluid distribution between the shaft passage and the plurality of chambers.

2. The motor assembly of claim **1**, wherein the drive section further comprises:

a housing; and

pins attached to the housing that contact the drive hammer such that the drive hammer can pivot about one pin of the pins to change position within the housing.

3. The motor assembly of claim **2**, wherein the change of position of the drive hammer causes the drive hammer to disengage from the drive section.

4. The motor assembly of claim **2**, wherein the drive hammer includes a slot that allows for rotational contact with a pin of the pins attached to the housing, and wherein the drive hammer further includes a trough that allows for sliding contact with a second pin of the pins attached to the housing.

5. The motor assembly of claim **4**, wherein the output shaft comprises:

a tab for releasably engaging the drive hammer.

6. The motor assembly of claim **5**, wherein the corresponding tabs are released from the drive section when a predetermined amount of torque is applied from the hammer to the drive section.

7. The motor assembly of claim **4**, wherein the two lobes strike the two corresponding tabs in a releasable manner.

8. The motor assembly of claim **1**, wherein the two corresponding tabs releasably engage the drive hammer.

9. The motor assembly of claim **1**, wherein the two lobes strike the two corresponding tabs in a releasable manner.

10. The motor assembly of claim **9**, wherein the corresponding tabs are released from the drive section when a predetermined amount of torque is applied from the hammer to the drive section.

11. The drill assembly of claim **1**, wherein the drive section further comprises:

a housing; and

pins attached to the housing that contact the drive hammer such that the drive hammer can pivot about one pin of the pins to change position within the housing.

12. The motor assembly of claim **11**, wherein the drive hammer includes a slot that allows for rotational contact with a pin of the pins attached to the housing, and wherein the drive hammer further includes a trough that allows for sliding contact with a second pin of the pins attached to the housing.

13. A drill assembly, comprising:

a motor assembly comprising:

a casing;

a vane motor disposed within the casing;

wherein the vane motor comprises:

a shaft having a shaft passage therethrough;

a motor assembly comprising a plurality of vanes defining a plurality of chambers, the motor assembly disposed around the shaft;

an orifice component disposed in the shaft passage and in fluid connectivity with the shaft passage that regulates fluid distribution between the shaft passage and the plurality of chambers;

a drive section coupled to the vane motor;

an output shaft coupled to the drive section; and

a drill bit assembly coupled to the output shaft of the motor assembly;

wherein the drive section comprises:

a drive hammer coupled to the vane motor that engages the output shaft to provide rotation thereto; and

wherein the drive hammer comprises two lobes that strike two corresponding tabs on the output shaft sequentially per revolution to provide two impulses per revolution to generate the provided rotation thereto;

wherein the output shaft comprises an output shaft passage therethrough in fluid connectivity with the shaft passage; and

wherein the orifice component comprises a body comprising a passage within the orifice component that regulates fluid distribution between the shaft passage and the chambers.

14. The motor assembly of claim **13**, wherein the change of position of the drive hammer causes the drive hammer to disengage from the drive section.

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