(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 June 2009 (11.06.2009)

PCT

(10) International Publication Number
WO 2009/073341 A2

(51) International Patent Classification:
*E21B 4/02* (2006.01) *E21B 4/00* (2006.01)

(21) International Application Number:
PCT/US2008/083504

(22) International Filing Date:
14 November 2008 (14.11.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/947,526 29 November 2007 (29.11.2007) US

(71) Applicant *(for all designated States except US)*: **SMITH INTERNATIONAL, INC.** [US/US]; 16740 Hardy Street, Houston, TX 77032 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **TRAYLOR, Leland, B.** [US/US]; 851 East Kasey Circle, Draper, UT 84020 (US).

(74) Agents: **BERGMAN, Jeffrey, S.** et al.; Osha Liang LLP, 909 Fannin Street, Suite 3500, Houston, TX 77010 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*[Continued on next page]*

(54) Title: APPARATUS AND METHOD FOR A HYDRAULIC DIAPHRAGM DOWNHOLE MUD MOTOR

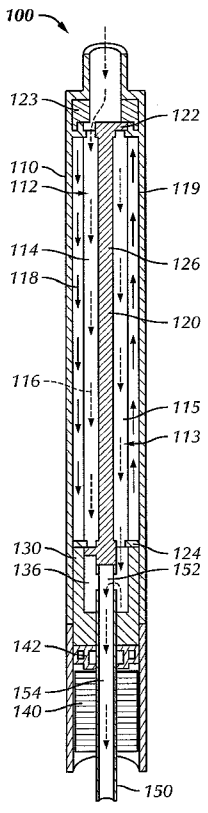



FIG. 1

(57) Abstract: A downhole motor to drill a wellbore including a pumping apparatus having a first chamber configured to receive a first fluid and a second fluid, and a first flexible diaphragm disposed with the first chamber configured to separate the first and second fluid, wherein the first flexible diaphragm is configured to transfer a hydraulic energy between the first fluid and the second fluid. In addition, the downhole motor includes a motor portion coupled to the pumping apparatus and configured to receive the second fluid and convert the hydraulic energy of the second fluid into a mechanical energy, thereby creating a torque. Further, the downhole motor includes a bit shaft coupled to the motor portion, configured to receive the torque from the motor portion and the first fluid from the pumping apparatus.

WO 2009/073341 A2

**Declarations under Rule 4.17:**

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

**Published:**

— *without international search report and to be republished upon receipt of that report*

# APPARATUS AND METHOD FOR A HYDRAULIC DIAPHRAGM DOWNHOLE MUD MOTOR

## Background of Disclosure

### Field of the Disclosure

**[0001]** Embodiments disclosed herein relate generally to apparatus and methods for downhole drilling operations. More specifically, embodiments disclosed herein relate to a downhole hole mud motor.

### Background Art

**[0002]** In the drilling of well bores in the oil and gas industry, it is common practice to use downhole motors to drive a drill bit through a formation. As used herein, a "downhole motor" may refer generally to any motor used in a well bore for drilling through a formation. These downhole motors may typically be driven by pumping drilling fluids (*e.g.*, "mud") from surface equipment downhole through the drill string. As such, this type of motor is commonly referred to as a mud motor. When in use, the drilling fluid may be forced from the surface through the motor portion of the mud motor, in which energy from the flow of the drilling fluid may be used to provide rotational force to a drill bit located below the mud motor. As used herein, a "motor portion" may refer to the portion of the downhole motor that generates torque. There are two primary types of mud motors: positive displacement motors ("PDM") and turbine motors.

**[0003]** The first type of mud motor, PDM, may be used to convert the energy of high-pressure drilling fluid into rotational-mechanical energy to rotate the drill bit. An early example of a PDM is given in U.S. Patent No. 4,187,918 ("Clark"). As shown in Clark, a PDM typically has a helical stator attached to a distal end of the drillstring. The PDM may also have an eccentric helical rotor that corresponds to the helical stator and is connected through a driveshaft to the remainder of a bottom hole assembly ("BHA") therebelow. Drilling fluids may be pressurized to flow through the bore of the drillstring to engage the stator and rotor, thereby creating a resultant

torque between the stator and the rotor. This torque may then be transmitted to the drill bit to rotate the drill bit. Historically, PDM's have been characterized as having a low-speed and high-torque when rotating the drill bit. Accordingly, PDM's may generally be best suited for use with roller cone and polycrystalline diamond compact (PDC) bits. However, the rotors of PDM's have been known to have eccentric motion, thereby creating large lateral vibrations that may damage other drill string components.

**[0004]** The second type of mud motor, the turbine motor, generally uses one or more turbine power sections to provide rotational force to a drill bit. Each power section may consist of a non-moving stator vane, and a rotor assembly comprising rotating vanes mechanically linked to a rotor shaft. These power sections are designed such that the vanes of the stator direct the flow of drilling fluid into corresponding rotor blades to provide rotation. The rotor shaft, which may be a single piece, or may comprise two or more connected shafts, such as a flexible shaft and an output shaft, then ultimately connects to and drives the drill bit. Thus, the high-speed drilling fluid flowing into the rotor vanes causes the rotor and the drill bit to rotate with respect to the stator housing. Historically, turbine motors have been characterized as having a high-speed and low-torque, when rotating the drill bit. Furthermore, because of the high speed, and because by design no component of the rotor moves in an eccentric path, the output of a turbine motor is typically smoother than the output of PDM's and considered appropriate for use with PDC bits drilling high compressive strength formations.

**[0005]** Drilling fluid, as used in oilfield applications, is typically pumped downhole through a bore of the drillstring at high pressure. Once downhole, the drilling fluid is pumped through the downhole mud motor, where the fluid is exposed to internal components of the downhole motor, such as bearings and seals. After the drilling fluid has passed through the downhole mud motor, the drilling fluid is then transferred to the drill bit and communicated to the well bore through a plurality of nozzles. Here the drilling fluid cools and lubricates the drill bit, in addition to cleaning drill cuttings away from cutting surfaces of the drill bit and the wellbore. The drilling fluid is then expelled to return to the surface through an annulus formed between the wellbore (*i.e.*, the inner diameter of either the formation or a casing string) and the outer profile of

the drillstring. Accordingly, the drilling mud returns to the surface carrying drill cuttings disposed therein. Because the drilling fluid is exposed to the internal components of the downhole motor, the chemical composition and viscosity of the drilling fluid must be carefully considered. The composition and viscosity may have a direct or indirect impact on the internal components of the downhole motor, such as reliability and maintainability.

**[0006]** Both the PDM and the turbine motor, discussed above, require the drilling fluid to be pumped from the surface and circulated through the motor portion of the downhole motor. Thus, the internal components of the PDM and the turbine motor are exposed to the drilling fluid and, therefore, may be affected by the viscosity and the composition of the drilling fluid. This exposure, as described above, may cause the internal components of the PDM and the turbine motor to wear down quickly. Further, this exposure may result in a less reliable and maintainable downhole motor.

**[0007]** Thus, there exists a need for a fluid driven downhole motor that is more reliable and maintainable.

## Summary of Disclosure

**[0008]** In one aspect, embodiments disclosed herein relate to a downhole motor for drilling a wellbore including a pumping apparatus having a first chamber configured to receive a first fluid and a second fluid, and a first flexible diaphragm disposed with the first chamber configured to separate the first and second fluid, wherein the first flexible diaphragm is configured to transfer a hydraulic energy between the first fluid and the second fluid, a motor portion coupled to the pumping apparatus and configured to receive the second fluid and convert the hydraulic energy of the second fluid into a mechanical energy, thereby creating a torque, and a bit shaft coupled to the motor portion, configured to receive the torque from the motor portion and the first fluid from the pumping apparatus.

**[0009]** In one aspect, embodiments disclosed herein relate to a method of operating a downhole motor including pumping a first fluid containing a hydraulic energy to the downhole motor, directing the flow of the first fluid into a first chamber of a pumping apparatus, transferring hydraulic energy from the first fluid to a second fluid through a

first flexible diaphragm disposed in the first chamber, directing the flow of the second fluid from the pumping apparatus into a motor portion, allowing the second fluid to flow through the motor portion, wherein the motor portion is configured to transfer hydraulic energy of the second fluid into a mechanical energy, thereby creating torque, rotating a bit shaft with the torque generated from the motor portion, and directing the flow of the first fluid from the pumping apparatus to the bit shaft.

**[0010]** Other aspects and advantages will be apparent from the following description and the appended claims.

## Brief Description of Drawings

**[0011]** Figure 1 shows a cross-sectional view of a downhole motor in accordance with embodiments of the present disclosure.

**[0012]** Figure 2 shows a cross-sectional view of a downhole motor in accordance with embodiments of the present disclosure.

**[0013]** Figure 3 shows a close cross-sectional view of a housing of a downhole motor in accordance with embodiments of the present disclosure

**[0014]** Figure 4 shows a cross-sectional view of a downhole motor in accordance with embodiments of the present disclosure.

**[0015]** Figure 5 shows a cross-sectional view of a downhole motor in accordance with embodiments of the present disclosure

**[0016]** Figure 6 shows a component view of a valve system in accordance with embodiments of the present disclosure.

**[0017]** Figure 7 shows a cross-sectional view of a downhole motor in accordance with the embodiments of the present disclosure.

## Detailed Description

**[0018]** Embodiments of the present disclosure relate to a downhole drilling system. More specifically, select embodiments of the present disclosure relate to a hydraulic diaphragm downhole mud motor. The downhole motor of the present disclosure may be integrated into the downhole drilling system and driven by a fluid that is pumped

therethrough. Further, the downhole motor of the present disclosure may be used to drill a wellbore by turning a drill bit.

**[0019]** Even more specifically, select embodiments relate to a downhole motor that is capable of using multiple types of fluids simultaneously. For example, in one embodiment a first fluid (such as drilling mud, or "mud fluid," herein) may be used in conjunction with a second fluid (such as a hydraulic fluid).

**[0020]** Generally, select embodiments disclosed herein relate to a downhole motor having a diaphragm pump with at least two chambers. Each chamber has a diaphragm disposed therein configured to separate a first fluid from a second fluid. The first fluid is transferred downhole through a drill string to the downhole motor. The first fluid flows through the downhole motor to a drill bit that releases the first fluid into the wellbore. However, while flowing through the downhole motor, the first fluid does not flow through the motor portion of the downhole motor. Thus, the first fluid is not exposed to the internal components of the motor portion. As a result, the first fluid is a mud fluid or other drilling fluid known in the art that provides a means to clean the wellbore. The second fluid is disposed in the downhole motor and is circulated through the motor portion of the downhole motor. Thus, to prevent wear on the internal components of the downhole motor, the second fluid is a clean hydraulic fluid or other non-abrasive fluid known in the art. Those having ordinary skill in the art will appreciate that other fluid combinations may be used.

**[0021]** Figure 1 shows a cross-sectional view of a downhole motor **100** in accordance with embodiments of the present disclosure. Downhole motor **100** includes a pumping apparatus **110**, a motor portion **140**, and a bit shaft **150**. As shown in Figure 1, the pumping apparatus **110** includes a first chamber **112** and a second chamber **113**. The first chamber **112** includes a first flexible diaphragm **114** disposed therein, and the second chamber **113** includes a second flexible diaphragm **115** disposed therein. The diaphragms **114, 115** separate a second fluid **118** from a first fluid **116** that are both received by the chambers **112, 113** of the pumping apparatus **110**.

**[0022]** In one embodiment, the diaphragms **114, 115** may be cylindrical in shape and manufactured out of a flexible material, such as rubber, Teflon, or other materials known in the art. In alternate embodiments, other shapes, including regular and

irregular shaped diaphragms may be used, such that the diaphragm may separate two fluids within a chamber **112, 113**. Furthermore, the flexibility of the diaphragms **114, 115** allows a transfer of hydraulic energy between the fluids **116, 118**. For example, the pumping apparatus **110** may receive a first fluid **116** in the first flexible diaphragm **114,** while a second fluid **118** is disposed in the first chamber **112,** outside the first flexible diaphragm **114**. As the first fluid **116** fills the first flexible diaphragm **114**, a pressure within the diaphragm **114** increases, causing the diaphragm **114** to expand. During this expansion, the first flexible diaphragm **114** transfers hydraulic energy from the first fluid **116** to the second fluid **118**, while maintaining physical separation of the fluids **116, 118**.

**[0023]** In the embodiment shown, the diaphragms **114, 115** are positioned proximate a center annulus of the pumping apparatus **110**. This allows the diaphragms **114, 115** to be closely aligned with the flow of the first fluid **116** entering the pumping apparatus **110**, thereby reducing hydraulic energy loss due to the redirection of the flow of the first fluid **116**. In an alternate embodiment, the diaphragms **114, 115** may be positioned proximate inner circumference **119** of the pumping apparatus **110**.

**[0024]** In one embodiment of the present disclosure, the pumping apparatus may include an odd number of chambers and diaphragms, for example, five chambers with a diaphragm disposed in each chamber. An odd number of chambers may decrease the amount of vibrations generated by the downhole motor during operations. However, one skilled the art would appreciate that the motor may have an even number of chambers without departing from the scope of embodiments disclosed therein.

**[0025]** The pumping apparatus **110** further includes a valve system **120** having an upper valve **122**, an upper valve housing **123**, a lower valve **124,** a fluid housing **130**, and a shaft **126**. The valves **122, 124** are coupled to the shaft **126**, which extends through the center annulus of the pumping apparatus **110**. The valves **122, 124** may be coupled to the shaft **126** through the use of threads, bearings, or other attachment methods known in the art. The valves **122, 124** are configured to control the flow of the first and second fluid **116, 118** entering and exiting the pumping apparatus **110**. In one embodiment the valve system **120** may be directly connected to the bit shaft

**150** or, in an alternate embodiment, the valve system **120** may be connected to another device (not shown) that turns the shaft **126** independently of the bit shaft **150**.

**[0026]** A component view of the valve system **120** in accordance with the embodiments of the present disclosure is shown in Figure 6. As shown in Figure 6, the upper valve **122** includes a top plate **171** and a bottom plate **173** both having a plurality of orifices **175** radially disposed about a central axis **177**. Each of the plates **173, 171** are configured to rotate around the central axis **177**. As the bottom and top plate **173, 171** rotate about the central axis **177**, an orifice **175** from the top plate **171** may align with an orifice **175** from the bottom plate **173**. This alignment may form a passageway allowing the first fluid **116** to flow through the upper valve **122**.

**[0027]** Further, the lower valve **124** includes a first plate **172** and a second plate **174** both having a plurality of orifices **175** radially disposed about the central axis **177**, similar to those of the upper valve **122**. However, the second plate **174** of the lower valve **223** also includes a plurality of bores **176** that are also radially disposed about the central axis **177**. Both plates **172, 174** may be configured, similar to the plates **171, 173** of the upper valve **122**, so as to rotate about the central axis **177**. An orifice **175** on the first plate **172** may be configured to align with an orifice **175** on the second plate **174** to form a passageway that will allow the first fluid **116** to flow through the lower valve **124**. Further, a bore **176** disposed on the second plate **174** may be configured to align with an opening in another component, such as the fluid housing **130** shown in Figure 1, that will allow the second fluid **118** to flow through the lower valve **124**.

**[0028]** As shown in Figure 6, the valve system includes an upper and a lower valve having disk-shaped plates with a plurality of openings (*e.g.*, orifices and bores) extending from the upper face to the lower face of each plate (*e.g.*, top plate). In an alternate embodiment, the valve system may include other type valve assemblies known in the art. For example, a cylinder type valve assembly **720**, as shown in Figure 7 may be used. Cylinder type valve assembly **720** includes an upper valve **722** and a lower valve **724**, each having a cylindrical shape and each valve having a plurality of openings extending through a wall of a cylinder. Further, the valve assembly **720** is configured to direct and control the flow of a first fluid and a second fluid, similar to the valve system shown in Figure 1.

**[0029]** In one embodiment, the valve system **120** of the downhole motor **100** may be configured to be driven independently by, for example, a turbine blade in the first fluid **116** or a separate motor portion **140**. A sensor may be configured to transmit and receive a signal that is transferred between the sensor and a controller (not shown). The controller may be located at the surface of the well and used to control the flow rate of the first fluid **116** flowing through the downhole motor **100**. This control may result in the downhole motor **100** having the capability of running at a variety of torques and speeds.

**[0030]** Referring back to Figure 1, the valves **122, 124** may be configured to control which chamber (*e.g.*, the first and second chambers **112, 113**) the first and second fluid **116, 118** enter and exit. For example, the upper valve **122** may be rotated to a position where an orifice **175** of the top plate **171** and an orifice **175** of the bottom plate **173** align above the first chamber **112**. While the orifices **175** of these plates **171, 173** are at least partially aligned above the first chamber **112**, the first fluid **116** will flow into the first flexible diaphragm **114** of the first chamber **112**.

**[0031]** After the first diaphragm **114** fills, the lower valve **124** may be rotated to a position where a bore **176** of the second plate **174** aligns with a first channel of the fluid housing **130** below the first chamber **112**. While the bore **176** and the channel are at least partially aligned below the first chamber **112**, the second fluid **118** may flow out of the first chamber **112** and into the first channel of the fluid housing **130**.

**[0032]** Once the second fluid **118** has circulated through the motor portion **140** and into a second channel of the fluid housing **130**, the lower valve **124** may be rotated to a position where a bore **176** aligns with a second channel in the fluid housing **130** below the second chamber **113**. While the bore **176** is at least partially aligned with the second channel of the fluid housing **130** below the second chamber **113**, the second fluid **118** may flow out of the fluid housing **130** and into the second chamber **113**.

**[0033]** Following the second fluid **118** filling the second chamber **113**, the lower valve **124** may be rotated to a position where an orifice **175** of the first plate **172** and an orifice **174** of the second plate **174** align below the second chamber **113**. When the orifices **175** of these plates **172, 174** are at least partially aligned below the second

chamber **113**, the first fluid **116** will flow out of the second flexible diaphragm **115** and into an annular space of the fluid housing **130**.

**[0034]** The fluid housing **130**, as shown in Figure 1, may be coupled to the pumping apparatus **110** and the motor portion **140**, using bolts, bearings, seals, or any other elements known in the art. As depicted in Figure 1, the pumping apparatus **110** may be coupled to one end of the housing **130**, *i.e.*, upper face, and the motor portion **140** may be coupled to the opposite end of the housing **130**, *i.e.*, a lower face.

**[0035]** Figure 3 shows a close cross-sectional view of the housing **130** of the downhole motor **100** in accordance with the embodiments of the present disclosure. As shown in Figure 3, the fluid housing **130** may include a first channel **132** and a second channel **134**. Each channel may extend the length of the housing **130**, thereby creating a passage way between the pumping apparatus **110** and the motor portion **140**. The channels **132, 134** may be of various shapes and cross-sections, such as a cylindrical, square, elliptical, triangular, or others known in the art. These channels **132, 134** are configured to transfer a second fluid **118** between the pumping apparatus **110** and the motor portion **140**. For example, the second fluid **118** exiting the first chamber **112** of the pumping apparatus **110** flows through the first channel **132** to the motor portion **140**. After the second fluid **118** has circulated through the motor portion **140**, the second fluid **118** exiting the motor portion **140** flows through the second channel **134** back into the second chamber **113** of the pumping apparatus **110**. One skilled in the art of drilling will appreciate that the fluid housing **130** may include additional fluid passages. For example, a fluid housing may include a first channel, a second channel, and a third channel, such that each channel is used to transport a fluid.

**[0036]** The motor portion **140** includes a motor valve **142**, and at least one thrust bearing (not shown). Additionally, the motor portion **140** may include, for example, a rotor and a stator, and other components known in the art. The motor valve **142** is coupled to the fluid housing **130** and controls the flow of the second fluid **118** entering and exiting the motor portion **140** of the downhole motor **100**. At least one thrust bearing may be disposed between the bit shaft **150** and the motor portion **140** to transfer torque from the motor portion **140** to the bit shaft **150**. The motor portion **140** is then driven by the second fluid **118** flowing therethrough. The second fluid

**118** flows through the motor portion **140**, wherein hydraulic energy of the fluid **118** is converted into mechanical energy to turn the bit shaft **150**.

**[0037]** In an alternate embodiment, the motor valve **142** may be replaced with a set (2) of opposed check valves. In this embodiment, the check valves may operate independent from the valve system **120**, thereby allowing the valve system **120** to be driven independently, for example, by a separate motor portion **140**. At least one of the two check valves is configured to control the flow of the second fluid **118** entering the motor portion **140**, while the other check valve is configured to control the flow of the second fluid **118** exiting the motor portion **140**.

**[0038]** Referring back to Figure 1, the fluid housing **130** also includes an annular space **136**. The annular space **136** may extend downward from the upper face some distance to a location above the lower face of the housing **130**. Further, the annular space **136** provides a passage way between the pumping apparatus **110** and the bit shaft **150**. For example, the first fluid **116** exiting the pumping apparatus flows into the annular space **136** of the fluid housing **130**. As the annular space **136** fills with the first fluid **116**, the first fluid **116** flows though an opening in the bit shaft **150**.

**[0039]** Finally, the bit shaft **150,** as shown in Figure 1**,** includes an opening **152** that may be located near the upper end of the bit shaft **150**. The bit shaft **150** may extend from a location below the downhole motor **100** upward through the motor portion **140** and into the fluid housing **130**. More specifically, the upper end of the bit shaft **150** may be received by the annular space **136** of the fluid housing **130**. Further, the bit shaft **150** may be coupled to the motor portion **140** by any means know in the art, for example, at least one thrust bearing. Furthermore, the bit shaft **150** includes a channel **154** that may be configured to transfer the first fluid **116** to a lower distal end of the bit shaft **150**. For example, the first fluid **116** flowing out of the second chamber **113** may flow into the annular space **136** of the fluid housing **130**. As the annular space **136** fills with the first fluid, the first fluid will flow through the opening **152** at the upper end of the shaft into the channel **154**. The first fluid **116** may then continue to flow downward through the channel **154** within the bit shaft **150** to the lower distal end of the bit shaft **150**.

**[0040]** It should be understood that the downhole motor **100,** in accordance with the embodiments disclosed herein, may be incorporated into a drilling assembly. The

drilling assembly may comprise of a drill string (not shown), the downhole motor **100**, a drill bit (not shown), and other components known in the art. Thus, the downhole motor **100** may be configured to be coupled to the drill string and the drill bit. One skilled in the art will appreciate that the downhole motor **100** may be used with pre-existing drill strings and drill bits. These pre-existing drill strings and drill bits may be coupled to the downhole motor **100** using attachment methods known in the art of drilling, for example, threaded connections, welding, and bearings.

**[0041]** During the operation of the downhole motor **100**, the first fluid **116** may be pumped downhole through the drill string to the downhole motor **100**. Once the fluid **116** reaches the downhole motor **100**, the upper valve **122** may be rotated to a position to allow the first fluid **116** into the first flexible diaphragm **114** of the first chamber **112**. The upper valve **122** is rotated at a predetermined speed. The predetermined speed may be dependent on the size of the wellbore, the type of formation, desired Rate of Penetration (ROP), and other factors known in the art.

**[0042]** As the first fluid **116** fills the first flexible diaphragm **114**, the first flexible diaphragm **114** expands. The expansion of the first flexible diaphragm **114** pressurizes the second fluid **118** also disposed in the first chamber **112**, thereby transferring hydraulic energy from the first fluid **116** to the second fluid **118** outside of the diaphragm **114**. The lower valve **124** may then be rotated to a position to allow the pressurized second fluid **118** to flow out of the first chamber **112** and into the first channel **132** of the fluid housing **130**.

**[0043]** The second fluid **118** may then be transferred through the first channel **132** to the motor portion **140**. The motor valve **142** may then allow the second fluid **118** from the first channel **134** to flow into the motor portion **140**. While the second fluid **118** flows through the motor portion **140**, the motor portion **140** converts the hydraulic energy of the second fluid **118** into mechanical energy, thereby creating torque. Further, the torque created by the motor portion **140** is transferred to the bit shaft **150** through at least one thrust bearing, which causes the bit shaft **150** to rotate.

**[0044]** After at least some of the second fluid **118** has passed through the motor portion **140**, the motor valve **142** may allow the second fluid **118** to flow into the second channel **134** of the fluid housing **130**. The lower valve **124** may then be rotated to a position to allow the second fluid **118** from the second channel **134** to

flow into the second chamber **113**, outside the second flexible diaphragm **115**. As the second fluid **118** fills the second chamber **113**, the second flexible diaphragm **115** compresses. The compression of the second flexible diaphragm **115** pressurizes the first fluid **116** disposed in the second flexible diaphragm **115**, thereby transferring hydraulic energy from the second fluid **118** to the first fluid **116**. The lower valve **124** may then be rotated to a position to allow the pressurized first fluid **116** to flow out of the second flexible diaphragm **115** and into the annular space **136** of the fluid housing **130**. As the annular space **136** fills with the first fluid **116**, the first fluid **116** may be forced to flow through the opening **152** of the bit shaft **150** into the channel **154**. Finally, the channel **154** within the bit shaft **150** may transfer the first fluid **116** to the drill bit attached to the lower distal end of the bit shaft **150**.

**[0045]** The drill bit may include nozzles (not shown) or other components known in the art that will receive the first fluid **116**. These nozzles may release the first fluid **116** into a wellbore. One skilled in the art will appreciate that the first fluid **116** may be used to clean and cool the exterior surface of the drill bit. Further, the first fluid **116** may remove material, also known as cuttings, resulting from the drilling of a formation by the drill bit. The first fluid **116** along with the cuttings that were removed may then be transported upward through the wellbore.

**[0046]** Referring now to Figure 2, the upper valve **122** is rotated to a position to allow the first fluid **116** to flow into the second flexible diaphragm **115** of the second chamber **113**. As the first fluid **116** fills the second flexible diaphragm **115**, the second flexible diaphragm **115** expands. The expansion of the first flexible diaphragm **115** pressurizes the second fluid **118** also disposed in the second chamber **113**, thereby transferring hydraulic energy from the first fluid **116** to the second fluid **118** outside of the diaphragm **115**. The lower valve **124** may then be rotated to a position to allow the pressurized second fluid **118** to flow out of the second chamber **113** and into the second channel **134** of the fluid housing **130**.

**[0047]** The second fluid **118** may then be transferred through the second channel **134** to the motor portion **140**. The motor valve **142** allows the second fluid **118** from the second channel **134** to flow into the motor portion **140**. While the second fluid **118** flows through the motor portion **140**, the motor portion **140** converts the hydraulic energy of the second fluid **118** into mechanical energy, thereby creating

torque. Further, the torque created by the motor portion **140** is transferred to the bit shaft **150** through at least one thrust bearing, which causes the bit shaft **150** to rotate.

**[0048]** After at least some of the second fluid **118** has passed through the motor portion **140**, the motor valve **142** may allow the second fluid **118** to flow into the first channel **132** of the fluid housing **130**. The lower valve **124** may then be rotated to a position to allow the second fluid **118** from the first channel **132** to flow into the first chamber **112**, outside the first flexible diaphragm **114**. As the second fluid **118** fills the first chamber **112**, the first flexible diaphragm **114** compresses. The compression of the first flexible diaphragm **114** pressurizes the first fluid **118** disposed in the first flexible diaphragm **114**, thereby transferring hydraulic energy from the second fluid **118** to the first fluid **116**. The lower valve **124** may then be rotated to a position to allow the pressurized first fluid **116** to flow out of the first flexible diaphragm **114** and into the annular space **136** of the fluid housing **130**. As the annular space **136** fills with the first fluid **116**, the first fluid **116** may be forced to flow through the opening **152** of the bit shaft **150** into the channel **154**. Finally, the channel **154** within the bit shaft **150** may transfer the first fluid **116** to the drill bit attached to the lower distal end of the bit shaft **150**.

**[0049]** One skilled in the art will understand that the flow of the first fluid **116** into the downhole motor **100** may be alternated between the first chamber **112** and the second chamber **113**, thereby allowing the drill bit to be continuously turned. Further, one skilled in the art would understand that the operation of the downhole motor **100** may start with the flow of the first fluid **116** entering the first chamber **112** or the second chamber **113**. Furthermore, in embodiments where the downhole motor includes three or more chambers, the flow of the first and second fluid may be alternated between one or more chambers.

**[0050]** Referring now to Figure 4, a cross-sectional view of a downhole motor **200** in accordance with embodiments of the present disclosure including a pumping apparatus **210**, a motor portion **240**, and a bit shaft **250**. The pumping apparatus **210** includes chambers **212, 213** and flexible diaphragms **214, 215** disposed therein. Flexible diaphragms **214, 215** may be similar to those shown in Figure 1 and discussed above. In this embodiment the flexible diaphragms **214, 215** of the pumping apparatus **210** receive the second fluid **218**. Further, the chambers **212, 213**

of the pumping apparatus **210** may include a plurality of upper openings and a plurality of lower openings that provide fluid communication between the chambers **212, 213** and a center annulus of the pumping apparatus **210**.

**[0051]** Additionally, the pumping apparatus **210** may include a valve system **220**, similar to that shown in Figure 1, including an upper valve **222**, a lower valve **224** and a shaft **226**. However, the upper and lower valves **222, 224** may include a plurality of upper and lower openings, respectively, that extend through the shaft **226**. Similar to Figure 1, the upper valve **222** and lower valve **224** may be configured to control the flow of the first fluid **218** entering and exiting the pumping apparatus **210**. However, instead of directing the first fluid **216** into a fluid housing **230**, as shown in Figure 1, the valve system **220** may direct the first fluid **216** into the shaft **226**. The shaft **226** is configured to transfer the first fluid **216** to the bit shaft **250**. For example, as the bit shaft **226** rotates, an upper opening of the upper valve **222** aligns with an upper opening (not shown) in the chambers **212, 213** and allows the first fluid **216** to alternatingly enter the chambers **212, 213**. Furthermore, as the bit shaft **226** rotates, a lower opening of the lower valve **224** aligns with a lower opening (not shown) in the chambers **212, 213** and allows the first fluid **216** to alternatingly exit the chambers **212, 213** and flow into the a channel **228** of the shaft **226**. Finally, the channel **228** of the shaft **226** may transport the first fluid to the bit shaft **250** coupled to the end of the shaft **226**. The first fluid **216** transported to the bit shaft **250** may further be transported through the bit shaft **250** to a drill bit attached to the lower distal end of the bit shaft **250**.

**[0052]** The motor portion **240**, as shown in Figure 4, includes a motor valve **242** and at least one thrust bearing (not shown). The motor portion **240** may be configured similar to the motor portion **140** discussed above with reference to Figure 1. However, as shown in Figure 4, the second fluid **218** may be transferred directly from the chambers **212, 213** to the motor portion **240**, instead of flowing through a channel of a fluid housing. In addition, the second fluid **218** may be transferred directly from the motor portion **240** back to the chambers **212, 213**, instead of flowing through a channel of a fluid housing.

**[0053]** The bit shaft **250**, as shown in Figure 4, may be coupled to the motor portion **240** by means of a thrust bearing, similar to the bit shaft shown in Figure 1. Further,

like the bit shaft **150** shown in Figure 1, the bit shaft **250** shown in Figure 4 includes a channel **256** that is configured to receive and transfer the first fluid **216** to the drill bit attached to the lower distal end of the bit shaft **250**. However, the channel **256** of bit shaft **250** in Figure 4 may receive the fluid **216** directly from pumping apparatus **210**, rather then from the annular space within the fluid housing, as shown in Figure 1.

**[0054]** Referring still to Figure 4, the downhole motor **200** is incorporated within a drilling assembly used to drill a formation, similar to the downhole motor **100** shown in Figure 1. In operating this drilling assembly the downhole motor **200** is configured to receive a first fluid **216** from the drill string. The upper valve **222** is rotated to a position to allow the first fluid **216** into the first chamber **212** of the pumping apparatus **210**. The valve system **220** is rotated at a predetermined speed. The predetermined speed may be dependent on the size of the wellbore, the type of formation, desired Rate of Penetration (ROP), and other factors known in the art.

**[0055]** As the first fluid **216** fills the first chamber **212**, the first flexible diaphragm **214** compresses. The compression of the first flexible diaphragm **214** pressurizes the second fluid **218** disposed in the first flexible diaphragm **214**, thereby transferring hydraulic energy from the first fluid **216** outside of the diaphragm **214** to the second fluid **218**. The motor valve **242** may then be opened to allow the pressurized second fluid **218** to flow out of the first flexible diaphragm **214** and into the motor portion **240**.

**[0056]** While the second fluid **218** flows through the motor portion **240**, the motor portion **240** may convert the hydraulic energy of the second fluid **218** into mechanical energy, thereby creating torque. Further, the torque created by the motor portion **240** is transferred to the bit shaft **250** through at least one thrust bearing, which causes the bit shaft **250** to rotate.

**[0057]** After at least some of the second fluid **218** has passed through the motor portion **240**, the motor valve **242** may direct the second fluid **218** to flow into the second flexible diaphragm **215** of the second chamber **213**. As the second fluid **218** fills the second flexible diaphragm **215**, the second flexible diaphragm **215** expands. The expansion of the second flexible diaphragm **215** pressurizes the first fluid **216** disposed in the second chamber **213**, thereby transferring hydraulic energy from the second fluid **218** to the first fluid **216** outside the second flexible diaphragm **215**. The

lower valve **224** may then be rotated to a position to allow the pressurized first fluid **216** to flow out of the second chamber **213** and into the channel **228** of the shaft **226**. The channel **228** of the shaft **226** then transfers the first fluid **216** to the channel **256** of the bit shaft **250**. Finally, the channel **256** of the bit shaft **250** transfers the first fluid **216** to the drill bit attached to the lower distal end of the bit shaft **250**. The drill bit may be configured similar to the drill bit discussed above with reference to Figure 1.

**[0058]** Referring now to Figure 5, the upper valve **222** is rotated to a position to allow the first fluid **216** into the second chamber **213** of the pumping apparatus **210**. As the first fluid **216** fills the second chamber **213**, the second flexible diaphragm **215** will compress. The compression of the second flexible diaphragm **215** will pressurize the second fluid **218** disposed in the second flexible diaphragm **215**, thereby transferring hydraulic energy from the first fluid **216** outside of the diaphragm **215** to the second fluid **218**. The motor valve **242** may then allow the pressurized second fluid **218** to flow out of the second flexible diaphragm **215** and into the motor portion **240**.

**[0059]** While the second fluid **218** flows through the motor portion **240**, the motor portion **240** may convert the hydraulic energy of the second fluid **218** into mechanical energy, thereby creating torque. Further, the torque created by the motor portion **240** is transferred to the bit shaft **250** through at least one thrust bearing, which causes the bit shaft **250** to rotate.

**[0060]** After at least some of the second fluid **218** has passed through the motor portion **240**, the motor valve **242** may direct the second fluid **218** to flow into the first flexible diaphragm **214** of the first chamber **212**. As the second fluid **218** fills the first flexible diaphragm **214**, the first flexible diaphragm **214** expands. The expansion of the first flexible diaphragm **214** pressurizes the first fluid **216** disposed in the first chamber **212**, thereby transferring hydraulic energy from the second fluid **218** to the first fluid **216** outside the first flexible diaphragm **214**. The lower valve **224** may then be rotated to a position to allow the pressurized first fluid **216** to flow out of the first chamber **212** and into the channel **228** of the shaft **226**. The channel **228** of the shaft **226** then transfers the first fluid **216** to the channel **256** of the bit shaft **250**. Finally,

the channel **256** of the bit shaft **250** transfers the first fluid **216** to the drill bit attached to the lower distal end of the bit shaft **250**.

**[0061]** One skilled in the art will understand that the flow of the first fluid **216** into the downhole motor **200** may be alternated between the first chamber **212** and the second chamber **213**, thereby allowing the drill bit to be continuously turned. Further, one skilled in the art will understand that the operation of the downhole motor **200** may start with the flow of the first fluid **216** entering the first chamber **212** or the second chamber **213**. Furthermore, in embodiments where the downhole motor includes three or more chambers, the flow of the first and second fluid may be alternated between one or more chambers.

**[0062]** Embodiments of the present disclosure may include one or more of the following advantages. Downhole motors found in accordance with one or more embodiments may use combinations of fluids *i.e.* (drilling mud and hydraulic fluid) to increase the life and reliability of the downhole motor. While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

## Claims

What is claimed is:

1. A downhole motor for drilling a wellbore, comprising:
   a pumping apparatus comprising;
      a first chamber configured to receive a first fluid and a second fluid;
      a first flexible diaphragm disposed within the first chamber and configured to separate the first and second fluid,
   wherein the first flexible diaphragm is configured to transfer a hydraulic energy between the first fluid and the second fluid;
   a motor portion coupled to the pumping apparatus and configured to receive the second fluid and convert the hydraulic energy of the second fluid into a mechanical energy, thereby creating a torque; and
   a bit shaft coupled to the motor portion, configured to receive the torque from the motor portion and the first fluid from the pumping apparatus.
2. The downhole motor assembly of claim 1, wherein the first fluid comprises a mud fluid.
3. The downhole motor assembly of claim 1, wherein the second fluid comprises a hydraulic fluid.
4. The downhole motor assembly of claim 1, wherein the first flexible diaphragm is configured to receive the first fluid.
5. The downhole motor assembly of claim 1, wherein the first flexible diaphragm is configured to receive the second fluid.
6. The downhole motor assembly of claim 1, wherein the pumping apparatus further comprises a second chamber configured to receive the first fluid and the second fluid.
7. The downhole motor assembly of claim 6, wherein the pumping apparatus further comprises a second flexible diaphragm disposed within the second chamber and configured to separate the first and second fluids.
8. The downhole motor assembly of claim 7, wherein the second flexible diaphragm is configured to transfer a hydraulic energy between the first fluid and the second fluid.
9. The downhole motor assembly of claim 8, wherein the second flexible diaphragm is further configured to receive the first fluid.
10. The downhole motor assembly of claim 8, wherein the second flexible diaphragm is further configured to receive the second fluid.

11. The downhole motor assembly of claim 1, further comprising at least one thrust bearing disposed between the bit shaft and the motor portion.
12. The downhole motor assembly of claim 1, further comprising a fluid housing coupled to the pumping apparatus and the motor portion.
13. The downhole motor assembly of claim 12, wherein the fluid housing comprises an annular space.
14. The downhole motor assembly of claim 12, wherein the fluid housing comprises a first channel and a second channel.
15. The downhole motor assembly of claim 1, wherein the pumping apparatus comprises a valve system.
16. The downhole motor assembly of claim 15, wherein the valve system comprises an upper valve, a lower valve, and a shaft.
17. The downhole motor assembly of claim 16, wherein the valve system further comprises a comprises at least one sensor.
18. The downhole motor assembly of claim 1, wherein the motor portion further comprises a motor valve configured to control the flow of the second fluid entering and exiting the motor portion.
19. The downhole motor assembly of claim 1, wherein the motor portion further comprises a at least two check valves configured to control the flow of the second fluid entering and exiting the motor portion.
20. A method of operating a downhole motor comprising:

pumping a first fluid containing hydraulic energy to the downhole motor;

directing the flow of the first fluid into a first chamber of a pumping apparatus;

transferring hydraulic energy from the first fluid to a second fluid through a first flexible diaphragm disposed in the first chamber;

directing the flow of the second fluid from the pumping apparatus into a motor portion;

allowing the second fluid to flow through the motor portion, wherein the motor portion is configured to transfer hydraulic energy of the second fluid into a mechanical energy, thereby creating torque;

rotating a bit shaft with the torque generated from the motor portion; and

directing the flow of the first fluid from the pumping apparatus to the bit shaft.

21. The method of claim 20, further comprising controlling the flow of the first fluid and the second fluid entering and exiting the pumping apparatus with a valve system.
22. The method of claim 20, further comprising controlling the flow of the second fluid entering and exiting the second fluid with at least one of the group consisting of a check valve and a motor valve.
23. The method of claim 20, further comprising transferring a torque generated by the motor portion to the bit shaft.
24. The method of claim 20, wherein the first fluid comprises a mud fluid.
25. The method of claim 20, wherein the second fluid comprises a hydraulic fluid.

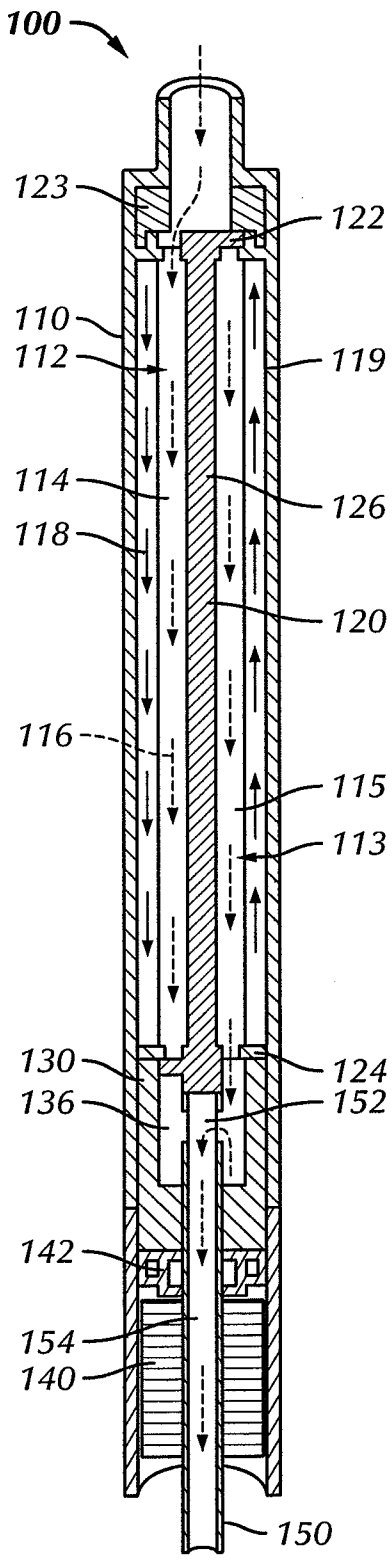

100
123
122
110
112
119
114
126
118
120
116
115
113
130
124
136
152
142
154
140
150

FIG. 1

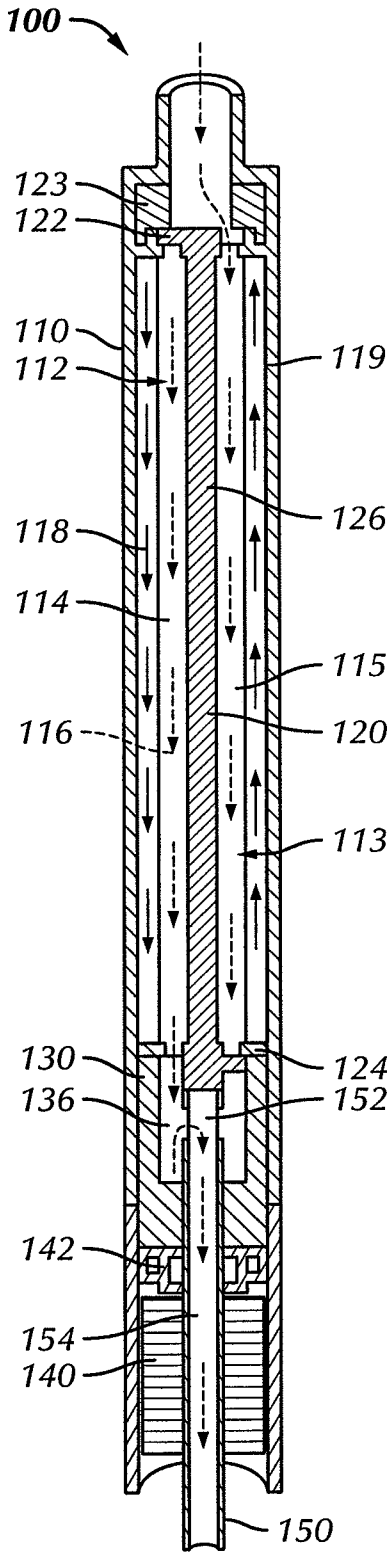

100
123
122
110
112
119
126
118
114
115
116
120
113
130
124
136
152
142
154
140
150

FIG. 2

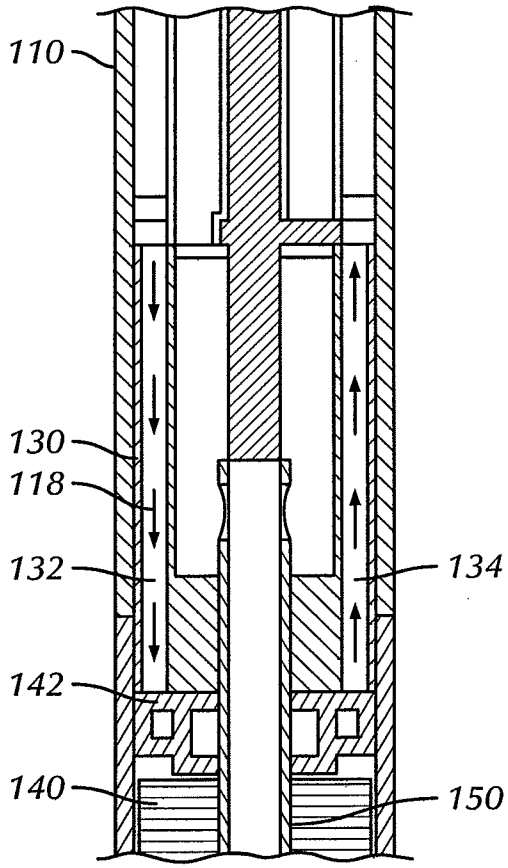

110
130
118
132
134
142
140
150

FIG. 3

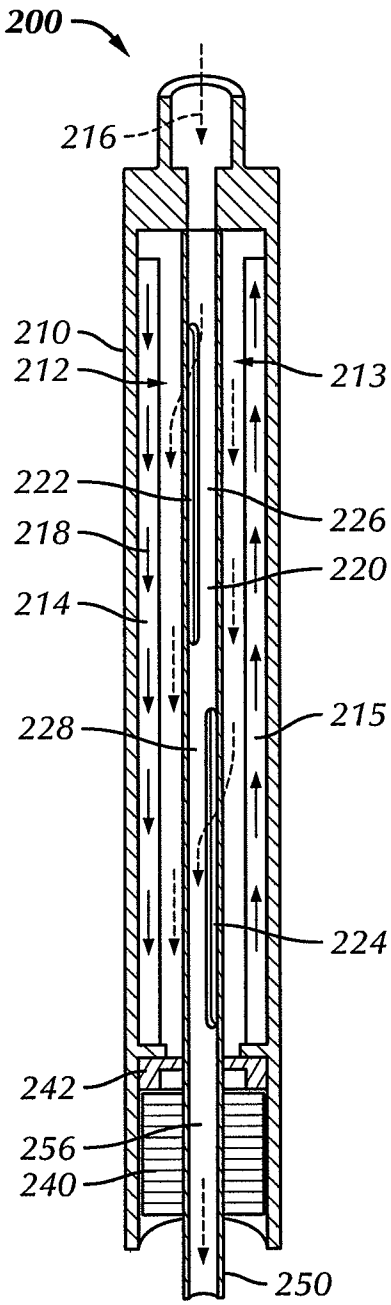

200
216
210
212
213
222
226
218
220
214
228
215
224
242
256
240
250

FIG. 4

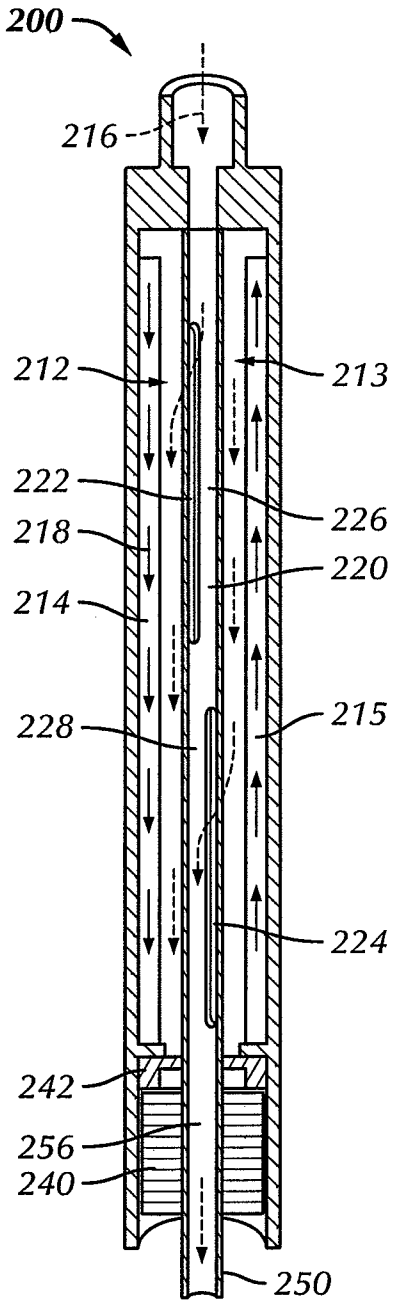

200
216
212
213
222
226
218
220
214
228
215
224
242
256
240
250

FIG. 5

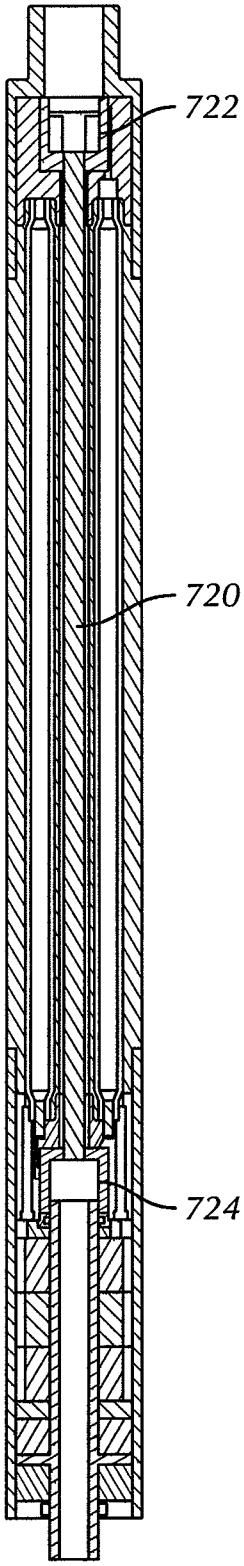

722
720
724

FIG. 7

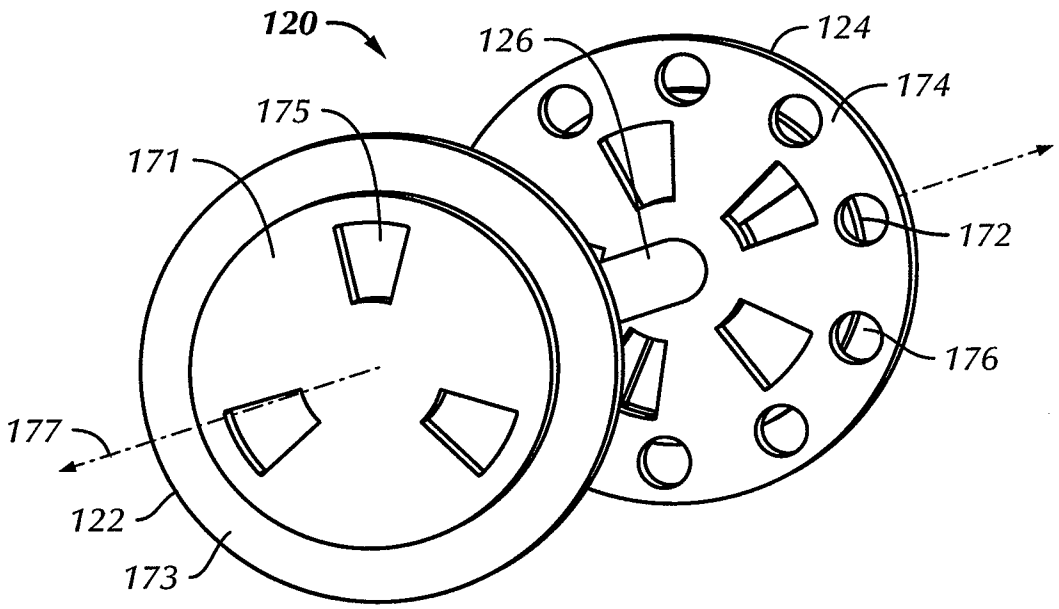



FIG. 6