



- (51) International Patent Classification:
E21B 7/04 (2006.01) E21B 19/24 (2006.01)
E21B 4/00 (2006.01)
- (21) International Application Number:
PCT/US2013/052619
- (22) International Filing Date:
30 July 2013 (30.07.2013)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
13/561,953 30 July 2012 (30.07.2012) US
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(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, BN, BR, BW, BY, BZ, CA, CH, CL, 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, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

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(54) Title: DRILL BIT WITH A FORCE APPLICATION DEVICE USING A LEVER DEVICE FOR CONTROLLING EXTENSION OF A PAD FROM A DRILL BIT SURFACE

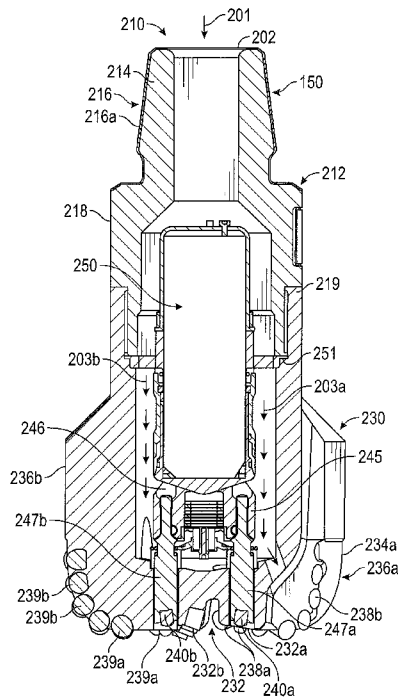


FIG. 2

(57) Abstract: In one aspect, a drill bit is disclosed that in one embodiment includes a pad configured to extend and retract from a surface of the drill bit and a force application device configured to extend and retract the pad, wherein the force application device includes a force action member that includes a lever action device configured to extend and retract the pad from the drill bit surface, in another aspect, a method of drilling a wellbore is provided that in one embodiment includes: conveying a drill string having a drill bit at an end thereof, wherein the drill bit includes a pad configured to extend and retract from a surface of the drill bit and a force application device that includes a lever action device configured to extend and retract the pad from the surface of the drill bit; and rotating the drill bit to drill the wellbore.

WO 2014/022338 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG). **Published:**

— *with international search report (Art. 21(3))*

Declarations under Rule 4.17:

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

**DRILL BIT WITH A FORCE APPLICATION DEVICE USING A LEVER DEVICE
FOR CONTROLLING EXTENSION OF A PAD FROM A DRILL BIT SURFACE**

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 13/561,953, filed on July 30, 2012, which is incorporated herein by reference in its entirety

BACKGROUND INFORMATION

Field of the Disclosure

[0002] This disclosure relates generally to drill bits and systems that utilize same for drilling wellbores.

Background of The Art

[0003] Oil wells (also referred to as "wellbores" or "boreholes") are drilled with a drill string that includes a tubular member having a drilling assembly (also referred to as the "bottomhole assembly" or "BHA"). The BHA typically includes devices and sensors that provide information relating to a variety of parameters relating to the drilling operations ("drilling parameters"), behavior of the BHA ("BHA parameters") and parameters relating to the formation surrounding the wellbore ("formation parameters"). A drill bit attached to the bottom end of the BHA is rotated by rotating the drill string and/or by a drilling motor (also referred to as a "mud motor") in the BHA to disintegrate the rock formation to drill the wellbore. A large number of wellbores are drilled along contoured trajectories. For example, a single wellbore may include one or more vertical sections, deviated sections and horizontal sections through differing types of rock formations. When drilling progresses from a soft formation, such as sand, to a hard formation, such as shale, or vice versa, the rate of penetration (ROP) of the drill changes and can cause (decreases or increases) excessive fluctuations or vibration (lateral or torsional) in the drill bit. The ROP is typically controlled by controlling the weight-on-bit (WOB) and rotational speed (revolutions per minute or "RPM") of the drill bit so as to control drill bit fluctuations. The WOB is controlled by controlling the hook load at the surface and the RPM is controlled by controlling the drill string rotation at the surface and/or by controlling

the drilling motor speed in the BHA. Controlling the drill bit fluctuations and ROP by such methods requires the drilling system or operator to take actions at the surface. The impact of such surface actions on the drill bit fluctuations is not substantially immediate. Drill bit aggressiveness contributes to the vibration, oscillation and the drill bit for a given WOB and drill bit rotational speed. Depth of cut of the drill bit is a contributing factor relating to the drill bit aggressiveness. Controlling the depth of cut can provide smoother borehole, avoid premature damage to the cutters and longer operating life of the drill bit.

[0004] The disclosure herein provides a drill bit and drilling systems using the same, configured to control the aggressiveness of a drill bit during drilling of a wellbore.

SUMMARY

[0005] In one aspect, a drill bit is disclosed that in one embodiment includes a pad configured to extend and retract from a surface of the drill bit, and a force application device configured to extend and retract the pad, wherein the force application device includes a force action member that includes a lever action device configured to extend and retract the pad from the drill bit surface.

[0006] In another aspect, a method of drilling a wellbore is provided that in one embodiment includes: conveying a drill string having a drill bit at an end thereof, wherein the drill bit includes a pad configured to extend and retract from a surface of the drill bit and a force application device that includes a lever action device configured to extend and retract the pad from the surface of the drill bit; and rotating the drill bit to drill the wellbore.

[0007] Examples of certain features of the apparatus and method disclosed herein are summarized rather broadly in order that the detailed description thereof that follows may be better understood. There are, of course, additional features of the apparatus and method disclosed hereinafter that will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The disclosure herein is best understood with reference to the accompanying figures in which like numerals have generally been assigned to like elements and in which:

FIG. 1 is a schematic diagram of an exemplary drilling system that includes a drill string that has a drill bit made according to one embodiment of the disclosure;

FIG. 2 shows a cross-section of an exemplary drill bit with a force application unit therein for extending and retracting pads on a surface of the drill bit, according to one embodiment of the disclosure;

FIG. 3 is a cross-section of a force application device that includes a lever action device that includes rollers configured to extend and retract pads from a drill bit surface;

FIG. 4 is a cross-section of the rollers of the force application device of **FIG. 3** in their inactive or unextended position;

FIG. 5 is a cross-section of the force application device of **FIG. 3** in their active or extended position;

FIG. 6 is a cross-section of a force application device that includes a lever action device that includes a number of hydraulically-operated levers configured to extend and retract pads from a drill bit surface;

FIG. 7 shows a cross-section of the levers of **FIG. 6**, wherein the upper lever is in active position and the lower lever in an inactive position; and

FIG. 8 shows a cross-section of the levers of **FIG. 6**, wherein the upper lever is in the inactive position and the lower lever in the active position.

DESCRIPTION OF THE EMBODIMENTS

[0009] FIG. 1 is a schematic diagram of an exemplary drilling system 100 that includes a drill string 120 having a drilling assembly or a bottomhole assembly 190 attached to its bottom end. Drill string 120 is shown conveyed in a borehole 126 formed in a formation 195. The drilling system 100 includes a conventional derrick 111 erected on a platform or floor 112 that supports a rotary table 114 that is rotated by a prime mover, such as an electric motor (not shown), at a desired rotational speed. A tubing (such as jointed drill pipe) 122, having the drilling assembly 190 attached at its bottom end, extends from the surface to the bottom 151 of the borehole 126. A drill bit 150, attached to the drilling assembly 190, disintegrates the geological formation 195. The drill string 120 is coupled to a draw works 130 via a Kelly joint 121, swivel 128 and line 129 through a pulley. Draw works 130 is operated to control the weight on bit ("WOB"). The drill string 120 may be rotated by a top drive 114a rather than the prime mover and the rotary table 114.

[0010] To drill the wellbore 126, a suitable drilling fluid 131 (also referred to as the "mud") from a source 132 thereof, such as a mud pit, is circulated under pressure through the drill string 120 by a mud pump 134. The drilling fluid 131 passes from the mud pump 134 into the drill string 120 via a desurger 136 and the fluid line 138. The drilling fluid 131a discharges at the borehole bottom 151 through openings in the drill bit 150. The returning drilling fluid 131b circulates uphole through the annular space or annulus 127 between the drill string 120 and the borehole 126 and returns to the mud pit 132 via a return line 135 and a screen 185 that removes the drill cuttings from the returning drilling fluid 131b. A sensor S₁ in line 138 provides information about the fluid flow rate of the fluid 131. Surface torque sensor S₂ and a sensor S₃ associated with the drill string 120 provide information about the torque and the rotational speed of the drill string 120. Rate of penetration of the drill string 120 may be determined from sensor S₅, while the sensor S₆ may provide the hook load of the drill string 120.

[0011] In some applications, the drill bit **150** is rotated by rotating the drill pipe **122**. However, in other applications, a downhole motor **155** (mud motor) disposed in the drilling assembly **190** rotates the drill bit **150** alone or in addition to the drill string rotation. A surface control unit or controller **140** receives: signals from the downhole sensors and devices via a sensor **143** placed in the fluid line **138**; and signals from sensors **S₁-S₆** and other sensors used in the system **100** and processes such signals according to programmed instructions provided to the surface control unit **140**. The surface control unit **140** displays desired drilling parameters and other information on a display/monitor **141** for the operator. The surface control unit **140** may be a computer-based unit that may include a processor **142** (such as a microprocessor), a storage device **144**, such as a solid-state memory, tape or hard disc, and one or more computer programs **146** in the storage device **144** that are accessible to the processor **142** for executing instructions contained in such programs. The surface control unit **140** may further communicate with a remote control unit **148**. The surface control unit **140** may process data relating to the drilling operations, data from the sensors and devices on the surface, data received from downhole devices and may control one or more operations drilling operations.

[0012] The drilling assembly **190** may also contain formation evaluation sensors or devices (also referred to as measurement-while-drilling (MWD) or logging-while-drilling (LWD) sensors) for providing various properties of interest, such as resistivity, density, porosity, permeability, acoustic properties, nuclear-magnetic resonance properties, corrosive properties of the fluids or the formation, salt or saline content, and other selected properties of the formation **195** surrounding the drilling assembly **190**. Such sensors are generally known in the art and for convenience are collectively denoted herein by numeral **165**. The drilling assembly **190** may further include a variety of other sensors and communication devices **159** for controlling and/or determining one or more functions and properties of the drilling assembly **190** (including, but not limited to, velocity, vibration, bending moment, acceleration, oscillation, whirl, and stick-slip) and drilling operating parameters, including, but not limited to, weight-on-bit, fluid flow rate, and rotational speed of the drilling assembly.

[0013] Still referring to FIG. 1, the drill string 120 further includes a power generation device 178 configured to provide electrical power or energy, such as current, to sensors 165, devices 159 and other devices. Power generation device 178 may be located in the drilling assembly 190 or drill string 120. The drilling assembly 190 further includes a steering device 160 that includes steering members (also referred to a force application members) 160a, 160b, 160c that may be configured to independently apply force on the borehole 126 to steer the drill bit along any particular direction. A control unit 170 processes data from downhole sensors and controls operation of various downhole devices. The control unit includes a processor 172, such as microprocessor, a data storage device 174, such as a solid-state memory and programs 176 stored in the data storage device 174 and accessible to the processor 172. A suitable telemetry unit 179 provides two-way signal and data communication between the control units 140 and 170.

[0014] During drilling of the wellbore 126, it is desirable to control aggressiveness of the drill bit to drill smoother boreholes, avoid damage to the drill bit and improve drilling efficiency. To reduce axial aggressiveness of the drill bit 150, the drill bit is provided with one or more pads 180 configured to extend and retract from the drill bit face 152. A force application unit 185 in the drill bit adjusts the extension of the one or more pads 180, which pads controls the depth of cut of the cutters on the drill bit face, thereby controlling the axial aggressiveness of the drill bit 150.

[0015] FIG. 2 shows a cross-section of an exemplary drill bit 150 made according to one embodiment of the disclosure. The drill bit 150 shown is a polycrystalline diamond compact (PDC) bit having a bit body 210 that includes a shank 212 and a crown 230. The shank 212 includes a neck or neck section 214 that has a tapered threaded upper end 216 having threads 216a thereon for connecting the drill bit 150 to a box end at the end of the drilling assembly 130 (FIG. 1). The shank 212 has a lower vertical or straight section 218. The shank 210 is fixedly connected to the crown 230 at joint 219. The crown 230 includes a face or face section 232 that faces the formation during drilling. The crown includes a number of blades, such as blades

234a and **234b**, each *n*. Each blade has a number of cutters, such as cutters **236** on blade **234a** at blade having a face section and a side section. For example, blade **234a** has a face section **232a** and a side section **236a** while blade **234b** has a face section **232b** and side section **236b**. Each blade further includes a number of cutters. In the particular embodiment of **FIG. 2**, blade **234a** is shown to include cutters **238a** on the face section **232a** and cutters **238b** on the side section **236a** while blade **234b** is shown to include cutters **239a** on face **232b** and cutters **239b** on side **236b**. The drill bit **150** further includes one or more pads, such as pads **240a** and **240b**, each configured to extend and retract relative to the surface **232**. In one aspect, a drive unit or mechanism **245** may carry the pads **240a** and **240b**. In the particular configuration shown in **FIG. 2**, drive unit **245** is mounted inside the drill bit **150** and includes a holder **246** having a pair of movable members **247a** and **247b**. The member **247a** has the pad **240a** attached at the bottom of the member **247a** and pad **240b** at the bottom of member **247b**. A force application device **250** placed in the drill bit **150** causes the rubbing block **245** to move up and down, thereby extending and retracting the members **247a** and **247b** and thus the pads **240a** and **240b** relative to the bit surface **232**. In one configuration, the force application device **250** may be made as a unit or module and attached to the drill bit inside via flange **251** at the shank bottom **217**. A shock absorber **248**, such as a spring unit, is provided to absorb shocks on the members **247a** and **247b** caused by the changing weight on the drill bit **150** during drilling of a wellbore. The spring **248** also may act as biasing member that causes the pads to move up when force is removed from the rubbing block **245**. During drilling, a drilling fluid **201** flows from the drilling assembly into a fluid passage **202** in the center of the drill bit and discharges at the bottom of the drill bit via fluid passages, such as passages **203a**, **203b**, etc. Exemplary embodiments of force application devices that utilize lever actions are described in more detail in reference to **FIGS. 3-8**.

[0016] **FIG. 3** shows a cross-section of a force application device **300** made according to an embodiment of the disclosure. The device **300** may be made in the

form of a unit or capsule for placement in the fluid channel of a drill bit, such as drill bit **150** shown in **FIG. 2**. The device **300** includes an upper chamber **302** that houses an electric motor **310** that may be operated by a battery (not shown) in the drill bit or by electric power generated by a power unit in the drilling assembly, such as the power unit **179** shown in **FIG. 1**. The electric motor **310** is coupled to a rotation reduction device **320**, such as a reduction gear, via a coupling **322**. The reduction gear **320** housed in a housing **304** rotates a drive shaft **324** attached to the reduction gear **320** at rotational speed lower than the rotational speed of the motor **310** by a known factor. The drive shaft **324** may be coupled to or decoupled from a rotational drive member **340**, such as a drive screw, by a coupling device **330**. In aspects, the coupling device **330** may be operated by electric current supplied from a battery in the drill bit (not shown) or a power generation unit, such as power generation unit **179** in the drilling assembly **130** shown in **FIG.1**. In one configuration, when no current is supplied to the coupling device **330**, it is in a deactivated mode and does not couple the drive shaft **324** to the drive screw **340**. When the coupling device **330** is activated by supplying electric current thereto, it couples or connects the drive shaft **324** to the drive screw **340**. When the motor **310** is rotated in a first direction, for example clockwise, when the drive shaft **324** and the drive screw **340** are coupled by the coupling device **330**, the drive shaft **324** will rotate the drive screw **340** in a first rotational direction, e.g., clockwise. When the current to the motor **310** is reversed when the drive shaft **324** is coupled to the drive screw **340**, the drive screw **340** will rotate in a second direction, i.e., in this case opposite to the first direction, i.e., counterclockwise.

[0017] Still referring to **FIG. 3**, the force application device **300** may further include a drive unit or drive member **350** (also referred herein as a lever action device) that utilizes a lever or lever-type action activated or deactivated by the drive screw **340** so that when the drive screw **340** rotates in one direction, a member **345** coupled to the drive screw **340** moves linearly in a first direction (for example downward) and when the drive screw **340** moves in a second direction (opposite to the first direction), the member **345** moves in a second direction, i.e., in this case upward.

The member 345 is in contact with the drive member 350. In aspects, the member 345 may be a piston member disposed in a hydraulic chamber 348. The drive member 350 is in contact with the pin member or pusher 380 via a carrier 382 driven by the drive member 350. The pin member 380 moves upward when the drive member 350 moves upward and moves downward when the drive member 350 moves downward. Bearings 335 may be provided around the drive screw 340 to provide lateral support to the drive screw 340. The pin 380 is configured to apply force on the drive unit, such as drive unit 245 shown in FIG.1. When the drive member 350 moves downward, the pin 380 causes the pads 240a and 240b (FIG. 2) to extend from the drill bit surface and when the drive member 350 moves upward, the pin 380 moves upward. The biasing member in the drive unit 245 causes the pads 240a and 240b to retract from the drill bit surface. A suitable sensor may be provided at any suitable location to provide information relating to the linear movement of the pin 380. For example a linear sensor 398a may provide signals relating to the movement of the carrier 382 or a sensor 398b may provide signals relating to the movement of the piston 345 or a sensor that provides signals relating to the rotations of the electric motor from which the linear motion of the pin can be calculated by correlation, etc. Such a sensor may be any suitable sensor, including, but not limited to, a hall-effect sensor and a linear potentiometer sensor. The sensor signals may be processed by electrical circuits in the drill bit or in the drilling assembly and a controller in response thereto may control the motor rotation and thus the movement of the pin 380 and the pads. A pressure compensation device 390, such as bellows, provides pressure compensation to the force application device 300.

[0018] Still referring to FIG. 3, the lever action device 350, in aspects, may include a profiled guide 352 that includes a number of articulated rollers 355. In the exemplary configuration of FIG 3, a roller 355a is in contact with the piston member 345 and another roller 355b is in contact with the carrier 382 that moves linearly within a chamber 384. The remaining rollers, collectively designated as 355c, interact and rotate with each other in the manner of their respective articulation.

Typically adjacent rollers move in opposite direction as described in more detail in reference to FIGS. 4 and 5.

[0019] FIG. 4 is a cross-section of the lever action device 350 wherein the rollers 355 are in their inactive or non-extended position. FIG. 4 shows the piston member 345 in the upper position inside the hydraulic chamber 348. In this inactive position, the carrier 382 will be in its upper position within the chamber 384. In the exemplary configuration of FIG. 4, when the piston member 345 moves downward, the rollers 355 will adjacent rollers 355 will rotate in opposite directions as indicated by their respective arrows. FIG. 5 shows a cross-section of the force application device 350 wherein the rollers are in their active position. In FIG. 4, the piston member 345 is placed in a downward position in the fluid chamber 348, which causes the adjacent rollers 355 to rotate in the opposite direction within the profiled guide 352. The net effect of the rotation of the rollers 355 is to push the push the carrier 384 downward, thus pushing the pin 380 downward. When the piston member 345 moves upward, the rollers rotate in the opposite direction from when the piston moves downward, thereby causing the carrier 382 and hence the pin 380 to move upward. The movement of the pin 384, the extension and retraction of the pads in the drill bit (FIG. 2) and hence the aggressiveness of the drill bit may be controlled by the rotation of the motor 310 (FIG. 3) that may be controlled by a controller in the downhole tool, a surface controller or a combination thereof based on the programmed instruction provide to the controller.

[0020] FIG. 6 shows a cross-section of a force application device 600 made according an embodiment of the disclosure. The device 600 may be made in the form of a unit or capsule for placement in the fluid channel of a drill bit, such as drill bit 150 shown in FIG. 2. The device 600 includes an upper chamber 602 that houses an electric motor 610 that may be operated by a battery (not shown) in the drill bit or by electric power generated by a power unit in the drilling assembly, such as the power unit 179 shown in FIG. 1. The electric motor 610 is coupled to a hydraulic pump 620 via a coupling 622. The device 600 further includes a drive device or mechanism 650 that may house therein a number of lever action units. The

exemplary drive section 650 is shown to include two hydraulically-operated lever action devices 660 and 670. The device 600 further includes a valve block 640 that provides a separate fluid path (such as 642a and 642b) from the pump 620 to each of the lever action devices, such as units 660 and 670. The lever action devices 650 and 670 cooperate with each other and together extend and retract the pin 680 as described in more detail later. When the pump 620 is operated by the motor 610, the pump 620 provides fluid under pressure to one or more of the lever action devices 660 and 670 based on instructions provided to a controller in the drill bit, bottomhole assembly and/or at the surface. A pressure compensation device 690, such as bellows, provides pressure compensation to the force application device 600.

[0021] FIG. 7 shows a cross-section of the drive device 650 wherein the upper lever action device 660 is in an active position and the lower lever action device 670 is in an inactive position. FIG. 8 shows a cross-section of the levers of FIG. 6, wherein the upper lever is in the inactive position and the lower lever in the active position. Referring to FIGS. 7 and 8, the lever action device 660 includes a fluid chamber 662 and a reciprocation piston 664 in the chamber 662, while the lever action device 670 includes a fluid chamber 672 and a piston 674. The lever action device 660 is coupled to lever action device 670 by a lever 666 about pivot points 668 and 678. The lever action device 670 is further coupled to the pin 680 via a lever 678 about pivot point 678 and 688. When a fluid under pressure is supplied to chamber 662, the piston 664 moves outward, which movement in turn moves the lever 666 radially outward, as shown in FIG. 7. Similarly, when the fluid under pressure is supplied to chamber 672, the piston 674 moves outward, as shown in FIG. 8, which action causes the lever 674 to move inward, as shown in FIG. 8. The vertical or linear motion of the lever causes the pin to move along with the lever 674. By articulating the supply of the fluid to the lever action devices 660 and 670 the amount of the linear movement of the pin 680 and hence the pads (242a and 242b of FIG. 2) may be controlled. A controller in the drill bit, bottomhole assembly and/or at the surface may be programmed to control the motor (610, FIG. 3) to control the

linear movement of the levers **660** and **670** to control the extension and retraction of the pads **242a** and **242b**, FIG. 2. Although two lever action devices **660** and **670** are shown, the force application device **600** may include any desired number of such devices.

[0022] The concepts and embodiments described herein are useful to control the axial aggressiveness of drill bits, such as a PDC bits, on demand during drilling. Such drill bits aid in: (a) steerability of the bit (b) dampening the level of vibrations and (c) reducing the severity of stick-slip while drilling, among other aspects. Moving the pads up and down changes the drilling characteristic of the bit. The electrical power may be provided from batteries in the drill bit or a power unit in the drilling assembly. A controller may control the operation of the motor and thus the extension and retraction of the pads in response to a parameter of interest or an event, including but not limited to vibration levels, torsional oscillations, high torque values; stick slip, and lateral movement.

[0023] The foregoing disclosure is directed to certain specific embodiments for ease of explanation. Various changes and modifications to such embodiments, however, will be apparent to those skilled in the art. It is intended that all such changes and modifications within the scope and spirit of the appended claims be embraced by the disclosure herein.

CLAIMS

1. A drill bit, comprising:
a pad configured to extend and retract from a surface of the drill bit; and
a force application device configured to extend the pad from the surface of the drill bit, the force application device including a drive device that includes a lever action device configured to extend and retract the pad from the drill bit surface.
2. The drill bit of claim 1, wherein the lever action device is hydraulically operated to move a lever member operatively coupled to the pad.
3. The drill bit of claim 2, wherein the lever action device includes a fluid chamber and piston in the fluid chamber, wherein the piston moves when a fluid under pressure is supplied to the chamber to move a lever that is operatively coupled to the pad to extend or retract the pad.
4. The drill bit of claim 2 further comprising a motor and a pump configured to supply a fluid under pressure to the lever action device.
5. The drill bit of claim 3, wherein a radial motion of the piston causes a linear motion of the pad.
6. The drill bit of claim 1, wherein the lever action device includes a plurality of co-acting rollers that move axially when subjected to a linear force.
7. The drill bit of claim 6 further comprising a force-acting device that applies the linear force on the plurality of rollers.
8. The drill bit of claim 6 further comprising a motor that drives a member configured to apply the linear force on the plurality rollers.
9. The drill bit of claim 1 further comprising a drive unit coupled to the pads, wherein the drive unit causes the pads to extend when a force is applied to the drive unit.
10. The drill bit of claim 9, wherein the drive unit includes a member that carries the pad and a biasing member configured to cause the pad to retract when force is released from the drive unit.
11. The drill bit of claim 1 further comprising a sensor configured to provide signals relating to the extending and retracting of the pads.

12. A drilling apparatus comprising:
 - a drilling assembly including a drill bit configured to drill a wellbore, wherein the drill bit further comprises:
 - a pad configured to extend and retract from a surface of the drill bit; and
 - a force application device configured to extend the pad from the surface of the drill bit, the force application device including a drive device that includes a lever action device configured to extend and retract the pad from the drill bit surface.
13. The drill bit of claim 12, wherein the lever action device is hydraulically-operated to move a lever member operatively coupled to the pad.
14. The drill bit of claim 13, wherein the lever action device includes a fluid chamber and piston in the fluid chamber, wherein the piston moves when a fluid under pressure is supplied to the chamber to move a lever that is operatively coupled to the pad to extend or retract the pad.
15. The drill bit of claim 12, wherein the lever action device includes a plurality of rollers that move axially when subjected to a linear force.
16. The drill bit of claim 15 further comprising a force-acting device that applies the linear force on the plurality of rollers.
17. The drill bit of claim 16 further comprising a motor that drives a member configured to apply the linear force on the plurality rollers.
18. A method of making a drill bit comprising:
 - providing a bit body having a pad configured to extend from a surface thereof;
 - providing a force application device in the drill bit configured to extend the pad from the surface of the drill bit, the force application device including a drive device that includes a lever action device configured to extend and retract the pad from the drill bit surface.
19. The method of claim 18, wherein the lever action device is hydraulically operated to move a lever member operatively coupled to the pad.
20. The method of claim 1, wherein the lever action device includes a plurality of rollers that move axially when subjected to a linear force.

21. A method of drilling a wellbore, comprising:

conveying a drill string into a wellbore, the drill string including a drill bit at an end thereof, wherein the drill bit includes a pad configured to extend and retract from a surface of the drill bit, and a force application device configured to extend the pad from the surface of the drill bit, the force application device includes a drive device that includes a lever action device configured to extend and retract the pad from the drill bit surface; and

drilling the wellbore with the drill string.

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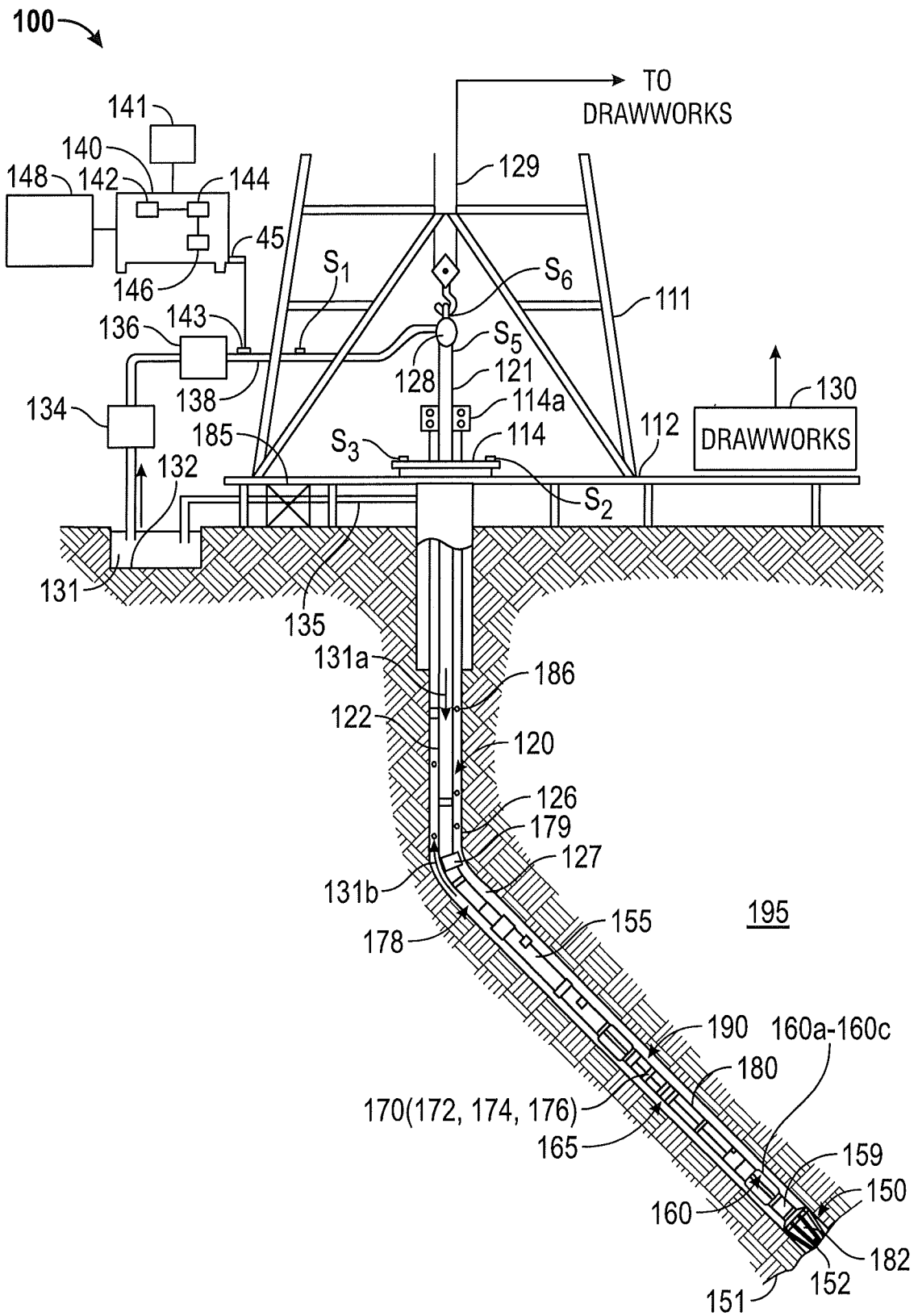


FIG. 1

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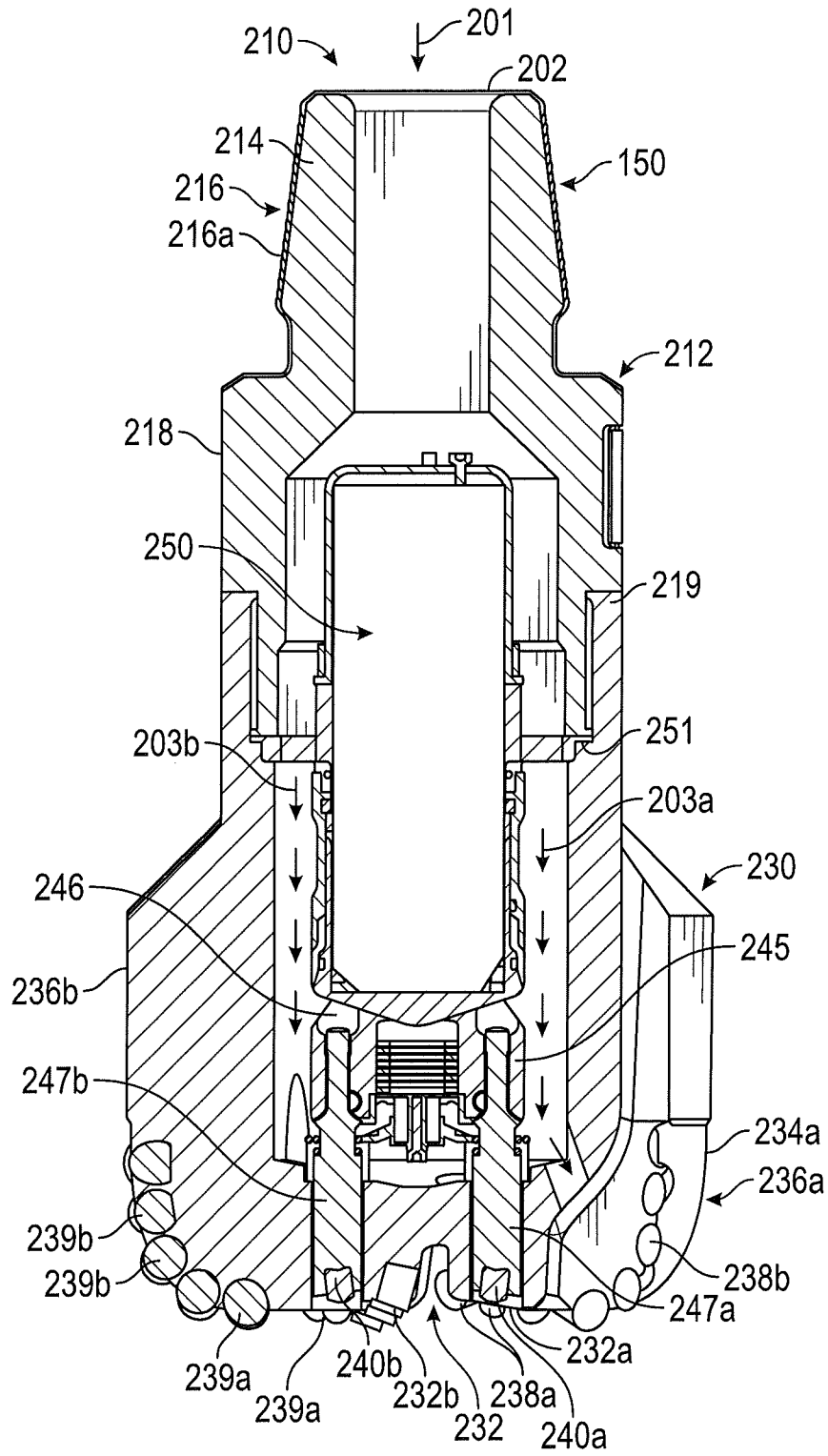


FIG. 2

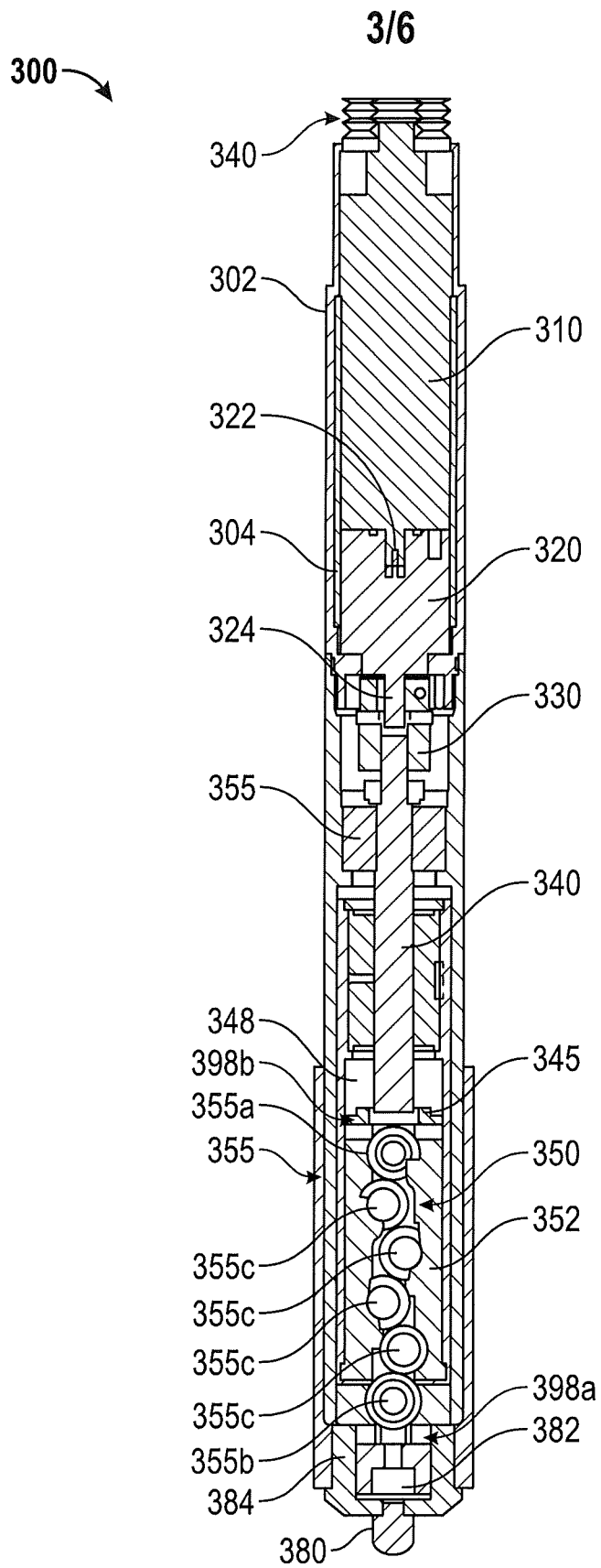


FIG. 3

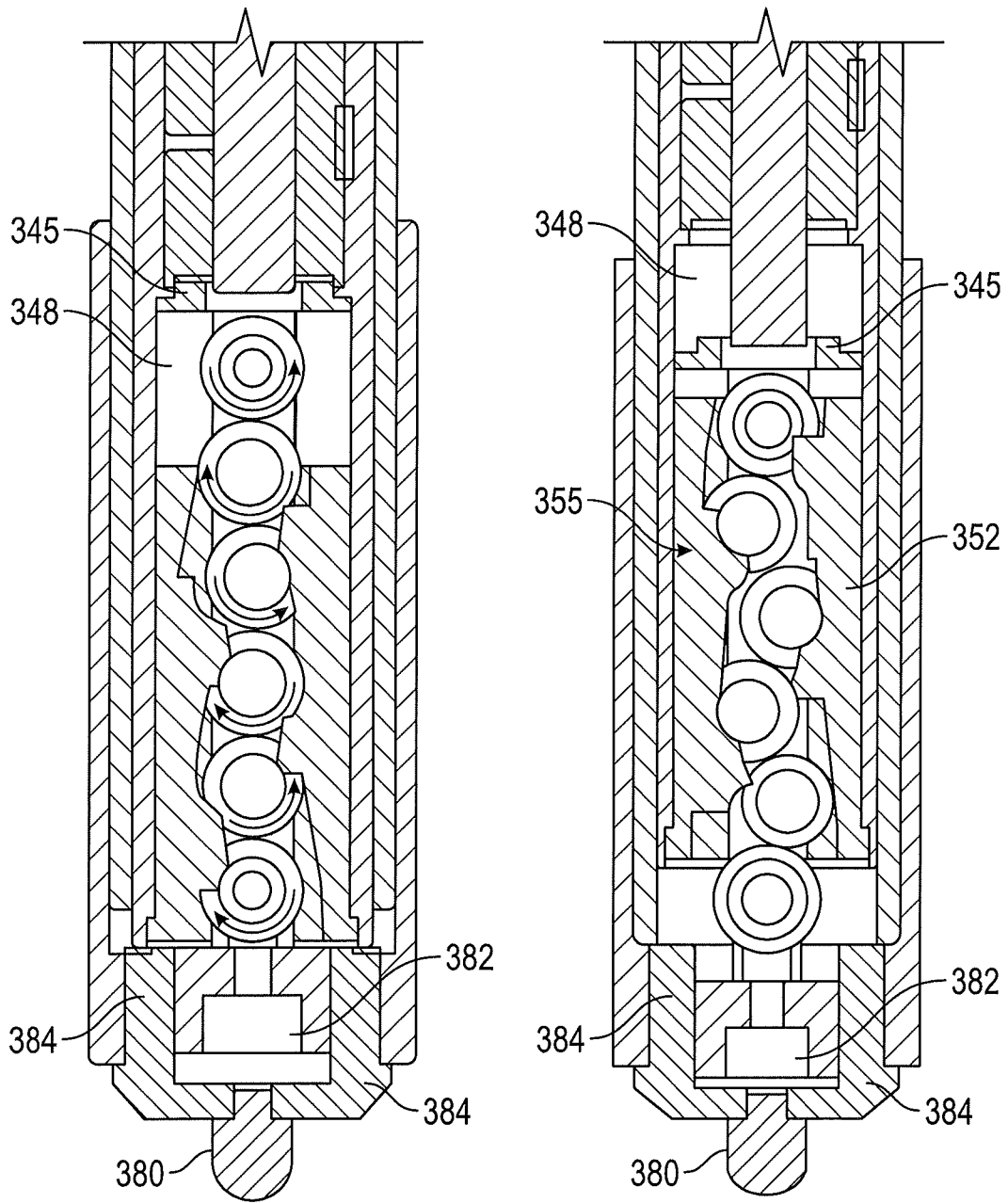


FIG. 4

FIG. 5

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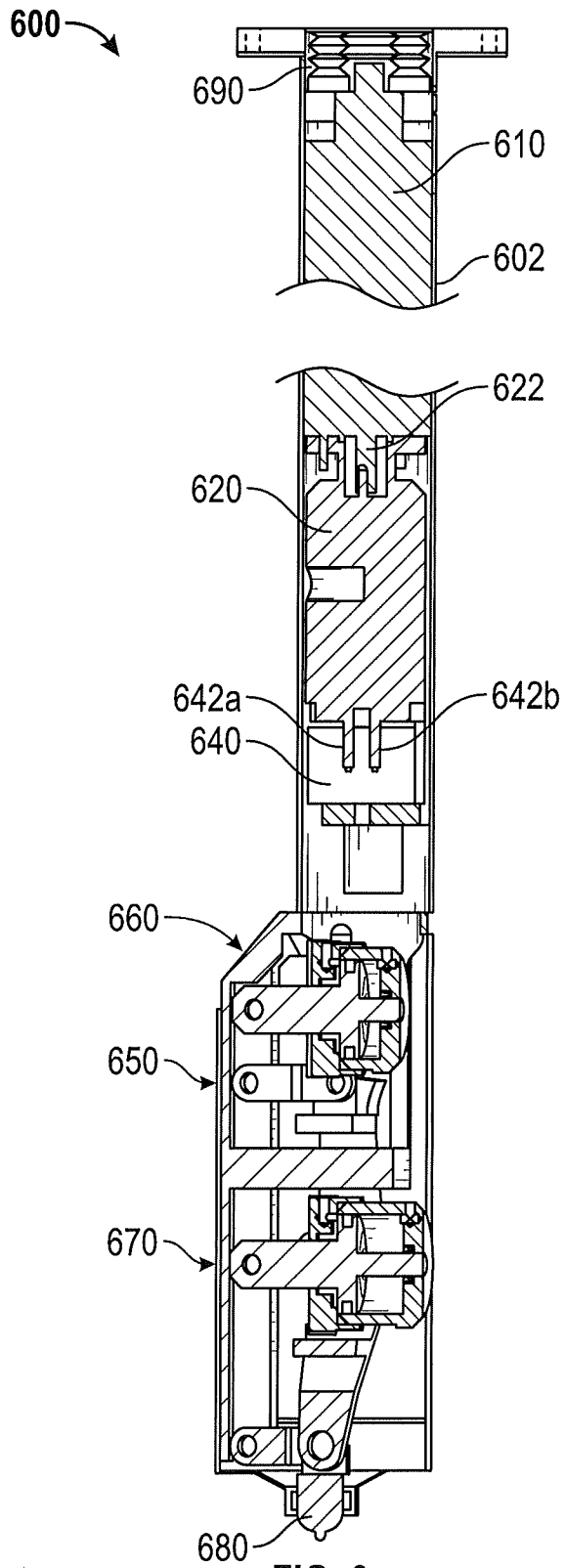


FIG. 6

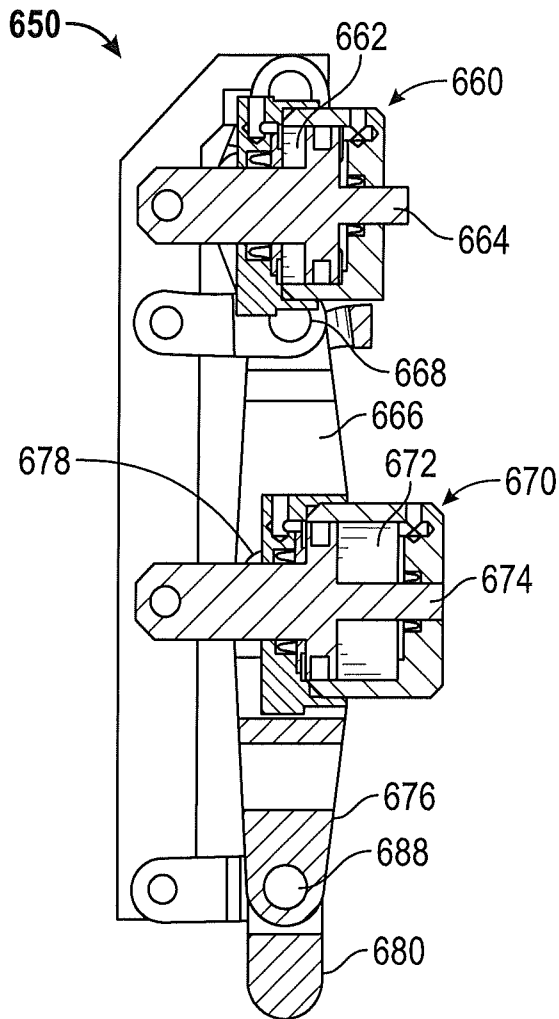


FIG. 7

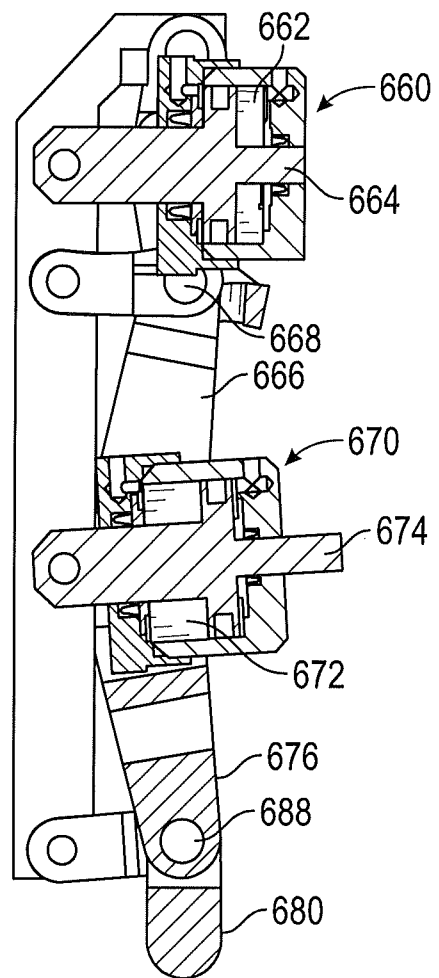


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/052619**A. CLASSIFICATION OF SUBJECT MATTER****E21B 7/04(2006.01)i, E21B 4/00(2006.01)i, E21B 19/24(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 7/04; E21B 4/02; E21B 4/00; E21B 7/06; E21B 10/42; E21B 19/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: drilling, drill bit, pad, force application, lever, and drive

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010-0071956 A1 (BEUERSHAUSEN, CHAD J.) 25 March 2010 See paragraphs [0019]-[0025] and figures 1-3A.	1-5, 9-14, 18-19, 21
A		6-8, 15-17, 20
Y	US 4185704 A (NIXON, JR., JEDDY D.) 29 January 1980 See column 3, lines 3-43 and figures 1-3.	1-5, 9-14, 18-19, 21
A	US 2010-0212966 A1 (HALL, DAVID R. et al.) 26 August 2010 See paragraphs [0037]-[0042], [0049] and figures 1-7, 13a-13b.	1-21
A	US 5582260 A (MURER, MARIO V. et al.) 10 December 1996 See column 2, line 33 - column 3, line 65 and figures 1-2.	1-21
A	US 5971085 A (COLEBROOK, MARK) 26 October 1999 See column 4, line 23 - column 5, line 22 and figures 1-2.	1-21

 Further documents are listed in the continuation of Box C. See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

24 October 2013 (24.10.2013)

Date of mailing of the international search report

25 October 2013 (25.10.2013)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/052619

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0071956 A1	25/03/2010	CA 2736710 A1 EP 2340346 A2 US 2010-0071962 A1 US 7971662 B2 US 8205686 B2 WO 2010-036834 A2 WO 2010-036834 A3 WO 2010-042797 A2 WO 2010-042797 A3	15/04/2010 06/07/2011 25/03/2010 05/07/2011 26/06/2012 01/04/2010 17/06/2010 15/04/2010 08/07/2010
US 4185704 A	29/01/1980	None	
US 2010-0212966 A1	26/08/2010	US 2010-0212884 A1 US 2010-0212885 A1 US 2010-0212886 A1 US 2010-0212965 A1 US 7669663 B1 US 8365842 B2 US 8365843 B2 US 8371400 B2	26/08/2010 26/08/2010 26/08/2010 26/08/2010 02/03/2010 05/02/2013 05/02/2013 12/02/2013
US 5582260 A	10/12/1996	CA 2128903 C EP 0624225 A1 EP 0624225 B1 WO 94-13928 A1	28/11/2000 17/11/1994 19/03/1997 23/06/1994
US 5971085 A	26/10/1999	EP 0841462 A2 EP 0841462 A3 EP 0841462 B1 GB 2322651 A	13/05/1998 20/01/1999 19/02/2003 02/09/1998