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(54) **METHOD AND SYSTEM FOR DRIVING A DOWNHOLE POWER UNIT**

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E21B 23/06 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 41/00*** (2013.01); ***E21B 23/06*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 1/00; E21B 1/02; E21B 1/04; E21B 10/36; E21B 41/00; E21B 6/00; E21B 4/06; E21B 4/00; E21B 6/02; E21B 6/04; E21B 6/06; E21B 6/08; E21B 23/06; E21B 23/00
See application file for complete search history.

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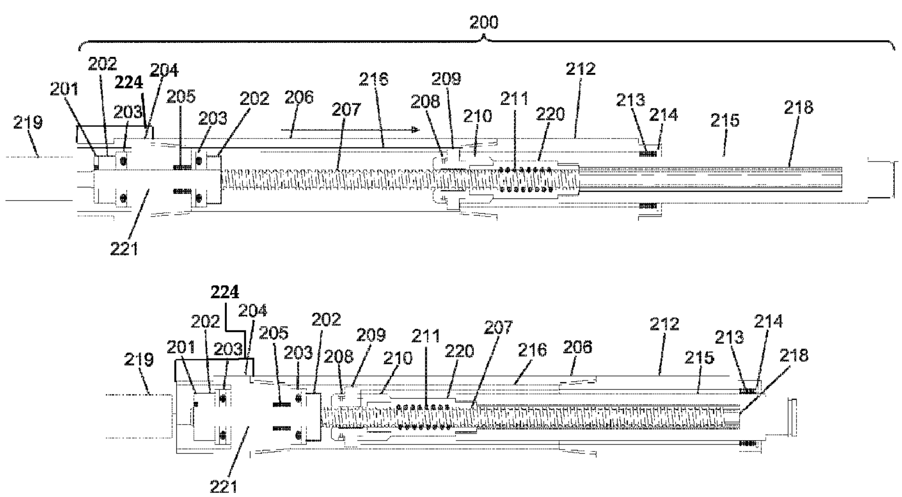
(57) **ABSTRACT**

A method and apparatus for setting a subsurface device in a wellbore. A downhole power unit comprises a power rod and a drive shaft. The power rod comprises a hollow interior. The drive shaft is located within the hollow interior, and the power rod is operable to selectively engage a subsurface device to be positioned downhole.

18 Claims, 2 Drawing Sheets



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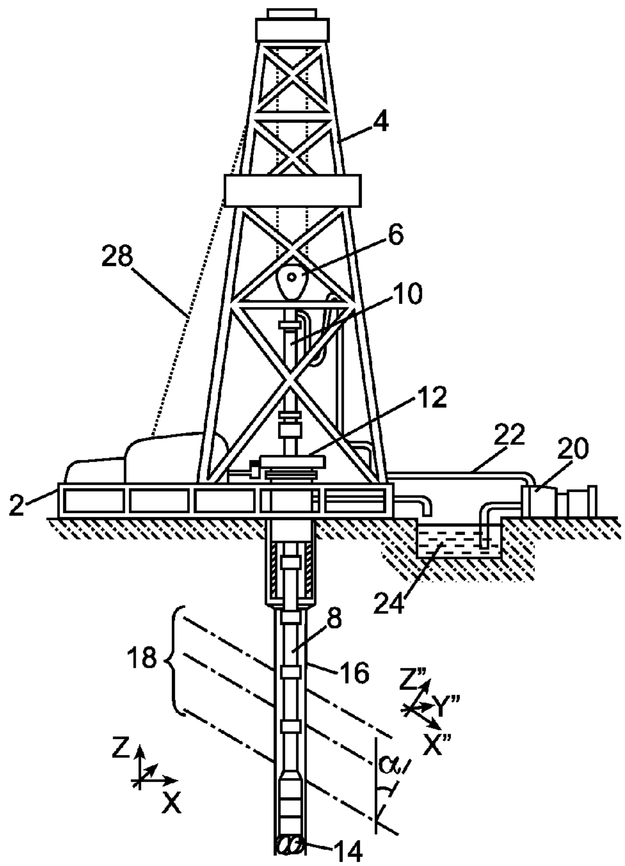

Fig. 1A

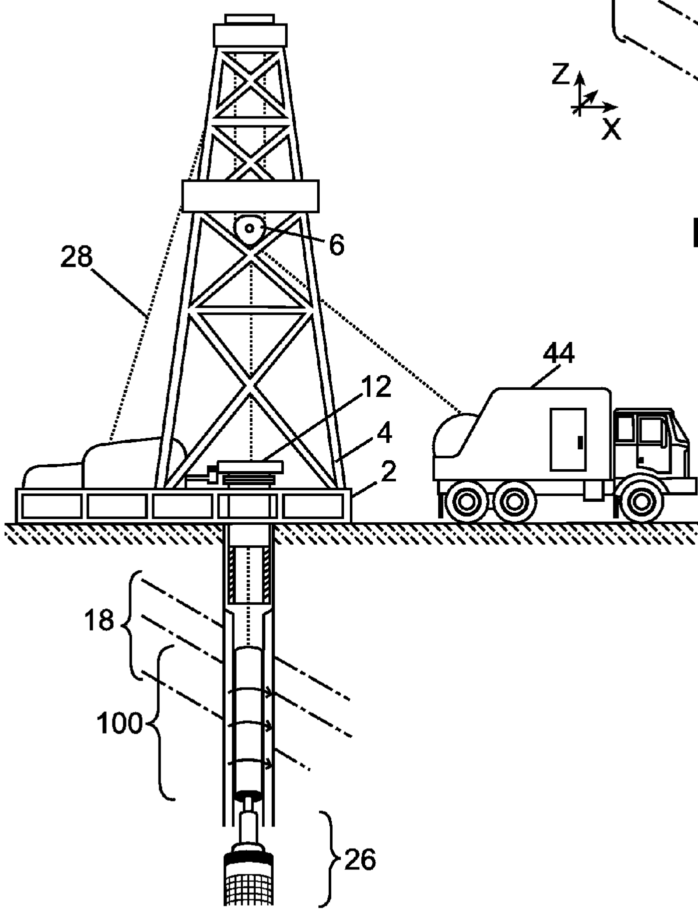

Fig. 1B

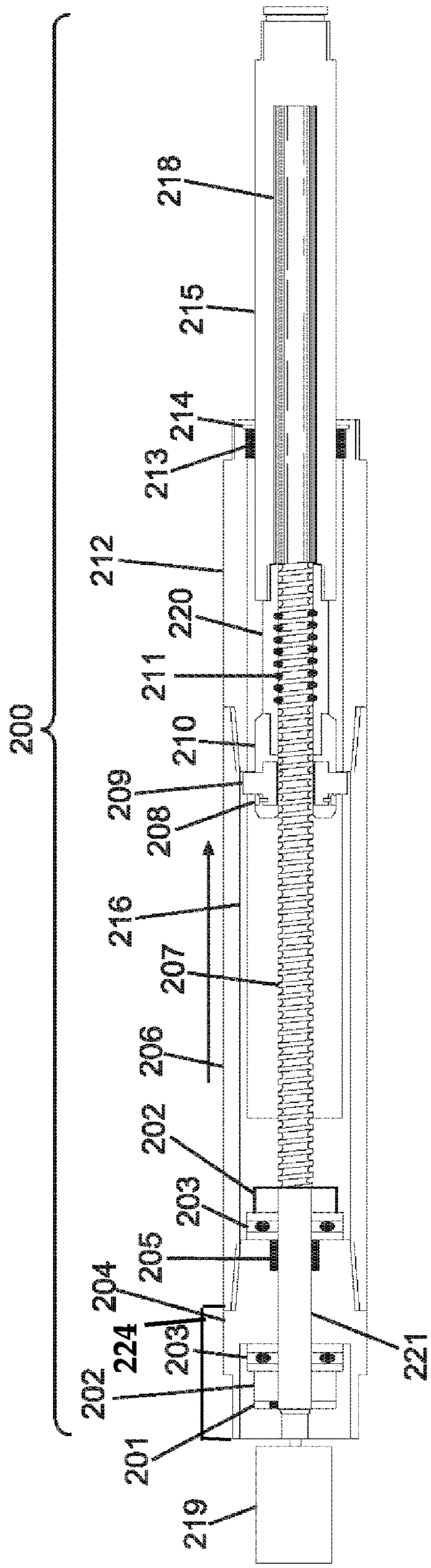
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Fig. 2A

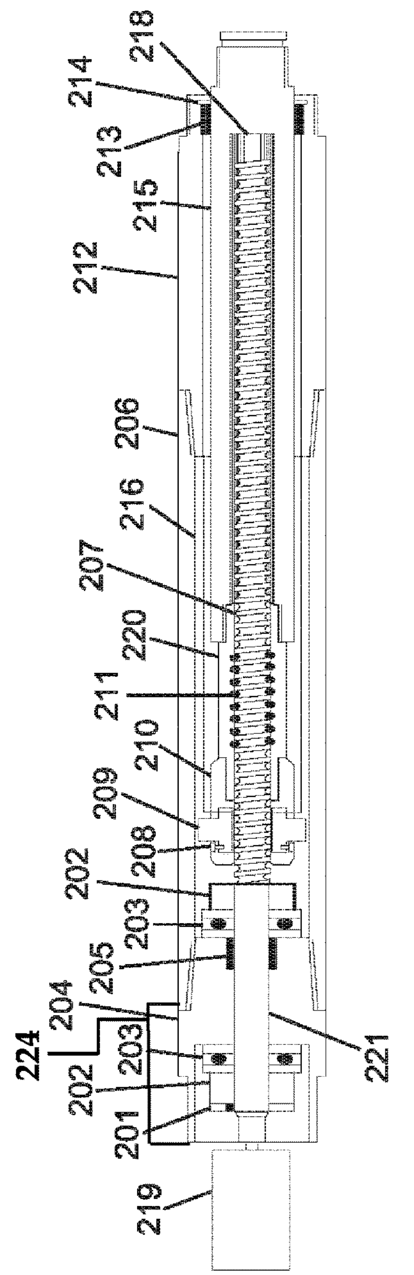
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Fig. 2B

METHOD AND SYSTEM FOR DRIVING A DOWNHOLE POWER UNIT

CROSS-REFERENCE TO RELATED APPLICATION

This application is a U.S. National Stage Application of International Application No. PCT/US2012/062155 filed Oct. 26, 2012, and which is hereby incorporated by reference in its entirety.

BACKGROUND

After drilling a wellbore that intersects a subterranean hydrocarbon-bearing formation, a variety of wellbore tools may be positioned in the wellbore during completion, production, or remedial activities. For example, temporary packers may be set in the wellbore during the completion and production operating phases of the wellbore. In addition, various operating tools including flow controllers (e.g., chokes, valves, etc.) and safety devices such as safety valves may be releasably positioned in the wellbore.

A number of subsurface wellbore devices such as plugs, safety valves, packers, and the like may be used when performing subterranean operations. Such tools are generally lowered downhole by either a wireline or a working string and may be configured with a fishing neck to facilitate recovery at a later time. Once downhole, the tool may be set at a desired location and released, allowing the wireline or work string to be retrieved.

The setting and retrieving of such tools may be performed mechanically by a work string or wireline or by electrically actuated power units. Electrically actuated power units may utilize a conductor in the wireline to accomplish actuation by surface power, after the tool is properly positioned. Alternatively, self-contained Downhole Power Units ("DPUs") which do not require electrical power from the surface and therefore permit using a slickline rather than a wireline may be used. The use of DPUs is desirable because of their relative speed and efficiency of use.

However, because DPUs are not powered from the surface, they can only apply a limited amount of force. Further, conventional DPUs are relatively long to prevent exposure of parts to wellbore pressure. It is desirable to develop a more compact DPU that can provide greater force than that supplied by traditional DPUs.

BRIEF DESCRIPTION OF THE DRAWING(S)

The present disclosure will be more fully understood by reference to the following detailed description of the preferred embodiments of the present disclosure when read in conjunction with the accompanying drawings, in which like reference numbers refer to like parts throughout the views, wherein:

FIG. **1**A depicts a wellbore drilling environment in accordance with an embodiment of the present disclosure;

FIG. **1**B depicts a DPU being inserted into a wellbore in accordance with an embodiment of the present disclosure;

FIG. **2**A depicts a DPU in accordance with an embodiment of the present disclosure in an extended position;

FIG. **2**B depicts the DPU of FIG. **2**A in a contracted position.

The disclosure may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the disclosure being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

DETAILED DESCRIPTION OF THE DISCLOSURE

Illustrative embodiments of the present invention are described in detail herein. In the interest of clarity, not all features of an actual implementation may be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions may be made to achieve the specific implementation goals, which may vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure.

The terms "couple" or "couples," as used herein are intended to mean either an indirect or a direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection, or through an indirect electrical or mechanical connection via other devices and connections. The term "upstream" as used herein means along a flow path towards the source of the flow, and the term "downstream" as used herein means along a flow path away from the source of the flow. The term "uphole" as used herein means along the drillstring or the hole from the distal end towards the surface, and "downhole" as used herein means along the drillstring or the hole from the surface towards the distal end.

It will be understood that the term "oil well drilling equipment" or "oil well drilling system" is not intended to limit the use of the equipment and processes described with those terms to drilling an oil wellbore. The terms also encompass drilling natural gas wellbores or hydrocarbon wellbores in general. Further, such wellbores can be used for production, monitoring, or injection in relation to the recovery of hydrocarbons or other materials from the subsurface. This could also include geothermal wellbores intended to provide a source of heat energy instead of hydrocarbons.

Turning now to FIG. **1**A, oil well drilling equipment used in an illustrative drilling environment is shown. A drilling platform **2** supports a derrick **4** having a traveling block **6** for raising and lowering a drill string **8**. A kelly **10** supports the drill string **8** as it is lowered through a rotary table **12**. A drill bit **14** is driven by a downhole motor and/or rotation of the drill string **8**. As bit **14** rotates, it creates a wellbore **16** that passes through various formations **18**. A pump **20** may circulate drilling fluid through a feed pipe **22** to kelly **10**, downhole through the interior of drill string **8**, through orifices in drill bit **14**, back to the surface via the annulus between the drill string **8** and the wellbore **16** wall, and into a retention pit **24**. The drilling fluid transports cuttings from the borehole into the pit **24** and aids in maintaining the borehole integrity.

At various times during the drilling process, the drill string **8** may be removed from the wellbore **16**. Once the drill string has been removed, a subsurface device **26** (e.g., a plug, packer, etc.) may be coupled to a DPU **100** and lowered downhole to the desired setting depth via a conveying member **28** as shown in FIG. **1**B. A timer initiates this operation. The conveying member **28** may be a slickline, wireline, coil tubing, joint tubing, or braided line. The subsurface device **26** may be used, for example, to seal off or isolate zones inside the wellbore **16**. Once the subsurface device **26** reaches the desired location within the wellbore **16**, the DPU **100** sets it in place via a process described in more detail below. Once the subsurface device **26** is securely set in place, the DPU **100** may be retrieved by the operator using the conveying member **28** or any other suitable means.

Referring now to FIG. **2**A, a cross-sectional view of a DPU in accordance with certain embodiments of the present disclosure is denoted generally with reference numeral **200**.

As illustrated in FIG. **2**A, the DPU **200** may include a guide housing **206** with a drive shaft **207** located therein. A first end of the drive shaft **207** may be rotatably coupled to a motor **219** as discussed in further detail below. A second end of the drive shaft **207** located downhole relative to the first end, may be coupled to a power rod **215**. In one embodiment, at least a portion of the drive shaft **207** may be threaded and may be coupled to a hollow interior **218** of the power rod **215** with a threaded engagement. Specifically, the power rod **215** may include a ball nut assembly **211**. In accordance with the illustrative embodiment of FIGS. **2**A and **2**B, the ball nut assembly **211** and the threads of the drive shaft **207** may form the female portion and male portion, respectively, of a threaded connection. Consequently, the hollow interior **218** of the power rod **215** may selectively engage the threaded portion of the drive shaft **207** in a threaded engagement.

The power rod **215** may include a coupling mechanism (e.g., slips, keys, or dogs) **209** that engages the guide housing **206** to rotationally fix the power rod **215** relative to the guide housing **206**. In certain implementations, the power rod **215** may include a similar coupling mechanism (not shown) to engage the wellbore or an outerstring to stabilize its movement. In the embodiment shown in FIGS. **2**A and **2**B, the guide housing **206** has grooves **216** that engage the keys **209**. A key block **210** is coupled to both the keys **209** and the ball nut assembly **211**. The key block **210** moves linearly with the keys **209** but does not engage the guide housing **206**. This arrangement prevents the keys **209**, key block **210**, and power rod **215** from moving rotationally when the drive shaft **207** is rotating but allows the keys **209**, key block **210**, power rod **215**, and ball nut housing **220** to move linearly. In certain implementations, the keys **209** may be fixed to the key block **210** by one or more key screws **208**.

Accordingly, the rotation of the drive shaft **207** in a first direction may rotate the drive shaft out of the ball nut assembly **211**, thereby extending the power rod **215** out of the DPU **200**. Similarly, a rotation of the drive shaft **207** in the opposite direction may rotate the drive shaft **207** into the ball nut assembly **211**, thereby retracting the power rod **215** back into the DPU **200**. FIGS. **2**A and **2**B depict the power rod in its extended and retracted position, respectively.

The DPU **200** may be moved uphole and downhole by a conveying member (not shown) such as a slickline, a wireline, or coil tubing. In certain implementations, the conveying member may be coupled to the power section (not shown) of the DPU **200**.

The motor **219** may be used to regulate rotation of the drive shaft **207**. In certain embodiments, the motor **219** may be a direct current (DC) electric motor of any suitable type and it may be coupled to a self-contained power source, eliminating the need for power to be supplied from an exterior source, such as a source at the surface. As would be appreciated by those of ordinary skill in the art, having the benefit of this disclosure, any suitable power source may be used in conjunction with the motor **219**. For example, in certain illustrative embodiments, the power source may include a battery assembly. In one implementation, battery assembly of the self contained power source may include a pack of one or more D-cell type alkaline batteries. Moreover, in certain illustrative embodiments, the motor **219** may be selectively activated and deactivated using a timer (not shown). Specifically, the timer may be set before the DPU **200** is directed downhole so that it will turn the motor **219** after a predetermined amount of time elapses. Additionally, the timer may be programmed to turn the motor **219** off after it has been on for a certain time period. As would be appreciated by those of ordinary skill in the art having the benefit of the present disclosure, any suitable timers may be used to control the operation of the motor **219**. For instance, the timer may be a jumper timer or one of various types of rotary selection timers.

The hollow interior **218** of the power rod **215** may be designed to be able to engage other components therein. For instance, in certain embodiments the hollow interior **218** may include or be coupled to a threaded ball nut assembly **211**. The motor **219** may be rotationally coupled to the drive shaft **207** so that energy generated by the motor **219** can be transferred to the drive shaft **207**. The drive shaft **207** and the motor **219** may be coupled using any suitable coupling mechanism. For instance, in certain embodiments, a first end of the drive shaft **207** which is coupled to the motor **219** may include a square portion that aligns with and engages a socket on the motor shaft **221**. Accordingly, the motor **219** may be rotationally coupled to the drive shaft **207**. Further, as discussed above, a portion of the drive shaft **207** may be threaded. The threaded portion of the drive shaft may be received within the hollow interior **218** of the power rod **215** through the ball nut assembly **211**. Accordingly, the drive shaft **207** may be coupled to the power rod **215** so that rotation of the drive shaft **207** is translated into a linear motion of the power rod **215**.

Once the motor **219** is activated (i.e., turned on), the motor shaft **221** will rotate. Because the motor shaft **221** is coupled to the drive shaft **207**, the rotation of the motor **219** will also rotate the drive shaft **207**.

As the drive shaft **207** rotates in a pre-set direction, it moves into the hollow interior **218** of the power rod **215**. When the drive shaft **207** reaches near the end of the hollow interior **218** of the power rod **215**, the DPU **200** may be in a retracted position as shown in FIG. **2**B. The keys **209** may reach a position where they may slide out of the grooves **216** on the guide housing **206**, enabling the keys **209**, key guide **210**, ball nut housing **220**, and power rod **215** to rotate with the rotation of the motor **219** and the drive shaft **207**. This free rotation may be referred to as "freewheel" mode. This serves to prevent the drive shaft **207** from traveling any further downhole and protects the motor **219** from damage. Eventually, the motor **219** will time out and turn off.

The motor **219** may also be operated in the opposite direction so that the drive shaft **207** extends uphole out of the hollow interior **218** of the power rod **215**. In this implementation, the grooves **216** on the guide housing **206** that engage the keys **209** may be configured so that a freewheel mode occurs when the tool is in an extended position. Specifically, the guide housing **206** may be configured so that the grooves **216** have openings on a downhole end thereof to permit the keys **209** to slide out of the grooves **216** of the guide housing **206** once the drive shaft **207** has reached its maximum extended position. Accordingly, in the same manner discussed above, in the maximum extended position the drive shaft **207** enters a freewheel position.

A plurality of retainer nuts **202** may be threaded onto an uphole end of the drive shaft **207**. A retainer locking disk **201** may be threaded on the drive shaft **207** and is located uphole of the retainer nuts **202**. The retainer nuts **202** ensure the drive shaft **207** does not become disengaged from the power rod **215** by rotating too far uphole. The retainer locking disk **201** may act to prevent the power rod **215** from moving from a predetermined stationary position. The retainer locking disk **201** may consist of any suitable structures known to those of ordinary skill in the art, having the benefit of the present disclosure. For instance, in certain illustrative embodiments, the locking disk **201** may include an allen screw or any type of bolt, or a threaded screw with a slot. Thrust bearings **203** may be threaded onto the uphole end of the drive shaft **207**. Thrust bearings **203** may allow the drive shaft **207** to rotate under loads from either direction. When the motor **219** is operated, the retainer locking disk **201** and the retainer nuts **202** rotate with the drive shaft **207**. The top sub-housing **204**, the guide housing **206**, and the lower housing **212** all move linearly but do not rotate.

In certain implementations, lubricating fluid may be provided in the hollow interior **218** of the power rod **215**. Wellbore pressure may be great at certain depths, causing the drive shaft **207** to rotate at a speed that is undesirably high. When the motor **219** is activated, the motor shaft **221** begins to rotate. The pressure inside the wellbore acting on the cross sectional area of the drive shaft **207** is greater than the pressure in the hollow interior **218** of the power rod **215**. The force applied to the power rod **215** is exerted to the drive shaft **207** which causes the drive shaft **207** to rotate at high speeds until external forces (i.e., the device being set) equal the forces applied to the power rod **215**. At that point, the continued rotation of the motor **219** would continue to turn the drive shaft **207** to retract the power rod **215** until the setting procedure is complete. The fluid will provide resistance to the rotation of the drive shaft **207** to slow down the rotation speed of the drive shaft **207**. As the drive shaft **207** enters the hollow interior **218** of the power rod **215**, the lubricating fluid may be forced out along space around the ball nut assembly **211**. This will also ensure that the ball nut assembly **211** is well lubricated. The appropriate amount of lubricating fluid to fill the hollow interior **218** of the power rod **215** may be measured in advance of the DPU **200** being lowered downhole.

Drive shaft seals **205** may operate to prevent fluid flow into the motor **219** and other circuitry in the power section of the DPU **200**. Rod seals **213** may be used as backup seals to prevent fluid flow into the motor **219** and other circuitry if the drive shaft seals **205** fail. A spiral retainer ring **214** may be used to keep the rod seals **213** in place and prevent them from blowing out due to internal pressure. Other types of retainers may be used in place of the spiral retainer ring **214**.

In certain implementations, a frictional braking system **224**, similar to a disk brake or drum brake on a car, may be coupled to the top sub housing **204**. The frictional braking system **224** may be another mechanism that may be used to slow the rotation of the drive shaft **207** and the motor **219**.

Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

What is claimed is:

1. A downhole power unit comprising:
- a motor;
- a drive shaft, coupled to the motor, and disposed within a guide housing; and
- a power rod comprising a hollow interior and a coupling mechanism that rotationally fixes the power rod to the guide housing,
- wherein the drive shaft selectively engages the hollow interior,
  - wherein rotation of the drive shaft extends the power rod linearly relative to the guide housing to an extended position, and wherein counter-rotation of the drive shaft retracts the power rod linearly relative to the guide housing to a retracted position, and
  - wherein a portion of the power rod extends outside the guide housing in the extended position, and
- wherein the power rod is operable to selectively engage a subsurface device to be positioned downhole.

2. The downhole power unit of claim **1**, wherein the hollow interior of the power rod contains lubricating fluid.

3. The downhole power unit of claim **1**, wherein the drive shaft further comprises a threaded portion.

4. The downhole power unit of claim **3**, wherein the hollow interior of the power rod selectively engages the threaded portion of the drive shaft in a threaded engagement.

5. The downhole power unit of claim **1**, further comprising:
- a plurality of ball nuts;
- wherein the motor operates to move the drive shaft rotationally, and wherein the drive shaft operates to move the ball nuts rotationally.

6. The downhole power unit of claim **1**, wherein a plurality of seals prevent fluid from entering the motor.

7. The downhole power unit of claim **1**, further comprising a frictional braking system, wherein the frictional braking system is operable to slow the rotation of the drive shaft and the motor.

8. The downhole power unit of claim **1**, wherein the drive shaft is positioned in a guide housing having a groove, wherein the power rod comprises one or more keys operable to engage the groove, and wherein when the one or more keys disengage the groove the rotation of the drive shaft in the first direction does not move the power rod linearly from the first position to the second position.

9. The downhole power unit of claim **1**, wherein the coupling mechanism is one of the following: a slip, a key, and a dog.

10. The downhole power unit of claim **1**, wherein the power rod is disposed within the guide housing when the power rod is in a retracted position.

11. A method of setting a subsurface device in a wellbore, comprising:
- lowering a subsurface device and a downhole power unit (DPU) into a wellbore;
- operating a motor on board the DPU;
- rotating a drive shaft of the DPU into a hollow interior of a power rod of the DPU, wherein the drive shaft is disposed within a guide housing, and wherein the power rod comprises a coupling mechanism that rotationally fixes the power rod to the guide housing;
- translating the power rod to an extended position such that a portion of the power rod extends outside of the guide housing;

retracting the power rod of the DPU to a retracted position such that the power rod is disposed within the guide housing; and

retrieving the DPU.

12. The method of claim **11**, wherein the hollow interior of the power rod of the DPU contains lubricating fluid.

13. The method of claim **11**, wherein the drive shaft of the DPU further comprises a threaded portion.

14. The method of claim **13**, wherein the hollow interior of the power rod of the DPU selectively engages the threaded portion of the drive shaft in a threaded engagement.

15. The method of claim **11**, further comprising:

rotating a plurality of ball nuts, wherein operating the motor causes the drive shaft to move rotationally, and rotation of the drive shaft causes the ball nuts to move rotationally.

16. The method of claim **11**, wherein a plurality of seals prevent fluid from entering the motor.

17. The method of claim **11**, further comprising:

operating a frictional braking system, wherein the frictional braking system is operable to slow the rotation of the drive shaft and the motor.

18. The method of claim **11**, wherein the drive shaft is positioned in a guide housing having a groove, wherein the power rod comprises one or more keys operable to engage the groove, and wherein when the one or more keys disengage the groove the rotation of the drive shaft in the first direction does not move the power rod linearly from the first position to the second position.

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