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Downhole power and communications system(s) and method(s) of using same

Abstract

Apparatus, method(s), and system(s) according to which electric power is generated in one or more coils by rotating a magnetic field generated by one or more permanent magnets. The one or more coils are connected to a collar. The collar is positioned downhole in an oil and gas wellbore. The one or more permanent magnets are connected to a rotor positioned within an internal passageway of the collar. A fluid is communicated along the internal passageway of the collar. The rotor, and thus the magnetic field generated by the one or more permanent magnets, are rotated using the fluid communicated along the internal passage.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a continuation of U.S. patent application Ser. No. 17/463,101, filed Aug. 31, 2021, the entire disclosure of which is hereby incorporated herein by express reference thereto.

TECHNICAL FIELD

(1) This application relates generally to downhole tool(s) used in oil and gas wellbore operations, and, more particularly, to downhole power and communications system(s), apparatus(es), and method(s) of using same.

BACKGROUND

(2) In some instances, measurement-while-drilling (“MWD”) and logging-while-drilling (“LWD”) tools are powered by a downhole turbine in the course of an oil and gas wellbore operation (e.g., a drilling operation). Existing turbines are probe-based, meaning that power-generating coil(s) (e.g., a generator or electric motor component(s)) is/are placed inside a probe housing, which is centered within an internal passage of a collar. The MWD/LWD tools are also often placed within the probe housing. A rotor portion of the probe also generally includes radially-extending blades adapted to rotate in response to an axial flow of fluid through the internal passage of the collar. Such a conventional configuration requires various complex seals between the rotor and the rest of the probe. Additionally, for various MWD/LWD tools it is desirable to deliver power to the collar portion of the tool. In order to transfer power generated by the coil(s) and data collected by the MWD/LWD tools within the probe housing to the collar, such a conventional configuration requires “crossover” wires (accompanied by various complex mechanical components) where the probe wires must cross the path of the fluid flow while remaining protectively encased in a mechanical housing. For various reasons, it would be desirable to eliminate the need for such crossover wires and the complex seals in downhole turbines. Therefore, what is needed is/are apparatus(es), system(s), and/or method(s) to address these and other problems in the design of downhole power generation equipment.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 is a schematic illustration of an oil and gas wellsite including a wellbore extending from a surface through one or more subterranean formations, and a bottom-hole assembly operably coupled to a conveyance string in the wellbore, according to one or more embodiments.
- (2) FIG. 2 is a diagrammatic illustration of a downhole power and communications system of the bottom-hole assembly of FIG. 1, according to one or more embodiments.
- (3) FIG. 3 is a flow diagram illustrating a method for powering one or more downhole tools using the downhole power and communications system of FIG. 2, according to one or more embodiments.
- (4) FIG. 4 is a diagrammatic illustration of a computing node for implementing one or more embodiments of the present disclosure.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(5) Referring to FIG. 1, in an embodiment, an oil and gas well system is generally referred to by reference numeral **10**. Well system **10** includes a mast **25** positioned over one or more subterranean oil and gas formation(s) **20**. The mast **25** supports lifting gear, which lifting gear includes a crown block **30** and a travel block **35**. The crown block **30** is connected to the mast **25** at or near a top portion of the mast **25**. The travel block **35** hangs from the crown block **30** by a drilling line **40**, which drilling line **40** extends from the lifting gear to drawworks **45**. The drawworks **45** are configured to reel out and reel in the drilling line **40**, causing the travel block **35** to be lowered and raised, respectively, relative to the mast **25**. A conveyance string **50** is connected to the travel block **35** and suspended within a wellbore **55** that extends from a surface location through various earth strata, including the formation(s) **20**. For example, the wellbore **55** may include a casing string (not shown) cemented in at least a portion thereof. An annulus **60** is defined between the conveyance string **50** and the wellbore **55**.

(6) A bottom-hole assembly **65** is connected to the conveyance string **50** at the distal (or downhole) end portion of the conveyance string **50**. In one or more embodiments, as in FIG. **1**, the bottom-hole assembly **65** includes a drilling tool **70** (including, e.g., a drill bit and a mud motor) and a downhole power and communications system **100**. In such embodiments, one or more mud pump(s) **75** are adapted to deliver drilling mud through a conduit **80** to the conveyance string **50**, and, ultimately, to the drilling tool **70** in the wellbore **55**. Additionally, in such embodiments, a drive system **85** (e.g., a top-drive, a rotary table, another drive system, or the like) is adapted to rotate the conveyance string **50** while applying weight-on-bit to the drilling tool **70** (via the conveyance string **50**).

(7) Although described as being part of the bottom-hole assembly **65** in combination with the drilling tool **70**, the drilling tool **70** may instead be omitted from the bottom-hole assembly, in which case the bottom-hole assembly **65** can be re-purposed for another downhole operation other than drilling, e.g., casing operations, or, rather than being incorporated into the bottom-hole assembly **65**, the system **100** may instead be incorporated into any one of a wide variety of differently-purposed bottom-hole assembl(ies), downhole tool(s), etc.

(8) A control system **90** is adapted to control (or assist with controlling) one or more components of the well system **10**. For example, the control system **90** may be adapted to transmit control signals to the drawworks **45**, the drive system **85**, the mud pump(s) **75**, and/or the bottom-hole assembly **65** (including the drilling tool **70** and/or the system **100**). In one or more embodiments, the control system **90** is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the control system **90** is located on-site at the well site. Alternatively, the control system **90** may be located remotely from the well site. In one or more embodiments, the control system **90** includes a plurality of controllers. In one or more embodiments, the control system **90** includes a plurality of controllers, with one or more controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.

(9) Referring to FIG. **2**, in an embodiment, the downhole power system is generally referred to by the reference numeral **100**. The system **100** includes a collar **105** adapted to be positioned in the wellbore **55**; when so positioned in the wellbore **55**, the collar **105** defines an uphole end portion **110a**, a downhole end portion **110b**, and an internal passageway **115** extending through the collar **105** from the uphole end portion **110a** to the downhole end portion **110b**. The internal passageway **115** defines an inside surface **120** of the collar **105**. The collar **105** also defines an outside surface **125**. One or more coil(s) **130** are connected to the collar **105** along the inside surface **120**. For example, the coil(s) **130** may be at least partially embedded into the inside surface **120** of the collar **105** (or even fully embedded with a radially innermost surface of the coil(s) **130** being flush with the inside surface **120**). For example, the coil(s) **130** may be at least partially received within internal pockets **131a-b** formed in the inside surface **120** of the collar **105**. As shown, the internal pockets **131a-b** are radially internal. Covers **132a-b** are connectable to the collar **105** over the internal pockets **131a-b**, respectively, to contain the coil(s) **130** within the internal pockets **131a-b**, and to seal the internal pockets **131a-b** from fluid(s) in the annulus internal passageway **115**. In one or more embodiments, the coil(s) **130** may be surrounded by epoxy (or another electrically insulative material) within the internal pockets **131a-b**. In one or more embodiments, the coil(s) **130** are part of the collar **105**. In addition, or instead, in one or more embodiments, the coil(s) **130** are part of a “stator” of the system **100**, which “stator” may be or include at least a portion of the collar **105**. In one or more embodiments, the internal pockets **131a-b** are combined into a single (e.g., annular) internal pocket, and the corresponding covers **132a-b** are combined into a single (e.g., annular) cover.

(10) A controller **135** is connected to the collar **105** along the outside surface **125**. For example, the controller **135** may be at least partially received within an external pocket **140a** formed in the outside surface **125** of the collar **105**. As shown, the external pocket **140a** is radially external. A

cover **141a** is connectable to the collar **105** over the external pocket **140a** to contain the controller **135** within the external pocket **140a**, and to seal the external pocket **140a** from fluid(s) in the annulus **60**. In one or more embodiments, the controller **135** is part of the collar **105**. The controller **135** is connected to, and adapted to receive electric power from, the coil(s) **130**. In one or more embodiments, the controller **135** is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller **135** includes a plurality of controllers.

(11) One or more sensor(s) **145** are also connected to the collar **105** along the outside surface **125**. For example, the sensor(s) **145** may be at least partially received within an external pocket **140b** formed in the outside surface **125** of the collar **105**. As shown, the external pocket **140b** is radially external. A cover **141b** is connectable to the collar **105** over the external pocket **140b** to contain the sensor(s) **145** within the external pocket **140b**, and to seal the external pocket **140b** from fluid(s) in the annulus **60**. In one or more embodiments, the sensor(s) **145** are part of the collar **105**. The sensor(s) **145** are connected to, and adapted to be in electrical communication with, the controller **135**. The sensor(s) **145** are further adapted to receive electric power from the coil(s) **130**, via the controller **135**. In addition, or instead, the sensor(s) **145** may be connected to, and adapted to receive electric power directly from, the coil(s) **130**.

(12) A power storage device **146** (a battery, a capacitor, another power storage device, the like, or any combination thereof) is also connected to the collar **105** along the outside surface **125**. For example, the power storage device **146** may be at least partially received within an external pocket **140c** formed in the outside surface **125** of the collar **105**. As shown, the pocket **140c** is radially external. A cover **141c** is connectable to the collar **105** over the external pocket **140c** to contain the power storage device **146** within the external pocket **140c**, and to seal the external pocket **140c** from fluid(s) in the annulus **60**. In one or more embodiments, the power storage device **146** is part of the collar **105**. The power storage device **146** is connected to, and adapted to be in electrical communication with, the controller **135**. The power storage device **146** is further adapted to receive and store electric power from the coil(s) **130**, via the controller **135**. In addition, or instead, the power storage device **146** may be connected to, and adapted to receive electric power directly from, the coil(s) **130**.

(13) Although described as being positioned in the separate external pockets **140a-c**, the controller **135**, the sensor(s) **145**, the power storage device **146**, or any combination thereof may be positioned together within the external pocket **140a**, the external pocket **140b**, or the external pocket **140c**. In addition, or instead, in one or more embodiments, any combination of the external pockets **140a-c** may be combined into a single external pocket; in such instances, a corresponding combination of the covers **141a-c** are combined into a single cover. Alternatively, the external pockets **140a-c** and the covers **141a-c**, may be omitted in favor of internal pocket(s) formed in the inside surface **120**, and internal cover(s) connectable over the internal pocket(s) to seal the internal pocket(s) from fluids in the internal passageway **115**.

(14) In one or more embodiments, as indicated by the ellipsis (“ . . . ”) in FIG. 2, any number of additional sensor(s) substantially similar to (or different from) the sensor(s) **145** can be connected to the collar **105** along the outside surface **125**, which additional sensor(s) are also connected to, and adapted to be in electrical communication with, the controller **135** and/or the coil(s) **130**. In addition, or instead, in one or more embodiments, as indicated by the ellipsis (“ . . . ”) in FIG. 2, any number of additional power storage device(s) substantially similar to (or different from) the power storage device **146** can be connected to the collar **105** along the outside surface **125**, which additional power storage device(s) are also connected to, and adapted to be in electrical communication with, the controller **135** and/or the coil(s) **130**. The number and arrangement along the collar **105** of these components, i.e., the controller **135**, the sensor(s) **145** (and, optionally, the additional sensor(s)), and the power storage device **146** (and, optionally, the additionally power storage device(s)), may be varied.

(15) In one or more embodiments, the sensor(s) **145**, the additional sensor(s), or any combination thereof, is/are, include, or is/are part of, but is/are not limited to, MWD tool(s) and/or LWD tool(s). The MWD tool(s) measure the physical properties of the wellbore **55** during drilling operations, such as, for example, pressure, temperature, and wellbore trajectory in three-dimensional space. The MWD tool(s) are capable of establishing the depth, bottom-hole location, and orientation of the drilling tool **70** and the bottom-hole assembly **65**. Further, the MWD tool(s) provide a range of measurements of the conveyance string **50**, the bottom-hole assembly **65**, and the wellbore **55**, including, but not limited to: forces acting on the conveyance string **50** and the bottom-hole assembly **65**; static and dynamic pressures within the drill string **50** and the annulus **60**; and the size and shape of the wellbore **55**. In contrast, the LWD tool(s) are adapted to measure the physical properties of the formation **20** during drilling operations. The LWD tool(s) are capable of a variety of logging operations such as, for example, density logging, gamma ray logging, resistivity logging, and sonic velocity logging, among others. These logging operations are utilized to determine a range of geological characteristics including, but not limited to, the density, porosity, resistivity, and lithology of the various earth strata and the formation **20**.

(16) A telemetry system **150** is also connected to the collar **105**. For example, the telemetry system **150** may be at least partially embedded within the collar **105**. In one or more embodiments, the telemetry system **150** is part of the collar **105**. In one or more embodiments, as in FIG. 2, the telemetry system **150** is or includes an electromagnetic ("EM") telemetry system. The telemetry system **150** is connected to, and adapted to be in electrical communication with, the controller **135**. The telemetry system **150** is further adapted to receive electric power from the coil(s) **130**, via the controller **135**. In addition, or instead, the telemetry system **150** may be connected to, and adapted to receive electric power directly from, the coil(s) **130**. In one or more embodiments in which the telemetry system **150** is or includes the EM telemetry system, the telemetry system **150** includes a gap sub **151** incorporated into the collar **105**. The gap sub **151** is separated from the rest of the collar **105** by an electrically insulative material **152**, which electrically insulative material **152** provides an electrical break in the collar **105**. Electrical power is modulated on both sides of the gap sub **151** via a conductor **153** crossing from one side of the electrically insulative material **152** to the other, and into contact with the gap sub **151**, thereby generating an EM telemetry signal. More particularly, the electrically insulative material **152** allows the conductor **153** to conduct a different electrical signal onto the gap sub **151** than that conducted onto the rest of the collar **105**; this difference generates the EM telemetry signal. In one or more embodiments, integrating the gap sub **151** into the collar **105** makes the telemetry system **150** more compact.

(17) Although described herein and shown in FIG. 2 as an EM telemetry system, in addition, or instead, the telemetry system may be, include, or be part of a mud pulse telemetry system, a wired telemetry system, another type of telemetry system, the like, or any combination thereof. Alternatively, in one or more embodiments, the telemetry system **150** is omitted and the system **100** is operated as a memory-only tool (with data being retrieved from the memory-only tool only after tripping the drill string and the memory-only tool out of the wellbore **55**). In one or more embodiments, the controller **135**, the sensor(s) **145**, the power storage device **146**, the telemetry system **150**, or any combination thereof, is/are, include, or is/are part of the MWD tool(s). In addition, or instead, in one or more embodiments, the controller **135**, the sensor(s) **145**, the power storage device **146**, the telemetry system **150**, or any combination thereof, is/are, include, or is/are part of the LWD tool(s).

(18) In one or more embodiments, the power storage device **146** provides supplemental power to the controller **135**, the sensor(s) **145**, the telemetry system **150**, or any combination thereof, when the fluid flow **160** through the internal passageway **115** is decreased below a threshold. The threshold may be pre-selected or it may be automatically set, e.g., based on power needs for a given function in view of downhole operations and/or other downhole conditions. For example, the fluid flow **160** through the internal passageway **115** may be decreased below the threshold to allow the

sensor(s) **145** to take a survey (e.g., a directional survey) while the drilling tool **70** is relatively still. In such instances, the coil(s) **130** provide little or no power due to the decreased fluid flow **160** through the internal passageway **115**, and the power storage device **146** provides additional power to supplement that provided by the coil(s) **130** (if any), which additional power runs one or more of the controller **135**, the sensor(s) **145**, and/or the telemetry system **150**. As a result, in operation, the power storage device **146** is generally used to provide power for taking the survey (using the controller **135** and the sensor(s) **145**) while the drilling tool **70** is relatively still. In one or more embodiments, both the power storage device **146** and the coil(s) **130** are used to provide power for taking the survey, with the power storage device **146** providing relatively more power than the coil(s) **130**. Thereafter, once the fluid flow **160** through the internal passageway **115** is restored to a level above the threshold, the coil(s) **130** are generally used to provide power for performing telemetry in order to communicate the survey results to the surface (using the controller **135** and the telemetry system **150**), resulting in a much stronger telemetry signal than in battery-only systems. In one or more embodiments, both the coil(s) **130** and the power storage device **146** are used to provide power for performing telemetry, with the coil(s) **130** providing relatively more power than the power storage device **146**.

(19) The system **100** also includes a support member **155** positioned within the internal passageway **115** of the collar **105** and fixedly connected to the inside surface **120** of the collar **105**. The support member **155** permits fluid flow therethrough and along the internal passageway **115**, as indicated by arrows **160**. A rotor **165** is also positioned within the internal passageway **115** of the collar **105**. The rotor **165** is rotationally connected to the support member **155**. Additionally, the rotor **165** includes one or more radially-extending blades (or other flow-receiving members) that cause the rotor **165** to rotate relative to the support member **155**, as indicated by arrow **166**, and about a central axis **170** in response to a fluid flowing (as indicated by the arrows **160**) through the internal passageway **115**. For example, support member **155** may be or include a bearing that rotationally supports the rotor **165** within the fluid flow **160**. Additionally, although shown as being located relatively closer to the uphole end portion **110a** of the collar **105** than the rotor **165**, the support member **155** may instead be positioned relatively closer to the downhole end portion **110b** of the collar **105**. In either case, the central axis **170** about which the rotor **165** is adapted to rotate is substantially parallel to, or coaxial with, the internal passageway **115** (and thus a direction of fluid flow within the internal passageway **115**). One or more permanent magnet(s) **175** are connected to the rotor **165** along a radially outward periphery of the rotor **165**. For example, the permanent magnet(s) **175** may be at least partially embedded into the radially outward periphery of the rotor **165** (or even fully embedded with a radially outermost surface of the permanent magnet(s) **175** being flush with the radially outward periphery of the rotor **165**). In one or more embodiments, the permanent magnet(s) **175** are part of the rotor **165**.

(20) Referring to FIG. 3, in an embodiment, a method of powering one or more downhole tools using the system **100** is generally referred to by the reference numeral **200**. The method **200** includes: at a step **205**, communicating fluid along the internal passageway **115** of the collar **105**; at a step **210**, rotating a magnetic field generated by the permanent magnet(s) **175**; at a step **215**, generating, from the rotating magnetic field, electric power in the coil(s) **130**; at a step **220**, powering, using the electric power generated in the coil(s) **130**, the telemetry system **150**, or the sensor(s) **145**, or the controller **135**; at a step **225**, storing the electric power generated in the coil(s) **130** on the power storage device **146**; and, at a step **230**, powering, using the electric power stored on the power storage device **146**, the telemetry system **150**, or the sensor(s) **145**, or the controller **135**. In one or more embodiments, the step **210** of rotating the magnetic field generated by the permanent magnet(s) **175** comprises rotating the rotor **165** using the fluid communicated along the internal passage **115**.

(21) In one or more embodiments, the operation of the system **100** and/or the execution of the method **200** eliminates the need for crossover wires (and the accompanying complex seals) in

downhole turbines, among other things.

(22) Referring to FIG. 4, with continuing reference to FIGS. 1 through 3, an illustrative node **1000** for implementing embodiment(s) of one or more of the control system(s) (e.g., the control system **90**), controller(s) (e.g., the controller **135**), element(s), apparatus, system(s) (e.g., the system **10**, the system **100**), method(s) (e.g., the method **200**), step(s), or any combination thereof, described above and/or illustrated in FIGS. 1 through 3, is depicted. The node **1000** includes a microprocessor **1000a**, an input device **1000b**, a storage device **1000c**, a video controller **135 1000d**, a system memory **1000e**, a display **1000f**, and a communication device **1000g** all interconnected by one or more buses **1000h**. In one or more embodiments, the storage device **1000c** may include a hard drive, CD-ROM, optical drive, any other form of storage device and/or any combination thereof. In one or more embodiments, the storage device **1000c** may include, and/or be capable of receiving, a CD-ROM, DVD-ROM, or any other form of non-transitory computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device **1000g** may include a modem, network card, or any other device to enable the node **1000** to communicate with other node(s). In one or more embodiments, the node and the other node(s) represent a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

(23) In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1 through 3 include at least the node **1000** and/or components thereof, and/or one or more nodes that are substantially similar to the node **1000** and/or components thereof. In one or more embodiments, one or more of the above-described components of the node **1000** and/or the embodiments described above and/or illustrated in FIGS. 1 through 3 include respective pluralities of same components.

(24) In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1 through 3 include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.

(25) In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

(26) In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

(27) In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD-ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

(28) In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present

disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

(29) In one or more embodiments, computer readable media include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment, a data structure may provide an organization of data, or an organization of executable code.

(30) In one or more embodiments, any networks and/or one or more portions thereof may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

(31) In one or more embodiments, a database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.

(32) In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part one or more of the embodiment(s) of one or more of the control system(s) (e.g., the control system **90**), controller(s) (e.g., the controller **135**), element(s), apparatus, system(s) (e.g., the system **10**, the system **100**), method(s) (e.g., the method **200**), step(s), or any combination thereof, described above and/or illustrated in FIGS. **1** through **3**. In one or more embodiments, such a processor may include one or more of the microprocessor **1000a**, any processor(s) that are part of the components of the system **10** (such as, for example, the control system **90**), the system **100** (such as, for example, the controller **135**), and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the system. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or may interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

(33) An apparatus has been disclosed. The apparatus generally includes: a collar adapted to be positioned downhole in a wellbore; a rotor disposed within an internal passageway of the collar and rotatable relative to the collar; one or more permanent magnets connected to the rotor, the one or more permanent magnets generating a magnetic field; and a coil connected to the collar and adapted to generate electric power from the rotating magnetic field. In one or more embodiments, the apparatus further includes: a telemetry system connected to the collar and adapted to be powered using the electric power generated in the coil; or one or more sensors connected to the collar and adapted to be powered using the electric power generated in the coil; or a controller connected to the collar and adapted to be powered using the electric power generated in the coil; or any combination thereof. In one or more embodiments, the apparatus includes: the telemetry

system connected to the collar and adapted to be powered using the electric power generated in the coil; and the controller connected to the collar and adapted to be powered using the electric power generated in the coil; wherein the telemetry system is connected to the controller; and wherein the controller is further adapted to send data and/or control signals to the telemetry system. In one or more embodiments, the apparatus further includes: a power storage device connected to the collar and adapted to store at least a portion of the electric power generated in the coil. In one or more embodiments, the apparatus further includes: a telemetry system connected to the collar and adapted to be powered using the electric power stored on the power storage device; or one or more sensors connected to the collar and adapted to be powered using the electric power stored on the power storage device; or a controller connected to the collar and adapted to be powered using the electric power stored on the power storage device; or any combination thereof. In one or more embodiments, the apparatus includes: the one or more sensors connected to the collar and adapted to be powered using the electric power stored on the power storage device; and the controller connected to the collar and adapted to be powered using the electric power stored on the power storage device; wherein the one or more sensors are connected to the controller; and wherein the controller is further adapted to receive data from the one or more sensors. In one or more embodiments, when the collar is positioned downhole in the wellbore, fluid is communicable along the internal passageway of the collar; and the rotor is rotatable relative to the collar using the fluid communicated along the internal passage.

(34) A method of generating electric power in a wellbore has also been disclosed. The method generally includes: rotating a magnetic field generated by one or more permanent magnets, the one or more permanent magnets being connected to a rotor positioned within an internal passageway of a collar, and the collar being positioned downhole in the wellbore; and generating, from the rotating magnetic field, electric power in one or more coils connected to the collar. In one or more embodiments, the method further includes: powering, using the electric power generated in the one or more coils: a telemetry system connected to the collar; or one or more sensors connected to the collar; or a controller connected to the collar; or any combination thereof. In one or more embodiments, the method includes powering, using the electric power generated in the one or more coils: the telemetry system connected to the collar; and the controller connected to the collar; wherein the telemetry system is connected to the controller; and wherein the method further includes sending data and/or control signals from the controller to the telemetry system. In one or more embodiments, the method further includes: storing at least a portion of the electric power generated in the one or more coils on a power storage device connected to the collar. In one or more embodiments, the method further includes: powering, using the electric power stored on the power storage device: a telemetry system connected to the collar; or one or more sensors connected to the collar; or a controller connected to the collar; or any combination thereof. In one or more embodiments, the method includes powering, using the electric power stored on the power storage device: the one or more sensors connected to the collar; and the controller connected to the collar; wherein the one or more sensors are connected to the controller; and wherein the method further includes receiving, using the controller, data from the one or more sensors. In one or more embodiments, the method further includes: communicating fluid along the internal passageway of the collar; wherein rotating the magnetic field generated by the one or more permanent magnets includes rotating the rotor using the fluid communicated along the internal passage.

(35) A system has also been disclosed. The system generally includes: one or more non-transitory computer readable media; and a plurality of instructions stored on the one or more non-transitory computer readable media and executable by one or more processors operably associated therewith to perform the following operation(s): rotating a magnetic field generated by one or more permanent magnets, the one or more permanent magnets being connected to a rotor positioned within an internal passageway of a collar, and the collar being positioned downhole in a wellbore; and generating, from the rotating magnetic field, electric power in one or more coils connected to

the collar. In one or more embodiments, the instructions are executable by the one or more processors to perform the following additional operation(s): powering, using the electric power generated in the one or more coils: a telemetry system connected to the collar; or one or more sensors connected to the collar; or a controller connected to the collar; or any combination thereof. In one or more embodiments, the instructions are executable by the one or more processors to perform the following operation(s): powering, using the electric power generated in the one or more coils: the telemetry system connected to the collar; and the controller connected to the collar; wherein the telemetry system is connected to the controller; and wherein the instructions are executable by the one or more processors to perform the following additional operation(s): sending data and/or control signals from the controller to the telemetry system. In one or more embodiments, the instructions are executable by the one or more processors to perform the following additional operation(s): storing at least a portion of the electric power generated in the one or more coils on a power storage device connected to the collar. In one or more embodiments, the instructions are executable by the one or more processors to perform the following additional operation(s): powering, using the electric power stored on the power storage device: a telemetry system connected to the collar; or one or more sensors connected to the collar; or a controller connected to the collar; or any combination thereof. In one or more embodiments, the instructions are executable by the one or more processors to perform the following operation(s): powering, using the electric power stored on the power storage device: the one or more sensors connected to the collar; and the controller connected to the collar; wherein the one or more sensors are connected to the controller; and wherein the instructions are executable by the one or more processors to perform the following additional operation(s): receiving, using the controller, data from the one or more sensors. In one or more embodiments, the instructions are executable by the one or more processors to perform the following additional operation(s): communicating fluid along the internal passageway of the collar; and wherein rotating the magnetic field generated by the one or more permanent magnets includes rotating the rotor using the fluid communicated along the internal passage.

(36) It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

(37) In one or more embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some (or all) of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

(38) Any spatial references, such as, for example, “upper,” “lower,” “above,” “below,” “between,” “bottom,” “vertical,” “horizontal,” “angular,” “upwards,” “downwards,” “side-to-side,” “left-to-right,” “right-to-left,” “top-to-bottom,” “bottom-to-top,” “top,” “bottom,” “bottom-up,” “top-down,” etc., are for the purpose of illustration only, may be relative to other features or references, and do not necessarily limit the specific orientation or location of the structure described above.

(39) In one or more embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In one or more embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

(40) In several embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

(41) Although several embodiments have been described in detail above, the embodiments

described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word “means” together with an associated function.

Claims

1. An apparatus for a wellbore, the apparatus comprising: a collar defining an internal passageway; a support member connected to the collar; a rotor connected to the support member and extending within the internal passageway; one or more permanent magnets connected to the rotor, wherein the one or more permanent magnets generate a magnetic field; and a stator connected to the collar and comprising one or more coils, the stator being non-rotatable relative to the collar; wherein at least one of the one or more coils of the stator axially overlaps at least one of the one or more permanent magnets so as to be at least partially radially aligned therewith; wherein fluid is communicable along the internal passageway through a flow path disposed radially between at least one of the one or more coils of the stator and at least one of the one or more permanent magnets; wherein the rotor, the one or more permanent magnets, and the magnetic field generated by the one or more permanent magnets are together rotatable relative to the stator; and wherein at least one of the one or more coils is spaced radially outwardly from at least one of the one or more permanent magnets.
2. The apparatus of claim 1, wherein the internal passageway defines an inside surface in the collar; wherein the support member extends within the internal passageway; and wherein the support member is connected to, and in contact with, the collar at the inside surface.
3. The apparatus of claim 1, wherein the support member is rigidly connected to the collar.
4. The apparatus of claim 1, wherein the rotor is rotationally connected to the support member.
5. The apparatus of claim 1, wherein the rotor further comprises one or more flow-receiving members; and wherein the one or more flow-receiving members are adapted to rotate the rotor relative to the collar by receiving fluid communicated along the internal passageway.
6. The apparatus of claim 1, wherein the one or more coils are adapted to generate electrical power in the wellbore from the rotating magnetic field; and wherein the collar further comprises: a power storage device adapted to store at least a portion of the electric power generated in the one or more coils; or a telemetry system adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; or one or more sensors adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; or a controller adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; or any combination thereof.
7. The apparatus of claim 6, wherein the collar further comprises: the one or more sensors adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; and the controller adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; and wherein the controller is further adapted to receive data from the one or more sensors.
8. The apparatus of claim 6, wherein the collar further comprises: the telemetry system adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; and the controller adapted to be powered using the electric power generated in the one or more coils or stored on the power storage device; and wherein the controller is further

adapted to send data and/or control signals to the telemetry system.

9. The apparatus of claim 1, wherein the support member is connected to a first portion of the collar; and wherein the stator is connected to a second portion of the collar that is spaced apart from the first portion of the collar to which the support member is connected.
 10. A method, comprising: rotating a magnetic field generated by one or more permanent magnets, the one or more permanent magnets being connected to a rotor, the rotor extending within an internal passageway of a collar and being connected to a support member, the support member being connected to the collar, and the collar being positioned downhole in a wellbore; wherein rotating the magnetic field generated by the one or more permanent magnets comprises rotating the rotor, the one or more permanent magnets, and the magnetic field generated by the one or more permanent magnets together relative to a stator connected to the collar and comprising one or more coils, the stator being non-rotatable relative to the collar; and wherein at least one of the one or more coils of the stator axially overlaps at least one of the one or more permanent magnets so as to be at least partially radially aligned therewith; and communicating fluid along the internal passageway through a flow path disposed radially between at least one of the one or more coils of the stator and at least one of the one or more permanent magnets; wherein at least one of the one or more coils is spaced radially outwardly from at least one of the one or more permanent magnets.
 11. The method of claim 10, wherein the support member is rigidly connected to the collar.
 12. The method of claim 10, wherein the rotor is rotationally connected to the support member.
 13. The method of claim 10, wherein rotating the magnetic field generated by the one or more permanent magnets further comprises: receiving, using one or more flow-receiving members of the rotor, fluid communicated along the internal passageway to rotate the rotor relative to the collar.
 14. The method of claim 10, wherein the internal passageway defines an inside surface in the collar; wherein the support member extends within the internal passageway; and wherein the support member is connected to, and in contact with, the collar at the inside surface.
 15. The method of claim 14, further comprising: generating, using the one or more coils, electric power in the wellbore from the rotating magnetic field; storing at least a portion of the electric power generated in the one or more coils on a power storage device; and powering, using the electric power generated in the one or more coils or stored on the power storage device: a telemetry system; or one or more sensors; or a controller; or any combination thereof.
 16. The method of claim 15, further comprising: powering, using the electric power generated in the one or more coils or stored on the power storage device: the one or more sensors; and the controller; and receiving, using the controller, data from the one or more sensors.
 17. The method of claim 15, further comprising: powering, using the electric power generated in the one or more coils or stored on the power storage device: the telemetry system; and the controller; and sending, using the controller, data and/or control signals to the telemetry system.
 18. The method of claim 14, wherein the support member is connected to a first portion of the collar; and wherein the stator is connected to a second portion of the collar that is spaced apart from the first portion of the collar to which the support member is connected.
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