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Lafleur et al.

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(54) **POWER SWITCH ACTUATOR FOR DOWNHOLE TOOLS**

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(52) **U.S. Cl.**
CPC ***E21B 17/028*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 17/028
See application file for complete search history.

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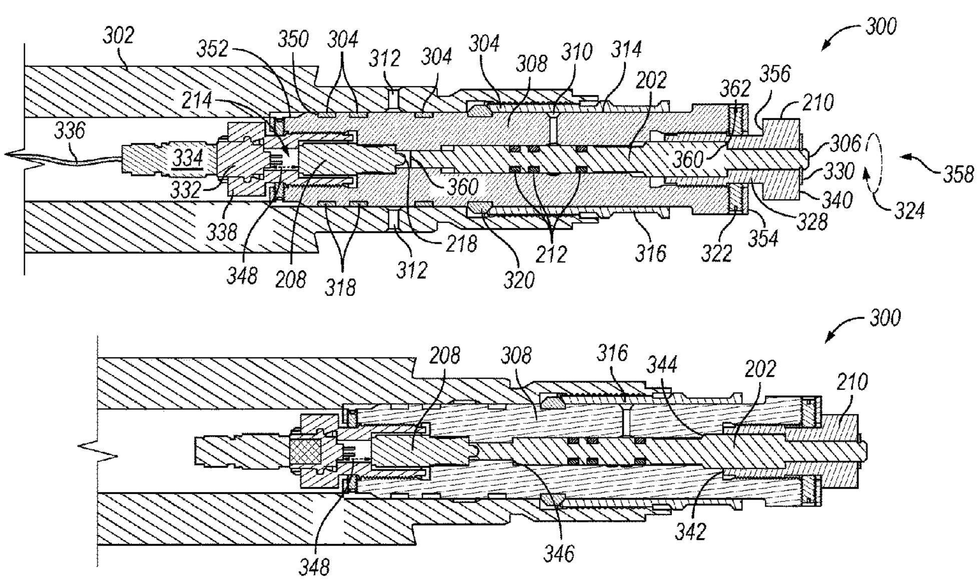
(57) **ABSTRACT**

In general, in one aspect, embodiments relate to an actuator assembly, that includes a plunger housing, a switch plunger disposed within the plunger housing, and a switch actuator configured to induce linear movement of the switch plunger along the plunger housing, where the actuator assembly is configured to change between an ON position and an OFF position by moving the switch plunger between extended and non-extended positions, and maintain a first pressure at one end of the switch plunger when an outer portion of the actuator assembly is exposed to a second pressure greater than the first pressure.

19 Claims, 8 Drawing Sheets



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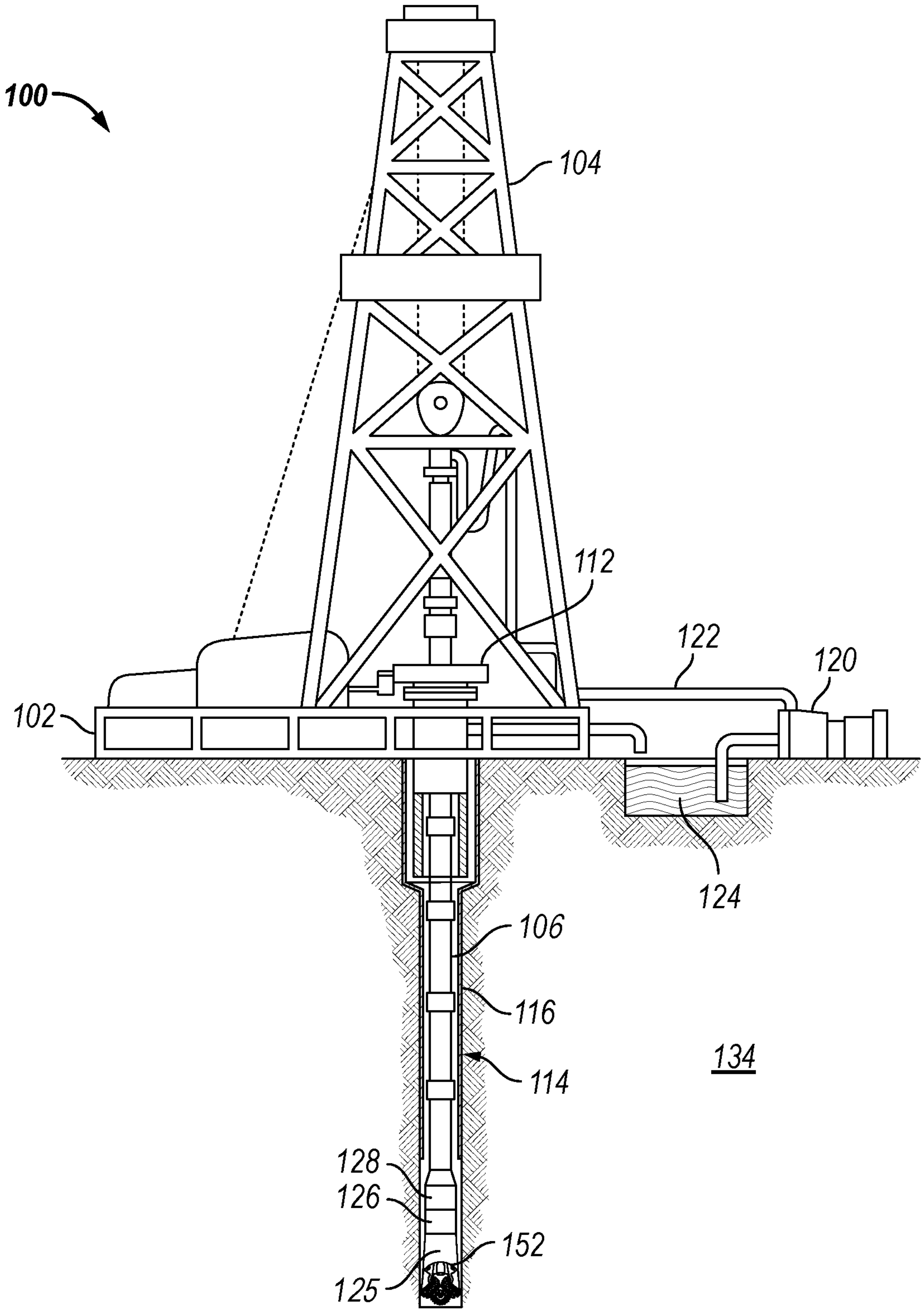

FIG. 1

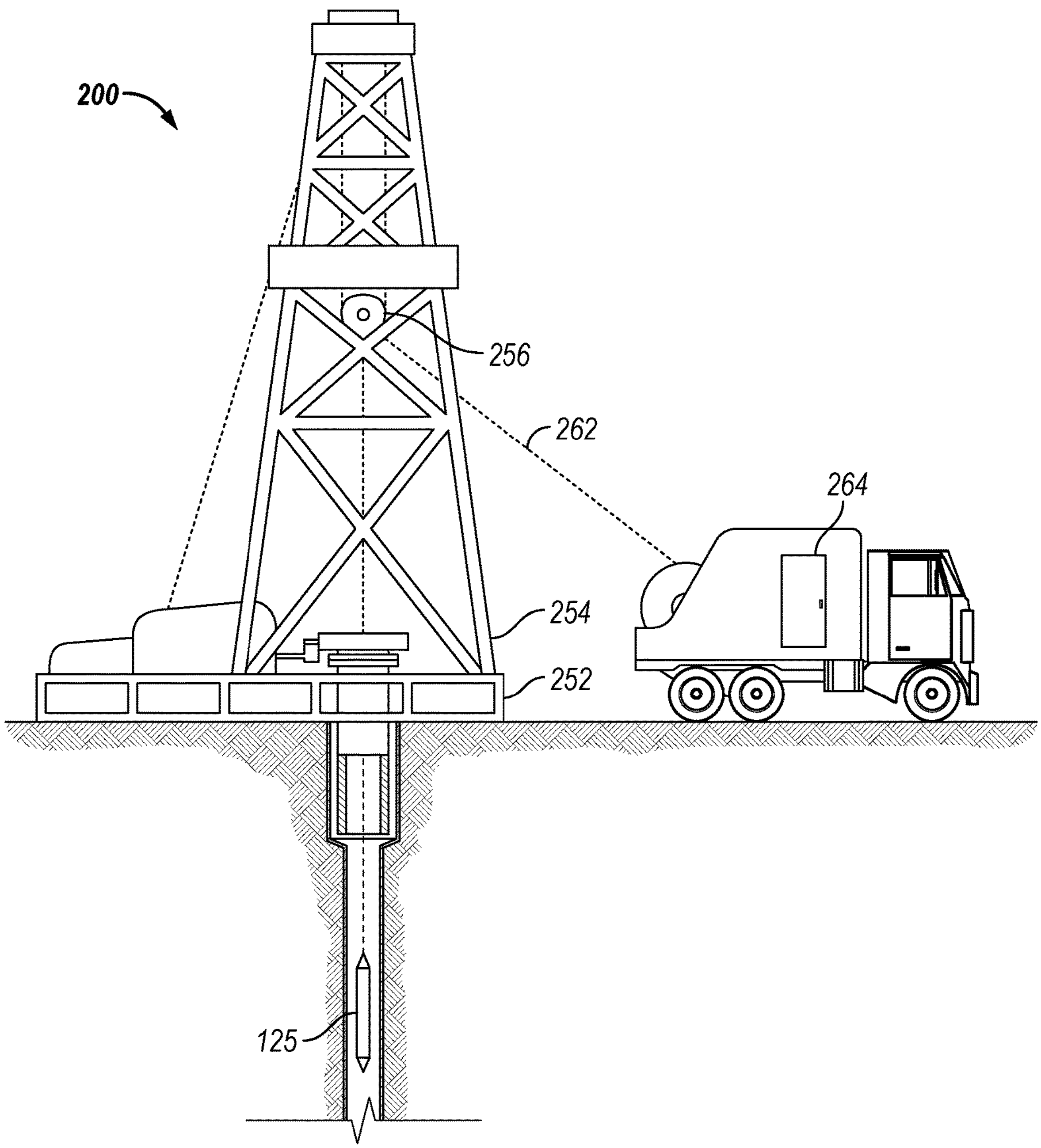

FIG. 2

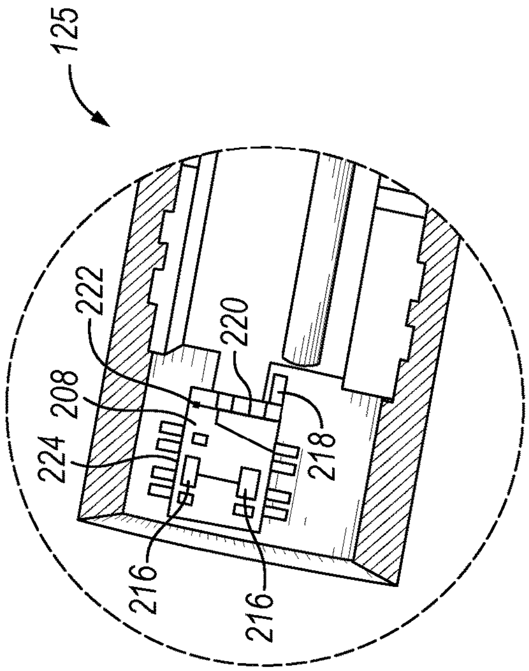
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FIG. 3B

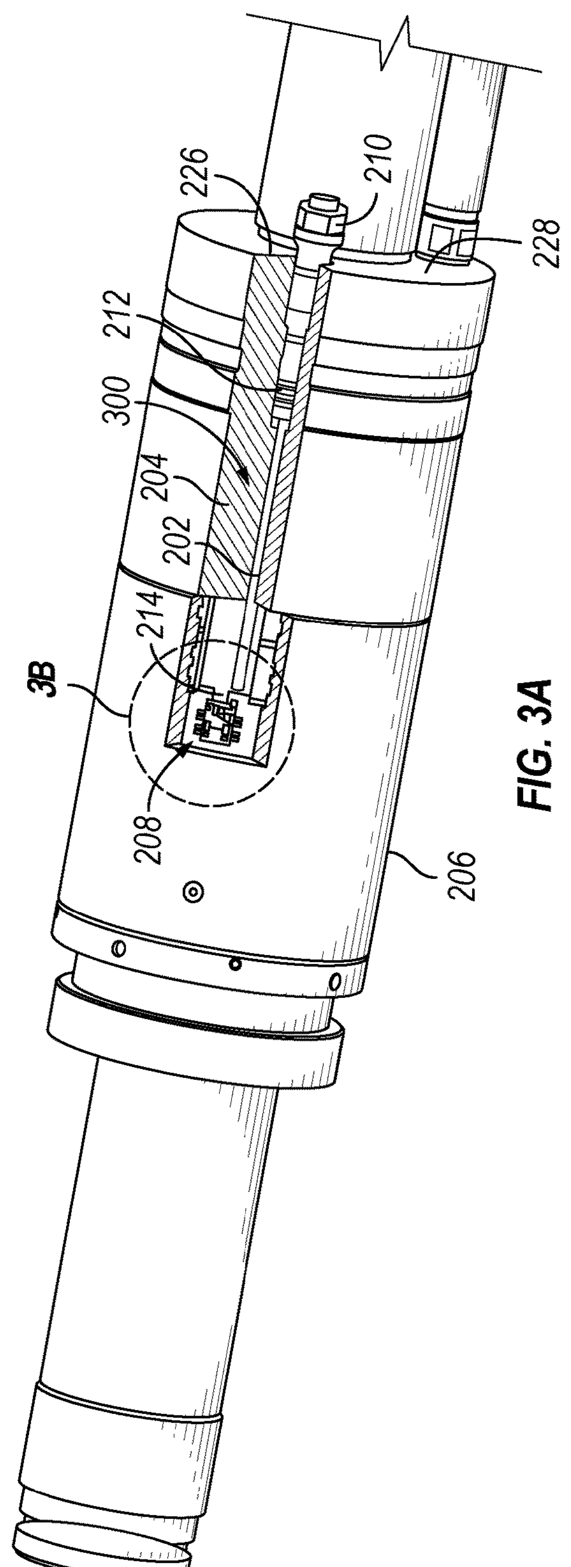
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FIG. 3A

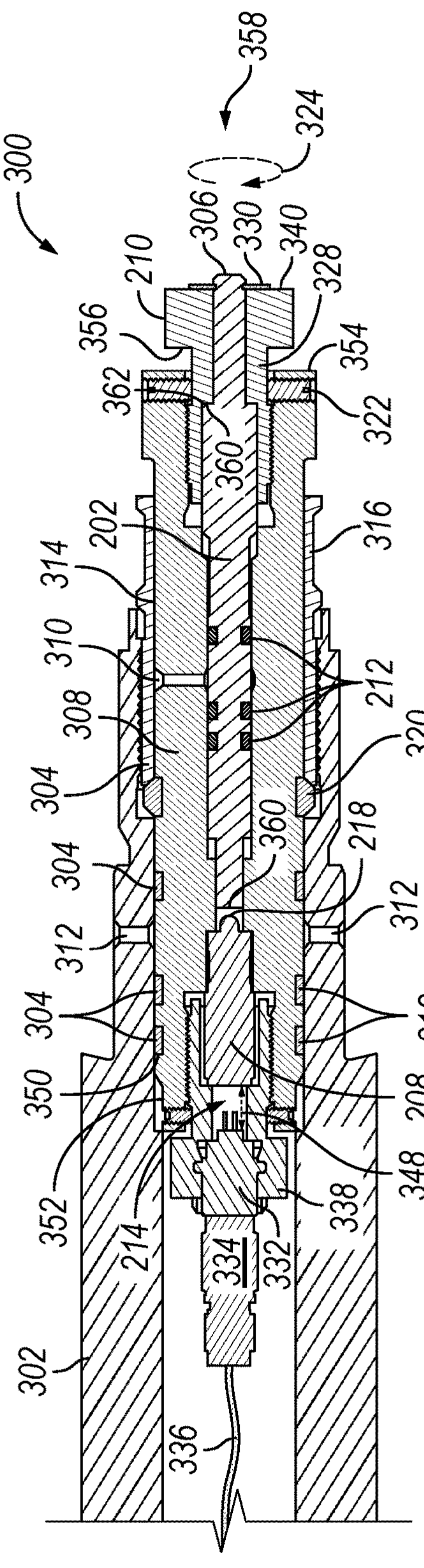
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FIG. 4A

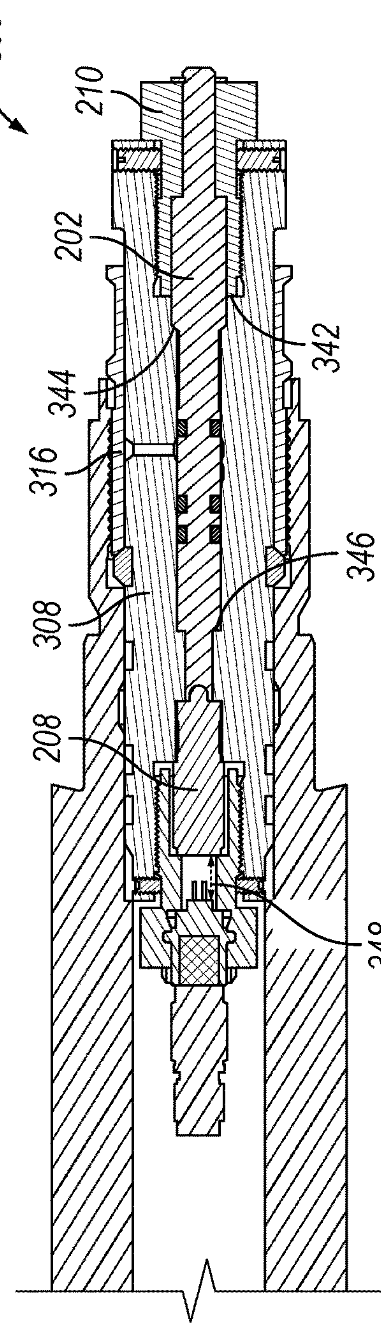
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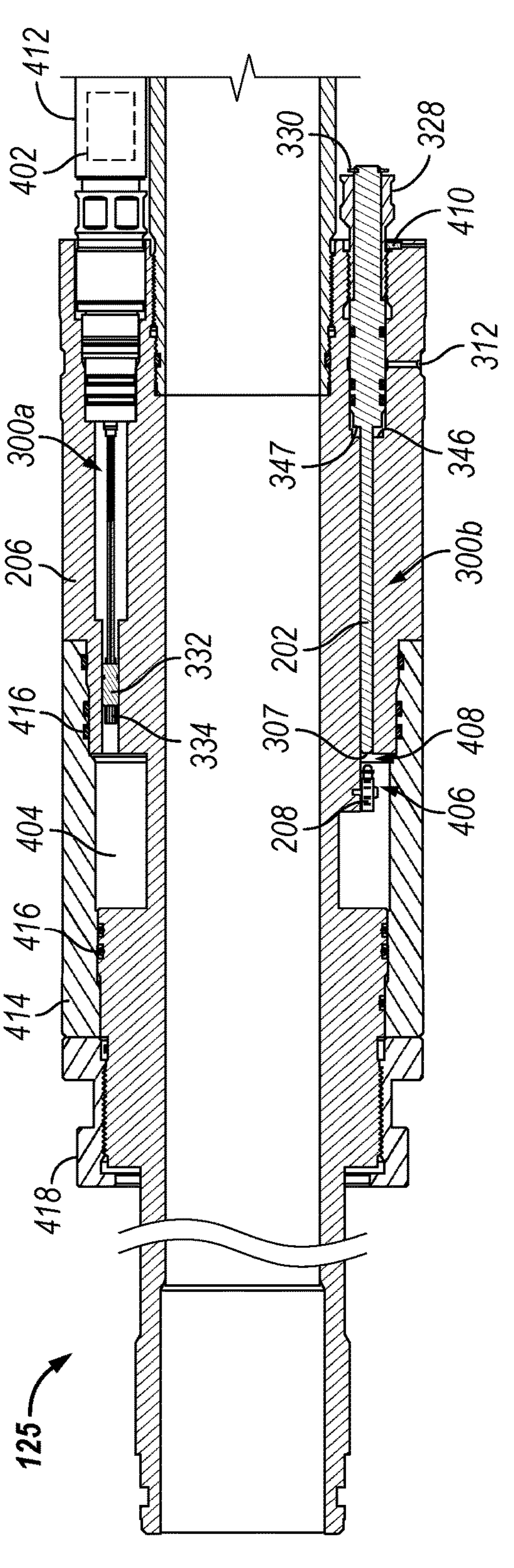
FIG. 4B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300a
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300b
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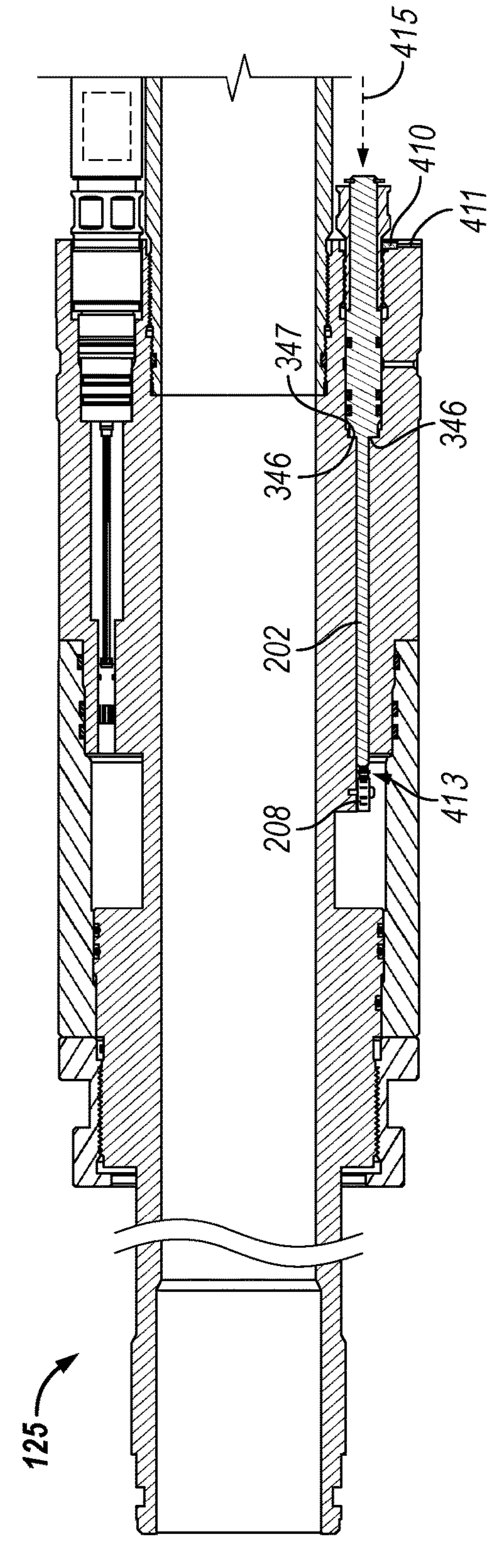
418
125

FIG. 5A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411
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346
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202
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413
125

FIG. 5B

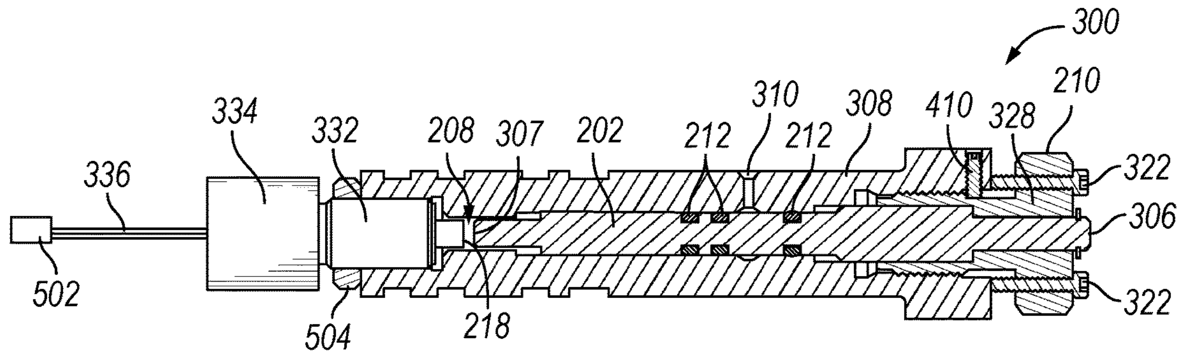


FIG. 6A

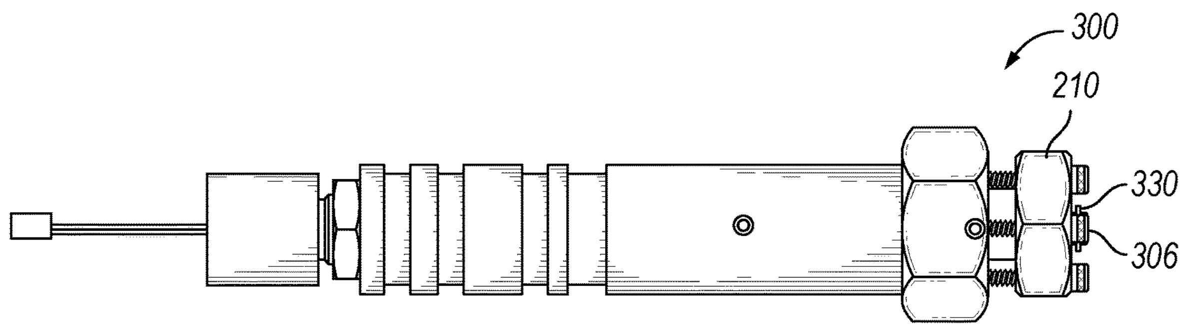


FIG. 6B

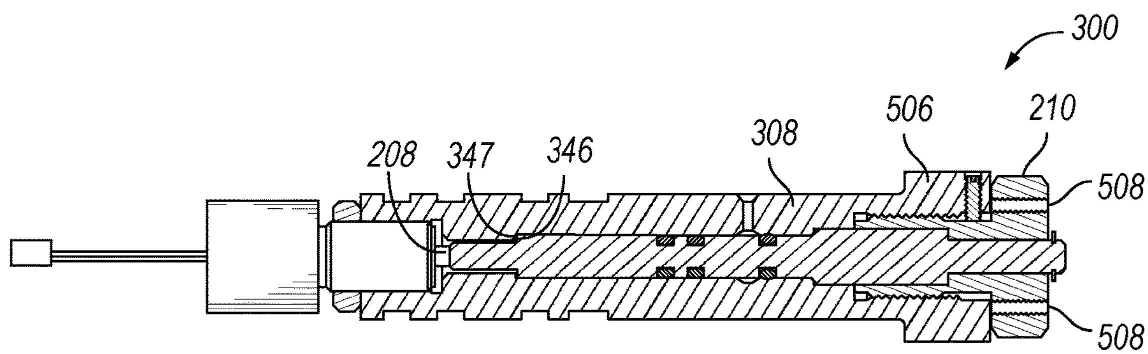


FIG. 6C

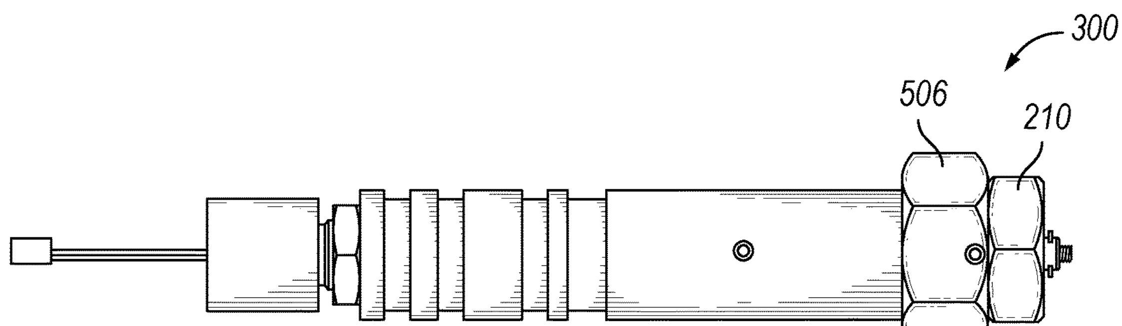


FIG. 6D

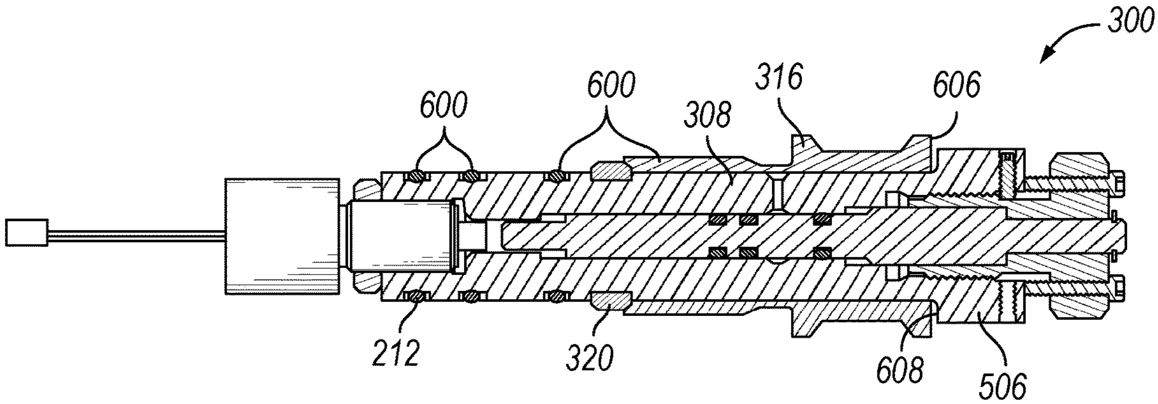


FIG. 7A

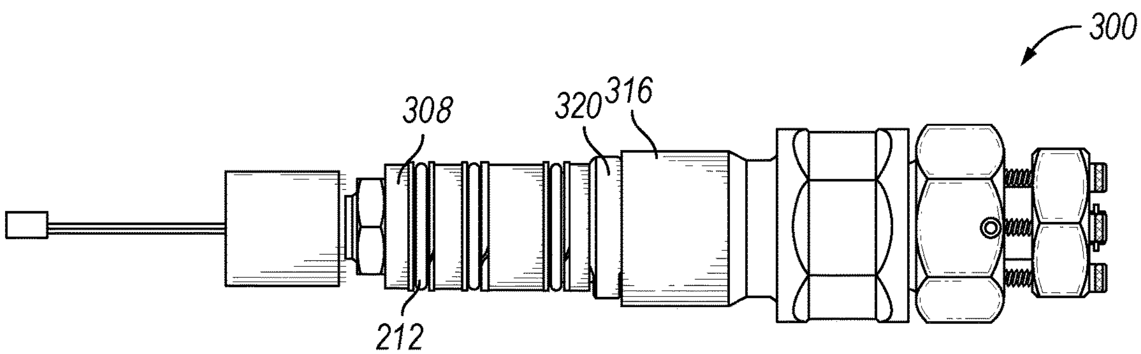


FIG. 7B

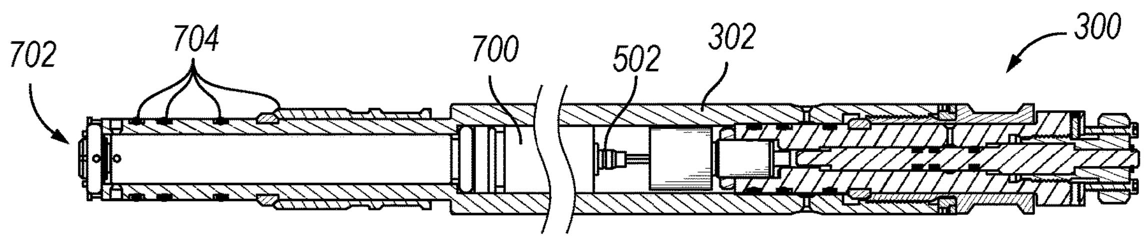


FIG. 8A

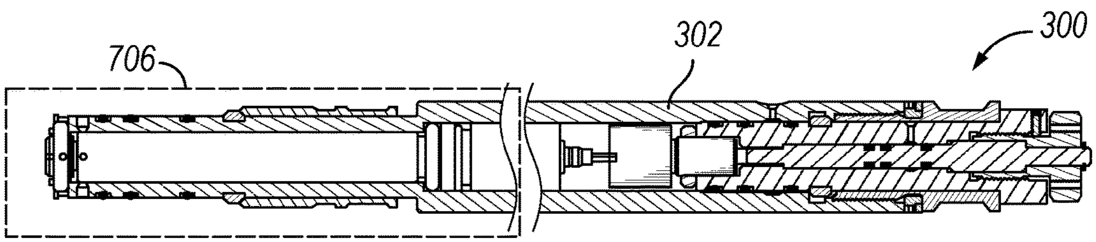
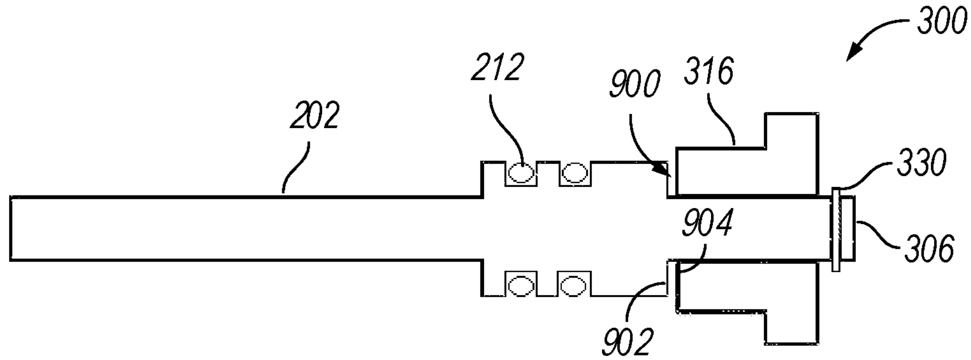


FIG. 8B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900
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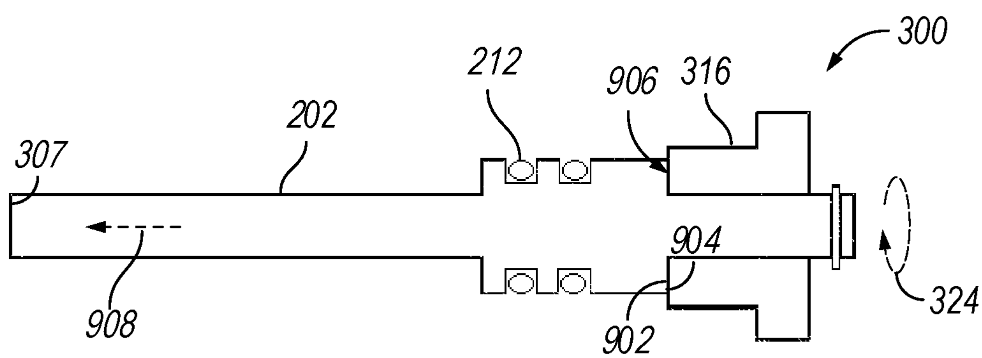
202
330
904
306
902

FIG.9A


300
212
906
316
202
307
904
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902
324

FIG.9B

POWER SWITCH ACTUATOR FOR DOWNHOLE TOOLS

BACKGROUND

In the oil and gas industry, downhole tools are often battery powered. Oftentimes, a mechanical ON-OFF switch may need to be switched on to connect the on-board battery to the internal electronics of the tool, thereby allowing the battery to power the tool. This generally occurs at the surface prior to deployment into the wellbore and often involves removing a pressure barrier, switching on the mechanical switch, reinstallation of the pressure barrier, and pressure testing thereafter to ensure correct reinstallation of the pressure barrier. Once the tool is ready to be deployed, it is lowered into the wellbore where it arrives at its target depth(s) to perform the tool's intended function.

There is a substantial amount of time in between when the tool is switched on and when the tool actually performs its function in the wellbore. During this time, the activated tool depletes the battery. Batteries generally have only limited operating time, and so tools equipped with greater battery capacities may be required to survive operations with longer run times. Moreover, a specially certified technician is sometimes needed to verify that the electrical components are assembled correctly, and the pressure barrier or seal appropriately installed. Further, cables used to connect electrical components are sometimes assembled with insufficient slack, requiring reassembly which further introduces delay.

Attempts to circumnavigate these problems and postpone toggling of the ON-OFF switch to the ON position include using magnetically actuated switches (Reed Switch), which may remove or eliminate the need for installation/reinstallation of the pressure barrier by allowing an operator to activate a switch from outside the tool. However, the metallic materials used in these types of switches may become magnetized in the wellbore, resulting in switch failure.

BRIEF DESCRIPTION OF THE DRAWINGS

These drawings illustrate certain aspects of some of the embodiments of the present disclosure and should not be used to limit or define the disclosure.

FIG. **1** is a schematic illustration showing a work string in a wellbore having an actuator section and an atmospheric chamber in accordance with some embodiments of the present disclosure.

FIG. **2** is a schematic illustration showing a downhole tool on a conveyance in a wellbore in accordance with some embodiments of the present disclosure.

FIG. **3**A illustrates a partially cut-out view of part of a tool string to show an actuator assembly in accordance with some embodiments of the present disclosure.

FIG. **3**B illustrates a close-up view of the actuator assembly of FIG. **3**A to show a mechanical switch in accordance with some embodiments of the present disclosure.

FIG. **4**A shows a schematic illustration of an actuator assembly in a pressure housing with the mechanical switch in an OFF position in accordance with some embodiments of the present disclosure.

FIG. **4**B shows the schematic illustration of the actuator assembly of FIG. **5**A with the mechanical switch in an ON position in accordance with some embodiments of the present disclosure.

FIG. **5**A shows a downhole tool including the actuator assembly disposed bilaterally on either side of the downhole tool and in respective OFF positions in accordance with some embodiments of the present disclosure.

FIG. **5**B shows the downhole tool of FIG. **5**A with the respective actuator assemblies in respective ON positions in accordance with some embodiments of the present disclosure.

FIG. **6**A is a cross-sectional view of an actuator assembly in an OFF position in accordance with some embodiments of the present disclosure.

FIG. **6**B shows a perspective view of the actuator assembly of FIG. **7**A in accordance with some embodiments of the present disclosure.

FIG. **6**C is a cross-sectional view of the actuator assembly of FIG. **7**A but in an ON position in accordance with some embodiments of the present disclosure.

FIG. **6**D shows a perspective view of the actuator assembly of FIG. **6**C in accordance with some embodiments of the present disclosure.

FIG. **7**A is a cross sectional view of an actuator assembly in an OFF position to show a power switch actuator disposed in a cartridge subassembly in accordance with some embodiments of the present disclosure.

FIG. **7**B is a perspective view of the actuator assembly of FIG. **8**A in accordance with some embodiments of the present disclosure.

FIG. **8**A is a cross sectional view of an actuator assembly in an OFF position and disposed in a pressure housing and connected to an electronic subassembly in accordance with some embodiments of the present disclosure.

FIG. **8**B is cross sectional view of FIG. **8**A but in an ON position to show powering of an electrical component of a downhole tool in accordance with some embodiments of the present disclosure.

FIG. **9**A is a cross sectional view of an actuator assembly having a spin collar and a switch plunger, and in an OFF position in accordance with some embodiments of the present disclosure. As mentioned, an actuator assembly may

FIG. **9**B is a cross sectional view of the actuator assembly of FIG. **9**B with the spin collar seated against a shoulder of the switch plunger, and in an ON position in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

Disclosed herein is a method of actuating a power switch on a battery-powered downhole tool, and more particularly, disclosed is an actuator assembly for actuating a mechanical switch on a downhole tool.

As used herein, a "downhole tool" or "battery powered downhole tool" is a downhole tool to be disposed in a wellbore and which uses energy stored by one or more batteries on-board the downhole tool. In examples, some or all of the operations performed by a downhole tool may, but need not necessarily be, powered by one or more on-board batteries. For example, a downhole tool may utilize battery power alone, or rely on both a combination of battery power and non-battery power to perform one or more operations.

As alluded to previously, downhole tools may be activated by connecting an on-board battery to internal wiring using a mechanical switch. This usually requires extensive and time-consuming procedures and specialized personnel to ensure that, following activation of the mechanical switch, the tool is pressure sealed to withstand the extreme downhole conditions of the wellbore and to ensure the electrical components are sufficiently isolated from the high-pressure, high-temperature wellbore fluids. Example actuator assemblies and their associated mechanical structures herein disclosed may eliminate the need for disassembly and reassembly of a pressure barrier to activate the mechanical switch. In addition, these may also eliminate the need to perform separate pressure tests following final make-up of a downhole tool, as well as eliminate the need for intermediate cable connectors between the downhole tool and the mechanical switch.

Further, a power switch actuator cartridge, or "cartridge subassembly," may allow the actuator assembly to be actuated and/or a pressure seal to be pressure tested by technicians without specialized certification. Example cartridge subassemblies may also facilitate assembly or disassembly of a downhole tool that includes an actuator assembly.

In examples, the actuator assembly may be characterized as a "powerless actuator," meaning that it may turn on the switch without needing to power the actuator itself. Powerless actuation may involve, for example, manual rotation of a nut, or flange, by personnel at a rig site without the need for assistance of external machinery or a power source.

Other advantages of the present disclosure may include an overall reduction in rig time, reduction in pressure testing requirements, an ability to assemble the downhole tool without the need to disassemble a pressure barrier to access the switch, the ability to turn tools easily and repeatedly on and off, reduction in the size and/or number of batteries, and replaceable packaging. Further advantages may include modular components that can be easily replaced on location, various assemblies and subassemblies that can be assembled and/or rebuilt easily, and scalability of the assemblies and subassemblies to be used on a variety of downhole tools.

FIG. **1** is a schematic diagram of an example drilling or completion environment. Environment **100** may include platform **102** that supports derrick having a traveling block for raising and lowering top drive and work string **114**. A top drive may support and rotate work string **114** as it is lowered through wellhead **112**. In turn, a drill bit **152**, located at the end of work string **114**, may create wellbore **116**, in some examples. Wellbore **116** may be formed through the Earth surface into a subterranean formation **134** in the Earth crust. Wellbore **116** may be vertical, deviated, horizontal, and/or curved at one or more regions of subterranean formation **134**. Wellbore **116** may be cased, open hole, contain tubing, and may generally comprise a hole in the ground, i.e., "borehole", extending any appropriate distance into subterranean formation **134**. In one or more examples, one or more regions of the wellbore **116** may be secured at least in part by cement. Servicing rig **104** may be a drilling rig, completion rig, workover rig, or other mast structure supporting work string **114**. In some examples, servicing rig **104** comprises a derrick and rig floor through which work string **114** extends downwards into wellbore **116**.

While this figure shows work string **114** as a drill string, it should be understood that work string **114** may alternatively comprise various other types of work strings, such as completion strings, perforating strings, workover string, tubing strings, etc. Work string **114** may be equipped to perform any suitable wellbore operation, for example, logging, intervention, drilling, fluid sampling, or the like. Further, although illustrated as being disposed on downhole tool **125** in a drilling operation, downhole tool **125** may also be disposed in wellbore **116** in a wireline operation. Also, while environment **100** is shown as a land-based environment, environment **100** may alternatively be a sea-based environment without departing from the spirit and scope of the disclosure.

Platform **102** is a structure which may be used to support one or more other components of environment **100** (e.g., derrick). Platform **102** may be designed and constructed from suitable materials (e.g., concrete) which are able to withstand the forces applied by other components (e.g., the weight and counterforces experienced by derrick). In any embodiment, platform **102** may be constructed to provide a uniform surface for drilling operations in environment **100**.

Derrick is a structure which may support, contain, and/or otherwise facilitate the operation of one or more pieces of the drilling equipment. In any embodiment, derrick may provide support for crown block, traveling block, and/or any part connected to (and including) work string **114**. Derrick may be constructed from any suitable materials (e.g., steel) to provide the strength necessary to support those components.

Wellhead **112** is a machine which may include one or more pipes, caps, and/or valves to provide pressure control for contents within wellbore **116** (e.g., when fluidly connected to a well). In any embodiment, during drilling, wellhead **112** may be equipped with a blowout preventer to prevent the flow of higher-pressure fluids (in wellbore **116**) from escaping to the surface in an uncontrolled manner. Wellhead **112** may be equipped with other ports and/or sensors to monitor pressures within wellbore **116** and/or otherwise facilitate drilling operations.

Work string **114** is a machine which may be used to carve wellbore **116** and/or gather data from wellbore **116** and the surrounding geology, or else perform other types of wellbore operations (e.g., completion). Work string **114** may include, without limiting to any single embodiment, drill pipe, one or more repeaters, and downhole tool **125**, for example. Work string **114** may rotate (e.g., via top drive) to form and deepen wellbore **116** (e.g., via drill bit **152**) and/or via one or more motor(s) attached to work string **114**, in some examples.

Wellbore **116** is a hole in the ground which may be formed by work string **114** (and one or more components thereof). Wellbore **116** may be partially or fully lined with casing to protect the surrounding ground from the contents of wellbore **116**, and conversely, to protect wellbore **116** from the surrounding ground.

Downhole tool **125** is a machine which may be equipped with one or more tools for creating, providing structure, and maintaining wellbore **116**, and/or one or more tools for measuring the surrounding environment (e.g., measurement while drilling (MWD), logging while drilling (LWD)). In any embodiment, downhole tool **125** may be disposed at (or near) the end of work string **114** (e.g., in the most "downhole" portion of wellbore **116**). In examples, downhole tool **125** may include an actuator assembly **300** for changing a mechanical switch located within atmospheric chamber section **126** between ON and OFF positions, to be discussed in greater detail in later figures.

Non-limiting examples of tools that may be included in downhole tool **125** include a drill bit **152**, casing tools (e.g., a shifting tool), a plugging tool, a mud motor, a drill collar (thick-walled steel pipes that provide weight and rigidity to aid the drilling process), actuators (and pistons attached thereto), a completion system (e.g., intelligent completion system), a steering system, and any measurement tool (e.g., sensors, probes, particle generators, etc.).

Further, downhole tool **125** may include a telemetry sub **128** to maintain a communications link with the surface (e.g., with an information handling system). Such telemetry communications may be used for (i) transferring tool measurement data from downhole tool **125** to surface receivers, and/or (ii) receiving commands (from the surface) to downhole tool **125** (e.g., for use of one or more tool(s) in downhole tool **125**). In examples, telemetry communications may be at least in part between downhole tool **125** and an information handling system, which may be disposed at a terrestrial surface (or sea-based platform).

An "information handling system," as used herein, may comprise any instrumentality or aggregate of instrumentalities operable to compute, estimate, classify, process, transmit, broadcast, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price.

An information handling system may further include a processing unit (e.g., microprocessor(s), central processing unit(s), etc.) that may process data from downhole tool **125**, discussed below, by executing software or instructions obtained from a local non-transitory computer readable media (e.g., optical disks, magnetic disks). The non-transitory computer readable media may store software or instructions of the methods described herein. Non-transitory computer readable media may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Non-transitory computer readable media may include, for example, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such wires, optical fibers, microwaves, radio waves, and other electromagnetic and/or optical carriers; and/or any combination of the foregoing. Information handling system may also include input device(s) (e.g., keyboard, mouse, touchpad, etc.) and output device(s) (e.g., monitor, printer, etc.). The input device(s) and output device(s) provide a user interface that enables an operator to interact with any device disposed or a part of downhole tool **125**, discussed below, and/or software executed by a processing unit. For example, information handling system may enable an operator to select analysis options, view collected log data, view analysis results, and/or perform other tasks.

Non-limiting examples of techniques for transferring tool measurement data (to the surface) include mud pulse telemetry and through-wall acoustic signaling. For through-wall acoustic signaling, one or more repeater(s) may detect, amplify, and re-transmit signals from downhole tool **125** to the surface (e.g., to an information handling system), and conversely, from the surface (e.g., from an information handling system) to downhole tool **125**.

Work string **114** may include a drill bit **152**. Drill bit **152** is a machine which may be used to cut through, scrape, and/or crush (i.e., break apart) materials in the ground (e.g., rocks, dirt, clay, etc.). Drill bit **152** may be disposed at the frontmost point of work string **114** and downhole tool **125**. In any embodiment, drill bit **152** may include one or more cutting edges (e.g., hardened metal points, surfaces, blades, protrusions, etc.) to form a geometry which aids in breaking ground materials loose and further crushing that material into smaller sizes. In any embodiment, drill bit **152** may be rotated and forced into (i.e., pushed against) the ground material to cause the cutting, scraping, and crushing action. Rotations of drill bit **152** may be caused by a top drive and/or one or more motor(s) located on work string **114** (e.g., on downhole tool **125**).

Environment **100** may include pump **120**. Pump **120** is a machine that may be used to circulate drilling fluid from a reservoir, through a feed pipe **122**, to derrick, to the interior of work string **114**, out through drill bit **152** (through orifices, not shown), back upward through wellbore **116** (around work string **114**), back into the reservoir, and to and from mud pit **124**, for example. In any embodiment, any appropriate pump **120** may be used (e.g., centrifugal, gear, etc.) which is powered by any suitable means (e.g., electricity, combustible fuel, etc.).

Work string **114** may comprise a conveyance **106** and a downhole tool **125**, comprising one or more on-board batteries and/or battery modules. In addition, work string **114** may comprise other downhole tools, such as one or more packers, one or more completion components, e.g., screens and/or production valves, one or more sensing components and/or measuring equipment, e.g., downhole sensors, sampling probes, etc., drilling equipment, the like, or other equipment not shown in FIG. **1**. Work string **114** may include, for example, any tool or tool string commonly associated with wellbore operations. While the present figures generally show a single downhole tool **125**, work string **114** may comprise any suitable number of downhole tools. For example, downhole tool **125** may comprise a single or a plurality of downhole tools, which may be coupled together on a tool string. As illustrated, downhole tool **125** is attached to conveyance **106** which in this figure is shown as a rigid conduit, but which may alternatively comprise, or be connected to, any suitable form of conveyance such as a wireline, drill string, coiled tubing, stick pipe, etc.

Actuator section **126** is integrated into the downhole tool **125**. Actuator section **126** may comprise one or more (e.g., a plurality of) actuator assemblies **300** (e.g., actuator assemblies **300***a* and **300***b* of FIG. **5**A). Each actuator assembly **300** (e.g., referring to FIG. **3**) of actuator section **126** may be equipped with tools such as the ones shown in FIGS. **4**A, **4**B to actuate mechanical switch(es) within a respective atmospheric chamber(s) of atmospheric chamber section **126** deep within downhole tool **125**. Actuator section **126** may also include one or more cartridge subassemblies, to be discussed in greater detail in later figures.

The atmospheric chamber(s) mentioned above may be disposed within an internal region of downhole tool **125**, for example, atmospheric chamber section **126**. Downhole tool **125** may comprise an outer housing which may be formed from a heavy metal such as steel, Inconel, etc. Such housing may protect the internal devices (e.g., mechanical switch **208** of FIG. **3**A) and the atmospheric chamber(s) of downhole tool **125** from the downhole environment that downhole tool **125** may experience in wellbore **116**.

Downhole tool **125** may further include wireless telemetry or logging capabilities, or both, such as to transmit or later provide information indicative of received energy/waveforms to operators on the surface or for later access and data processing for the evaluation of formation **134** properties.

In some embodiments, one or more telemetry devices may communicate with a surface receiver, such as via a wired drill pipe. In other cases, downhole tool **125** may communicate with a surface receiver by wireless signal transmission. In at least some cases, one or more of the actuator section **126** may receive electrical power from a wire that extends to the surface, including wires extending through a wired drill pipe. In at least some instances the methods and techniques of the present disclosure may be performed by a computing device on the surface. In some embodiments, the computing device may be included in surface receiver. For example, surface receiver of wellbore operating environment **100** at the surface may include one or more of wireless telemetry, processor circuitry, or memory facilities, such as to support substantially real-time processing of data received from one or more of the actuator section **126**. In some embodiments, data is processed at some time subsequent to its collection, wherein the data may be stored on the surface at surface receiver, stored downhole in telemetry sub **128**, or both, until it is retrieved for processing.

In examples, as drill bit **152** extends the wellbore **116** through the formation **134**, measurement devices of downhole tool **125** may collect measurements relating to various formation properties as well as the orientation of the tool and various other drilling conditions.

The downhole tool **125** may also include a telemetry sub **128** to transfer measurement data to a surface receiver and to receive commands from the surface. In some embodiments, a telemetry sub **128** may communicate with a surface receiver using mud pulse telemetry. In other cases, a telemetry sub **128** does not communicate with the surface, but rather stores logging data for later retrieval at the surface when the logging assembly is recovered. Notably, downhole tool **125** may also operate using a non-conductive cable (e.g., slickline, etc.) with a local power supply, such as batteries and the like. When employing non-conductive cable, communication may be supported using, for example, wireless protocols (e.g., EM, acoustic, etc.) and/or measurements and logging data may be stored in local memory for subsequent retrieval at the surface, as is appreciated by those skilled in the art.

FIG. **2** illustrates a diagrammatic view of a conveyance logging wellbore operating environment **200** in which the present disclosure may be implemented. As depicted in FIG. **2**, hoist **256** may be included as a portion of platform **252**, such as that coupled to derrick **254**, and used with a conveyance **262** to raise or lower equipment such as downhole tool **125** into or out of a borehole. A conveyance **262** may provide a communicative coupling between the downhole tool **125** and a logging facility **264** at the surface. Conveyance **262** may include wires (one or more wires), slicklines, cables, or the like, as well as tubular conveyances such as coiled tubing, joint tubing, or other tubulars, and may include a downhole tractor. Additionally, power can be supplied via conveyance **262** to power the tool. The downhole tool **125** may have a local power supply, such as batteries, downhole generator, and the like. As with FIG. **1**, downhole tool **125** may also have an actuator section **126** (e.g., referring to FIG. **1**) as well as an atmospheric chamber section **126** (e.g., referring to FIG. **1**). These may likewise house, or be attached to, respective actuator assemblies (e.g., actuator assemblies **300***a*, **300***b*, etc. of FIG. **5**A) each configured to actuate a respective mechanical switch (e.g., mechanical switch **208** of FIG. **3**) disposed within atmospheric chamber section **126**. When employing non-conductive cable, coiled tubing, pipe string, or downhole tractor, communication may be supported using, for example, wireless protocols (e.g., EM, acoustic, etc.), and/or measurements and logging data may be stored in local memory for subsequent retrieval.

FIG. **3**A illustrates a partially cut-out sectional view of part of a tool string to show an actuator assembly **300** in accordance with some embodiments of the present disclosure. In general, actuator assembly **300** is configured to actuate a mechanical switch disposed within the downhole tool **125** by moving the switch between OFF and ON positions via linear and/or rotational movement of a switch plunger **202**. As mentioned, the particular configuration of the actuator assembly **300** and its related structures may ensure that there remains a seal during and after switch activation.

Actuator assembly **300** comprises a switch plunger **202** extending lengthwise through an internal region **204** of downhole tool **125** disposed within a housing **206** thereof. Switch plunger **202** is a rod, shaft, linear piston, or other linear element that may move along the length of plunger housing **308** to actuate mechanical switch **208**. The purpose of switch plunger **202** is to allow actuator assembly **300** to actuate mechanical switch **208** over a distance spanning the length of switch plunger **202** such that mechanical switch **208** is safely isolated within the downhole tool **125** (e.g., referring to FIG. **1**) away from the wellbore environment. Switch plunger **202** may have any suitable length including, for example, a length from about 0.5 feet (ft) to about 4.5 ft, or any ranges therebetween. In examples, switch plunger **202** has a sufficient length to allow for actuation of mechanical switch **208** from outside downhole tool **125**, such as via rotation of a switch actuator **210**. Notably, mechanical switch **208** is embedded deep within the downhole tool **125** to isolate it from external forces (e.g., vibration). Namely, this eliminates the need for cantilevered parts typically required for minimizing vibrational effects associated with downhole use of downhole tool **125**.

Actuation of mechanical switch **208** may involve rotating of switch actuator **210** to cause switch plunger **202** to move closer to mechanical switch **208** until mechanical switch **208** is toggled to an ON position, which may connect internal wiring of downhole tool **125** to one or more batteries, thereby powering the downhole tool **125**. In examples, actuation of actuator assembly **300** may be achieved while maintaining a constant or nearly constant pressure (e.g., variation less than +/−5 pounds per square inch (psi), +/−1 psi, +/−0.1 psi, or ranges therebetween) at the region housing mechanical switch **208** during actuation.

Housing **206** may comprise or be an outer sleeve which may in some examples be configured to open to allow access to mechanical switch **208** from the outside. Part or all of housing **206** may be slidable so that opening of housing **206** comprises sliding (e.g., slidable sleeve **414**) to reveal mechanical switch **208**, or may comprise a removable panel, hatch, door, or the like, to allow access to mechanical switch **208**, for example. Housing **206** may be formed from a heavy metal such as steel, Inconel, etc. Such housing may protect the internal devices (e.g., mechanical switch **208** of FIG. **3**A) and the atmospheric chamber(s) of downhole tool **125** from the downhole environment that downhole tool **125** may experience in wellbore **116** (e.g., referring to FIG. **1**).

FIG. **3**B illustrates a close-up view of the actuator assembly **300** of FIG. **3**A to show mechanical switch **208** in accordance with some embodiments of the present disclosure. In this example, mechanical switch **208** is a device disposed within an inner region of downhole tool **125** by a pair of screws **216**. A surface **218** of mechanical switch **208** may interface with switch plunger **202** to cause mechanical switch **208** to close part of a circuit involving downhole electronics of downhole tool **125** and battery/ies, such as by pushing a button **222** with a flexible plate **220** attached to surface **218**. In the illustrated example, mechanical switch **208** may comprise a plurality of wire connectors **224** to electrically couple various electrical components of the downhole tool **125** to mechanical switch **208**.

While only a single actuator assembly **300** is shown by FIGS. **2**A and **2**B, downhole tool **125** may house a plurality of actuator assemblies and mechanical switches, and thus a plurality of switch actuators **210** may extend out from surface **228** through respective apertures **226** circumferentially disposed on surface **228** of housing **26** about a central axis of downhole tool **125**.

FIG. **4**A shows a schematic illustration of an actuator assembly **300** in a pressure housing **302** of a with the mechanical switch in an OFF position in accordance with some embodiments of the present disclosure. As illustrated, actuator assembly **300** is disposed in pressure housing **302**, which functions to isolate region **214** from wellbore pressure at surface **306**. Region **214** may thus be characterized as an "atmospheric chamber" in some examples and may be at atmospheric pressure even when downhole tool **125** (e.g., referring to FIG. **1**) is disposed at extreme depths downhole, e.g., between 1,000 and 30,000 feet, or any ranges therebetween.

In this example, actuator assembly **300** comprises a switch plunger **202** disposed in a plunger housing **308** having a pressure test port **310**. As shown, at least a portion of switch plunger **202** may extend out from actuator assembly **300** such that in some examples, a surface **306** may be exposed to the wellbore environment when the tool is disposed downhole. On the other end opposite surface **306**, switch plunger **202** has a contact surface **307** for contacting mechanical switch **208**. In alternative embodiments where actuator assembly **300** comprises one or more electrical leads, switch plunger **202** may actuate the tool by closing an electrical circuit, which may displace the need for a mechanical switch. For example, the actuator assembly **300** (e.g., switch plunger **202**) may contact positive and negative electrical leads to complete/close an electrical circuit.

Plunger housing **308** is an annular housing that in some examples may house switch plunger **202**. In examples, plunger housing **308** may encompass most of the length spanned by switch plunger **202** and may also extend beyond the contact surface **307** to also encompass mechanical switch **208** and at least a portion of connector **332**. Plunger housing **308** may also have one or more annular grooves **350** radially disposed on its outer surface **352** for holding one or more respective annular sealing elements **318** (e.g., sealing rings). On the wellbore-facing side **358** of actuator assembly **300**, plunger housing **308** may have a surface **354** oriented to seat against an underside **356** of switch actuator **210** or an element (e.g., shipping spacer) disposed therebetween. Plunger housing **308** may have any suitable shape and may include one or more shoulders ("travel stop") for receiving corresponding interfacing surfaces of switch plunger **202**, to be discussed later.

Switch actuator **210** is another device (e.g., annular member) of actuator assembly **300** for actuation a mechanical switch. In examples, switch actuator **210** may comprises a flanged portion and a plunger driver **328**. The outer flanged portion may be configured to rotate. Plunger driver **328** may have a shoulder **360** configured to interface with a contact surface **362** of switch plunger **202**, whereby linear movement along plunger housing **308** as switch actuator **210** rotates is imparted to switch plunger **202** to move plunger driver **328** towards mechanical switch **208** during actuation.

Snap ring **330**, or "retaining ring," may be disposed around and end of switch plunger **202** at the wellbore-facing side **358** of actuator assembly **300**. Snap ring **330** may ensure plunger driver **328** remains attached to switch actuator **210** when plunger driver **328** and switch actuator **210** are rotated to pull plunger driver **328** towards wellbore-facing side **358** away from switch **208**, e.g., when mechanical switch **208** is switched to an OFF position.

Switch **208** may connect via a connector **332** and a wiring harness **334** to wiring **336**. Wiring **336** may be coupled to a resistive load associated with a function of downhole tool **125** (e.g., referring to FIG. **1**), e.g., internal electronics, so that when mechanical switch **208** is activated, the internal electronics of the tool are powered.

In one or more examples, an annular member **338** at least partially disposed in plunger housing **308** may separate connector **332** from switch **208** by a distance **348**. Distance **348** may be unchanged by actuation of actuator assembly **300**. In examples, this may further guarantee that the connection between mechanical switch **208** and connector **348** remains undisturbed by actuation of the actuator assembly **300**.

In some examples, another pressure test port **312** may be disposed in pressure housing **302**. These pressure test ports **310**, **312** may be used to conduct pressure surveys of regions within actuator assembly **300** and/or pressure housing **302** to quickly verify that the isolated regions within downhole tool **125** (e.g., referring to FIG. **1**), e.g., region **214**, are properly sealed off from the outside. A pressure test may involve, for example, pressurizing one of these test ports and determining whether or not the pressure declines over time or remains stable. A drop in pressure would indicate leakage and improper scaling by annular sealing elements **212** or **318**. In other examples, however, no pressure tests are required as the annular sealing elements **212** and **318** may sufficiently guarantee region **214** is isolated from wellbore pressures at surface **306**.

This figure also shows a cartridge subassembly **304** which is disposed on the outer surface **314** of plunger housing **308**, and which may comprise spin collar **316** and annular sealing elements **318**, **320** (e.g., scaling rings). Split ring **320** may have an irregular (e.g., polygonal) cross section and protrude some distance out from surface **314**, as shown. When spin collar is installed on plunger housing **308** (from left to right in this figure) (e.g., prior to installation of actuator assembly **300** within pressure housing **206**), split ring **320** restrains spin collar **316** on plunger housing **308** as split ring **320** may be compressed into a depressed configuration by the inner diameter of spin collar **316**. Once spin collar **316** is set at a desired position within pressure housing **206**, actuator assembly **300** may be pushed so that split ring **320** slides past spin collar **316** where it expands into a respective annular groove of pressure housing **206**.

Cartridge subassembly **304** may be disposed between actuator assembly **300** and pressure housing **302**. An advantage associated with cartridge subassembly **304** may be improved ergonomics during assembly since it may allow, in some examples, for different regions of the downhole tool **125** (e.g., referring to FIG. **1**) to be pressure tested in different stages of assembly. For example, a first assembly stage may comprise disposing cartridge subassembly **304** within pressure housing **302**, and a second assembly stage may comprise disposing actuator assembly **300** within cartridge subassembly **304**. Alternatively, a first assembly stage may comprise first disposing actuator assembly **300** within cartridge subassembly **304** with the second stage comprising disposing the combined actuator assembly and cartridge subassembly in the pressure housing **302**.

Anti-rotation screws **322** may be used to prevent rotation of actuator assembly **300** when actuation of mechanical switch **208** is not desired. In some examples, actuation may involve removing or loosening of anti-rotation screws **322** followed by rotation of switch actuator **210** as indicated by an arrow at **324**. Accordingly, FIG. **4**B shows the schematic illustration of the actuator assembly **300** of FIG. **4**A with the mechanical switch in an ON position in accordance with some embodiments of the present disclosure.

To actuate actuator assembly **300**, anti-rotation screws **322** (e.g., referring to FIG. **4**A) are first removed to allow switch actuator **210** to rotate. This may cause switch plunger **202** to depress contact surface **218** (e.g., referring to FIG. **4**A) of mechanical switch **208**. One or more internal surfaces of actuator assembly **300** may function as a travel stop to prevent over-rotation of switch actuator **210** and thus over-insertion of switch plunger **202** at the interface with switch **208**. For example, respective interfacing surfaces indicated at **342**, **344**, and/or **346** may function to stop extension of switch plunger **202** in actuator assembly **300**, to use non-limiting examples, when switch actuator **210** is fully rotated into the ON position. In addition, the rate and/or amount of insertion may be controlled by threads or spiral tracks which may be disposed on inner and outer surfaces of plunger housing **308** and switch plunger **202**, respectively, in some examples. Threads or tracks may be additionally, or alternatively placed at the respective interfacing surfaces of spin collar **316** and plunger housing **308** to achieve the same effect. Thus, the amount of depression applied to a contact surface **218** of mechanical switch **208** may the same each time actuator assembly **300** is fully actuated based on the location of the one or more stops and/or threads/tracks.

FIG. **5**A shows part of a downhole tool **125** including two of the actuator assembly **300** disposed bilaterally on either side of the downhole tool **125** and in respective OFF positions in accordance with some embodiments of the present disclosure. While FIG. **5**A only shows two of these assemblies, any suitable number may be included with downhole tool **125**, for example, between 1 and 15, or any ranges therebetween. These may be disposed circumferentially about a central axis of downhole tool **125** as mentioned, or in any suitable configuration. In this example, a battery module **402** is connected to actuator assembly **300** and may provide power to downhole tool **125**. Battery module **402** may comprise any arrangement or configuration of one or more batteries, which may be disposed within a housing **412** of battery module **402**. Batteries of battery module **402** may power, for example, a downhole PCB, pressure and/or temperature gauges, electrically actuated flow control valves, an electrically actuated pyrotechnic charge to initiate a tool release mechanism, telemetry devices e.g., signal repeater, combinations thereof, or the like, to use non-limiting examples. In examples, battery module **402** may be wired to a downhole PCB assembly that controls power distribution to a plurality of on-board devices, e.g., one or more of those listed above.

Also notated by this figure is an atmospheric chamber **404**, connector **332** to wiring harness **334**, snap ring **330**, and pressure test port **312**. Mechanical switch **208** may be disposed within atmospheric chamber **404**, in some examples. Importantly, this view also shows an example of a shoulder **346** ("travel stop"), which is designed to catch a respective seating surface **347** of switch plunger **202**. In examples, switch plunger **202** has a stepped profile, e.g., shoulder, to facilitate seating of seating surface **347** against shoulder **346** (e.g., as shown by FIG. **5**B).

As mentioned, housing **206** may be configured to slide open to expose atmospheric chamber **404** such as via sliding of a removeable sleeve **414** concentrically disposed about housing **206**. A plurality of annular sealing elements **416** (e.g., O-rings), disposed between removeable sleeve **414** and housing **206** above and below atmospheric chamber **404**, may be used to ensure a good pressure seal between atmospheric chamber and the downhole environment of wellbore **116** (e.g., referring to FIG. **1**), such as the three shown by FIG. **5**A. A locking member **418** may be removably installed below sleeve **414** to lock removeable sleeve **414** in place when it is installed over atmospheric chamber **404**, and may thus abut, or be substantially adjacent to, slidable sleeve **414**. Locking member **418** may be threaded onto housing **206**, and there may include additional anti-rotation screws threaded therethrough to prevent vibration from loosening locking member **418**. As with other members of downhole tool **125**, locking member **418** and/or removeable sleeve **414** may be formed from a heavy metal such as steel, Inconel, etc.

An OFF position **406** may comprise a gap **408** formed between an contact surface **307** of switch plunger **202** and mechanical switch **208**. Gap **408** in the OFF position **406** may be any suitable distance, for example, between 0.01 centimeters and 10 centimeters, or any ranges therebetween. One or more anti-rotation screws **410** may be used to secure the axial and/or radial orientation of actuator assembly **300** by preventing axial drift of switch plunger **202** along a length of actuator assembly **300**. These may be installed at any point during assembly such as, for example, after mechanical switch **208** is switched to an ON position (e.g., ON position **413** of FIG. **5**B).

Accordingly, FIG. **5**B shows the downhole tool **125** of FIG. **5**A with the respective actuator assemblies **300** in respective ON positions **413** in accordance with some embodiments of the present disclosure. As illustrated, an ON position **413** may comprise removal of gap **408** (e.g., referring to FIG. **5**A) such that an end of switch plunger **202** contacts a contact surface **218** (e.g., referring to FIG. **3**) of mechanical switch **208**. In this position, seating surface **347** is seated against shoulder **346** to limit over-insertion of switch plunger **202** into switch **208**, as shown.

In addition, or alternatively to shoulder **346**, anti-rotation screw **410** may be set within a respective port **411** to engage plunger driver **328**. Wellbore pressure indicated by an arrow at **412** which might otherwise cause axial drift of switch plunger **202** along the tool and thus over-insertion and/or damage to the mechanical switch **208** may be counteracted by one or more additional anti-rotation screws **410**. Once set, anti-rotation screw **410** is designed to prevent the drift and thus prevent damaging of mechanical switch **208**.

FIG. **6**A is a cross-sectional view of an actuator assembly **300** in an OFF position in accordance with some embodiments of the present disclosure. In the illustrated example, pressure test port **310** is disposed at a point approximately halfway between ends **306**, **307** of switch plunger **202**. Annular sealing elements **212** are shown being disposed on switch plunger **202** on either side of pressure test port **310**, such that at least two seals are downhole pressure test port **310** and at least one uphole pressure test port **310**, in this example. This may more securely isolate one or more regions downhole pressure test port **310**, as well as ensure that a pressure test is accurate. Also visible in this figure are anti-rotation screws **322** and **410**, as well as mechanical switch **208**, connector **332**, and wiring harness **334**, previously discussed. In this manner, mechanical switch **208** may be electrically coupled to an electrical connection point **502** via wiring **336**. Rotation of plunger driver **328** attached to switch actuator **210** may impart linear movement along the length of housing **308** to switch plunger **202** such that it actuates mechanical switch **208**, as discussed. An ON-OFF switch jam nut may fix the position of connector **332** and/or mechanical switch **208** relative to switch plunger **202**, thereby ensuring pressure applied to contact surface **218** does not cause these components to shift when switch plunger **202** is actuated. This Figure also shows an annular element (e.g., flange) disposed about a region of the tool containing connector **332**.

FIG. **6**B shows a perspective view of the actuator assembly **300** of FIG. **6**A in accordance with some embodiments of the present disclosure. During disassembly, snap ring **330** installed at or near uphole surface **306** allows switch actuator **210** to exert upward pressure on switch plunger **202** as switch actuator **210** is rotated away from away from contact surface **218** (e.g., referring to FIG. **6**A). Disassembly may further comprise removal of anti-rotation screws **322** prior to rotation to allow switch actuator **210** to separate from a flanged portion **506** of housing **308**.

FIG. **6**C is a cross-sectional view of the actuator assembly **300** of FIG. **6**A but in an ON position in accordance with some embodiments of the present disclosure. As illustrated, anti-rotation screws **322** (e.g., referring to FIGS. **5**A, **5**B) are removed from their respective ports **508** and switch actuator **210** is moved closer to flanged portion **506** of housing **308**. Also visible in this figure is a more depressed configuration of mechanical switch **208** relative to that shown by FIG. **6**A, as well as shoulder **346** seated against surface **347**. In this configuration, an electrical test may be performed at a manufacturing facility, regional workshop, or a wellsite to determine appropriate connectivity between electrical components. Such an electrical test may confirm actuator assembly **300** depresses mechanical switch **208** and that mechanical switch **208** closes the electrical circuit prior to installing, in some example, a larger module comprising the actuator assembly **300** and the mechanical switch **208** into the downhole tool **125**. In some examples, this electrical test may be performed prior to installation within the downhole tool **125**, e.g., at the wellsite or at a manufacturing plant.

FIG. **6**D shows a perspective view of the actuator assembly of FIG. **6**C in accordance with some embodiments of the present disclosure. As illustrated, a downhole side of switch actuator **210** may be seated against, or near to, an uphole side (e.g., wellbore-facing side **358** of FIG. **4**A) of flanged portion **506** in the ON position.

FIG. **7**A is a cross sectional view of an actuator assembly **300** in an OFF position to show a power switch actuator **210** disposed in a cartridge subassembly **600** in accordance with some embodiments of the present disclosure. Cartridge subassembly **600** may, in some examples, provide a replaceable structure (e.g., cartridge) within which actuator assembly **300** is disposed. This may allow for improved ergonomics of assembly as compared to other forms of switch activated downhole tools. Split ring **320** may have a polygonal cross section and be configured to contact spin collar **316**.

FIG. **7**B is a perspective view of the actuator assembly **300** of FIG. **7**A in accordance with some embodiments of the present disclosure. This figure shows how spin collar **316** may seat against split ring **320**. Also visible are annular sealing elements **212** disposed about respective portions of housing **308**.

FIG. **8**A is a cross sectional view of an actuator assembly **300** disposed in pressure housing **302** and in an OFF position in accordance with some embodiments of the present disclosure. This view further shows an electronic subassembly **702** within pressure housing **302**. As illustrated, electrical contact point **502** is connected to an electrical component(s) **700** of a downhole tool **125** (e.g., referring to FIG. **1**). Electrical component(s) **700** may be, for example, a protected circuit board (PCB), a battery powered tool such as a memory gauge, acoustic repeater, telemetry device, actuator(s), etc., or any battery powered device or electronics, for example. Further downhole from electrical component **700** is an electronic subassembly **702** which may connect to another wiring harness, for example. Electronic subassembly **702** may include, without limitation, an electrical connector. In essence, electronic subassembly **702** may serve to electrically couple the mechanical switch **208** to one or more on-board electronic devices of the downhole tool **125** to allow it to perform its intended function. For example, an electrical connector of electronic subassembly **702** may connect electrical component **700** to one or more resistive loads associated with the intended function(s) of the downhole tool **125** (e.g., referring to FIG. **1**), e.g., a wellbore operation such as logging, sensing, sampling, intervention, etc.

This view also shows another cartridge subassembly **704** between electrical component **700** and electronic subassembly **702**. Similar to cartridge subassembly **600** (e.g., referring to FIG. **7**A, **6**B), cartridge subassembly **704** may facilitate assembly/disassembly and may comprise a replaceable cartridge and annular sealing elements.

FIG. **8**B is a cross sectional view of the actuator assembly **300** and pressure housing **302** of FIG. **8**A, but with actuator assembly **300** in an ON position in accordance with some embodiments of the present disclosure. In the ON position **413** (e.g., referring to FIG. **5**B), the electrical component(s) **700** is/are powered allowing the tool to be powered and thus the specific actions of the tool to be performed after or during the tool is/is being lowered to its target depth(s) in the wellbore. The area indicated at **706** may be entirely disposed within the downhole tool **125** (e.g., referring to FIG. **1**).

In an alternative embodiment, rather than a switch actuator to actuate the switch, another method may include pushing a switch mechanism. In examples, mechanical switch **208** may have a fixed position within downhole tool **125** (e.g., referring to FIG. **1**). In examples, plunger driver **328** and snap ring **330** (e.g., referring to FIG. **4**A) may be removed and switch plunger **202** redesigned as a hex, or other feature, to enable rotational engagement of threads within downhole tool **125** to move switch plunger **202** to "push" the mechanical switch **208**. In some examples, this may additionally, or alternatively, involve omitting threads of pressure housing **206** so that switch plunger **202** may be linearly actuated directly. For example, plunger driver **328**, snap ring **330**, anti-rotation screws **410**, and threads (e.g., of pressure housing **206**) may be omitted and switch plunger **202** may be manually depressed from outside the tool (e.g., at surface **306** of FIG. **4**A) prior to running the tool in the wellbore, or else depressed by downhole pressure acting on a piston area (e.g. at surface **306** of FIG. **4**A) of switch plunger **202**, e.g., once the external pressure rises to a pre-determined threshold. Actuating mechanical switch **208** with switch plunger **202** directly with wellbore pressure may further postpone activating the tool and thus prolong the operating time of the tool even further by causing on-board batteries to not power the tool until sometime after downhole tool **125** has been introduced into the wellbore or traveled beyond a target depth (e.g., at least 1 meter, at least 10 meters, at least 25 meters, etc.) with an associated threshold pressure sufficient to actuate the tool. For example, this could be achieved by disposing a threshold pressure element (e.g., spring, rupture disk, shear screw, elastic band, etc.) in the downhole tool **125**, having a specific property (e.g., elastic modulus, rupture pressure, breaking pressure, compressive strength, tensile strength, etc.) such that the tool is not powered until wellbore pressure overcomes the property of the threshold pressure element. Where the threshold pressure element is a spring, such may be disposed about the major outer diameter of switch plunger **202** at an area between shoulder **346** and surface **347**, for example.

In another alternative embodiment, rather than extended and non-extended positions of the switch plunger **202** (e.g., referring to FIG. **3**) corresponding to ON and OFF positions (e.g., of mechanical switch **208** of FIG. **3**), respectively, these may instead correspond to OFF and ON positions, respectively. For example, the mechanical switch **208** (e.g., referring to FIG. **3**) may be biased in a reverse direction relative to the configuration shown by the figures.

In other alternative embodiments, rather than having only a dual position, i.e., the ON and OFF positions, actuator assembly **300** (e.g., referring to FIG. **3**) may be configured to switch between a plurality (e.g., 3, 4, 5, 6, 10, etc., or any ranges therebetween) of switch settings. For example, a corresponding plurality of actuation distances of switch plunger **202** (e.g., referring to FIG. **3**) may each correspond to a separate position or configuration associated with a different setting of the downhole tool **125** (e.g., referring to FIG. **1**).

In another alternative embodiment, the mechanical switch **208** may itself be rotated to change between ON and OFF positions. For example, contact surface **307** of switch plunger **202** (e.g., referring to FIG. **4**A) may be machined to match a rotation shaft (not shown) for interfacing with mechanical switch **208**. Switch plunger **202** may include, for example wrench flats, a hex socket, splines, or other features enabling the mechanical switch **208** to be turned, which may allow for actuation of the mechanical switch **208** via rotation of the rotation shaft and switch plunger **202**. In some examples, this may be achieved with a roller lever to actuate the mechanical switch **208**, for example, by pushing a lever arm of the roller lever with a roller disposed at an interface between switch plunger **202** and the lever arm. Thus, an axial motion of switch plunger **202** may cause rotational movement of the lever arm of a roller lever which may, in some examples, increase the range of motion of the switch plunger **202** relative to other disclosed embodiments.

FIG. **9**A is a cross sectional view of an actuator assembly **300** having a spin collar **316** and a switch plunger **202**, and in an OFF position in accordance with some embodiments of the present disclosure. Rather than pushing on a split ring (e.g., split ring **320** of FIG. **4**A), an actuator assembly **300** may be configured such that actuation of mechanical switch **208** (e.g., referring to FIG. **4**A) is instead achieved by imparting linear movement directly to switch plunger **202** by spin collar **316**. In the illustrated OFF position, there may be a gap **900** between a shoulder **902** of switch plunger **202** and a contact surface **904** of spin collar. This figure also shows annular sealing elements **212** disposed about switch plunger **202**, as well as snap ring **330** and surface **306**.

FIG. **9**B is a cross sectional view of the actuator assembly of FIG. **9**B with the spin collar **316** seated against the shoulder **902** of the switch plunger **202**, and in an ON position in accordance with some embodiments of the present disclosure. As illustrated, the gap **900** (e.g., referring to FIG. **9**A) is removed so that, as spin collar **316** is rotated downwards as indicated by the dotted line at **324**, it directly pushes the switch plunger **202** in the downhole direction towards mechanical switch **208** (e.g., referring to FIG. **3**A). Sealing elements **212** may thus maintain an effective seal that isolates contact surface **707** from wellbore pressure at surface **306** (e.g., referring to FIG. **9**A).

Advantageously, the present disclosure may provide an example actuator assembly that may be mechanically actuated at a rig floor without the need for external or internal power to actuate the assembly. Further, example actuator assemblies and related structures may be manufactured with components free or essentially free of materials susceptible to de-magnetization, while still allowing for pressure isolation of internal regions of downhole tools. These may eliminate or reduce the need for complex and time-consuming pressure testing procedures during make-up of a tool string. The methods and systems may include any of the various features disclosed herein, including one or more of the following statements.

Statement 1: An actuator assembly, comprising: a plunger housing; a switch plunger disposed within the plunger housing; and a switch actuator configured to induce linear movement of the switch plunger along the plunger housing, wherein the actuator assembly is configured to: change between an ON position and an OFF position by moving the switch plunger between extended and non-extended positions; and maintain a first pressure at one end of the switch plunger when an outer portion of the actuator assembly is exposed to a second pressure greater than the first pressure.

Statement 2: The actuator assembly of statement 1, wherein the first and second pressures are atmospheric and downhole pressures, respectively.

Statement 3: The actuator assembly of statements 1 or 2, wherein the outer portion of the actuator assembly comprises the switch actuator and/or another end of the switch plunger.

Statement 4: The actuator assembly of any of statements 1-3, further comprising one or more annular sealing elements disposed between the switch plunger and an inner surface of the plunger housing.

Statement 5: The actuator assembly of any of statements 1-4, wherein at least two annular sealing elements are disposed at one or more regions of the switch plunger downhole a pressure test port extending radially through the plunger housing.

Statement 6: The actuator assembly of any of statements 1-5, further comprising one or more seating surfaces of the switch plunger and one or more corresponding shoulders of the plunger housing for limiting over-insertion of the switch plunger past the ON position.

Statement 7: The actuator assembly of any of statements 1-6, further comprising one or more anti-rotation screws disposed in the switch actuator.

Statement 8: The actuator assembly of any of statements 1-7, disposed in a cartridge subassembly, the cartridge subassembly comprising: a split ring configured to slide under a spin collar; the spin collar; and two or more additional annular sealing elements disposed within respective annular grooves on the outside of the housing of the actuator assembly below the spin collar.

Statement 9: The actuator assembly of statement 8, wherein the split ring has a polygonal cross section and is disposed substantially adjacent to the spin collar when the actuator assembly and the cartridge subassembly are disposed within a pressure housing of a downhole tool.

Statement 10: The actuator assembly of any of statements 1-7, wherein the switch plunger comprises a shoulder, wherein the shoulder is pushed on by a contact surface of a spin collar disposed around at least a portion of the actuator assembly.

Statement 11: The actuator assembly of any of statements 1-10, further comprising an ON-OFF switch jam nut disposed near or at the mechanical switch to fix a position of the mechanical switch relative to the switch plunger.

Statement 12: A method, comprising: inducing linear movement of a switch plunger along a plunger housing of an actuator assembly to actuate a mechanical switch; powering a downhole tool with one or more on-board batteries as a result of the linear movement, and introducing the downhole tool into a wellbore; and maintaining a region housing the mechanical switch at a stable pressure that is less than a wellbore pressure while the powered tool is disposed in the wellbore.

Statement 13: The method of statement 12, wherein the region comprising the mechanical switch is a chamber maintained at or near atmospheric pressure while the downhole tool is lowered to a depth greater than 500 feet, and wherein the wellbore pressure exceeds 500 pounds per square inch.

Statement 14: The method of statements 12 or 13, further comprising seating one or more contacting surfaces of the switch plunger against one or more corresponding shoulders of the plunger housing to prevent over-insertion of the switch plunger.

Statement 15: The method of any of statements 12-14, further comprising removing one or more anti-rotation screws from the switch actuator prior to initially inducing the linear movement of the switch plunger.

Statement 16: The method of any of statements 12-15, further comprising fixing an axial configuration of the switch plunger with one or more additional anti-rotation screws after changing from an OFF position to an ON position.

Statement 17: The method of any of statements 12-16, wherein inducing linear movement of the switch plunger to change from the OFF position to the ON position is performed without an external or internal power source, and wherein after the actuator assembly is installed in the downhole tool, the downhole tool is not pressure tested before being introduced to the wellbore.

Statement 18: A tool string, comprising: a conveyance for suspending a downhole tool in a wellbore; the downhole tool, comprising: a mechanical switch disposed within a pressure sealed chamber; and an actuator assembly, comprising: a switch plunger disposed within a housing and configured to actuate the mechanical switch from outside the downhole tool via linear movement along a housing; a battery module connected to, or disposed within, the downhole tool.

Statement 19: The tool string of statement 18, wherein the actuator assembly is configured such that actuation of the mechanical switch is performed without any need for external power and/or pressure testing.

Statement 20: The tool string of statements 18 or 19, wherein the downhole tool further comprises: a replaceable cartridge between the actuator assembly and a pressure housing a connector coupled to the mechanical switch in the pressure sealed chamber; one or more annular sealing elements between the switch plunger and the housing; one or more additional annular scaling elements between the actuator assembly and the pressure housing; and a snap ring disposed on an end of the switch plunger and in contact with the switch actuator.

Statement 21: The tool string of any of statements 18-20, the tool string further comprising: one or more additional actuator assemblies, each comprising a switch plunger disposed within a housing and configured to actuate another respective mechanical switch from outside the downhole tool via rotation of another respective switch actuator; and one or more additional battery modules connected to the downhole tool for every additional actuator assembly.

For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as, ranges from any lower limit may be combined with any other lower limit to recite a range not explicitly recited, in the same way, ranges from any upper limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range are specifically disclosed. In particular, every range of values (of the form, “from about a to about b,” or, equivalently, “from approximately a to b,” or, equivalently, “from approximately a-b”) disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values even if not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

Therefore, the present embodiments are 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 embodiments may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Although individual embodiments are discussed, all combinations of each embodiment are contemplated and covered by the disclosure. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. 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 disclosure.

What is claimed is:

1. An actuator assembly, comprising:

a plunger housing;

a switch plunger disposed within the plunger housing; and

a switch actuator configured to induce linear movement of the switch plunger along the plunger housing,

wherein the actuator assembly is configured to:

change between an ON position and an OFF position by moving the switch plunger between extended and non-extended positions;

maintain a first pressure at one end of the switch plunger when an outer portion of the actuator assembly is exposed to a second pressure greater than the first pressure, and

a cartridge subassembly disposed on an outer surface the plunger housing, wherein the cartridge subassembly includes a spin collar and a split ring, and wherein the split ring is configured to slide under the spin collar.

2. The actuator assembly of claim **1**, wherein the first and second pressures are atmospheric and downhole pressures, respectively.

3. The actuator assembly of claim **1**, wherein the outer portion of the actuator assembly comprises the switch actuator, wherein the switch actuator comprises a rotatable flanged portion.

4. The actuator assembly of claim **1**, further comprising one or more annular sealing elements disposed between the switch plunger and an inner surface of the plunger housing.

5. The actuator assembly of claim **1**, wherein at least two annular sealing elements are disposed at one or more regions of the switch plunger downhole of a pressure test port extending radially through the plunger housing.

6. The actuator assembly of claim **1**, further comprising one or more seating surfaces of the switch plunger and one or more corresponding shoulders of the plunger housing for limiting over-insertion of the switch plunger past the ON position.

7. The actuator assembly of claim **1**, further comprising one or more anti-rotation screws disposed in the switch actuator.

8. The actuator assembly of claim **1**, wherein the cartridge subassembly further includes

two or more additional annular sealing elements disposed within respective annular grooves on the outside of a housing of the actuator assembly below the spin collar.

9. The actuator assembly of claim **1**, wherein the split ring has a polygonal cross section and is disposed substantially adjacent to the spin collar when the actuator assembly and the cartridge subassembly are disposed within a pressure housing of a downhole tool.

10. The actuator assembly of claim **1**, wherein the switch plunger comprises a shoulder, wherein the shoulder is pushed on by a contact surface of the spin collar disposed around at least a portion of the actuator assembly.

11. The actuator assembly of claim **1**, further comprising an ON-OFF switch jam nut disposed near or at a mechanical switch to fix a position of the mechanical switch relative to the switch plunger.

12. A method, comprising:

inducing linear movement of a switch plunger along a plunger housing of an actuator assembly to actuate a mechanical switch, wherein inducing linear movement of the switch plunger to change from the OFF position to the ON position is performed without an external or internal power source, and wherein after the actuator assembly is installed in the downhole tool, the region housing the mechanical switch is not pressure tested before the downhole tool is introduced into the wellbore;

fixing an axial configuration of the switch plunger with one or more additional anti-rotation screws after changing from an OFF position to an ON position;

powering a downhole tool with one or more on-board batteries as a result of the linear movement, and

introducing the downhole tool into a wellbore; and

maintaining a region housing the mechanical switch at a stable pressure that is less than a wellbore pressure while the powered tool is disposed in the wellbore.

13. The method of claim **12**, wherein the region comprising the mechanical switch is a chamber maintained at or near atmospheric pressure while the downhole tool is lowered to a depth greater than 500 feet, and wherein the wellbore pressure exceeds 500 pounds per square inch.

14. The method of claim **12**, further comprising seating one or more contacting surfaces of the switch plunger against one or more corresponding shoulders of the plunger housing to prevent over-insertion of the switch plunger.

15. The method of claim **12**, further comprising removing one or more anti-rotation screws from the actuator assembly to allow for the inducing linear movement of the switch plunger.

16. A tool string, comprising:

a conveyance for suspending a downhole tool in a wellbore;

the downhole tool, comprising:

a mechanical switch disposed within a pressure sealed chamber, wherein the mechanical switch is configured to actuate between an ON position and an OFF position, wherein the mechanical switch is configured to close part of a circuit in the ON position; and

an actuator assembly, comprising:

a switch plunger disposed within a plunger housing and configured to actuate the mechanical switch from outside the downhole tool via linear movement along the housing, wherein linear movement of the switch plunger is induced outside of the wellbore and without an external or internal power source; and

a switch actuator disposed at least partially within the plunger housing wherein the switch actuator is configured to move linearly along the plunger housing in response to manual rotation the switch actuator, wherein the switch actuator is configured to interface with the switch plunger such that linear movement the switch actuator is configured to induce linear movement of the switch plunger along the plunger housing; and

a battery module connected to, or disposed within, the downhole tool, and wherein the battery module is connected to the circuit.

17. The tool string of claim **16**, wherein the actuator assembly is configured such that actuation of the mechanical switch is performed without any need for external pressure testing.

18. The tool string of claim **16**, wherein the downhole tool further comprises:

a replaceable cartridge between the actuator assembly and a pressure housing

a connector coupled to the mechanical switch in the pressure sealed chamber;

one or more annular sealing elements between the switch plunger and the housing;

one or more additional annular sealing elements between the actuator assembly and the pressure housing; and

a snap ring disposed on an end of the switch plunger and in contact with the switch actuator.

19. The tool string of claim **16**, the tool string further comprising:

one or more additional actuator assemblies, each comprising a switch plunger disposed within a housing and configured to actuate another respective mechanical switch from outside the downhole tool via rotation of another respective switch actuator, and

one or more additional battery modules connected to the downhole tool for every additional actuator assembly.

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