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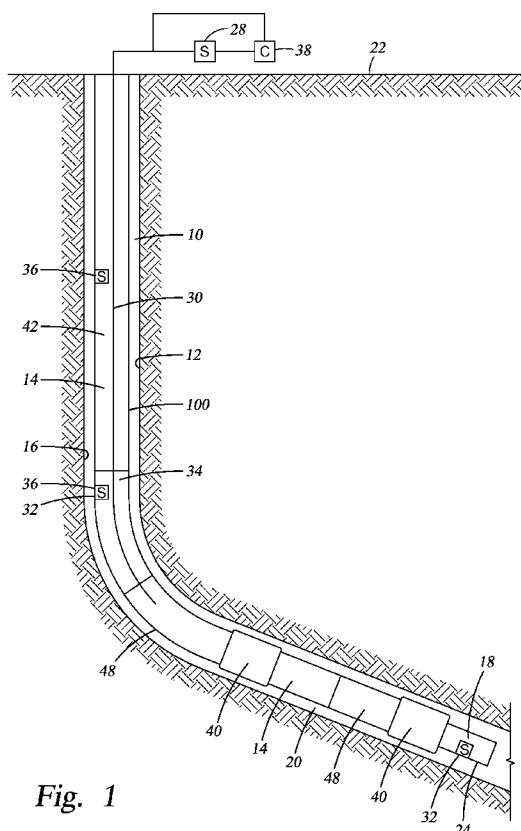


Fig. 1

(57) Abstract: A downhole tool assembly includes a tubular having a flowbore extending along a longitudinal axis of the tubular. An electric actuating mechanism supported by the tubular and distanced from the longitudinal axis of the tubular; and, a valve assembly connected to the tubular and fluidically connected to the flowbore. The valve assembly including: an outer portion having at least one port; and an electrically actuated inner portion concentrically positioned within the outer portion and operable by the actuating mechanism to selectively block the at least one port in a first condition of the valve assembly and unblock the at least one port in a second condition of the valve assembly. A method of actuating a valve assembly in a downhole tubular.



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ELECTRICALLY OPERATED VALVE AND METHOD THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Application No. 14/325873, filed on July 8, 2014, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] In the completion and production industry for natural resources, the formation of boreholes/completions for the purpose of production or injection of fluid is common. The boreholes/completions are used for exploration or extraction of natural resources such as hydrocarbons, oil, gas, water, and alternatively for CO₂ sequestration. Coiled tubing or string is run into the borehole/completion for varying purposes and valves, such as circulation valves, have been used on the tubing or string to enable circulation of fluids between the inside and the outside of the tubing. Such valves are typically mechanically operable including ball-activated features and pressure-operated features.

[0003] The art would be receptive to improved alternative devices and methods for operating a valve within a borehole/completion.

BRIEF DESCRIPTION

[0004] A downhole tool assembly includes a tubular having a flowbore extending along a longitudinal axis of the tubular; an electric actuating mechanism supported by the tubular and distanced from the longitudinal axis of the tubular; and, a valve assembly connected to the tubular and fluidically connected to the flowbore, the valve assembly including: an outer portion having at least one port; and an electrically actuated inner portion concentrically positioned within the outer portion and operable by the actuating mechanism to selectively block the at least one port in a first condition of the valve assembly and unblock the at least one port in a second condition of the valve assembly.

[0005] A method of actuating a valve assembly in a downhole tubular, the method includes inserting a tubular having a flowbore into a borehole; employing a peripherally positioned electric motor within the tubular; actuating an electrically activated valve assembly with the motor, the valve assembly including an outer portion having at least one port and an inner portion movably configured within the outer portion; and, selectively moving the inner portion to block the at least one port in a first condition of the valve assembly and selectively moving the inner portion to expose the at least one port in a second

condition of the valve assembly; wherein fluid flow through the tubular during both the first and second conditions of the valve assembly is not blocked.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The following descriptions should not be considered limiting in any way.

With reference to the accompanying drawings, like elements are numbered alike:

[0007] FIG. 1 shows a schematic diagram of a downhole tool assembly in a borehole incorporating an exemplary electrically operable valve assembly;

[0008] FIG. 2 shows a cross sectional exploded side view of an exemplary embodiment of the downhole tool assembly of FIG. 1;

[0009] FIG. 3 shows cross-sectional side view of an exemplary embodiment of an axially shiftable valve assembly;

[0010] FIG. 4 shows a cross-sectional view of the axially shiftable valve assembly taken along line 4-4 of FIG. 3;

[0011] FIG. 5 shows a cross sectional side view of an exemplary embodiment of a rotatably adjustable valve assembly;

[0012] FIG. 6 shows a cross-sectional view of the rotatably adjustable valve assembly taken along line 6-6 of FIG. 5;

[0013] FIG. 7 shows a side plan view of an exemplary inner portion of the valve assembly of FIG. 5; and,

[0014] FIGS. 8A-8C show cross sectional views of alternate exemplary embodiments of a power generation sub for the downhole tool assembly of FIG. 2.

DETAILED DESCRIPTION

[0015] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0016] FIG. 1 shows a downhole tool assembly 100 positioned within a borehole 10 lined with a casing 12. The borehole 10 has a generally vertical section and may further include a deviated or horizontal section 20. Alternatively, the borehole 10 is an open-type borehole where the formation wall 16 is not lined with casing 12. The downhole tool assembly 100 includes a tubular string 14, such as, but not limited to, coiled tubing, production string, and drilling string. The string 14 includes any number of connected tubing pieces and may be spoolable onto a reel (not shown) provided at a surface location 22. At a

downhole end 24 of the string 14, a tool 18 may be carried for performing a downhole operation. While illustrated at the downhole end 24, one or more tools 18 may be provided anywhere between the downhole end 24 and surface location 22. Alternatively, the string 14 need not include any tool 18. The string 14 may also be used primarily for well production stages using coiled tubing, where the valve assembly 40 is employed for circulating or redirecting production fluids as needed to direct such fluids to surface, bypass blockages, etc., or for injection of stimulating or fracturing fluids as needed from an interior to an exterior of the string 14.

[0017] A power source 28 providing electrical energy may be provided at the surface location 22, and sends an electrical signal, such as via line 30. A surface control unit 38 is used to electrically control operation of a valve assembly 40, such as a circulation valve, by using a motor powered by the power source 28 or a power generation sub as will be further described below. Whenever valve operation is necessary, the valve assembly 40 is activated by an actuation mechanism to move to a full or partially open condition based on required flow regimes to allow for circulation of fluids from inside to outside, outside to inside, downhole to uphole, or uphole to downhole, either as a one off operation or multi-repeated cycles.

[0018] While the valve assembly 40 may be controlled via the control unit 38 at any time, whether programmed or by operator input, in an exemplary embodiment of the downhole tool assembly 100, sensor modules 32 may also be directly incorporated into the string 14 or tool 18 to detect changes in the environment of the string 14 within the borehole 10 to indicate when an operation of a circulation valve assembly 40 is necessary. The sensor module 32 could be incorporated into a logging bottom hole assembly 34, provided separately along interconnections of the string 14 or other locations along the string 14, or provided within the tool 18. The sensor module 32 may contain sensors 36, circuitry, and processing software and algorithms relating to environment of the borehole indicative of a necessity for operation of a valve assembly 40. Such parameters may include pressure, flow speed, and other measurements related to the environment of the string 14. Signals from sensors 36 in the sensor module 32 or sensors 36 provided elsewhere along the string 14 are either processed by the sensor module 32, sent to a surface location 22 such as surface control unit 38 for operator evaluation, or directly to a valve assembly 40 for immediate or subsequent action. The surface control unit 38 or processor may receive signals from the sensors 36 and processes such signals according to programmed instructions provided to the surface control unit 38. The surface control unit 38 may also display information on a

display/monitor utilized by an operator. The surface control unit 38 may include a computer or a microprocessor-based processing system, memory for storing programs or models and data, a recorder for recording data, and other peripherals. The control unit 38 may be adapted to notify the operator when operating conditions indicate a need for circulation or other valve operation. The surface control unit 38 may also be used for other operations of the string 14 and tool 18 not described herein. A communication sub (not shown) may obtain the signals and measurements and transfers the signals, using two-way telemetry, for example, to be processed at the surface location 22. Alternatively, the signals can be processed using a downhole processor in the tool 18 or sensor module 32. In the event a signal is sent indicating a need for circulation or other valve operation, the valve assembly 40 is electrically activated.

[0019] The selective valve operation does not impede operation of the tool(s) 18, string 14, or any downhole procedure. Furthermore, as will be further described below, even when the valve assembly 40 is activated, flow through a flowbore 42 of the string 14 is not blocked or restricted so as to allow for flow therethrough for use by the tool 18 or downhole operations requiring such flow, such as production through the coiled tubing of the string 14.

[0020] Turning now to FIG. 2, the downhole tool assembly 100 is shown including the valve assembly 40. The string 14 includes a tubular wall 44 surrounding the flowbore 42. While the valve assembly 40 is depicted downhole of the string 14, additional lengths of the string 14 may also be connected downhole of the valve assembly 40. Additionally, multiple valve assemblies 40 may be provided along the string 14 as exemplified in FIG. 1.

[0021] An exemplary embodiment of the downhole tool assembly 100 includes a logging bottom hole assembly ("BHA") 34. The logging BHA may be a separate component from the valve assembly 40. Also included in the downhole tool assembly is a motor 46, which may be incorporated into a power supply sub 48, and an electrically activated valve assembly 40.

[0022] The logging BHA 34 is attachable to the string 14. The logging BHA 34 includes an uphole end 54 connected to the string 14, and a downhole end 56. The logging BHA 34 also includes flowthrough, such that a flowbore 58 of the logging BHA 34 is in fluid communication with the flowbore 42 of the string 14. The logging BHA 34 may create any type of geophysical log by making at least one type of measurement of rock or fluid property in the borehole 10 or within the flowbore 58 of the logging BHA 34 itself. The measurements are taken using at least one type of sensor, including, but not limited to, sensors to measure pressure, temperature, spontaneous potential, and radiation, as well as a

variety of sensors such as acoustic (sonic), electric, inductive, magnetic resonance, etc. One of the sensors in the logging BHA 34 may be the sensor 36 that detects environmental conditions within the borehole 10. The data from the measurements secured by the logging BHA 34 may be recorded at the surface control unit 38, or alternatively the logging BHA 34 may include a memory storage unit for subsequent creation of a well log. Since the information from the logging BHA 34 can be used by operators to gain an understanding of the borehole 10 for any desired downhole operation, the logging BHA 34 need not be directly part of the valve assembly 40 even if information obtained from the logging BHA 34 is utilized by the valve assembly 40. Alternatively, the valve assembly 40 may be electrically operated using signals initiated by an operator or from other sensors 36, 28 as previously described.

[0023] Connected downhole of string 14, and the logging BHA 34 if utilized, is a power supply sub 48. The power supply sub 48 includes an uphole end 60 and a downhole end 62 and includes flowthrough via a flowbore 66. The uphole end 60 of the power supply sub 48 is connected downhole of the logging BHA 34 or string 14. In one exemplary embodiment, a conductor 64 passes through the string 14, logging BHA 34, and into the power supply sub 48. The conductor 64 is formed of one or more insulated wires or bundles of wires adapted to convey power and/or data, and may be included with or part of the signal conducting line 30 that delivers signals from the surface location 22 to motor 46. The conductor 64 can include metal wires, or alternatively other carriers such as fiber optic cables that may be provided in a tubing encapsulated cable ("TEC") such as an armored metal clad water sealed cable. The conductor 64 can deliver the signal provided by the sensors 28 or operator input previously described, as well as carry the signals from the downhole sensors 36. Additionally, by use of either direct or alternating current transmittal through the conductor 64, the power supply sub 48 is capable of providing sufficient power to operate the valve assembly 40 connected downhole of the power supply sub 48. The conductor 64 is either provided within a protective channel (not shown) incorporated within the string 14 or passed through the flowbores 42, 58 of the string 14 and logging BHA 34, such as via a wireline. Advantages of using conductor 64 to conduct current from the surface 22 include the ability to conduct high amounts of electrical energy from the surface 22 and the supply from the surface 22 is relatively unlimited.

[0024] The power supply sub 48 is a tubular that peripherally supports the motor 46 and may alternatively or additionally include a power storage unit such as one or more batteries 68. Batteries 68 can be used as a local source of power for downhole electrical

devices, such as the electrically activated valve 40 or a tool 18, but the batteries 68 must be arranged to fit within space constraints that exist within the borehole 10 and string 14. Electrically recharging the battery 68 can occur through the conductor 64, and replacing the battery 68, if required, may be accomplished via a wireline operation or upon retrieval of the battery 68 from the borehole 10.

[0025] When necessary to open the valve assembly 40, or close the valve assembly 40, such as determined by a surface operator or via the logging BHA 34 or sensor 36 or 28 that a condition within or exterior to the string 14 has necessitated valve operation, then the power supply sub 48 will utilize an actuating mechanism linked to the motor 46 to activate the electrically operated valve assembly 40. The electrically operated valve assembly 40 shares substantially the same flowpath, and likewise may share substantially the same longitudinal axis when interconnected with the power supply sub 48, logging BHA 34, and string 14. While the valve assembly 40, power supply sub 48, and logging BHA 34 have been described and illustrated as separate elements, another exemplary embodiment would include the integration of any combination of such subs, although separating the components into different subs generally eases replacement of defective parts. Also, while the different subs are described as interconnected, it should be understood that the elements may be separated from each other by any additional lengths of string 14 or connectors.

[0026] When actuated by the power supply sub 48, the electrically operated valve assembly 40 will either open or close or be positioned at an interim location between fully opened and fully closed. The valve assembly 40 is accessible to the flow bore 42 of the assembly 100, but does not block or restrict the flow bore 104 even when in use, nor does it interrupt the normal flow through the flow bore 104 and string 14. Thus, any downhole tools, such as tool 18, which depend on the flow through the flow bore 42, still receive the flow. Also, the downhole tool assembly 100 is suited for well production through the flow bore 42, since the flow bore 42 is not blocked by any of the above-described portions of the assembly 100.

[0027] As depicted in FIGS. 3-4, one exemplary embodiment of the valve assembly 140 includes a longitudinally displaceable or axially shiftable inner portion 110 of the valve assembly 140 that covers/blocks or uncovers/exposes at least one port 112 in an outer portion 114 of the valve assembly 140. The outer portion 114 may be connected with the tubular of the power supply sub 48 so as to substantially share the same longitudinal axis as the power supply sub 48 and downhole tool assembly 100 and to fluidically connect with the flowbore 42 of the downhole tool assembly 100. One exemplary embodiment of an actuating

mechanism 115 to move the inner portion 110 in an uphole or downhole direction includes a screw rod 116 rotated by motor 46 within a threaded aperture 118 in the inner portion 110. The inner portion 110 has a substantially tubular-shaped cross-section, with at least one section 120 of the inner portion 110 sized to accommodate the threaded aperture 118. The section 120 may have a larger peripheral wall thickness than a wall thickness of the remainder of the peripheral wall. As can be mechanically understood, rotation of the screw rod 116 in a first direction will move the inner portion 110 in a downhole direction (further from surface location 22), while rotation of the screw rod 116 in a second direction, opposite the first direction, will move the inner portion 110 in an uphole direction. The outer portion 114 may include two or more longitudinally spaced ports 112 such that movement of the inner portion 110 in the uphole or downhole direction provides more or less fluid access between the flow bore 42 and the annulus surrounding the downhole tool assembly 100. For example, if the inner portion is positioned as shown in FIG. 3 in a first condition, the valve assembly 140 is fully closed/blocked. If the inner portion 110 is moved by the motor 46 to reveal all the ports 112, then the valve assembly 140 is fully opened in a second condition of the valve assembly 140. The valve assembly 140 may further include any number of additional conditions between fully closed and fully opened. For example, in the illustrated embodiment, if one or more of the ports 112 are unblocked, but one or more of the ports 112 are blocked, and then the motor 46 is intentionally stopped to halt further movement of the inner portion 110, then the valve assembly 100 is in a partially opened position, a third condition. The inner portion 110 may be positionable in any of the port revealing positions described above, and may then be subsequently partially or fully closed or fully opened by selecting the appropriate rotation direction of the screw rod 116. While the inner portion 110 has been depicted to reveal the ports 112 successively by moving the inner portion 110 in an uphole direction, alternatively the inner portion 110 could be arranged such that the inner portion 110 must move in a downhole direction to successively reveal the ports 112. Also, while discrete axially spaced ports 112 have been illustrated, the outer portion 114 may alternatively include an elongated longitudinal slot where a third condition (between fully opened and fully closed) is achieved by halting the inner portion 110 at a position where the longitudinal slot is both partially covered and partially revealed by the inner portion 110. In still another exemplary embodiment, the inner portion 110 may include apertures that align or misalign with the ports 112 of the outer portion 114.

[0028] FIGS. 5-7 show an alternative arrangement of a valve assembly 240 for rotatably moving the inner portion 210 relative to the outer portion 214. An actuating

mechanism 215 includes a gear set 216 that meshes with a rotatable driving gear 218 which in turn meshes with gear teeth 220 on a surface, such as an interior surface 222, of the inner portion 210. The gear teeth 220 need only be limited to a first section of the inner portion 210, while a remainder of the surface 222 may be free of gear teeth 220. The driving gear 218 is rotated in a first direction or an opposite second direction, such as by rotation of motor shaft 224 fixedly attached to an initial gear in the gear set 216. Rotation of the driving gear 218 rotates the inner portion 210. The inner portion 210 may be axially constrained by uphole and downhole shoulders 230, 232 protruding radially inwardly from outer portion 214. The inner portion 210 includes one or more windows 226 that are alignable with or cover one or more ports 212 in the outer portion 214. As in the valve assembly 140, the valve assembly 240 is configured to be selectively movable between a first condition in which the valve ports 212 are fully covered by an imperforate portion 228 of the inner portion 210, a second condition in which the valve ports 212 are completely accessible to a flow bore 42 of the downhole tool assembly 100, and a third condition in which the valve ports 212 are only partially blocked by the imperforate portion 228 of the inner portion 210.

[0029] In other exemplary embodiments, the power supply sub 48 may include a downhole electrical generating mechanism 70 (FIGS. 8A-8D) to continuously generate electricity and supply electricity as needed to the motor 46 or a storage location, such as the electrical generating apparatus described by U.S. Pat. No. 5,839,508 to Tubel et al, herein incorporated by reference in its entirety. The electrical generating mechanism 70 may utilize the power of passing fluid (hydraulic energy), magnetic field, a turbine, spring energy, piezoelectrics, etc. When the power supply sub 48 is employed as a power generation sub 72, power is scavenged, or harvested, from sources of potential energy within the borehole 10 including, but not limited to, fluids moving inside the flowbore 66. The power generation sub 72 may harvest vibrational energy, such as the vibrational energy harvesting mechanism described by U.S. Patent Application 2009/0166045 to Wetzel et al. The flow through the flowbore 66 is a source of vibrational energy downhole, and vibration enhancement mechanisms as described in Wetzel et al. may be added in the flowbore 66 to produce a locally more turbulent flow. Additionally, vibrations created by the tool 18 are also harvestable by the power generation sub 72. When harvesting energy from the movement of fluid within the flowbore 66, the fluid can be used to rotate a rotatable element such as a turbine or a rotatable magnet within a coil. The rotating turbine can be connected to an electrical generator that communicates with an energy storage device, such as a battery 74. Rotation of a magnet within a coil will induce magnetic flux on the coil and a converter can

convert AC electrical output to DC electrical energy as needed. As shown in FIG. 3A, the electrical generating mechanism 70 of the power generation sub 72 may occupy a lateral passageway 76 so as not to block the main flowbore 66, or may alternatively be positioned within an annulus 78 surrounding the flowbore 66 as depicted in FIG. 3B. Alternatively, as shown in FIG. 3C, hydraulic pressure from the surface 22 can be used to generate power in an electrical generating mechanism 70 by delivering fluid under pressure via a hydraulic line 80 to react with the electrical generating mechanism 70.

[0030] In the embodiments described above, neither the valve assembly 40, 140, 240 nor the actuating mechanism 115, 215 required to actuate the valve assembly 40, 140, 240 block flow through the flowbore of the downhole tool assembly 100. Any of the above described embodiments of an electrically operated valve assembly and power supply sub may be used in plurality and sections of string 14 may be interposed therebetween. While fluid flow is illustrated in one particular direction, it should be understood that the fluid flow within the flowbores 42, 58, 66, 104 of the above described exemplary embodiments may be in either uphole or downhole direction depending upon the particular application of the string.

[0031] A method of operating a valve assembly 40, 140, 240 in a downhole tool assembly 100 includes inserting a tubular such as the string 14 into the borehole 10, determining a need for opening or blocking flow between the flowbore of the tubular and the annulus between the tubular and the borehole 10, sending a signal to a control unit 28 or motor 46 in response to the determined need, actuating an electrically activated valve assembly 40, the valve assembly 40 having a flow bore 104 fluidically connected to a flowbore 42 of the tubular, and altering the flow between the tubular and surrounding borehole 10 by operation of the valve assembly 40. The method enables a partial opening of flow between the flowbore and annulus. Flow through the flowbores 42, 104 of the string 14 and valve assembly 40 is not blocked during activation and non-activation of the valve assembly 40. The method further includes generating power in a power generating sub 48.

[0032] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the

claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

CLAIMS

What is claimed is:

1. A downhole tool assembly (100) comprising:
a tubular (14) having a flowbore (42) extending along a longitudinal axis of the tubular (14);
an electric actuating mechanism (115, 215) supported by the tubular (14) and distanced from the longitudinal axis of the tubular (14); and,
a valve assembly (40, 140, 240) connected to the tubular (14) and fluidically connected to the flowbore (42), the valve assembly (40, 140, 240) including:
an outer portion (114, 214) having at least one port (112, 212); and
an electrically actuated inner portion (110, 210) concentrically positioned within the outer portion (114, 214) and operable by the actuating mechanism (115, 215) to selectively block the at least one port (112, 212) in a first condition of the valve assembly (40, 140, 240) and unblock the at least one port (112, 212) in a second condition of the valve assembly (40, 140, 240).
2. The downhole tool assembly (100) of claim 1 wherein the inner portion (110, 210) is further movable to selectively block only a portion of the at least one port (112, 212) in a third condition of the valve assembly (40, 140, 240), leaving a remainder of the at least one port (112, 212) unblocked in the third condition.
3. The downhole tool assembly (100) of claim 1 wherein the inner portion (210) further includes at least one aperture (226) configured to be selectively aligned and misaligned with the at least one port (212) of the outer portion (214).
4. The downhole tool assembly (100) of claim 1 wherein the inner portion (110) is configured to be longitudinally shiftable relative to the outer portion (114).
5. The downhole tool assembly (100) of claim 4 wherein the actuating mechanism (115) includes a screw rod (116) rotatable by a motor (46), the inner portion (110) including a threaded aperture (118) configured to longitudinally shift the inner portion (110) upon rotation of the screw rod (116), wherein the threaded aperture (118) is located within a peripheral wall (120) of the inner portion (110).
6. The downhole tool assembly (100) of claim 1 wherein the inner portion (210) is configured to be rotatable and substantially longitudinally stationary within the outer portion (214).
7. The downhole tool assembly (100) of claim 6 wherein a surface (222) of the inner portion (210) includes gear teeth (220) and the actuating mechanism (215) includes a

driving gear (218) having teeth engageable with the gear teeth (220) of the surface (222) of the inner portion (210), wherein the gear teeth (220) of the inner portion (210) are located on a first section of the inner portion (210), and a second section of the inner portion (210) further includes at least one aperture (226) configured to be selectively aligned and misaligned with the at least one port (212) of the outer portion (214).

8. The downhole tool assembly (100) of claim 1 further comprising an electric motor (46) operating the actuating mechanism (115, 215), the electric motor (46) substantially positioned within a peripheral wall (44) of the tubular (14).

9. The downhole tool assembly (100) of claim 8 wherein the motor (46) is configured to receive electricity from a surface location (22).

10. The downhole tool assembly (100) of claim 1 further comprising a power generating member (72), wherein flow through the tubular (14) is used to generate power in the power generating member (72).

11. The downhole tool assembly (100) of claim 1 further comprising a sensor (36) configured to detect a condition indicative of a need to activate the valve assembly (40, 140, 240), and a motor (46) configured to actuate the actuating mechanism (115, 215) and valve assembly (40, 140, 240) in response to the sensed condition.

12. A method of actuating a valve assembly (40, 140, 240) in a downhole tubular (14), the method comprising:

inserting a tubular (14) having a flowbore (42) into a borehole (10);

employing a peripherally positioned electric motor (46) within the tubular (14);

actuating an electrically activated valve assembly (40, 140, 240) with the motor (46), the valve assembly (40, 140, 240) including an outer portion (114, 214) having at least one port (112, 212) and an inner portion (110, 210) movably configured within the outer portion (114, 214); and,

selectively moving the inner portion (110, 210) to block the at least one port (112, 212) in a first condition of the valve assembly (40, 140, 240) and selectively moving the inner portion (110, 210) to expose the at least one port (112, 212) in a second condition of the valve assembly (40, 140, 240);

wherein fluid flow through the tubular (14) during both the first and second conditions of the valve assembly (40, 140, 240) is not blocked.

13. The method of claim 12 further comprising selectively moving the inner portion (110, 210) to block a portion of the at least one port (112, 212) and expose a portion

of the at least one port (112, 212) in a third condition of the valve assembly (40, 140, 240) and selectively maintaining the valve assembly (40, 140, 240) in the third condition.

14. The method of claim 12 wherein selectively moving the inner portion (110) includes longitudinally moving the inner portion (110) relative to a longitudinal axis of the tubular (14) by employing the motor (46) to rotate a screw rod (116) within a threaded aperture (118) within a peripheral wall (120) of the inner portion (110).

15. The method of claim 12 wherein selectively moving the inner portion (210) includes rotatably moving the inner portion (210) by employing the motor (46) to rotate a driving gear (218) meshing with gear teeth (220) on a surface (222) of the inner portion (210).

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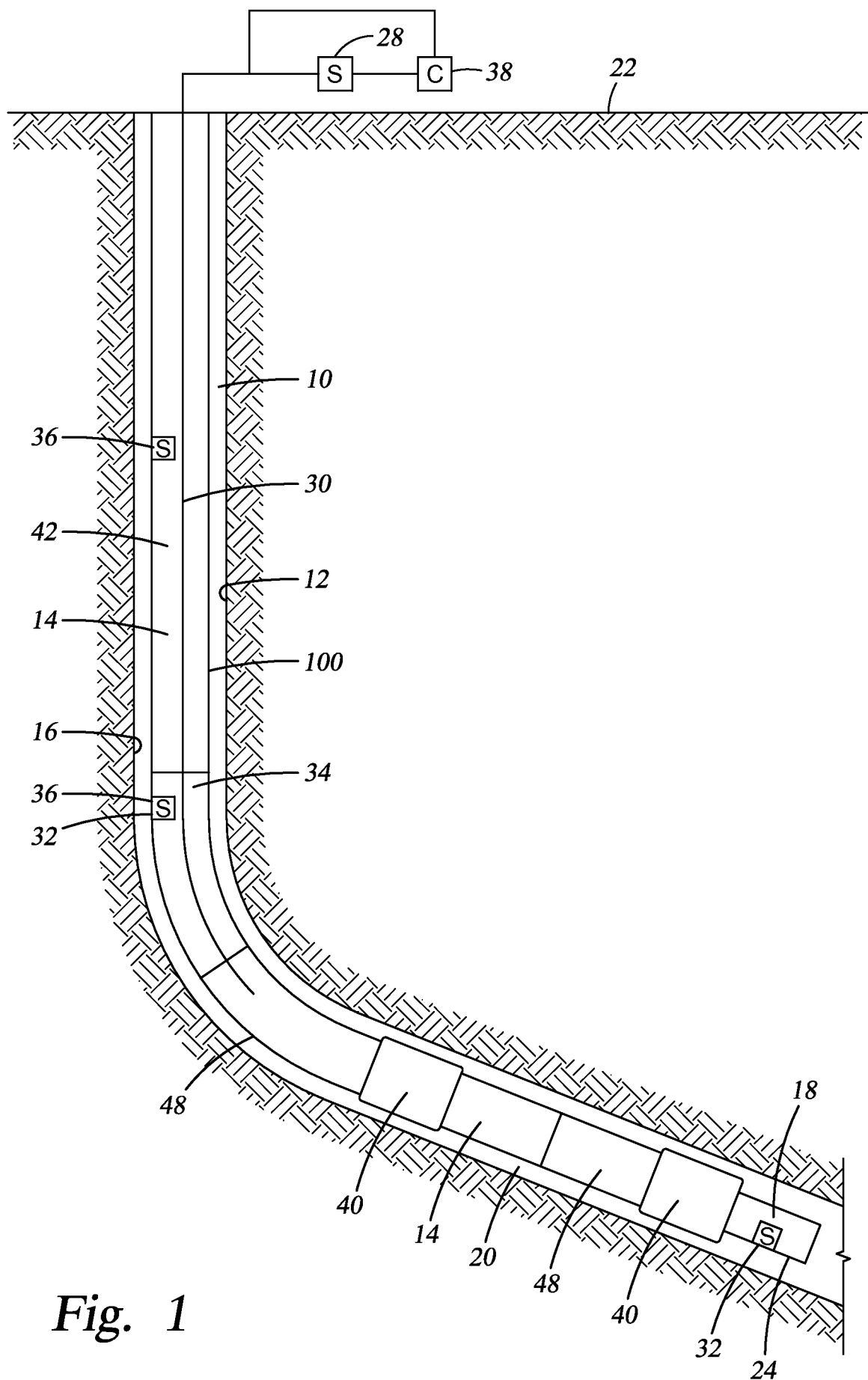


Fig. 1

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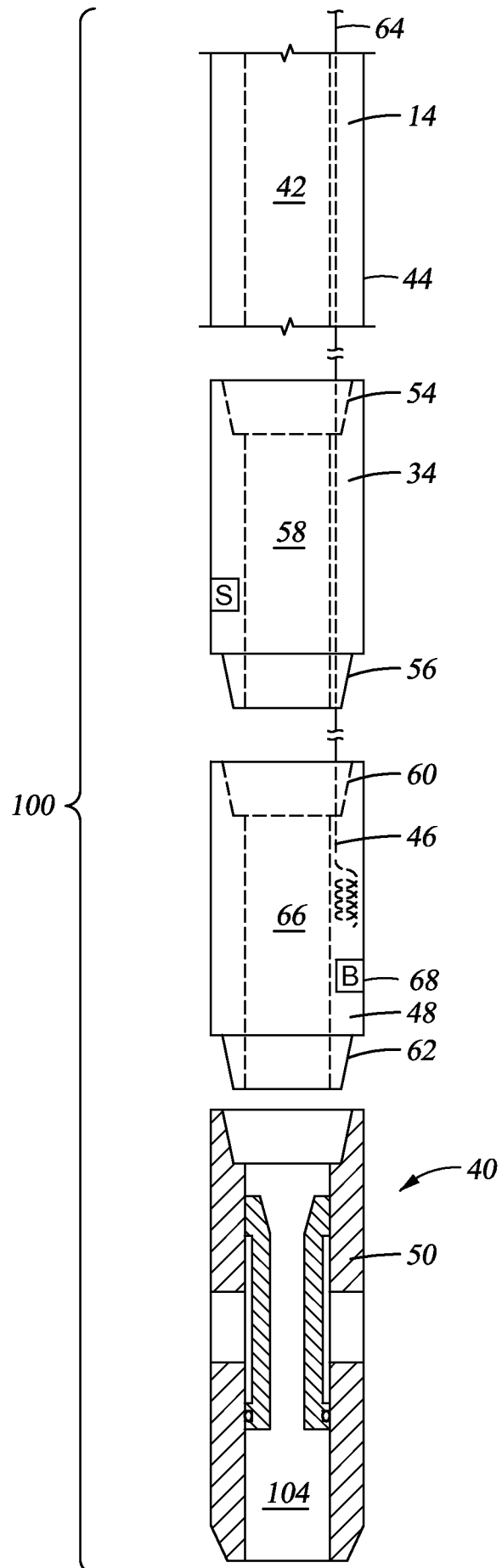


Fig. 2

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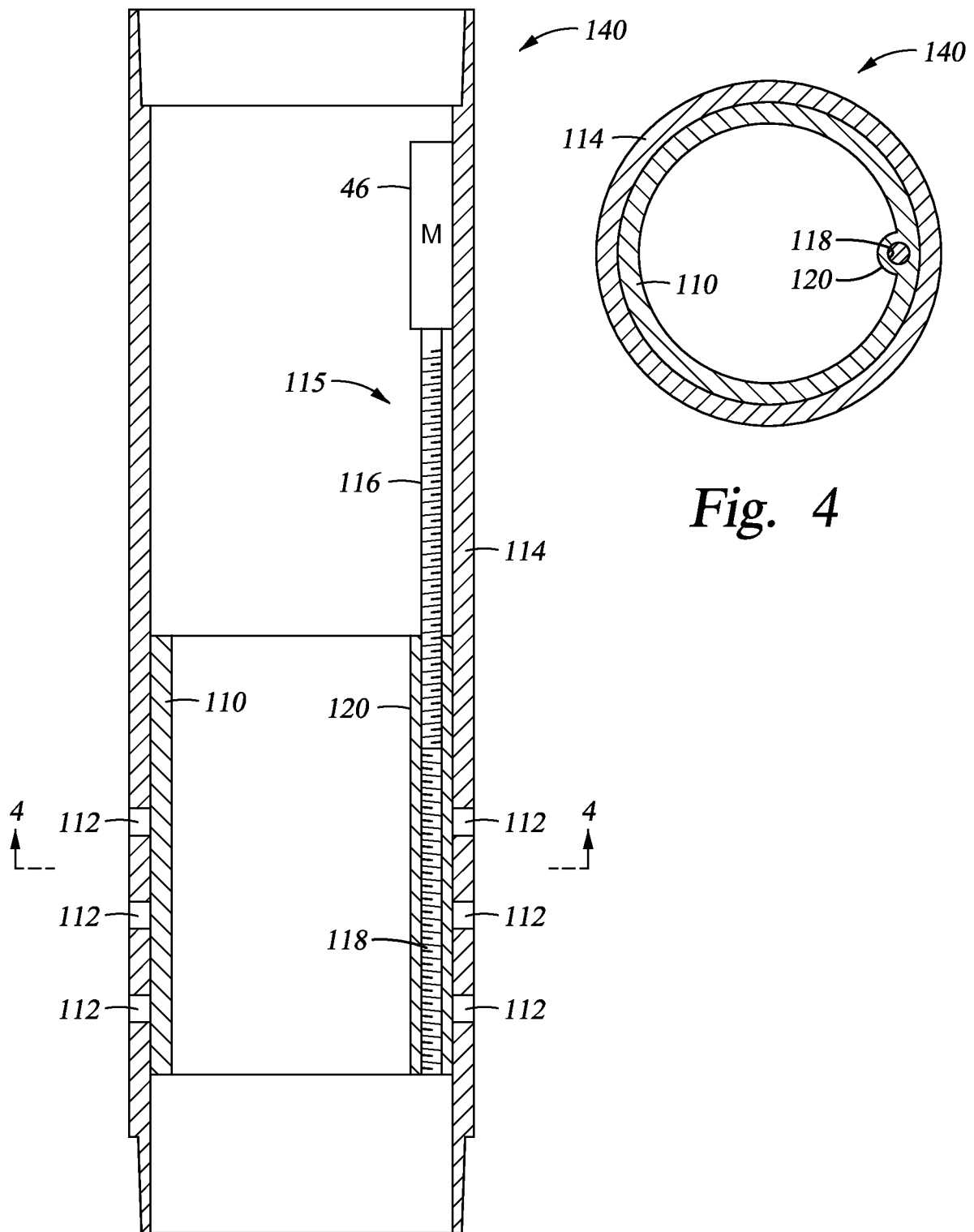


Fig. 4

Fig. 3

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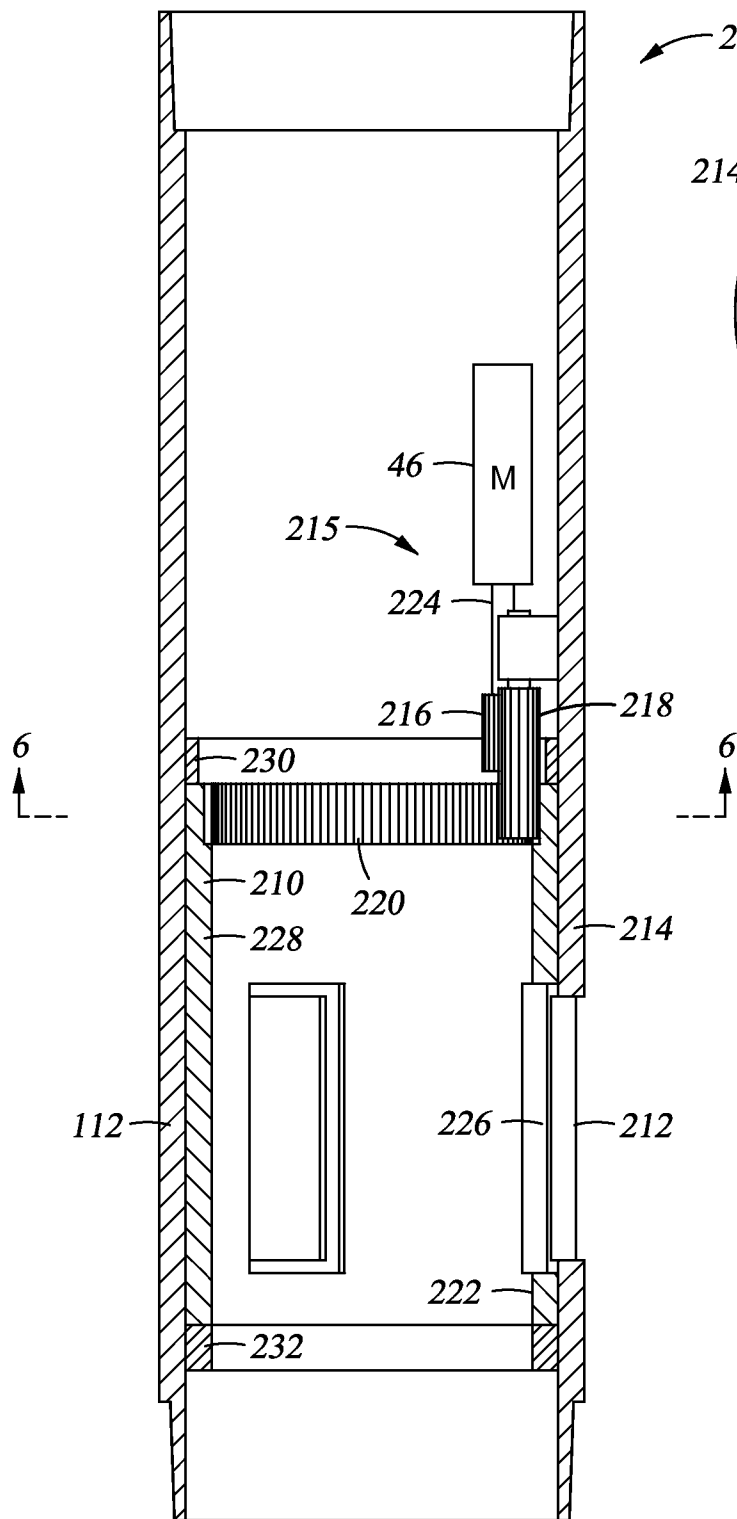


Fig. 5

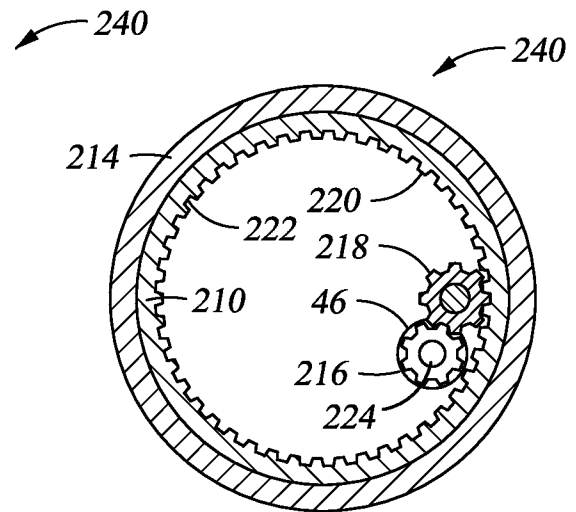


Fig. 6

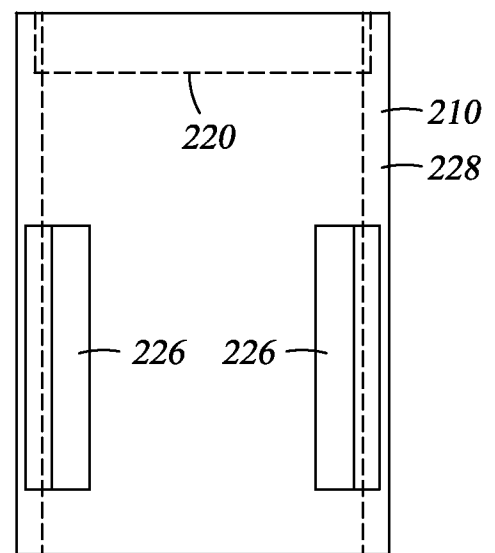


Fig. 7

Fig. 8A

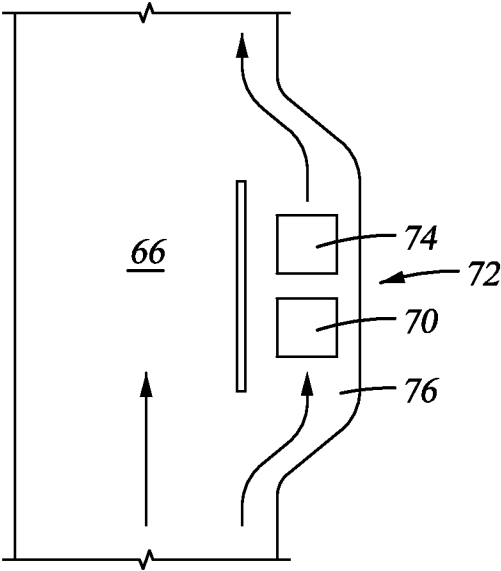


Fig. 8B

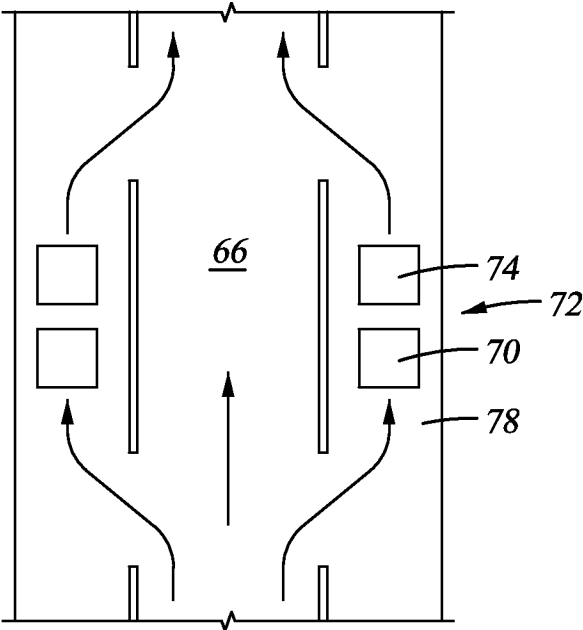
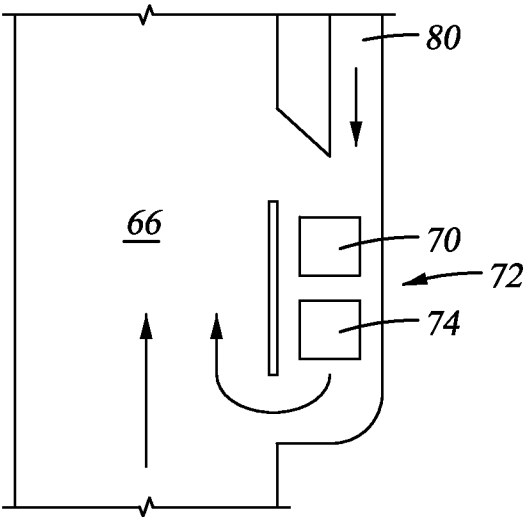


Fig. 8C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/033504**A. CLASSIFICATION OF SUBJECT MATTER****E21B 34/06(2006.01)i, E21B 17/00(2006.01)i, E21B 21/08(2006.01)i, E21B 43/12(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 34/06; E21B 34/00; G05B 11/32; E21B 4/04; E21B 23/00; E21B 34/10; E21B 17/00; E21B 21/08; E21B 43/12

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: tubular, electric, actuate, mechanism, valve, port

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4967845 A (SHIRK, STEVEN H.) 06 November 1990 See column 1, line 12 - column 4, line 40; column 5, lines 12-49; column 7, lines 16-59; and figures 1A-1B, 2B-2C.	1-15
Y	EP 0551163 A1 (HALLIBURTON COMPANY) 14 July 1993 See column 2, lines 7-14; column 5, line 24 - column 7, line 16; column 13, lines 23-57; and figures 2, 5, 8, 9A-9I.	1-15
Y	US 2005-0133216 A1 (BARTLETT, CHRISTOPHER D.) 23 June 2005 See paragraph [0034]; and figure 2.	7, 15
A	US 2013-0032355 A1 (SCOTT et al.) 07 February 2013 See paragraphs [0005]-[0011], [0026]-[0028], [0044]; and figures 1-2, 5.	1-15
A	US 2010-0090639 A1 (LIBERALE et al.) 15 April 2010 See paragraphs [0011]-[0013], [0023]-[0029]; and figures 2-4.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

18 August 2015 (18.08.2015)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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