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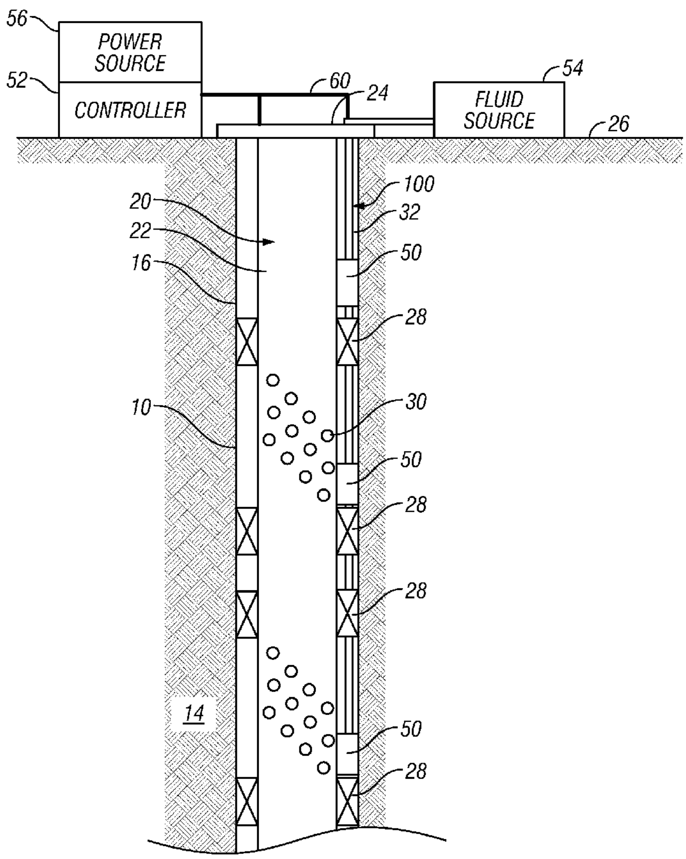
(54) Title: WELLBORE POWER AND/OR DATA TRANSMISSION DEVICES AND METHODS



(57) Abstract: A signal transmission device transmits power and / or data between one or more surface devices and one or more downhole devices positioned in a wellbore. The signal transmission device includes at least one conductive element that electrically couples to one or more downhole devices and electrically couples at a surface end to the one or more surface devices. The conductive element is also coupled to the wellbore tubular to form a conductive circuit. The conductive element can also include a bore for conveying fluid from a surface source.

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BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

[0001] This disclosure relates generally to methods and devices for conveying power and data between the surface and one or more downhole locations.

Description of the Related Art

[0002] Valuable hydrocarbon deposits, such as those containing oil and gas, are often found in subterranean formations located thousands of feet below the surface of the Earth. To recover these hydrocarbon deposits, boreholes or wellbores are drilled by rotating a drill bit attached to a drilling assembly (also referred to herein as a "bottom hole assembly" or "BHA"). Thereafter, a casing is positioned in the wellbore and one or more production zones in the wellbore are completed using appropriate equipment such as packers, in-flow devices, submersible pumps etc.

[0003] Many of the devices presently deployed downhole utilize electrical power and / or communicate with surface equipment using electrical conductors. At the same time, these downhole devices can require fluid supplied from a surface source for control and /or energy. Conventionally, a cable for supplying electrical power and hydraulic fluid to downhole equipment includes a tubular having a bore for conveying a hydraulic fluid and an electrical conductor. The electrical conductor is formed of a metal core concentrically disposed within a metal tubular. The metal core and the metal tubular are separated by a suitable electrical insulator. The hydraulic fluid tubular and the electrical conductor run side-by-side and are wrapped in a common encapsulation. As is known in the art, wellbores can span thousands of meters and include deviated legs or sections. Moreover, the annular space through which conventional cables run can be limited. Conventional cables have a relatively large cross-sectional profile because they include separate conduits or conductors for hydraulic fluid and electrical power. Thus, such cables can easily be damaged during installation. Such damage can compromise the ability of the cable to carrying data and /or power.

[0004] The present disclosure addresses these and other drawbacks of the prior art cables.

SUMMARY OF THE DISCLOSURE

[0005] In aspects, the present disclosure provides a method for providing signal transmission between one or more surface devices and one or more downhole devices positioned in a wellbore. The method may include positioning a wellbore tubular in the wellbore; coupling a conductive element to the wellbore tubular to form a conductive circuit; and coupling the surface devices to the downhole devices using the conductive element. The signal transmission may include data signals, command signals, and / or electrical power and transmitted across the circuit formed by the conductive element and the wellbore tubular. Illustrative uses for these signals include controlling or energizing the downhole devices. In aspects, the method may include conveying a fluid along a bore in the conductive element. The method may also include conveying a formation fluid to the surface using the wellbore tubular.

[0006] In aspects, the present disclosure provides a system for providing signal transmission in a wellbore. In one arrangement, the system may include a surface device; a downhole device; a conductive element electrically coupled to the surface device and the downhole device; and a wellbore tubular positioned in the wellbore. The wellbore tubular is electrically coupled to the conductive element. The surface device or devices may transmit data signals, and / or electrical power to the downhole device or devices using the conductive element. In one arrangement, the conductive element may be formed as a tubular having a bore configured to convey a fluid and may include a surface fluid source configured to supply the fluid into the bore of the tubular. In other embodiments, the conductive element may be formed as a solid core encapsulated with sheathing. The conductive element may be formed as a plurality of end-to-end segments and /or a continuous element. Additionally, in aspects, the wellbore tubular may be a production tubing configured to convey a fluid to the surface.

[0007] It should be understood that examples of the more important features of the disclosure have been summarized rather broadly in order that detailed description thereof that follows may be better understood,

and in order that the contributions to the art may be appreciated. There are, of course, additional features of the disclosure that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] For detailed understanding of the present disclosure, references should be made to the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals and wherein:

[0009] **Figure 1** schematically illustrates a sectional elevation view of a sectional elevation view of a system utilizing a signal transmission device made in accordance with one embodiment of the present disclosure;

[0010] **Figure 2** schematically illustrates one signal transmission device made in accordance with one embodiment of the present disclosure for conveying fluid and power/ data signals;

[0011] **Figure 3** schematically illustrates one signal transmission device made in accordance with one embodiment of the present disclosure for conveying power/ data signals; and

[0012] **Figure 4** schematically illustrates an exemplary connection for a signal transmission device made in accordance with one embodiment of the present disclosure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The present disclosure relates to devices and methods for providing signal transmission between surface equipment and downhole equipment. As used herein, the term signal is broadly used to encompass data, commands and electrical power. The present disclosure is susceptible to embodiments of different forms. There are shown in the drawings, and herein will be described in detail, specific embodiments of the present disclosure with the understanding that the present disclosure is to be considered an exemplification of the principles of the disclosure, and is not intended to limit the disclosure to that illustrated and described herein. Indeed, as will become apparent, the teachings of the present disclosure can be utilized for a variety of well tools and in all phases of well construction and production. Accordingly, the embodiments discussed below are merely illustrative of the applications of the present disclosure.

[0014] Referring initially to **Fig. 1**, there is shown an exemplary wellbore **10** that has been drilled through a formation **14**. The wellbore **10** is cased by metal casing **16**, as is known in the art. The wellbore **10** has a production assembly, generally indicated at **20**, disposed therein by a tubing string **22** that extends downwardly from a wellhead **24** at the surface **26**. Zone isolation members such as packers **28** positioned along one or more production zones along the wellbore **10** channel formation fluids into the tubing string **22** via suitable perforations **30**. An annulus **32** is defined between the production assembly **20** and the wellbore casing **16**. While a land well is shown, it should be understood that the present teachings can also be applied to subsea wells also. During production, fluid from the formation **14** flows up to the surface within the tubing string **22**.

[0015] Numerous tools and devices can be deployed downhole to ensure safe and optimal production of hydrocarbons from the production zones in the formation **14**. For instance, the wellbore **10** can include instrumentation such as sensors for measuring various parameters of interest such as temperature, pressure, density, flow rates, fluid chemistry, water cut, fluid make-up, etc. The sensors can also report on the health or status of downhole equipment. An exemplary electronics package has been designated with the numeral **50**. Such instrumentation can also include appropriate processors for processing data collected by the sensors, communication devices for transmitting and receiving data to and from the surface, and controllers for operating the sensors and communication devices. Still other devices will be known to those versed in the art.

[0016] Other downhole devices that are not shown include devices such as submersible pump assemblies, valve actuators, or other flow control devices. In some applications, these downhole devices are controlled using command signals transmitted from the surface and may themselves transmit data to the surface. Moreover, for operation, these downhole devices may require power supplied from a surface source such as an electrical power source or a hydraulic / pneumatic source.

[0017] Accordingly, equipment at the surface includes control and power devices that energize, communicate with, and / or control these downhole devices. One exemplary arrangement includes a power source **52** that provides electrical power, a fluid source **54** that provides pressurized fluid, and a controller **56**. The controller **56** can be programmed to perform a number of functions, including receiving and recording sensor data, monitoring the operation of downhole devices such as sensors, monitoring characteristics of the production fluid such as flow rates and chemistry, and transmitting command signals to the downhole devices. The controller **56** can use one or more processors that contain preprogrammed instructions, memory for storing data, a recorder for recording data and other known peripherals. The power source **52** can supply AC or DC power. The fluid source **54** can provide a pressurized hydraulic fluid or a pressurized gas.

[0018] In embodiments of the present disclosure, power transfer and /or data communication between the surface devices and downhole devices is enabled by a circuit **60** formed between a transmission device **100** and a wellbore tubular such as the tubing string **22**. The tubing **22** is formed at least partially of a conductive material, such as metal. As will be described in greater detail below, the transmission device **100** and the tubing **22** form a complete electrical circuit that enables the transmission of signals, including, data signals, command signals and / or electrical power.

[0019] Referring now to **Figs. 1** and **2**, in one arrangement, the transmission device **100** is formed as a spoolable cable that includes an electrically conductive element **102** encapsulated by an insulating sheathing **104**. In one arrangement, the electrically conductive element **102** is a tubular that has a flow bore **106** that at one end is coupled to the surface fluid source **24** and coupled at the other end to one or more downhole devices (not shown). The fluid conveyed across the flow bore **106** can be a liquid such as hydraulic fluid or pneumatic gas such as air or nitrogen. The conductive tubular **102** is electrically coupled to the power source **52** and / or controller **56** at the surface end. At the downhole end, the conductive tubular **102** is electrically coupled to one or more downhole tools, such as a controller or instrumentation **50**. The instrumentation **50** is electrically coupled to the tubing **22** via a suitable connection (not shown). The tubular **102** can be formed of known electrically conductive metals such as copper.

[0020] Referring now to **Figs. 1** and **2**, in one operating mode, the surface controller **56** uses the circuit **60** formed by the tubular **102** and the tubing **22** to transmit and/or receive data signals from the downhole instrumentation **50**. The tubular **102** operates as the supply branch and the tubing **22** operates as the return branch, or *vice versa*. The data signals can include sensor measurement data, status reports, or instructions to downhole equipment such as actuators for pumps or valves. Additionally, the power source **52** can use the circuit **60** to transmit electrical power to the downhole instrumentation **50** or other downhole equipment such as a submersible pump. At the same time or at a different time, the fluid source **54** can use the bore **106** of the tubular **102** to supply pressurized fluid, such as a liquid or a gas, to energize or otherwise operate downhole equipment. The fluid source **54** may also supply chemicals or additives into the wellbore via the tubular **102**.

[0021] It should be appreciated that the **Fig. 2** embodiment can be utilized to concurrently or sequentially transmit electrical signals and convey fluid. Thus, the **Fig. 2** embodiment has a relatively smaller cross-sectional profile as compared to convention hydraulic and power conducting cables. The **Fig. 2** embodiment can also be utilized to convey only electrical signals or only fluid.

[0022] In certain applications, however, a conduit for fluid transfer may not be needed. Referring now to **Fig. 3**, there is shown one variant that transmits only power / data signals. The transmission device **120** can includes an electrically conductive element formed as a core **122** encapsulated by an insulating sheathing **124**. The core **122** can be solid or have a bore. It should be appreciated that the cross-sectional profile of the **Fig. 3** embodiment has been reduced because a bore suitable for fluid flow has been eliminated. At the surface end, the conductive core **122** is electrically coupled to the power source **52** and / or controller **56**. At the downhole end, the conductive core **122** is electrically coupled to one or more downhole tools, such as a controller or instrumentation **50**. Also, at the downhole end, a suitable connector (not shown) electrically couples the instrumentation **50** to the tubing **22** (**Fig. 1**).

[0023] The **Fig. 3** embodiment operates in a manner similar to the **Fig. 2** embodiment. With the **Fig. 3** embodiment, the circuit **60** (**Fig. 1**) is formed by the core **122** and the tubing **22** to transmit and/or receive data signals from the downhole instrumentation **50** and to convey electrical power.

[0024] As shown in **Fig. 1**, the transmission device **100** may in certain applications cross a body **70** of a downhole tool such as a splitter, tubing hanger or packer. Referring now to **Fig. 4**, there is shown an end of the transmission device **100** mated to the body **70** via a connection **140**. The connection **140** utilizes swellable materials to form an electrically and /or hydraulically insulated junction between the transmission device **100** and the body **70**. In one embodiment, the connection **140** includes a reduced diameter encapsulation section **142** and a section having little or no encapsulation **144**. Surrounding the end is a sleeve **146** of swellable material disposed within an outer tube **148**. The tubular **102** of the transmission device **100** connects to a feed-through section **150** via a threaded connection **152**. To keep the tubular **102** electrically insulated from the body **70, a** support tube **154** concentrically disposed around the threaded connection **152** and an insulating sleeve **156** is positioned between the tubular **102** and the body **70**. During assembly, an injection device such as syringe is inserted between the swellable material and the transmission device **100** to inject an oil into the cavity **158**. The oil triggers the swelling process as it fills the cavity **158**. The sleeve **146** swells to form a seal in the connection **140**. It should be appreciated that such a connection can be used to form the electrical junction between the electrically conductive tubular **102** and the tubing **22**.

[0025] In other embodiments, O-rings and / or metal olive's can be used to form a seal from the outer metal tube to the cable encapsulation and support tube. In such embodiments, threaded connections at each end would energize the olives/ seals. For an electro-hydraulic system, a splitter can be used to separate the electrical and hydraulic connections to the appropriate tools. The hydraulic flow path may include an insulating joint to ensure that the conductive tubing in the conductor is electrically insulated from the hydraulic connections that could be connected to the tool body.

[0026] It should be understood that the above embodiments are merely non-limiting illustrations of the teachings of the present disclosure. Numerous variants can be made to these embodiments. For example, while a circular cross-section is shown for the tubular **102**, it should be appreciated that any shape, *e.g.*, oval or square, can be utilized. Further, the transmission device **100** can be a single element or made-up of a plurality of end-to-end segments. Still further, the bore of the tubular can be connected to fluid sources other than a hydraulic source or a pneumatic source. For example, the tubular can be connected to a chemical supply source to supply one or more additives or materials into the production fluid. Additionally, the transmission device can include a plurality of conductive elements, each of which couple to the same or different well bore tubular. Thus, multiple circuits could thereby be formed. Such arrangements may use multiplexers or other suitable devices to transmit data signals. Additionally, while in the embodiments described above, the circuit **60** is shown using a production tubing **22**. In other embodiments, other wellbore tubulars such as the casing **16** or a liner (not shown), drill string (not shown), or coiled tubing (not shown) could also be used instead of or in addition to the tubing **22**.

[0027] The foregoing description is directed to particular embodiments of the present disclosure for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes to the embodiment set forth above are possible without departing from the scope of the disclosure. It is intended that the following claims be interpreted to embrace all such modifications and changes.

THE CLAIMS

What is claimed is:

1. A method for providing signal transmission between one or more surface devices and one or more downhole devices positioned in a wellbore, comprising:

positioning a wellbore tubular in the wellbore;

coupling a conductive element to the wellbore tubular, the conductive element and the wellbore tubular forming a conductive circuit; and

coupling the one or more surface devices to the one or more downhole devices with the conductive element.

2. The method of claim 1 further comprising: transmitting a signal across the circuit formed by the conductive element and the wellbore tubular.

3. The method of claim 2 wherein the signal is one of (i) data, (ii) a command, and (iii) electrical power.

4. The method of claim 1 further comprising controlling the one or more downhole devices with the one or more surface devices.

5. The method of claim 1 further comprising energizing the one or more downhole devices with the one or more surface devices.

6. The method of claim 1 further comprising:

conveying a fluid along a bore in the conductive element.

7. The method of claim 1 further comprising:

conveying a formation fluid to the surface using the wellbore tubular.

8. A system for providing signal transmission in a wellbore, comprising:

at least one surface device;

at least one downhole device;

a conductive element electrically coupled to the at least one surface device and the at least one downhole device; and

a wellbore tubular positioned in the wellbore, the wellbore tubular being electrically coupled to the conductive element.

9. The system of claim 8 wherein the surface device is configured to transmit one of: (i) data signals, and (ii) electrical power to the at least one downhole device using the conductive element.

10. The system of claim 8 wherein the conductive element is formed as a tubular having a bore configured to convey a fluid.

11. The system of claim 10 further comprising a surface fluid source configured to supply the fluid into the bore of the tubular.

12. The system of claim 8 wherein the conductive element is formed as a solid core encapsulated with a sheathing.

13. The system of claim 8 wherein the wellbore tubular is a production tubing configured to convey a fluid to the surface.

14. The system of claim 8 wherein the conductive element is formed as a plurality of end-to-end segments.

15. An apparatus for providing signal transmission between a surface device and one or more downhole devices positioned in a wellbore, comprising:

(a) a wellbore tubular positioned in the wellbore; and

(b) a conductive element coupled to the surface device, to the one or more downhole devices and to the wellbore tubular, the conductive element and the wellbore tubular forming a conductive circuit.

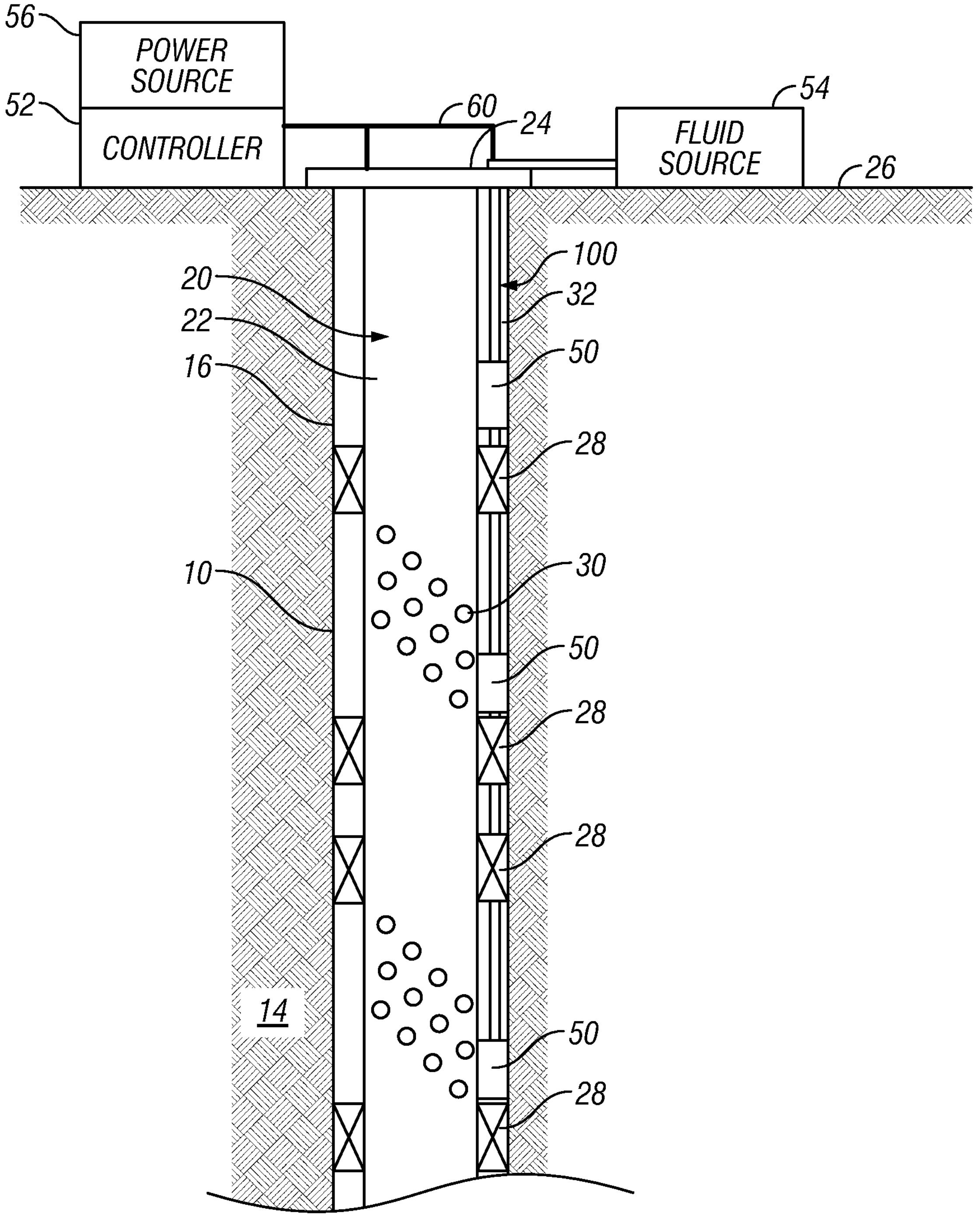
16. The apparatus of claim 15 wherein the conductive circuit is configured to convey one of: (i) data signals, and (ii) electrical power.

17. The apparatus of claim 15 wherein the conductive element is formed as a tubular having a bore configured to convey fluid.

18. The apparatus of claim 15 wherein the conductive element is formed as a solid core encapsulated with a sheathing.

19. The apparatus of claim 15 wherein the conductive element is a spoolable cable.

20. The apparatus of claim 15 wherein the wellbore tubular is a production tubing configured to convey a fluid to the surface.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CONTROLLER
60
24
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FIG. 1

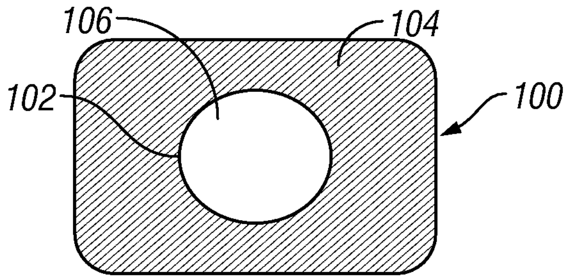

FIG. 2

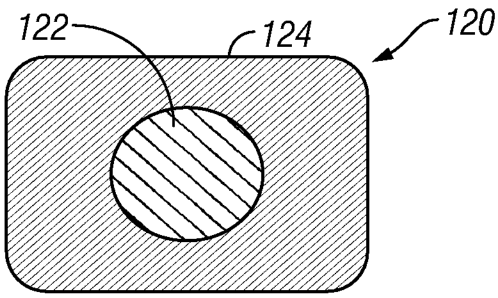

FIG. 3

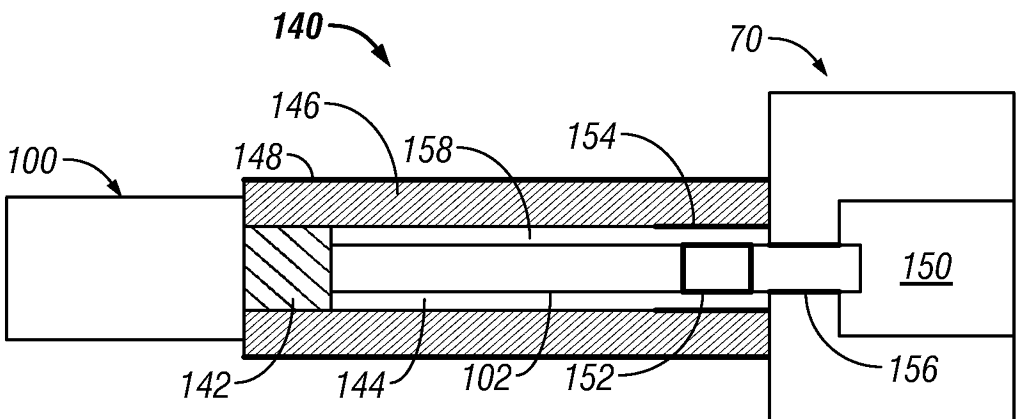

FIG. 4