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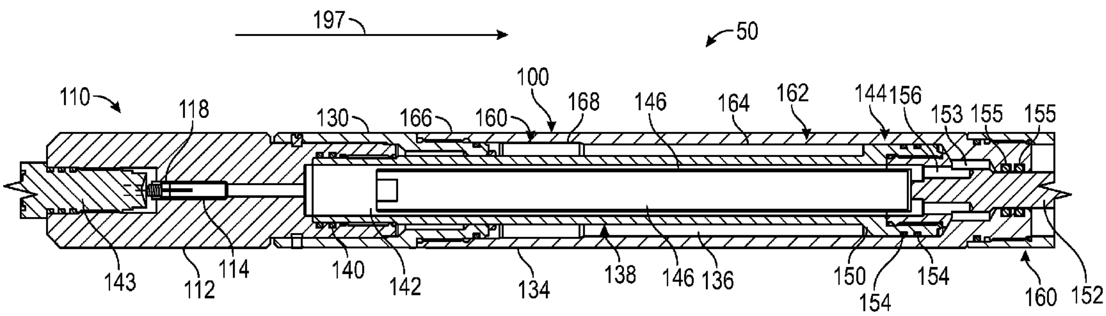
(54) **Title**: DEVICES AND RELATED METHODS FOR ACTUATING WELLBORE TOOLS WITH A PRESSURIZED GAS



(57) **Abrégé/Abstract**:
An apparatus for activating a wellbore tool includes a cylinder, a shaft, and a pressure dissipater. The cylinder has a first inner surface defining a smooth bore section and a second inner surface adjacent to the first inner surface. The shaft has a piston section that includes at least one seal forming a fluid seal with the first inner surface when the seal is at a nominal diameter. The pressure dissipater is formed along the second inner surface of the cylinder, the pressure dissipater contacts and physically destabilizes the at least one seal after the at least one seal exits the smooth bore section.

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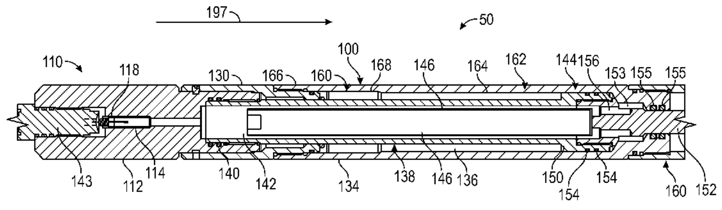

FIG. 1

(57) **Abstract**: An apparatus for activating a wellbore tool includes a cylinder, a shaft, and a pressure dissipater. The cylinder has a first inner surface defining a smooth bore section and a second inner surface adjacent to the first inner surface. The shaft has a piston section that includes at least one seal forming a fluid seal with the first inner surface when the seal is at a nominal diameter. The pressure dissipater is formed along the second inner surface of the cylinder, the pressure dissipater contacts and physically destabilizes the at least one seal after the at least one seal exits the smooth bore section.

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TITLE: **DEVICES AND RELATED METHODS FOR ACTUATING WELLBORE TOOLS WITH A PRESSURIZED GAS**

INVENTOR(S): **LAGRANGE, Timothy E.; and BAKER, Kevin L.**

BACKGROUND OF THE DISCLOSURE

1. Field of Disclosure

[0001] The present disclosure relates to an apparatus and method for actuating a downhole tool with a pressurized gas.

2. Description of the Related Art

[0002] During the construction, completion, recompletion, or work-over of oil and gas wells, there may be situations wherein one or more well tools may need to be mechanically actuated *in situ*. One known method for actuating a well tool is to generate a pressurized gas using a pyrotechnic charge and then convey the pressurized gas into a device that converts the pressure into mechanical energy, *e.g.*, a piston-cylinder arrangement that converts the pressure into motion of a selected tool or tool component. In aspects, the present disclosure is related to the need enhanced tools that use high pressure gas.

SUMMARY OF THE DISCLOSURE

[0003] In aspects, the present disclosure provides an apparatus for activating a wellbore tool. The apparatus may include a cylinder having a first inner surface defining a smooth bore section and a second inner surface adjacent to the first inner surface; a shaft having a piston section that includes at least one seal forming a fluid seal with the first inner surface when the seal is at a nominal diameter; and a pressure dissipater formed along the second inner surface of the cylinder, the pressure dissipater contacting and physically destabilizing the at least one seal after the at least one seal exits the smooth bore section.

[0004] In aspects, the present disclosure also provides a well tool that includes an upper sub, a pressure sub, and a lower sub. The upper sub has a housing that includes a first chamber for receiving an igniter. The igniter generates a flame output when detonated. The pressure sub has a cylinder, a shaft, a power charge, and a pressure dissipater. The cylinder has an inner surface defining a bore. The cylinder bore has a smooth bore section defined by an inner surface that is dimensionally non-varying both circumferentially and axially and a pressure chamber that generates the pressure needed to displace the cylinder in a direction away from the upper sub. The shaft is disposed in the cylinder bore and has a bore, a first end connected to the upper sub, and a second end on which a piston assembly is formed. The piston assembly includes at least one seal contacting the inner surface of the cylinder. The power charge is disposed in the shaft bore and is formed of an energetic material that generates a gas when ignited by the flame output of the igniter. The pressure dissipater is formed at a terminal end of the cylinder. The pressure dissipater contacts and physically destabilizes the at least one seal after the at least one seal exits the smooth bore section. The lower sub is connected to the cylinder and is configured to axially displace a component of the separate wellbore device.

[0005] The above-recited examples of features of the disclosure have been summarized rather broadly in order that the 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

[0006] 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:

FIG. 1 is a schematic sectional view of one embodiment of a gas energized well tool according to one embodiment of the present disclosure;

FIG. 2 is a sectional side view of a pressure dissipater for the gas energized well tool in accordance with one embodiment of the present disclosure;

FIG. 3 depicts an end view of a concave surface discontinuity for the **Fig. 2** pressure dissipater; and

FIG. 4 schematically illustrates a well system that may deploy a gas energized well tool having a pressure dissipater in accordance with one embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0007] As will become apparent below, the present disclosure provides an efficient device dissipating or bleeding off a high pressure fluid, such as a gas or gas / liquid used to actuate a wellbore tool. 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 present disclosure, and is not intended to limit the disclosure to that illustrated and described herein.

[0008] Referring **Fig. 1**, there is shown one embodiment of a well tool **50** that uses a pressure dissipater **100** according to the present disclosure. Merely for ease of discussion, the well tool **50** is shown as a pyrotechnic actuator that is used to actuate a separate well tool (not shown) using a translating assembly. The well tool **50** may include an upper sub **110**, a pressure sub **130**, and a lower sub **160**. The term "sub" is intended to generically refer to a section or a portion of a tool string. While a sub may be modular and use threaded connections, no particular configuration is intended or implied by the use of the term sub. Generally, the upper sub **110** generates a flame output that ignites a gas generating energetic material in the pressure sub **130**. The pressure sub **130** maintains a fluid pressure in pressure chamber that may be energized by the high-pressure gas. In some embodiments, the pressure chamber may also include a liquid, such as hydraulic oil. The lower sub **160** converts the fluid pressure into the kinetic energy used to displace the lower sub **160**. The lower sub **160** axially displaces a component of the separate wellbore device (not shown). Thus, the well tool **50** may be used to axially displace or otherwise move, shift, or load a separate wellbore device (not shown), which may be a packer, a swage, a bridge plug, etc.

[0009] The upper sub **110** includes a housing **112** that has a first chamber **114** for receiving an igniter **118**. In one non-limiting embodiment, the igniter **118** may be a pyrotechnic device that generates a flame output when detonated by a suitable signal (*e.g.,* electrical signal, hydraulic pressure, impact, etc.).

[0010] The pressure sub **130** may be formed as a piston-cylinder assembly wherein a cylinder **134** slides relative to a shaft **138** fixed to the upper sub **110**. The shaft **138** has a first end **140** that connects with the upper sub **110**, a bore **142**, and a piston assembly **144**. A power charge **146** disposed in the bore **142** may be formed of an energetic material that undergoes a deflagration when ignited by the flame output of the igniter **118**. The energy from a deflagration primarily generates a gas at sufficient pressure and with enough volume to actuate the separate well tool (not shown). Shock waves are minimal, if not nonexistent, in a deflagration. The bore **142** is sealed with a device such as an adapter **143** in the upper sub **110** such that the generated gas can only flow away from the upper sub **110**.

[0011] The cylinder **134** includes a bore **136** in which the shaft **138** is disposed. The bore **136** includes a smooth bore section **162** and the pressure dissipater **100**. The smooth bore section **162** may be defined by an inner surface **164** that is dimensionally non-varying both circumferentially and axially. That is, the inner surface **164** conforms to a diameter that does not vary over a specified axial length. Additionally, the bore **136** includes a pressure chamber **153** that generates the pressure needed to displace the cylinder **134** in a direction away from the upper sub **110.**

[0012] In one embodiment, the pressure chamber **153** may be formed using seals provided on the piston assembly **144**. For example, the piston assembly **144** may include a head **150** that is connected to a mandrel **152**. The pressure chamber **153** may be defined by one or more seals **154** positioned on the head **150** and one or more seals **155** disposed in the cylinder **134** that are positioned around the mandrel **152**. The seals **154** may be elastomeric o-rings or other similar type of seals. Gas enters the pressure chamber **153** via passages **156** formed on the mandrel **152**.

[0013] The pressure dissipater **100** dissipates fluid pressure in the pressure chamber **153** after the cylinder **134** has moved axially, or stroked, a predetermined distance. Referring to **Fig. 2,** the pressure dissipater **100** physically destabilizes the seals **154** after the seals **154** exit the smooth bore section **162**. By physically destabilized, it is meant that the body of the seals **154** are torn, ruptured, sheared, cut, shredded, or otherwise damaged to an extent that the seals **154** cannot maintain a fluid tight sealing contact with an adjacent surface. In one arrangement, the pressure dissipater **100**, which may be located at or near a terminal end **166** of the cylinder **134**, includes an enlarged diameter bore **167** along which a concave surface discontinuity **168** is formed. The enlarged diameter section **167** has a diameter greater than the diameter of the smooth bore section **162** and extends to the end of the terminal end **166**.

[0014] Referring now to **Fig. 3**, there is a cross-section shown of the pressure dissipater **100** that shows the concave surface discontinuity **168** in greater detail. In one embodiment, the concave discontinuity **168** may be a recess such as a groove, slot, or channel formed on an inner surface **172** that defines the enlarged diameter section **167**. The discontinuity **168** may be straight or curved. The concave discontinuity **168** may be longitudinally aligned and have a length that may partially or completely traverse the enlarged diameter section **167**. By longitudinally aligned, it is meant that discontinuity **168** is parallel with a longitudinal axis of the well tool **50** (**Fig. 4**), which is generally aligned with a wellbore **25** (**Fig. 4**). In other embodiments not shown, the discontinuity may be protrusion that projects from the inner surface **172**. While one discontinuity **168** is shown, two or more discontinuities may be circumferentially spaced along the inner surface **172**. Also, the surface discontinuity **168** may have rounded corners as shown or have sharp edges. The length and depth of the surface discontinuity **168** are selected to deform and damage the seals **154** sufficiently to allow high-pressure gas, and other fluids such as oil if present, to leak across the seals **154** and thereby bleed pressure from the pressure chamber **153**.

[0015] Referring to **FIG. 4,** there is shown a well construction and/or hydrocarbon production facility **20** positioned over a subterranean formation of interest **22**.The facility **20** can include known equipment and structures such as a platform **26** at the earth's surface **28**, a rig **30**, a wellhead **32**, and cased or uncased pipe/tubing **34**. A work string **36** is suspended within the wellbore **25** from the platform **26**. The work string **36** can include drill pipe, coiled tubing, wire line, slick line, or any other known conveyance means. The work string **36** can include telemetry lines or other signal/power transmission mediums that establish one-way or two-way telemetric communication from the surface to the well tool **50** connected to an end of the work string **36**. For brevity, a telemetry system having a surface controller (*e.g.,* a power source) **38** adapted to transmit electrical signals via a cable or signal transmission line **40** disposed in the work string **36** is shown. The well tool 50 may be a device activated by gas pressure and may include a pressure dissipater 100.

[0016] Referring now to **Figs. 1-4**, in one method of operation, the well tool **50** is conveyed into the wellbore **25** using the work string **36**. After being positioned as desired, a suitable signal is transmitted to detonate the igniter **118**. In one non-limiting arrangement, an electrical signal is conveyed via the cable **40**. Alternatively, a pressure increase or drop bar may be used. The igniter **118** generates a flame output that ignites the power charge **146**. The power charge **146** undergoes a deflagration that generates a high-pressure gas.

[0017] During operation, the power charge **146**, when ignited, generates a high pressure gas that flows from the shaft bore **142** via the passages **156** into the pressure chamber **153**. Because the seals **154** are intact, a relatively fluid tight seal prevents the high-pressure gas, and other gases or liquids, in the pressure chamber **153** from escaping. When the fluid pressure in the pressure chamber **153** is sufficiently high, the cylinder **134** is axially displaced in the direction shown by arrows **197** and activates the separate well tool (not shown). Initially, the seals **154** slide along the inner surface **164** of the smooth bore section **162** and the seals **155** slide along the mandrel **152**. During the time the seals **154** are in the smooth bore section **162**, the seals **154** are in a nominal sealing diameter.

[0018] Toward the end of the cylinder stroke, the seals **154** exit the smooth bore section **162** and enter the enlarged diameter section **167** of the pressure dissipater **100**. Because of the larger bore diameter, the gas pressure in the chamber **153** can diametrically expand the seals **154**. Upon expanding diametrically from the nominal sealing diameter, portions of the seals **154** flow or extrude into the surface discontinuities **168**. As the seals **154** slide axially along the enlarged diameter section **167**, the concave discontinuities **168** physically destabilizes the seals **154**. That is, it is the physical contact between the seals **154** and the concave discontinuities **168** that causes the destabilization. Upon being destabilized, the ability of the seals to maintain a seal drops dramatically. Thus, gas leaks past the seals **154** and the fluid pressure in the chamber **153** drops. When the well tool **50** is now extracted from the wellbore **25**, the pressure in the chamber **153** has bled down to dropped to a level that allows safe handling at the surface.

[0019] It should be understood that the present disclosure is susceptible to many embodiments. For instance, while a gas is described as the primary pressure source for moving the piston, a liquid may also be used. For example, a hydraulic oil may be used in a pressure chamber. Also, the movement of the piston may be modulated by metering the flow of the hydraulic oil through an orifice. In these embodiments, the hydraulic oil as well as the high pressure gas cooperate to move the piston and both are bleed from the tool after the seal is ruptured.

[0020] As used in this disclosure, the term "longitudinal" or "long" refers to a direction parallel with a bore of a tool or a wellbore. For example, the tool **100** has a longitudinal axis that is parallel with the longitudinal axis of the wellbore.

[0021] 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. Thus, it is intended that the following claims be interpreted to embrace all such modifications and changes.

What is claimed is:

1. A well tool, comprising:

an upper sub having a housing that includes a first chamber for receiving an igniter, the igniter generating a flame output when detonated;

a pressure sub having:

- a cylinder having an inner surface defining a bore, the cylinder bore having:
  - a smooth bore section defined by an inner surface that is dimensionally non-varying both circumferentially and axially, and
  - a pressure chamber that generates the pressure needed to displace the cylinder in a direction away from the upper sub, and
- a shaft disposed in the cylinder bore, the shaft having a bore, a first end connected to the upper sub, and a second end on which a piston assembly is formed, the piston assembly including at least one seal contacting the inner surface of the cylinder,
- a power charge disposed in the shaft bore, the power charge being formed of an energetic material that generates a gas when ignited by the flame output of the igniter, and
- a pressure dissipater formed at a terminal end of the cylinder, the pressure dissipater contacting and physically destabilizing the at least one seal after the at least one seal exits the smooth bore section; and

a lower sub connected to the cylinder and configured to axially displace a component of a separate wellbore device.

2. The well tool of claim 1, wherein the piston assembly includes a head that is connected to a mandrel and at least one additional seal positioned around the mandrel, wherein the at least one seal is positioned on the head, and wherein the gas enters the pressure chamber via passages formed on the mandrel.

3. The well tool of claim 1, wherein the pressure dissipater is configured to dissipate a fluid pressure in the pressure chamber after the cylinder has moved axially a predetermined distance relative to the shaft.

4. The well tool of claim 3, wherein the pressure dissipater physically destabilizes the at least one seal by at least one of: tearing, rupturing, shearing, cutting, and shredding.

5. The well tool of claim 1, wherein the pressure dissipater includes an enlarged diameter section formed adjacent to the smooth bore section, the enlarged diameter section having a diameter greater than the diameter of the smooth bore section and a concave surface discontinuity formed thereon.

6. The well tool of claim 5, wherein the concave surface discontinuity is a recess formed on an inner surface that defines the enlarged diameter section.

7. The well tool of claim 6, wherein the recess is aligned with a longitudinal axis of the well tool and at least partially traverses the enlarged diameter section.

8. The well tool of claim 7, wherein the recess is one of: a groove, a slot, and a channel.

9. The well tool of claim 7, wherein the pressure dissipater is configured to dissipate a fluid pressure in the pressure chamber after the cylinder has moved axially a predetermined distance relative to the shaft, and wherein the predetermined distance is at least a distance necessary to allow the at least one seal to slide through the smooth bore section and the enlarged diameter section.

10. An apparatus for activating a wellbore tool, comprising:

- a cylinder having a first inner surface defining a smooth bore section and a second inner surface adjacent to the first inner surface;
- a shaft having a piston section that includes at least one seal forming a fluid seal with the first inner surface when the seal is at a nominal diameter; and
- a pressure dissipater formed along the second inner surface of the cylinder, the pressure dissipater contacting and physically destabilizing the at least one seal after the at least one seal exits the smooth bore section, wherein the pressure dissipater includes an enlarged

diameter section defined by the second inner surface and a surface discontinuity formed on the second inner surface of the cylinder, wherein the enlarged diameter section has a larger diameter than the smooth bore section, and wherein the surface discontinuity is concave recess extending longitudinally along at least a portion of the enlarged diameter section.

11. The apparatus of claim 10, wherein the pressure dissipater includes a plurality of surface discontinuities circumferentially distributed on the second inner surface.

12. The apparatus of claim 10, wherein the pressure dissipater is configured to dissipate a fluid pressure in the pressure chamber after the cylinder has moved axially a predetermined distance relative to the shaft, and wherein the predetermined distance is at least a distance necessary to allow the at least one seal to slide through the smooth bore section and the enlarged diameter section.

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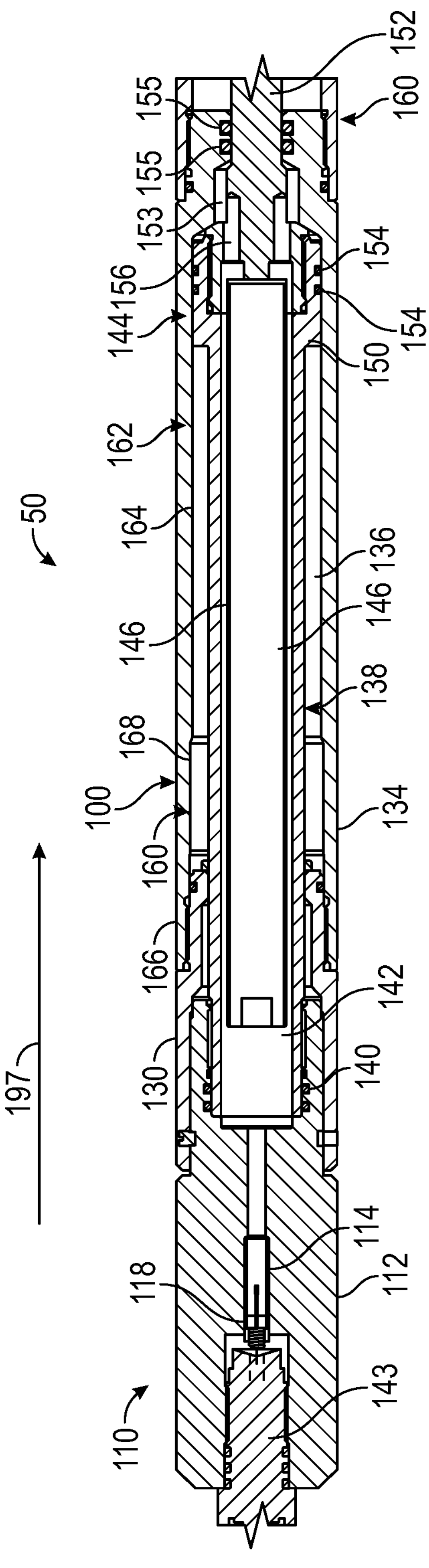
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FIG. 1

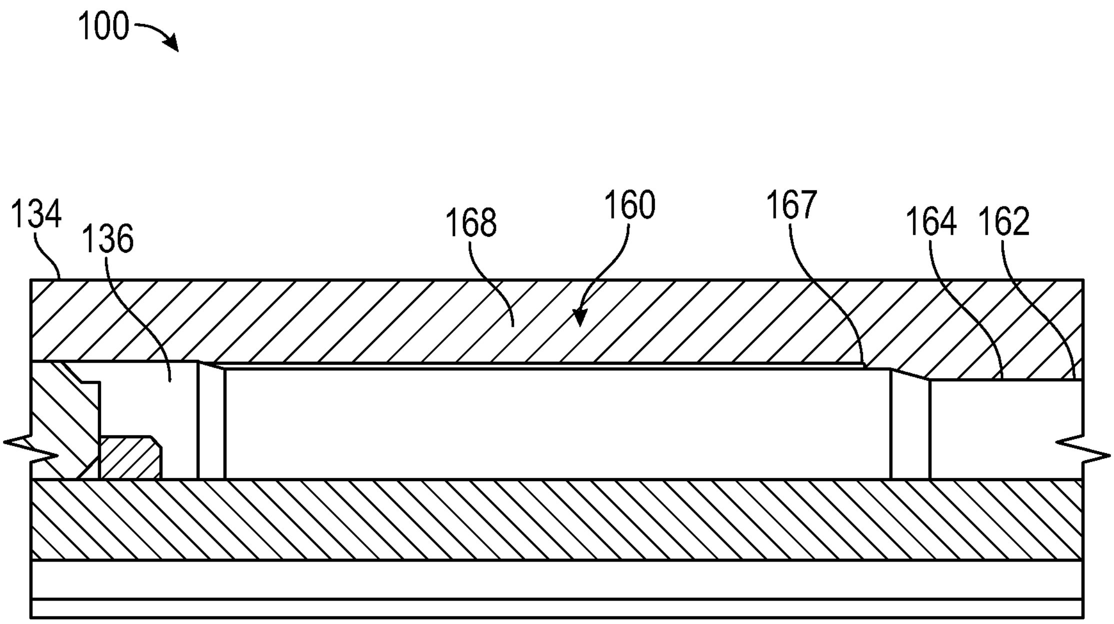


FIG. 2

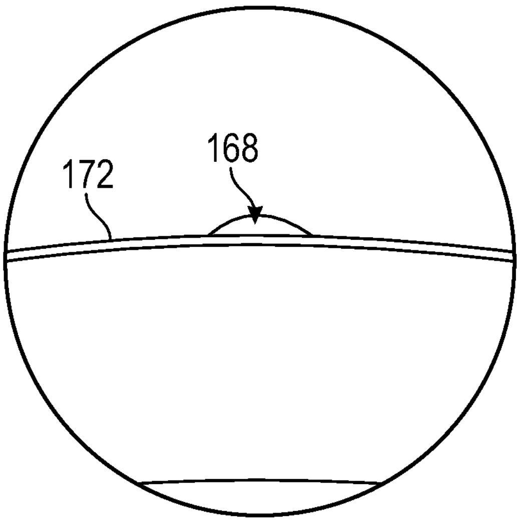


FIG. 3

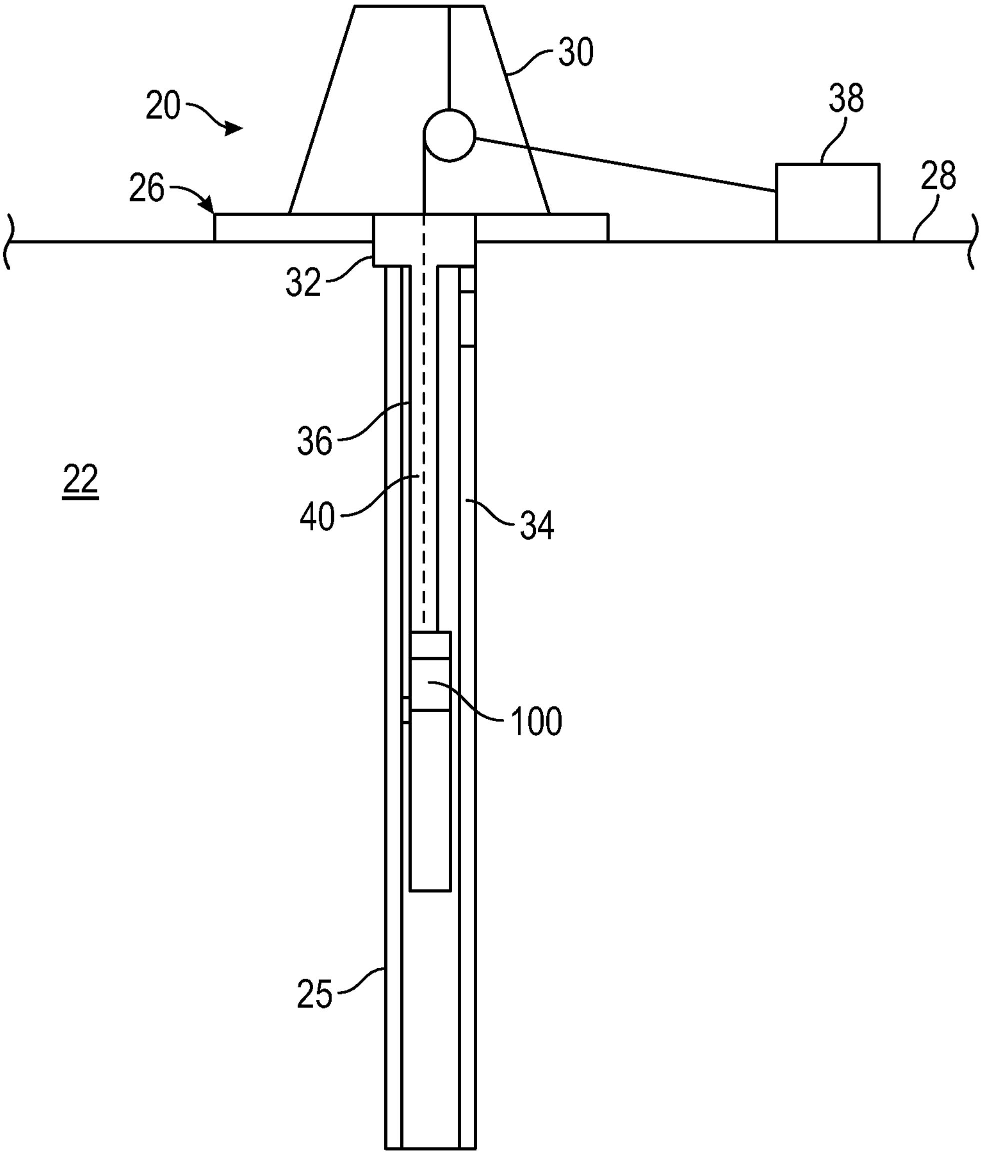
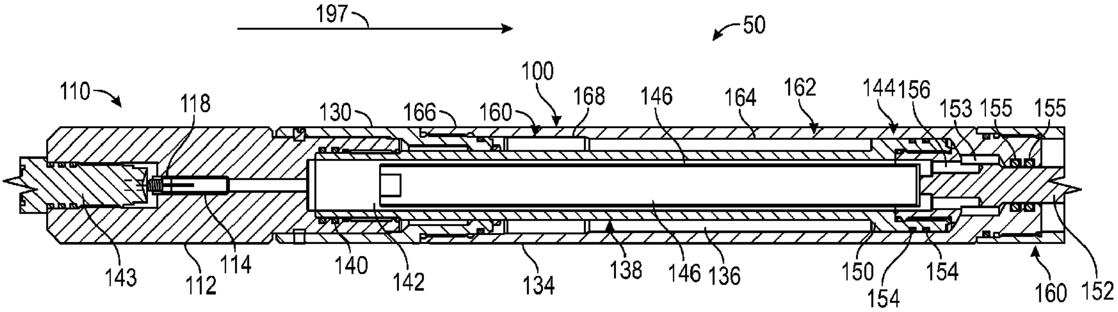


FIG. 4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