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(54) Title: SELECTIVE PLUG AND METHOD

(57) Abstract: A selective plug including a body; and an incrementing configuration in operable communication with the body capable of causing the plug to selectively pass a number of bore-hole restrictions to reach and engage a target restriction and method.

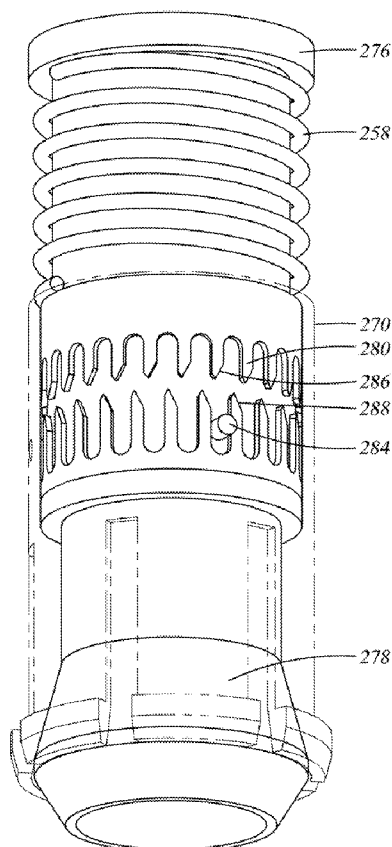


Fig. 4



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SELECTIVE PLUG AND METHOD

BACKGROUND

[0001] In the Drilling and completion industries it is often desirable to affect tools or formations at a great distance from a surface located facility such as a rig. One example of an operation intended to affect a formation is a fracturing operation. In order to perform such an operation, hydraulic pressure is built within a tubing string until the pressure exceeds formation capability for holding that pressure and fractures form in the formation. This type of operation is most effective if done in small incremental sections of a borehole for reasons related to control and distribution of fractures to serve the ultimate purpose of the borehole. Such purposes include hydrocarbon production, CO₂ sequestration, etc.

[0002] In the art, fracturing discrete locations of the borehole tends to require a number of tools that increase expense initially and generally create other issues to be overcome after the fracturing process is complete such as removal of the tools that enabled the pressuring of a discrete location. Where multiple fracturing locations are contemplated, generally a staged system must be built and administered correctly for it to work. One such system uses progressively larger seat diameters from the toe back to surface and then progressively increasing diameter balls. While the system works well, it is limited by the number of different size balls that can be used. Tolerance is required in any system and therefore limits the number of diameters that will be functional even further.

[0003] Since fracturing and other operations where discrete locations are desired to be isolated or accessed continue to become more prevalent and ubiquitous, alternate systems for accessing and manipulating the downhole environment is always well received.

SUMMARY

[0004] A selective plug including a body; and an incrementing configuration in operable communication with the body capable of causing the plug to selectively pass a number of borehole restrictions to reach and engage a target restriction.

[0005] A method for conducting borehole operations including determining where in a borehole an operation is desired; setting a selective plug; and deploying the selective plug into the borehole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Referring now to the drawings wherein like elements are numbered alike in the Figures:

[0007] Figure 1 is a schematic cross sectional view of a selective plug described herein;

[0008] Figure 2 is a schematic cross sectional view of another embodiment of a selective plug described herein;

[0009] Figure 3 is a schematic cross sectional view of yet another embodiment of a selective plug as described herein;

[0010] Figure 4 is a perspective partial phantom view of the embodiment of Figure 3; and

[0011] Figure 5 is another perspective cross sectional view of the embodiment of Figure 3.

DETAILED DESCRIPTION

[0012] Referring to Figure 1, a selective plug 10 is illustrated. The plug 10 is settable to pass through a number of restrictions (one shown as 12) in a borehole. Generally the restriction 12 will protrude radially inwardly from a casing 14 but the invention is not limited to cased boreholes but rather is usable in any borehole configuration where restrictions are employed. The plug itself comprises a body 16 sized to be able to pass through restrictions in the borehole in which the plug is intended to be employed. The body supports a seal member 18 at an outside surface 20 thereof, the seal member intended to provide a pressure tight interaction with the target restriction 12. The degree of sealing required depends upon the degree of pressure that is intended to be applied to the borehole system, the higher the intended pressure the higher the contact force of the seal member 18 with the restriction 12 and hence the more robust the pressure seal.

[0013] The body 16 further includes openings 22 (two shown but more may be disposed about the periphery of the body 16). The openings 22 allow for the through passage of rotationally secured keys 24. The keys are interactive with the restriction(s) 12 as a rotational axis 26 of each key comes into proximity with the restriction 12. As can be viewed in Figure 1, one of the keys 24 is illustrated in contact with the restriction 12. Each of the keys 24 includes a biasing arrangement 25 at the rotational axis 26 to cause the key to move to a position where

engagement with a next restriction will occur. The other side of the key is in communication with a ratchet housing 28 where a plurality of ratchet teeth 30 are positioned. The keys and the ratchet housing together form an incrementing configuration. It is to be appreciated that a number of ratchet teeth are illustrated but that in a commercial embodiment there may be many more. The number of ratchet teeth must be enough to allow incremental movement of the ratchet housing 28 through all of the restrictions that will be passed through. In one embodiment, there will be at least as many teeth as all the restrictions in a particular or a hypothetical borehole. Either way the point is that with enough teeth 30 it is possible to set the plug to pass as many restrictions as desired even if the target restriction is the deepest one in the borehole. This will be more clear when operation of the plug is discussed.

[0014] Finally, the ratchet housing 28 includes a dampener 32 comprising in one embodiment, a fluid chamber 34 and a piston 36 bifurcating the fluid chamber 34. The piston includes a flow passage 38 having a relatively restricted dimension through which fluid may pass from one end of the piston to the other end of the piston thereby moving the fluid in the fluid chamber 34 from one side of the piston to the other during operation of the plug 10. The function of the dampener 32 is to slow the reaction of the keys 24 when they rotate due to contact with a restriction 12. This causes a pressure spike uphole of the plug 10 that can be detected to verify that the plug 10 has encountered a restriction. Counting the verification events then provides confidence that when the plug does land without passing a restriction, it is the correct target restriction. It is to be appreciated that although the dampener provides for desirable functionality, it is not required for the plug to operate with respect to its primary objective, which is to selectively pass a number of restrictions and to not pass a target restriction. The plug 10 will do so whether or not a pressure spike is produced or received at a remote location.

[0015] In embodiments that do include the dampener 32 a variation of its structure allows for easier setting of the plug 10 by including a check valve 40, which provides a much greater flow area for movement of the piston 36 in a setting direction than it does for piston movement during operation of the plug 10.

[0016] Finally the plug 10 includes a selection indicator 42. An operator uses the indicator to set the plug 10 to bypass a number of restrictions that will cause the plug to set in the target restriction.

[0017] Operation of the plug illustrated in Figure 1 begins with the setting of the number of restrictions that are to be passed in a borehole. The ratchet housing 28 is moved within the body 16 to set one or more of the keys 24 in a position between two of the teeth 30. Selecting a position means that a leading end 44 of ratchet housing 28 is spaced a certain distance from an inside surface 46 of body 16. When the distance is absorbed by movement of the ratchet housing 28 pursuant to the action of keys 24 while passing restrictions 12, the ratchet housing 28 is physically prevented from moving further and hence the keys are physically prevented from rotating further. Whatever key 24 that is in contact with a target restriction 12 at this time will prevent further advancement of the plug 10 and the borehole is ready for pressurization to whatever extent has been designed into the plug 10. The distance between end 44 and surface 46 is slowly absorbed by the movement of the ratchet housing 28 because as each key 24 engages a restriction, a force is placed upon the key. Because the key is allowed to move about a rotational axis 26 the force acting on the key 24 from the restriction is transmitted through the key to rotational axis 26. The rotational axis 26 changes the direction of the force to apply it to one of the plurality of teeth 30 thereby pushing the ratchet housing 28 toward surface 46. This action continues until the angle of the key 24 has exhausted its force providing potential through rotation. As will be appreciated from the Figure, at least one other of the keys 24 is offset from the first discussed key 24. This allows the second key 24 to engage the next one of the plurality of teeth 30 when the first discussed one of the plurality of teeth is still resting on a crown of the last actuated one of the plurality of teeth. Following another rotational change in key 24 position the first key will come off the crest of the tooth it was resting on and drop into the next trough between two of the plurality of teeth 30. From this position the key is again positioned to have effect on the ratchet housing 28 at the next restriction 12. The number of keys that are being used to move the ratchet housing 28 at a given restriction can be as few as one or as many as is practicable in the space available in the body 16 depending upon desires for particular applications. The keys each return to the position where engagement with teeth and restriction is possible via the biasing arrangement 25 such as a torsion spring.

[0018] As noted above, the ratchet housing 28 is moved such that end 44 moves away from surface 46 during setting of the plug 10. In embodiments where dampener 32 is employed a specific embodiment of the dampener 32 includes the check valve 40 noted above. Due to the increased flow area that is gained through the check valve 40, an operator moving the ratchet

housing 28 for setting purposes will not have to work as hard as he or she would if the check valve were not present (which is certainly contemplated in some embodiments).

[0019] In another embodiment of a selective plug 110, referring to Figure 2, the same ultimate goal of producing a plug that will bypass a selected number of restrictions before remaining in one for some period of time is accomplished. Similar to the foregoing embodiment there are a number of restrictions 12 in a borehole that may be cased or open providing there is a mechanism for providing restrictions 12. In the embodiment of Figure 2, a body 116 includes one or more openings 122 (one shown) where in each of which is a key 124 that is articulated to the body 116 at pivot 150. The key further includes an articulated lever 152 that is configured to engage one of a plurality of teeth 130. As illustrated there are two keys 124a and 124b and two accompanying levers 152a and 152b. These are spaced axially from one another to enable the counting function of the plug 110. It is important to note that the one or more keys that are included in the plug 110 are in one embodiment arranged around the body 116. It is not intended that the reader presume that because the illustrated keys 124 are axially arranged that all of the possible keys 124 that may be incorporated in the embodiment would be axially arranged. It is also not necessarily required that there be axially spaced keys but rather that there be a mechanism to hold the spring 158 while a key that has urged the ratchet housing 128 toward the right hand side of the drawing in Figure 2 moves to a reset position, having emerged from the compression of the restriction 12. This will be further described hereunder. The body 116 further includes one or more dogs 154 that are extendible radially outwardly of the body 116 under circumstances of actuation of the plug 110.

[0020] The teeth 130 are positioned upon a ratchet housing 128. The ratchet housing further includes a one or more dog supports 156 thereon that at a particular position of the ratchet housing 128 will support the dogs 154 in a radially outwardly extended position. This position is achieved when the ratchet housing 128 is fully stroked within the body 116 by having passed through the selected number of restrictions 12. To ensure that the ratchet housing 128 moves by only one tooth increment per restriction passed, a biasing arrangement 158 is included such as a compression spring that bears against one end of the body 116 and one end of the ratchet housing 128 as illustrated. These components make up an incrementing configuration for this embodiment.

[0021] Finally, at an uphole end of the ratchet housing, a wiper 160 is disposed to enable the plug 110 to be moved through the borehole using fluid pressure applied from uphole and a selection indicator 142 to assist the operator in setting the plug 110 to bypass a desired number of restrictions.

[0022] In operation, the plug 110 is initially manually set at a surface location by an operator. The ratchet housing 128 is positioned relative to the body 116 such that a selected number of teeth 130 are required to be ratcheted through before the dog support 156 moves to support the dogs 154. The number of teeth is the same as the number of restrictions through which the plug is being set to pass before it is to hold its position to support another operation such as a fluid pressure build up uphole of the plug 110 for tool actuation or fracturing, etc. Because the biasing arrangement 158 applies a force on the ratchet housing 128 in a direction to the left in the drawing Figure 2, the lever 152 is caught in a trough of the teeth 130. The lever is hence urged by the tooth it is engaged with against the key 124a causing the key to pivot radially outwardly of the body 116. The radial dimension of the one or more keys 124 is greater than the restrictions that the plug 110 will encounter during its trip downhole. The key(s) 124 will thus land on the restrictions 12 that it/they arrive at and be urged radially inwardly by the restriction. The radially inward urging causes the lever 152a to apply a force to the tooth with which it is engaged overcoming the oppositely acting force from the biasing arrangement 158 and thereby moving the ratchet housing 128 toward end 162 of body 116. The movement is incremental but is for a sufficient distance to allow lever 152b to engage its next-in-line tooth 130 to hold the new position that the key 124a and lever 152a passing through the restriction have achieved for the ratchet housing 128. Because of the positioning of the keys 124a and 124b or the length of levers 152a and 152b, the keys 124a and 124b and 152a and 152b together act as an escapement to facilitate maintenance of the ratchet housing 128 in its incremental position. The key 124a will move radially outwardly again based upon a torsion spring disposed at pivot 150 or similar making it ready to engage the next restriction 12. The same is true for key 124b. The described sequence continues until the dog support 156 arrives at the dogs 154 and supports them. The next restriction through which the plug 110 is moved will encounter the supported dogs 154. Since the dogs 154 do not yield to the restriction 12, the plug 110 will maintain its position in the target restriction to allow whatever fluid pressure holding operation is desired.

[0023] In yet another embodiment, referring to Figures 3-5, a selective plug 210 having the same capabilities as the plugs described hereinbefore is illustrated. This embodiment includes a body 216 having a flared end 264. The flared end is in one embodiment includes ramped surfaces 266 and 268. Surface 266 assists in directing the plug 210 through a restriction by avoiding a sharp shoulder that otherwise might catch on a portion of the restriction 12 while surface 268 cooperates with a collet 270 in the operation of the plug 210 as will be further elucidated hereunder. A wiper 260 is positioned at an opposite end of the body 216 from the flared end 264.

[0024] Upon the body 216 is mounted a key 224 that is interactive with a rotator 276 in operation of the plug 210. The key 224 further provides a seat 274 for a biasing arrangement 258. The biasing arrangement will in one embodiment comprise a compression spring such as a coil spring as shown. The biasing arrangement 258 acts between the seat 274 and the collet 270, urging the two apart from one another.

[0025] The rotator 276 is disposed between the collet 270 and the body 216 and provides, in one embodiment, the selectivity in target restriction in cooperation with key 224. A selection indicator 242 is also provided for purposes identical to those described above.

[0026] Before making reference to Figures 4 and 5 to illustrate the rotator 276 and the key 224 interaction, it is helpful to understand the high level operation of the plug. The plug 210 will be set by positioning the rotator 276 relative to the key 224 and then introduced to the borehole. When the plug 210 encounters a restriction 12, the collet 270 lands on the restriction 12 and a load is transferred into the collet 270. The load provides a greater force than does the biasing arrangement 258 and so the collet moves relative to the body 216 allowing the flared end 264 of the body 216 to move through the restriction and at the same time unsupport one or more collet fingers 278. Once the fingers 278 are unsupported they will flex radially inwardly causing the outside diameter of the collet 270 at fingers 278 to become smaller than the restriction and therefore move therethrough. At each restriction this movement is possible thereby allowing the plug 210 to pass through an unlimited number of restrictions. To limit the number of restrictions through which the plug 210 will pass and thereby select a target restriction upon which the plug 210 will seat for a period of time, the rotator 276 and key 224 are included in the plug 210.

[0027] Referring now to Figures 4 and 5, understanding of the rotator 276 and key 224 and how they interact to produce an incrementing configuration will improve. In Figure 4, the

collet 270 has been illustrated in phantom to allow a viewer to see the rotator 276. Rotator 276 is, in one embodiment, configured with a J-slot 280 on an outside dimension surface thereof and a plurality of step profile teeth 282 on an inside dimension surface thereof (Fig 5). The Jslot 280 interacts with a lug 284 attached to the collet 270. Each time the collet 270 is urged against the bias of biasing arrangement 258, the lug 284 contacts an angled surface 286 of the Jslot 280 and causes the rotator 276 to rotate a small degree. Each time the collet 270 moves back toward the flared end 264, the lug will contact another angled surface 288 and the rotator will rotate another small increment. Based upon the position of the step profile 282 relative to the key 224, a selected number of restrictions 12 will be passed before the key 224 engages a step of the step profile 282 and prevents the collet 270 from cycling. Upon this condition, the next restriction encountered by the plug 210 will not be passed but the plug 210 will seat thereon and whatever operation was intended may be carried out.

[0028] Finally it is to be understood while one or more embodiments have been shown and described, modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

CLAIMS

- 1 A selective plug comprising:
a body; and
an incrementing configuration in operable communication with the body capable of causing the plug to selectively pass a number of borehole restrictions to reach and engage a target restriction.
- 2 The selective plug as claimed in claim 1 wherein the incrementing configuration comprises a ratchet housing.
- 3 The selective plug as claimed in claim 1 wherein the ratchet housing includes a plurality of teeth.
- 4 The selective plug as claimed in claim 3 wherein one or more keys mounted at the body contact one or more of the plurality of teeth at least some of the time while the plug is in use.
- 5 The selective plug as claimed in claim 1 wherein the incrementing configuration increments each time the plug passes a restriction in a borehole while the plug is in use.
- 6 The selective plug as claimed in claim 1 wherein one or more keys mounted at the body are positioned to contact a restriction encountered by the plug and transmit a force of the contact to a ratchet housing to increment the ratchet housing within the body.
- 7 The selective plug as claimed in claim 6 wherein one or more of the one or more keys includes a lever responsive to key movement to transfer force to the ratchet housing.
- 8 The selective plug as claimed in claim 4 wherein the one or more keys are biased to an operable position.
- 9 The selective plug as claimed in claim 8 wherein the one or more keys are biased by a spring.
- 10 The selective plug as claimed in claim 9 wherein the spring is a torsion spring.
- 11 The selective plug as claimed in claim 1 wherein the incrementing configuration includes a biasing arrangement.
- 12 The selective plug as claimed in claim 11 wherein the biasing arrangement is a spring
- 13 The selective plug as claimed in claim 1 wherein the incrementing configuration further includes a dampener.

14 The selective plug as claimed in claim 13 wherein the dampener comprises a fluid chamber bifurcated by a piston having a flow orifice therethrough.

15 The selective plug as claimed in claim 14 wherein the piston further includes a check valve to reduce force necessary to move the piston through the chamber in one direction.

16 The selective plug as claimed in claim 1 wherein the incrementing configuration includes a selection indicator.

17 The selective plug as claimed in claim 1 wherein the body includes a seal member positioned to interact with a restriction in a borehole to create a pressure seal.

18 The selective plug as claimed in claim 6 wherein the one or more keys are offset relative to one another in the body.

19 A method for conducting borehole operations comprising:
determining where in a borehole an operation is desired;
setting a selective plug; and
deploying the selective plug into the borehole.

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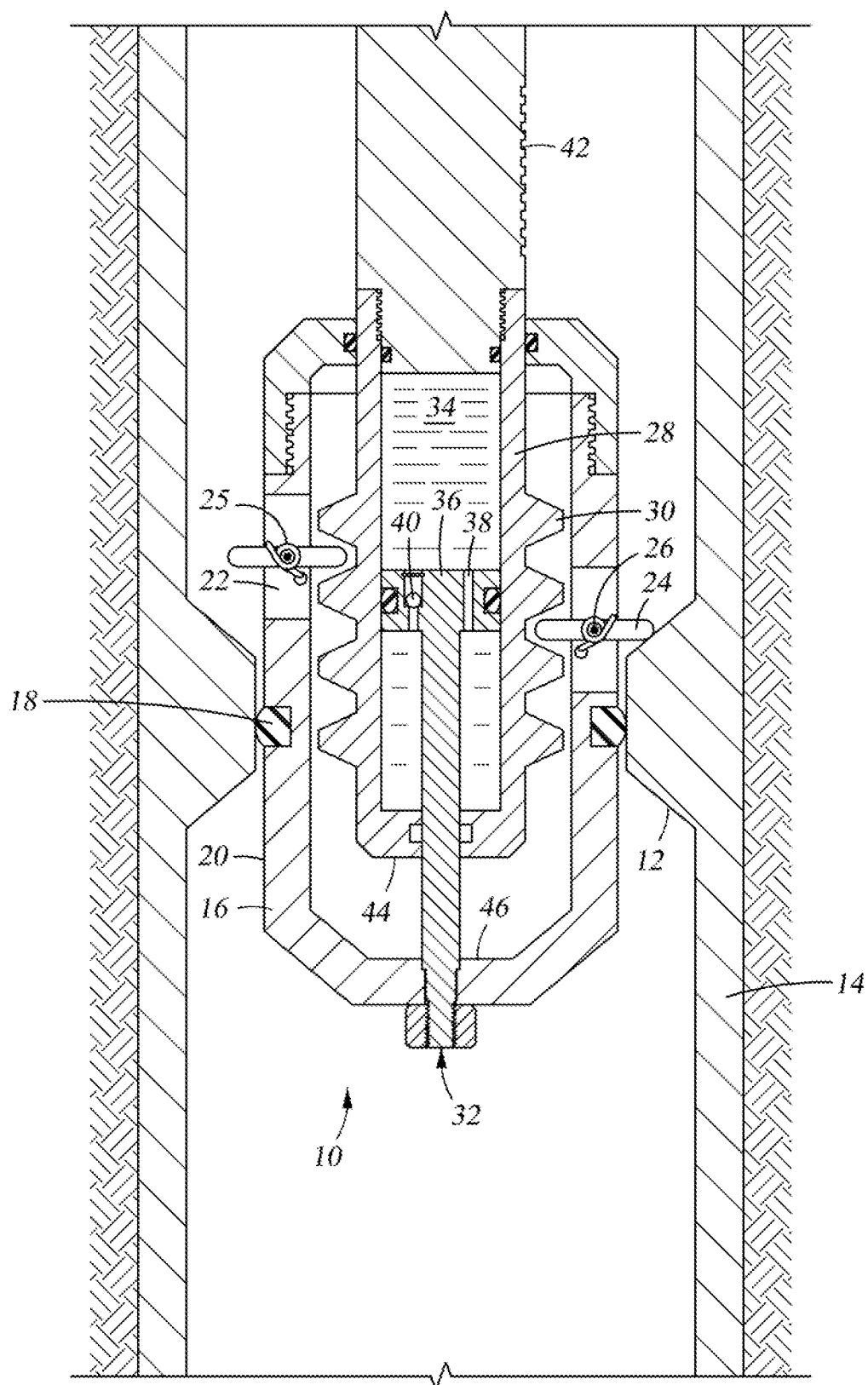
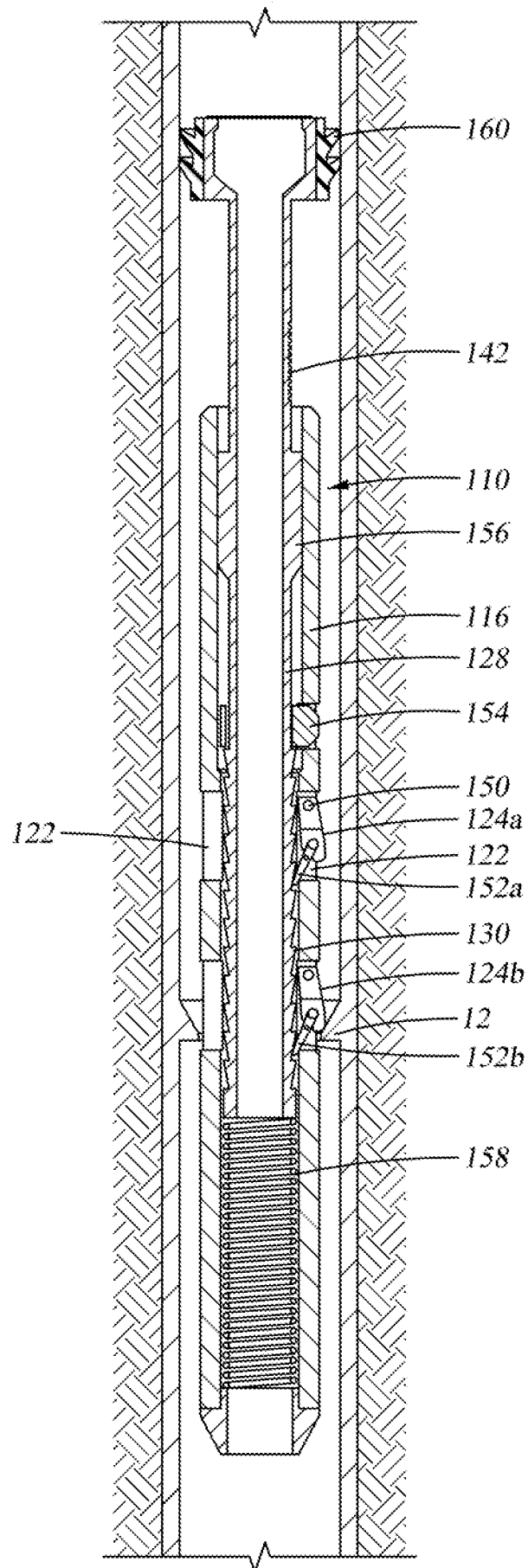


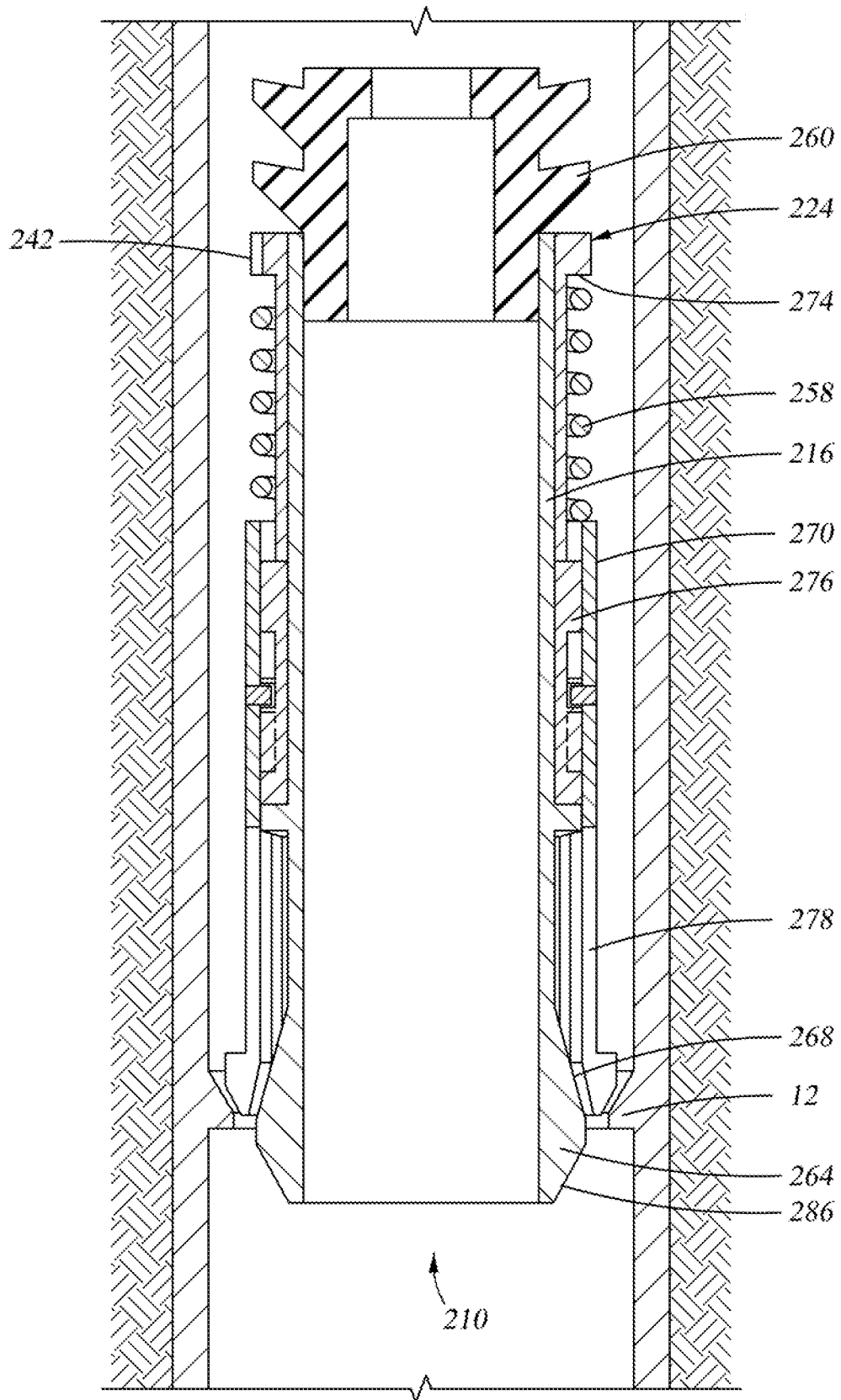
Fig. 1

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Fig. 2



3/5

*Fig. 3*

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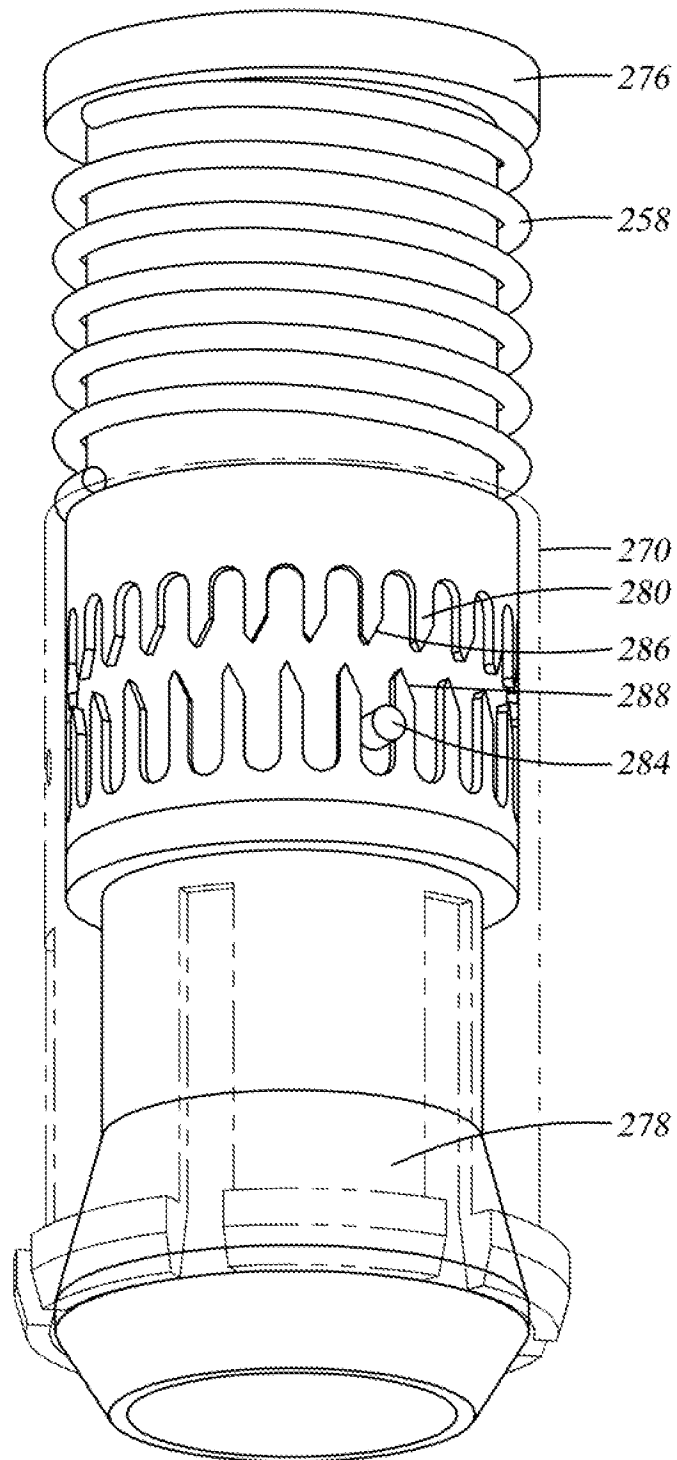


Fig. 4

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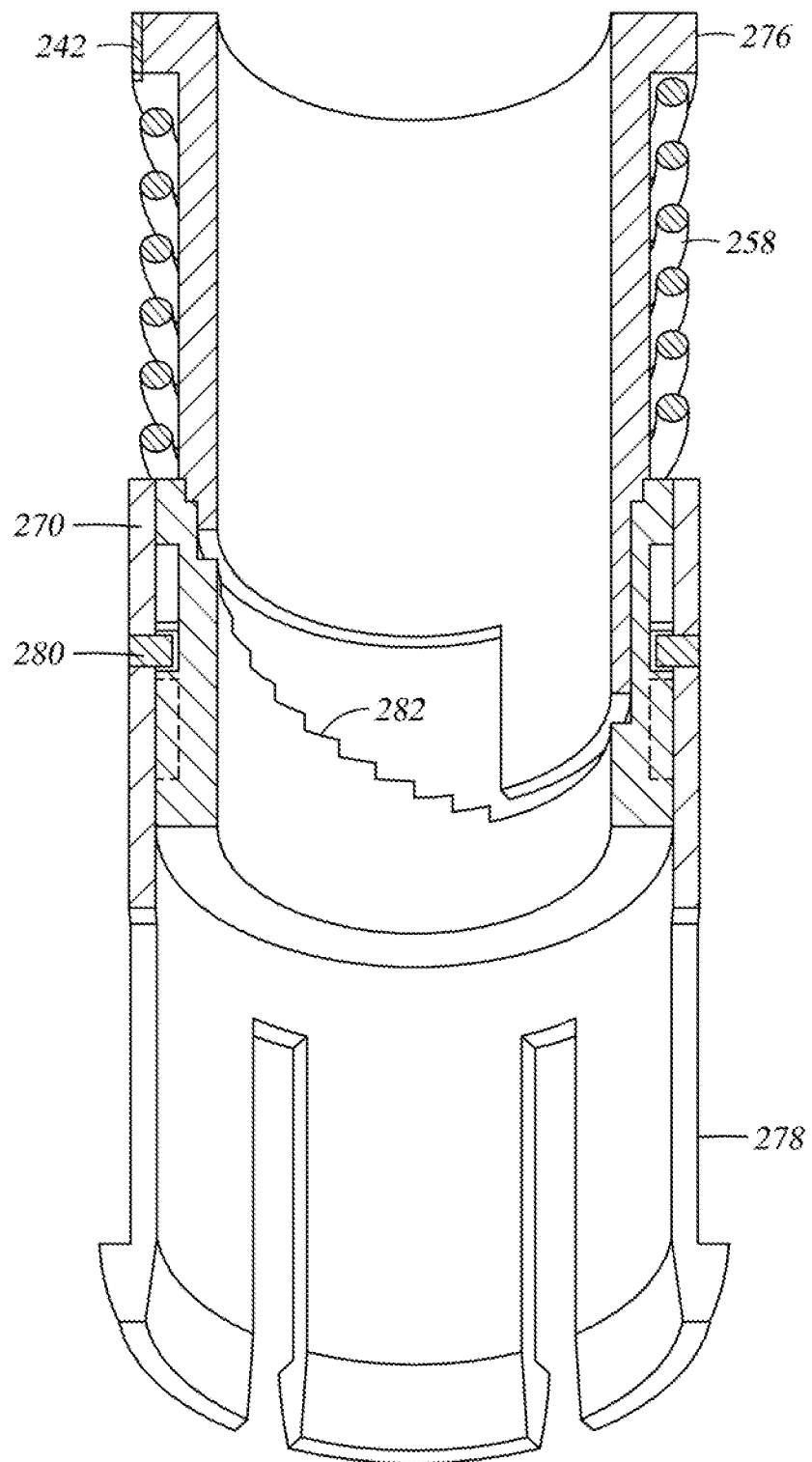


Fig. 5