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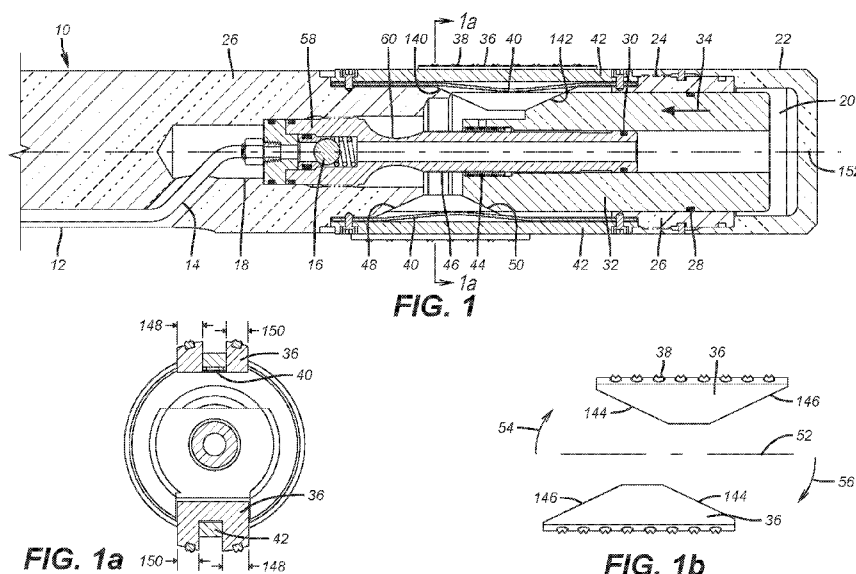
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(54) Title: HYDRAULIC WHIPSTOCK ANCHOR



(57) Abstract: A whipstock anchor is hydraulically set and locked in the set position. Release occurs with a pull induced component failure that relieves hydraulic pressure that allows the slips to retract. Release can occur with a remotely actuated circuit that burns a retainer for a piston whose movement opens a vent or initiates a chemical reaction to undermine a lock ring. Movement of a single cone or opposed cones extends the slips. The cone angles being different (cone angles do not have to be different, it is preferred to have the slip angles different) adds a skew to the slips and positions the top of the whipstock against the tubular top in a horizontal run. A bottom cap is removable to convert to setting by set down weight or to attach a hydraulically operated packer below the slips. Slips can be extended with radial movement of pistons.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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APPLICATION FOR PATENT

Title: Hydraulic Whipstock Anchor

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FIELD OF THE INVENTION

[0001] The field of the invention is hydraulic anchor assemblies for whipstocks in borehole use and more particularly anchors that release in a variety of ways, or cock the whipstock or that can be modularly built to optionally add setting capability with setting down weight or be reconfigured to add a hydraulically actuated sealing functionality to the anchor.

BACKGROUND OF THE INVENTION

[0002] Whipstocks are long tapered ramps that are secured in a tubular string to guide a mill assembly laterally to make an exit through the tubular wall for the start of a lateral bore. The taper angle is gradual, in the order of about 1-3 degrees. The ramp is typically oriented with a bottom hole assembly so that the ramp faces the direction of the desired lateral. In some instances there can be a need to have the lateral exit in a downward direction off a horizontal bore. In such cases it is advantageous to ensure that the top of the whipstock is pushed against the top of the horizontal run so that after the window in the casing has been milled a drilling assembly that will be deployed on a subsequent run will pass freely through the window in the casing without engaging the top of the whipstock.

[0003] Anchors that hydraulically extend from one side of a whipstock lower end to skew the whipstock are described in US 6843314. A design that uses a nonparallel slip face to the surrounding tubular for skewing the whipstock is described in US 8505651. Another way a whipstock is mounted off center in a surrounding tubular is to use an eccentrically mounted sealing element that is set with set down weight after an anchor is set mechanically or hydraulically is shown in US 2015/0345241. A non-releasing anchor that sets hydraulically and has the set position locked with a body lock ring is shown in US 5154231. A mechanically actuated whipstock anchor using relative movement of opposed inclined surfaces is shown in US 6360821.

[0004] What is needed and provided by the illustrated embodiments of the present invention is a hydraulic whipstock anchor that holds the set and can be released in a variety of ways. One way is to vent trapped hydraulic pressure

that holds the slips out and one way that is done is to pull tension and fail a component that lets the hydraulic pressure relieve so that the slips can retract. Another way to slip release is to remotely close a circuit that allows electrical current to heat and break a wire to release a piston whose movement opens a vent port. Alternatively release of the piston can allow fluids to pass through a port that undermine a mechanical lock ring that holds the slips extended. The slips can be wedged out radially with axial movement of a cone or by radial piston movement with the slips on the piston ends. The anchor design can be modular so that removal of an end cap allows alternative slip setting by setting down weight or the ability to add a packer component to the housing end that is actuated hydraulically with the slips. Cocking of the whipstock top end to an upper part of a horizontal run for a downward casing exit can be accomplished with ramps sloped at different angles that induce a turning moment on the slips to rotate the whipstock body. Preferably the slips will be offset along the axis of the whipstock to further increase the turning moment to rotate the whipstock body. Alternatively, the slip assembly can be mounted on an axis that skews with respect to the whipstock body to impart a turning moment to the whipstock body for desired positioning of the top end of the whipstock. These and other aspects of the present invention will be more readily apparent to those skilled in the art from a review of the description of the preferred embodiments and the associated drawings while recognizing that the full scope of the invention is to be determined from the appended claims.

SUMMARY OF THE INVENTION

[0005] A whipstock anchor is hydraulically set and locked in the set position. Release occurs with a pull induced component failure that relieves hydraulic pressure that allows the slips to retract. Release can occur with a remotely actuated circuit that burns a retainer for a piston whose movement opens a vent or initiates a chemical reaction to undermine a lock ring. Movement of a single cone or opposed cones extends the slips. The cone angles being different adds a skew to the slips and positions the top of the whipstock against the tubular top in a horizontal run. A bottom cap is removable to convert to setting by set down weight or to attach a hydraulically operated packer below the slips. Slips can be extended with radial movement of pistons.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a section view of a locking anchor design with a tensile release;

[0007] FIG. 1a is the view along line 1a-1a of FIG. 1

[0008] FIG. 1b is an enlarged view of the slips in FIG. 1 showing the taper angle difference;

[0009] FIG. 2 is a section view of an alternative embodiment showing a skew in the anchor body with respect to the whipstock axis;

[0010] FIG. 2a is the view along line 2a-2a of FIG. 2

[0011] FIG. 3 is a section view of an embodiment showing opposed cone movement for slip extension;

[0012] FIG. 3a is the view along line 3a-3a of FIG. 3;

[0013] FIG. 3b is an outside view of the slip retainer of FIG. 3;

[0014] FIG. 3c is a detailed section view of the slips in FIG. 3 showing differing opposed taper angles;

[0015] FIG. 4 is a section view of an embodiment that releases with a remote signal that allows a piston to move to release hydraulic pressure;

[0016] FIG. 4a is the view along line 4a-4a of FIG. 4;

[0017] FIG. 5 is a section view of an embodiment that moves a slip radially with a radially oriented piston and releases with a remote signal that vents hydraulic pressure;

[0018] FIG. 5a is an outside view of the slips showing a retainer for the moving slips;

[0019] FIG. 6 illustrates a modular hydraulically operated packer that can be mounted to the slip assembly;

[0020] FIG. 7 is a section view of an anchor that is releases with a remote signal that allows a piston to move to release an agent to undermine a body lock ring for anchor release;

[0021] FIG. 7a is a view along line 7a-7a of FIG. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] Referring to FIG. 1, a whipstock **10** has a ramp **12** and an associated hydraulic line **14** that typically is run behind the ramp **12** to protect the line **14** from the advancing window mill that is not shown. A check valve **16** in line **14** allows flow one way into passage **18** to chamber **20** defined by

cap 22 secured at thread 24 to housing 26. Cone 32 is sealed with seals 28 and 30 so that built up pressure in chamber 20 moves cone 32 in the direction of arrow 34 toward the housing 26. Two slips 36 are shown at 180 degree spacing although different spacing and number of slips is contemplated. The slips 36 have external carbide or hardened inserts 38 to dig into the surrounding tubular that is not shown to support the whipstock 10. A biasing spring 40 pushes between a respective slip 36 and a retainer 42 that limits the outward travel of each slip 36. A lock ring 44 is moved along ratchet profile 46 as cone 32 moves in the direction of arrow 34 to prevent reverse movement of the cone 32. The lock ring 44 in effect maintains the set of the slips 36 against the surrounding tubular that is not shown. Preferably ramp surfaces 48, 50, 140 and 142 have the same slope. Slip surface 144 has a slightly smaller slope than ramp surfaces 48, 50, 140 and 142, and slip surface 146 has a slightly greater slope than ramp surfaces 48, 50, 140 and 142 to put whipstock axis 152 into a cocked position with respect to horizontal axis 52 as schematically illustrates in FIG. 1b. In a preferred embodiment the angle difference on opposed slip surfaces 144 and 146 is a degree but larger or even smaller differences are contemplated to skew the slip orientation in opposed directions as between slips with 180 degree spacing. The desired result is a skew is imparted to the whipstock 10 to keep its upper end (not shown) against the inside diameter (ID) of a horizontal pipe for making a downwardly oriented window exit. In essence the slips hardened inserts 38 are parallel to each other but both are skewed with the whipstock axis 152 to impart a rotational moment to whipstock 10 as indicated by arrows 54 and 56. Preferably ramps surfaces 48 and 50 will be closer to the top of the whipstock than ramps surfaces 140 and 142 to provide a fulcrum effect to create a greater force to keep the top of the whipstock pushed tighter against the ID of the horizontal pipe. Preferably the sloping surfaces 144 and 146 on the slips 36 are parallel to their respective opposing ramp surfaces 48, 140, 50, and 142 on cone 32 and housing 26 however, some angular difference is also contemplated as an option. Hardened inserts 38 are imbedded into slips 36 on either side of retainer 42. Width 148 on one side of slip 36 is greater than width 150 on the other side of slip 36. Having different widths on either side of slip 36 makes it possible to use identical slips at 180 degree spacing in

housing 26 and have them installed in the proper orientation. Retainers 42 cannot be installed if slips 36 are installed in housing 26 incorrectly. Whipstock axis 152 will also be rotated if the slope of slip surfaces 144 and 146 are identical and housing ramp angle 48 is larger than ramp angle 140 and cone ramp angle 50 is smaller than ramp angle 142. Mandrel 58 has a necked down portion 60 so that when a tensile force is exerted on the whipstock 10 with slips 36 extended to the surrounding tubular the cone 32 and lock ring 44 retain the lower end of the mandrel 58 because the slips 36 bite into the surrounding tubular. The tensile force on mandrel 58 increases until a tensile failure occurs at necked down portion 60. As the mandrel 58 breaks at 60 the pressure in chamber 20 dissipates and the housing 26 has the ability to move up and away from the set slips 36 so they are no longer wedged against the surrounding tubular. The cone 32 is retained by cap 22 after the tensile failure at 60. It should be noted if the hydraulic system is filled with incompressible fluid the check valve 16 can hold the pressure against the set slips 36 using cone 32, however, the body lock ring 44 insures that the slips 36 cannot back away from the surrounding tubular after the set.

[0023] FIG. 2 is somewhat different than FIG. 1 in that a single radially moving slip 36 is used and is opposed by segment 62 with hardened or carbide inserts 64. Cone 32 is modified to have a taper only under the single slip 36 whose extension brings the inserts 64 to the surrounding tubular wall. In this version the hardened inserts 38 in slip 36 are parallel to hardened inserts 64 in segment 62, but are at a small angle with respect to whipstock axis 152 of the whipstock 10 such that extension of slip 36 until inserts 64 reach the surrounding tubular 180 degrees away will wind up pushing the top end of the whipstock against the surrounding pipe to keep it out of the way of the advancing window mill. Housing 26 is conically shaped below arrows 66 to provide clearance when the bottom of the whipstock 10 is rotated toward the tubing wall. The skew in FIG. 2 can be further enhanced with the orienting of the one slip 36 akin to the manner previously described in the discussion of FIG. 1b.

[0024] FIG. 3 is the same as FIG. 1 with the exception that there are opposed pistons that move on opposite sides of the slips 36. Mandrel 58 that was threaded to housing 26 in FIG. 1 is now slidably mounted after breaking

shear pin **68**. A lock ring **70** only allows mandrel **58** to move in the direction of arrow **72** with its final position locked in with lock ring **70**. As before cone **32** moves in an opposite direction toward slips **36** and its set position is locked with lock ring **44**. Pin **74** extends from housing **26** into slot **76** in mandrel **58** to prevent relative rotation between the two. As before release occurs with a tensile failure at decked down portion **60** in response to a tensile force on whipstock **10**.

[0025] In FIG. 4 the arrangement of the gripping is the same as FIG. 2 in that there is a slip **36** located 180 degrees opposite a segment **62** with hardened or carbide inserts **64**. As before pressure in line **14** goes through check valve **16** and against piston **80** that has a peripheral seal **82**. Spring **84** pushes piston **80** away from slip **36** until the spring force is overcome with pressure in line **14**. Piston **80** has a through bore **78** blocked by plug **86** that has a seal **88**. A battery and signal receiver **90** gets a remote signal to close a circuit which then heats a wire **92** operatively connected to retainer **94** to defeat it which constitutes the trigger so that plug **86** can move and take seal **88** past vent passage **96** to relieve the pressure above piston **80** which in essence allows spring **84** to push piston **80** away from slip **36** to allow removal of the whipstock **10** without well intervention which means avoiding sticking tools in the borehole to accomplish the task. Again in this version the hardened inserts **38** in slip **36** are parallel to hardened inserts **64** in segment **62**, but are at a small angle with respect to whipstock axis **152** of the whipstock **10** such that extension of slip **36** until inserts **64** reach the surrounding tubular 180 degrees away will wind up pushing the top end of the whipstock against the surrounding pipe to keep it out of the way of the advancing window mill. Surface **98** is stationary as the slip **36** is guided at end **100** by a rail or dovetail. In this design the line **14** pressure held by check valve **16** holds the set position of the slip **36**.

[0026] The signal can be sent without well intervention in a variety of known ways such as acoustic, electromagnetic, mud pulse or vibration. A fixed lug retrieval tool that engages the whipstock for whipstock retrieval could mechanically close a circuit that would initiate opening of the trigger. The fixed lug retrieval tool could include a magnet that activates a sensor in the whipstock. Using the fixed lug retrieval tool to initiate pressure release

could include running a wire from the whipstock to the battery. That is, a sensor is optional in the anchor. Closing the circuit to active the pressure release could be controlled from the whipstock instead of at the anchor.

[0027] FIG. 5 uses line **14** and check valve **16** to feed pressure to radially extend pistons **110** that each have hardened or carbide inserts **112**. Located 180 degrees opposite are fixed inserts **114**, that are parallel to hardened inserts **112**, but at an angle with respect to whipstock axis **152**. There are return springs **116** on each piston **110**. The release system in FIG. 5 works the same way as in FIG. 4 in response to a remote signal to vent pressure and allow return springs **116** to retract the pistons **110**. As with FIG. 4 the applied line **14** pressure trapped by the check valve **16** holds the set position. Any different amount of pistons **110** can be used and some can be articulated in a 180 degree opposed orientation. As before a retainer **42** limits the extension of the pistons when there is no surrounding tubular present.

[0028] FIG. 6 is intended to show that cap **22** of FIG. 1 can be removed at thread **24**. When that happens cone **32** can be converted to set down weight operation against hole bottom. Alternatively, a packer module **120** can be attached at thread **24** to in essence recreate chamber **20** for operation of cone **32** as in FIG. 1 but to also extend a passage for hydraulic pressure to port **122** to drive piston **124** against seal assembly **126** and against fixed surface **128** so that slips **36** can be extended as well as a seal assembly **126**. A lock ring **130** holds the set of the seal assembly **126**. As before a tensile force on the whipstock **10** creates a tensile failure at necked down portion **60** to allow release of at least the slips **36**.

[0029] FIG. 7 has a slightly different release system that acts to undermine the lock ring **44**. The layout is similar to FIG. 4 with the difference being that actuation of plug **86** by system **90** based on a remote signal moves seal **88** past passage **96** to allow fluid in chamber **130** to reach lock ring **44** and undermine it with chemical attack or an equivalent way.

[0030] Those skilled in the art will appreciate that the various design alternatives presented show a whipstock anchor that can be hydraulically set and can hold the set position with a check valve on the hydraulic line. Alternatively a lock ring can hold the set position and release occurs when a tensile force results in tensile failure of a mandrel to release the hydraulic

pressure. Alternatively a release of hydraulic pressure can be remotely actuated with release of a retained plug whose movement vents hydraulic pressure or disables or undermines a lock ring chemically. A single piston can extend a slip with movement against a fixed surface or two pistons can be pushed in opposed directions. Movable slips can be oriented in opposition to each other or a movable slip can be opposite a fixed slip with inserts. Cocking of the whipstock can be accomplished by skewing the housing for the slips with respect to a whipstock axis or skewing the slip axis relative to an aligned whipstock and anchor housing axis. The designs feature simplicity in a hydraulically set anchor for a packer with a resultant economy in manufacturing. A removable cap can be used for hydraulic operation of a piston and with the cap removed for operating the piston with set down weight. A seal module can be secured in place of the end cap to allow setting a packer with the anchor and to release the anchor and the seal assembly when necked down portion **60** is broken.

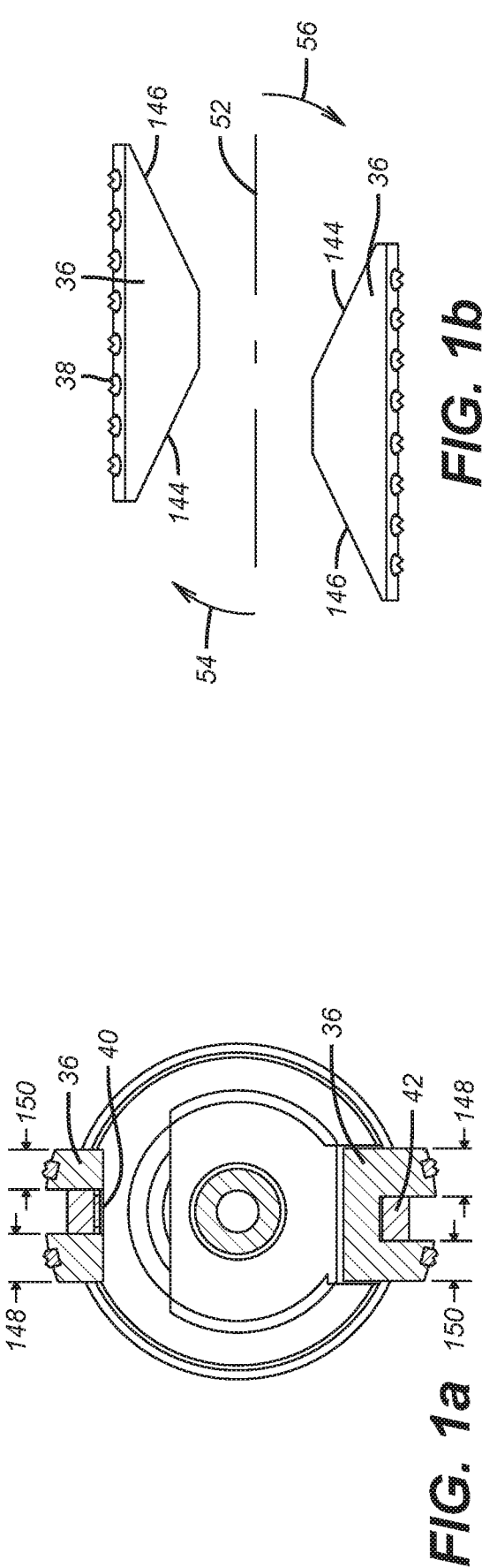
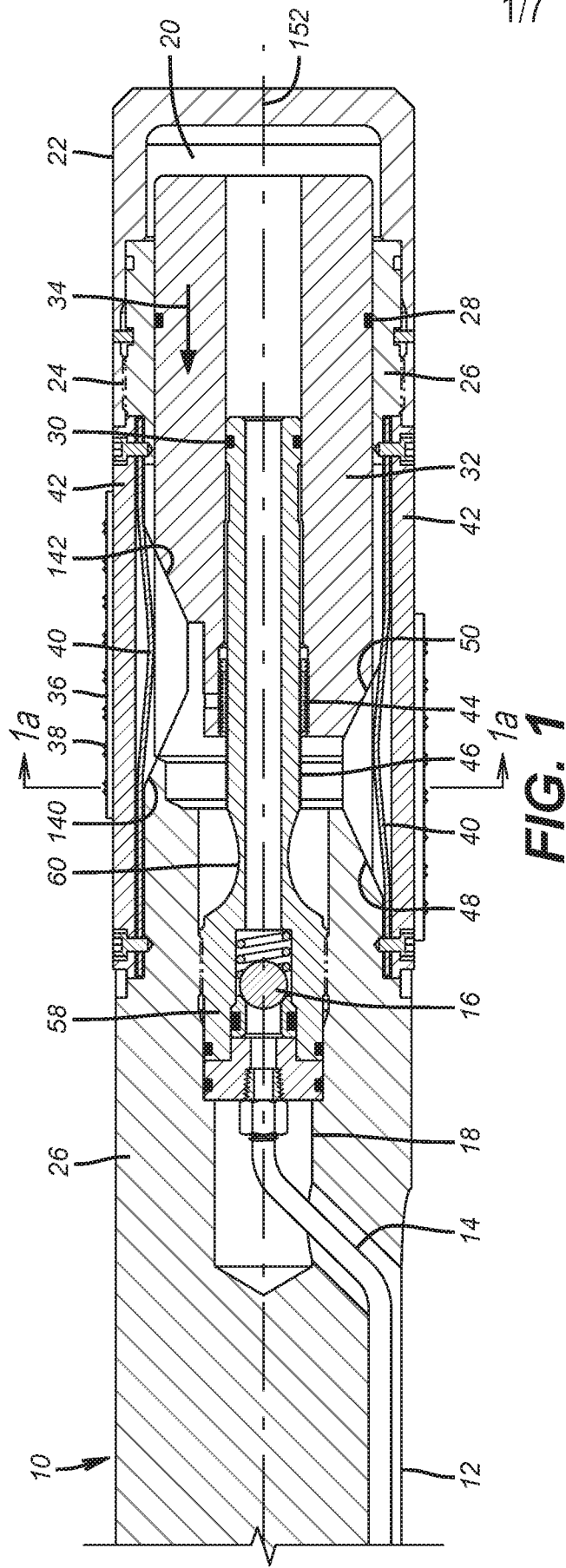
[0031] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below:

We claim:

1. An anchored borehole tool assembly, comprising:
a borehole tool (10,12);
an anchor housing (22,24,26) featuring at least one radially extendible slip (36) actuated by at least one piston (32) selectively operated by hydraulic pressure (14,16,18) provided into said housing (20); **characterized by** said housing further comprising a pressure retaining device (16) to hold said at least one slip (36) extended by holding hydraulic pressure applied to said housing (20,32,34).
2. The assembly of claim 1, wherein:
said hydraulic pressure in said housing is relieved with failure of a component (60) in said housing allowing said slip (36) to be retracted.
3. The assembly of claim 1, wherein:
said hydraulic pressure in said housing is relieved with opening a vent valve (86,88,96) in said housing allowing said slip (36) to be retracted.
4. The assembly of claim 1, wherein:
said hydraulic pressure in said housing is relieved with undermining (86,88,96 130,90) at least one locking member (44) for said at least one slip (36) in said housing allowing said slip to be retracted.
5. The assembly of claim 4, wherein:
said at least one locking member is undermined by opening a valve (86,88,96) to release a fluid to reach said at least one locking member(42).
6. The assembly of claim 5, wherein:
said valve (86,88,96) is signaled to open from a remote location without borehole intervention.
7. The assembly of claim 6, wherein:
said valve comprises a selectively retained piston (86), whereupon said remote signal a restraint on said piston (86) is removed such that piston movement opens a fluid reservoir (130) to said at least one locking member (42) to undermine said at least one locking member with said fluid.
8. The assembly of claim 1, wherein:
said at least one piston is selectively mechanically operated for extension of said at least one slip by exposing said at least one piston (32) with removal (24) of a cover (22) on said housing.

9. The assembly of claim 1, wherein:
removal of a cover (22) on said housing adapts said housing to accept a packer assembly (126) for hydraulic operation using the hydraulic pressure in said housing that operates said at least one slip (36).
10. The assembly of claim 1, wherein:
a mandrel (58) is surrounded by said at least one piston (32);
movement of said piston (32) relative to said mandrel is locked with a locking member (44) against reverse movement of said at least one piston;
said mandrel having a decreased dimension portion (60) that breaks or fails in response to a tensile force on said tool transmitted to one end of said mandrel with an opposing end of said mandrel retained by said at least one slip (36) resisting said tensile force through said at least one piston and said locking member (44);
said breaking or failing of said decreased dimension portion (60) of said mandrel allows a portion of said mandrel to move away from said at least one slip (36) for retraction of said at least one slip.
11. The assembly of claim 1, wherein:
said at least one slip comprises a plurality of pistons (32,58) disposed for movement in opposite directions toward said at least one slip (36) with each piston locked (44,70) against reverse movement away from said at least one slip.
12. The assembly of claim 1, wherein:
said tool has a first longitudinal axis (152) and said slips have a second longitudinal axis that is skewed with respect to said first longitudinal axis such that extension of said at least one slip cocks an end of said tool toward a wall of the borehole.
13. The assembly of claim 1, wherein:
said at least one slip comprises a plurality of circumferentially spaced slips (36) each of said slips having opposed end tapers (48,50) that slide on opposing ramps, wherein said tapers have the same angle with said opposing ramps at different angles or said tapers (48,50) have the different angles with said opposing tapers having the same angle such that extension of said slips cocks an end of said tool toward a wall of the borehole.

14. An anchored borehole tool assembly, comprising:
a borehole tool (10,12);
an anchor housing featuring a plurality of radially extendible slips (36) actuated by at least one piston (32) selectively operated by hydraulic pressure provided into said housing(14,16,18); **characterized by**
wherein radial extension of said slips (36) skews the axis (152) of at least said borehole tool with respect to an axis of the borehole.
15. The assembly of claim **13**, wherein:
said slips (36) having different widths on opposed sides of a retainer to insure the proper installation orientation.
16. The assembly of claim **14**, wherein:
a mandrel (58) is surrounded by said at least one piston;
movement of said piston relative to said mandrel is locked with a locking member (44) against reverse movement of said at least one piston;
said mandrel having a decreased dimension portion (60) that breaks or fails in response to a tensile force on said tool transmitted to one end of said mandrel with an opposing end of said mandrel retained by said slips resisting said tensile force through said at least one piston (36) and said locking member (44);
said breaking or failing of said decreased dimension portion of said mandrel allows a portion of said mandrel (58) to move away from said slips for retraction of said slips.
17. The assembly of claim **14**, wherein:
said tool has a first longitudinal axis and said slips have a second longitudinal axis that is skewed with respect to said first longitudinal axis such that extension of said slips cocks an end of said tool toward a wall of the borehole.
18. The assembly of claim **14**, wherein:
said slips are circumferentially spaced such that each of said slips comprises opposed end tapers that slide on opposing ramps, wherein said tapers have the same angle with said opposing ramps (48,50) at different angles or said tapers have the different angles with said opposing tapers having the same angle such that extension of said slips cocks an end of said tool toward a wall of the borehole.



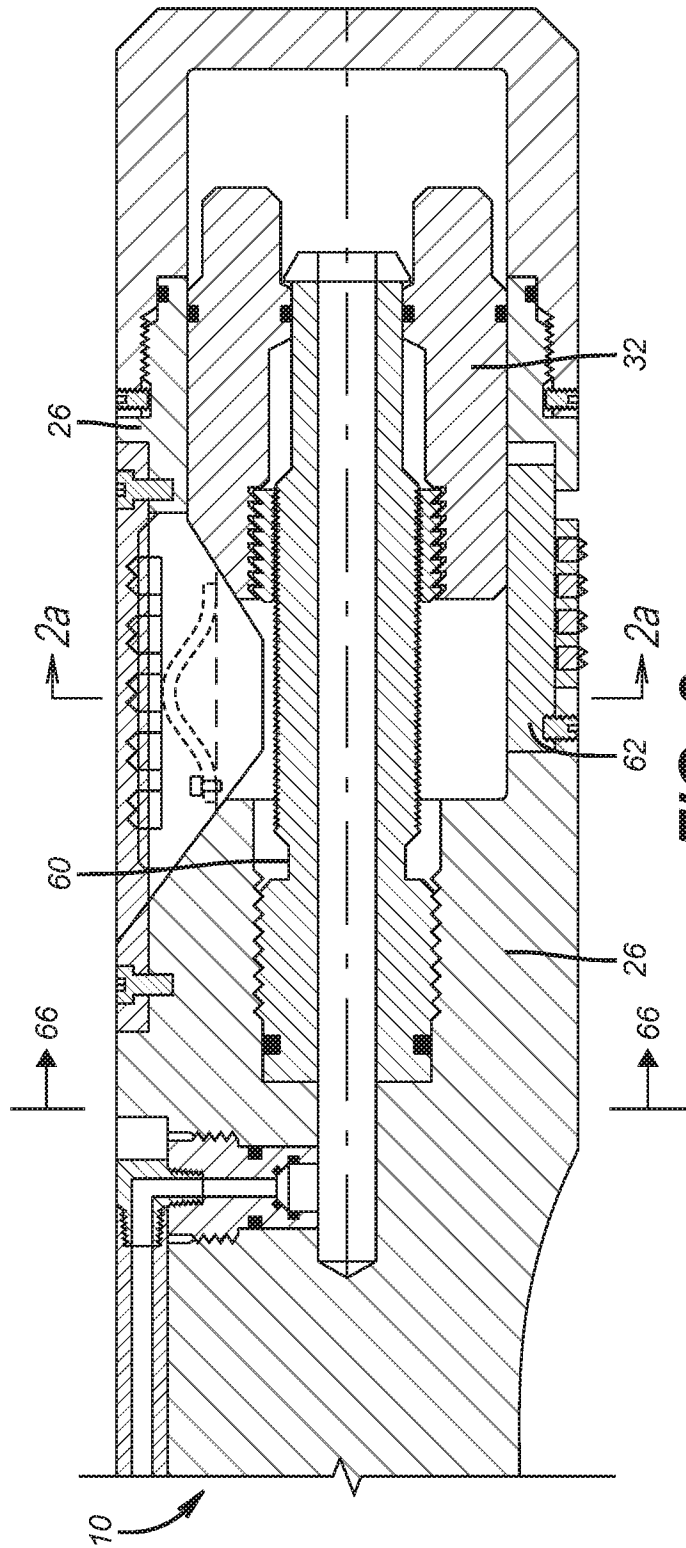


FIG. 2

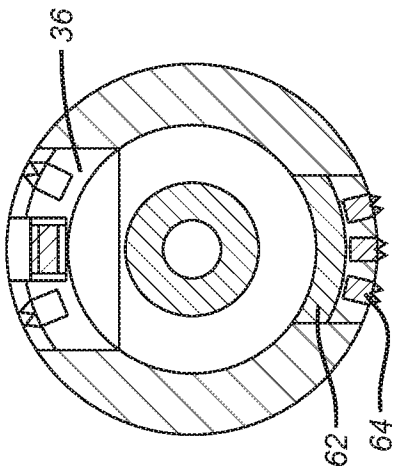
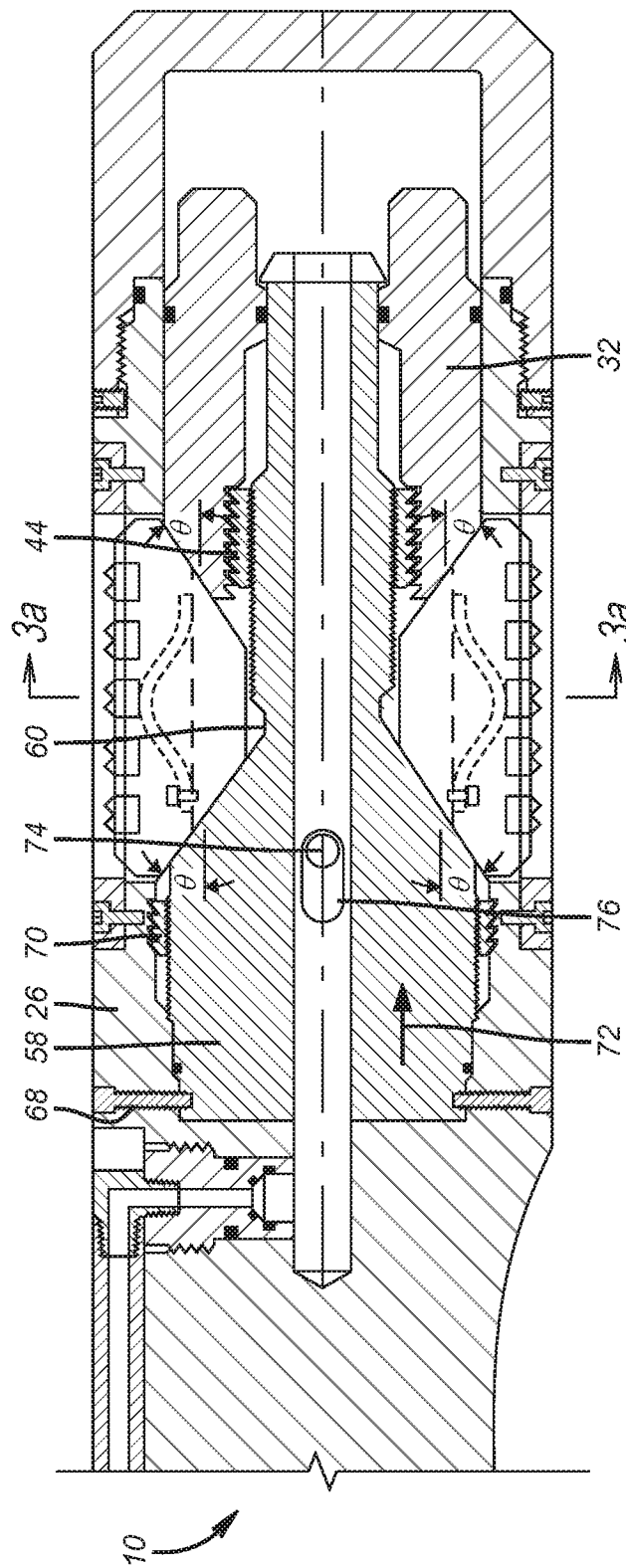


FIG. 2a



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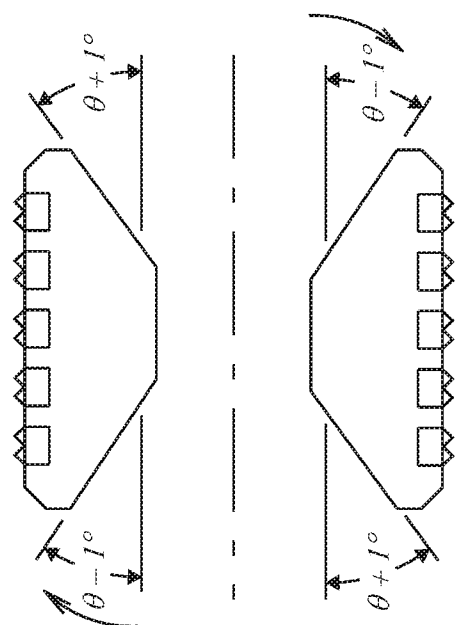


FIG. 3C

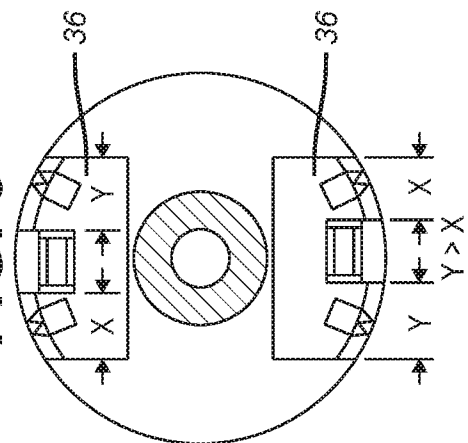


FIG. 3a

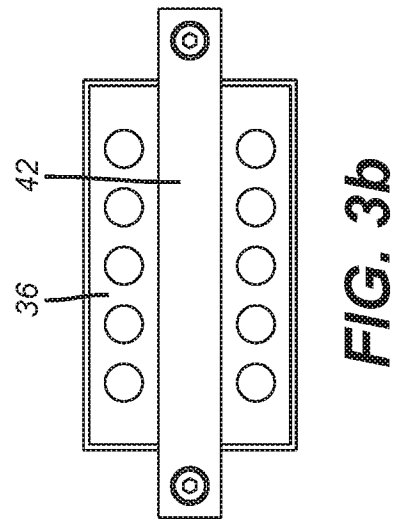


FIG. 3b

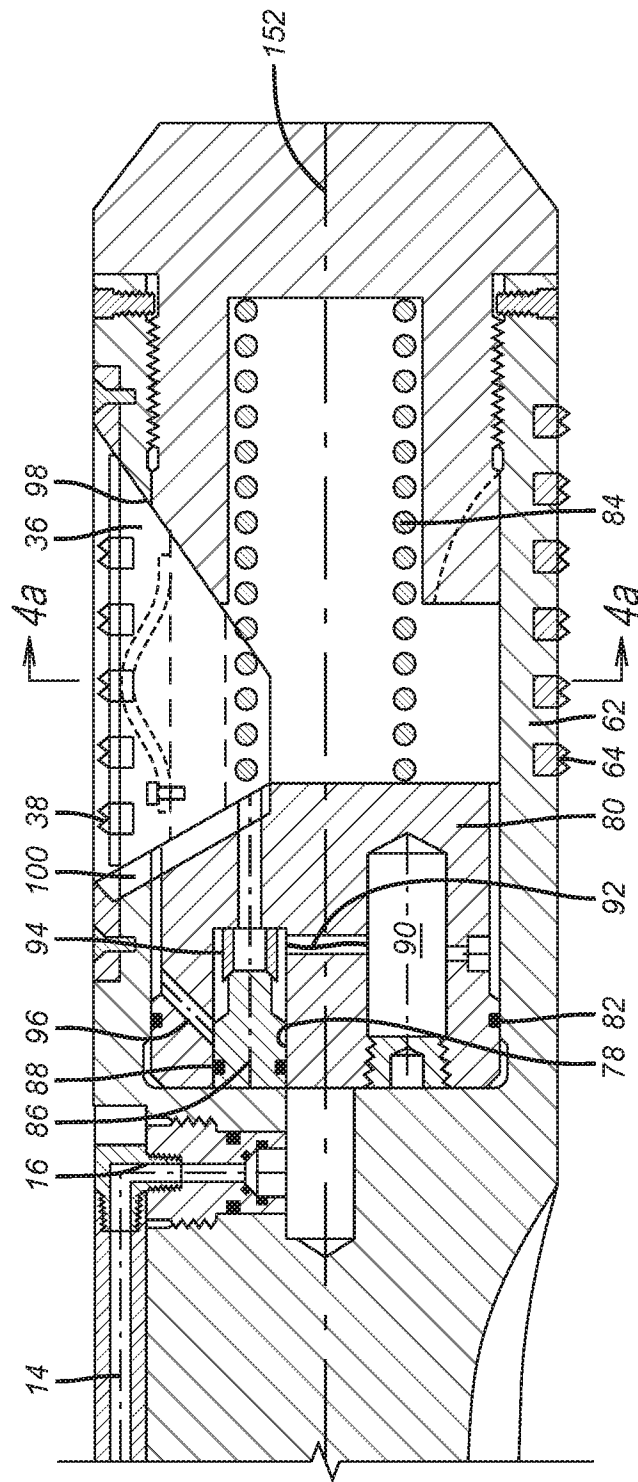


FIG. 4

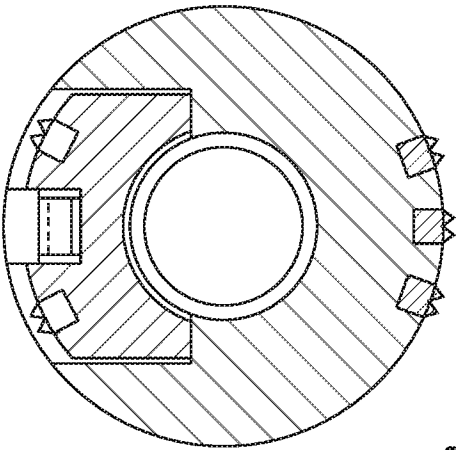
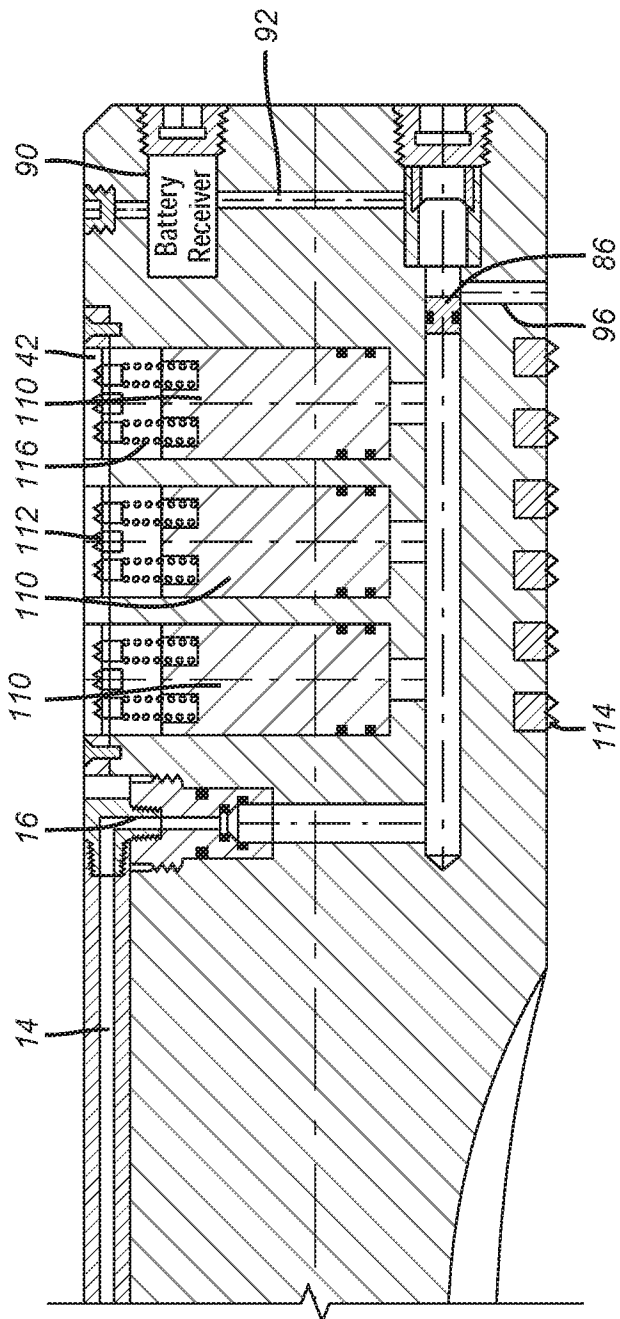


FIG. 4a



5. **FIG. 4**

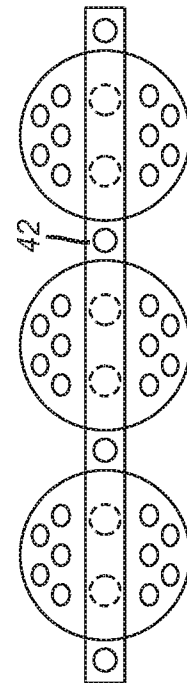


FIG. 5a

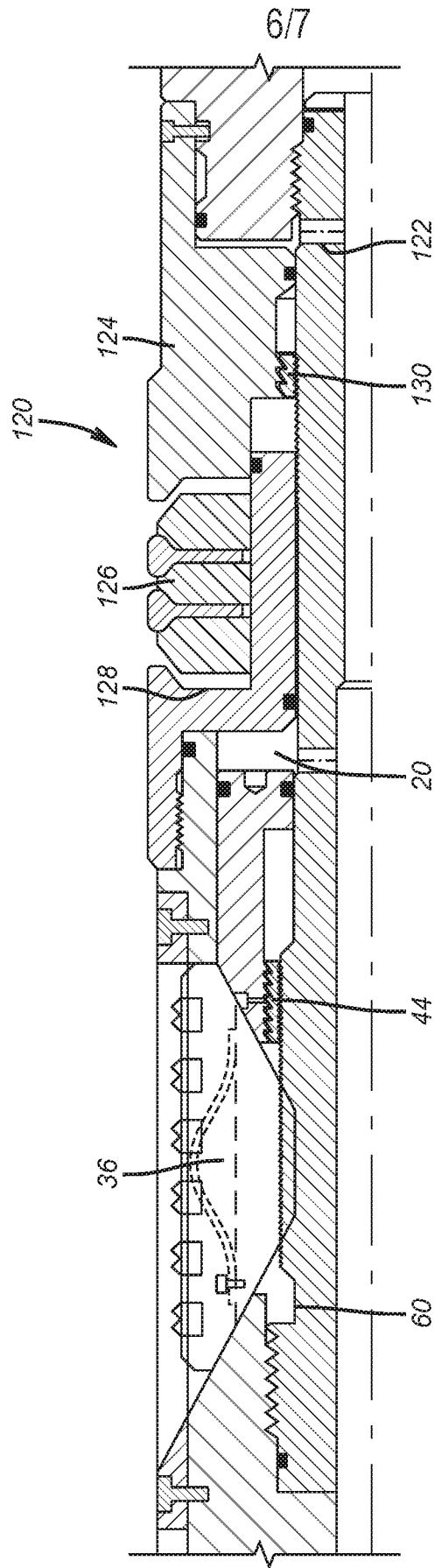


FIG. 6

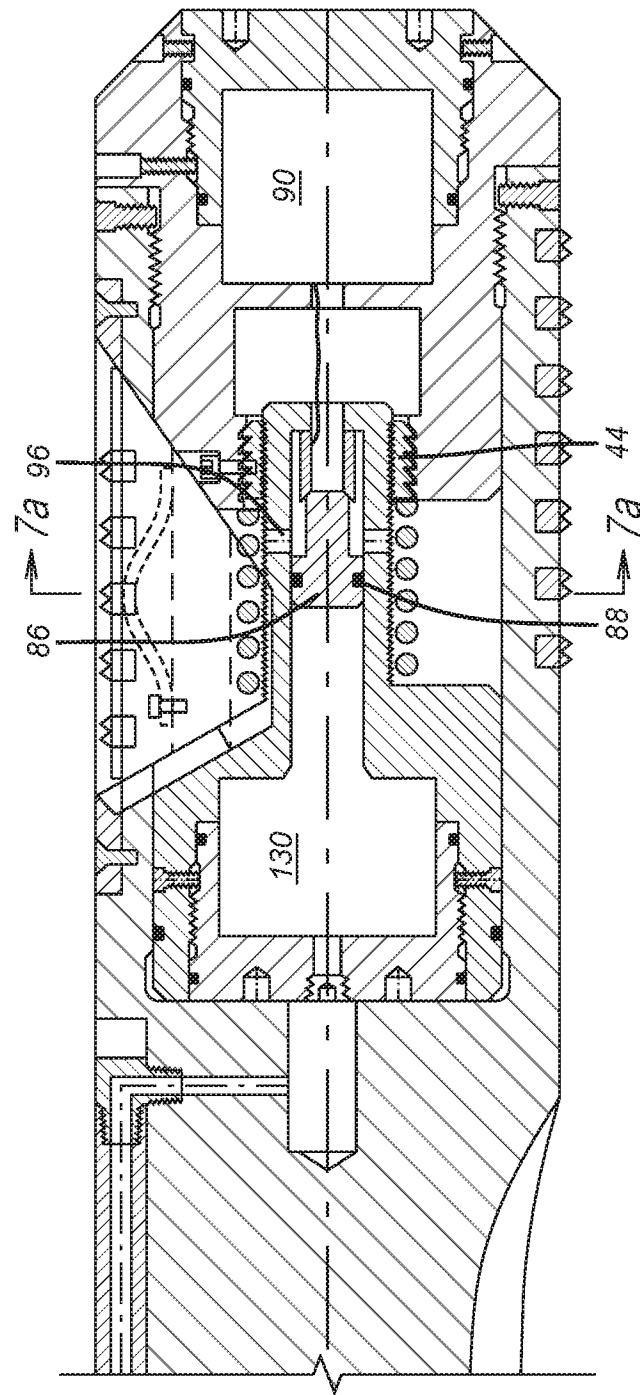


FIG. 7

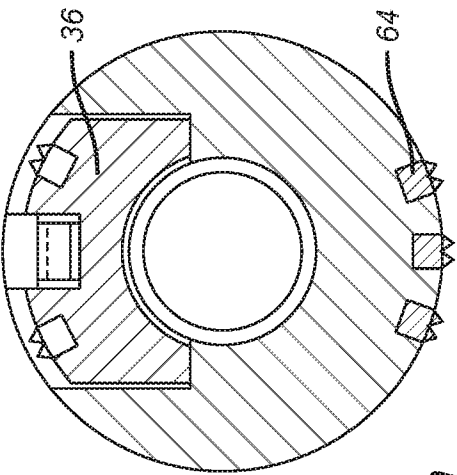


FIG. 7a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/029405**A. CLASSIFICATION OF SUBJECT MATTER****E21B 23/01(2006.01)i, E21B 23/04(2006.01)i, E21B 7/06(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 23/01; F21B 23/06; E21B 19/10; E21B 29/06; E21B 7/08; E21B 23/12; E21B 7/06; E21B 43/11; E21B 23/04

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: whipstock, anchor, slip, piston, vent valve, locking, cover, undermining, failure, mandrel, tensile force, skew, cock, taper, ramp

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2013-0299160 A1 (LOTT, CHARLES) 14 November 2013 See paragraphs [0033], [0040]-[0042] and figures 1, 2E-3C, 8A.	1-3, 8, 9, 11, 12, 14, 17 4-7, 10, 13, 15, 16, 18
Y	US 2003-0183388 A1 (TOULOUSE et al.) 02 October 2003 See paragraphs [0022], [0023] and figure 3.	1-3, 8, 9, 11, 12
Y	US 2007-0175629 A1 (HARRIS, ROBERT D.) 02 August 2007 See paragraphs [0015], [0016] and figure 3.	12, 14, 17
A	US 4530398 A (GREENLEE et al.) 23 July 1985 See claims 1-5 and figures 2a-2e.	1-18
A	US 5427179 A (BAILEY et al.) 27 June 1995 See column 3, line 6 - column 4, line 3 and figure 3.	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 July 2017 (26.07.2017)

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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.

PCT/US2017/029405

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