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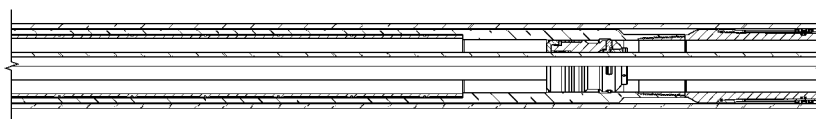
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(71) Applicant: **BAKER HUGHES INCORPORATED**
[US/US]; P.O. Box 4740, Houston, TX 77210 (US).(72) Inventors: **MORENO, Mario**; 31545 Ember Trail Ln., Spring, TX 77386 (US). **FRASER, James, M.**; 34 Deerfern Pl., Spring, TX 77381 (US). **SMITH, Sidney, K., Jr.**; 1406 Axelridge, Conroe, TX 77384 (US). **PALMIERI, Abbie, J.**; 2735 Cohn St., Houston, TX 77007 (US). **EWING, Daniel, C.**; 3510 Cinco Lakes Dr., Katy, TX 77450 (US). **KRUGER, Matthew, J.**; 26503 Border St., Spring, TX 77373 (US). **HALFMAN, Eric**; 21903 Romero Lane, Magnolia, TX 77355 (US). **ADAMS, Jarandon, J.**; 7935 Astley Lane, Spring, TX 77379 (US).(74) Agent: **CHANDLER, Kimberly, L.**; Intellectual Property Counsel, Baker Hughes Incorporated, P.O. Box 4740, Houston, TX 77210-4740 (US).(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: ONE TRIP INTERVENTIONLESS LINER HANGER AND PACKER SETTING APPARATUS AND METHOD

**FIG. 2c**

(57) Abstract: A liner hanger and packer are set at different times in a single trip without, intervention. The running tool has a ball seat that accepts a ball for pressuring up which results in movement of a mandrel with a magnet mounted to it past a valve triggered by the magnetic field. Potential energy is released to set the liner hanger. Further mandrel movement then releases the running tool once the liner is supported by the hanger. After a cement job that starts with confirmation of release of the running tool, the same magnet is moved past another valve adjacent the liner top packer. Another valve is triggered open to release potential energy and move parts that set the packer. The running tool is removed from the liner and brought to the surface. A continuous Movements of the running tool components in a single trip without well intervention accomplish the settings.



ONE TRIP INTERVENTIONLESS LINER HANGER AND PACKER SETTING APPARATUS AND METHOD

Inventors: Mario Moreno; James M. Fraser; Sydney K. Smith Jr.; Abbie J. Palmieri; Daniel C. Ewing; Matthew J. Kruger; Eric Halfmann and Jarandon J. Adams

FIELD OF THE INVENTION

[0001] The field of the invention is actuators and actuation methods for operating a subterranean tool and more particularly actuation of a tool disposed about a tubular without a wall opening in the tubular using potential energy in the actuator.

BACKGROUND OF THE INVENTION

[0002] Many operations in a subterranean borehole involve the setting of tools that are mounted outside of a tubular string. A common example is a packer or slips that can be used to seal an annular space or/and support a tubular string from another. Prior mechanical actuation techniques for such devices, which used applied or hydrostatic pressure to actuate a piston to drive slips up cones and compress sealing elements into a sealing position, involved openings in the tubular wall. These openings are considered potential leak paths that reduce reliability and are not desirable.

[0003] Alternative techniques were developed that accomplished the task of tool actuation without wall openings. These devices used annular fluid that was selectively admitted into the actuator tool housing and as a result of such fluid entry a reaction ensued that created pressure in the actuator housing to operate the tool. In one version the admission of water into a portion of the actuator allowed a material to be reacted to create hydrogen gas which was then used to drive a piston to set a tool such as a packer. Some examples of such tools that operate with the gas generation principle are U.S. Pat. No. 7,591,319 and US Publications 2007/0089911 and 2009/0038802.

[0004] These devices that had to generate pressure downhole were complicated and expensive. In some instances the available space was restricted for such devices limiting their feasibility. US 8813857 shows an actuator that goes in the hole with stored potential energy that employs a variety of signaling techniques from the surface to actuate the tool and release the setting pressure/force. The preferred potential energy source is compressed

gas. This design incorporated a magnet dropped or pumped into the borehole that communicated with a valve to initialize the pressure generation step to actuate the tool due to valve operation. This design required multiple deliveries of wiper plugs with magnets for actuation of more than a single tool. In the case of a liner hanger and liner top packer that is to be set after a cement job with the liner hanger already set, the design in this reference would require multiple darts which creates some uncertainty that the darts would reach their destination and actuate the respective tools. The present invention delivers multiple tools that need to be set at different times with a running tool that contains the trigger for actuation so that in a single trip multiple tools can be set in one trip into the hole at different times without wall openings in the tubular. Those skilled in the art will further understand the invention from a review of the description of the preferred embodiment and the associated drawings while further appreciating that the full scope of the invention is to be determined by the appended claims.

SUMMARY OF THE INVENTION

[0005] A liner hanger and packer are set at different times in a single trip without intervention. The running tool has a ball seat that accepts a ball for pressuring up which results in movement of a mandrel with a magnet mounted to it past a valve triggered by the magnetic field. Potential energy is released to set the liner hanger. Further mandrel movement then releases the running tool once the liner is supported by the hanger. After a cement job that starts with confirmation of release of the running tool, the same magnet is moved past another valve adjacent the liner top packer. Another valve is triggered open to release potential energy and move parts that set the packer. The running tool is removed from the liner and brought to the surface. A continuous Movements of the running tool components in a single trip without well intervention accomplish the settings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIGS. 1a-1g show the liner supported by a running tool in the run in position;

[0007] FIGS. 2a-2g show the liner hanger set;

[0008] FIGS. 3a-3g show the running tool released;

[0009] FIGS. 4a-4g show the wiper plugs released depicting the condition at the end of cementing;

[0010] FIGS. 5a-5g show the setting of the liner packer with further movement of the running tool.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Referring to FIGS. 1a-1g a liner 10 has no wall penetrations and is supported by a running tool 12 at dogs 14 that extend into grooves 16 in the liner 10. The running tool 12 has a mandrel 18 and telescoping components 20 and 22 near a lower end thereof. Component 22 has a seat 24 that accepts a ball 26 as shown in FIG. 2f. Pressure on seat ball 26 extends component 22 out from component 20 with the result that a magnet 28 moves past a sensor package 30 that is activated by the field moving past it as a result of axial movement of magnet 28. The result of getting a signal allows the package 30 to open a valve (not shown) to the annulus pressure. A piston assembly 36 defines low pressure chambers 32 and 34 such that on opening of the valve that is not shown a net uphole force is created on the piston assembly 36 to drive slips 38 up a ramp 40 and into the wall of the surrounding tubular 42.

[0012] At this point a larger ball 44 is dropped onto a seat 46 in the running tool 12 as shown in FIG. 3b. Pressure is applied to shift a sleeve to release the dogs 14 out of the grooves 16 so that the running tool 12 is released from the surrounding tubular 42. The actuation of the slips 38 into the surrounding tubular 42 now supports the liner 10. The running tool 12 can now be picked up to ensure that it has fully released from the liner 10 before cement is delivered in a known manner and the leading and trailing wiper plugs 48 are released to push the cement into an annular space that is not shown that surrounds the liner 10 in the borehole also in a known manner as shown in FIG. 4g. It should be noted that balls 26 and 44 get blown out through their respective seats into a ball catcher 50.

[0013] After the cementing is completed and it is time to set the packer 54 the magnet 28 is picked up with the running tool 12 as shown in FIG. 5d-e so that a sensor package 52 identical to the sensor package 30 is triggered to open a second valve that is not shown. Here again a net force results on a piston assembly 56 that defines chambers 58 and 60 initially at low pressure. As before with setting the hanger slips 38 the opening of the second valve puts an

unbalanced force on the piston assembly 56 that breaks shear pins and releases dogs that allow movement of the piston assembly 56 in an uphole direction to compress the packer 54 into a sealing position against the surrounding tubular 42. At this point the running tool can be pulled out of the hole.

[0014] Those skilled in the art will now appreciate that the present invention associates a signal device with the running tool and allows an initial movement to set a first tool, which in the preferred embodiment is a liner hanger. Subsequent movements of the running tool in the same trip then sets another tool, which in the preferred embodiment is a liner top packer. While the source of potential energy is described as using hydrostatic pressure or applied pressure on top of hydrostatic in the surrounding annulus, other pressure sources can be deployed for piston movement. For example, a reaction that generates gas as a result of valve opening can be the source of potential energy to set one or more pistons to operate tools in sequence. It should be noted that the liner has no wall openings that can present potential leak paths. While a magnetic field is preferred in the described embodiment, other triggering signals are contemplated such as vibratory, acoustic or mud pulses to name a few. The invention allows in a single trip the setting of multiple tools with a single triggering source that is sequentially brought into proximity with signal receivers to trigger a movement that applies force to a piston to set multiple tools sequentially without wellbore intervention. In the preferred embodiment the triggering source is on a running tool for the tools ultimately set with the movement of the running tool that eventually comes out of the hole.

[0015] 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. A method of operating multiple tools at a subterranean location, comprising:

running in, to a predetermined subterranean location, a tubular string (10) on a running tool (12), said running tool connected adjacent a lower end of a running string; **characterized by**

mounting the multiple tools (38, 54) and actuators therefor (36,56) exterior to said tubular string for said running in;

mounting a triggering device (28) on said running tool for said running in;

sequentially setting said multiple tools (38,54) with said triggering device;

releasing from said tubular string (10) and removing said running tool (12) and running string from the subterranean location.

2. The method of claim 1, comprising:

moving said triggering device (28) with respect to said tubular string (10) to actuate a first of said tools.

3. The method of claim 2, comprising:

continuing to support said tubular string with said running tool when actuating said first of said tools.

4. The method of claim 3, comprising:

mounting said triggering device on a telescoping component (20,22) of said running tool.

5. The method of claim 4, comprising:

moving said triggering device (28) longitudinally with applied pressure to said telescoping component.

6. The method of claim 5, comprising:

landing an object (26) on a seat (24) to allow pressure buildup to move said telescoping component (20,22).

7. The method of claim 6, comprising:

selectively blocking a passage in said running tool;

building pressure in said running tool to release said running tool (12) from said tubular string (10) when said tubular string is supported due to setting of said first tool (38).

8. The method of claim 1, comprising:
moving said running tool (12) with said running string after setting a first of said tools (38) and after said releasing from said tubular string (10) to set a second of said tools (54).
9. The method of claim 8, comprising:
setting said first (38) and second (54) tools with discrete longitudinal movements of said triggering device (30,52).
10. The method of claim 9, comprising:
mounting said triggering device on a telescoping component (20,22) of said running tool.
11. The method of claim 10, comprising:
moving said telescoping component relative to said tubular string (10) to set a first said tool with internal pressure in said running tool (12).
12. The method of claim 11, comprising:
making said first of said tools a hanger (38) for said tubular string.
13. The method of claim 12, comprising:
making a second of said tools a packer (54) for said tubular string.
14. The method of claim 13, comprising:
using a magnet (28) as said triggering device.
15. The method of claim 1, comprising:
employing a magnet (28) as said triggering device.
16. The method of claim 1, comprising:
employing hydrostatic pressure (32,34) available at the subterranean location to selectively drive discrete pistons (36,56) that comprise said actuators to set a first (38) and second (54) of said multiple tools.
17. The method of claim 16, comprising:
employing said triggering device (28) to open a valve such that hydrostatic pressure is allowed to act on said pistons (36,56) against an opposing lower pressure force (32,38,54,60) to drive said pistons sequentially in setting said first and second tools.
18. The method of claim 17, comprising:
providing a hanger (38) and a packer (54) as said first and second tools.

19. The method of claim 1, comprising:
communicating a setting signal for setting said multiple tools through a wall of said tubular string that lacks penetrations.
20. The method of claim 7, comprising:
dropping a second object (44) on a second seat (46) in said running tool for said selectively blocking;
blowing out said object and said second object into a catcher (50) at a lower end of said tubular string (10).

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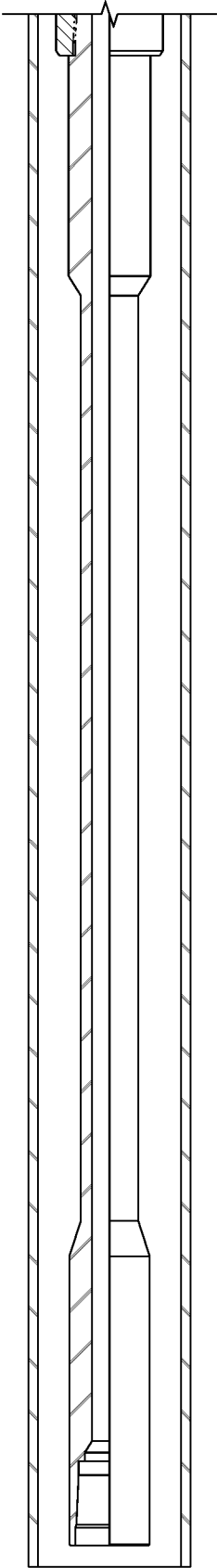


FIG. 1a

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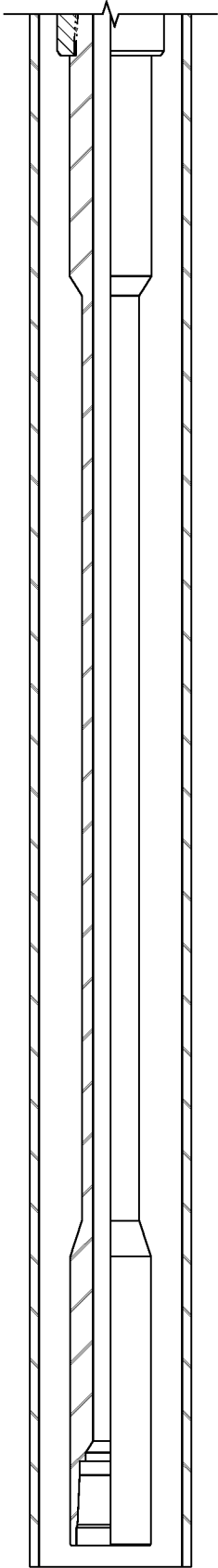


FIG. 2a

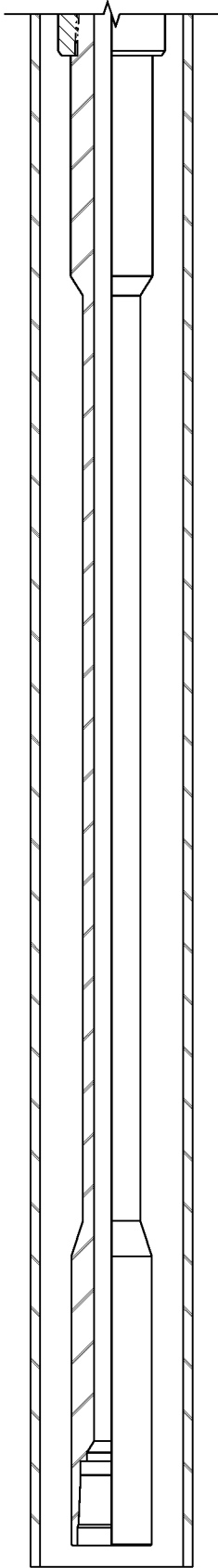


FIG. 3a

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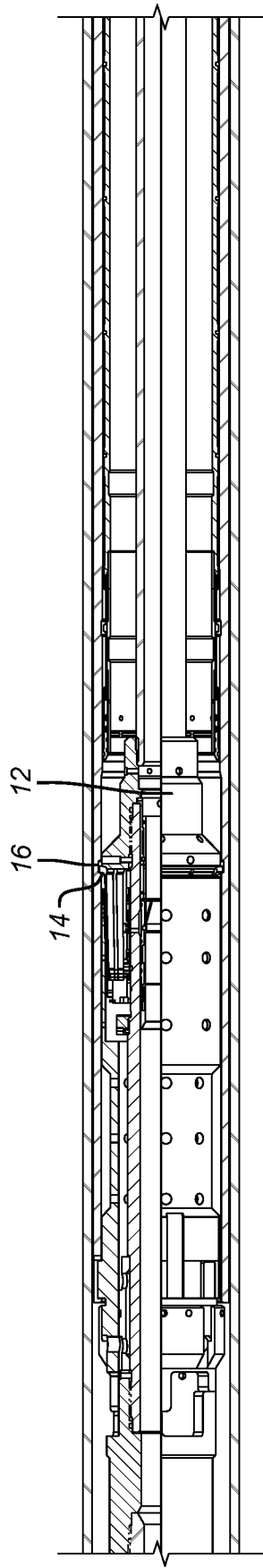


FIG. 1b

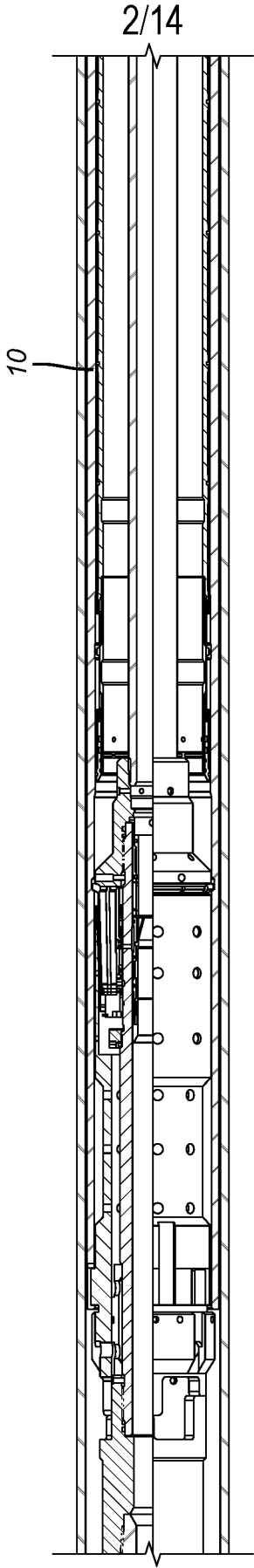


FIG. 2b

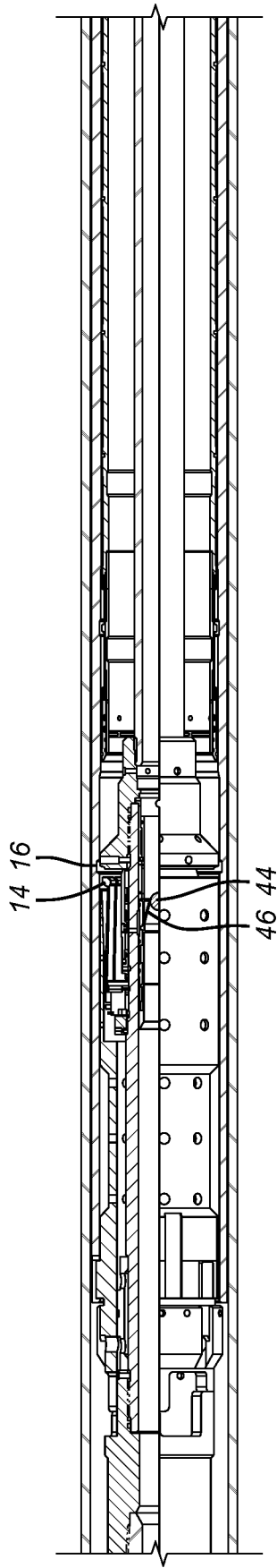


FIG. 3b

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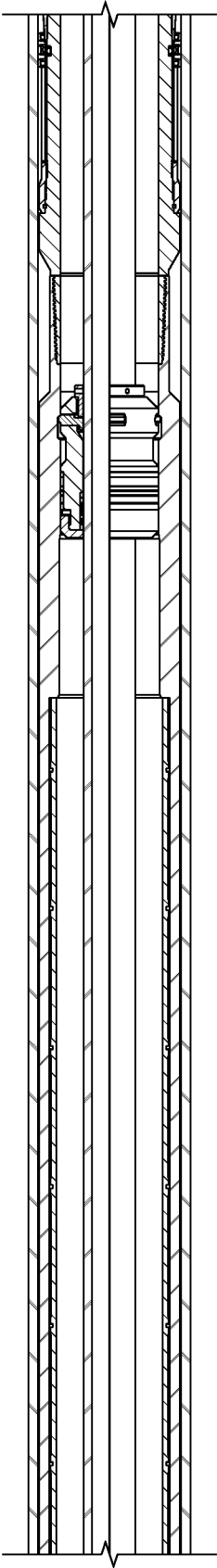


FIG. 1c

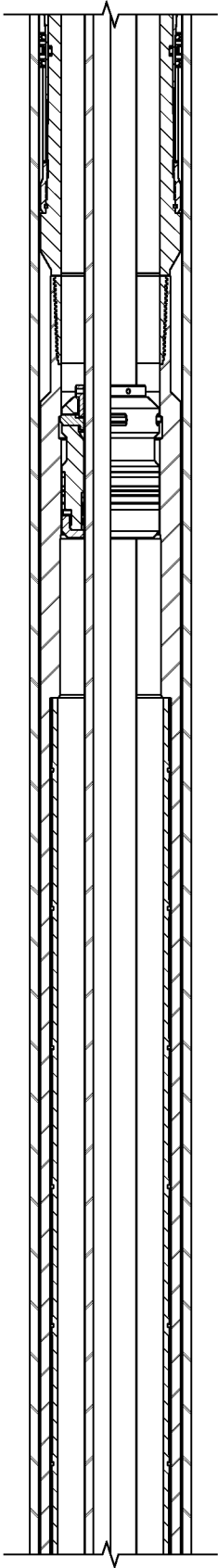


FIG. 2c

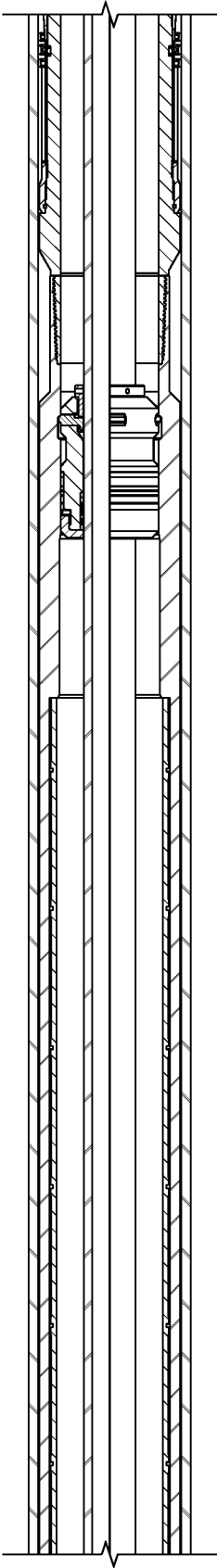


FIG. 3c

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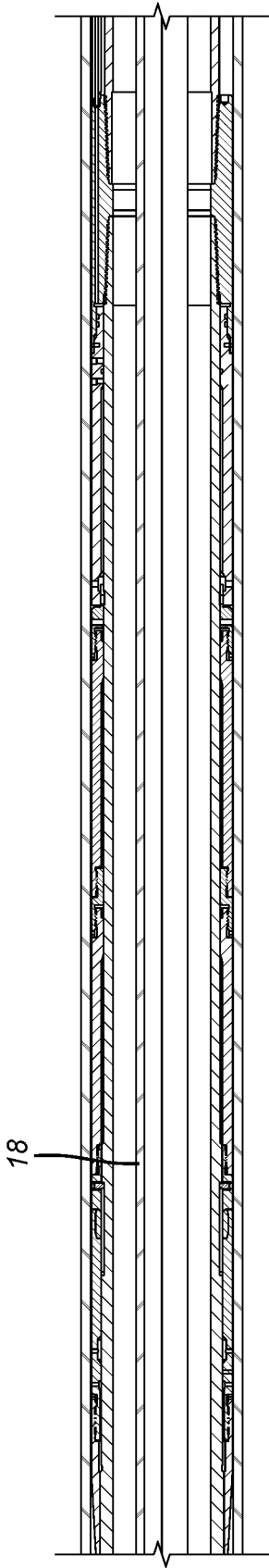


FIG. 1d

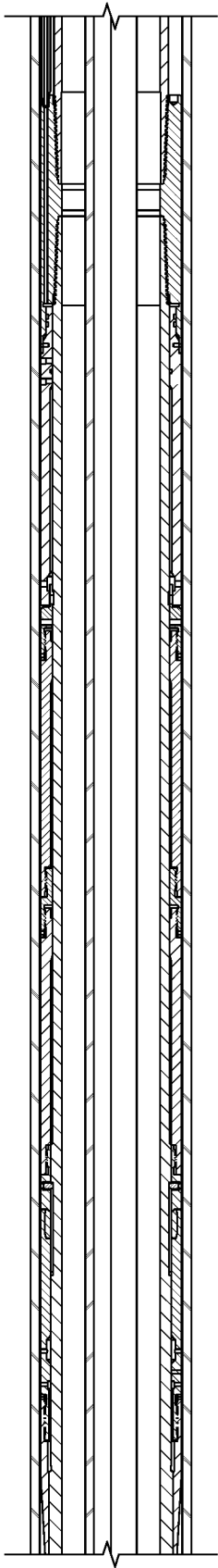


FIG. 2d

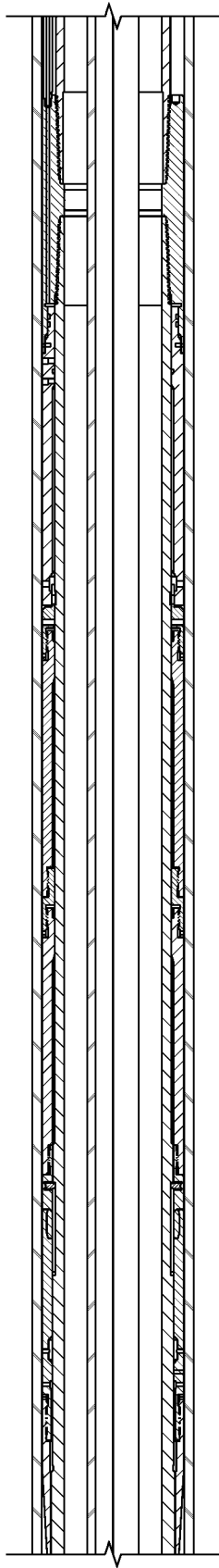


FIG. 3d

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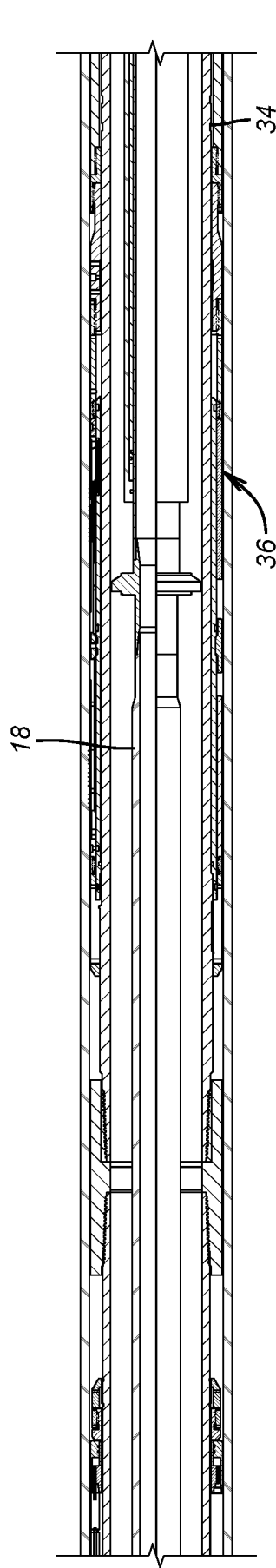


FIG. 1e

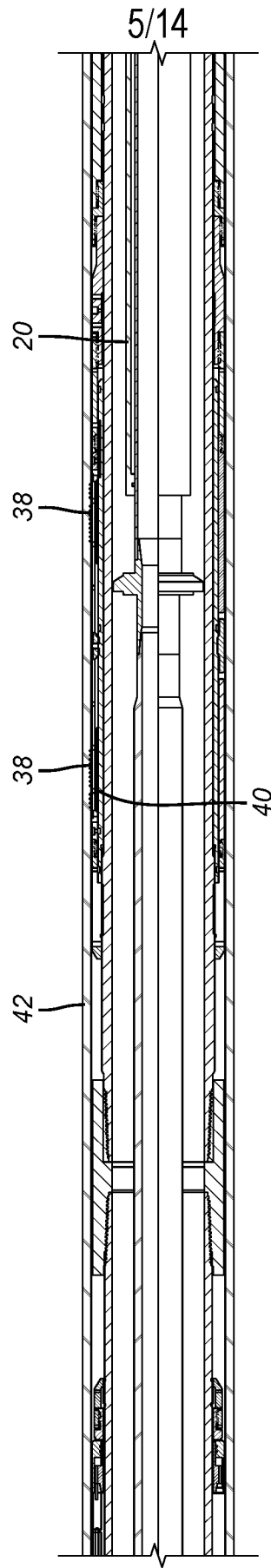


FIG. 2e

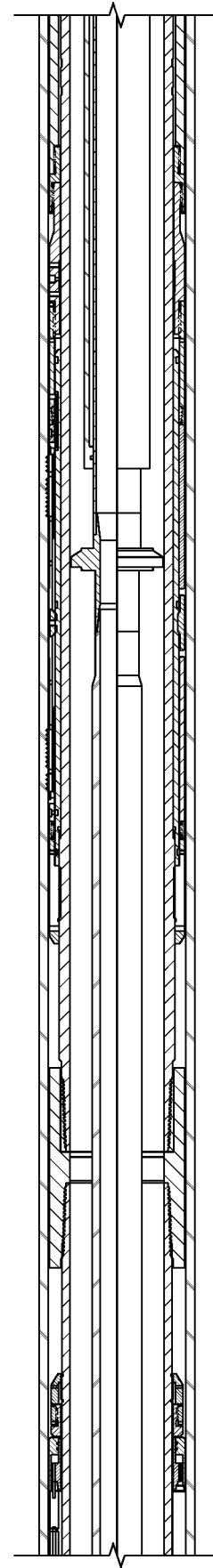


FIG. 3e

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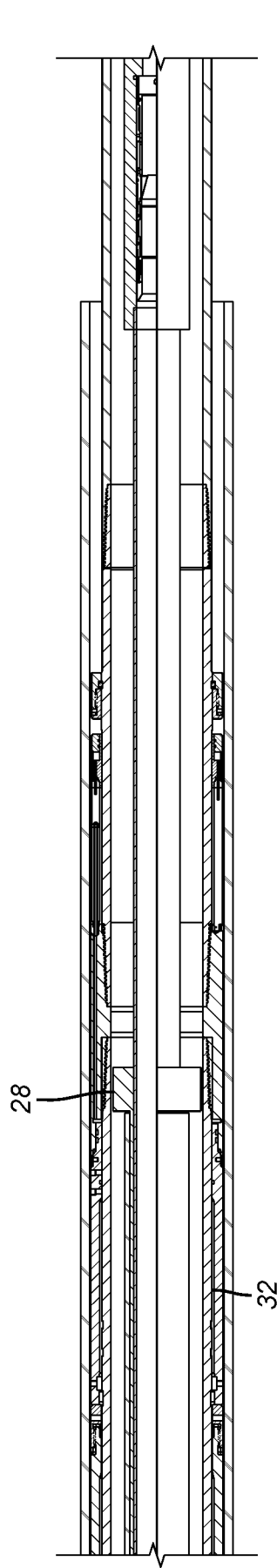


FIG. 1f

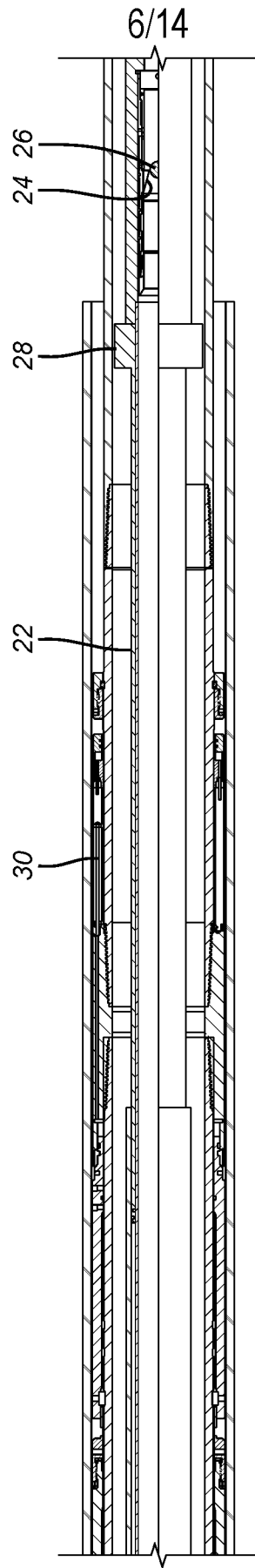


FIG. 2f

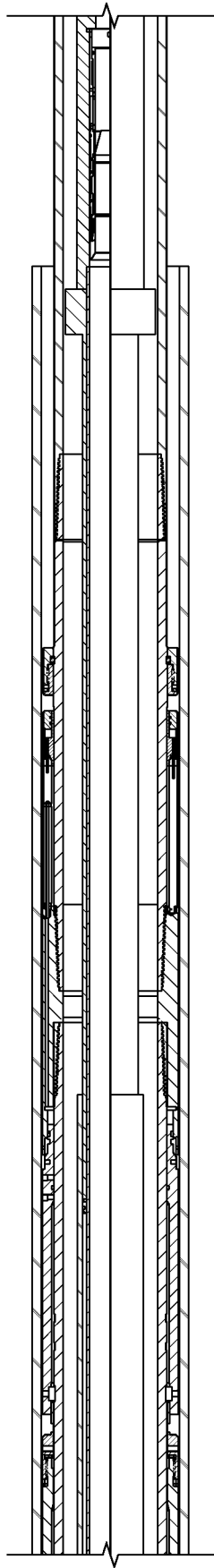


FIG. 3f

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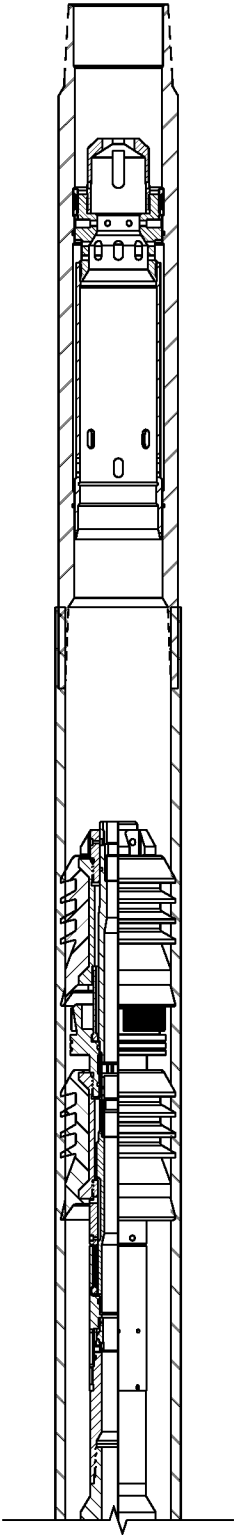


FIG. 1g

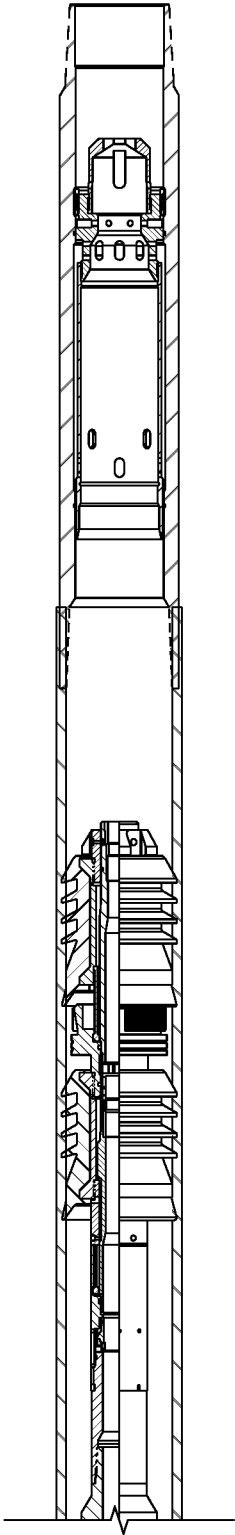


FIG. 2g

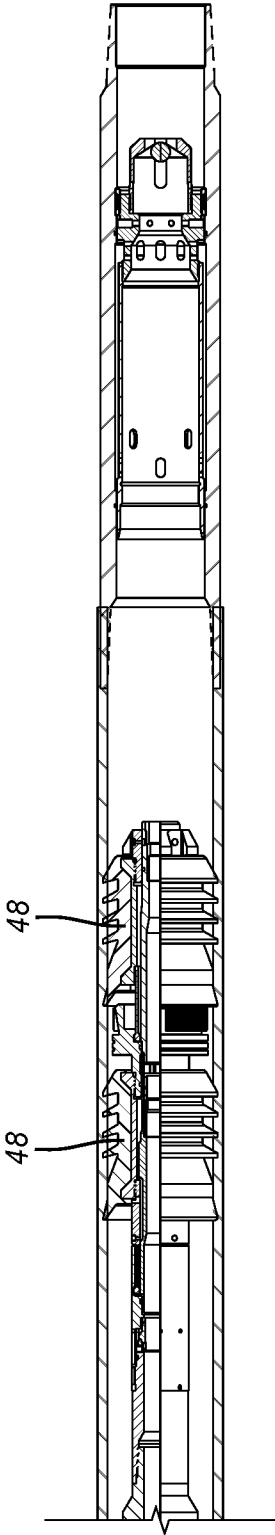


FIG. 3g

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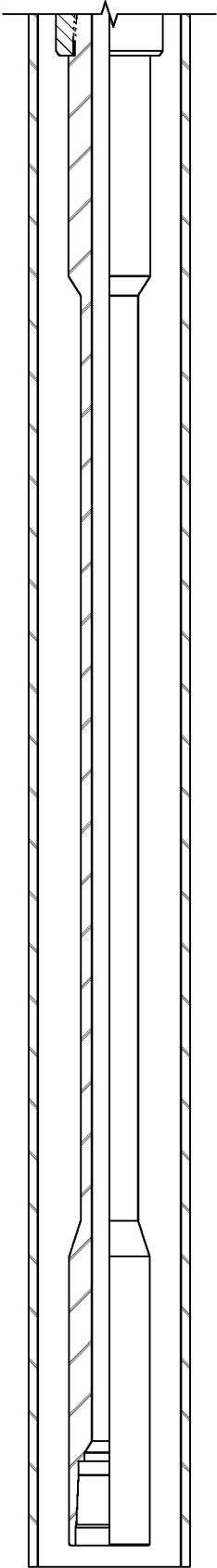


FIG. 4a

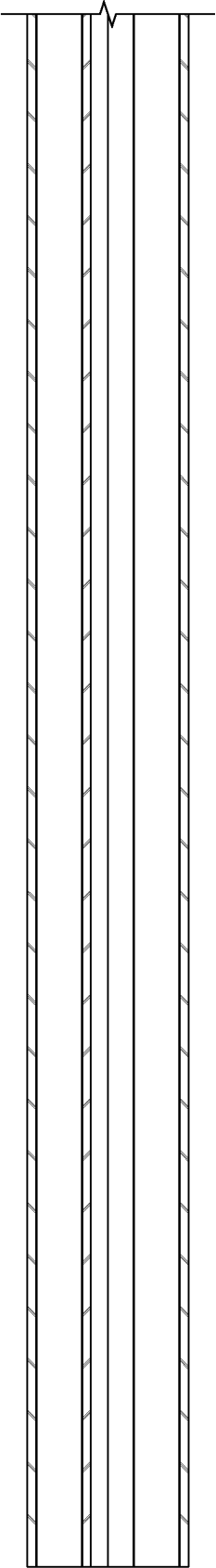


FIG. 5a

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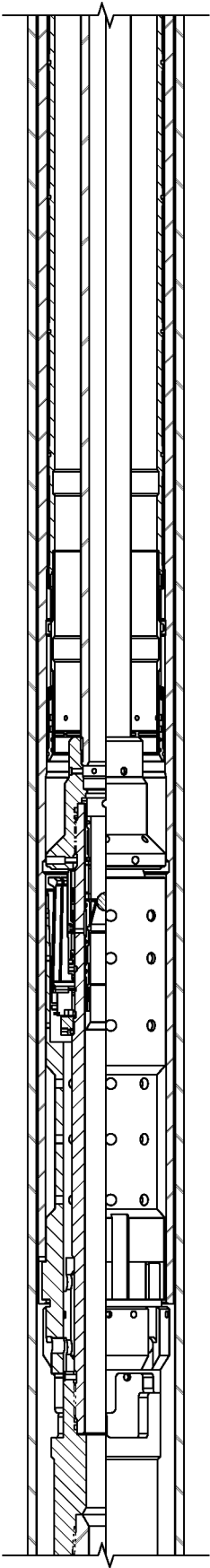


FIG. 4b

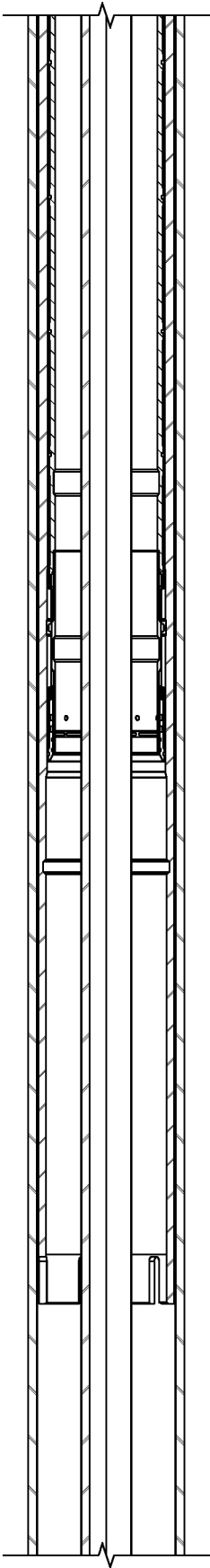


FIG. 5b

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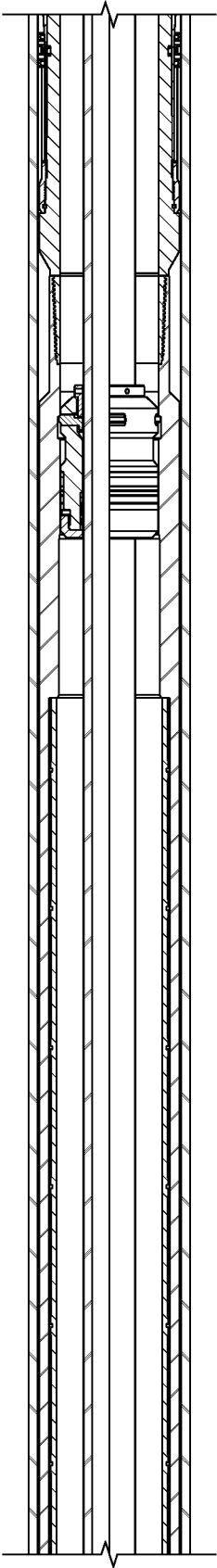


FIG. 4c

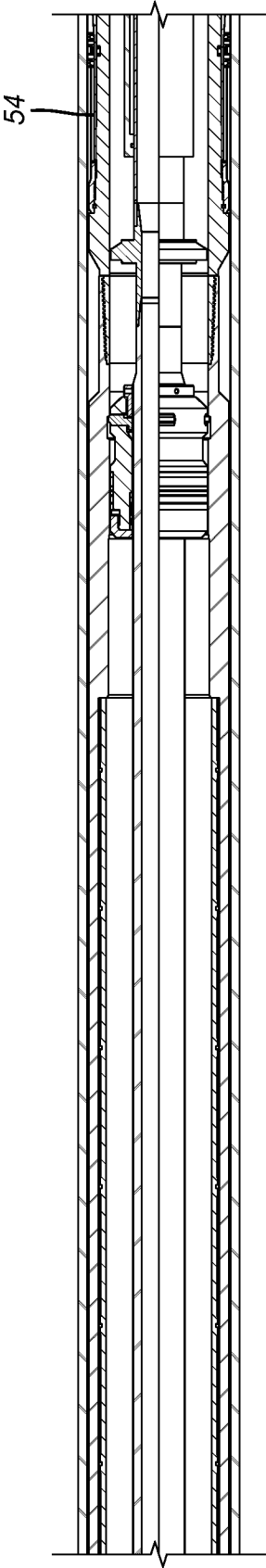


FIG. 5c

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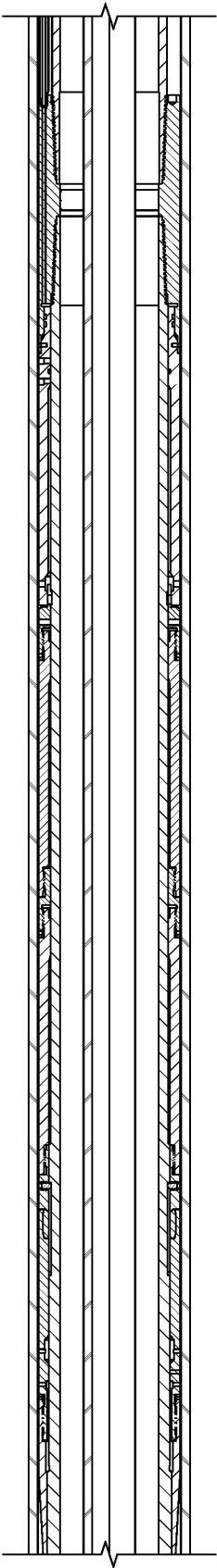


FIG. 4d

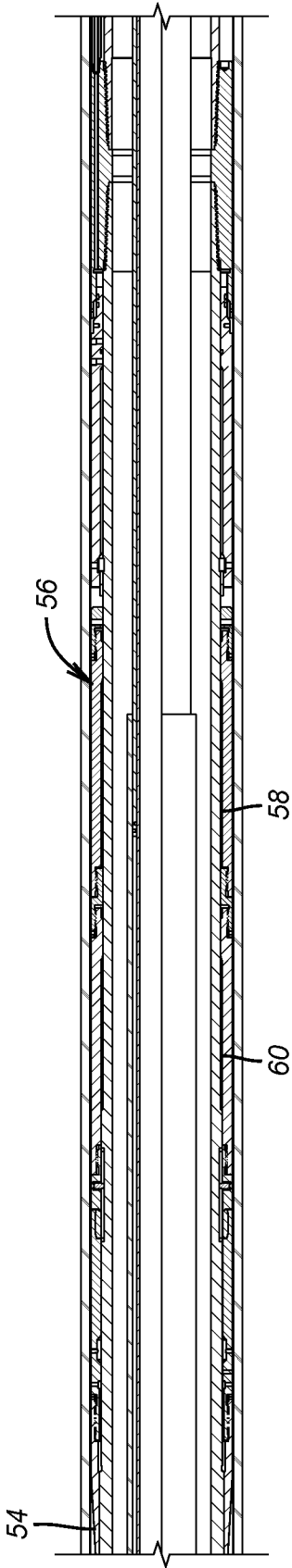


FIG. 5d

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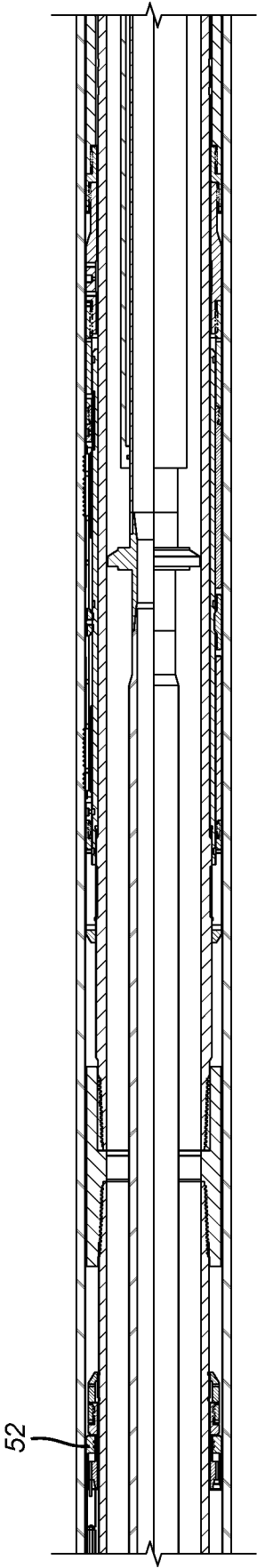


FIG. 4e

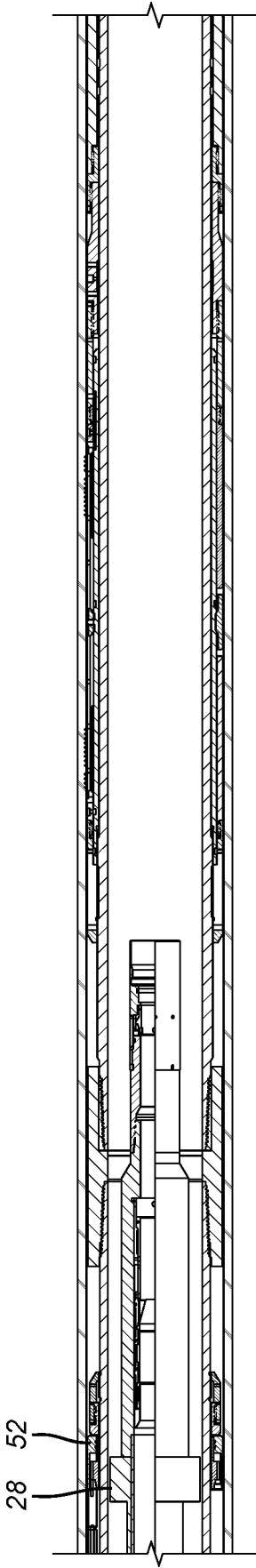


FIG. 5e

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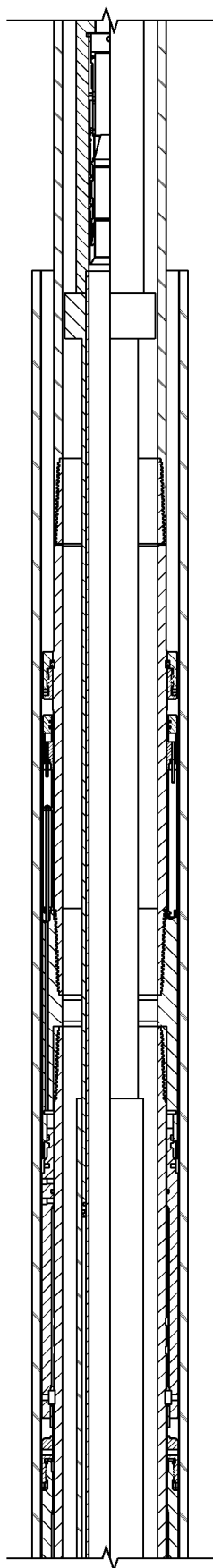


FIG. 4f

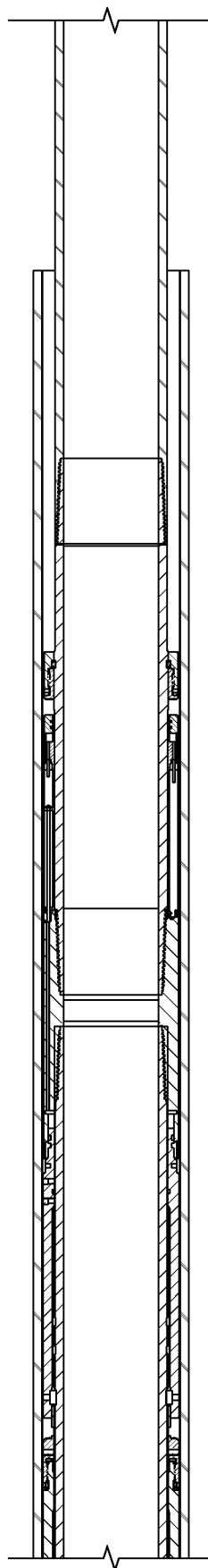


FIG. 5f

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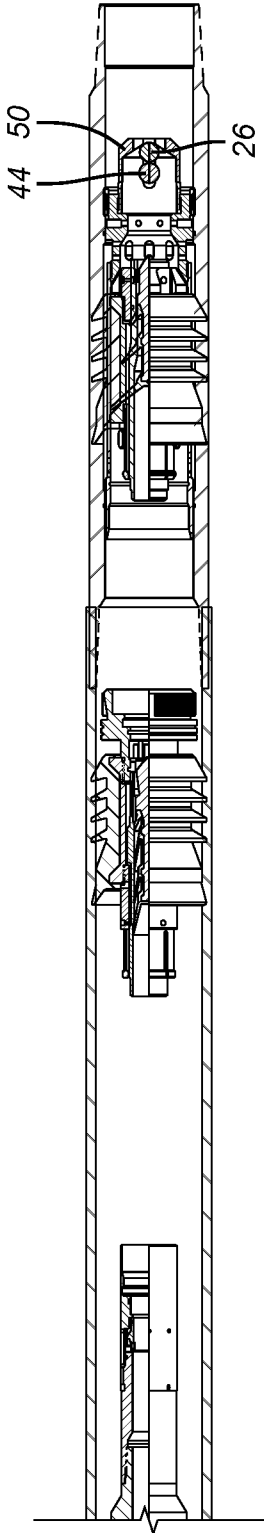


FIG. 4g

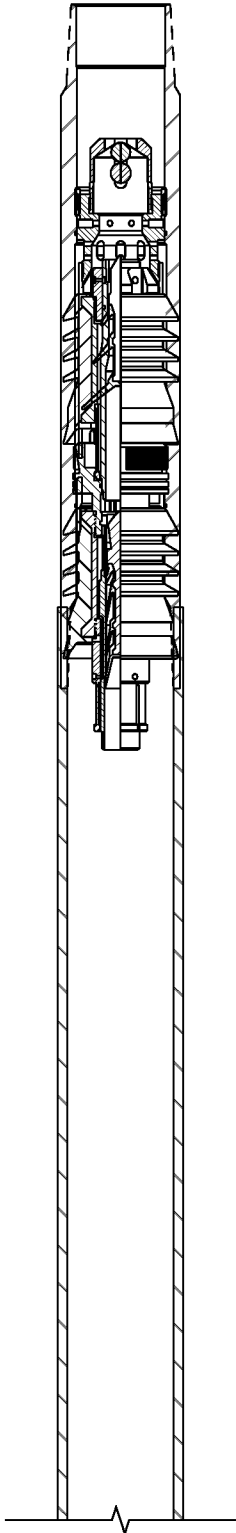


FIG. 5g

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/027888**A. CLASSIFICATION OF SUBJECT MATTER****E21B 23/01(2006.01)i, E21B 23/06(2006.01)i, E21B 33/12(2006.01)i, E21B 43/10(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; E21B 47/00; E21B 34/06; E21B 23/06; E21B 34/00; E21B 33/12; E21B 47/09; E21B 23/00; E21B 34/10; E21B 43/10

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: multiple tools, triggering device, actuator, release, mount, and packer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0048308 A1 (LEHR et al.) 28 February 2013 See paragraphs [0046]–[0049] and figures 1–18.	1–3, 8–9, 15–19
A		4–7, 10–14, 20
Y	US 2004-0256113 A1 (LOGIUDICE et al.) 23 December 2004 See paragraphs [0032], [0039], [0045], [0066] and figures 1–3.	1–3, 8–9, 15–19
Y	US 2014-0144653 A1 (BAKER HUGHES INCORPORATED) 29 May 2014 See paragraph [0011] and figures 1–2.	16–18
A	US 2009-0071654 A1 (O'MALLEY et al.) 19 March 2009 See paragraphs [0014]–[0018] and figures 1–3.	1–20
A	US 2008-0236819 A1 (FOSTER et al.) 02 October 2008 See paragraphs [0011]–[0012] and figures 1A–1B.	1–20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"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

16 July 2016 (16.07.2016)

Date of mailing of the international search report

26 July 2016 (26.07.2016)

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International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Dal Kyong

Telephone No. +82-42-481-8440



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Information on patent family members

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