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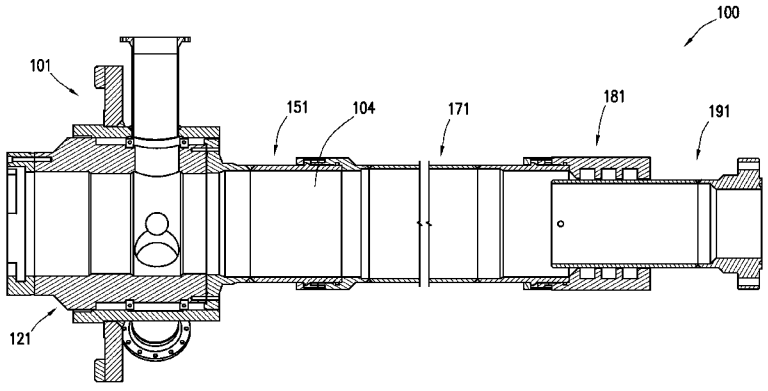

FIG. 1

(57) Abstract: A diverter for a drilling operation includes a diverter support housing, a diverter body assembly, and an upper packer assembly. The diverter body assembly couples to the diverter support housing by a breach lock system. The upper packer assembly couples to the diverter body assembly by a breach lock system. The upper packer includes at least two outer seals to seal between the upper packer and the diverter body and at least two inner seals to seal between the upper packer and a drill string. The seals may be fluid actuated. The diverter may couple to an overshot assembly by one or more breach lock locking rings. The overshot assembly may include a plurality of seals adapted to engage the outer surface of a riser, casing, or mandrel.

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DIVERTER FOR DRILLING OPERATION

Cross-Reference to Related Applications

[0001] This application is a nonprovisional application which claims priority from U.S. provisional application number 62/201,362, filed August 5, 2015, the entirety of which is hereby incorporated by reference.

Technical Field/Field of the Disclosure

[0002] The present disclosure relates to diverters for drilling operations.

Background of the Disclosure

[0003] While drilling a wellbore, a diverter may be positioned to divert any high pressure fluid resulting from, for example, a blowout, away from the drilling floor. A diverter may couple to an upper end of a casing or a riser and be positioned about the drill string as the wellbore is drilled. Traditionally, the diverter is positioned beneath the drill floor or rotary table and includes one or more outlets that may be coupled to exhaust conduits away from the drill floor.

Summary

[0004] The present disclosure provides for a diverter assembly. The diverter assembly may include a diverter body assembly. The diverter body assembly may include a diverter body fluidly coupled to the annulus of a wellbore via a casing or riser. The diverter body may include one or more diverter outlet ports fluidly coupled to the annulus of the wellbore. The diverter assembly may further include an upper packer assembly adapted to form a seal between the diverter body and a drill string passing therethrough. The upper packer assembly may include a packer sleeve mechanically coupled to the diverter body and including a breach lock slot. The

upper packer assembly may further include an upper packer body having one or more packer breach lock tabs adapted to engage with the breach lock slots of the packer sleeve.

[0005] The present disclosure also provides for a method. The method may include providing a diverter body assembly. The diverter body assembly may include a diverter body fluidly coupled to the annulus of a wellbore via a casing or riser. The diverter body may include one or more diverter outlet ports fluidly coupled to the annulus of the wellbore. The method may further include coupling a packer sleeve to the diverter body. The method may further include inserting an upper packer body into the packer sleeve such that one or more packer breach lock tabs of the upper packer body engage one or more corresponding breach lock slots of the packer sleeve. The method may further include rotating the upper packer body to a closed position such that the breach lock slots retain the packer body to the packer sleeve. The method may further include sealing, with the upper packer body, between the diverter body and a drill string passing therethrough.

Brief Description of the Drawings

[0006] The present disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0007] FIG. 1 depicts a cross section view of a diverter assembly consistent with at least one embodiment of the present disclosure.

[0008] FIG. 2 depicts a perspective view of a diverter support housing consistent with at least one embodiment of the present disclosure.

[0009] FIG. 3 depicts a perspective view of the housing cylinder of the diverter support housing of FIG. 2.

[0010] FIG. 4 depicts a cross section view of the housing cylinder of FIG. 3.

[0011] FIG. 5 depicts a cross section view of a diverter body assembly consistent with at least one embodiment of the present disclosure.

[0012] FIG. 5A depicts a cross section view of a diverter body assembly consistent with at least one embodiment of the present disclosure.

[0013] FIG. 5B depicts a cross section view of a diverter body assembly consistent with at least one embodiment of the present disclosure.

[0014] FIG. 6 depicts a cross section view of a diverter body of the diverter assembly of FIG. 5.

[0015] FIG. 7 depicts a perspective view of the diverter body of FIG. 6.

[0016] FIG. 8 depicts a diverter upper retainer of the diverter assembly of FIG. 5.

[0017] FIG. 9 depicts a cross section of a diverter lower assembly, spacer spool, overshot, and mandrel consistent with at least one embodiment of the present disclosure.

[0018] FIG. 10 depicts a lock ring consistent with at least one embodiment of the present disclosure.

Detailed Description

[0019] It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of

components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0020] FIG. 1 depicts a cross section of diverter assembly 100 consistent with at least one embodiment of the present disclosure. In some embodiments, diverter assembly 100 may include diverter support housing 101. Diverter support housing 101 may be mechanically coupled to a drill floor (not shown) or other component of a drilling rig by, for example and without limitation, one or more structural beams underneath and supporting the drill floor. Diverter support housing 101 may be mechanically coupled to diverter body assembly 121. Diverter body assembly 121 may be mechanically coupled to diverter lower assembly 151, which may be mechanically coupled to spacer spool pipe 171. Spacer spool pipe 171 may be mechanically coupled to overshot housing 181. Diverter body assembly 121, diverter lower assembly 151, spacer spool pipe 171, and overshot housing 181 may each be generally tubular and may form diverter assembly bore 104 therethrough. In some embodiments a drill string (not shown) may extend through diverter assembly bore 104. Overshot housing 181 may fit around a tubular such as a riser or a portion of casing such that diverter assembly bore 104 is coupled to the annulus of the wellbore via the riser or portion of casing.

[0021] In some embodiments, as depicted in FIGS. 2-4, diverter support housing 101 may include housing cylinder 102. Housing cylinder 102 may be coupled to base plate 103 as shown in FIG. 2. Base plate 103 mechanically couples diverter support housing 101 to the drilling rig. In some embodiments, one or more outlet pipes may be fluidly connected to diverter assembly

bore 104. In some embodiments, outlet pipes 105 may be formed at least partially in diverter support housing 101. During operation, one or more outlet pipes 105 may conduct fluid from diverter assembly bore 104, which is fluidly connected to the interior of diverter assembly 100 as discussed herein below. In some embodiments, outlet pipes 105 may include couplers adapted to couple to exhaust conduits, allowing fluids to be routed to locations away from the drilling rig. For example and without limitation, the couplers may be flange couplings 107 as shown in FIG. 2, though one having ordinary skill in the art with the benefit of this disclosure will understand that any pipe coupling may be used without deviating from the scope of this disclosure. Outlet pipes 105 (shown removed in FIGS. 3, 4) may couple to outlet ports 109 formed in housing cylinder 102. In some embodiments, inlet ports 111 may be fluidly coupled to inlet pipes 113 to, for example, allow fluid to be introduced into housing cylinder 102.

[0022] As shown in FIGS. 3 and 4, in some embodiments, housing cylinder 102 may include housing breach lock slots 115. Housing breach lock slots 115 may, as understood in the art, allow one or more corresponding breach lock tabs 123 (FIG. 5) from diverter body assembly 121 to axially enter thereinto and, upon rotation of diverter body assembly 121, axially lock diverter body assembly 121 to diverter support housing 101. In some embodiments, housing breach lock slots 115 may include rotation stop 117 to retard further rotation of diverter body assembly 121 when in a locked position. Likewise, rotation of diverter body assembly 121 in the opposite direction may move breach lock tabs 123 into an open position, to allow diverter body assembly 121 to be axially removed from diverter support housing 101. Rotation stop 117 may in some embodiments retard rotation of diverter body assembly 121 in both rotational directions.

[0023] As depicted in FIGS. 5 and 6, in some embodiments, diverter body assembly 121 may include diverter body 125. Diverter body 125 may include one or more diverter outlet ports 127,

corresponding with outlet ports 109 of diverter support housing 101 thereby fluidly coupling diverter outlet ports 127 to outlet pipes 105 and the annulus of a wellbore. In some embodiments, as depicted in FIG. 5, one or more seals 129 may be positioned between diverter body 125 and housing cylinder 102 to, for example and without limitation, provide a fluid seal between diverter outlet ports 127 and outlet ports 109. In some embodiments, diverter body 125 may be fluidly coupled to the annulus of a wellbore via a casing or riser.

[0024] In some embodiments, diverter body assembly 121 may include upper packer assembly 131. Upper packer assembly 131 may form a fluid seal between diverter body 125 and a drill string (not shown) passing therethrough. Upper packer assembly 131 may include packer sleeve 132. Packer sleeve 132 may fit within packer recess 133 (shown in FIG. 6) within diverter body 125. Packer sleeve 132 may, in some embodiments, be coupled to diverter body 125 by, for example and without limitation, threaded fasteners such as bolts 137. Upper packer assembly 131 may include upper packer body 136 adapted to fit within packer sleeve 132. In some embodiments, upper packer body 136 may be inserted into or removed from packer sleeve 132 in an axial direction. In some embodiments, upper packer body 136 may be coupled to packer sleeve 132 and thus to diverter body 125 by upper retainer 135. In some embodiments, upper retainer 135 may include one or more breach lock slots 139 (shown in detail in FIG. 8) corresponding to one or more corresponding breach lock tabs 140 positioned on an end of upper packer body 136 to allow upper packer body 136 to couple thereto as upper packer body 136 is rotated into a closed position from the open position used to insert upper packer body 136 into packer sleeve 132.

[0025] In some embodiments, as depicted in FIG. 5, upper packer assembly 131 may include two outer seals 141 coupled to upper packer body 136. Outer seals 141 may provide a fluid seal

between upper packer assembly 131 and diverter body 125. In some embodiments, upper packer assembly 131 may include two inner seals 143 coupled to upper packer body 136. Inner seals 143 may provide a fluid seal between upper packer assembly 131 and a drill string (not shown) during a drilling operation. In some embodiments, outer seals 141 and inner seals 143 may be fluid actuated to extend and seal between the respective members. In some such embodiments, outer seals 141 and inner seals 143 may be, for example and without limitation, inflatable seals. In some embodiments, outer seals 141 and inner seals 143 may be inflated simultaneously or may be selectively inflated independently. In some embodiments, outer seals 141 and inner seals 143 may be inflated by one or more ports. In some embodiments, inner seals 143 may provide a fluid seal against multiple diameters or pipe sizes of a drill string. One having ordinary skill in the art with the benefit of this disclosure will understand that any number of outer seals 141 and inner seals 143 may be utilized without deviating from the scope of this disclosure. For example, in some embodiments, as depicted in FIG. 5A, upper packer assembly 131' may include three outer seals 141' and three inner seals 143'. In some embodiments, outer seals 141' may be positioned as part of upper packer assembly 131'. In some embodiments, as depicted in FIG. 5B, outer seals 141'' may be positioned as part of packer sleeve 132' positioned within diverter body 125 as previously discussed. In such an embodiment, outer seals 141'' may seal against upper packer assembly 131''.

[0026] Stresses on outer seals 141 and inner seals 143 may cause the seals to deteriorate. In order to service or replace seals 141, 143, upper packer body 136 may be removed from the rest of diverter body assembly 121. In some such embodiments, upper packer body 136 may be rotated such that breach lock tabs 140 are aligned with breach lock slots 139 in an unlocked position, allowing upper packer body 136 to be axially removed from diverter body assembly

121. Replacement may similarly be accomplished by axially inserting upper packer body 136 into diverter body assembly 121 and rotating upper packer body 136 until breach lock tabs 140 are in a locked position within breach lock slots 139.

[0027] In some embodiments, as shown in FIG. 5, diverter lower assembly 151 may couple to the lower end of diverter body 125. In some embodiments, diverter lower assembly 151 may couple to diverter body 125 by a breach-lock assembly as described herein. In some embodiments, diverter lower assembly 151 may include mounting flange 153 to mechanically couple diverter lower assembly 151 to the lower end of diverter body 125 by, for example and without limitation, threaded fasteners such as bolts 155. Diverter lower assembly 151 may be a tubular member. As depicted in FIG. 9, diverter lower assembly 151 may include a breach lock assembly including lock ring retainer 157. Lock ring retainer 157 may be a generally annular protrusion from the exterior surface of diverter lower assembly 151. Lock ring retainer 157 may, for example, retain lock ring 161 to diverter lower assembly 151. As depicted in FIG. 10, lock ring 161 may include retaining flange 163 adapted to contact lock ring retainer 157 and prevent lock ring 161 from sliding off the end of diverter lower assembly 151. Lock ring 161 may further include breach lock slots 165 to couple to spacer spool pipe 171 and between spacer spool pipe 171 and overshot housing 181 as discussed herein.

[0028] In some embodiments, diverter lower assembly 151 may couple to spacer spool pipe 171 as depicted in FIG. 9. In some embodiments, spacer spool pipe 171 may include upper coupler 173. In some embodiments upper coupler 173 may include one or more breach lock tabs 175 adapted to engage with breach lock slots 165 of lock ring 161. In such an embodiment, spacer spool pipe 171 may be coupled to diverter lower assembly 151 by axially engaging the two members and inserting breach lock tabs 175 into breach lock slots 165 of lock ring 161. Lock

ring 161 may then be rotated such that breach lock slots 165 engage breach lock tabs 175, retaining diverter lower assembly 151 to spacer spool pipe 171.

[0029] In some embodiments, spacer spool pipe 171 may include lock ring retainer 177. Lock ring retainer 177 may be a generally annular protrusion from the exterior surface of spacer spool pipe 171. Lock ring retainer 177 may, for example, retain lock ring 161 to spacer spool pipe 171 as discussed above with respect to diverter lower assembly.

[0030] In some embodiments, spacer spool pipe 171 may couple to overshot housing 181. In some embodiments, overshot housing 181 may include upper coupler 183. In some embodiments upper coupler 183 may include one or more breach lock tabs 185 adapted to engage with breach lock slots 165 of lock ring 161. In such an embodiment, overshot housing 181 may be coupled to spacer spool pipe 171 by axially engaging the two members and inserting breach lock tabs 185 into breach lock slots 165 of lock ring 161. Lock ring 161 may then be rotated such that breach lock slots 165 engage breach lock tabs 185, retaining spacer spool pipe 171 to overshot housing 181.

[0031] In some embodiments, as shown in FIG. 9, overshot housing 181 may be adapted to slip over a casing portion or riser, depicted as mandrel 191. Overshot housing 181 may be tubular and may include a plurality of seals 187 positioned within annular grooves 189 formed on the inner surface thereof. Seals 187 may serve to provide a fluid seal between mandrel 191 and diverter assembly bore 104. In some embodiments, two or three seals 187 may be utilized. In some embodiments, mandrel 191 may include lower coupler 197. Lower coupler 197 may allow mandrel 191 to couple to additional drilling components. In some embodiments, lower coupler 197 may include coupler flange 199.

[0032] The foregoing outlines features of several embodiments so that a person of ordinary skill in the art may better understand the aspects of the present disclosure. Such features may be replaced by any one of numerous equivalent alternatives, only some of which are disclosed herein. One of ordinary skill in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. One of ordinary skill in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

Claims:

1. A diverter assembly comprising:

a diverter body assembly including a diverter body, the diverter body being fluidly coupled to the annulus of a wellbore via a casing or riser, the diverter body including one or more diverter outlet ports fluidly coupled to the annulus of the wellbore, and

an upper packer assembly adapted to form a seal between the diverter body and a drill string passing therethrough, the upper packer assembly including:

a packer sleeve, the packer sleeve mechanically coupled to the diverter body, the packer sleeve including a breach lock slot; and

an upper packer body having one or more packer breach lock tabs adapted to engage with the breach lock slots of the packer sleeve.

2. The diverter assembly of claim 1, wherein the packer breach lock tabs are formed as part of an upper retainer coupled to the packer body.

3. The diverter assembly of claim 1, wherein the upper packer assembly further comprises at least two outer seals, the outer seals positioned on an outer surface of the upper packer body such that the outer seals form a seal between the upper packer body and the diverter body or packer sleeve.

4. The diverter assembly of claim 3, wherein the outer seals are fluid actuated.

5. The diverter assembly of claim 1, wherein the upper packer assembly further comprises at least two inner seals, the inner seals positioned on an inner surface of the upper packer body such that the inner seals form a seal between the upper packer body and the drill string.

6. The diverter assembly of claim 5, wherein the inner seals are fluid actuated.

7. The diverter assembly of claim 1, wherein the diverter body assembly is coupled to an overshot assembly, the overshot assembly including a plurality of inner seals, the inner seals adapted to form a seal against the outer surface of a mandrel.

8. The diverter assembly of claim 7, wherein the diverter body assembly is coupled to the overshot assembly by a diverter lower assembly, the diverter lower assembly coupled to the diverter body.

9. The diverter assembly of claim 8, wherein the diverter lower assembly comprises a lock ring retainer formed as an annular extension on the outer surface of the diverter lower assembly adapted to engage with a retaining flange of a lock ring, the lock ring having a lock ring breach lock slot.

10. The diverter assembly of claim 9, wherein the overshot assembly further comprises one or more overshot breach lock tabs adapted to engage with the lock ring breach lock slot such that the overshot assembly is able to be coupled to or removed from the diverter lower assembly when the lock ring is in an open position and is retained to the diverter lower assembly when the lock ring is in a closed position, the lock ring moved between the open and closed positions by rotation.

11. The diverter assembly of claim 9, further comprising a spacer spool pipe coupled between the diverter lower assembly and the overshot wherein the spacer spool pipe comprises one or more spacer breach lock tabs adapted to engage with the lock ring breach lock slot such that the spacer spool pipe is able to be axially coupled to or removed from the diverter lower assembly when the lock ring is in an open position and is axially retained to the diverter lower assembly when the lock ring is in a closed position, the lock ring moved between the open and closed positions by rotation.

12. The diverter assembly of claim 11, wherein the spacer spool pipe further comprises a second lock ring retainer formed as an annular extension on the outer surface of the spacer spool pipe adapted to engage with a retaining flange of a second lock ring, the second lock ring having a second lock ring breach lock slot.

13. The diverter assembly of claim 12, wherein the overshot assembly further comprises one or more overshot breach lock tabs adapted to engage with the second lock ring breach lock slot such that the overshot assembly is able to be axially coupled to or removed from the spool spacer pipe when the second lock ring is in an open position and is axially retained to the spool spacer pipe when the second lock ring is in a closed position, the second lock ring moved between the open and closed positions by rotation.

14. The diverter assembly of claim 1, wherein the diverter body further comprises one or more diverter breach lock tabs each adapted to engage with a corresponding housing breach lock slot formed in a diverter support housing cylinder such that the diverter body is able to be axially inserted or removed from the diverter support housing when in an open position and

is axially retained to the diverter support housing when in a closed position, the diverter body moved between the open and closed positions by rotation.

15. A method comprising:

providing a diverter body assembly including a diverter body, the diverter body being fluidly coupled to the annulus of a wellbore via a casing or riser, the diverter body including one or more diverter outlet ports fluidly coupled to the annulus of the wellbore;

coupling a packer sleeve to the diverter body;

inserting an upper packer body into the packer sleeve such that one or more packer breach lock tabs of the upper packer body engage one or more corresponding breach lock slots of the packer sleeve;

rotating the upper packer body to a closed position such that the breach lock slots retain the packer body to the packer sleeve; and

sealing, with the upper packer body, between the diverter body and a drill string passing therethrough.

16. The method of claim 15, wherein the upper packer assembly further comprises at least two outer seals, the outer seals positioned on an outer surface of the upper packer body such that the outer seals form a seal between the upper packer body and the diverter body or the packer sleeve.

17. The method of claim 15, wherein the upper packer assembly further comprises at least two inner seals, the inner seals positioned on an inner surface of the upper packer body such that the inner seals form a seal between the upper packer body and the drill string.

18. The method of claim 15, further comprising coupling the diverter body assembly to an overshot assembly with a diverter lower assembly, the overshot assembly including a plurality of inner seals, the inner seals adapted to form a seal against the outer surface of a mandrel.

19. The method of claim 18, wherein the diverter lower assembly comprises a lock ring retainer formed as an annular extension on the outer surface of the diverter lower assembly adapted to engage with a retaining flange of a lock ring, the lock ring having a lock ring breach lock slot.

20. The method of claim 19, further comprising:

axially engaging the diverter lower assembly with the overshot assembly such that one or more overshot breach lock tabs formed on the overshot assembly engage with the lock ring breach lock slot; and

rotating the lock ring into a closed position.

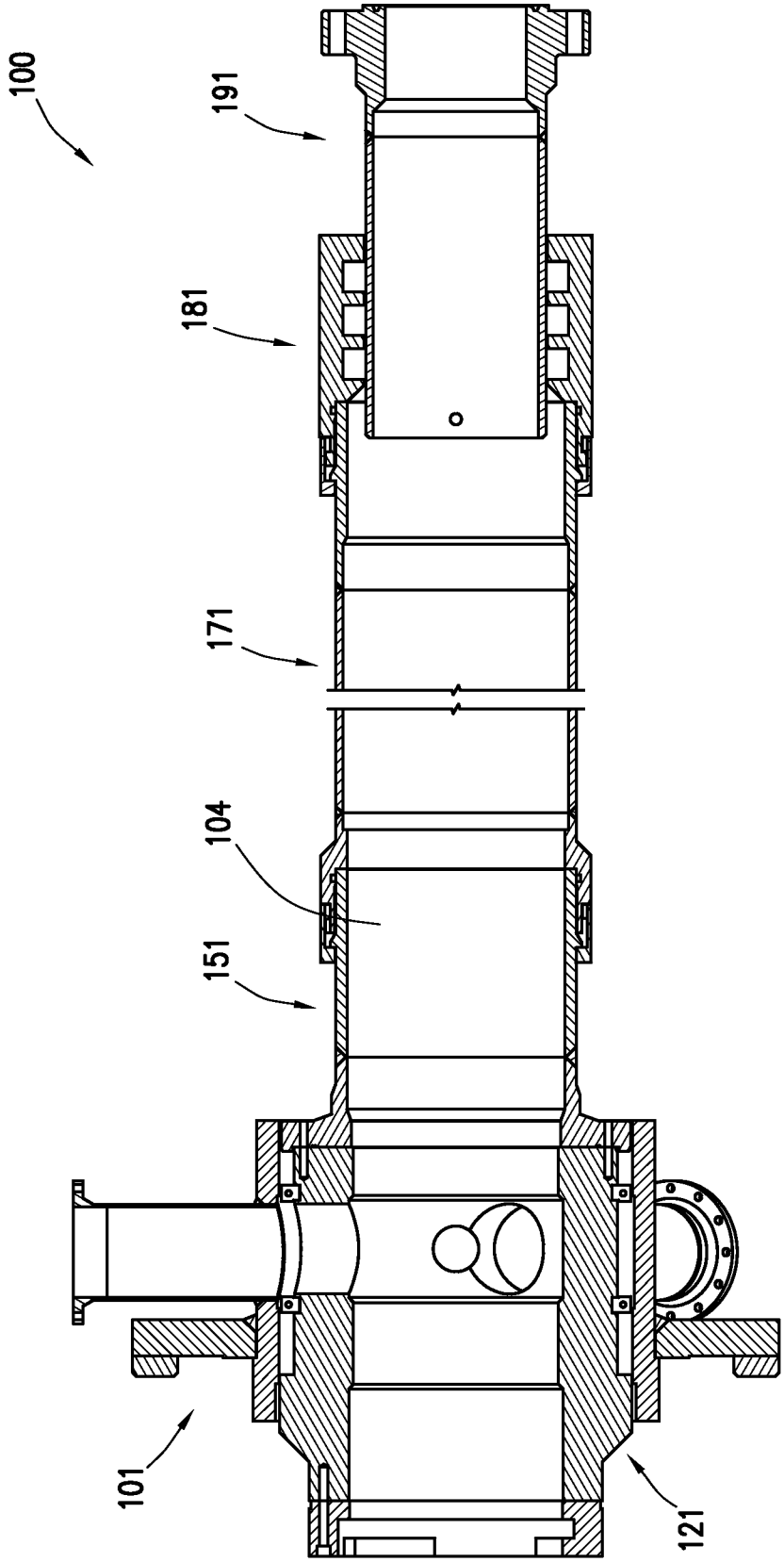

FIG. 1

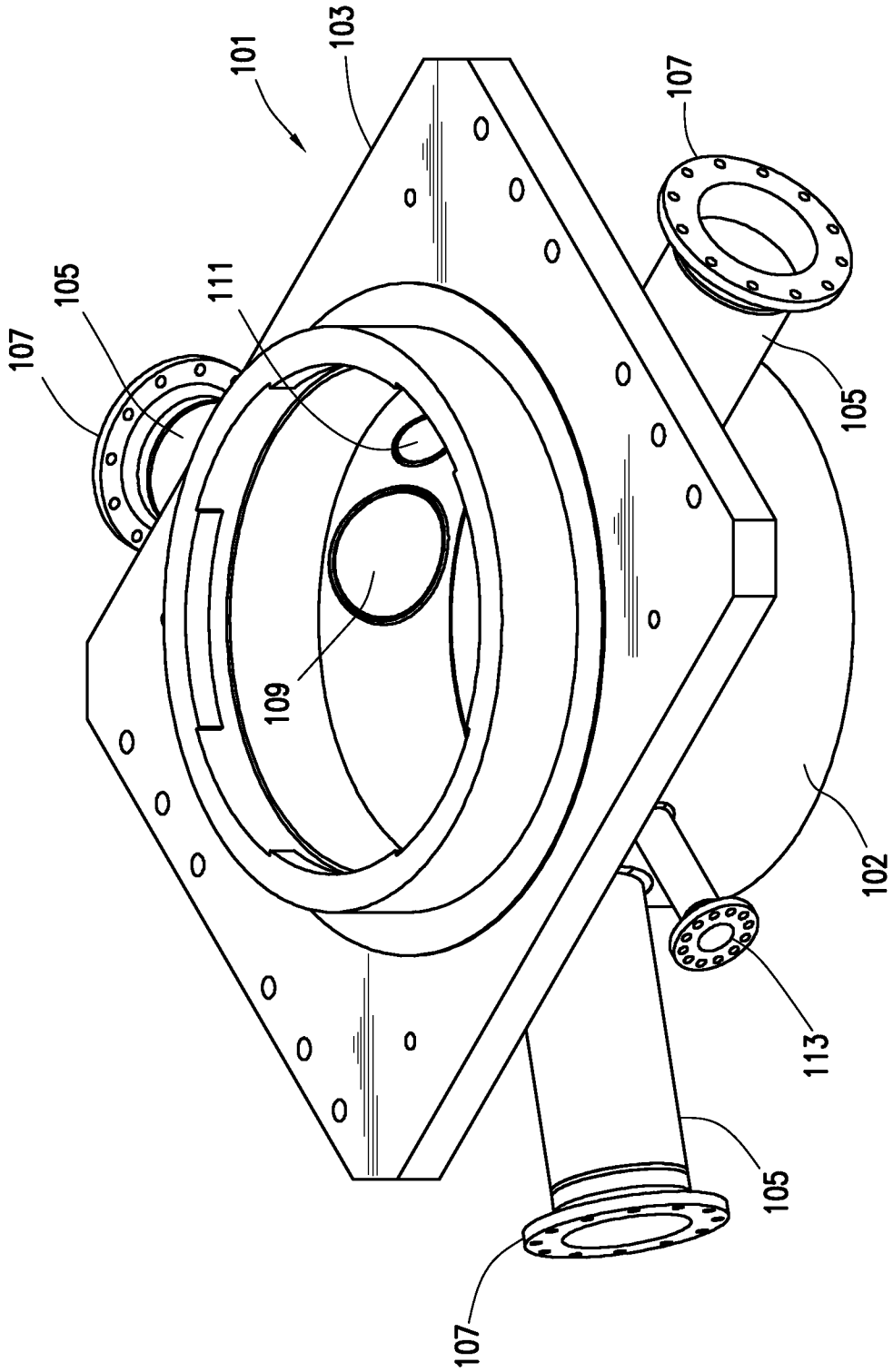

FIG. 2

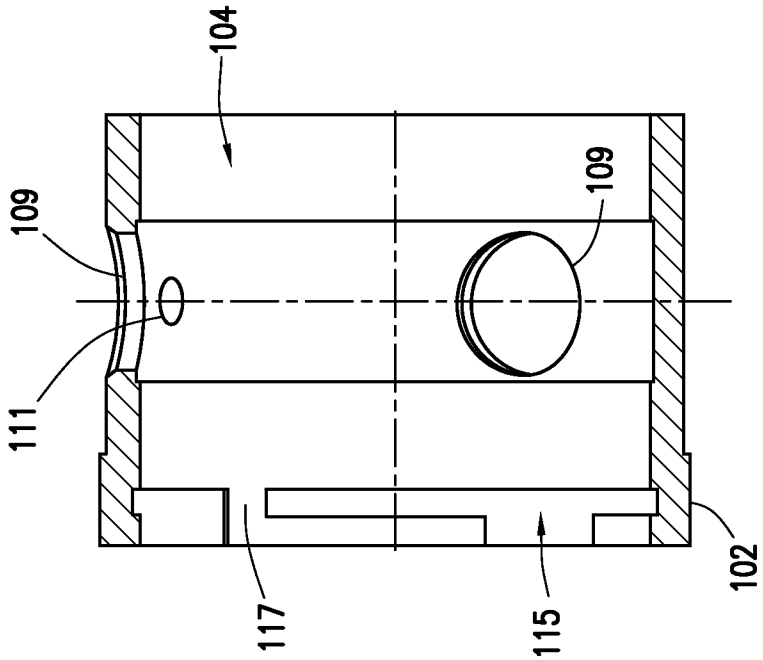

FIG. 4

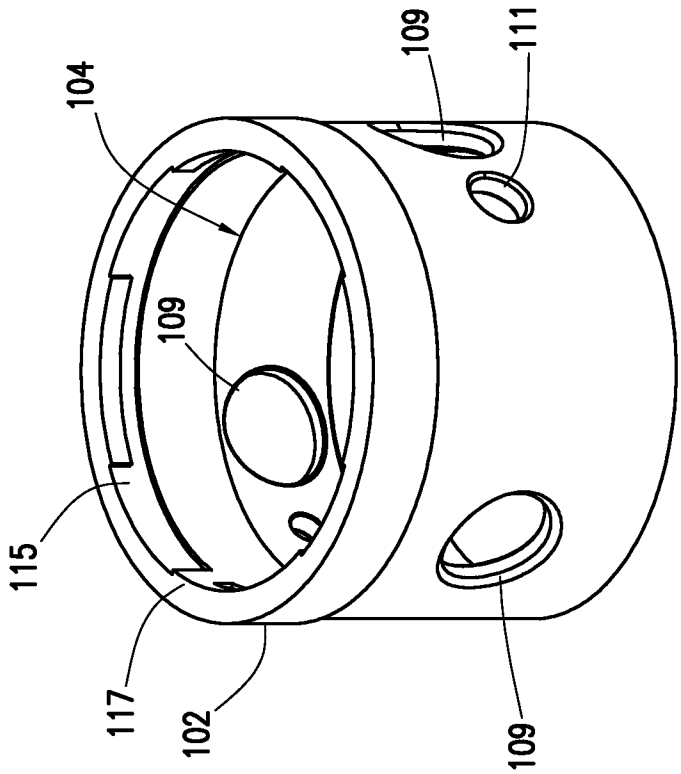

FIG. 3

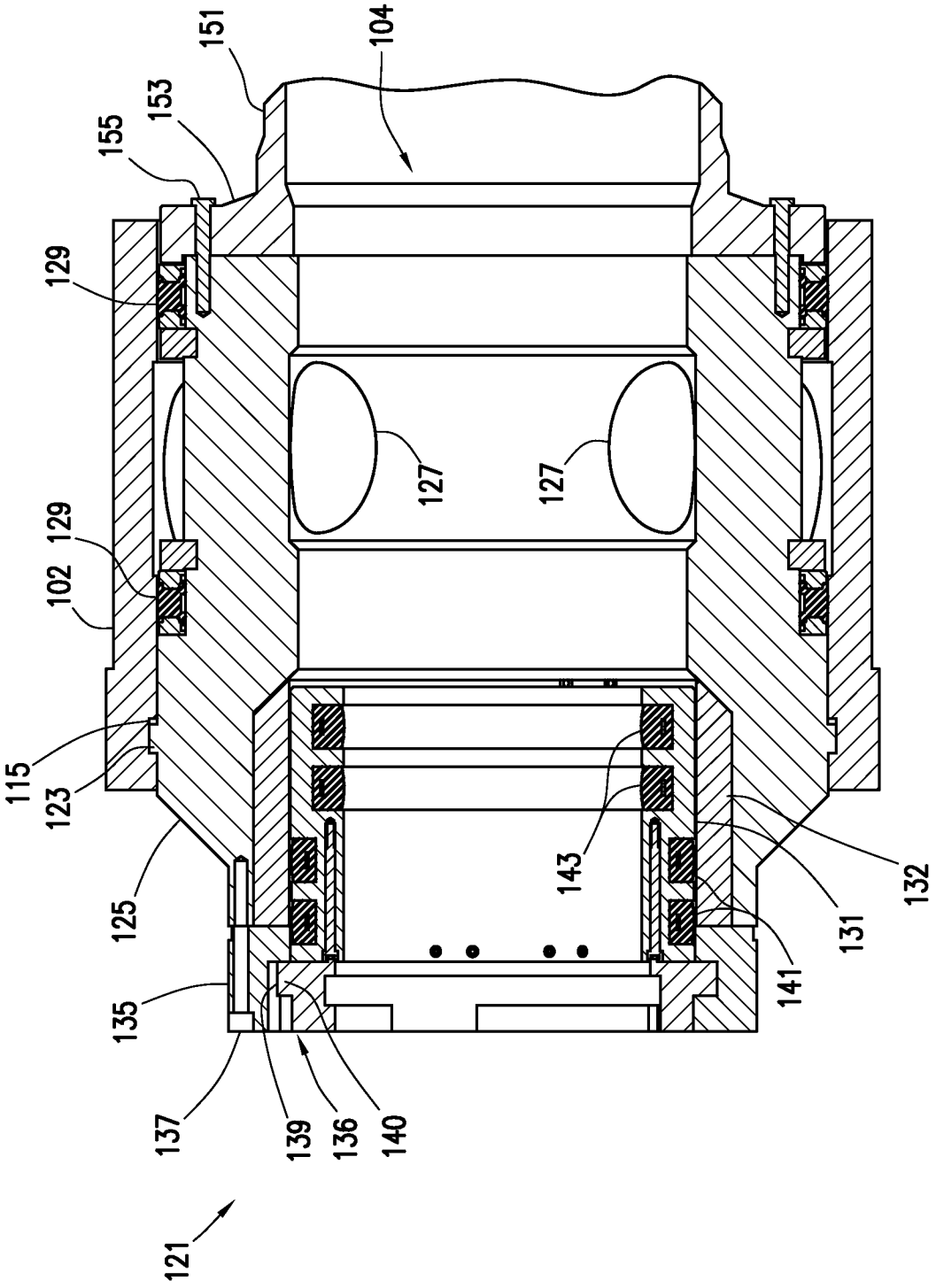
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FIG. 5

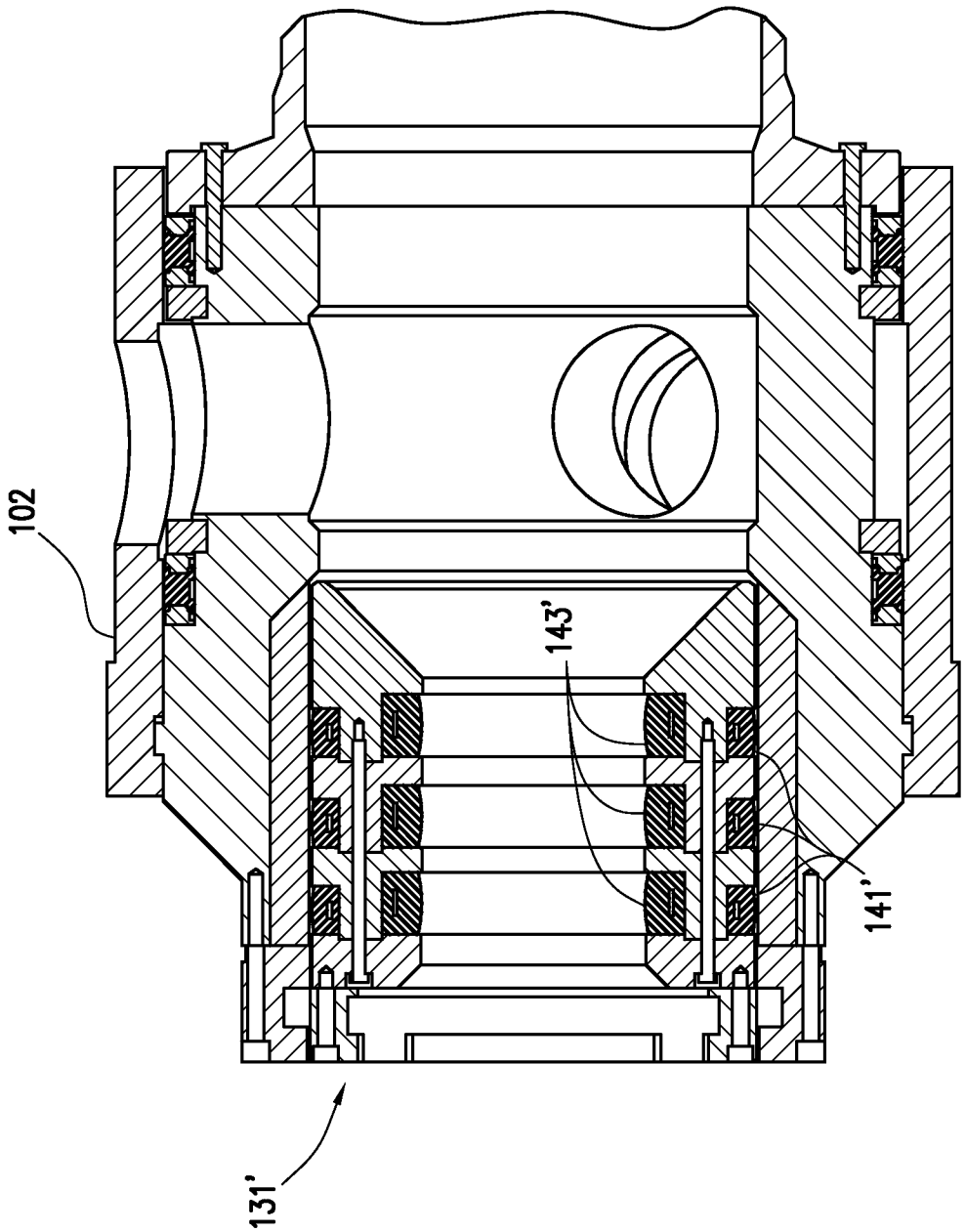

FIG. 5A

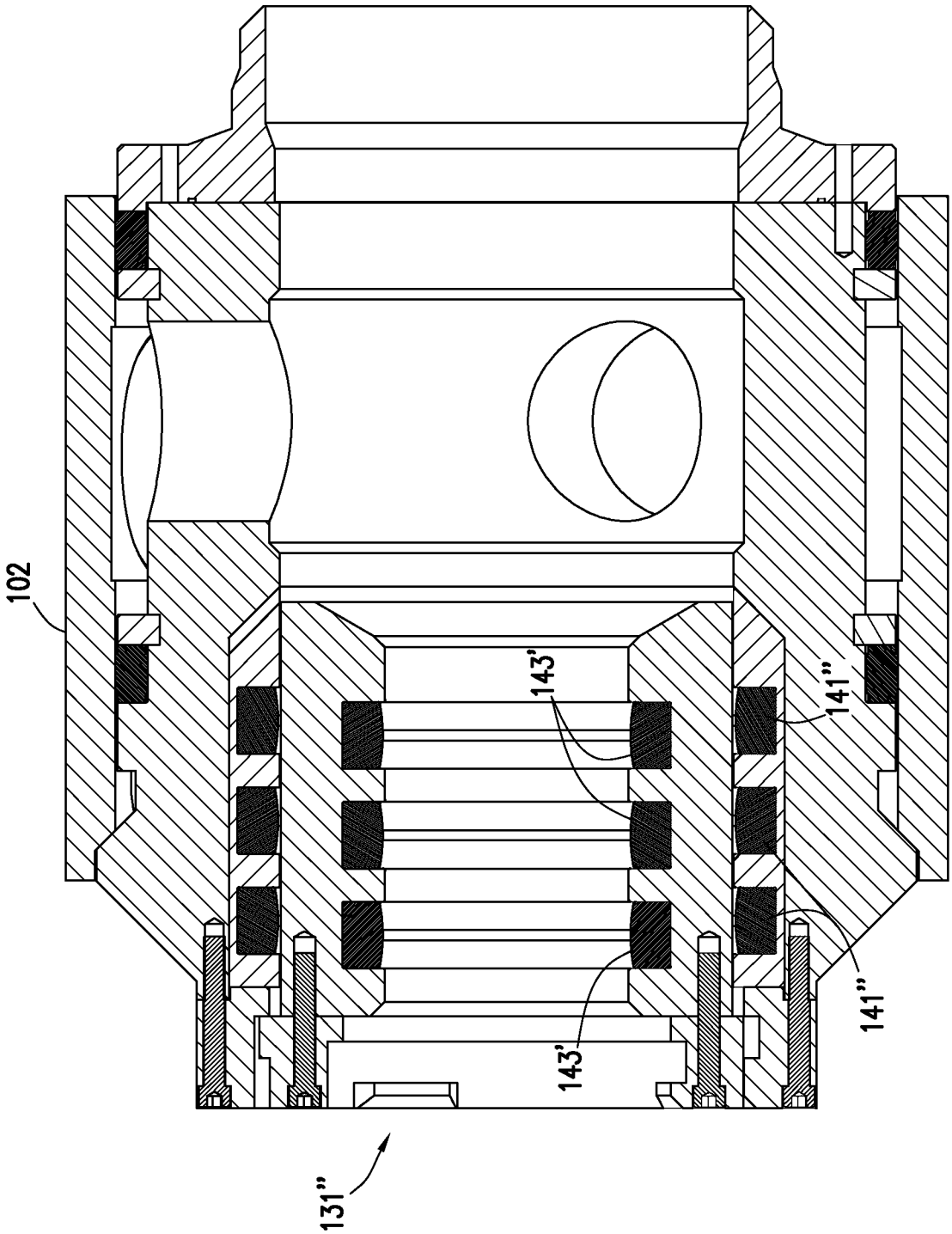

FIG. 5B

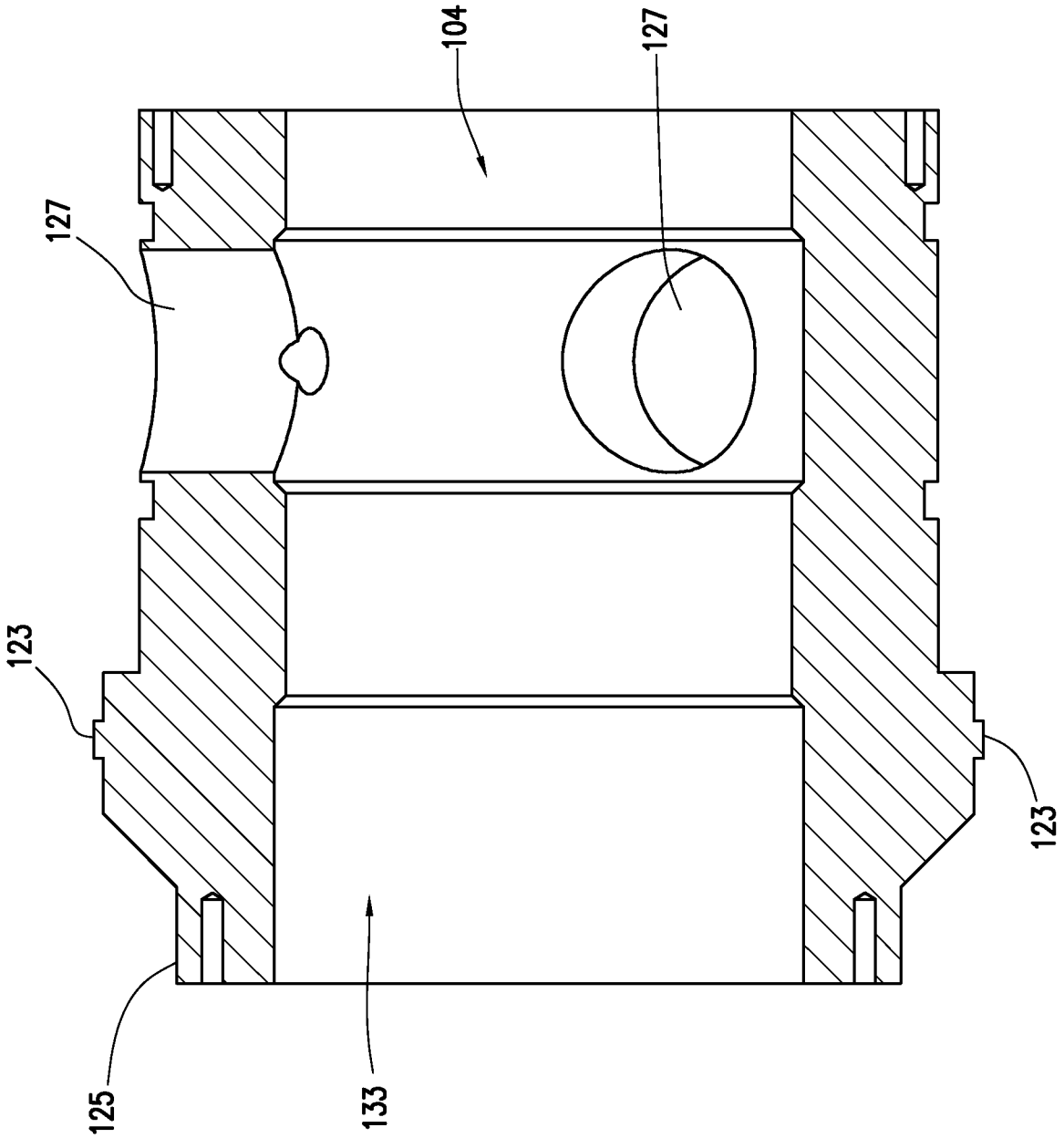

FIG. 6

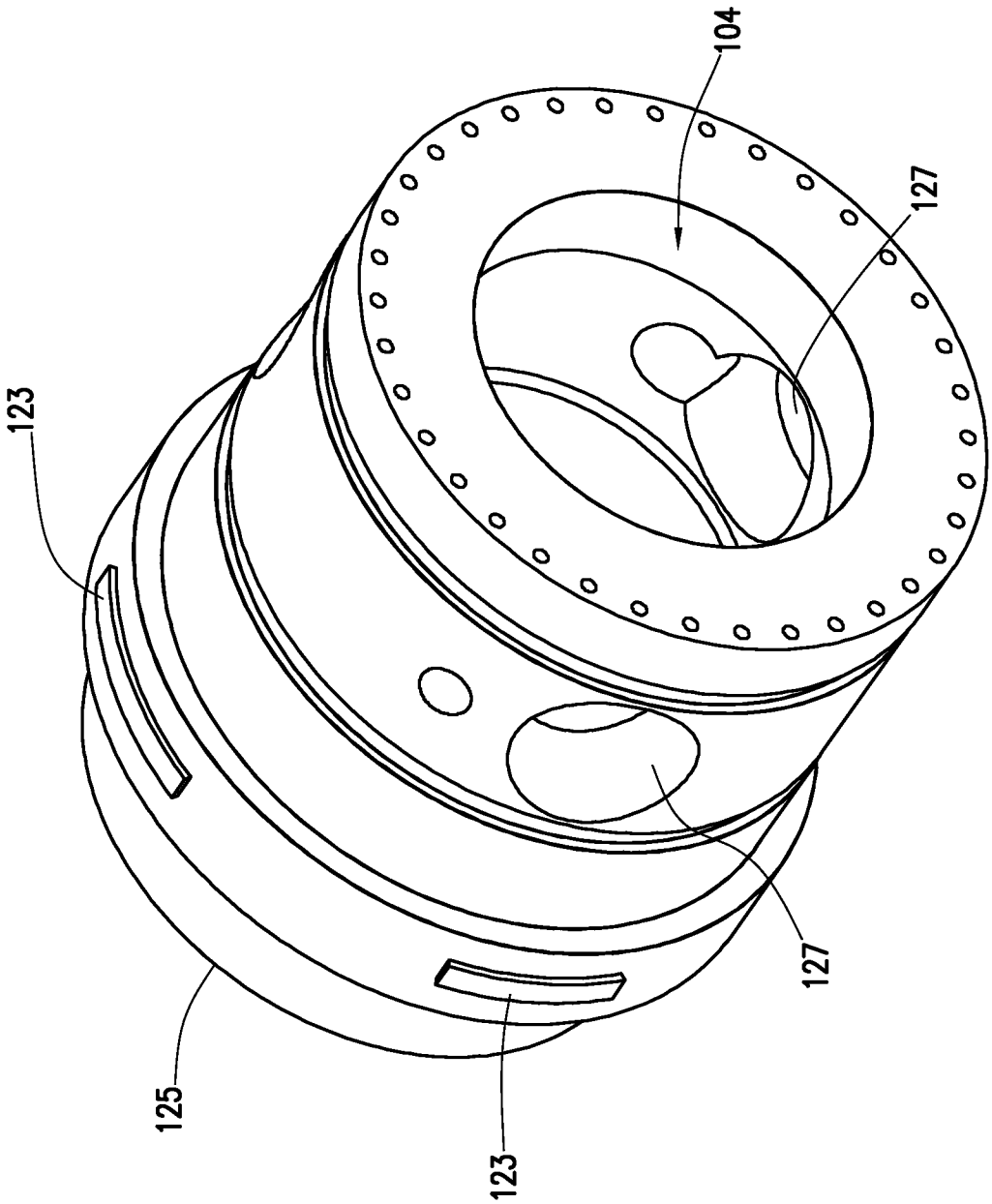

FIG. 7

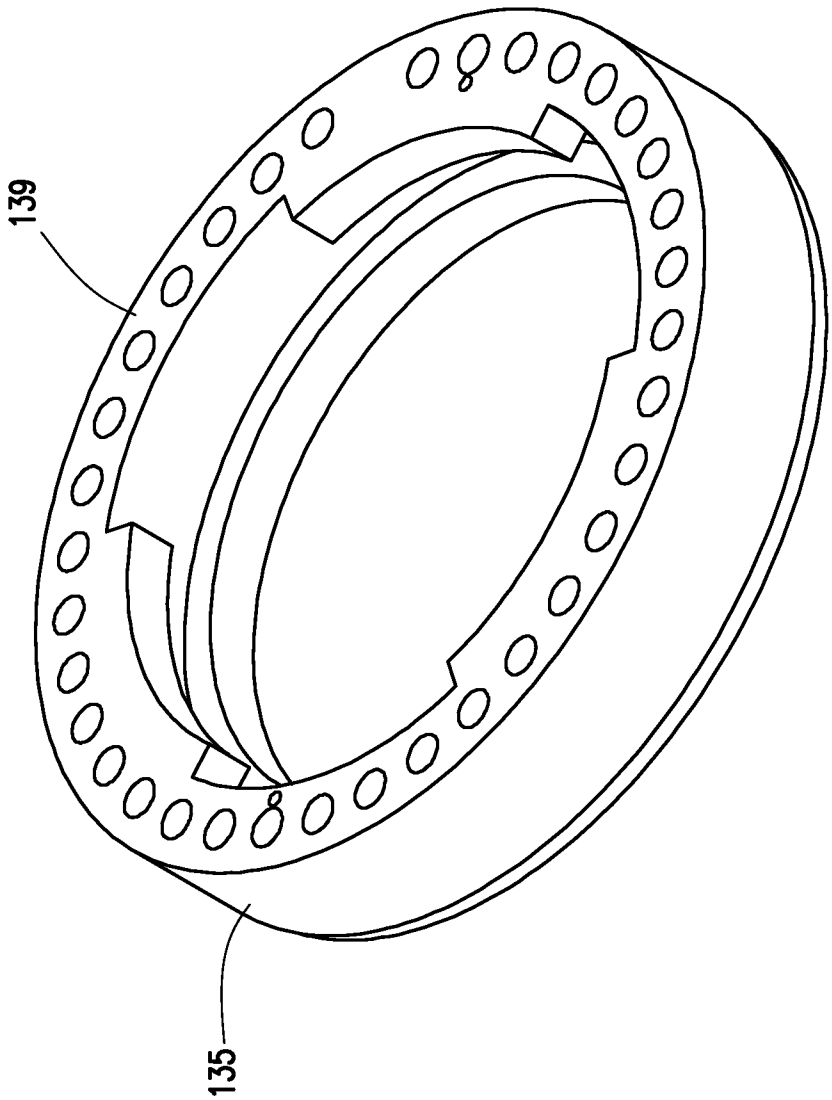

FIG. 8

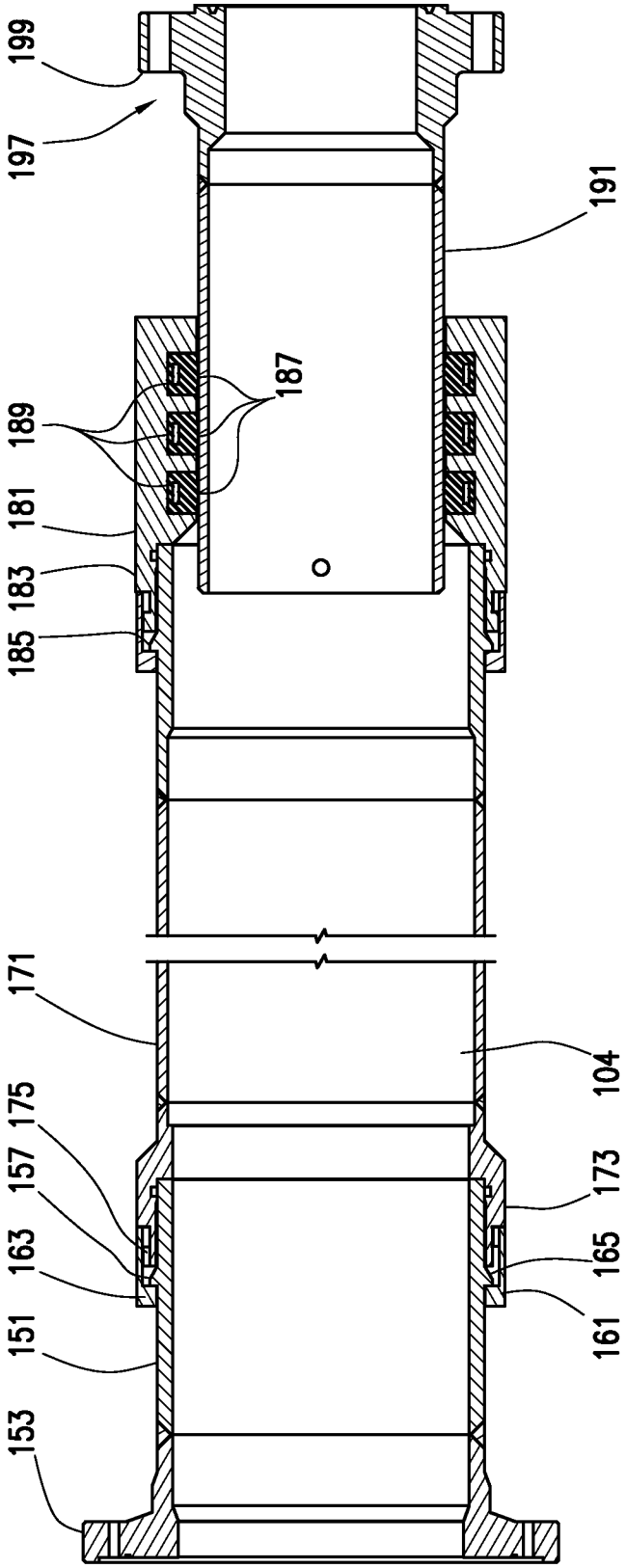
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FIG. 9

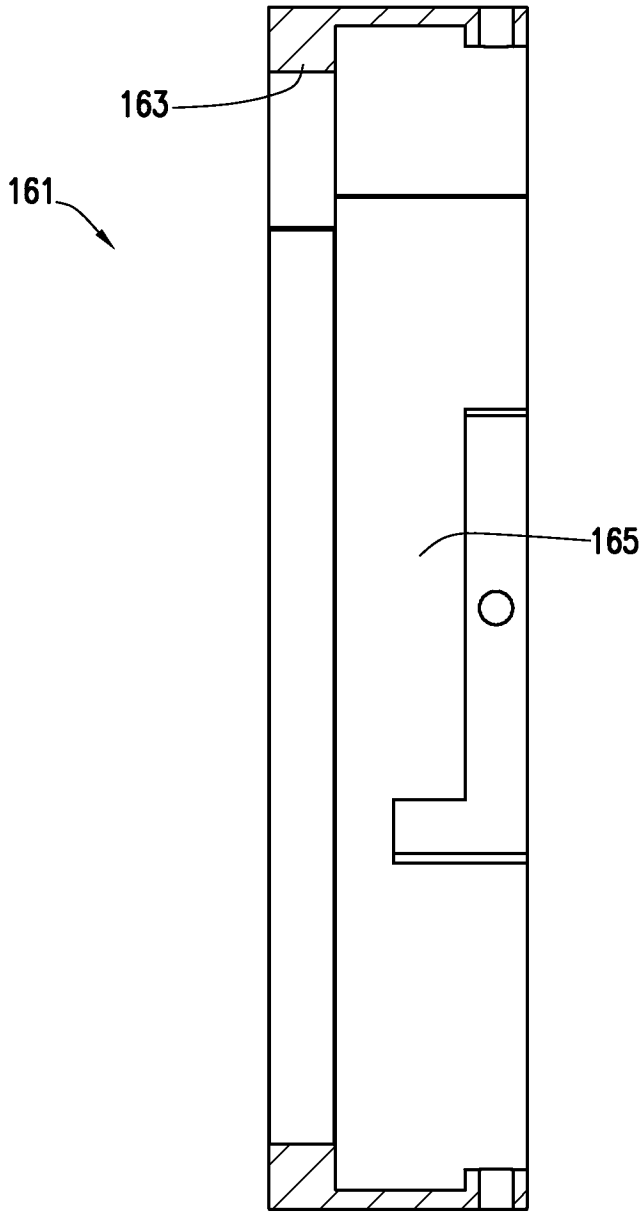

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/34804

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 17/046, E21B17/08, E21B19/16, E21B33/02, E21B33/038, F16B7/20, F16B21/04 (2016.01)
CPC - E21B 17/046, E21B17/085, E21B19/16, E21B33/02, E21B33/038, F16B7/20, F16B21/04
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)
IPC: E21B 3/04, 17/046, 17/08, 19/16, 33/02, 33/035, 33/038, 33/08, 33/126, 43/013; F16B 7/20, 21/04 (2016.01)
CPC: E21B 3/04, 17/046, 17/085, 19/16, 33/02, 33/035, 33/038, 33/08, 33/126, 43/013; F16B 7/20, 21/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 166/ 84.1, 85.3, 88.1, 84.4, 95.1, 347, 360, 368, 378; 277/322; 285/108, 109, 123.12, 324, 326, 351, 361, 396; 175/195, 214

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; EBSCO; Search Terms: diverter, breech, bayonet, lock, mount, block, joint, couple, connect, catch, tab, key, spline, stud, lug, projection, slot, notch, groove, channel, recess, ring, band, hoop, pack, seal, inflate, rotate, twist, turn, drill string, overshot, spool, spacer, riser

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,971,148 A (Roche, J. et al) 20 November 1990 (20.11.1990) figures 1A, 9A, 9B, 10A, 10B; column 1, lines 5-10, 20-25; column 5, lines 10-20, 25-40; column 10, lines 45-50, 60-68; column 11, lines 10-15, 20-30;	1-3, 14-16 ---------- 4-13, 17-20
Y	US 2014/0060805 A1 (Campbell, R. et al) 06 March 2014 (06.03.2014) figure 3; paragraph [0024]	4
Y	US 5,178,215 A (Yenulis, G. et al) 12 January 1993 (12.01.1993) figure 2; column 7, lines 15-25	5, 6, 17
Y	US 5,211,228 A (Watkins, B.) 18 May 1993 (18.05.1993) figures 1A-1C; column 1, lines 15-20; column 2, lines 30-40	7-13, 18-20
Y	US 2004/0207202 A1 (Parks, W.) 21 October 2004 (21.10.2004) figures 1-3, 5; paragraphs [0009], [0019], [0021]	9-13, 19, 20
A	US 8,720,574 B2 (Cuiper, G. et al) 13 May 2014 (13.05.2014) entire document	1-20
A	US 8,701,796 B2 (Weatherford/Lamb, Inc.) 22 April 2014 (22.04.2014) entire document	1-20
A	US 2011/0147009 A1 (Dupal, K. et al) 23 June 2011 (23.06.2011) entire document	1-20
A	US 6,244,359 B1 (Bridges, C. et al) 12 June 2001 (12.06.2001) entire document	1-20

☐ 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	Date of mailing of the international search report
04 August 2016 (04.08.2016)	30 AUG 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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