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(54) Title: EXPLOSIVE DISCONNECT

(57) Abstract: A coupling system includes a lower marine riser package having a connector at a bottom end and at least one blowout preventer pressure control element coupled to a wellhead and having a connector at an upper end. Explosively frangible fasteners are used to couple the connector on the lower marine riser package to the connector on the at least one blowout preventer pressure control element. A method for separating a lower marine riser package from a blowout preventer coupled to a subsea wellhead includes closing a least one pressure control element in the blowout preventer. At least one explosively frangible fastener coupling the blowout preventer to the lower marine riser package is detonated. The lower marine riser package is then lifted from the blowout preventer.

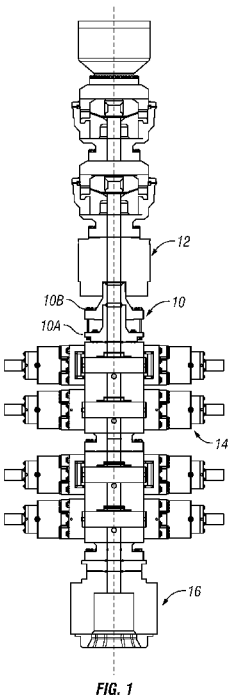


FIG. 1

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[Continued on next page]

Declarations under Rule 4.17:

— *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))*

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

EXPLOSIVE DISCONNECT

Background

[0001] This disclosure relates to the field of well pressure control apparatus. More particularly, the disclosure relates to methods and devices for quickly disconnecting a lower marine riser package (LMRP) or other device from a well pressure control device coupled to a subsea wellhead.

[0002] Marine wellbore drilling techniques known in the art include the use of a pressure control apparatus such as a blowout preventer ("BOP") disposed proximate the water bottom and coupled to the upper end of a surface conduit or casing disposed in the well (e.g., a "wellhead"). The BOP may comprise one or more sets of reversibly operable "ram=type" pressure control elements, for example, "blind rams" and "shear rams", and in some embodiments an annular seal. Blind rams fully close an interior bore of the BOP housing to hydraulically isolate the well below the BOP housing. Shear rams may be provided to enable cutting through conduit and/or drilling tools disposed within the interior bore in the BOP housing and subsequently closing to hydraulically isolate the well below the shear rams. Annular seals may be used where it is desired to hydraulically isolate the well while enabling a conduit such as drill pipe, or other drilling tools to pass through the interior bore of the BOP housing.

[0003] Each of the foregoing ram-type pressure control elements may be disposed in opposed pairs on the BOP housing and may be operated by respective hydraulic ram actuators, e.g., pistons disposed in respective cylinders. Hydraulic fluid pressure to operate the various ram-type pressure control elements and/or the annular seal may be controlled by an hydraulic fluid line extending from a control valve manifold to a drilling platform on the water surface, and by providing a plurality of accumulators each having hydraulic fluid and gas (e.g., nitrogen) under pressure to supply a relatively large volume of fluid rapidly in the event it becomes necessary to close any one or more of the pressure control elements in the BOP. The accumulators also can supply hydraulic fluid even in the event the hydraulic fluid line to the surface becomes blocked or disconnected. A

plurality of the foregoing types of pressure control elements may be connected to each other along the respective interior bores to form a BOP "stack."

[0004] A BOP "stack" (i.e., two or more of the foregoing types of well pressure control devices arranged longitudinally one atop the other) may be coupled, at one longitudinal end opposed to the longitudinal end connected to the wellhead, to a conduit (e.g., a "riser") that extends to a drilling platform proximate the water surface. Coupling to the riser may be through a set of devices called a "lower marine riser package" (LMRP). In certain situations, for example, adverse weather conditions, that make it desirable to move the riser and the drilling platform away from the well location, it then becomes necessary to disconnect the riser from the BOP stack. Disconnection may be performed, for example, by uncoupling the LMRP from the BOP stack after closing one or more pressure control elements in the BOP stack. Uncoupling may include, for example and without limitation, unthreading threaded connectors, removing coupling bolts from mating flanges and/or releasing a profile connector by rotating components of the LMRP.

[0005] Disconnecting the LMRP from the BOP stack in a station keeping emergency is a very important function for a BOP stack. It is known in the art to take one minute or longer to complete an emergency disconnect. Using known methods for LMRP disconnection such as by uncoupling the example devices described above may require that disconnection decisions are made early, e.g., dynamic positioning watch circles need to consider the disconnect time. In addition, permissible LMRP connector release angles can be smaller than flex joint angle ratings. That is, the LMRP release angle can be governing as to the amount of movement of the drilling platform during disconnect operations.

Summary

[0006] A coupling system according to one aspect of the present disclosure includes a lower marine riser package having a connector at a bottom end and at least one blowout preventer pressure control element coupled to a wellhead and having a connector at an upper end. Explosively frangible fasteners are used to couple the connector on the lower marine riser package to the connector on the at least one blowout preventer pressure

control element. A method for separating a lower marine riser package from a blowout preventer coupled to a subsea wellhead includes closing a least one pressure control element in the blowout preventer. At least one explosively frangible fastener coupling the blowout preventer to the lower marine riser package is detonated. The lower marine riser package is then lifted from the blowout preventer.

[0007] In some embodiments the connector on the lower marine riser package is coupled to the connector on the at least one blowout preventer pressure control element by the explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the at least one blowout preventer pressure control element.

[0008] In some embodiments the explosively frangible fasteners comprise explosively frangible nuts.

[0009] In some embodiments the connector on the at least one blowout preventer pressure control element comprises a profile connection at one longitudinal end.

[0010] In some embodiments the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

[0011] In some embodiments a plurality of blowout preventer pressure control elements are coupled to the wellhead.

[0012] In some embodiments the lower marine riser package comprises at least one blowout preventer pressure control element.

[0013] A method for separating a lower marine riser package from a blowout preventer coupled to a subsea wellhead according to another aspect of the present disclosure includes closing at least one pressure control element in the blowout preventer. At least one explosively frangible fastener coupling the blowout preventer to the lower marine riser package is detonated. The lower marine riser package is then lifted from the blowout preventer.

[0014] In some embodiments, prior to detonating the at least one explosively frangible fastener, at least one auxiliary line extending between the lower marine riser package and the blowout preventer is uncoupled.

[0015] In some embodiments a connector on the lower marine riser package is coupled to a corresponding connector on the blowout preventer by a plurality of explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the blowout preventer.

[0016] In some embodiments the explosively frangible fasteners comprise explosively frangible nuts.

[0017] In some embodiments the connector on the blowout preventer comprises a profile connection at one longitudinal end.

[0018] In some embodiments the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

Brief Description of the Drawings

[0019] FIG. 1 shows an example embodiment of a LMRP connected to a subsea BOP stack, wherein the subsea BOP stack is connected to a subsea wellhead.

[0020] FIG. 2 shows the example embodiment of FIG. 1 wherein the LMRP has been disconnected from the subsea BOP stack. The LMRP is shown canted at a relatively large angle with reference to the subsea BOP stack.

[0021] FIG. 3 shows a cross-section of an example embodiment of an explosive quick disconnect mandrel system according to the present disclosure.

[0022] FIG. 4 shows a perspective side view of the example embodiment shown in FIG. 3.

[0023] FIG. 5 shows a cross-section of the example explosive quick disconnect system of FIG. 3 after explosive removal of fasteners (e.g., studs and threaded nuts) that join an upper mandrel to a lower mandrel.

[0024] FIG. 6 shows a perspective side view of the illustration of FIG. 5.

Detailed Description

[0025] FIG. 1 shows an example embodiment of a lower marine riser package (LMRP) 12 connected to a subsea BOP "stack" 14 (i.e., a plurality of vertically assembled wellbore pressure control elements assembled to each other to produce a series connected set of well shut in valves), wherein the subsea BOP stack 14 is connected to a subsea wellhead (not shown) using a connector 16. A connector such as a double mandrel 10 may be used to connect the LMRP 12 to the BOP stack 14. The LMRP 12 may itself comprise one or more pressure control elements, or in some embodiments the LMRP 12 may not have any such pressure control elements.

[0026] The double mandrel 10 may comprise a lower mandrel 10A coupled to an upper end of the BOP stack 14 and an upper mandrel 10B coupled to a lower and of the LMRP 14. The lower mandrel 10A may be connected to the BOP stack 14, e.g., by a profile coupling, bolted flange, or any other connection known in the art. The upper mandrel 10B may be connected to the LMRP 12, for example, in any similar manner as the connection between the lower mandrel 10A and the BOP stack 14. A riser (not shown) may extend from the top of the LMRP 12 to a drilling platform (not shown) on the water surface. Although the BOP stack 14 shown in the various drawing figures and described herein may include a plurality of wellbore pressure control elements, for purposes of the present disclosure only one such pressure control element is needed.

[0027] FIG. 2 shows the LMRP 12 disconnected from the BOP stack 14 by uncoupling the lower mandrel 10A from the upper mandrel 10B. The lower mandrel 10A and upper mandrel 10B may be configured such that much greater angle between the longitudinal axis of the LMRP 12 and the BOP stack 14 may be obtained than by disconnect devices and methods known in the art.

[0028] In the present example embodiment, and referring to FIG. 3, such uncoupling may comprise detonating explosive frangible fasteners, for example explosively frangible nuts

10C and/or explosively frangible studs 10D which may couple a flange 10B1 on the upper mandrel 10B to a corresponding flange 10A1 on the lower mandrel 10A. Such explosively frangible nuts and/or explosively frangible studs may be obtained, for example, from Pacific Scientific Energetic Materials Company, 7073 West Willis Road, Chandler, Arizona 85226. Example products sold by the foregoing organization comprise frangible nuts which are broken apart by detonation of an explosive charge and explosive bolts which are similarly broken apart. In the present example embodiment, such frangible nuts 10C may be used on one or both ends of studs 10D that pass through openings in the upper mandrel flange 10B1 and lower mandrel flange 10A1. FIG. 4 shows a perspective side view of the coupled upper mandrel 10B and lower mandrel 10A, wherein explosive nuts 10C are used on one end of the studs 10D.

[0029] FIGS. 5 and 6 show, respectively, a cross section view and a perspective side view of the upper mandrel 10B being separated from the lower mandrel 10A after detonation of the explosively frangible fasteners (e.g., nuts 10C in FIGS. 3 and 4). The upper mandrel 10B may be separated from the lower mandrel 10A simply by lifting the LMRP (12 in FIG. 2) from the BOP stack (14 in FIG. 2). Profile connections 10B2 and 10A2 may be provided on one longitudinal end of each of the upper mandrel 10B and lower mandrel 10A respectively whereby the upper mandrel 10B may be coupled to the LMRP (12 in FIG. 2) using the profile connection 10B2. When the upper mandrel 10B is separated from the lower mandrel 10A, the profile connection 10A2 on the lower mandrel 10A may provide a mechanism to enable attaching devices to the lower mandrel 10A, e.g., to reconnect either the LMRP (12 in FIG. 2) or a capping stack to the BOP stack (14 in FIG. 2).

[0030] A system according to the present disclosure may comprise a BOP stack which is connected to the wellhead by a connector. A first mandrel with explosively frangible fasteners is located on top of the BOP stack. A lower marine riser package (LMRP) is connected to the mandrel by means of a connector. In some embodiments, the connector may be a second mandrel having a bolt flange corresponding to a bolt flange on the first mandrel. In some embodiments, the second mandrel may have a profile connector at one end for coupling to the LMRP. In some embodiments, the first mandrel may comprise a

profile connector similar in configuration to the profile connector on the second mandrel, whereby after separation of the two mandrels, a connection may be provided on the first mandrel to reconnect the LMRP or to connect a capping stack or other device to the BOP stack.

[0031] Auxiliary connections between the LMRP and the BOP stack may comprise choke and kill lines, boost lines, hydraulic and/or electric power lines and sensors.

[0032] In some embodiments, a double mandrel arrangement with explosive nuts may be used between the BOP stack and the LMRP. This would allow the first mandrel to be released from the lower stack but would still maintain an intact mandrel connection to reconnect either the LMRP or capping stack to the lower stack.

[0033] In some embodiments the explosively frangible fasteners could be attached to any other flanged connection on the BOP stack or LMRP. In some embodiments, explosively frangible studs, bolts, or another type of explosively frangible fastener could be used instead of explosively frangible nuts.

[0034] A method for separating a LMRP from a BOP stack according to some embodiments may comprise closing a pressure control element, e.g., a shearing element (either a static force operated shear ram or a kinetic energy operated shear ram) in a BOP stack coupled at its upper end to a lower marine riser package (LMRP). All auxiliary connections between the BOP stack and LMRP (if any are present) are disconnected. Explosively frangible fasteners that couple the LMRP to the BOP stack are detonated to separate the LMRP from the BOP stack. In some embodiments, reconnection of the LMRP to the BOP stack or coupling of another device such as a capping stack may be performed by latching dogs onto a connecting profile at one end of the mandrel or connector on an upper longitudinal end of a mandrel on the BOP stack.

[0035] Although only a few examples have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the examples. Accordingly, all such modifications are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function

and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 112(f), for any limitations of any of the claims herein, except for those in which the claim expressly uses the words "means for" together with an associated function.

Claims

What is claimed is:

1. A coupling system, comprising:
a lower marine riser package having a connector at a bottom end thereof;
at least one blowout preventer pressure control element coupled to a wellhead and having a connector at an upper end thereof;
explosively frangible fasteners disposed to couple the connector on the lower marine riser package to the connector on the at least one blowout preventer pressure control element.

2. The coupling system of claim 1 wherein the connector on the lower marine riser package is coupled to the connector on the at least one blowout preventer pressure control element by the explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the at least one blowout preventer pressure control element.

3. The coupling system of claim 1 wherein the explosively frangible fasteners comprise explosively frangible nuts.

4. The coupling system of claim 1 wherein the connector on the at least one blowout preventer pressure control element comprises a profile connection at one longitudinal end.

5. The coupling system of claim 1 wherein the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

6. The coupling system of claim 1 further comprising a plurality of blowout preventer pressure control elements coupled to the wellhead.

7. The coupling system of claim 1 wherein the lower marine riser package comprises at least one blowout preventer pressure control element.

8. A method for separating a lower marine riser package from a blowout preventer coupled to a subsea wellhead, comprising:

closing at least one pressure control element in the blowout preventer;

detonating at least one explosively frangible fastener coupling the blowout preventer to the lower marine riser package; and

lifting the lower marine riser package from the blowout preventer.

9. The method of claim 8 further comprising, prior to detonating the at least one explosively frangible fastener, uncoupling at least one auxiliary line extending between the lower marine riser package and the blowout preventer.

10. The method of claim 8 wherein a connector on the lower marine riser package is coupled to a corresponding connector on the blowout preventer by a plurality of explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the blowout preventer.

11. The method of claim 10 wherein the explosively frangible fasteners comprise explosively frangible nuts.

12. The method of claim 10 wherein the connector on the blowout preventer comprises a profile connection at one longitudinal end.

13. The method of claim 10 wherein the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

AMENDED CLAIMS
received by the International Bureau on 02 April 2018 (02.04.2018)

What is claimed is:

1. A coupling system, comprising:
a lower marine riser package having a connector at a bottom end thereof;
at least one blowout preventer pressure control element coupled to a wellhead and having a connector at an upper end thereof;
explosively frangible fasteners comprising explosively frangible nuts disposed to couple the connector on the lower marine riser package to the connector on the at least one blowout preventer pressure control element.

2. The coupling system of claim 1 wherein the connector on the lower marine riser package is coupled to the connector on the at least one blowout preventer pressure control element by the explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the at least one blowout preventer pressure control element.

3. The coupling system of claim 1 wherein the connector on the at least one blowout preventer pressure control element comprises a profile connection at one longitudinal end.

4. The coupling system of claim 1 wherein the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

5. The coupling system of claim 1 further comprising a plurality of blowout preventer pressure control elements coupled to the wellhead.

6. The coupling system of claim 1 wherein the lower marine riser package comprises at least one blowout preventer pressure control element.

7. A method for separating a lower marine riser package from a blowout preventer coupled to a subsea wellhead, comprising:
closing at least one pressure control element in the blowout preventer;

detonating at least one explosively frangible fastener coupling the blowout preventer to the lower marine riser package, the at least one explosively frsngible fastener comprising an explosively frangible nut; and

lifting the lower marine riser package from the blowout preventer.

8. The method of claim 7 further comprising, prior to detonating the at least one explosively frangible fastener, uncoupling at least one auxiliary line extending between the lower marine riser package and the blowout preventer.

9. The method of claim 7 wherein a connector on the lower marine riser package is coupled to a corresponding connector on the blowout preventer by a plurality of explosively frangible fasteners being disposed through a corresponding bolt flange on each of the connector on the lower marine riser package and the connector on the blowout preventer.

10. The method of claim 9 wherein the connector on the blowout preventer comprises a profile connection at one longitudinal end.

11. The method of claim 10 wherein the connector on the lower marine riser package comprises a profile connection to couple the connector on the lower marine riser package to the lower marine riser package.

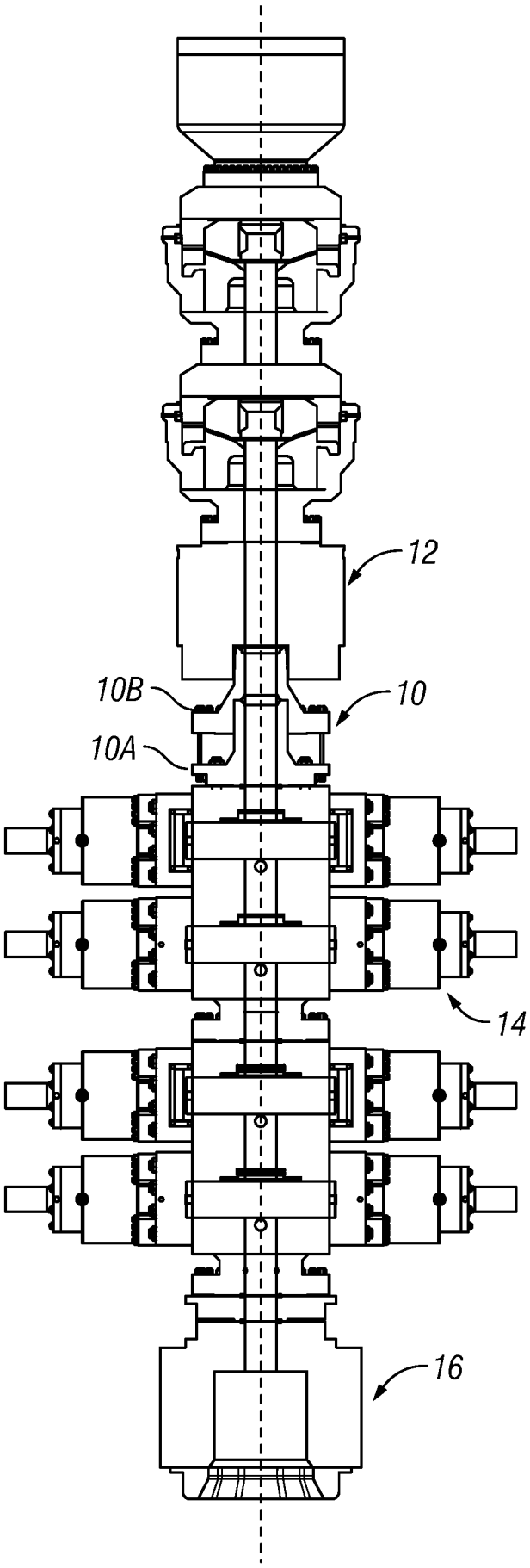


FIG. 1

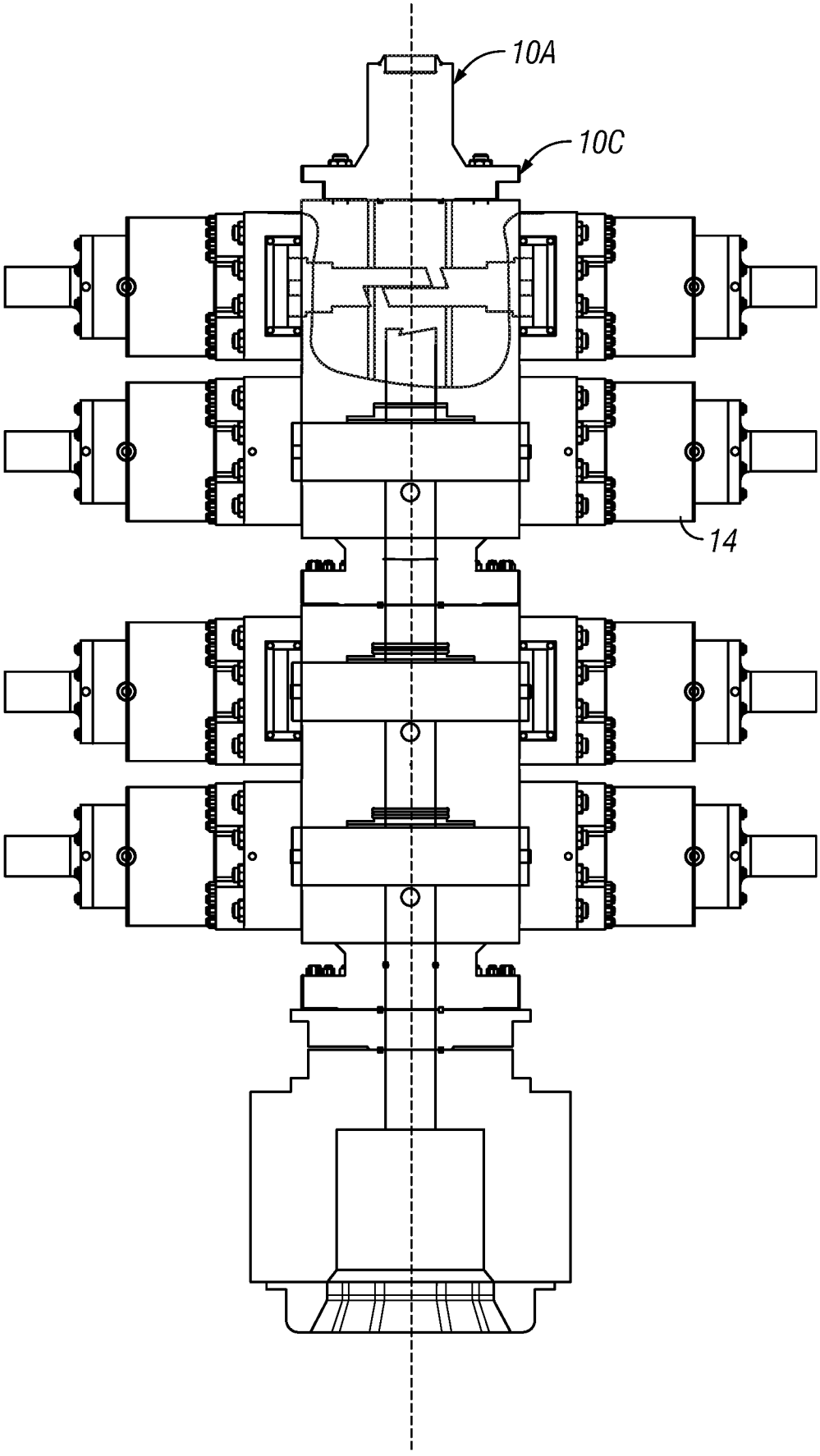


FIG. 2

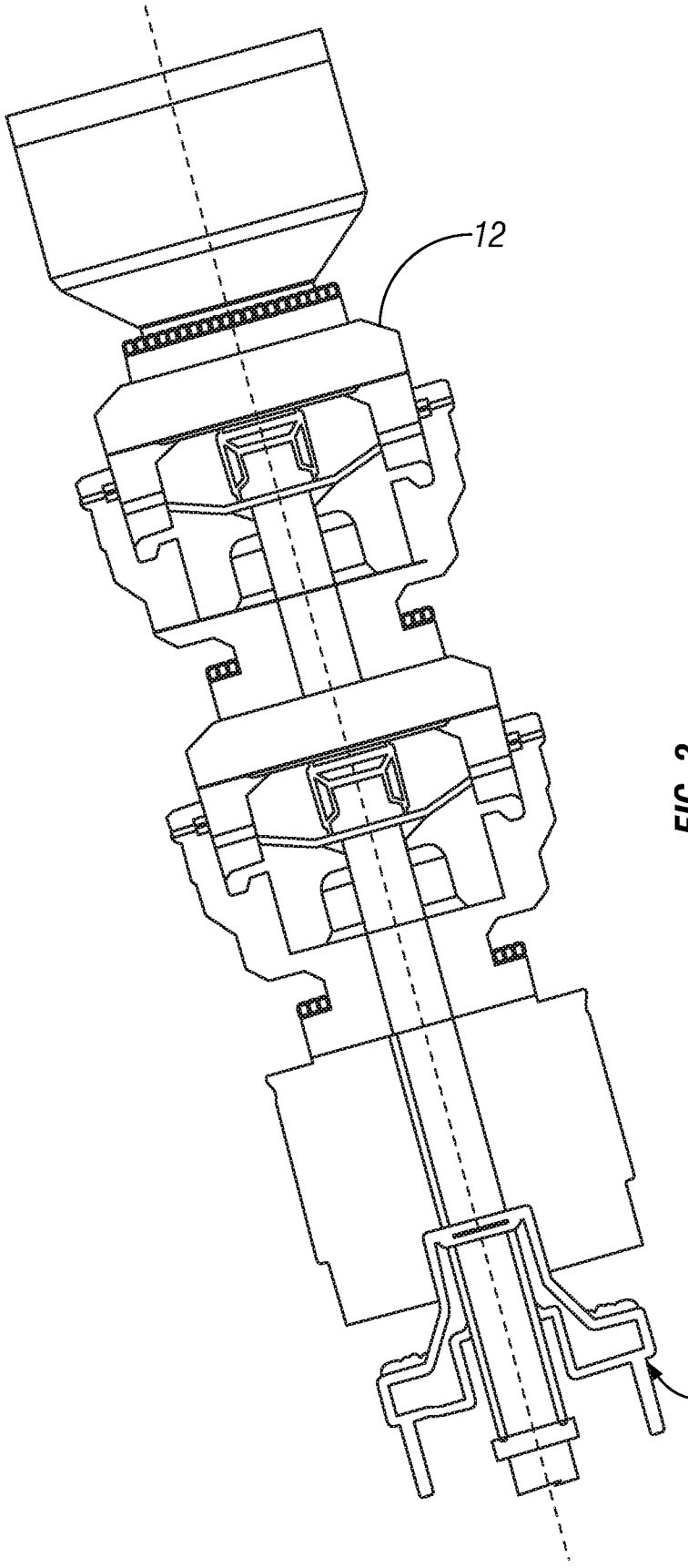


FIG. 2
(Cont'd)

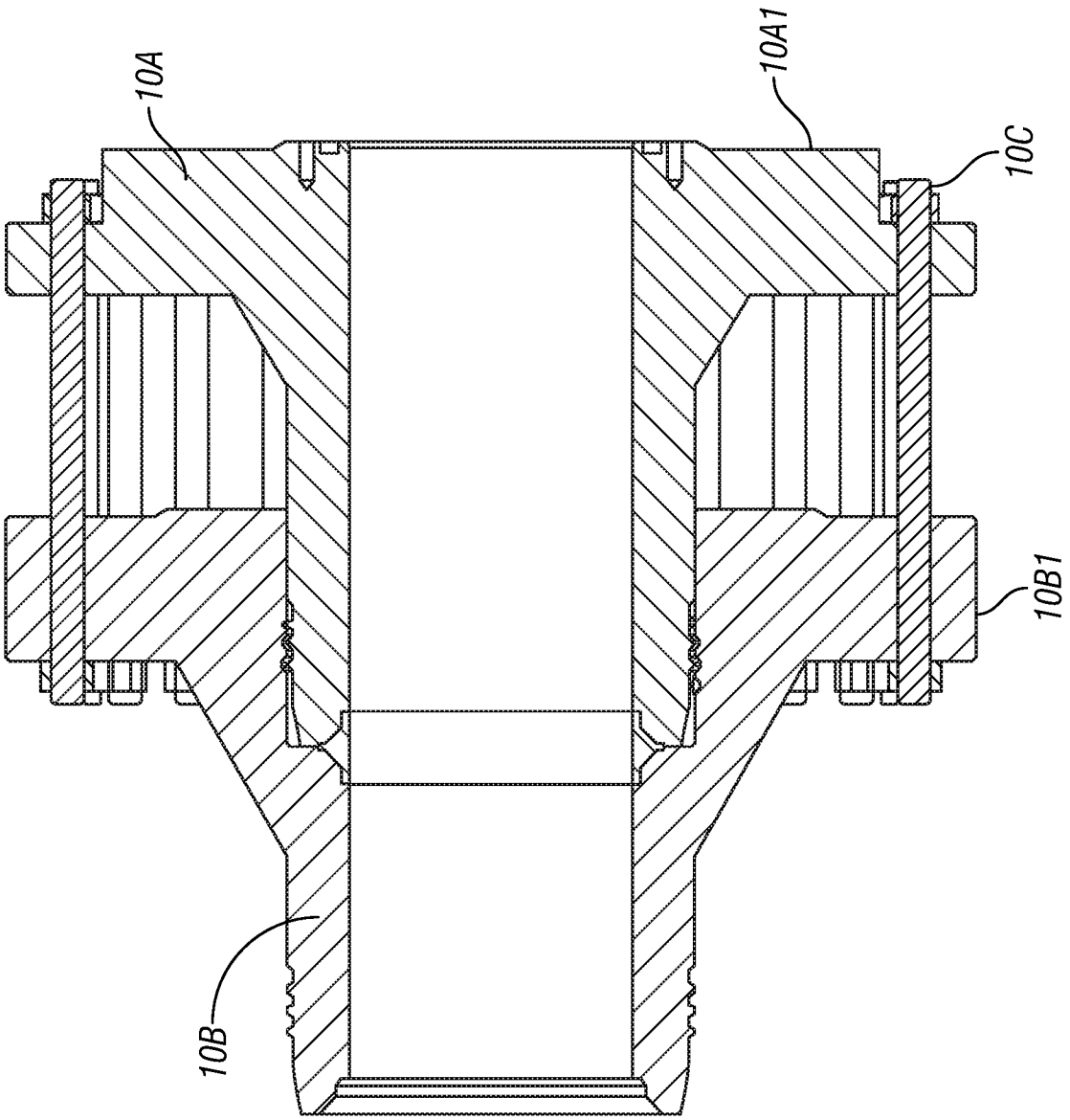


FIG. 3

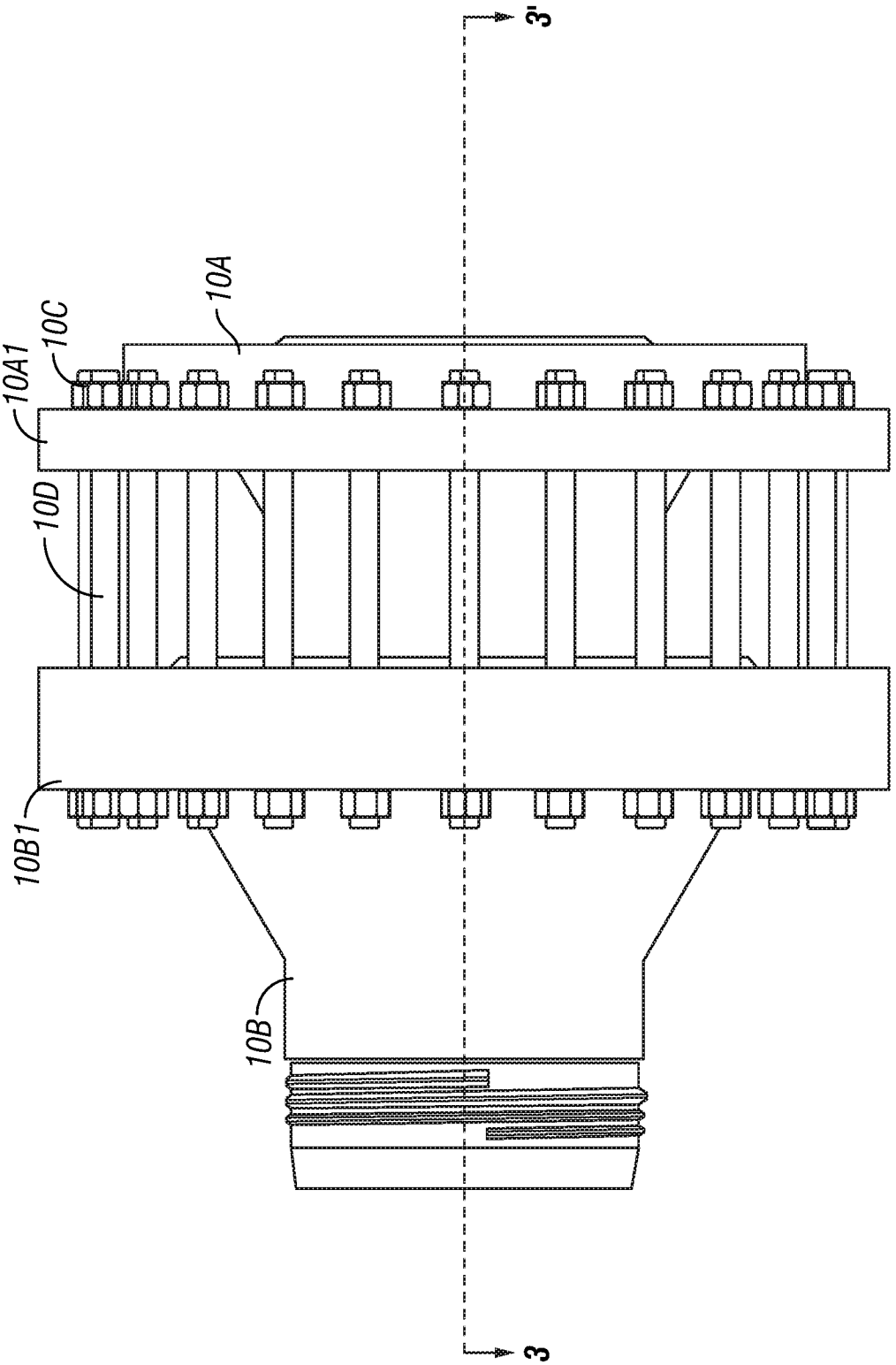


FIG. 4

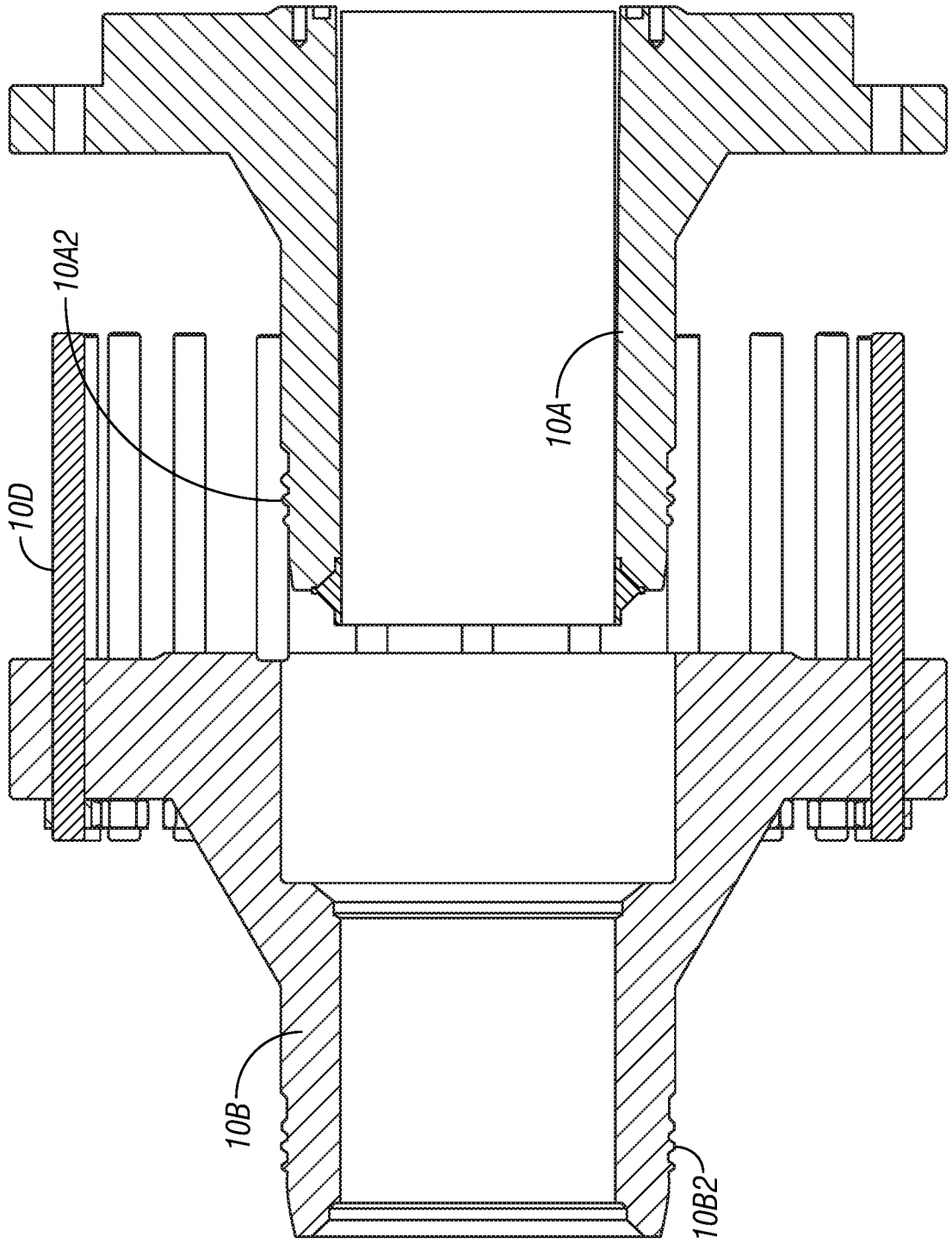


FIG. 5

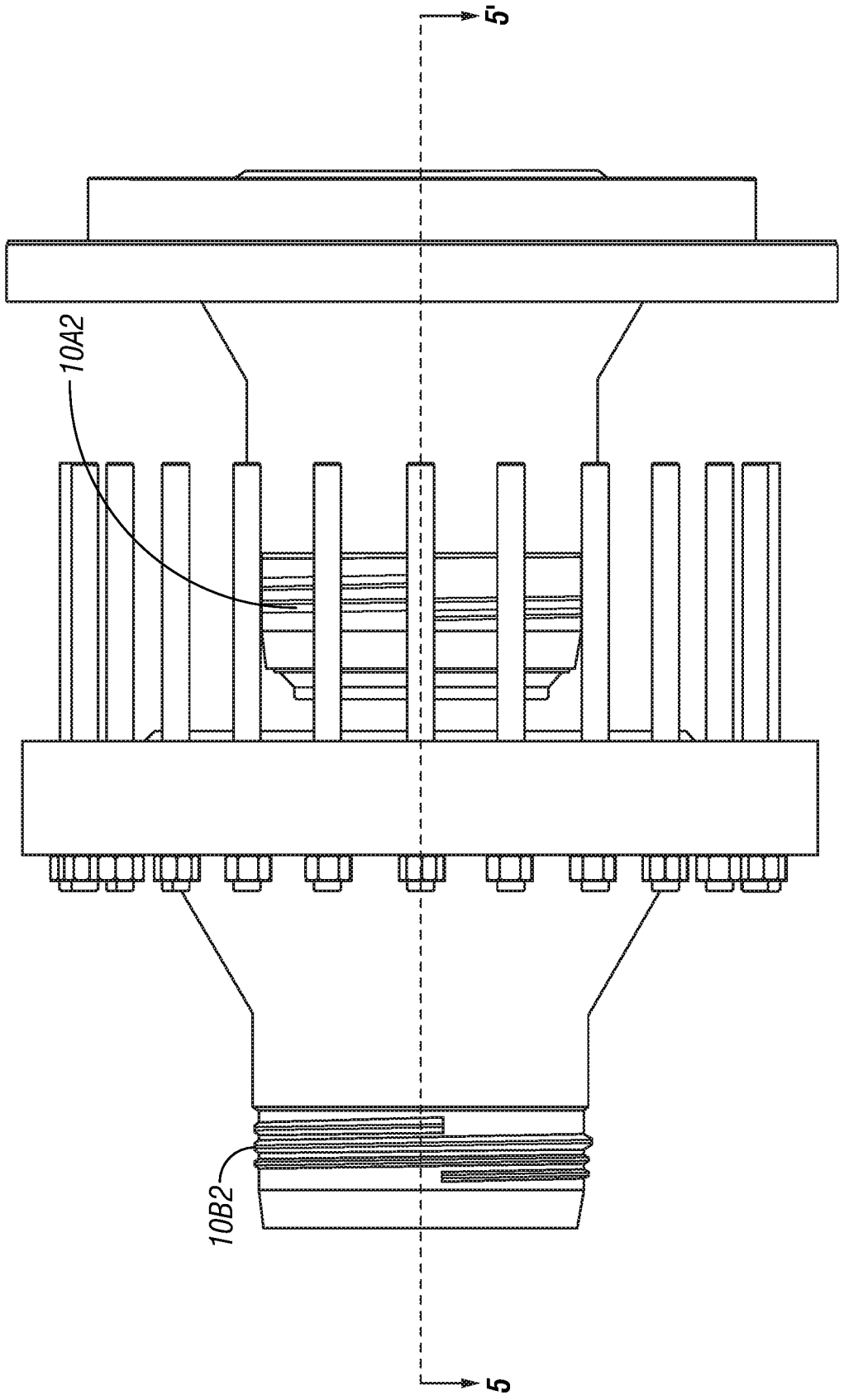


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/57826

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 33/035, E21B 33/064, E21B 43/01, E21B 7/12, E21B 29/12, E21B 33/06 (2018.01)
CPC - E21B 33/035, E21B 33/064, E21B 43/01, E21B 7/12, E21B 29/12, E21B 33/06

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)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

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 4,424,988 A (Cowx) 10 January 1984 (10.01.1984) Entire document especially col 2, ln 35-42; col 3, ln 3-16, 64-68; col 4, ln 1-11 and figs. 1 and 2	1, 2, 6-8, 10 ---------- 3-5, 9, 11-13
Y --- A	US 2001/0001633 A1 (Fisher) 24 May 2011 (24.05.2001) Entire document especially para [0036]-[0037] and figs. 1 and 8	1, 2, 6-8, 10 ---------- 3-5, 9, 11-13
Y	US 8,770,298 B2 (Gustafson) 8 July 2014 (08.07.2014) Entire document especially col 3, ln 3-13 and fig. 1	6, 7
A	US 2015/0345231 A1 (Thomas) 3 December 2015 (03.12.2015) Entire document especially para [0029] and figs. 1 and 2	3, 11
A	US 2013/0192843 A1 (Abel) 1 August 2013 (01.08.2013) Entire document	1-13
A	US 2014/0190703 A1 (Tennant et al.) 10 July 2014 (10.07.2014) Entire document	1-13
A	US 2004/0099420 A1 (Kotria et al.) 27 May 2004 (27.05.2004) Entire document	1-13
A	US 2011/0247827 A1 (Humphreys) 13 October 2011 (13.10.2011) Entire document	1-13
A	US 6,227,300 B1 (Cunningham et al.) 8 May 2001 (08.05.2001) Entire document	1-13

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

* Special categories of cited documents:
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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	Date of mailing of the international search report
10 January 2018	05 FEB 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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