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14/132,743 18 December 2013 (18.12.2013) US(71) Applicant: **BAKER HUGHES INCORPORATED**
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74014 (US).(74) Agent: **HENDRYX, Thomas, N.**; Baker Hughes Incorporated,
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AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
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MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
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GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
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(54) Title: ROTATING FLEXIBLE JOINT FOR USE IN SUBMERSIBLE PUMPING SYSTEMS

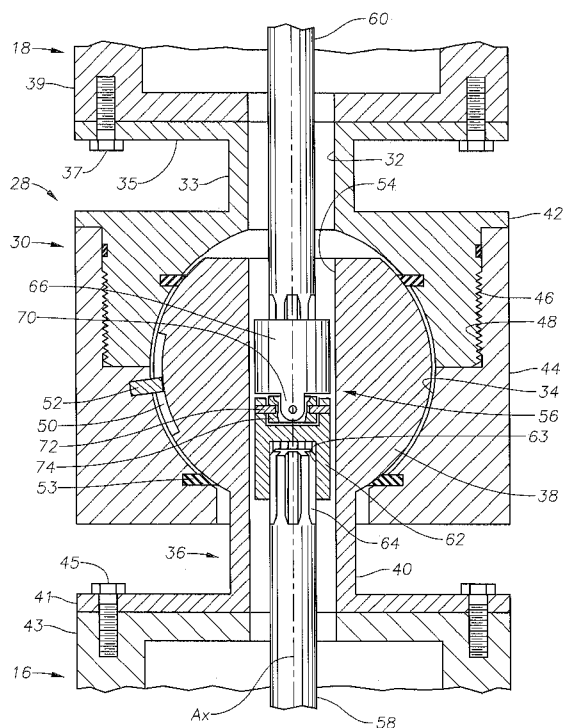


FIG. 2

(57) Abstract: An electrical submersible pumping system (ESP) for pumping fluids from a wellbore is made of segments, which include a motor, a seal section, a pump, and a shaft assembly connected to an output of the motor drives the pump. The motor, seal section, and pump are elongate members and coupled end to end to one another by housing connectors and shaft connectors. At least one of the housing connectors and shaft connectors have portions that are pivotable with other portions, so that adjacent segments of the ESP system can pivot with respect to one another. The housing connector can be a ball and socket assembly, where the ball fits within a spherically shaped chamber in the socket assembly. Opposing ends of the housing connector can mount to respective segments by threads or bolt flanges. The pivotal shaft connector may be a universal joint.



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ROTATING FLEXIBLE JOINT FOR USE IN SUBMERSIBLE PUMPING SYSTEMS

Cross-Reference to Related Application:

This application claims priority to and the benefit of co-pending U.S. Non-Provisional Application 14/132,743, filed December 18, 2013, and co-pending U.S. Provisional Application 61/739561, filed December 19, 2012, the full disclosure of which is hereby incorporated by reference herein for all purposes.

Field of the Disclosure:

The present disclosure relates in general to electrical submersible well pump assemblies, and in particular to a well pump assembly having segments that are coupled to each other by a connector that allows pivoting between adjacent segments.

Background:

In oil wells and other similar applications in which the production of fluids is desired, a variety of fluid lifting systems have been used to pump the fluids to surface holding and processing facilities. It is common to employ various types of downhole pumping systems to pump the subterranean formation fluids to surface collection equipment for transport to processing locations. One such conventional pumping system is a submersible pumping assembly which is supported and immersed in the fluids in the wellbore. The submersible pumping assembly includes a pump and a motor to drive the pump to pressurize and pass the fluid through production tubing to a surface location. A typical electrical submersible pump assembly ("ESP") includes a submersible pump, an electric motor and a seal section interdisposed between the pump and the motor. Sometimes the ESP assembly can include a separator to isolate fluids of different phases from one another. Depending on the particular application, the pump is usually a centrifugal pump or a progressing cavity pump.

Not all wells from which fluid is pumped with an ESP assembly are vertical. Some wells are deviated, i.e. not vertical, and some have are highly deviated and include horizontal portions. Because the upper portions of substantially all wells are vertical, wells having a horizontal portion bend when transitioning from vertical to horizontal. The bend in the well can introduce difficulties when deploying the ESP assembly, as the segments of the ESP assemblies form an elongate rigid member; which must flex to the same radius as the bend when being inserted downhole.

Summary:

The electrical submersible pump assembly disclosed herein has segments attached end to end and including a motor, a pump, and a seal section between the pump and the motor. Each of the segments has a housing and a rotatable shaft. At least one pivotal housing connector is attached between the housings of adjacent segments, allowing pivoting of the housings relative to each other. At least one pivotal shaft connector is attached between the shafts of adjacent segments. The shaft connector allows pivoting of the shafts of adjacent segments.

Preferably, the pivotal shaft connector is a universal joint mounted within the pivotal housing connector. The pivotal housing connector prevents axial rotation of one of the housings relative to the other of the housings. In the embodiment shown, the pivotal housing connector has two flanges facing in opposite directions. The flanges are bolted or secured by threads to the housings.

The pivotal housing connector may comprises a ball and socket arrangement. A key and slot located between the socket and the ball element prevent axial rotation of one of the housings relative to the other of the housings.

Brief Description of the Drawings:

Some of the features and benefits of the present disclosure having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a side partial sectional view of an example of an electrical submersible pumping (ESP) system disposed in a deviated wellbore in accordance with the present disclosure.

Figure 2 is a side sectional view of an example of a connector for pivotingly connecting adjacent segments of the ESP system of Figure 1 and in accordance with the present disclosure.

While the subject device and method will be described in connection with the preferred embodiments but not limited thereto. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the present disclosure as defined by the appended claims.

Detailed Description:

The present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which exemplary embodiments of the disclosure are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout.

Figure 1 is a side partial sectional view of an example of an electrical submersible pump assembly 10 deployed within a wellbore 12 that has a vertical portion 14A and a deviated portion 14B, both normally being cased. Deviated portion 14B may be horizontal. The embodiment of the pump assembly 10 illustrated includes a motor 16 on its lower end whose upper end is coupled with a seal section 18. Seal section 18 has means, such as a bladder, for reducing a pressure differential between lubricant in the motor and hydrostatic well fluid pressure. An optional separator 20 is shown attached on an upper end of seal section 18 and distal from motor 16. A pump 22 is shown mounted onto an end of separator 20 distal from seal section 18. Production tubing 24 is shown connected to an end of pump 22 opposite separator 20 and extending upward through the wellbore 12. An upper end of the production tubing 24 terminates within a wellhead assembly 26 shown mounted on surface above an opening to the wellbore 12. An inlet 27 is shown formed through a side wall of separator 20 which allows for fluid within wellbore 12 to enter the pump assembly 10. Inside the separator 20, different phases within the fluid (not shown) are isolated from one another. Liquid extracted from the wellbore fluid is directed to the pump 22, where it is pressurized and delivered to production tubing 24 for delivery to the wellhead assembly 26. The vapor fraction of the wellbore fluid can be directed

up the wellbore 12 to the wellhead assembly 26, and outside of the pump assembly 10. Embodiments of a pump assembly 10 not having a separator 20 exist, in these embodiments inlet 27 may be provided on the pump 22.

The segments of the pump assembly 10, e.g., motor 16, seal section 18, separator 20, and pump 22, are connected to one another by connectors 28 shown set between each adjacent segment. Each connector 28 is pivotable, so that the segments that it joins can pivot relative to each other when passing through the transition between well vertical portion 14A and horizontal portion 14B. . That is, each segment can pivot into an orientation with its axis oblique to an axis of an adjacent segment. Thus when the pump assembly 10 encounters a curved transition in the wellbore 12, the pivoting connectors 28 introduces pliability to the pump assembly 10 so it can flex to a curved shape of the wellbore 12 and be inserted past the bend in the wellbore 12.

Alternately, some of the connectors between segments could be rigid, non pivoting types, and others could be pivotal connectors 28. As an example, some of the segments of pump assembly 10 are much longer than others, such as a length of motor 16 versus seal section 18. An operator may choose to employ a rigid connection between motor 16 and seal section 18, as an example. Also, motor 16 could be tandem motors coupled together and pump 22 could comprise tandem pumps 22. The tandem components could be coupled together by conventional rigid connectors or by pivotal connectors 28.

Referring now to Figure 2, an example of a connector 28 is shown in a side sectional view. Figure 2 illustrates the connector 28 connecting between seal section 18 and motor 16, but the description applies to the other modules of pump assembly 28, as well. Further, even though connector 28 is shown connecting motor 16 with seal section 18, a conventional non pivotal

connector could be employed between motor 16 and seal section 18, and pivotal connector 28 employed elsewhere in pump assembly 10.

Connector 28 includes a housing connector or socket assembly 30 having a passage or bore 32 extending along an axis A_X of the socket assembly 30. A curved cavity 34, which may be spherical, is formed within the socket assembly 30 and circumscribes a mid-portion of bore 32; socket cavity 34 movably receives therein a male portion 36 of socket assembly 30. The male portion 36 of socket assembly 30 has a curved member shown to be spherically-shaped ball 38 shown set within cavity 34.

Socket assembly 30 has an annular collar 33 with an external flange 35 on an end opposite cavity 34. External flange 35 threadingly secures to a housing 39 of seal section 18, such as by bolts 37. Alternately, flange 35 could be rigidly connected in other manners, such as by external threads on flange 35 that engage internal threads in seal section housing 39.

Male portion 36 has an annular collar 40 extending downward from ball 38 to outside of the socket assembly 30. Collar 40 has a flange 41 that threadingly couples to a housing 43 of motor 16, such as by bolts 45. Alternately, the outer diameter of flange 41 could have external threads that engage internal threads in housing 43. Connector 28 could be inverted with flange 41 rigidly connecting to seal section 18 and flange 35 rigidly connecting to motor 16.

The socket assembly 30 is shown having a male end 42 that threadingly couples to a female end 44, where female end 44 circumscribes a portion of the ball 38 adjacent collar 40, and also circumscribes a portion of collar 40. Male end 42 circumscribes a portion of ball 38 distal from collar 40. Included with male end 42 is an annular external pin portion 46 that extends axially towards the collar 40 and has threads provided along at least some of its outer

surface. Pin portion 46 inserts into a box 48 that is coaxially formed within female end 44 and configured to receive pin portion 46 therein. Threads provided along an inner surface of box 48 mate with threads on the outer portion of pin 46 to form a threaded connection that extends coaxially around axis A_x . In one example of assembly of the connector 28, while male and female ends 42, 44 are initially disconnected from one another, ball portion 36 inserts into spherical cavity 34 and is oriented so that collar 40 projects through an opening formed in the side of female end 44 formed by bore 32. With ball 38 positioned inside cavity 34, the pin 46 on male end 42 can be inserted within box 48 on female end 44, and a threaded connection formed to couple together male and female ends 42, 44.

A slot 50 and key 52 are located between ball 38 and spherical cavity 34 to restrict pivotal movement of ball 38 in cavity 34 to a single plane. Figure 2 shows key 52 mounted to a circumferential portion of cavity 34 and slot 50 on ball 38, but that arrangement could be reversed. Slot 50 is elongated more than a height of key 52 to enable ball 38 to pivot at an oblique angle relative to axis A_x . Slot 50 and key 52 prevent rotation of ball 38 in socket 34 about axis A_x , thus connectors 28 prevent axial rotation of the housings of the various segments of ESP 10 relative to each other. Arrangements other than slot 50 and key 52 are feasible to prevent rotation of ball 38 in cavity 34 about axis A_x are feasible.

Still referring to Figure 2, a passage or bore 54 is shown formed axially through the ball portion 36 and generally coaxial with axis A_x . Bore 54 is in fluid communication with passage 32, and both are in fluid communication with interior portions of seal section 18 and motor 16. Preferably bores 32 and 54 are sealed from exterior well fluid, and this may be done with seals 53 that seal between socket cavity 34 and ball 38. In this example, one seal 53 is

mounted to male end 42 within cavity 34 and another to female end 44 within cavity 34, but other arrangements are feasible.

A pivotal shaft connector or coupling assembly 56, shown set within bore 54, rotationally couples motor shaft 58 to seal section shaft 60. Shaft coupling assembly 56 transmits torque between shafts 58, 60 and allows shafts 58, 60 to tilt oblique to axis Ax. Shaft coupling assembly 56 is preferably a universal joint. In the example of Figure 2, shaft coupling assembly 56 has a first coupling member 62 and a second coupling member 66. First coupling member 62 is shown in cross section, and second coupling member 66 is shown in a side view. Each coupling member 62, 66 has an internal splined receptacle 63. Each shaft 58, 60 has a splined end 64 that inserts into and meshes with one of the splined receptacles 63.

Each shaft coupling member 62, 66 has circumferentially spaced apart lugs 70 on the end opposite its splined receptacle 63. Lugs 70 extend axially and are spaced apart 180 degrees. Pins 72 extend between lugs 70 and a central gimbal 74, which may be a cylindrical disk. Lugs 70 and pins 72 on one of the coupling members 62, 66 are spaced 90 degrees from those on the other coupling member 62, 66. Coupling members 62, 66 allow tilting of shafts 58, 60 relative to each other, but still transmit rotation. Shaft coupling assembly 56 is centrally located within ball bore 54 and sealed from well fluids by seals 53. Other types of shaft coupling assemblies 56 rather than the universal joint shown are feasible.

During operation, the operator secures the various segments, such as motor 16, seal section 18, pump 20, and optionally gas separator 22 with connectors, at least one of which will be a pivotal connector 28. While lowering the pump assembly 10 in cased well 12, the segments can pivot relative to each other when reaching the transition between the vertical

portion 14A and the inclined portion 14B of well 12. While pivoting, ball 38 will pivot relative to cavity 34 oblique to axis Ax, rotating about a center point of ball 38 along the portion of axis Ax within ball bore 54. Similarly, shaft coupling 62 will pivot relative to shaft coupling 66 about a center point of gimbal 74 perpendicular to the portion of axis Ax passing through shaft coupling 56. The center or pivot points of socket assembly 30 and shaft connector 56 may coincide with each other.

When reaching the desired depth, typically pump assembly 10 will be within a straight portion of the inclined section 14B of well 12. Motor 16, seal section 18, separator 20 and pump 22 will again be co-axial with each other. The operator supplies electrical power to motor 16, which causes shaft 58 to rotate. Shaft coupling 56 transmits the rotation to seal section shaft 60. The various couplings between the shafts of the segments of pump assembly 10 cause pump 22 to operate and pump fluid from the well. Housings 39 and 43 of seal section 18 and motor 16 do not rotate about their axes. Slot and key 50, 52 prevent housings 39 and 43 from axial rotation relative to each other. Pump assembly 10 can also be operated with segments within a curved transition of well 12. Shaft coupling 56 will transmit rotation of shaft 58 to shaft 60 even when the axis of shaft 58 is inclined relative to the axis of shaft 60.

It is understood that variations may be made in the above without departing from the scope of the disclosure. While specific embodiments have been shown and described, modifications can be made by one skilled in the art without departing from the spirit or teaching of this disclosure. The embodiments as described are exemplary only and are not limiting. Many variations and modifications are possible and are within the scope of the disclosure. Accordingly, the scope of protection is not limited to the embodiments described, but is only

limited by the claims that follow, the scope of which shall include all equivalents of the subject matter of the claims.

Claims:

1. An electrical submersible pump assembly disposable within a wellbore comprising:

segments attached end to end and including a motor, a pump, and a seal section between the pump and the motor;

each of the segments having a housing and a rotatable shaft mounted therein;

at least one pivotal housing connector attached between the housings of adjacent ones of the segments, allowing pivoting of the housings of the adjacent ones of the segments relative to each other; and

at least one pivotal shaft connector attached between the shafts of the adjacent ones of the segments, the shaft connector allowing pivoting of the shafts of the adjacent ones of the segments.

2. The assembly according to claim 1, wherein the pivotal shaft connector is mounted within the pivotal housing connector.

3. The assembly according to claim 1, wherein each of the housings of the adjacent ones of the segments has a longitudinal axis, and the pivotal housing connector prevents axial rotation of one of the housings relative to the other of the housings of the adjacent ones of the segments.

4. The assembly according to claim 1, wherein:

the pivotal housing connector has two flanges facing in opposite directions;

one of the flanges is secured by threads to the housing of one of the segments of the adjacent ones of the segments; and

the other of the flanges is secured by threads to the housing of the other of the segments of the adjacent ones of the segments.

5. The assembly according to claim 1, wherein:

the at least one pivotal housing connector comprises a plurality of the pivotal housing connectors; and

the at least one pivotal shaft connector comprises a plurality of the pivotal shaft connectors.

6. The assembly of claim 1, wherein the pivotal housing connector is configured to allow pivotal movement in a single plane of the housing of one of the segments relative to the housing of the other segment of the adjacent ones of the segments.

7. The assembly of claim 1, wherein the pivotal housing connector comprises a ball and socket arrangement.

8. The assembly of claim 1, wherein each of the housings of the adjacent ones of the segments has an axis, and the pivotal housing connector comprises:

a ball element rigidly secured to and extending from the housing of one of the adjacent ones of the segments;

a spherical socket rigidly secured to and extending from the housing of the other of the adjacent ones of the segments, the socket movably receiving the ball element; and

a key and slot located between socket and the ball element to prevent axial rotation of one of the housings relative to the other of the housings.

9. The assembly of claim 1, wherein the pivotal shaft connector comprises a universal joint.

10. A submersible well pump assembly, comprising:

a plurality of modules, including a pump module, a motor module, and a seal section module located between the motor module and the pump module;

a pivotal housing connector joining housings of at least two of the modules together, each of the housings having an axis, the pivotal housing connector being configured to prevent axial rotation of one of the housings relative to the other of the housings;

a universal joint joining drive shafts of the at least two of the modules together; and wherein

the pivotal housing connector and the pivotal shaft connector allow tilting movement of the housings relative to each other and the shafts relative to each other.

11. The assembly according to claim 10, wherein the pivotal housing connector comprises:

a first member attached to one of the housings and having a curved receptacle;

a second member attached to the other of the housings and have a curved member movably carried in the receptacle;

a passage extending through the first and second members, the passage being sealed from an exterior of the submersible pump assembly; and wherein

the universal joint is located with the passage.

12. The assembly according to claim 11, further comprising a key and slot arrangement located in the housing connector, the key and slot arrangement restricting movement of the housings relative to each other in a single plane.

13. The assembly according to claim 10, further comprising:

a first flange on a first end of the housing connector that bolts to one of the housings; and

a second flange on a second and opposite end of the housing connector that bolts to the other of the housings.

14. The assembly according to claim 10, wherein the pivotal housing connector comprises:

a socket member having a spherical socket on one end and a socket member flange on an opposite end that threadingly secures to one of the housings;

a ball member having a ball movably carried in the socket and having a ball flange opposite the ball that threadingly secures to the other of the housings;

a key and slot arrangement between the socket and the ball to restrict movement of the ball in the socket to a single plane;

a passage in the socket member that joins a passage in the ball member;

seals between the socket and the ball to seal the passages from an exterior of the well pump assembly; and wherein
the universal joint is located in the passage.

15. The assembly according to claim 10, wherein each of the shafts has a splined end, and the universal joint comprises:

a first coupling having a splined receptacle that meshes with the splined end of one of the shafts; and

a second coupling having a splined receptacle that meshes with the splined end of the other of the shafts, the first and second couplings being pivotally joined to each other so as to transmit torque from one of the shafts to other of the shafts and allow pivotal movement of the shafts relative to each other.

16. The assembly according to claim 10, wherein each of the shafts has a splined end, and the universal joint comprises:

a first coupling having a splined receptacle that meshes with the splined end of one of the shafts;

a second coupling having a splined receptacle that meshes with the splined end of the other of the shafts;

a central gimbal;

first lugs on opposite sides of the first coupling and pinned to the gimbal to allow pivotal movement of the first coupling relative to the central gimbal; and

second lugs on opposite sides of the second coupling and pinned to the gimbal 90 degrees from the first lugs to allow pivotal movement of the second coupling relative to the central gimbal.

17. The assembly according to claim 10, wherein:

the pivotal housing connector comprises:

a socket member having a spherical socket on one end and a socket member flange on an opposite end that bolts to one of the housings;

a ball member having a ball movably carried in the socket and having a ball flange opposite the ball that bolts to the other of the housings;

a key and slot arrangement between the socket and the ball to restrict movement of the ball in the socket to a single plane;

a passage in the socket member that joins a passage in the ball member;

the pivotal shaft connector is located in the passages and comprises:

a first coupling having a splined receptacle that meshes with a splined end of one of the shafts; and

a second coupling having a splined receptacle that meshes with a splined end of the other of the shafts, the first and second couplings being pivotally joined to each other so as to transmit torque from one of the shafts to other of the shafts and allow pivotal movement of the shafts relative to each other.

18. A method of pumping well fluid from a well having a vertical portion and a deviated portion, comprising:

providing a submersible pump assembly having a plurality of modules, including a pump module, a motor module, and a seal section module;

pivotaly joining housings of at least two of the modules together;

pivotaly joining drive shafts of the at least two of the modules together;

lowering at least part of the submersible pump assembly into the deviated portion of the well;

while transitioning between the vertical portion into the deviated portion, allowing the housings of the at least two of the modules to pivot relative to each other, and allowing the drive shafts of the at least two of the modules to pivot relative to each other; and

when at a desired depth providing power to the motor to rotate the shafts and operate the pump.

19. The method according to claim 18, wherein each of the housings has an axis, and the method further comprises preventing axial rotation of the housings relative to each other about the respective axis of each of the housings.

20. The method according to claim 19, wherein pivotally joining the drive shafts further comprises:

- joining ends of each of the drive shafts with a pivotal drive shaft connector;
- isolating the pivotal drive shaft connector from well fluid in the well.

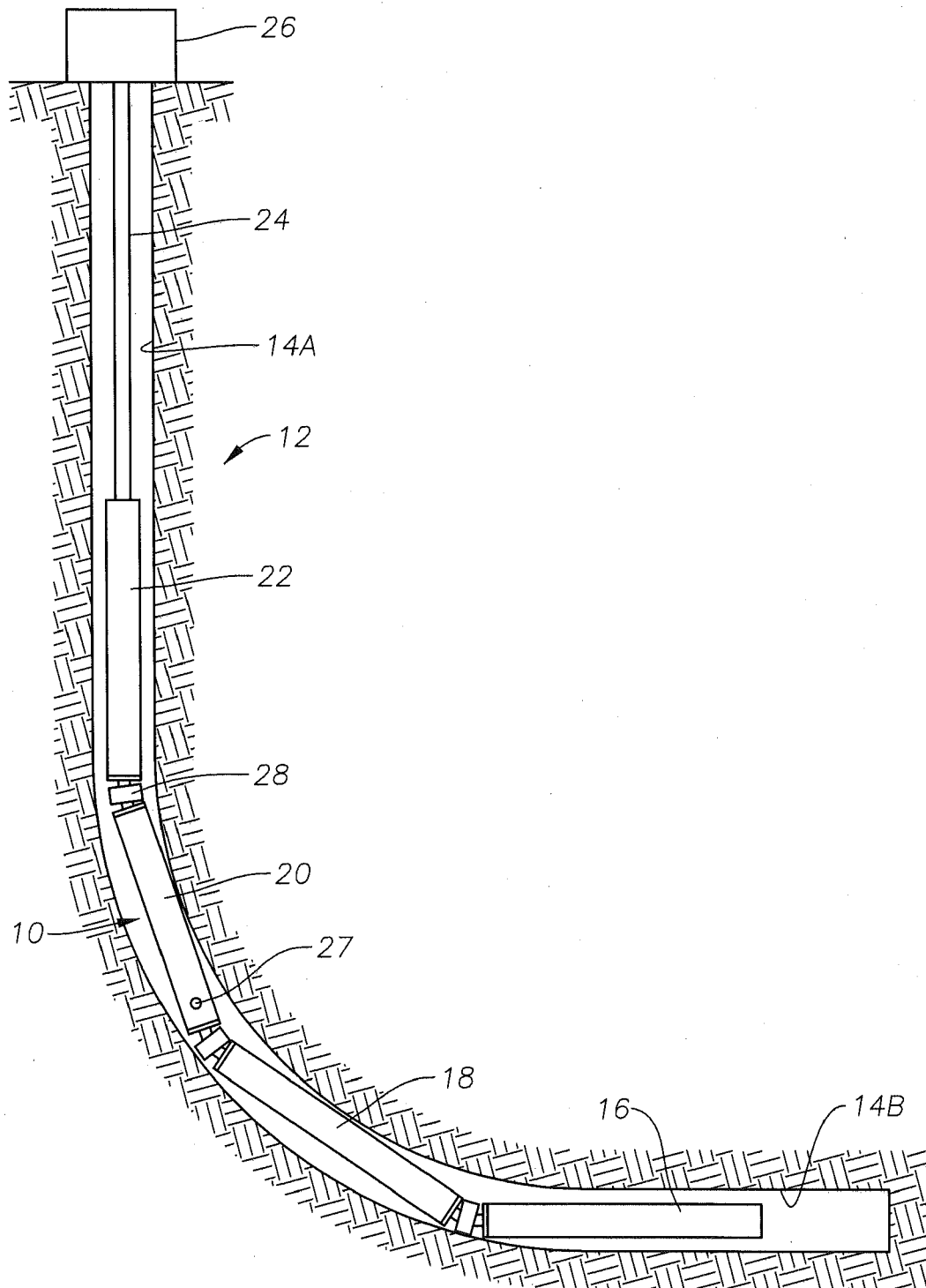
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FIG. 1

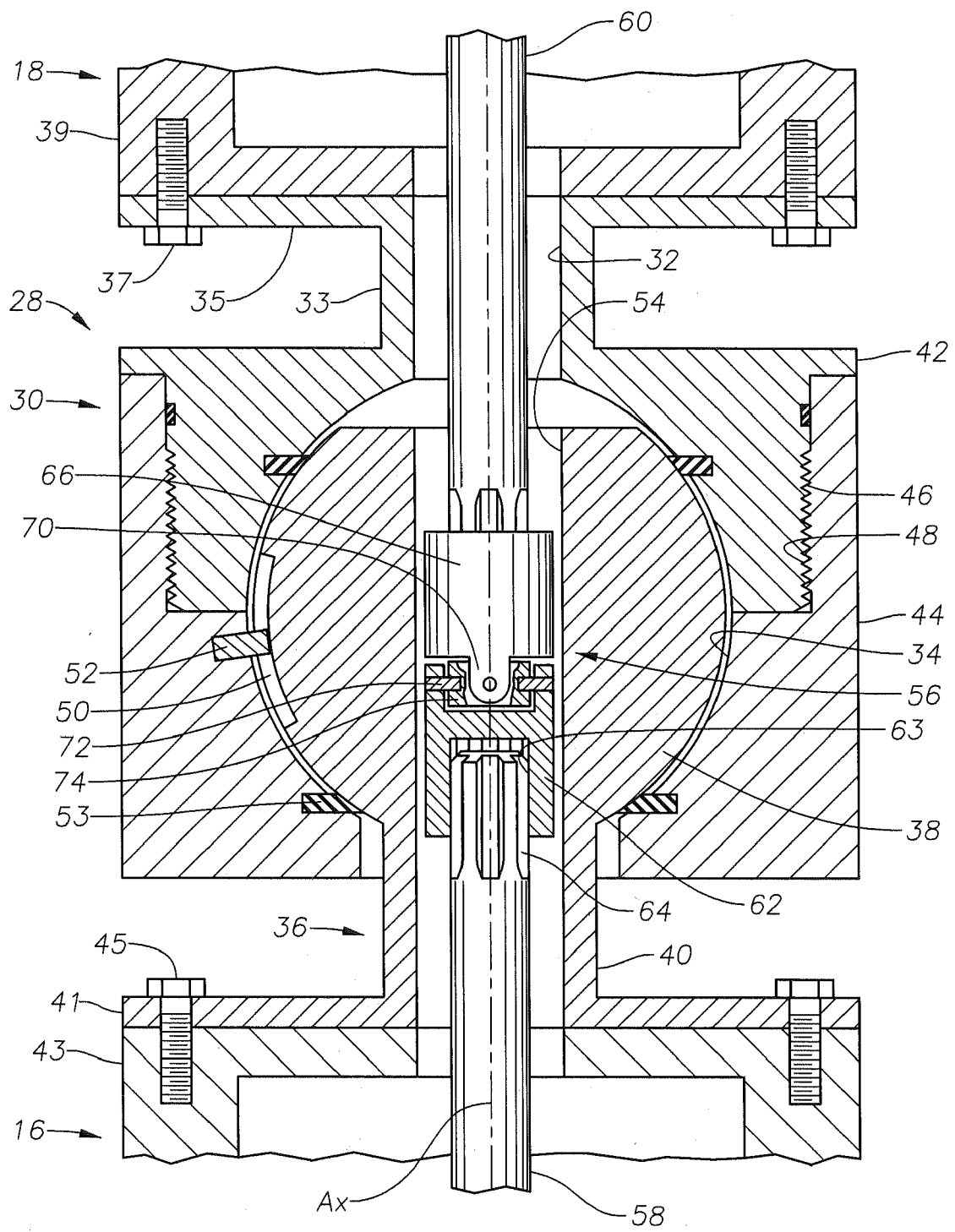


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/076458**A. CLASSIFICATION OF SUBJECT MATTER****E21B 17/05(2006.01)i, E21B 19/22(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 17/05; H02K 15/00; E21B 3/00; F04B 35/04; E21B 43/00; F16D 3/16; E21B 23/00; F16D 3/04; E21B 19/22

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: ESP, motor, seal section, shaft, housing, and connector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0150751 A1 (MERRILL et al.) 17 June 2010 See paragraphs [0019]-[0025]; claim 1; and figures 2-4.	1-20
A	US 4982801 A (ZITKA et al.) 08 January 1991 See claim 1 and figures 1-3.	1-20
A	US 2002-0179305 A1 (MACK et al.) 05 December 2002 See paragraphs [0009]-[0010]; claims 1-3; and figures 1-13.	1-20
A	US 5078650 A (FOOTE, DEAN) 07 January 1992 See claim 1 and figures 1-2.	1-20
A	US 5288271 A (NELSON et al.) 22 February 1994 See claims 1,4 and figures 1-3.	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

07 April 2014 (07.04.2014)

Date of mailing of the international search report

09 April 2014 (09.04.2014)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/076458

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0150751 A1	17/06/2010	CA 2746095 A1 GB 201109587 D0 GB 2477694 A GB 2477694 B RU 2011127912 A SG 172065 A1 US 8419390 B2 WO 2010-068833 A2 WO 2010-068833 A3	17/06/2010 20/07/2011 10/08/2011 12/12/2012 20/01/2013 28/07/2011 16/04/2013 17/06/2010 14/10/2010
US 4982801 A	08/01/1991	None	
US 2002-0179305 A1	05/12/2002	CA 2418480 A1 CA 2418480 C CA 2605887 A1 CA 2605887 C US 2005-0199384 A1 US 6883604 B2 US 7325601 B2 WO 02-099284 A1 WO 2006-116467 A1	12/12/2002 01/05/2007 02/11/2006 23/04/2013 15/09/2005 26/04/2005 05/02/2008 12/12/2002 02/11/2006
US 5078650 A	07/01/1992	GB 2230316 A GB 9008367 D0	17/10/1990 13/06/1990
US 5288271 A	22/02/1994	None	