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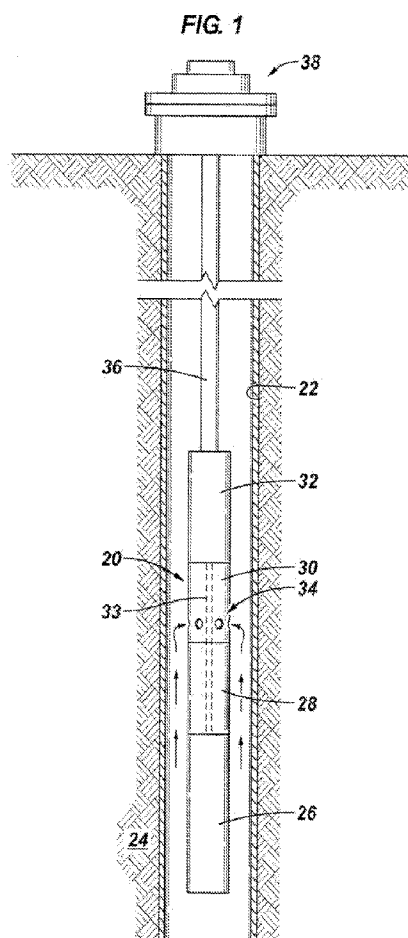
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(54) Title: METHOD AND APPARATUS TO CONTROL WATER MIGRATION INTO ELECTRICAL SUBMERSIBLE PUMP MOTORS



(57) Abstract: A seal assembly for an electrical submersible pumping system that communicates downhole pressure to a pump motor and seals wellbore fluids from the motor. The seal assembly includes a chamber circumscribing a pump shaft and a bladder in the chamber. The outer surface of the bladder is in fluid communication with the wellbore fluid. The inside of the bladder contains dielectric fluid that is ported to the pump motor in an annulus between the pump shaft and a sleeve. A water absorbing elastomer is disposed inside of the bladder for absorbing water that may migrate into the bladder from the wellbore.



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METHOD AND APPARATUS TO CONTROL WATER MIGRATION INTO ELECTRICAL SUBMERSIBLE PUMP MOTORS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of co-pending U.S. Provisional Application Serial No. 61/641,970, filed May 3rd, 2012, the full disclosure of which is hereby incorporated by reference herein for all purposes.

BACKGROUND

1. Field of Invention

[0002] The present disclosure relates in general to submersible well pumps, and in particular to seal assemblies used in combination with the motors that drive submersible well pumps.

2. Background of the Invention

[0003] 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.

[0004] Pressure within the ESP is generally at about atmospheric pressure prior to being inserted into a wellbore. Because wellbore pressure often significantly exceeds atmospheric pressure, the pressure within the ESP is equalized to wellbore pressure, thereby reducing

pressure differential across the ESP housing. One hazard of high ESP housing pressure differentials is the wellbore fluid could breach seals and leak into the motor of the ESP. This is of special concern with regard to the motor, where the conducting fluids within the wellbore could create electrical shorts to damage the motor. The seal section communicates wellbore fluid pressure to the motor fluid pressure thereby minimizing pressure differentials and prolonging seal life. The seal section can also protect the motor from contamination as the wellbore fluid usually contains deleterious substances such as particulate solids and other debris from the formation.

SUMMARY OF INVENTION

[0005] Disclosed herein are example methods and devices for pumping fluid from a wellbore. In one example, disclosed is an electrical submersible pump assembly disposable within a wellbore which includes a motor having dielectric fluid, a pump coupled to the motor, and a seal section having dielectric fluid that is in communication with the dielectric fluid in the motor. In this example an absorption assembly is disposed in the seal section, so that when moisture migrates into the seal section, the moisture is absorbed by the absorption assembly. A bladder can be included in the seal section for keeping wellbore fluid separate from dielectric fluid in the seal and in the motor. In an example, the absorption assembly is an elastomer secured to a mount. In this example, the absorbing material can be a hydrophilic elastomer. In one example, the absorbing material is formed into an annular shape and circumscribes a shaft coupling the pump and motor. The electrical submersible pump assembly can further include a composite bladder made up of hydrophobic elastomer on an outer surface of the bladder, and hydrophilic elastomer on an inner surface of the bladder. In an optional embodiment, the absorption assembly includes a hydrophilic elastomer and is strategically located in an expected flow path of moisture from fluid from the wellbore and the motor.

[0006] Also disclosed herein is an example of an electrical submersible pump assembly disposable within a wellbore, and which includes a housing, a motor, a pump coupled to the motor by a shaft, a seal section comprising a flexible bladder with an outer surface in pressure communication with pressure ambient to the housing and an inner surface in pressure communication with the motor. Also included with this example is a moisture absorbing material disposed in the seal section for absorbing moisture in the seal section. In an example, the bladder circumscribes an elongated sleeve coaxially mounted around the shaft and an annulus is defined between the shaft and sleeve. In this example, a port may optionally be included that is formed radially through a sidewall of the sleeve, and a flow path is defined between the seal through the port and the annulus. In an example, a cylindrical bulkhead is included inside the housing, and wherein the moisture absorbing material comprises an annular member coupled to the bulkhead.

[0007] A method of pumping fluid from a wellbore is disclosed that includes providing a submersible pumping system made up of a motor, a pump coupled with the motor, a seal section for equalizing pressure in the motor with pressure ambient to the motor, and dielectric fluid in the seal, in the motor, and in a passage extending between the seal and the motor. The example method further includes providing a moisture absorbing material in the dielectric fluid and in a location that is in an expected path of moisture flow from ambient to the housing and to the motor, so that when wellbore fluid from the wellbore leaks into the dielectric fluid, moisture in the wellbore fluid is absorbed in the moisture absorbing material. The submersible pumping system is inserted into the wellbore and the motor is activated to operate the pump. The moisture absorbing material can be mounted to a bulkhead in the housing and can circumscribe the shaft. The moisture absorbing material can optionally be provided on an inner surface of a flexible bladder in the seal section, which is in contact with

the dielectric fluid, and an outer surface of the bladder is in contact with the wellbore fluid. In an example, a moisture repelling material is provided on an outer surface of the bladder.

BRIEF DESCRIPTION OF DRAWINGS

[0008] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0009] Figure 1 is a side partial sectional view of an example of an electrical submersible pumping (ESP) system disposed in a wellbore in accordance with the present invention.

[0010] Figure 2 is a side sectional view of an example of a seal section of the ESP of Figure 1 and in accordance with the present invention.

[0011] Figure 3 is a perspective view of an example embodiment of an absorption assembly in accordance with the present invention.

[0012] 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 OF THE EXEMPLARY EMBODIMENTS

[0013] The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which exemplary embodiments of the invention are shown. This invention 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 invention to those skilled in the art. Like numbers refer to like elements throughout.

[0014] Figure 1 illustrates in side view an example of an electrical submersible pumping system 20 (ESP) disposed in a wellbore 22, where the wellbore 22 intersects a subterranean formation 24. The ESP 20 of Figure 1 includes a motor 26 on its lower end, a seal section 28 attached to an upper end of the motor 26, and an optional separator 30 stacked above the seal section 28. The ESP 20 further includes a pump 32 on the end of the separator 30 opposite this seal section 28. Wellbore fluids, shown illustrated by arrows, enter the ESP 20 via a fluid inlet 34 shown on the separator 30. After entering the fluid inlet 34, the wellbore fluids may be directed through the separator 30 and onto the pump 32. The separator 30 can be used to remove or separate any vapor that may be mixed within the wellbore fluid. Liquid separated from the fluid by separator 30 is directed from separator 30 to the pump 32, and the gas or vapor separated from the fluid is diverted from separator 30 to a bypass around the pump 32.

[0015] A shaft 33, shown in dashed line, is coupled between the motor 26 and pump 32 for driving the pump 32. In ESP 20 embodiments not including a separator 30, fluid can flow directly to the pump 32 from the wellbore 22 through a fluid inlet 34 shown formed through an outer housing of the pump 32. The pump 32 pressurizes the wellbore fluid and directs it into production tubing 36 shown attached to one end of the pump 32. The production tubing 36 extends within the wellbore 22 and terminates at an upper end at a wellbore assembly 38. From the wellbore assembly 38, the produced wellbore fluid can be transmitted for subsequent processing.

[0016] A side sectional view of an example embodiment of the seal section 28 is illustrated in Figure 2. In the example of Figure 2 the seal section 28 includes an annular upper housing 40 that defines an outer surface of a portion of the seal section 28. An upper bulkhead 42 having a substantially cylindrical outer surface is shown is coaxially inserted into an upper

end of the upper housing 40 and threadingly attached thereto. A cylindrically shaped cavity 44 is formed on an upper end of the upper bulkhead 42; cavity 44 is generally coaxial with upper bulkhead 42 and extends axially along a portion of the length of the upper bulkhead 42. An axial bore 46 projects from a lower end of the cavity 44 and intersects a lower terminal end of the upper bulkhead 42. Shaft 33 is shown inserted through cavity 44 and bore 46. Further in the example of Figure 2, an annular seal assembly 50 circumscribes the upper end of the shaft 33 within a lower portion of the cavity 44 and extending axially downward into bore 46; where an outer circumference of seal assembly 50 contacts an inner surface of the bore 46. Internal bearings 52 are illustrated below the seal assembly 50 set in the annular space between shaft 33 and bore 46.

[0017] Also illustrated in the example of Figure 2 is an annular sleeve 54 whose upper end couples with a lower facing surface of the upper bulkhead 42 and circumscribes a portion of the shaft 33 below the upper bulkhead 42. A lower end of the sleeve 54 couples to an upper end of a middle bulkhead 56, shown having a cylindrical outer surface and substantially coaxial with upper bulkhead 42. Similar to the upper bulkhead 42, the middle bulkhead 56 has a reduced diameter portion that coaxially inserts into the housing 40, and an enlarged outer diameter portion that defines a portion of an outer surface of the seal section 28. Threads (not shown) on the outer surface of the reduced diameter portion and inner surface of the housing 40 provide for threaded engagement between the middle bulkhead 56 and housing 40.

[0018] A bladder 58 is illustrated in the example embodiment of the seal section 28 of Figure 2, where the bladder 58 has a tubular configuration with flexible membrane like walls, and with upper and lower ends. The upper end of bladder 58 is shown coupled to an outer surface of the sleeve 54 proximate where the sleeve 54 connects to the upper bulkhead 42. The lower

end of the bladder 58 is secured to an upper end of the middle bulkhead 56. The connections between the bladder 58 and sleeve 54 and bulkhead 56 define a fluid and pressure barrier that defines an outer and inner plenums 60, 62. Outer plenum 60 is in a space between an outer surface of the bladder 58 and inner surface of the housing 40. Inner plenum 62 is bounded on its outer radial periphery by the bladder 58 and inner radius by sleeve 54. A lower axial end of inner plenum 62 terminates at an upper end of the middle bulkhead 56, and its upper axial end is defined where the sidewalls of bladder 58 depend radially inward to couple with the outer surface of sleeve 54.

[0019] Still referring to Figure 2, an axial passage 64 is shown formed through the upper bulkhead 42, and extends substantially parallel to and radially outward from an axis of the upper bulkhead 42. The axial passage 64 provides fluid communication between the cavity 44 and outer plenum 60. Although not shown in Figure 2, the cavity 44 is in fluid communication with outside of the ESP system 20, so that when the ESP system 20 is submerged within wellbore fluid, wellbore fluid (not shown) may enter the cavity 44, make its way through the passage 64, and into the outer plenum 60. With increasing depth in the wellbore, static head of the wellbore fluid exceeds pressure in the inner plenum 62 thereby forcing dielectric fluid within the inner plenum 62 into the sleeve 54 through ports 66 formed radially through the sidewall of the sleeve 54. As such, an annulus 68 set between the sleeve 54 and shaft 33 is in pressure communication with the wellbore through the dielectric fluid. As is known, breaches may occur in the bladder 58 or seal assembly 50 thereby allowing wellbore fluid to enter the inner plenum 62. To account for the unwanted presence of water in the dielectric fluid, an upper absorption assembly 70 is shown provided within the inner plenum 62 and strategically disposed therein so that the upper absorption assembly 70 is in the flow path of any water that may flow along the shaft 33 and towards the motor 26 (Figure 1). Being positioned in the possible path of water, or other contaminating substance, the

upper absorption assembly 70 may capture and retain the water or other material and prevent its ingress into the motor 26.

[0020] A redundant seal assembly is illustrated in the example of Figure 2; that in one example is similar to the seal assembly described above, and which includes a lower housing 72 that mounts on a lower end of the middle bulkhead 56. A sleeve 74 is shown coaxially disposed within the lower housing 72 and having an upper end connecting to a lower end of the middle bulkhead 56. A lower end of the sleeve 74 is illustrated engaged with an upper end of a lower bulkhead 76. A bladder 78 is set within the housing 72 and having upper and lower ends respectively coupled with the sleeve 74 and upper end of the lower bulkhead 76. The bladder 78, like bladder 58, defines an outer plenum 80 that is in pressure communication with inner plenum 62 via porting (not shown) extending through the middle bulkhead 56. An inner plenum 82 is shown defined within the bladder 78. A seal assembly 84 shown set in an annular channel formed in middle bulkhead 56 and circumscribing shaft 33, where the channel is proximate a lower terminal end of the middle bulkhead 56.

[0021] In one example of operation, as the inner plenum 62 is pressurized from the flow of wellbore fluid into the outer plenum 60, and in turn pressurizes outer plenum 80, pressure ports on the bladder 78 pressurized inner plenum 82 that communicates through ports 86 in the sleeve 74 and into an annulus 88 between the sleeve 74 and shaft 33. A lower absorption assembly 90 is shown anchored within bladder 78. The lower absorption assembly 90 is similar to the upper absorption assembly 70 and thus may capture and retain water or other matter deemed harmful to the motor 26. The potentially damaging matter absorbed by lower absorption assembly 90 may have flowed along a path that avoided the upper absorption assembly 70, or the upper absorption assembly 70 may have been saturated so that the matter could not be absorbed.

[0022] Referring now to Figure 3, an example of an absorption assembly 70, 90 is shown in a side perspective view. In this example the assembly 70, 90 includes an absorbing member 92 coupled to an annular mount 94. In one example, the member 92 is generally annular, and may contain or be formed from a moisture absorbing material. Example materials include a hydrophilic elastomer or polymer. When put into contact with moisture, the elastomer can absorb the moisture and in turn increase its volumetric size. The mount 94 can be formed from any suitable material and may include bolt holes for anchoring to the bulkheads 56, 76. Optionally, the mount 94 can be press fit onto the sleeve 54, 74, thereby allowing its positioning at multiple axial locations along the sleeve 54, 74. Although in the example of Figure 2, the assemblies 70, 90 are set in the respective bladders 58, 78 and distal from ports 66, 86, the assemblies 70, 90 may be set adjacent the ports 66, 86. Optionally, the absorption assemblies 70, 90 may be a lattice like structure (not shown) having obliquely arranged members set at various locations within the bladders 58, 78.

[0023] In one optional embodiment, one or both of the bladders 58, 78 are formed from a composite material. In this example, an outer surface of the bladder(s) 58, 78 includes or is made up of hydrophobic material which repels moisture from the bladder(s) 58, 78. Optionally, an inner surface of the bladder(s) 58, 78 includes or is made up of hydrophilic material, which absorbs moisture that might be present within the bladder(s) 58, 78. This example may or may not include absorption assemblies 70, 90.

[0024] It is understood that variations may be made in the above without departing from the scope of the invention. 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 invention. The embodiments as described are exemplary only and are not limiting. For example, a moisture absorbing material the same or similar to that described

above can be strategically disposed at locations susceptible to electrical shorting when exposed to moisture or a collection of moisture. Example locations include proximate the plug-in connector (also commonly referred to as a pothead), where the motor connects to the seal, and the bottom base of the motor. Many variations and modifications are possible and are within the scope of the invention. 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:
 - a motor having dielectric fluid;
 - a pump coupled to the motor;
 - a seal section having dielectric fluid that is in communication with the dielectric fluid in the motor; and
 - an absorption assembly disposed in the seal section, so that when moisture migrates into the seal section, the moisture is absorbed by the absorption assembly.
2. The electrical submersible pump assembly of claim 1, further comprising a bladder in the seal section that defines a barrier between fluid from the wellbore and dielectric fluid in the seal and in the motor.
3. The electrical submersible pump assembly of claim 1, wherein the absorption assembly comprises an elastomer secured to a mount.
4. The electrical submersible pump assembly of claim 3, wherein the absorbing material comprises a hydrophilic elastomer.
5. The electrical submersible pump assembly of claim 3, wherein the absorbing material circumscribes a shaft coupling the pump and motor and defines an annular shape.
6. The electrical submersible pump assembly of claim 1, further comprising a composite bladder made up of hydrophobic elastomer on an outer surface of the bladder, and hydrophilic elastomer on an inner surface of the bladder.
7. The electrical submersible pump assembly of claim 1, wherein the absorption assembly comprises a hydrophilic elastomer and is strategically located in an expected flow path of moisture from fluid from the wellbore and the motor.
8. An electrical submersible pump assembly disposable within a wellbore comprising:
 - a housing;
 - a motor;

- a pump coupled to the motor by a shaft;
 - a seal section comprising a flexible bladder with an outer surface in pressure communication with pressure ambient to the housing and an inner surface in pressure communication with the motor; and
 - a moisture absorbing material disposed in the seal section for absorbing moisture in the seal section.
9. The electrical submersible pump assembly of claim 8, wherein the bladder circumscribes an elongated sleeve coaxially mounted around the shaft, and wherein an annulus is defined between the shaft and sleeve.
 10. The electrical submersible pump assembly of claim 9, further comprising a port formed radially through a sidewall of the sleeve, and wherein a flow path is defined between the seal through the port and the annulus.
 11. The electrical submersible pump assembly of claim 8, further comprising a cylindrical bulkhead inside the housing, and wherein the moisture absorbing material comprises an annular member coupled to the bulkhead.
 12. A method of pumping fluid from a wellbore comprising:
 - a. providing a submersible pumping system comprising a motor, a pump coupled with the motor, a seal section for equalizing pressure in the motor with pressure ambient to the motor, and dielectric fluid in the seal, in the motor, and in a passage extending between the seal and the motor; and
 - b. providing a moisture absorbing material in the dielectric fluid and in a location that is in an expected path of moisture flow from ambient to the housing and to the motor, so that when wellbore fluid from the wellbore leaks into the dielectric fluid, moisture in the wellbore fluid is absorbed in the moisture absorbing material; and
 - c. inserting the submersible pumping system into the wellbore and activating the motor to operate the pump.
 13. The method of claim 12, wherein the moisture absorbing material is mounted to a bulkhead in the housing and circumscribes the shaft.

14. The method of claim 12, wherein the moisture absorbing material is provided on an inner surface of a flexible bladder in the seal section, and wherein the inner surface of the bladder is in contact with the dielectric fluid and an outer surface of the bladder is in contact with the wellbore fluid.
15. The method of claim 14, wherein a moisture repelling material is provided on an outer surface of the bladder.

FIG. 1

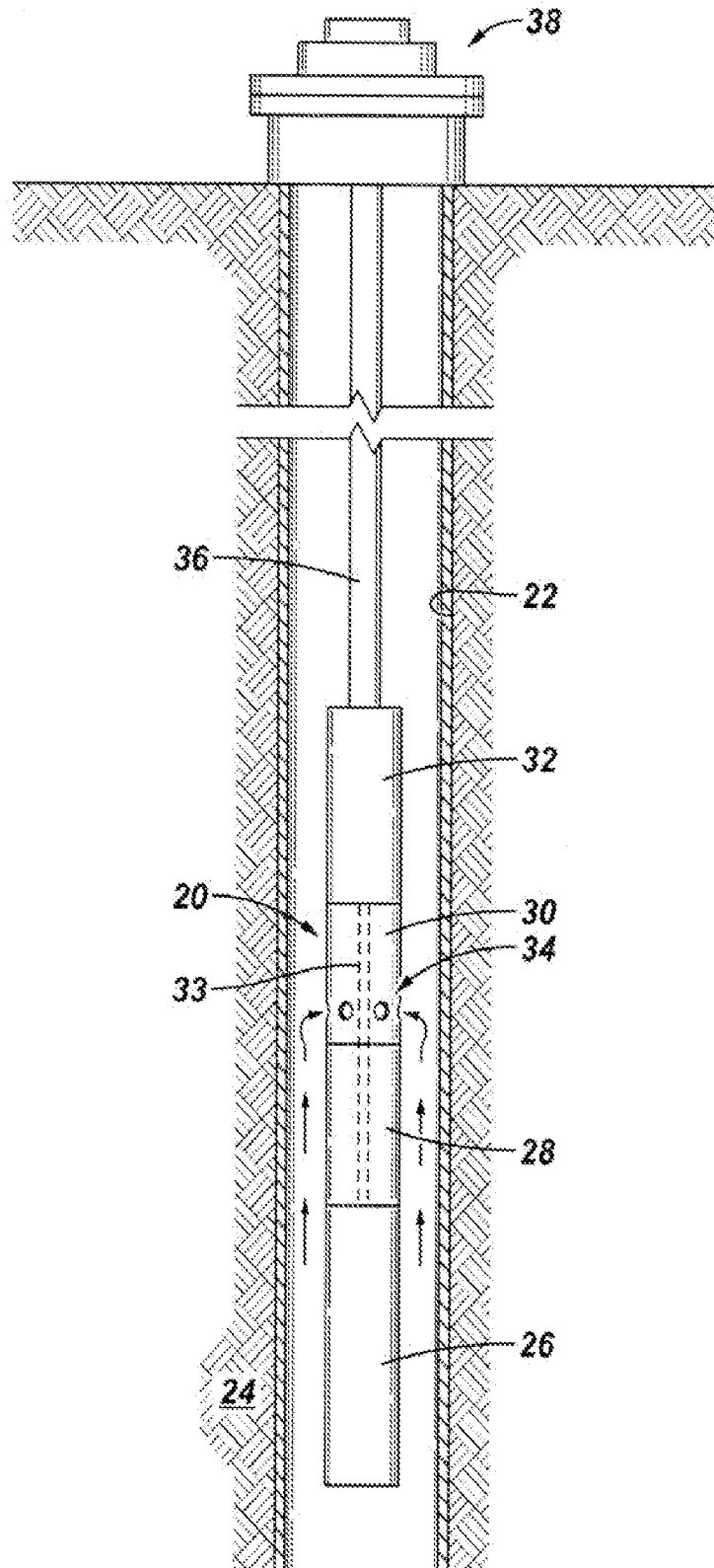


FIG. 2

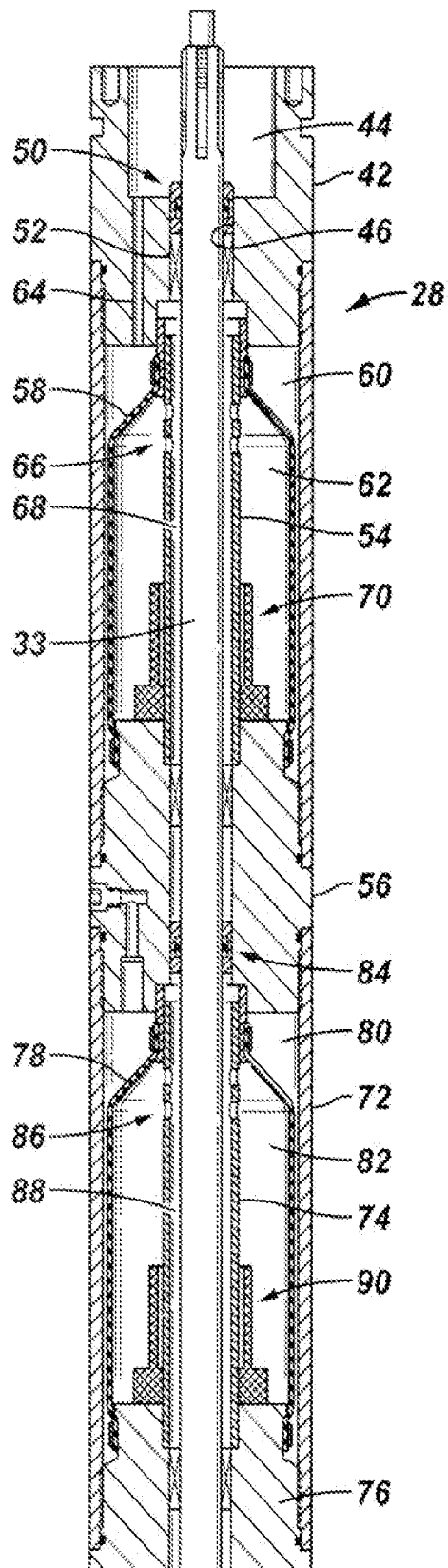
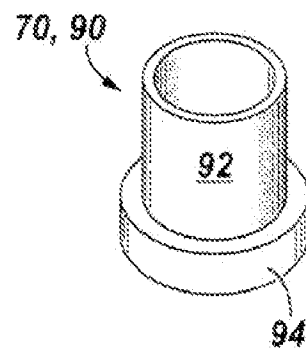


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/039478**A. CLASSIFICATION OF SUBJECT MATTER****E21B 43/16(2006.01)i, E21B 33/122(2006.01)i, E21B 21/08(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 43/16; F04B 17/00; E21B 43/00; F04B 15/00; F04B 17/03; E21B 43/38; E21B 33/122; E21B 21/08

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, pump, motor, sealing, absorption, bladder, and elastomer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007-0140876 A1 (PARMETER et al.) 21 June 2007 See paragraphs [0012]-[0015],[0023]; claim 5; and figures 1-3.	1-15
Y	US 6981853 B2 (DU et al.) 03 January 2006 See column 5, lines 3-60; claim 5; and figures 2-3.	1-15
A	US 2010-0111711 A1 (CHILCOAT et al.) 06 May 2010 See abstract; paragraphs [0007]-[0010]; and figures 1-2.	1-15
A	US 5622222 A (WILSON et al.) 22 April 1997 See abstract; column 2, line 56 - column 3, line 67; and figures 1,2A-2C.	1-15
A	US 6666664 B2 (GROSS, EDWIN) 23 December 2003 See abstract; claims 1,17,27; and figures 1-3.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007-0140876 A1	21/06/2007	CA 2633403 A1 CA 2633403 C CN 101336344 A CN 101336344 B US 7665975 B2 WO 2007-075781 A2 WO 2007-075781 A3	05/07/2007 13/09/2011 31/12/2008 03/11/2010 23/02/2010 05/07/2007 30/08/2007
US 6981853 B2	03/01/2006	CA 2389419 A1 CA 2389419 C CA 2600376 A1 CA 2600376 C CA 2601277 A1 CA 2601277 C US 2002-0192090 A1 US 2004-0136849 A1 US 2005-0167096 A1 US 2007-0207046 A1 US 2011-0014071 A1 US 6688860 B2 US 7217107 B2 US 7806670 B2	18/12/2002 26/02/2008 18/12/2002 17/11/2009 18/12/2002 17/11/2009 19/12/2002 15/07/2004 04/08/2005 06/09/2007 20/01/2011 10/02/2004 15/05/2007 05/10/2010
US 2010-0111711 A1	06/05/2010	CA 2742031 A1 US 8221092 B2 WO 2010-051197 A2 WO 2010-051197 A3	06/05/2010 17/07/2012 06/05/2010 02/09/2010
US 5622222 A	22/04/1997	CA 2183613 A1	27/03/1997
US 6666664 B2	23/12/2003	US 2003-156947 A1	21/08/2003