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[Continued on next page]

(54) Title: CIRCULATION PUMP FOR COOLING MECHANICAL FACE SEAL OF SUBMERSIBLE WELL PUMP AS-
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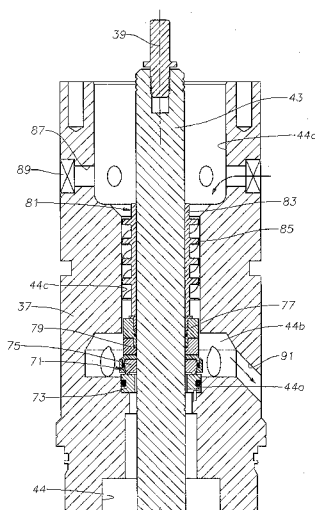


FIG. 3

(57) Abstract: A modal attenuator includes annular chambers disposed between an attenuator body and a perforated screen surrounding a primary flow path. The modal attenuator in some arrangements is in the form of an expander section. In some arrangements one or both of the height and the width of the annular chambers may vary along the length of the attenuator body such that the volumes of the chambers vary along the length of the attenuator body. Each chamber preferably has an open end facing the perforated screen such that acoustic waves passing through the perforated screen can enter into the chamber through the open end.

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PCT PATENT APPLICATION

Circulation Pump for Cooling Mechanical Face Seal of Submersible Well Pump Assembly

Cross-Reference to Related Application

This application claims priority to U.S. Provisional Application S.N. 62/150,519, filed April 21, 2015, and U.S. Non-Provisional Application S.N. 15/085,092, filed March 30, 2016, the full disclosure of which is hereby incorporated by reference herein for all purposes.

Field of the Disclosure

This disclosure relates in general to submersible well pump assemblies and in particular to a motor shaft seal section having a circulation pump to flow fluid past a mechanical shaft seal for cooling.

Background

One type of pump assembly used particularly in oil producing wells has a submersible pump and electrical motor filled with a dielectric motor lubricant. The motor rotates a shaft assembly to drive the pump. A seal section connects between the motor and the pump. The seal section has a shaft seal to seal well fluid from contaminating the motor lubricant.

Normally, the shaft seal is a mechanical face seal having a rotating component or seal runner with an elastomeric boot mounted to the shaft for rotation with the shaft. A spring biases the seal runner against a stationary seal base. The interface between the seal runner and the seal base seals the well fluid from the motor lubricant.

The region of well fluid surrounding the upper portion of the mechanical face seal is relatively stagnant, although the rotation of the seal runner provides some disturbance to well

fluid in this region. The rotational, sliding engagement of the seal runner with the seal base generates heat at the interface. Heat produced at the interface transfers through the head of the seal section and through the lubricant. In some installations, the heat transfer that occurs may be inadequate to cool the face seal to a desired temperature, thus decreasing the life.

Summary

An electrical submersible pump assembly includes a production pump, a motor containing a motor lubricant and operatively coupled to the production pump for driving the pump. A seal section is coupled to the motor between the motor and the pump. A rotatable drive shaft extends through the seal section. A shaft seal in the seal section seals around the shaft. A circulation pump is mounted to the shaft and within the seal section for rotation therewith. The circulation pump has a discharge that discharges fluid around the shaft seal.

In one embodiment, the circulation pump has a hub and a helical flight mounted to the hub. The helical flight extends in a plurality of turns around the hub.

The circulation pump may be located between the shaft seal and an upper end of the seal section. The shaft seal has a rotating component and a non-rotating component. The rotating component is located in a discharge flow path of the circulation pump.

Brief Description of the Drawings

So that the manner in which the features, advantages and objects of the disclosure, as well as others which will become apparent, are attained and can be understood in more detail, more particular description of the disclosure briefly summarized above may be had by reference to the embodiment thereof which is illustrated in the appended drawings, which drawings form a

part of this specification. It is to be noted, however, that the drawings illustrate only a preferred embodiment of the disclosure and is therefore not to be considered limiting of its scope as the disclosure may admit to other equally effective embodiments.

Figure 1 is a side view of an electrical submersible pump assembly in accordance with this disclosure.

Figure 2 is a sectional view of a pressure equalizer of the submersible pump assembly of Figure 2.

Figure 3 is a sectional view of a head of the pressure equalizer of Figure 2.

Detailed Description of the Disclosure

The methods and systems of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The methods and systems of the present disclosure may be 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 its scope to those skilled in the art. Like numbers refer to like elements throughout.

It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation.

Referring to Fig. 1, an electrical submersible pump (ESP) 11 typically includes an electrical motor 13. Motor 13 is normally a three-phase AC motor and may be connected in tandem to other motors. Motor 13 is filled with a dielectric motor lubricant for lubricating the internal rotating components. A thrust bearing unit 15 is illustrated at an upper end of motor 13. The terms “upper” and “lower” are used only for convenience and not in a limiting manner. A pressure equalizer or seal section 17 is shown connected to an upper end of thrust bearing unit 15, or thrust bearing unit 15 could be incorporated with seal section 17. In this example, seal section 17 has features to reduce a pressure differential between the motor lubricant in motor 13 and the exterior well fluid hydrostatic pressure. The pressure equalizing features of seal section 17 could alternately be located below motor 13, and shaft sealing portions of seal section 17 located above motor 13.

A production pump 19 connects to the upper end of seal section 17 in this example. Production pump 19 could be a centrifugal pump having a large number of stages, each stage having an impeller and a diffuser. Alternately, production pump 19 could be another type, such as a progressing cavity pump. A string of production tubing 23 secures to the upper end of production pump 19 and supports ESP 11 in a well. Production tubing 23 may be sections of pipe with threaded ends secured together, or it could be continuous coiled tubing. Production pump 19 has an intake 21 for drawing in well fluid, which is discharged into production tubing 23. An optional gas separator could be connected to production pump 19; if so, intake 21 would be in the gas separator. A power cable 25 extends downward alongside production tubing 23 from a wellhead (not shown) to motor 13 for supplying power to motor 13.

Figure 2 shows one example of a pressure equalizer for seal section 17, but other types of pressure equalizers would work, including those located below motor 13. Referring to Fig. 3,

seal section 17 has a cylindrical housing 33. A lower adapter 35 secures, such as by threads, to the lower end of housing 33. A head member, connector member, or upper adapter 37 secures, such as by threads, to an upper end of housing 33 and may be considered to be a part of housing 33. Lower and upper adapters 35, 37 are spaced axially apart from each other along longitudinal axis 39. Lower adapter 35 has a bore 41 through which a drive shaft 43 extends. Drive shaft 43 extends from motor 13 (Fig. 1) through a bore 44 in upper adapter 37 into engagement with production pump 19 (Fig. 1) for driving the pump. Drive shaft 43 is typically an assembly in several sections connected by splined ends. Bushings are located in lower adapter 35 and upper adapter 37 for providing radial support to drive shaft 43.

A non rotating guide tube 45 surrounds but is not in contact with shaft 43. Guide tube 45 is supported at its lower end by a lower cap 47, which mounts to lower adapter 35. Guide tube 45 is supported at its upper end by an upper cap 49, which mounts to a lower end of upper adapter 37 within a recess.

In this embodiment, seal section 17 has a metal, outer bellows 51 with an outer diameter only slightly smaller than the inner diameter of housing 33. Alternately, another type of flexible member could be employed, such as an elastomeric bag. Outer bellows 51 has a fixed or lower end 53 that is secured by a retainer 55 to lower cap 47. Outer bellows 51 has a floating or upper end 57 spaced axially above lower end 53. Outer bellows 51 is cylindrical and has a corrugated, flexible sidewall.

A cup-shaped interconnect member 59 fits within outer bellows 51. Interconnect 59 is a sleeve with an upper end 61 having an external flange that overlies and secures sealingly to outer bellows upper end 57. Interconnect 59 has a lower end 63 with an internal flange having a

central opening 64 slightly larger in diameter than guide tube 45. Interconnect 59 has an outer diameter that is smaller than the inner diameter of outer bellows 51. Interconnect 59 moves up and down with outer bellows upper end 57 as outer bellows 51 moves between a contracted position and an extended position.

A metal, inner bellows 67 has a lower end within outer bellows 51. The lower end of inner bellows 67 secures and seals to lower end 63 of interconnect 59. Inner bellows 67 has an upper end that secures and seals to upper cap 49 in this embodiment. Inner bellows 67 is cylindrical, corrugated, and has a smaller outer diameter than the inner wall of outer bellows 51. The inner diameter of inner bellows 67 is slightly larger than the outer diameter of guide tube 45. One or more ports 68 communicate motor lubricant within guide tube 45 to the interior of inner bellows 67 and the interior of outer bellows 51, which are in fluid communication with each other.

A well fluid chamber 69 in housing 33 surrounds outer bellows 51 and inner bellows 67. A port (not shown) either in upper adapter 37 or lower adapter 35 admits well fluid to well fluid chamber 69. The main lubricant communication path from motor 13 (Fig. 1) to upper port 29 (Fig. 1) is through guide tube 45, because the upper end of guide tube 45 is not closed off. The interiors of guide tube 45, outer bellows 51, and inner bellows 67 define a lubricant chamber in fluid communication with the motor lubricant in motor 13 (Fig. 1).

Referring to Figure 3, drive shaft 43 extends through bore 44 of upper adapter 37 and has an upper end that couples to a drive shaft in production pump 19 (Fig. 1). A shaft or mechanical face seal 71 mounts in bore 44 for sealing well fluid from entry into the interiors of inner bellows 67, outer bellows 51 and guide tube 45 (Fig. 2). Mechanical face seal 71 is conventional, having

a non-rotating annular seal base 73 sealed within bore 44. A seal runner 75 has a lower side that sealingly engages the upper side of seal base 73 in rotating sliding engagement. A retainer 77, sealed and connected to shaft 43 for rotation therewith, joins seal runner 75 with a boot 79 that causes seal runner 75 to rotate in unison. Boot 79 has a spring that biases seal runner 75 against base 73.

A circulation pump 81 is located in bore 44 just above retainer 77. Circulation pump 81 is preferably an inducer type having a hub 83 that engages shaft 43 for rotation therewith. A helical flight 85 extends radially outward from hub 83 and has multiple turns that extend around axis 39. The lower end of circulation pump 81 abuts seal retainer 77 in this example. Other types of circulation pumps are feasible.

Bore 44 has a number of different diameters, including an annular seal base area 44a into which seal base 75 is rigidly secured. An annular circulation pump discharge area 44b joins seal base area 44a and extends upward. Circulation pump discharge area 44b has a diameter larger than seal base area 44a and contains seal runner 75. The diameter of circulation pump discharge area 44b is also larger than the outer diameter of seal runner 75 and boot 79. The upper side of seal base 73 may be flush with the lower side of circulation pump discharge area 44b, which is shown as a flat surface located in a plane perpendicular to axis 39.

Bore 44 has a circulation pump area 44c that joins the upper end of circulation pump discharge area 44b and extends upward at a smaller diameter than circulation pump discharge area 44b. The outer edges of circulation pump flight 85 are closely spaced but not touching the inner side of circulation pump area 44c. The outer diameter of retainer 77 is preferably slightly

smaller than the outer diameters of flight 85. An upper portion of retainer 77 may be located within circulation pump area 44c.

Bore 44 has a larger diameter circulation pump inlet area 44d that joins and extends upward from circulation pump area 44c. The upper end of circulation pump 81 is located at the lower end of inlet area 44d. Inlet area 44d is in fluid communication with well fluid. In this embodiment, at least one inlet port 87 (four shown) extends laterally outward from bore inlet area 44d to the exterior of head member 37 for admitting well fluid. Filters 89 of various types may be placed within each inlet 87.

At least one outlet port 91 (three shown) joins circulation pump discharge area 44b and extends outward and downward to the exterior of head member 37. The junctions between outlet ports 91 and enlarged diameter chamber 44b are located radially outward from seal runner 75.

During operation, as shaft 43 rotates, circulation pump 81 will rotate as well as seal runner 75. Circulation pump 81 draws well fluid from inlet ports 87 and pumps the well fluid through circulation pump discharge area 44b and out outlet ports 91 as indicated by the arrows. The well fluid flows past portions of mechanical seal 71, providing cooling. More particularly, the well fluid flows around retainer 77, boot 79 and alongside seal runner 75. The cooling caused by the circulation of well fluid over portions of mechanical seal 71 increases the life of the seal.

While the disclosure has been shown and described in only one of its forms, it should be apparent to those skilled in the art that changes may be made. For example, the turns of the circulation pump flights could be reversed, cause well fluid to flow in from the lower side and be discharged out the upper side of the circulation pump. In addition to being in a head member,

the circulation pump could be located between chambers of a pressure equalizer for circulating motor lubricant over an intermediate mechanical seal, rather than well fluid.

Claims

1. An electrical submersible pump assembly (11), comprising a production pump (19), a motor (13) containing a motor lubricant and operatively coupled to the production pump for driving the production pump, a seal section (17) coupled to the motor between the motor and the production pump, a rotatable drive shaft (43) extending through the seal section, and a shaft seal (71) in the seal section that seals around the shaft; characterized by:

a circulation pump (81) mounted to the shaft and within the seal section for rotation therewith;

and

the circulation pump having a discharge that discharges fluid around the shaft seal.

2. The assembly according to claim 1, wherein the circulation pump comprises:

a hub (83); and

a helical flight (85) mounted to the hub and extending in a plurality of turns around the hub.

3. The assembly according to claim 1, wherein the circulation pump is located between the shaft seal and an upper end of the seal section.

4. The assembly according to claim 1, wherein:

the shaft seal has a rotating component (75) and a non-rotating component (73); and

wherein the rotating component is located in a discharge flow path (44b, 91) of the circulation pump.

5. The assembly according to claim , further comprising an inlet port (87) that extends laterally through the seal section to an exterior of the seal section for delivering well fluid to an intake of the circulation pump.

6. The assembly according to claim 5, further comprising:

a filter (89) in the inlet passage.

7. The assembly according to claim 5, further comprising:

an outlet passage (91) axially spaced from the inlet passage and extending to the exterior of the seal section from the discharge of the circulation pump for discharging the well fluid.

8. The assembly according to claim 1, wherein the circulation pump is located in a circulation pump bore area (44c) in the seal section and comprises:

a hub (83);

a helical flight (85) mounted to the hub and extending in a plurality of turns around the hub; and wherein

an outer edge of the helical flight is closely spaced to an inner wall of the circulation pump bore area.

9.. The assembly according to claim, wherein:

the shaft seal has a seal runner (75) that rotates against a non-rotating seal base (73);

the seal section has a bore (44);

the bore has an annular seal base area (44a) joined on an upper end by an annular circulation pump discharge bore area (44b) having a larger diameter than the seal base area;

the bore has a circulation pump area (44c) extending upward from the circulation pump discharge bore area and being of smaller diameter than the circulation pump discharge bore area;

the seal base is mounted in the seal base area;

the seal runner is located in the circulation pump discharge bore area;

the circulation pump is located in the circulation pump area; and

an outlet port (91) leads from the circulation pump discharge bore area laterally to an exterior of the seal section.

10. The assembly according to claim 9, wherein:

the bore has an annular circulation pump intake area (44d) above and of larger diameter than the circulation pump area; and

an inlet port leads (87) laterally from the exterior of the seal section to the circulation pump intake area to admit well fluid to the circulation pump intake area.

11. The assembly according to claim 1, further comprising:

a movable pressure equalizing element (51) in the seal section, the pressure equalizing element having one side in fluid communication with lubricant in the motor for equalizing a pressure of the lubricant with well fluid on the exterior of the seal section.

12. The assembly according to claim 1, wherein the shaft seal comprises a rotating component (75) that rotates and seals against a non-rotating component (73) and the assembly further comprises:

an annular circulation pump discharge area (44b) surrounding and of larger inner diameter than an outer diameter of the rotating component; and

an outlet port (91) extending from the circulation pump discharge area to the exterior of the seal section.

13. The assembly according to claim 12, further comprising:

an annular circulation pump intake area (44d) of larger inner diameter than an outer diameter of the circulation pump; and

an inlet port (87) extending from the exterior of the seal section to the circulation pump intake area.

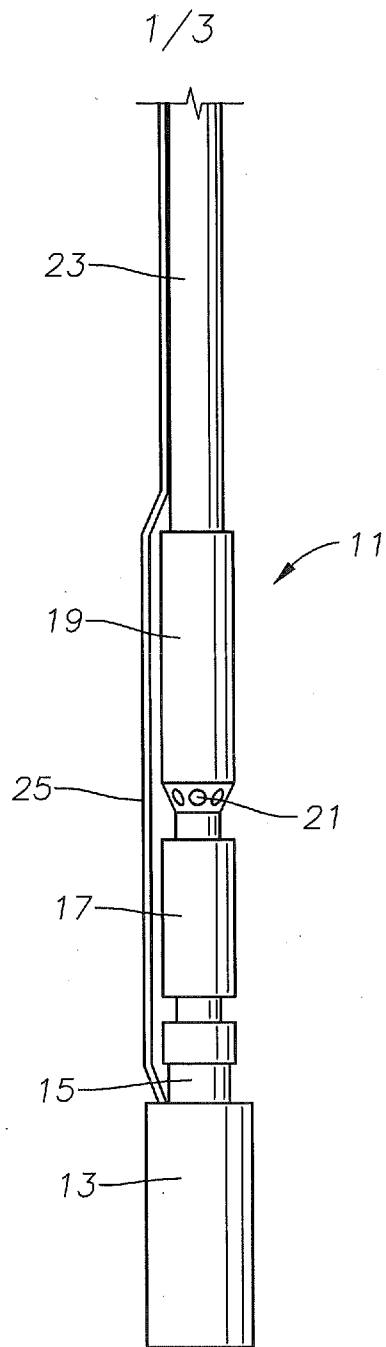


FIG. 1

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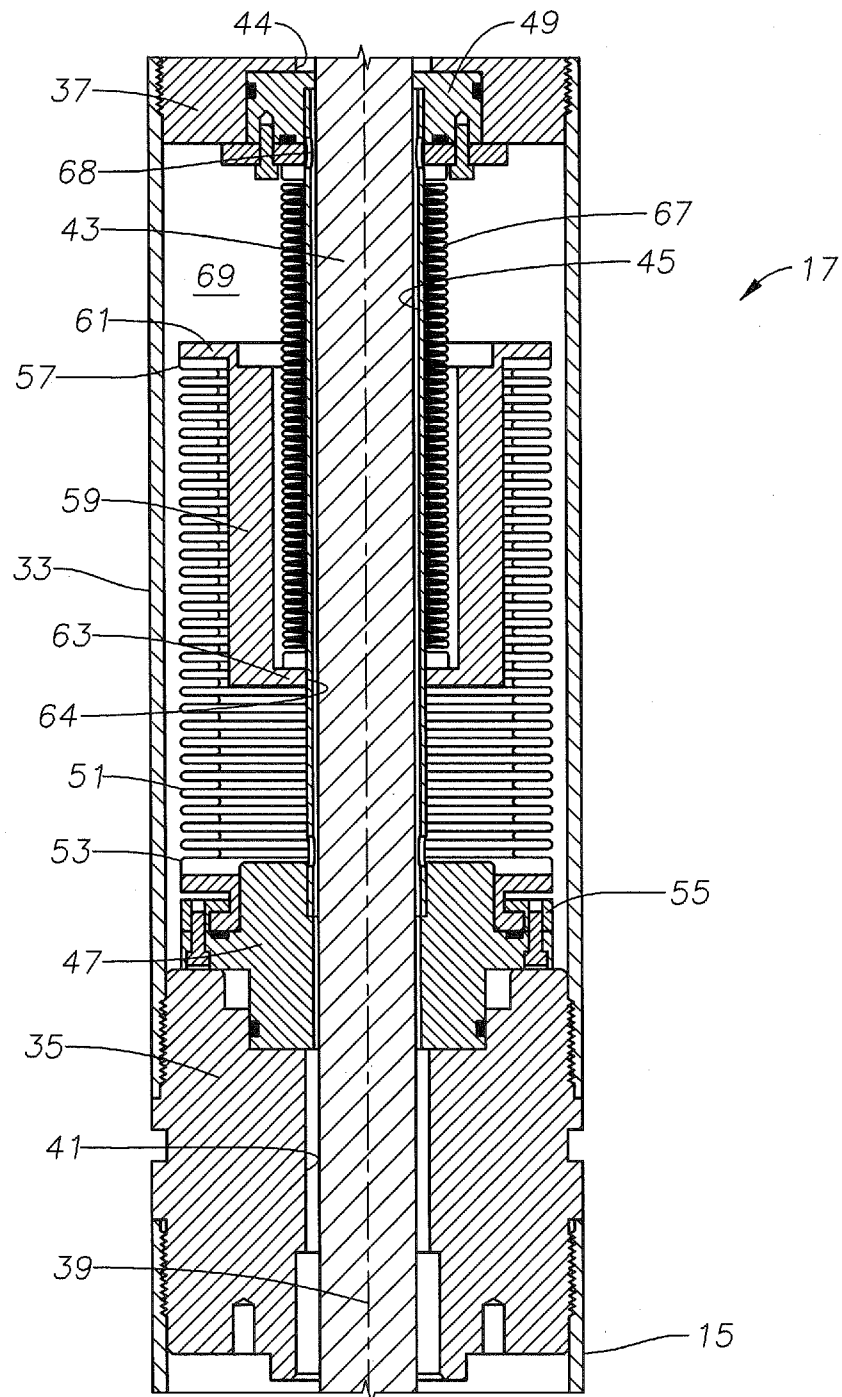


FIG. 2

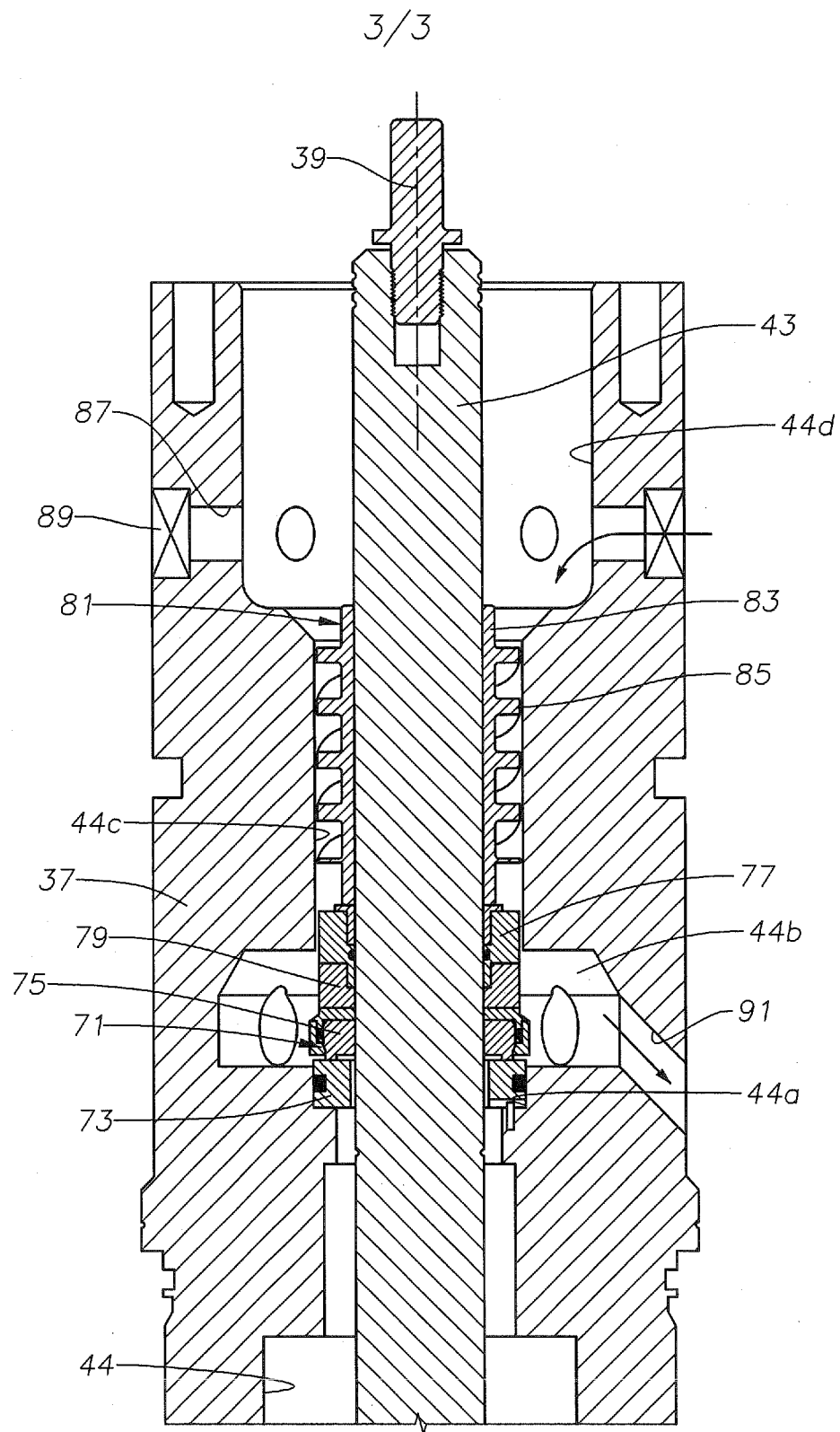


FIG. 3

A. CLASSIFICATION OF SUBJECT MATTER**F04B 47/06(2006.01)i, F04B 53/14(2006.01)i, E21B 43/12(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)

F04B 47/06; F04B 17/00; F04B 39/02; F04D 13/10; F16C 1/24; F16C 33/72; F04B 17/03; F04D 29/06; F04B 53/14; E21B 43/12

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: pump, motor, lubricant, seal, circulation, shaft, hub, discharge, filter, inlet, outlet

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 [0001], [0005]-[0006], [0010]-[0023]; and figures 1-3.	1-13
Y	US 2010-0143160 A1 (FORSBERG, MICHAEL A.) 10 June 2010 See paragraphs [0003], [0008]-[0012], [0024]-[0026], [0035]-[0039]; and figures 1, 4.	1-13
A	US 2009-0010773 A1 (PARMETER et al.) 08 January 2009 See paragraphs [0001], [0014]-[0030]; and figures 1, 2A-2C.	1-13
A	US 2009-0161997 A1 (BEAUCHAMP et al.) 25 June 2009 See paragraphs [0002], [0009]-[0012], [0029]-[0039]; and figures 1-5.	1-13
A	WO 2007-022125 A1 (BAKER HUGHES INCORPORATED) 22 February 2007 See page 1, lines 4-6; page 3, line 10 - page 4, line 31; and figures 1-4.	1-13



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

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"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

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"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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