



- (51) **International Patent Classification:**
F04B 47/06 (2006.01) *E21B 43/12* (2006.01)
- (21) **International Application Number:**
PCT/US2016/024663
- (22) **International Filing Date:**
29 March 2016 (29.03.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/140,977 31 March 2015 (31.03.2015) US
15/075,359 21 March 2016 (21.03.2016) US
- (71) **Applicant:** BAKER HUGHES INCORPORATED
[US/US]; P.O. Box 4740, Houston, TX 77210-4740 (US).
- (72) **Inventor:** DUAN, Ping; 21515 Amber Grain Lane,
Cypress, TX 77433 (US).
- (74) **Agents:** HENDRYX, Thomas, N. et al.; Baker Hughes In-
corporated, P.O. Box 4740, Houston, TX 77210-4740
(US).

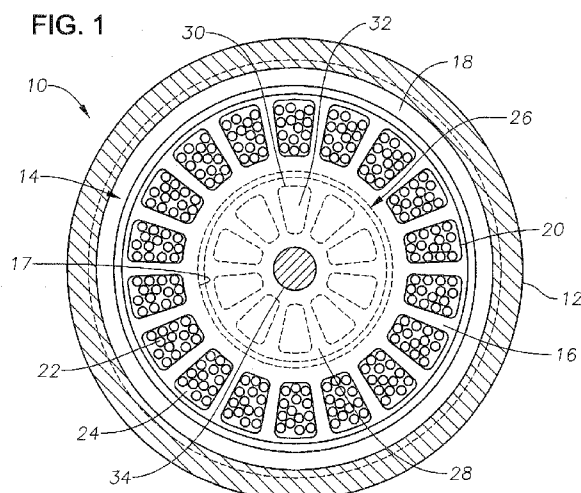
(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) **Title:** ELECTRICAL SUBMERSIBLE PUMP WITH MOTOR WINDING ENCAPSULATED IN BONDED CERAMIC



(57) **Abstract:** An electrical submersible pump assembly (45) has a motor (10) with a stator stack of limitations (16). The stack has slots (20) through which magnet wires (22) are wound. An encapsulate (24) surrounds and bonds the magnet wires together within each slot. The encapsulate includes ceramic particles (25) within a polymer adhesive matrix (27). The polymer matrix may be a fluoropolymer adhesive. Each of the magnet wires may have an electrical insulation layer (22b) surrounding a copper core (22a). The ceramic particles are rounded and much smaller than a cross-sectional area of each of the magnet wires. At least some of the magnet wires may be in contact with a perimeter (21) of the slot. The polymer matrix fills all voids within each of the slots. The ceramic particles may be porous.



PCT PATENT APPLICATION

Electrical Submersible Pump with Motor Winding Encapsulated in Bonded Ceramic

Cross Reference to Related Application

This application claims priority to U.S. Provisional Application S.N. 62/140,977, filed March 31, 2015, and U.S. Non-Provisional Application S.N. 15/075,359, filed March 21, 2016, the full disclosure of which is hereby incorporated by reference herein for all purposes.

Field

The present disclosure relates to downhole pumping systems submersible in well bore fluids. More specifically, the present disclosure relates to an electrical submersible pump with motor windings that are encapsulated in a composition of ceramic and polymer.

Background

Submersible pumping systems are often used in hydrocarbon producing wells for pumping fluids from within the well bore to the surface. These fluids are generally liquids made up of produced liquid hydrocarbon and often water. One type of system used in this application employs an electrical submersible pump ("ESP"). ESP's are typically disposed at the end of a length of production tubing and have an electrically powered motor. Often, electrical power may be supplied to the pump motor via an electrical power cable from the surface that is strapped alongside the tubing.

ESP motors have stators with axially oriented slots and insulated magnet wires wound through the slots in a selected pattern. A sheet of an insulation material is usually wrapped

around each bundle of magnet wires within each of the slots. The magnet wires extend below a lower end of the stator in loops spaced around a longitudinal axis of the motor. The magnet wires may be bonded in the slots with an epoxy resin to resist mechanical vibration during operation. In one technique, magnet wire leads are spliced to upper ends of three of the magnet wires. The magnet wire leads extend from the upper end of the stator to internal contacts in a motor electrical plug-in receptacle. A dielectric lubricant fills the motor for lubricating bearings within the motor.

Typically, the pumping unit is disposed within the well bore just above where perforations are made into a hydrocarbon producing zone. In this position the produced fluids flow past the outer surface of the pumping motor and absorb heat generated by the motor. In spite of the heat transfer between the fluid and the motor, the motor may still overheat. Overheating may be a problem when the fluid has a high viscosity, a low specific heat, or a low thermal conductivity. This is typical of highly viscous crude oils. Also, the motor may be forced to operate at an elevated temperature past its normal operating temperature in steam injection wells. Elevated well temperatures can reduce motor life. Undesirable chemicals may be formed when the epoxy resin degrades under high temperature. These chemicals can damage the insulation layers of the magnet wires.

Summary

An electrical submersible pumping ("ESP") assembly has a pump driven by an electrical motor. The motor has a stack of stator laminations, the stator laminations having slots formed therethrough. Magnet wires are wound through the slots. An encapsulate bonds the magnet

wires within each of the slots together. The encapsulate comprises ceramic particles bonded together within a polymer matrix.

The ceramic particles may have a size of 20 mesh to 140 mesh. The ceramic particles may be generally spherical. Each of the ceramic particles has a cross-sectional area much smaller than a cross-sectional area of each of the magnet wires. The ceramic particles may be porous.

The polymer matrix is an electrical insulation material. The polymer matrix preferably comprises a fluoropolymer that is selected from a group consisting of perfluoroalkoxy ("PFA"), fluorinated ethylene propylene ("FEP"), polytetrafluoroethylene ("PTFE"), and combinations thereof.

In the embodiment shown, each of the magnet wires comprises an electrical insulation layer surrounding a copper core. Each of the slots has a perimeter; and at least some of the magnet wires may be in contact with the perimeter. The polymer matrix fills all voids within each of the slots.

Brief Description of Drawings

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:

FIG. 1 is a transverse cross sectional view of a motor for use with an electrical submersible pumping system, the motor being constructed in accordance with this disclosure.

FIG. 2 is an enlarged view of one of the stator slots of the motor of FIG. 1, schematically illustrating an encapsulate in the slot having ceramic particles dispersed within a polymer matrix.

FIG. 3 is a side perspective view of an example of a method of encapsulating magnet wires in the motor of FIGS. 1 and 2.

FIG. 4 is a side partial sectional view of the motor of FIG. 1 integrated with an electrical submersible pumping system and disposed in a wellbore.

While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

Detailed Description

The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system 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. In an embodiment, usage of the term “about” includes +/- 5% of the cited magnitude. In an embodiment, usage of the term “substantially” includes +/- 5% of the cited magnitude.

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.

Figure 1 shows an axial partial sectional view of an upper end of a motor 10 for use with an electrical submersible pumping system ("ESP"). The motor 10 is equipped with a generally cylindrical housing 12 which covers and protects components of the motor 10 against harsh downhole conditions, and provides an external support in which the components are contained. Motor 10 will typically be filled with a liquid dielectric motor lubricant. Illustrated within housing 12 is a stator assembly 14, which includes a stator stack 16 made up of a series of laminations that are coaxially stacked together. Each lamination is typically a thin, steel disc. The laminations of stator stack 16 have central openings 17 that define a bore of stator assembly 14. An annular ring 18 shown set on an upper surface of stator stack 16 has an inner diameter less than an outer diameter of stator stack 16 and retains stack 16 within housing 12.

A series of slots 20 are formed axially through each of the laminations in stack 16 and which extend along a length of stack 16. Slots 20 as shown are formed equidistant apart from one another, extending circumferentially around the bore of the stator stack 16. Referring to FIG. 2, each slot 20 has a perimeter 21 that may be generally trapezoidal in shape, as shown. An opening (not shown) may lead from each slot 20 to central opening 17. Alternately, each slot 20 may be completely enclosed by its perimeter 21.

A number of motor or magnet wires 22 are wound along the length of each of the slots 20. Normally, motor 10 (Fig. 1) is a three-phase motor and will have three separate magnet wires 22. Each magnet wire 22 extends the length of stator assembly 14 and has multiple turns within each slot 20. Preferably, each magnet wire 22 has a metal core 22a, normally copper, that is encased in a high temperature electrical insulation layer 22b.

An encapsulate 24 surrounds and rigidly bonds the magnet wires 22 together within each slot 20 and forms a protective coating around the magnet wires 22. In this embodiment, there is no liner surrounding the bundle of magnet wires 22 in each slot 20; rather encapsulate 24 and magnet wires 22 completely fill each slot 20. Part of encapsulate 24 will be bonded to and in contact with perimeter 21 of each slot 20. Also, some of the magnet wires 22 will be in contact with slot perimeter 21.

Encapsulate 24 is made up of a mixture of ceramic particles 25 bonded together by a polymer matrix 27. Ceramic particles 25 are dispersed throughout polymer matrix 27. Ceramic particles 25 are formed of a hard material with high electrical insulation properties. Ceramic particles 25 may be porous to the dielectric motor lubricant contained within motor 10 so as to increase the rate of heat transfer from motor 10.

Ceramic particles 25 have cross-sectional dimensions much smaller than the cross-sectional dimension of each magnet wire 22. For example, ceramic particles 25 may be in a particle range size from about 20 mesh to about 140 mesh. In one optional embodiment, ceramic particles 25 are generally rounded or spherical and do not have sharp edges. The rounded shape of the ceramic particles 25 reduces the chances for damaging magnet wire insulation layers 22b.

Ceramic particles 25 may comprise proppants or micro-spheres, such as those used for downhole gravel packing having a trade name of Carboaccucast®, and which may be commercially available from the Carbo Corporation, 575 N. Dairy Ashford Rd, Suite 300, Houston, Texas, 77079, (281) 921 6400. In a non-limiting example, ceramic particles 25 may comprise Carboaccucast® ID50 having a particle size of from about 50 mesh to about 100 mesh. Alternate embodiments exist wherein ceramic particles 25 comprise alumina (99.9% Al₂O₃), aluminum silicate, Al₂SiO₅, berillia (99% BeO), boron nitride, BN, cordierite, Mg₂Al₄Si₅O₁₈, forsterite, mg₂SiO₄, porcelain, steatite, Mg₃Si₄O₁₁•H₂O, titanates of Mg, Ca, Sr, Ba, and Pb, barium titanate, glass bonded, zirconia, ZrO₂, fused silica, SiO₂, micas, muscovite, ruby, natural, phlogopite, amber, natural, fluorophlogopite, synthetic, glass-bonded mica, and combinations thereof.

Polymer matrix 27 is formed of a polymer adhesive that heat cures after filling each slot 20. Example polymer adhesives for polymer matrix 27 include fluoropolymers. Example fluoropolymers for polymer matrix 27 include perfluoroalkoxy alkanes (“PFA”), fluorinated ethylene propylene (“FEP”), and polytetrafluoroethylene (“PTFE”). Preferably, polymer matrix 27 has good chemical resistance properties at elevated temperatures. Elevated temperatures are those that can typically occur downhole, and may be those that exceed about 150° F.

One method of manufacturing polymer matrix 27 employs a fluoropolymer supplied as a powder that has a particle size ranging from about 20 micron to about 200 micron. In a non-limiting example, polymer matrix 27 may include a fluoro-polymer powdered binder NC-1500 available from Daikin Chemicals, 20 Olympic Drive Orangeburg, N.Y. 10962, <http://www.daikin-america.com/>, and which is a thermal-fusible FEP based fine powder having a particle size of from about 30 microns to about 60 microns.

Referring again to Fig. 1, a rotor assembly 26 is shown circumscribed by stator assembly 14, where the rotor assembly 26 rotates with respect to stator assembly 14. Rotor assembly 26 includes several rotor stacks 28 (only one shown) axially separated from each other by radial bearings. Rotor stack 28, similar to stator stack 16, is made up of a number of rotor laminations or steel discs that are stacked on top of one another in a coaxial arrangement. Slots 30 are formed axially through each of the rotor laminations, so that when the laminations are stacked, the slots 30 extend through the entire length of the rotor stack 28. Slots 30 are shown substantially equidistant apart from one another at multiple angular locations around the rotor stack 28. Elongate rotor bars 32 are set in slots 30, wherein in one example the rotor bars 32 include a magnetic material. Thus, in one example, energizing the magnet wires 22 with an electrical current creates an alternating electromagnetic field (not shown). The rotor bars 32 are responsive to the electromagnetic field thereby causing rotation of the rotor assembly 26. Coaxial within the rotor assembly 26 is an elongate shaft 34 that couples to and rotates with the rotor assembly 26.

In one non-limiting example, the mixture of ceramic particles 25 and polymer powder for polymer matrix 27 includes about 100 parts of ceramic particles 25 and about 30 parts of polymer matrix 27 powder. Ceramic particles 25 may have a size of about 50 mesh to about 100 mesh, and the powder for polymer matrix 27 may have a particle size of about 30 microns to about 60 microns. Yet further optionally, the polymer matrix 27 may include a chemical resistant fluoro-polymeric powder, such as FEP. Further optionally in this example, new stainless steel components are installed in the stator and end attachments, and the slots 20 in the stator stack 16 are filled with the mixture of ceramic particles 25 and powder for polymer matrix 27.

Schematically illustrated in Figure 3 is one example of how the encapsulate 24 of Figs 1 and 2 can be formed within slots 20. As shown, a mixture 38 of ceramic particles 25 and powdered polymer matrix 27 is combined within a container 36 having an outlet 37. Mixture 38 exits the outlet 37 and enters a shroud 40 that is set over the upper end of motor 10. At the opposite end of motor 10 is a vacuum system 41 that draws air from within the motor 10, and thus the slots 20 (Figs. 1 and 2), thereby drawing in mixture 38 to fill all voids and interstices that may exist between the magnet wires 22 in the slots 20 (FIGS. 1 and 2). Optionally, a filter 42 may be within vacuum system 41 for blocking ceramic particles 27 or the powders of polymer matrix 27 from exiting the lower end of vacuum system 41. In one embodiment, filter 42 comprises a 100 mesh steel screen for capturing ceramic particles 25 and polymer matrix 27 powders that may make their way through the entire length of motor 10. In one alternative, a vacuum pump 44 is included on the lower end of vacuum system 41, wherein a hose connects vacuum pump 44 to the lower end of pump 10 so that the vacuum pump 44 can apply suction to the lower end of the slots 20. A mechanical shaker (not shown), can be used to further ensure mixture 38 fills any remaining voids in the slots 20.

After mixture 38 of ceramic particles 25 and polymer matrix 27 powders fill slots 20 around magnet wires 22, mixture 38 can be heated. The heating may be done either by heating the entire motor 10 or by conducting electricity through magnet wires 22 for heating the mixture 38. In one example, a melting point of the powders of polymer matrix 27 is about 260° C to about 350° C; thus the mixture 38 is heated to at least this temperature, thereby melting the powders of polymer matrix 27. The heating and subsequent cooling causes bonding of ceramic particles 25 within polymer matrix 27 to magnet wires 22, forming a solid, rigid encapsulate 24 within slots 20 for protecting wires 22. The heating does not affect ceramic particles 25.

Optionally, heating of the entire motor 10 can take place within a high temperature tubular oven 43. In a non-limiting example, the motor 10 is heated for a period of time up to about 5 hours, and the upper and lower openings of slots 20 are plugged to retain mixture 38 in the slots 20. Yet further optionally, a nitrogen blanket is applied to the motor 10 to remove volatiles released during heating. Melting, then cooling the polymer matrix 27 powders forms an integrated tough structural bonding material that secures the magnet wires 22 in place within slots 20. As indicated above, the presence of ceramic particles 25 within the encapsulate 24 creates a porosity for encapsulate 24, which increases heat transfer away from motor.

Shown in partial side sectional view in Figure 4 is one example of the motor 10 used in conjunction with an electrical submersible pump (ESP) system or assembly 45. Here the ESP system 45 is disposed in a wellbore 46 on a lower end of a string of production tubing 48. An upper end of production tubing 48 connects to a wellhead assembly 50, shown capping an upper end of wellbore 46. Motor 10 couples to a pump 58, which is shown provided on an upper end of ESP system 45. Shaft 34 connects to impellers 54 (shown in phantom view) within pump 58. Pump 58 pumps well fluid from within wellbore 46 so it may be discharged to the production tubing 48 and pumped to the wellhead assembly 50. A seal section 56 is provided between the pump 52 and motor 10 for equalizing pressure within the ESP system 45 with the hydrostatic pressure of well fluid in wellbore 46. An intake 58 is shown formed through a housing of the pump 52 so that fluid within wellbore 46 can make its way to the impellers 54 for pressurization and delivery to production tubing 48. In this example, the fluids pressurized by the ESP system 45 are produced from a formation 60 that is intersected by the wellbore 46.

The present invention described herein is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. The chemically

inert encapsulation of the motor wires replaces chemically instable epoxy resin. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.

Claims

1. An electrical submersible pumping (“ESP”) assembly (45) having a pump (58) driven by an electrical motor (10), the motor having a stack of stator laminations (16), the stator laminations having slots (20) formed therethrough, and magnet wires (22) wound through the slots, characterized by:

an encapsulate (24) that bonds the magnet wires within each of the slots together, the encapsulate comprising ceramic particles (25) bonded together within a polymer matrix (27).
2. The ESP assembly of claim 1, wherein the ceramic particles have a size of 20 mesh to 140 mesh.
3. The ESP assembly of claim 1, wherein the polymer matrix comprises a fluoropolymer that is selected from a group consisting of perfluoroalkoxy (“PFA”), fluorinated ethylene propylene (“FEP”), polytetrafluoroethylene (“PTFE”), and combinations thereof.
4. The ESP assembly of claim 1, wherein each of the magnet wires comprises an electrical insulation layer (22b) surrounding a copper core (22a).
5. The ESP assembly of claim 1, wherein the ceramic particles are generally spherical.
6. The ESP assembly of claim 1, wherein each of the ceramic particles has a cross-sectional area much smaller than a cross-sectional area of each of the magnet wires.
7. The ESP assembly of claim 1, wherein:

each of the slots has a perimeter (21); and

at least some of the magnet wires are in contact with the perimeter.

8. The ESP assembly of claim 1, wherein:
the polymer matrix fills all voids within each of the slots.
9. The ESP assembly of claim 1, wherein:
the polymer matrix is formed of an electrical insulation material.
10. The ESP assembly of claim 1, wherein the ceramic particles are porous.
11. The ESP assembly according to claim 1, wherein:
the polymer matrix comprises a fluoropolymer adhesive.
12. The ESP assembly of claim 1, wherein:
each of the slots has a perimeter;
at least some of the magnet wires are in contact with the perimeter; and
a portion of the polymer matrix is in contact with the perimeter.

1/3

FIG. 1

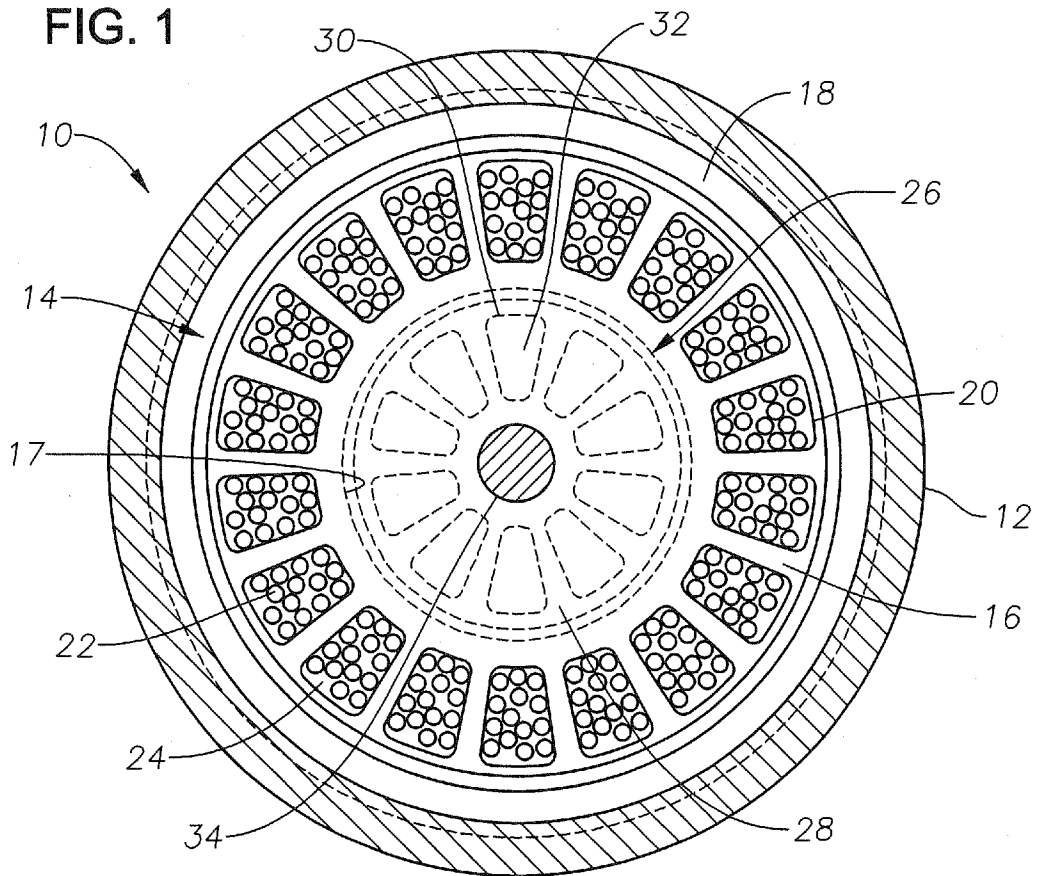


FIG. 2

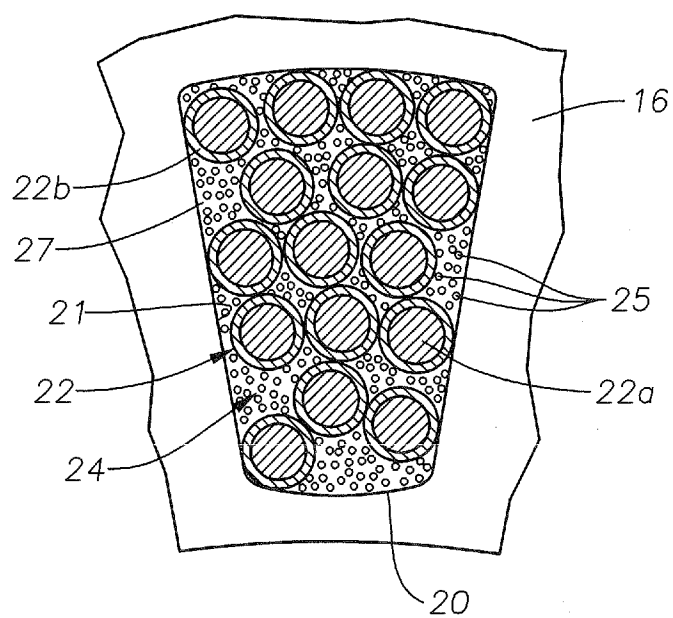
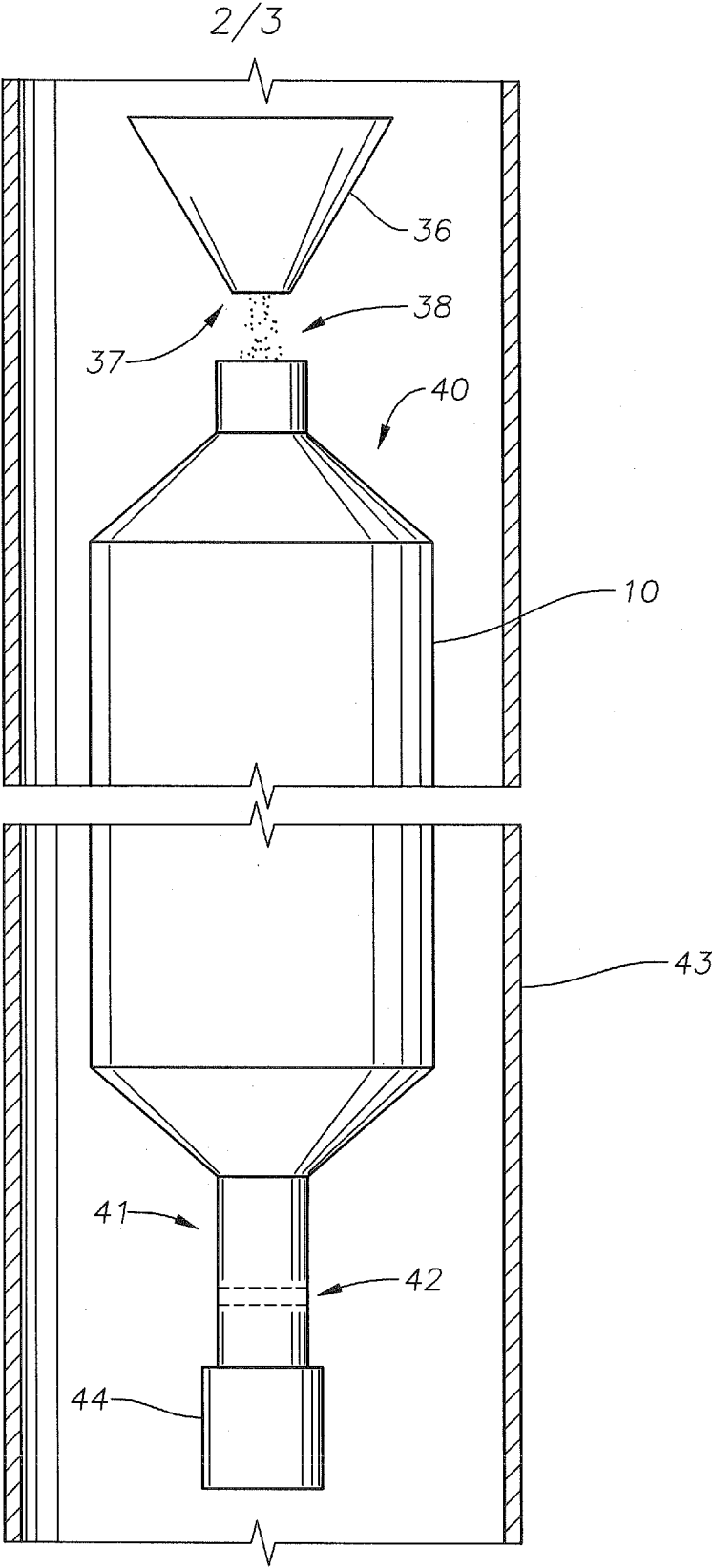
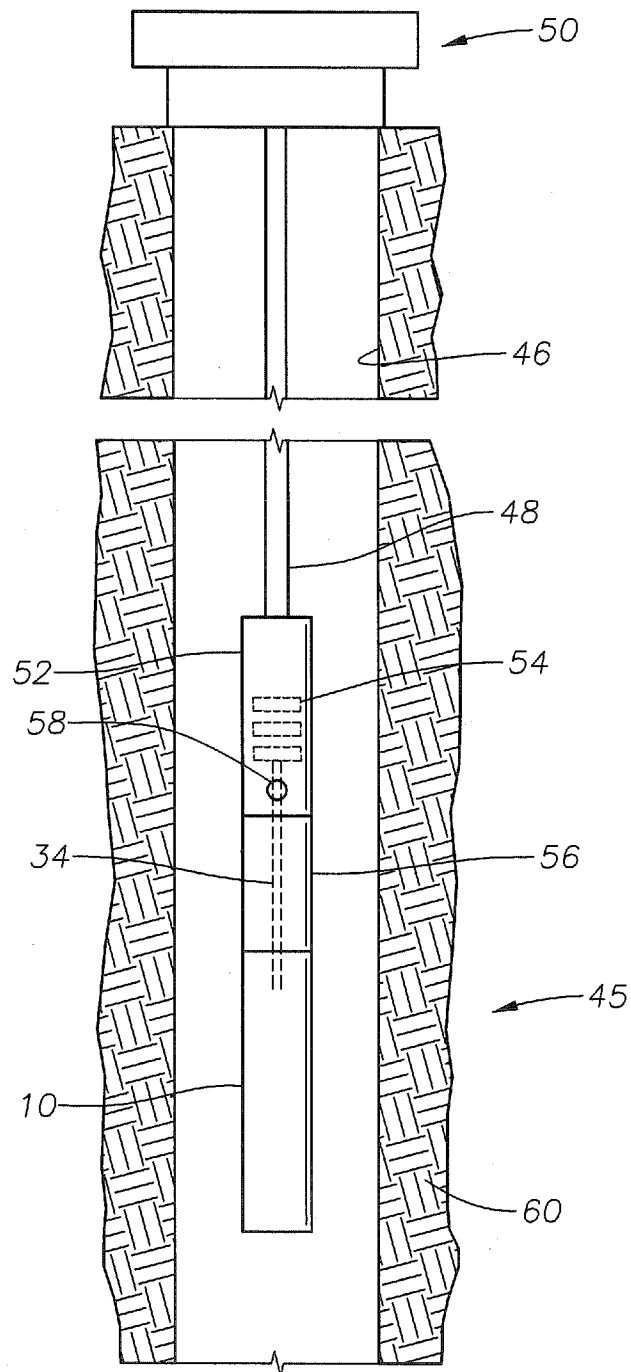


FIG. 3



3/3

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/024663**A. CLASSIFICATION OF SUBJECT MATTER****F04B 47/06(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; B05D 5/12; F04D 13/08; F04B 35/04; H02K 3/44; H02K 15/04; H02K 3/30; H02K 1/04; H02K 5/132; H02K 15/12; 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: electrical submersible pump, motor, stator, encapsulate, polymer, ceramic, and insulation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0091202 A1 (PARMETER et al.) 09 April 2009 See paragraphs [0007], [0016]–[0018] and figures 1–3.	1–12
Y	US 2006-0261683 A1 (DU et al.) 23 November 2006 See paragraphs [0083]–[0087], [0100], [0108] and figures 5, 10.	1–12
A	US 2013-0069478 A1 (HAMER, COLIN) 21 March 2013 See paragraphs [0007], [0014]–[0015] and figure 2.	1–12
A	US 2010-0156215 A1 (GOERTZEN et al.) 24 June 2010 See paragraphs [0051]–[0052] and figure 2A.	1–12
A	US 2012-0025646 A1 (SHEERAN et al.) 02 February 2012 See paragraphs [0020]–[0023] and figures 2–3.	1–12



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

04 July 2016 (04.07.2016)

Date of mailing of the international search report

04 July 2016 (04.07.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

KIM, Jin Ho

Telephone No. +82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/024663

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0091202 A1	09/04/2009	CN 101815842 A	25/08/2010
		CN 101815842 B	19/06/2013
		RU 2010116816 A	10/11/2011
		RU 2442880 C2	20/02/2012
		US 7679242 B2	16/03/2010
		WO 2009-046070 A2	09/04/2009
		WO 2009-046070 A3	02/07/2009
US 2006-0261683 A1	23/11/2006	AU 2003-251832 A1	02/02/2004
		CA 2486453 A1	22/01/2004
		CN 100511924 C	08/07/2009
		CN 101017997 A	15/08/2007
		CN 101017997 B	13/10/2010
		CN 1493104 A	28/04/2004
		CN 1669203 C	14/09/2005
		EP 1354396 A1	22/10/2003
		EP 1354396 B1	26/09/2007
		EP 1522134 A2	13/04/2005
		EP 1626480 A1	15/02/2006
		EP 1626480 B1	01/10/2008
		JP 03917520 B2	23/05/2007
		JP 2004-518390 A	17/06/2004
		JP 2005-533475 A	04/11/2005
		KR 10-2004-0007433 A	24/01/2004
		US 2002-0089240 A1	11/07/2002
		US 2002-0089241 A1	11/07/2002
		US 2002-0148100 A1	17/10/2002
		US 2004-0012271 A1	22/01/2004
		US 2004-0056537 A1	25/03/2004
		US 2004-0056538 A1	25/03/2004
		US 2004-0056539 A1	25/03/2004
		US 2005-0278937 A1	22/12/2005
		US 2005-0280321 A1	22/12/2005
		US 2006-0254046 A1	16/11/2006
		US 2006-0255678 A1	16/11/2006
		US 2006-0261700 A1	23/11/2006
		US 2011-0018370 A1	27/01/2011
		US 6735846 B2	18/05/2004
		US 6946758 B2	20/09/2005
		US 7013552 B2	21/03/2006
		US 7096566 B2	29/08/2006
		US 7215048 B2	08/05/2007
		US 7464455 B2	16/12/2008
		US 7591063 B2	22/09/2009
		US 7685697 B2	30/03/2010
		US 7814641 B2	19/10/2010
		US 8203239 B2	19/06/2012
		WO 02-056445 A1	18/07/2002
		WO 2004-008603 A2	22/01/2004

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/024663

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013-0069478 A1	21/03/2013	CN 103023187 A EP 2573908 A2 EP 2573908 A3 KR 10-2013-0032826 A	03/04/2013 27/03/2013 29/10/2014 02/04/2013
US 2010-0156215 A1	24/06/2010	CA 2688859 A1 US 8604656 B2	19/06/2010 10/12/2013
US 2012-0025646 A1	02/02/2012	MX 2013001014 A US 8508083 B2 WO 2012-015859 A2 WO 2012-015859 A3	07/03/2013 13/08/2013 02/02/2012 12/04/2012