

(19)



(11)

EP 3 077 677 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

13.11.2019 Bulletin 2019/46

(51) Int Cl.:

F04D 13/10 ^(2006.01) **H02J 11/00** ^(2006.01)
F04D 5/00 ^(2006.01) **E03B 3/08** ^(2006.01)
E21B 49/08 ^(2006.01) **F04D 15/02** ^(2006.01)
F04D 13/06 ^(2006.01)

(21) Application number: **14867021.9**

(22) Date of filing: **03.12.2014**

(86) International application number:

PCT/US2014/068371

(87) International publication number:

WO 2015/084957 (11.06.2015 Gazette 2015/23)

(54) **GROUNDWATER SAMPLING PUMP**

GRUNDWASSERENTNAHMEPUMPE

POMPE DE PRÉLÈVEMENT D'EAUX SOUTERRAINES

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **03.12.2013 US 201361911273 P**

(43) Date of publication of application:

12.10.2016 Bulletin 2016/41

(73) Proprietor: **Q.E.D. Environmental Systems, Inc.**
Ann Arbor, MI 48106 (US)

(72) Inventors:

• **COLBY, Douglas D.**
Clarkston, Michigan 48348 (US)

• **REESBECK, Thomas T.**

Ann Arbor, Michigan 48108 (US)

(74) Representative: **Staeger & Sperling**

Partnerschaftsgesellschaft mbB

Sonnenstraße 19

80331 München (DE)

(56) References cited:

EP-A1- 2 077 374 US-A1- 2002 071 759

US-A1- 2006 180 302 US-A1- 2006 180 302

US-A1- 2007 166 178 US-A1- 2010 211 226

US-A1- 2010 211 226 US-A1- 2011 300 008

US-A1- 2012 292 051

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

RELATED APPLICATIONS

[0001] The present application claims priority from U.S. Provisional Patent Application Serial No. 61 /911,273, filed December 3, 2013.

FIELD

[0002] The present disclosure relates to groundwater sampling pumps, used to collect water samples from groundwater fed wells.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] Groundwater sample pump systems are known which use DC motors to pump effluent from a well upward to ground level where a sample is drawn for off-site analysis. Known systems use a full speed pump and a throttle device at a discharge location to reduce discharge flow for collecting the sample. A disadvantage of known systems is that the throttle device reduces volume flow rate, but locally increases the flow velocity, making collection of a small volume sample difficult. In addition, power consumption of known groundwater sample pump systems can range from 20 up to 40 Amperes, and commonly requires a high current AC power source with an AC/DC converter to provide DC power for pump motor operation, which is both heavy and expensive. An AC power source is often not available at remote well sites, therefore the operator must bring a separate source of AC power. Also, known sampling systems use a centrifugal pump which at operating speed (12,000 to 15,000 rpm) results in cavitation at the impeller when the flow rate is reduced downstream by the sample throttle device US 2007/0166178 A1 discloses a sampling pump configured for use in a wellbore for pumping liquids collecting in the wellbore, and comprising a regenerative impeller driven by an electric motor and controlled by a float switch. A control box connected to a solar panel controls the pump operations. The prior art pump fails to disclose the following features of the present invention: the semicircular discharge channel extending from a tapered minimum area channel end, in a semicircular path, to a maximum area channel end proximate the discharge opening ; the semicircular supply channel beginning at a tapered minimum area channel end and extending in a semicircular path to a maximum area channel end positioned proximate to an inlet bore; and the reel assembly having a reel rotatably supported from a frame, the reel configured to enable the flexible cable assembly to be wound thereon when the sampling pump is not in use, and unwound from the reel as the pump outer housing is lowered down into the wellbore. Further prior art wellbore pumps are known from

US 2006/0180302 A1 and US 2010/0211226 A1. Document US 2002/0071759 A1 discloses details of the casing of a prior art regenerative pump.

5 SUMMARY

[0005] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

10 **[0006]** In one aspect the present disclosure relates to a sampling pump configured for use in a wellbore for pumping liquids collecting in the wellbore. The sampling pump according to the invention comprises the features of claim 1

15 **[0007]** In another non-claimed aspect the present disclosure relates to a sampling pump configured for use in a wellbore for pumping liquids collecting in the wellbore. The sampling pump may comprising a pump component having an outer housing configured to be inserted into the well bore, an inlet and an outlet each being operably associated with the outer housing at opposite ends of the outer housing. A pump element may be housed in the outer housing. A direct current (DC) motor may be housed within the outer housing for driving the pump element. The pump element may be in communication with the inlet and the outlet, and configured to draw liquids out from the wellbore into the outer housing and to the outlet when driven rotationally by the DC motor. A flexible cable assembly may be in communication with the outlet for supplying DC power to the pump component when the pump component is positioned in the wellbore. A reel assembly may be included which has a reel rotatably supported from a frame, the reel configured to enable the flexible cable assembly to be wound thereon when the pump component is not in use. A DC electrical connector is supported on the frame for enabling DC power from an external DC power source to be coupled to the reel assembly for powering the DC motor. A fluid level sensor is operably associated with the housing for detecting when the housing is positioned in fluid. The sensor may be configured to display a first optical signal when submerged in water and a second optical signal when not submerged in water. A DC battery may be supported on the reel assembly for providing electrical power to the fluid level sensor while no power is being supplied to the DC motor. A user engageable switch may be included for selectively applying and turning off power to the fluid level sensor while no power is being supplied to the DC motor. A control panel may be supported from the frame of the reel assembly. The control panel may be in electrical communication with the fluid sensor and configured to enable a user to control on and off operation of the DC motor, as well as to connect DC power from an external DC power source to the control panel.

55 **[0008]** In another non-claimed aspect the present disclosure relates to a sampling pump assembly including a pump outer housing having an inlet end cap with multiple water inlet ports. The inlet end cap is connected to

the pump outer housing using bayonet pins extending through L-shaped slots in a first housing connector. An outlet end cap is connected to the pump outer housing using bayonet pins and has a tubing connector for releasably connecting an effluent tube thereto. A pump is included which has a regenerative impeller connected to a brushless DC motor. The brushless DC motor is positioned within the pump outer housing and the regenerative impeller is positioned within the inlet end cap. The brushless DC motor may operate at approximately 8,000 rpm providing a lift of at least up to about 45.72m (150 feet), and possibly higher. A sensor extends beyond the outlet end cap and provides a sensing signal when the pump assembly becomes submerged below a water surface in a wellbore in which the pump outer housing is positioned. A reel assembly is included which has a rotatable support reel for supporting a flexible cable assembly for supplying DC power to the brushless DC motor. The flexible cable assembly is able to be wound onto the rotatable support reel. At least one internal battery is carried by the reel assembly which provides electrical power for the sensor. An LED is provided with the reel assembly and is configured to flash continuously as the sampling pump assembly is lowered into a wellbore and prior to the sensor contacting water. The LED changes to a continuously illuminated condition when the pump assembly extends below a water level surface in the wellbore. Multiple distance marks are created on the flexible cable assembly to enable a user to determine a depth that the pump outer housing is positioned within the wellbore.

[0009] According to several additional aspects, a sampling pump assembly includes a pump outer housing having a housing inlet end releasably connected thereto. The housing inlet end includes multiple water inlet ports and is connected to the pump outer housing using one or more bayonet pins radially extending through one or more L-shaped slots created in a first housing connector. At an opposite end of the pump outer housing from the housing inlet end is an inlet end cap which is similarly connected using one or more bayonet pins received in an L-shaped slot of a second housing connector. The inlet end cap receives a tubing connector for releasably connecting an effluent tube. A sensor extends beyond the inlet end cap and provides a sensing function for the period when sampling pump assembly is operated and submerged below a water volume surface.

[0010] In various other aspects of the present disclosure the sampling pump assembly is readied to be lowered into a well, a first switch, located on a control panel of the reel, is switched from an "off" to an "on" position. An internal battery provided within the reel provides sufficient electrical power for operation of the sensor as the sampling pump assembly is lowered. An LED also present on the control panel flashes continuously as the sampling pump assembly is lowered into the well and prior to sensor contacting a water volume within the well. As the sampling pump assembly enters the water volume

and extends below a water level surface, water contacts the sensor, which creates an electrical signal indicating that the entire sampling pump assembly is positioned below the water level surface. At this time, the LED changes from a continuous flashing condition to a continuous energized "on" condition. The "on" condition of the LED visually indicates to the operator that the sampling pump assembly is fully submerged within the water volume.

[0011] After the LED changes to the continuous "on" condition, the sampling pump assembly is drawn upward until the LED changes back to the continuous flashing operation, at which time a plurality of distance marks provide a depth indicated in 1 foot incremental positions along the outer casing of a cable assembly identifying depth in feet of the position of the sampling pump assembly within the well. The sampling pump assembly is lowered back into the well until the LED changes again to the continuous "on" condition. An external source of 12 VDC electrical power is then connected to the reel and the operator switches a second switch from an "off" to an "on" position, which starts operation of the DC motor.

[0012] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0013] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

FIG. 1 is a front elevational view of a groundwater sampling pump of the present disclosure;

FIG. 2 is an end elevational view of the pump of FIG. 1;

FIG. 3 is a cross sectional side elevational view taken at section 3 of FIG. 1;

FIG. 4 a front elevational view of an impeller housing assembly of the present disclosure;

FIG. 5 is a cross sectional front elevational view taken at section 5 of FIG. 4;

FIG. 6 is a top plan view of the impeller housing of FIG. 4;

FIG. 7 is a bottom plan view of an impeller retention member of the housing assembly of FIG. 4;

FIG. 8 a front perspective view of a groundwater sampling pump and reel assembly of the present disclosure including the groundwater sampling pump of FIG. 1;

FIG. 9 is a partial cross sectional front elevational view of the groundwater sampling system mounted to a well pipe;

FIG. 10 is a front elevational view of a control panel

provided on a reel of the groundwater sampling system;

FIG. 11 is a graph of flow rate versus well depth for the groundwater sampling system of the present disclosure;

FIG. 12 is a circuit diagram of a control system for the groundwater sampling pump of FIG. 8;

FIG. 13 is a circuit diagram of a pump control system portion for the groundwater sampling pump of FIG. 8;

FIG. 14 is a side elevation view of another embodiment of a groundwater sampling pump in accordance with the present disclosure;

FIG. 15 is a view of a portion of the pump assembly of FIG. 14;

FIG. 15a is an enlarged view of the circled portion in FIG. 15;

FIG. 16 is a cross sectional side view of the bayonet pins engaged within their respective slots and compressing a gasket to achieve a watertight seal within the pump housing;

FIG. 17 is a cross sectional side view of an annular, replaceable motor shaft seal that is used in the pump assembly of FIG. 14;

FIG. 18 is a plan view of a first surface of an impeller retainer used in the pump assembly of FIG. 14;

FIG. 19 is a side view of the impeller retainer of FIG. 18;

FIG. 20 is a plan view of a second surface (i.e., opposing surface) of the impeller retainer of FIG. 18;

FIG. 21 is a plan view of a first surface of an impeller housing used in the pump assembly of FIG. 14;

FIG. 22 is a side view of the impeller housing shown in FIG. 21; and

FIG. 23 is a plan view of a second surface (i.e., opposing surface) of the impeller housing of FIG. 21.

[0014] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0015] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0016] Referring to FIG. 1, a sampling pump assembly 10 includes a pump outer housing 12 having a housing inlet end 14 releasably connected thereto. The housing inlet end 14 includes multiple water inlet ports 16. The housing inlet end 14 is connected to the pump outer housing 12 using one or more bayonet pins 18 radially extending through an L-shaped slot 20 created in a first housing connector 22. The housing inlet end 14 is oriented such that the bayonet pin 18 is received in the L-shaped slot, and the housing inlet end 14 is axially rotated to releasably lock the housing inlet end 14 in position. At an opposite end of the pump outer housing 12 from the housing inlet end 14 is an outlet end cap 24 which is similarly connected using one or more bayonet pins 26

received in an L-shaped slot 28 of a second housing connector 30. The outlet end cap 24 receives a tubing connector 32 for releasably connecting an effluent tube shown and described in greater detail in reference to FIG.

9. A sensor 34 extends beyond the outlet end cap 24 and provides a sensing function for the period when sampling pump assembly 10 is operated and submerged below a water volume surface, as described in greater detail in reference to FIG. 9. According to several aspects, the sampling pump assembly components such as the pump outer housing 12, the housing inlet end 14, and the outlet end cap 24 can be constructed of a metal material, such as stainless steel. Other materials can also be used.

[0017] Referring to FIG. 2 and again to FIG. 1, the tubing connector 32 communicates with a discharge chamber 36 where water pumped by the sampling pump assembly 10 is received for discharge. A conduit connector 38 is also provided which provides the ability to both receive and seal conduits providing electric power as well as control signals to the operating components of sampling pump assembly 10.

[0018] Referring to FIG. 3 and again to FIGS. 1-2, a conduit 39 is shown in an exemplary position retained by the conduit connector 38. The conduit 39 provides electrical power, as previously noted, for operating the components of sampling pump assembly 10. The housing inlet end 14 provides an inlet chamber 40 proximate to a housing inlet end wall 14a. A filter 42, such as a metal or plastic screen, is releasably connected to an inlet end wall 44 which defines a boundary wall for the inlet chamber 40 opposite to the housing inlet end wall 14a. Water flowing into the inlet chamber 40, via the water inlet ports 16, passes through the filter 42 and enters an impeller chamber 46. The inlet end wall 44 defines a portion of housing inlet end 14 which is sealed against an inner perimeter wall of pump outer housing 12 at the time the bayonet pins 18 are engaged, using one or more seal members 48 such as O-rings. A pump element in the form of a "regenerative" impeller 50, positioned within impeller chamber 46, is held in rotational position using an impeller retainer 52. A connecting member 54 extends partially through and positively rotatably engages impeller 50. The connecting member 54 extends through a motor shaft seal 55 to allow for fluid sealed rotation of impeller 50. Impeller 50 is connected to and rotated by operation of a brushless DC motor 56 having a motor shaft 57 extending into and connected with the connecting member 54. The motor shaft seal 55 prevents water within impeller chamber 46 from entering a sealed enclosure having DC motor 56 contained therein. A circuit board 58, as well as DC motor 56, are positioned within a watertight cavity 60 provided by a pump inner housing 62 which is slidably received within the pump outer housing 12. The components of the circuit board 58 may be potted to hermetically seal them. Additionally, a plurality of electrically conductive metal pins 61 may project from the circuit board 58 into the space between the motor 56 and the edge of the circuit board 58 to detect if water is

present in this space. The metal pins 61 sense the presence of water by detecting when a conductive path between them has been formed.

[0019] The brushless DC motor 56 using regenerative impeller 50 can operate at lower speed (approximately 8,000 rpm) than known pump systems. This provides the necessary lift while minimizing pump cavitation.

[0020] A flow passage 64 is circumferentially created between a tubular shaped outer perimeter wall of the pump inner housing 62 and an inner wall of the tubular shaped pump outer housing 12. Fluid discharged by operation of the impeller 50 passes through the flow passage 64 in a flow direction "A" to be subsequently discharged from the sampling pump assembly 10. As the impeller 50 is rotated by operation of DC motor 56, fluid drawn through the impeller 50 from the impeller chamber 46 is radially outwardly discharged into an impeller outlet region 66 which communicates with the flow passage 64.

[0021] After the water flows from the impeller outlet region 66 and through the flow passage 64, the water flow enters one or more collecting ports 68 and further flows through a discharge port 70 created in a pump top end member 72. The pump top end member 72 is received within the outlet end cap 24 and is provided with a plurality of end member seals 74, such as O-rings, to provide a fluid seal between pump top end member 72 and an inner wall of the pump inner housing 62. The end member seals 74 therefore prevent water within either the collecting ports 68 or discharge port 70 from entering the watertight cavity 60. After flowing through the discharge port 70, the pumped water enters the discharge chamber 36. The tubing connector 32 is releasably coupled to the pump top end member 72 using connector threads 76 such that a discharge bore 78 of the tubing connector 32 is coaxially aligned with discharge chamber 36. All of the water pumped by rotation of impeller 50 therefore discharges from discharge chamber 36 via discharge bore 78. Similar to the tubing connector 32, the conduit connector 38 is threadably connected to the pump top end member 72 using conduit connector threads 80. According to several aspects, there are two diametrically opposed ones of the bayonet pins 18 provided as bayonet pins 18, 18' and two diametrically opposed ones of the bayonet pins 26 provided as bayonet pins 26, 26'. The quantity of bayonet pins can vary at the discretion of the manufacturer.

[0022] Referring to FIG. 4 and again to FIG. 3, an impeller assembly 82 includes the impeller retainer 52 partially extending from an impeller housing 84. The impeller housing 84 can be fixed about its circumference to the pump outer housing 12, for example by welding.

[0023] Referring to FIG. 5 and again to FIG. 4, the impeller assembly 82 provides the impeller housing 84, which includes a housing flange 86 extending radially outward from the impeller housing 84 to provide a location for fixing the impeller housing 84 to the pump outer housing 12. A housing cylinder wall 88 is cylindrical in shape and includes both a first counterbore 90 and a second

counterbore 92 created therein. The impeller 50 is rotatably positioned within the first counterbore 90, and the impeller retainer 52 is non-rotatably received in the second counterbore 92. The first counterbore 90 has a smaller diameter than a diameter of the second counterbore 92 such that the impeller retainer 52 overlaps the impeller 50. A clearance "B" is provided between an outer perimeter wall of the impeller 50 and the inner wall defined by the first counterbore 90. Clearance "B" allows for a water film to be continuously provided between the impeller 50 and the housing cylinder wall 88, thereby minimizing friction as the impeller 50 rotates. A connecting member slot 94 is centrally created through the impeller 50 which receives and engages the connecting member 54 extending from the motor shaft 57, thereby providing positive engagement for rotation of impeller 50. A seal ring slot 96 is provided proximate to the connecting member slot 94 to provide for a seal between the connecting member 54 and the impeller housing 84.

[0024] The impeller housing 84 is provided with a discharge opening 98 through which the water displaced by rotation of impeller 50 is received. The discharge opening 98 is in communication with a semicircular shaped discharge channel 100 which is created as a recess on a housing inner face 101 of impeller housing 84. The discharge channel 100 is in fluid communication with multiple impeller flow passages 102 extending through impeller 50. The housing inner face 101 is spaced from an impeller discharge side 104 of impeller 50 also by a fluid layer, minimizing friction as the impeller 50 rotates. On an opposite side of impeller 50 from the impeller discharge side 104 is an impeller supply side 106. A semicircular shaped supply channel 107 is created as a recess in a retainer face 108 of the impeller retainer 52. Multiple impeller vanes 109, positioned within the impeller flow passages 102, direct water which is provided through semicircular supply channel 107 into the semicircular discharge channel 100. The semicircular supply channel 107 is created in a retainer first portion 110 which as previously noted is received within the second counterbore 92 of housing cylinder wall 88. A threaded bore 112 is created in a retainer second portion 114 which can have a smaller diameter than the retainer first portion 110. The threaded bore 112 allows for a threaded tool (not shown) to be used to remove the impeller retainer 52 and thereby to remove the impeller 50 for service.

[0025] Referring to FIG. 6 and again to FIG. 5, the semicircular discharge channel 100 extends from a tapered minimum area channel end 116, in a semicircular path, to a maximum area channel end 118, positioned proximate to the discharge opening 98. All of the water entering semicircular discharge channel 100 is thereby discharged out through discharge opening 98.

[0026] Referring to FIG. 7 and again to FIG. 5, the semicircular supply channel 107, created in the retainer face 108 of impeller retainer 52, begins at a tapered minimum area channel end 120 and extends in a semicircular path to a maximum area channel end 122 positioned proximate to the impeller 50.

mate to an inlet bore 124 extending axially through the retainer first portion 110 of impeller retainer 52. All water entering inlet bore 124 therefore passes through the semicircular supply channel 107 to be drawn through the impeller vanes 109 of impeller 50 and discharged into the semicircular discharge channel 100.

[0027] Referring to FIG. 8 and again to FIGS. 1-3, the sampling pump assembly 10 forms a portion of a groundwater sampling pump system 126. The groundwater sampling pump system 126 further includes a reel assembly 125 having an A-shaped frame 128 that can be made, for example, from metal tubing. The A-shaped frame 128 includes each of a first arm 130 and an oppositely positioned second arm 132 supported therebetween by a handle portion 134. The handle portion 134 is provided to allow manual carrying of the groundwater sample pump system 126. A first leg 136 extends at a substantially transverse orientation with respect to a distal end of first arm 130. A second leg 138 similarly extends from the second arm 132. The first and second legs 136, 138 allow the groundwater sampling pump system 126 to be either supported from a ground surface or from a well pipe which will be better described in reference to FIG. 9. A bracket 140 is fixed between each of the first and second arms 130, 132 and rotatably supports a reel 142 on the A-shaped frame 128. An electrical cable assembly 144 is wound onto reel 142 and is electrically connected to the sampling pump assembly 10. A control panel 146 supported at a central portion of the reel 142 provides local operator control and operation of groundwater sampling pump system 126, as will be better described in reference to FIGS. 9 and 10. A hollow tube 148 is fixed to each of the first and second arms 130, 132 proximate to a juncture with the first and second legs 136, 138. The hollow tube 148 also acts as a storage tube where the sampling pump assembly 10 can be internally stored when not in use. The sampling pump assembly 10 is retained within the storage or hollow tube 148 using a releasable pin 150 installed or withdrawn using a pin loop 152 connected to the releasable pin 150.

[0028] A U-shaped brace 154 is connected to a post 156 which is fixed to the storage or hollow tube 148. The U-shaped brace 154 assists with mounting the groundwater sampling pump system 126 to a well pipe, which is shown and better described in reference to FIG. 9. In addition to the cable assembly 144 connected to the sampling pump assembly 10, a rigid support rod 158, having an eyelet 160, can be releasably fixed to the pump top end member 72 of sampling pump assembly 10. A lift cable 162, such as a braided steel wire, can be connected to the eyelet 160 and extended into the well along with sampling pump assembly 10 if it is desired to use additional lift capability for removal of sampling pump assembly 10 from the well.

[0029] Referring to FIG. 9 and again to FIGS. 3 and 8, the groundwater sampling pump system 126 can be temporarily attached to a well 164 normally configured as a well pipe partially extending above a ground level 166

and predominantly extending below the ground level 166. The sampling pump assembly 10 is inserted downwardly into an interior bore 168 of the well 164 to draw water samples from the well 164 by unreeling the cable assembly from reel 142. The U-shaped brace 154 is positioned within the interior bore 168 of well 164 and makes direct contact with a well inner wall surface 170, while the second leg 138 is positioned in direct contact with a well upper surface 172, and the first leg 136 is positioned in direct contact with a well outer wall surface 174 of well 164. This configuration of groundwater sample pump system 126 positions the post 156 proximate to an opening of well 164. In addition to supporting the U-shaped brace 154, the post 156 provides a bearing surface for sliding motion of cable assembly 144 as the sampling pump assembly 10 is inserted and/or withdrawn into or out of the well 164. Prior to insertion of the sampling pump assembly 10, an effluent tube 176, such as a clear plastic tube, is connected to the tubing connector 32 of sampling pump assembly 10. During insertion of the sampling pump assembly 10, both the cable assembly 144 and the effluent tube 176 are lowered at approximately the same rate to prevent bends from forming in either of these items within the well. If the lift cable 162 is also used, the lift cable 162, the cable assembly 144 and the effluent tube 176 are all lowered at approximately the same rate to prevent bends from forming in any of these items within the well.

[0030] As the sampling pump assembly 10 is readied to be lowered into the well, a first switch 178c, located on the control panel 146 is switched from an "off" to an "on" position. An internal battery provided (component 210 discussed in connection with FIG. 13) on the reel 142 provides sufficient electrical power for operation of the sensor 34 as the sampling pump assembly 10 is lowered. An LED 180, also present on the control panel 146, flashes continuously as the sampling pump assembly 10 is lowered into the well and prior to sensor 34 contacting a water volume 182 within the well. The water volume 182 is normally located above a well lower end 184 in a normal condition of well 164 such that the water inlet ports 16 are positioned above the well bottom. As the sampling pump assembly 10 enters the water volume 182 and extends below a water level surface 186, water contacts the sensor 34, which creates an electrical signal indicating that the entire sampling pump assembly 10 is positioned below the water level surface 186. At this time, the LED 180 changes from a continuous flashing condition to a continuous energized "on" condition. The "on" condition of LED 180 visually indicates to the operator that the sampling pump assembly 10 is fully submerged within the water volume 182.

[0031] After the LED 180 changes to the continuous "on" condition, the operator can manually withdraw the sampling pump assembly 10 upward until the LED 180 changes back to the continuous flashing operation, at which time the operator can visually use a plurality of distance marks 188 which provide a depth indicated in 1

foot incremental positions along the outer casing of the electrical cable assembly 144 upward from zero at the sampling pump assembly 10. The distance marks 188 provide a measurable depth in feet of the position of sampling pump assembly 10 within well 164 for recordation and pump operational purposes. The operator then re-lowers the sampling pump assembly 10 back into the well 164 until the LED 180 changes again to the continuous "on" condition. At this time, the operator changes the position of first switch 178 back to the "off" position and connects an external source of 12 VDC electrical power to the reel 142. After the external source of electrical power is connected, the operator switches a second switch 190 from an "off" to an "on" position, which starts operation of the DC motor 56 provided within sampling pump assembly 10. After the DC motor 56 continues in operation for a period of time, a water flow exits from the effluent tube 176. Stagnant water is then pumped out from the well for some period of time until fresh water is drawn into the well 164. After an additional period of time to purge the remaining stagnant water from the effluent tube 176, a fresh water sample is then collected in a sample container 192.

[0032] After the first switch 178 is returned to its "off" position, the operator connects external power to the reel 142 by manually making a plug-in connection between a power coupling 194 and an electrical connector 196 provided on control panel 146. Power coupling 194 is connected via a power cable 198 to a 12 VDC power source 200, such as a 12-volt DC battery of an automotive vehicle. Hand operated clamps (not shown), such as commonly provided with automotive jumper cable sets, may also be connected at ends of the power cable 198 to facilitate releasable connection of the groundwater sample pump system 126 to the power source 200. During pump operation the sensor is powered by the 12-volt DC battery. The sensor 34 provides an additional on-off feature such that the DC motor 56 is automatically de-energized when the sensor 34 detects that the sampling pump assembly 10 is above the water level surface 186 of the well water volume 182.

[0033] Referring to FIG. 10 and again to FIG. 9, the components provided on control panel 146 include: (1) the first switch 178, which can be a toggle "on/off" switch or any type of single pole switch; (2) the second switch 190, which can also be a toggle "on/off" switch or any type of single pole switch; (3) the LED 180, which according to several aspects can provide a green-colored indication light; and (4) the connector 196, to which the operator connects the power coupling 194. Also provided with the control panel 146 is a pump speed selector 202 which according to several aspects is an axially rotatable potentiometer which is rotated by the operator to control an operating speed of the DC motor 56 between a zero operating speed and a maximum operating speed. A maximum speed, and therefore maximum pumping rate, of DC motor 56 is dependent on the depth that the sampling pump assembly 10 is positioned within well 164 and

therefore is based on a height "C" (shown in reference to FIG. 9) that the total column or height of lift is required of the DC motor 56. During operation of groundwater sample pump system 126, the operator can rotate the pump speed selector 202 to its maximum rotated "on" position, allowing maximum flow rate to discharge from effluent tube 176 for a period of time determined by the operator. After this period of operation, the operator can then rotate the pump speed selector 202 counterclockwise to select a slow rate of discharge flow from effluent tube 176 which suits a desired fill rate of the sample container 192.

[0034] Referring to FIG. 11 and again to FIGS. 3, 9 and 10, a standard 12 VDC battery such as the battery of an automotive vehicle can provide operative electrical power for operation of brushless DC motor 56. Power consumption for DC motor 56 ranges between approximately 50 to 150 watts, at a current of 1 to 8 Amperes. In comparison, as noted herein the power consumption of known centrifugal pump groundwater sampling pump systems can range from 20 up to 40 Amperes, and commonly require a high current AC power source with conversion to DC power, therefore power consumption of the groundwater sample pump system 126 is reduced by up to approximately 80% compared to known systems. Based on use of a 12 VDC power source 200, graph 1 of FIG. 11 identifies a range of flow rates for groundwater sample pump system 126 of approximately 1.25 gpm at the well surface or ground level 166 reducing to a flow rate of zero at approximately 44.2 to 45.7m (145 to 150 feet) maximum well depth "C".

[0035] According to further aspects, a voltage booster (shown and described in reference to FIG. 12) can be provided, which boosts the 12 VDC voltage up to 18 VDC. Using the voltage booster, the range of flow rates for groundwater sample pump system 126 shown as graph 2 of FIG. 11 can be increased from approximately 1.6 gpm at the well surface or ground level 166 and reducing to a flow rate of approximately 0.7 gpm at 45.7m (150 feet) well depth "C". It is anticipated that using the voltage booster can provide a maximum pump operating depth of approximately 54.9m (180 feet) while still using the same 12 VDC power source 200.

[0036] Referring to FIG. 12, a circuit diagram provides components and data input and output ports for operation of groundwater sample pump system 126. Electronic Speed Control (ESC) for the DC pump is provided at ESC 202 which is connected to a first microcontroller 204. An output of the sensor 34 is also connected to first microcontroller 204, which is also provided with a programming port 206 to enter system operating variables and control set points. A power input and regulator section 208 is provided to control power to operate the brushless DC motor 56, which can include a voltage booster increasing the voltage output from 12 VDC to approximately 18 VDC for increasing an operating depth of the sampling pump assembly 10. The microcontroller 204 can also be used to form an hour meter to track the total time that the DC

motor 56 operates. The total time may be displayed to the user by controlling a blinking action (i.e., on/off action) of the LED 180. For example, the LED 180 may be blinked once when the assembly 10 is first powered on if the total run time is between 0-100 hours. The LED 180 may be blinked twice if the total run time is between 100- 200 hours, three times if the total run time is between 200-300 hours, etc. The blinking action may be repeated, for example three times, with a short off interval between each on/off sequence. After that the LED 180 may be used in connection with its water sensing operation to indicate when the pump outer housing 12 is submerged in water.

[0037] Referring to FIG. 13 and again to FIG. 9, remote operation and collection of data for groundwater sample pump system 126 can also be provided. A small capacity second battery 210, such as a 9-volt battery, is located on the reel 142 and provides operating power for LED 180 and sensor 34 during initial installation of the sampling pump assembly 10 into the well 164, as well as powering microcontroller 204 and a second microcontroller 212 when the main 12VDC power source is not connected. Second battery 210 provides sufficient power to test operation of brushless DC motor 56 prior to insertion into the well. Second battery 210 is connected to the second microcontroller 212, which in turn is in communication with and regulates operation of both the LED 180 and the pump speed selector 202. A wireless frequency transceiver, for example a Bluetooth® protocol wireless transceiver 214, can also be optionally used which communicates with the second microcontroller 212 via a communication path 216. The Bluetooth® protocol transceiver 214 provides for remote wireless communication between the groundwater sampling pump system 126 and a portable electronic device 218, such as a smart phone, via a wireless signal path 220. The portable electronic device 218 can also communicate data between the sampling pump system 126 and one or more cloud-based subsystems 222 using a wireless transmission path 224.

[0038] In addition to the small second battery 210 that provides temporary power for operation of the LED 180 and sensor 34, an additional larger capacity rechargeable battery 226 can also be provided with reel 142. Battery 226 is sized to provide limited operating time for DC motor 56 to provide sample flow from well 164 when the power source 200 is not available. Battery 226 may be releasably mounted via any suitable mounting bracket or fixture (not shown) to the A-shaped frame 128 for convenience.

[0039] The groundwater sampling pump system 126 can be controlled, operated and have data uploaded or downloaded using the portable electronic device 218, such as a smartphone, tablet, laptop, or virtually any other form of personal electronic device. This allows motor speed control, water level status indication, time of operation of the motor 56, battery state, troubleshooting, historical data such as past motor operating run times and speed settings and other data to be collected and remotely accessed for individual wells. The operator can

therefore access other well site data in addition to previous data from well 164 to determine potential settings for operation of groundwater sample pump system 126 at the specific well such as well 164.

[0040] The groundwater sampling pump system 126 offers several advantages. These include: (1) the provision of a pump system having a 12-volt brushless DC motor with circuitry provided in the pump assembly housing and with communication lines for control of the system grouped together with power cables extending from the circuitry of the pump assembly housing to a reel positioned at a ground level position, such that the DC motor operating speed and current are reduced from known sample pump systems thereby improving operating efficiency; (2) the use of a regenerative impeller with the 12-volt brushless DC motor permits the operating speed of the DC motor to be reduced from approximately 12,000 to 15,000 rpm of known sample pump systems having centrifugal impellers down to approximately 8,000 rpm, which significantly reduces cavitation at the impeller, improving pump assembly and impeller life and reducing impact on water samples withdrawn from the well; (3) the reel used to retain the pump assembly power and control cabling includes a built-in controller providing local control of the pump assembly; (4) a water sensor is provided with the pump assembly that is remotely connected to an LED on a panel of the reel providing visual indication when the pump is submerged in the well water volume; (5) a local battery, such as a 9-volt battery, is also provided with the reel that provides power for the sensor prior to connection of a main 12-volt power system to the pump assembly 10; (6) a signal from the sensor provides an additional on-off feature such that the pump is automatically de-energized when the sensor indicates the pump assembly is above the surface of the well water volume; (7) bayonet pins engaged in L-shaped slots of the pump assembly housing provide a releasable assembly; (8) a separate battery in addition to the 9-volt battery provided for LED operation can also be provided in the reel to provide limited operation of the DC motor; and (9) the groundwater sampling pump system 126 can be controlled, operated and have data uploaded or downloaded using remote devices such as a portable phone or tablet allowing motor speed control, water level status indication, time of operation of the motor, battery state, troubleshooting, historical data such as past motor operating run times and speed settings and other data to be collected and remotely accessed for individual wells.

[0041] Referring to FIG. 14, a sampling pump assembly 300 can be seen in accordance with another embodiment of the present disclosure. The pump assembly 300 is substantially identical in construction and operation to the sampling pump assembly 10 discussed above, with the exceptions noted below. The sampling pump assembly 300 includes a housing 302 having a curving J-shaped 306 slot at a first end 304, and a similar curving J-shaped slot 310 in a housing connector 308 associated with a housing inlet end component 312. FIG. 15A illustrates

the J-shaped slot 310 in greater detail. Since the construction of the J-shaped slots 306 and 310 are identical in this example, only the detailed construction of J-shaped slot 310 will be provided. Also, it will be appreciated that a pair of J-shaped slots 306 spaced about 180 degrees apart from one another are included on the housing 302, and likewise a pair of the J-shaped slots 310 are included on housing connector 308 and spaced apart about 180 degrees from one another, although only one of each of the J-shaped slots 306 and 310 is visible in FIG. 14.

[0042] J-shaped slot 310 includes a gradually curving section 314 and a slightly enlarged end portion 316. End portion 316 helps to define a point 318 which provides a positive retention feature when bayonet pin 320 (FIG. 15) is urged into the gradually curving section 314 of the J-shaped slot 310 and then urged over point 318.

[0043] With further reference to FIGS. 15, 15A and 16, During travel into and through the curving portion 314, at least one interior gasket 322 (FIG. 16) will begin to be compressed by a distal edge 324 of impeller chamber 326 as the bayonet pin 320 reaches, and moves past, point 318. Point 318 helps to effect a positive "snapping" or "clicking" action/feel as the bayonet pin 320 is urged over the point 318 into full engagement within enlarged end portion 316. Creation of the snapping/clicking action is assisted by the slight compressibility of the internal gasket mentioned above. A positive retention of the bayonet pin 320 and locking action within the enlarged end portion 316 occurs because the enlarged end portion 316 defines a distance D1 which slightly less than a Distance D2. As the bayonet pin 320 is urged over the point 318 and fully engages in the end portion 316, the user feels a definite snapping or clicking action (i.e., tactile feedback), which indicates the bayonet pin is fully seated in the enlarged end portion 316. At this stage, point 318 helps to prevent the bayonet pin 320 from being urged back into the curving portion 314 without some definite counter rotational force applied by the user. This retention, and an excellent fluid tight seal between components 302 and 312 is thus accomplished without the need for any separate sleeves or locking rings, as otherwise required with some previously developed bayonet locking designs.

[0044] FIG. 17 illustrates an easily accessible and replaceable annular motor shaft seal 350 integrated into the pump assembly 300. In this example the motor shaft 57 can be seen engaged with the connecting member 54. Surrounding the connecting member 54 is an annular seal 350. The seal 350 may be preferably be a PTFE FlexiSeal sealing element commercially available from the Parker Hannifin Corporation, or any suitable equivalent form of seal. Surrounding the seal 350 may be a sealing retainer 352 having a body portion 354 and a pair of O-rings 356 and 358 seated in upper and lower annular recesses 360 and 362 respectively. Both the seal 350 and the sealing retainer 352 rest on a precision dimensioned spacer 364, which in turn rests on an end face

366 of the motor shaft 57. It will be noted that that outer diameter of the spacer 364 is just slightly greater, for example by about 0,38mm (0.015 inch), than the outer diameter of the body portion 354, but preferably about 0.13 mm (0.005 inch) smaller than the internal diameter of a recess 363 of a removable bearing retainer component 368. This tight tolerance allows the seal 350 to sit centered to the connecting member 54 throughout the entire assembly shown in FIG. 17 without being moved off center.

[0045] The removable bearing retainer component 368 has a pair of bores 370 which receive a pair of threaded fasteners 372. Threaded fasteners 372 engage within threaded blind holes in the end face 366 of the motor shaft 57. Threaded fasteners 372 enable the bearing retainer component 368 to be quickly and easily removed in the field by an individual using only a conventional hand tool such as an Allen wrench, screwdriver, etc. Disassembly and reassembly can be performed in the field without complex procedures. When disassembled, the PTFE FlexiSeal sealing element 350 and/or the sealing retainer 352 can thus be easily replaced without the need for special tools. The concentric arrangement of the sealing retainer 352 with the PTFE FlexiSeal sealing element 350 further enables the sealing retainer 352 to be essentially perfectly concentrically aligned with sealing element 350 and the motor shaft 57, which further helps to ensure a watertight seal between the bearing retainer component 368 and the motor shaft 57. Referring to FIGS. 18-20, various views of an impeller retainer 380 in accordance with another embodiment of the present disclosure may be seen. FIGS. 21 -24 illustrate various views of another embodiment of an impeller housing 382 that may be used with the impeller retainer 380. Impeller retainer 380 forms a pump inlet with a ramped surface 384 (FIG. 20) that helps even more efficiently direct incoming flow into a volute portion 386 (FIG. 18). In FIGS. 18 and 20, volute portions 384a and 386a communicate with each other. Similarly, in FIGS. 21-23, the impeller housing 382 includes a ramped portion 388 that even more efficiently helps to direct the flow out from volute portion 390. In FIGS. 21 and 23, the flow enters the volute portion 390 at point 390a and leaves at portion 390b of the volute portion 390. As the flow leaves portion 390a in enters the ramped portion 388 in FIG. 21. Accordingly, the ramped portions 384 and 388 enable even more efficiently directing flow into and out from the volute formed by volute portions 386 and 390.

[0046] Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the

disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[0047] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0048] When an element or layer is referred to as being "on," "engaged to," "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0049] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0050] Spatially relative terms, such as "inner," "outer," "beneath," "below," "lower," "above," "upper," and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, ele-

ments described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0051] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

Claims

1. A sampling pump configured for use in a wellbore for pumping liquids collecting in the wellbore, the sampling pump comprising:

a sampling pump assembly (10) having a pump outer housing (12) configured to be inserted into the well bore, the pump outer housing (12) having an inlet and an outlet;

a regenerative pump element formed by an impeller (50) having a plurality of impeller vanes (109);

an impeller assembly (82) including:

an impeller housing (84) fixed about its outer circumference to the pump outer housing (12) having a semicircular shaped discharge channel (100) on an inner face (101) of the impeller housing (84), the semicircular shaped discharge channel (100) being in communication with impeller flow passages (102) extending through the impeller (50) and with a discharge opening (98), and the semicircular discharge channel (100) extending from a tapered minimum area channel end (116), in a semicircular path, to a maximum area channel end (118) proximate the discharge opening ;

an impeller retainer (52) having a semicircular supply channel (107) beginning at a tapered minimum area channel end (120) and extending in a semicircular path to a maximum area chan-

nel end (122) positioned proximate to an inlet bore (124);

a direct current (DC) motor and a circuit board (58) housed within a watertight cavity (60) provided by a pump inner housing (62), which is slidably received within the pump outer housing (12), the direct current motor for driving the impeller (50), the impeller (50) being in communication with the inlet and the outlet, and configured to draw liquids out from the wellbore into the pump outer housing (12) and to the outlet when driven rotationally by the DC motor;

a flexible cable assembly (144) in communication with the sampling pump assembly (10) supplying DC power to the DC motor;

a reel assembly (125) having a reel rotatably supported from a frame (128), the reel configured to enable the flexible cable assembly (144) to be wound thereon when the sampling pump is not in use, and unwound from the reel as the pump outer housing (12) is lowered down into the wellbore;

a DC connector supported on the frame for enabling an external DC power source to be coupled to the reel assembly (125) for powering the DC motor;

a fluid level sensor operably associated with the pump outer housing (12) for detecting when the pump outer housing (12) is positioned in fluid; and

a control panel (146) supported from the frame of the reel assembly (125), the control panel (146) being in electrical communication with the fluid sensor and configured to enable a user.

to control on and off operation of the DC motor; and

to connect an external DC power source to the control panel (146) to power the impeller (50).

2. The sampling pump of claim 1, wherein the flexible cable assembly (144) includes markings thereon indicate a length unit of measurement.

3. The sampling pump of claim 1, wherein the DC motor comprises a brushless DC motor.

4. The sampling pump of claim 1, further comprising:

a DC battery carried on the frame and electrically coupled to the sensor (34) for powering the sensor;

a first switch (178) associated with the control panel (146) for turning on and off DC power to the sensor (34); and

an indicator in communication with the sensor (34) for indicating when the pump outer housing (12) is present in the fluid in the wellbore.

5. The sampling pump of claim 4, further comprising a second switch (190) on the control panel (146) for enabling a user to power on and off the DC motor.

6. The sampling pump of claim 4, wherein the indicator comprises an optical device that provides a signal to indicate to a user when the sensor (34) has been submerged in fluid.

7. The sampling pump of claim 6, wherein the indicator comprises an optical element that when powered on flashes intermittently before contacting fluid, and then remains in a continuously illuminated state while submerged in fluid.

8. The sampling pump of claim 1, wherein the frame includes a structure for receiving the sampling pump assembly and storing the sampling pump assembly when the sampling pump assembly is not in use.

9. The sampling pump of claim 1, further comprising a user adjustable speed control operably associated with the control panel (146) for enabling a user to adjust a speed of the DC motor, and thus a flow rate produced by the impeller (50).

10. The sampling pump of claim 1, wherein the sensor (34) is configured to automatically turn off the DC motor when the sensor (34) detects that it is no longer submerged in fluid.

11. The sampling pump of claim 1, wherein the control panel (146) is configured to log a total run time that the impeller (50) is running and to display the total run time to a user.

12. The sampling pump of claim 1, further comprising a short range wireless transceiver (214) for enabling the control panel (146) to communicate wirelessly with a remote personal electronic device of a user.

13. The sampling pump of claim 1, further comprising a tube adapted to be secured to the outlet of the pump outer housing (12) for channeling fluid pumped by the impeller (50) out from the wellbore.

Patentansprüche

1. Entnahmepumpe, die zur Verwendung in einem Bohrloch zum Pumpen von Flüssigkeiten, die sich im Bohrloch sammeln, ausgebildet ist, die Entnahmepumpe umfassend:

eine Entnahmepumpenanordnung (10) mit einem Pumpenaußengehäuse (12), das ausgebildet ist, um in das Bohrloch eingesetzt zu werden, wobei das Pumpenaußengehäuse (12) ei-

nen Einlass und einen Auslass aufweist;
 ein regeneratives Pumpenelement, das durch
 ein Laufrad (50) mit einer Vielzahl von Laufrad-
 schaufeln (109) ausgebildet ist;
 eine Laufradanordnung (82) umfassend:

ein Laufradgehäuse (84), das um seinen
 Außenumfang an dem Pumpenaußenge-
 häuse (12) mit einem halbkreisförmigen
 Auslasskanal (100) auf einer Innenfläche
 (101) des Laufradgehäuses (84) befestigt
 ist, wobei der halbkreisförmige Auslasska-
 nal (100) in Verbindung mit sich durch das
 Laufrad (50) erstreckenden Laufradströ-
 mungskanälen (102) und mit einer Auslas-
 söffnung (98) steht und sich der halbkreis-
 förmige Auslasskanal (100) von einem ver-
 jüngten Kanalende (116) mit minimaler Flä-
 che in einem halbkreisförmigen Pfad zu ei-
 nem Kanalende (118) mit maximaler Fläche
 in der Nähe der Auslassöffnung erstreckt;
 einen Laufradhalter (52) mit einem halb-
 kreisförmigen Versorgungskanal (107), der
 an einem verjüngten Kanalende (120) mit
 minimaler Fläche beginnt und sich in einem
 halbkreisförmigen Pfad zu einem Kanalende
 (122) mit maximaler Fläche erstreckt,
 das in der Nähe einer Einlassbohrung (124)
 angeordnet ist;
 einen Gleichstrommotor (DC) und eine Lei-
 terplatte (58), die in einer wasserdichten
 Kavität (60) aufgenommen ist, die von ei-
 nem Pumpeninnengehäuse (62) vorgese-
 hen ist, das verschiebbar in dem Pumpen-
 außengehäuse (12) aufgenommen ist, der
 Gleichstrommotor zum Antreiben des Lauf-
 rads (50), wobei das Laufrad (50) mit dem
 Einlass und dem Auslass in Verbindung
 steht und zum Absaugen von Flüssigkeiten
 aus dem Bohrloch in das Pumpenaußenge-
 häuse (12) und zum Auslass ausgebildet
 ist, wenn es durch den Gleichstrommotor
 rotierend angetrieben wird;
 eine flexible Kabelanordnung (144) in Ver-
 bindung mit der Entnahmepumpenanord-
 nung (10), die dem Gleichstrommotor
 Gleichstrom zuführt;
 eine Spulenordnung (125) mit einer Spu-
 le, die drehbar von einem Rahmen (128)
 gelagert ist, wobei die Spule ausgebildet ist,
 um der flexiblen Kabelanordnung (144) zu
 ermöglichen darum aufgewickelt zu sein,
 wenn die Entnahmepumpe nicht in Betrieb
 ist, und von der Spule abgewickelt zu sein,
 wenn das Pumpenaußengehäuse (12)
 nach unten in das Bohrloch abgesenkt wird;
 einen Gleichstromanschluss, der auf dem
 Rahmen zum Ermöglichen einer externen

Gleichstromquelle mit der Spulenord-
 nung (125) zum Betreiben des Gleichstrom-
 motors gekoppelt zu sein, gelagert ist;
 einen Fluidpegelsensor, der dem Pumpen-
 außengehäuse (12) funktionell zugeordnet
 ist, zum Erfassen, wann das Pumpenau-
 ßengehäuse (12) in Fluid angeordnet ist;
 und
 eine Steuertafel (146), die vom Rahmen der
 Spulenordnung (125) gelagert wird, wo-
 bei die Steuertafel (146) in elektrischer Ver-
 bindung mit dem Fluidsensor steht und aus-
 gebildet ist, um einem Benutzer zu ermög-
 lichen:

das Ein- und Ausschalten des Gleich-
 strommotors zu steuern; und
 eine externe Gleichstromquelle an das
 Bedienfeld (146) anzuschließen, um
 das Laufrad (50) zu betreiben.

2. Entnahmepumpe gemäß Anspruch 1, wobei die fle-
 xible Kabelanordnung (144) Markierungen darauf
 umfasst, die eine Längeneinheit anzeigen.
3. Entnahmepumpe gemäß Anspruch 1, wobei der
 Gleichstrommotor einen bürstenlosen Gleichstrom-
 motor umfasst.
4. Entnahmepumpe gemäß Anspruch 1, ferner umfas-
 send:
 eine Gleichstrombatterie, die auf dem Rahmen
 getragen und elektrisch mit dem Sensor (34)
 zum Betreiben des Sensors gekoppelt ist;
 einen ersten Schalter (178), der dem Steuerfeld
 (146) zum Ein- und Ausschalten der Gleich-
 spannung zu dem Sensor (34) zugeordnet ist;
 und
 einen Indikator in Verbindung mit dem Sensor
 (34) zum Anzeigen, wann sich das Pumpenau-
 ßengehäuse (12) in dem Fluid in dem Bohrloch
 befindet.
5. Entnahmepumpe gemäß Anspruch 4, ferner umfas-
 send einen zweiten Schalter (190) auf dem Steuer-
 feld (146), um einem Benutzer das Ein- und Aus-
 schalten des Gleichstrommotors zu ermöglichen.
6. Entnahmepumpe gemäß Anspruch 4, wobei der In-
 dikator eine optische Vorrichtung umfasst, die ein
 Signal bereitstellt, um einem Benutzer anzuzeigen,
 wenn der Sensor (34) in Flüssigkeit eingetaucht ist.
7. Entnahmepumpe gemäß Anspruch 6, wobei der In-
 dikator ein optisches Element umfasst, das beim Ein-
 schalten intermittierend blinkt, bevor es das Fluid
 kontaktiert, und dann in einem kontinuierlich be-

leuchteten Zustand verbleibt, während es in das Fluid eingetaucht ist.

8. Entnahmepumpe gemäß Anspruch 1, wobei der Rahmen eine Struktur zur Aufnahme der Entnahmepumpenanordnung und zur Aufbewahrung der Entnahmepumpenanordnung umfasst, wenn die Entnahmepumpenanordnung nicht in Gebrauch ist. 5
9. Entnahmepumpe gemäß Anspruch 1, ferner umfassend eine benutzereinstellbare Drehzahlsteuerung, die dem Steuerfeld (146) funktionsfähig zugeordnet ist, um es einem Benutzer zu ermöglichen, eine Drehzahl des Gleichstrommotors und damit eine vom Laufrad (50) erzeugte Fördermenge einzustellen. 10 15
10. Entnahmepumpe gemäß Anspruch 1, wobei der Sensor (34) zum automatischen Abschalten des Gleichstrommotors ausgebildet ist, wenn der Sensor (34) erkennt, dass er nicht mehr in Flüssigkeit eingetaucht ist. 20
11. Entnahmepumpe gemäß Anspruch 1, wobei das Steuerfeld (146) zum Protokollieren einer Gesamtlaufzeit, die das Laufrad (50) läuft, und zum Anzeigen der Gesamtlaufzeit für einen Benutzer ausgebildet ist. 25
12. Entnahmepumpe gemäß Anspruch 1, ferner umfassend einen drahtlosen Kurzstrecken-Sender-Empfänger (214), der es dem Steuerfeld (146) ermöglicht, drahtlos mit einer persönlichen elektronischen Fernbedienungsvorrichtung eines Benutzers zu kommunizieren. 30 35
13. Entnahmepumpe nach Anspruch 1, ferner umfassend einen Schlauch, der zur Befestigung am Auslass des Pumpenaußengehäuses (12) ausgebildet ist, zum Leiten von Fluid, das durch das Laufrad (50) aus dem Bohrloch gefördert wird. 40

Revendications

1. Pompe de prélèvement configurée pour une utilisation dans un puits de forage afin de pomper des liquides s'accumulant dans le puits de forage, la pompe de prélèvement comprenant : 45 50
 - un ensemble de pompe de prélèvement (10) ayant un boîtier extérieur de pompe (12) configuré pour être inséré dans le puits de forage, le boîtier extérieur de pompe (12) ayant une entrée et une sortie ; 55
 - un élément de pompe régénératif formé par une roue (50) ayant une pluralité d'aubes de roue (109) ;

un ensemble de roue (82) comprenant :

un boîtier de roue (84) fixé autour de sa circonférence extérieure au boîtier extérieur de pompe (12) ayant un canal de décharge de forme semi-circulaire (100) sur une face intérieure (101) du boîtier de roue (84), le canal de décharge de forme semi-circulaire (100) étant en communication avec des passages d'écoulement de roue (102) s'étendant à travers la roue (50) et avec une ouverture de décharge (98), et le canal de décharge semi-circulaire (100) s'étendant d'une extrémité de canal à zone minimale en pointe (116), dans une trajectoire semi-circulaire, jusqu'à une extrémité de canal à zone maximale (118) à proximité de l'ouverture de décharge ;
 un dispositif de retenue de roue (52) ayant un canal d'alimentation semi-circulaire (107) commençant au niveau d'une extrémité de canal à zone minimale en pointe (120) et s'étendant dans une trajectoire semi-circulaire jusqu'à une extrémité de canal à zone maximale (122) positionnée à proximité d'un alésage d'entrée (124) ;
 un moteur à courant continu (CC) et une carte de circuit imprimé (58) logés dans une cavité étanche (60) fournie par un boîtier intérieur de pompe (62), qui est reçu de manière coulissante dans le boîtier extérieur de pompe (12), le moteur à courant continu permettant d'entraîner la roue (50), la roue (50) étant en communication avec l'entrée et la sortie, et configurée pour extraire des liquides du puits de forage dans le boîtier extérieur de pompe (12) et jusqu'à la sortie lorsqu'elle est entraînée en rotation par le moteur CC ;
 un ensemble de câble flexible (144) en communication avec l'ensemble de pompe de prélèvement (10) alimentant le moteur CC en courant continu ;
 un ensemble de bobine (125) ayant une bobine supportée en rotation à partir d'un châssis (128), la bobine étant configurée pour permettre à l'ensemble de câble flexible (144) d'être enroulé sur celle-ci lorsque la pompe de prélèvement n'est pas utilisée, et déroulé de la bobine lorsque le boîtier extérieur de pompe (12) est abaissé dans le puits de forage ;
 un connecteur CC supporté sur le châssis pour permettre à une source de courant continu externe d'être couplée à l'ensemble de bobine (125) afin d'alimenter le moteur CC ;
 un capteur de niveau de fluide associé de

- manière fonctionnelle au boîtier extérieur de pompe (12) pour détecter le moment où le boîtier extérieur de pompe (12) est positionné dans le fluide ; et
un panneau de commande (146) supporté à partir du châssis de l'ensemble de bobine (125), le panneau de commande (146) étant en communication électrique avec le capteur de fluide et configuré pour permettre à un utilisateur de :
- commander la mise en marche et l'arrêt du moteur CC ; et
 - connecter une source de courant continu externe au panneau de commande (146) afin d'alimenter la roue (50).
2. Pompe de prélèvement selon la revendication 1, dans laquelle l'ensemble de câble flexible (144) comprend des marques sur celui-ci indiquant une unité de mesure de longueur.
 3. Pompe de prélèvement selon la revendication 1, dans laquelle le moteur CC comprend un moteur CC sans balai.
 4. Pompe de prélèvement selon la revendication 1, comprenant en outre :
 - une batterie CC portée sur le châssis et couplée de manière électrique au capteur (34) pour alimenter le capteur ;
 - un premier interrupteur (178) associé au panneau de commande (146) pour allumer et éteindre le courant continu jusqu'au capteur (34) ; et
 - un indicateur en communication avec le capteur (34) pour indiquer le moment où le boîtier extérieur de pompe (12) est présent dans le fluide dans le puits de forage.
 5. Pompe de prélèvement selon la revendication 4, comprenant en outre un second interrupteur (190) sur le panneau de commande (146) pour permettre à un utilisateur de mettre en marche et d'arrêter le moteur CC.
 6. Pompe de prélèvement selon la revendication 4, dans laquelle l'indicateur comprend un dispositif optique qui fournit un signal afin d'indiquer à un utilisateur le moment où le capteur (34) a été immergé dans le fluide.
 7. Pompe de prélèvement selon la revendication 6, dans laquelle l'indicateur comprend un élément optique qui, lorsqu'il est allumé, clignote par intermittence avant d'entrer en contact avec le fluide, puis reste dans un état éclairé de manière constante tandis qu'il est immergé dans le fluide.
 8. Pompe de prélèvement selon la revendication 1, dans laquelle le châssis comprend une structure afin de recevoir l'ensemble de pompe de prélèvement et stocker l'ensemble de pompe de prélèvement lorsque l'ensemble de pompe de prélèvement n'est pas utilisé.
 9. Pompe de prélèvement selon la revendication 1, comprenant en outre une commande de vitesse réglable par un utilisateur associée de manière fonctionnelle au panneau de commande (146) pour permettre à un utilisateur de régler une vitesse du moteur CC, et ainsi un débit produit par la roue (50).
 10. Pompe de prélèvement selon la revendication 1, dans laquelle le capteur (34) est configuré pour éteindre automatiquement le moteur CC lorsque le capteur (34) détecte qu'il n'est plus immergé dans le fluide.
 11. Pompe de prélèvement selon la revendication 1, dans laquelle le panneau de commande (146) est configuré pour enregistrer un temps de fonctionnement total de la roue (50) et pour afficher le temps de fonctionnement total à un utilisateur.
 12. Pompe de prélèvement selon la revendication 1, comprenant en outre un émetteur-récepteur sans fil à courte portée (214) pour permettre au panneau de commande (146) de communiquer sans fil avec un dispositif électronique personnel distant d'un utilisateur.
 13. Pompe de prélèvement selon la revendication 1, comprenant en outre un tube adapté pour être fixé à la sortie du boîtier extérieur de pompe (12) afin d'acheminer le fluide pompé par la roue (50) à l'extérieur du puits de forage.

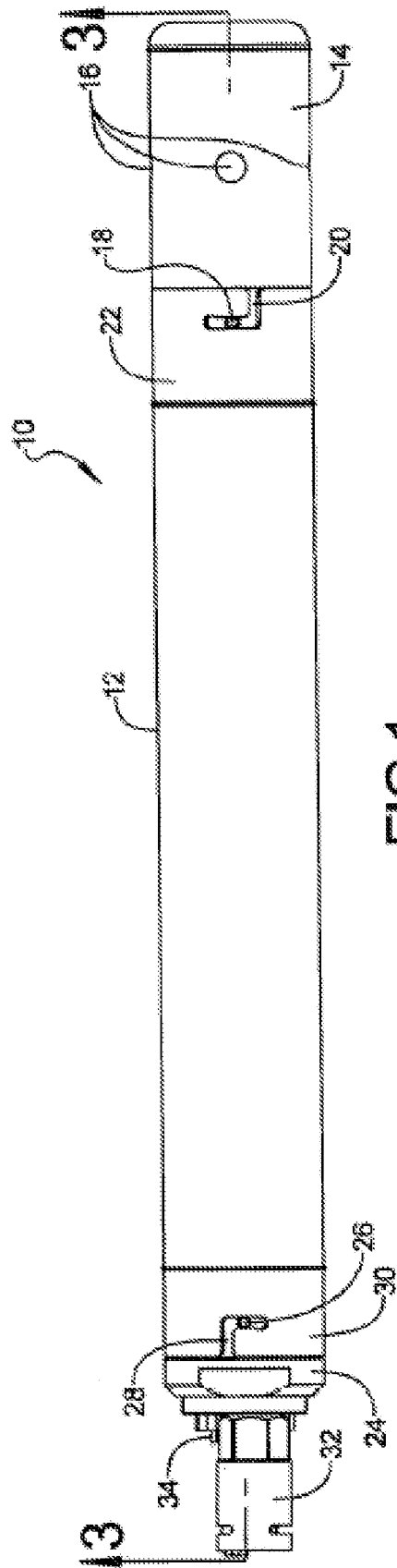


FIG 1

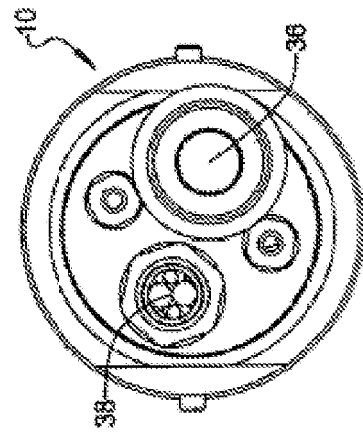
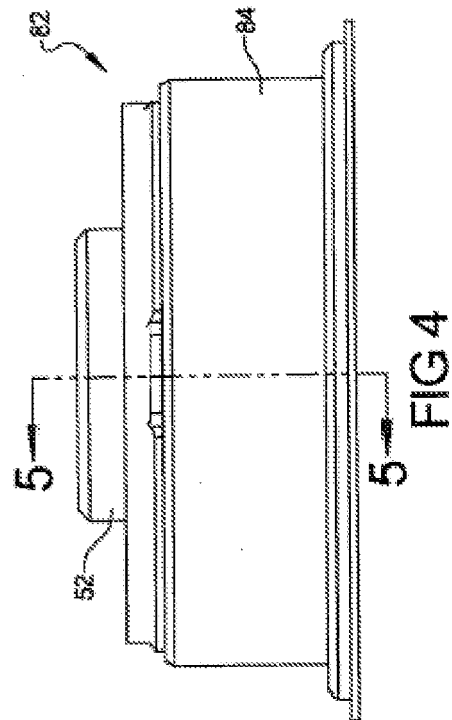
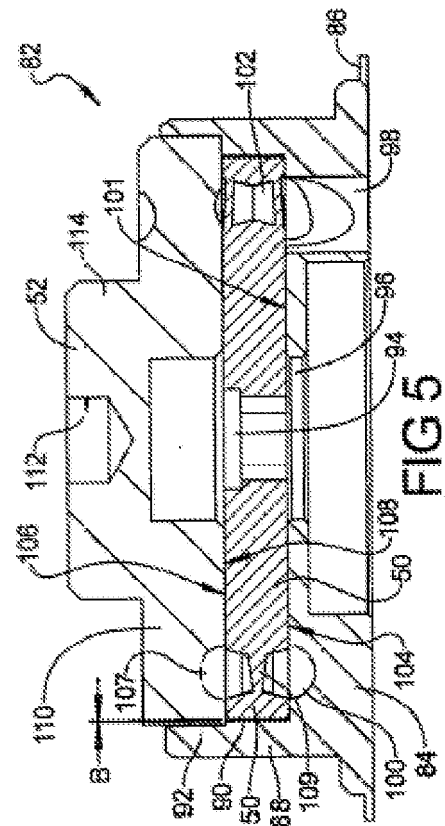
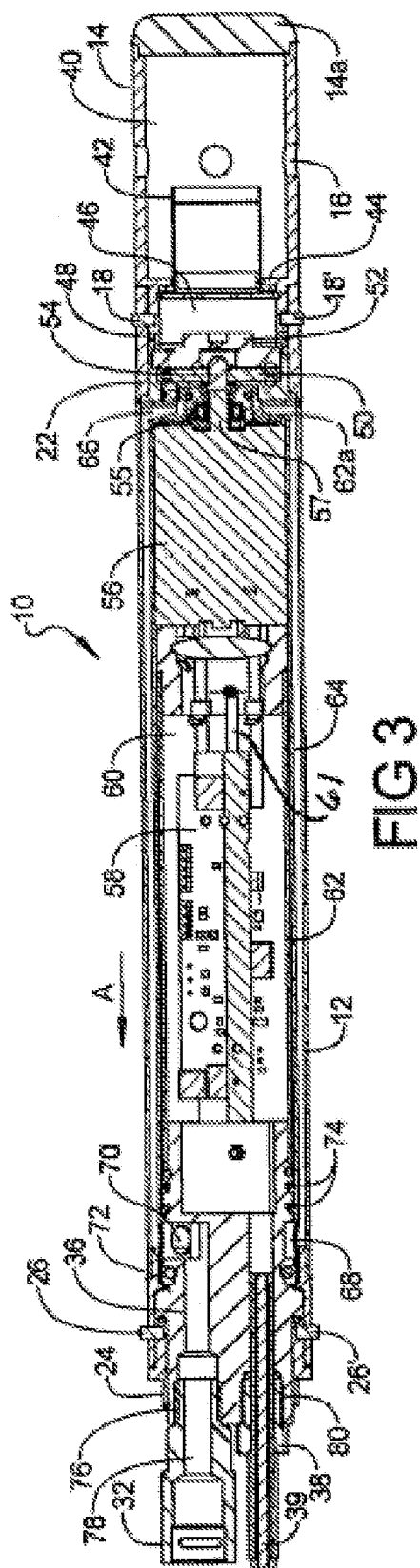


FIG 2



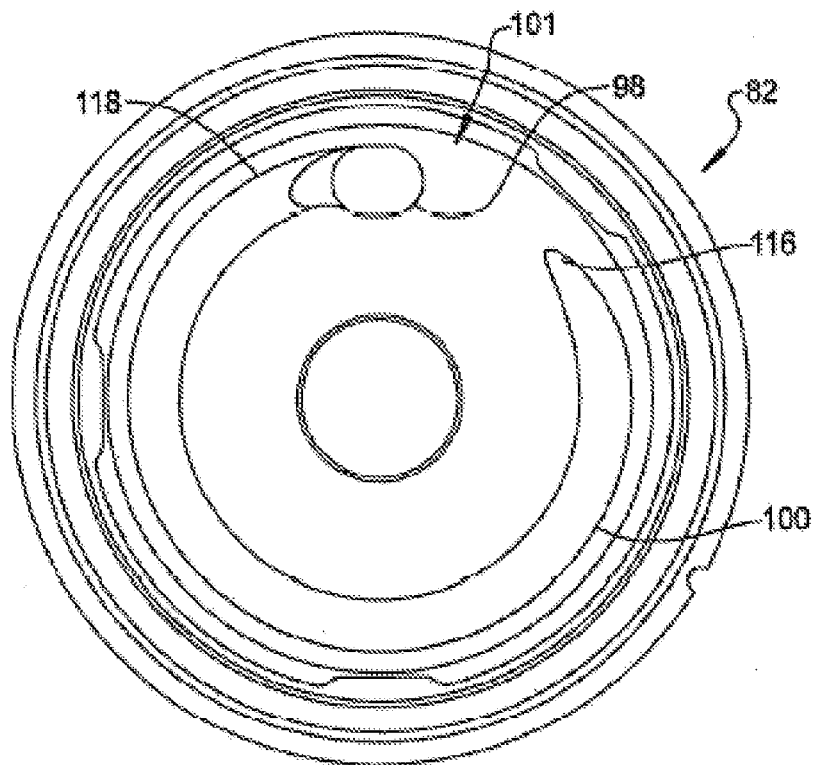


FIG 6

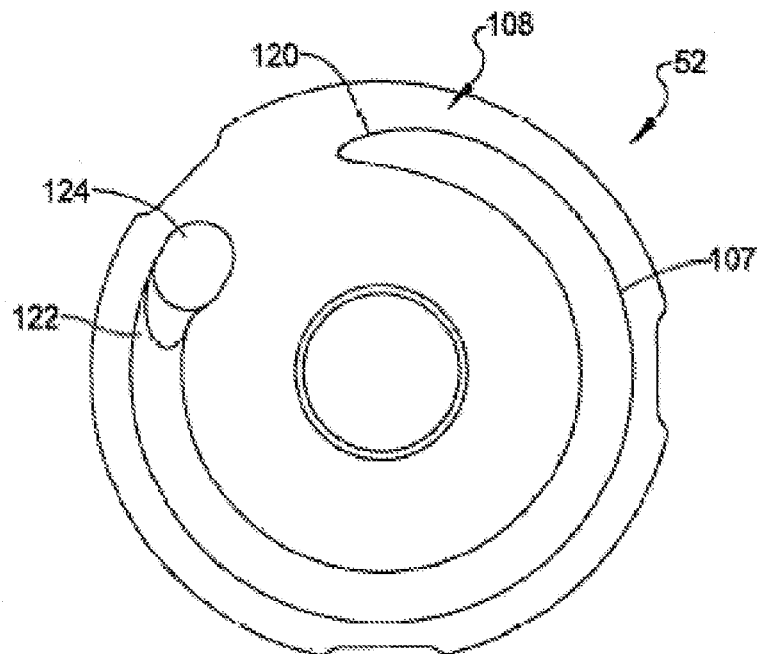


FIG 7

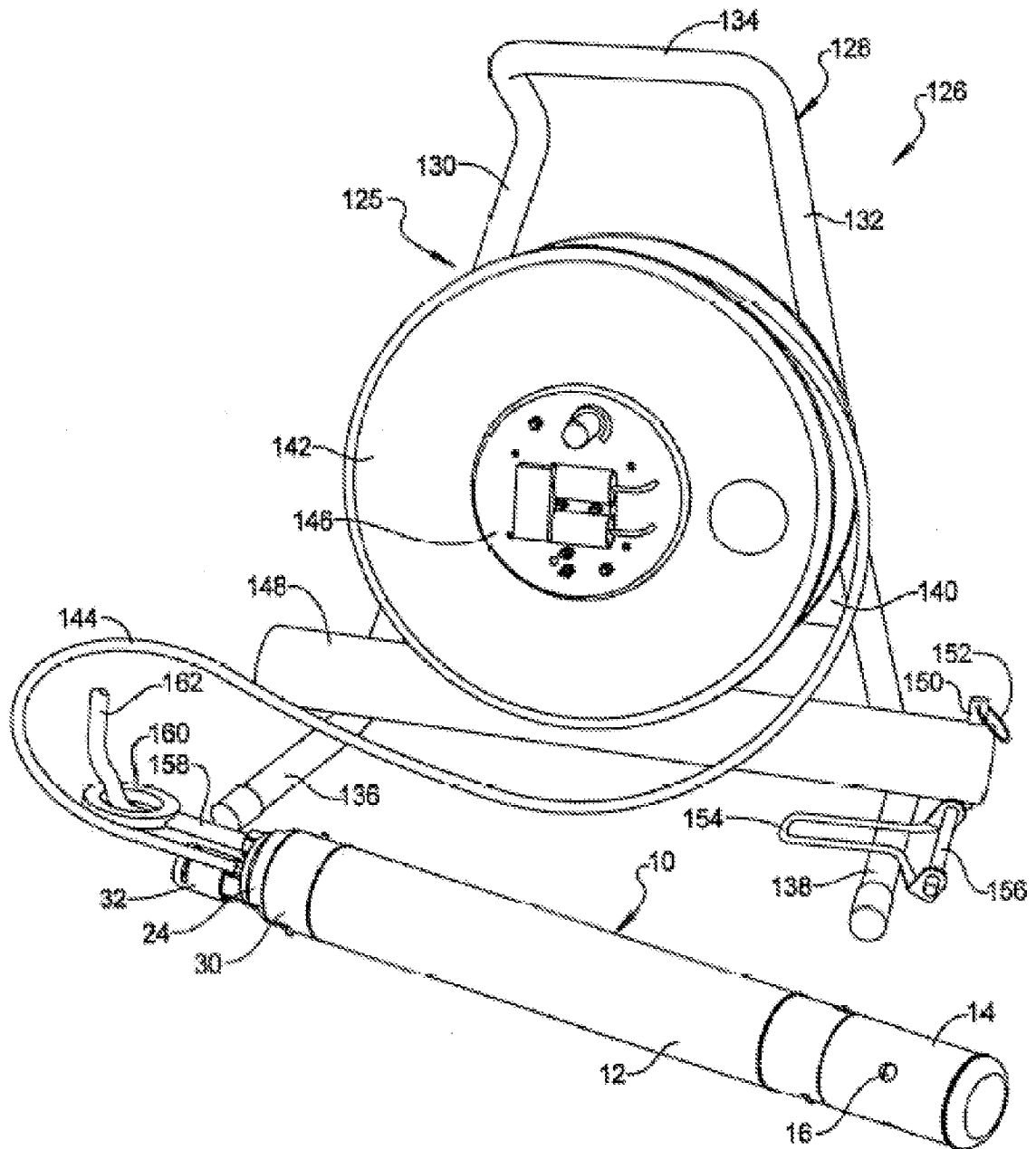


FIG 8

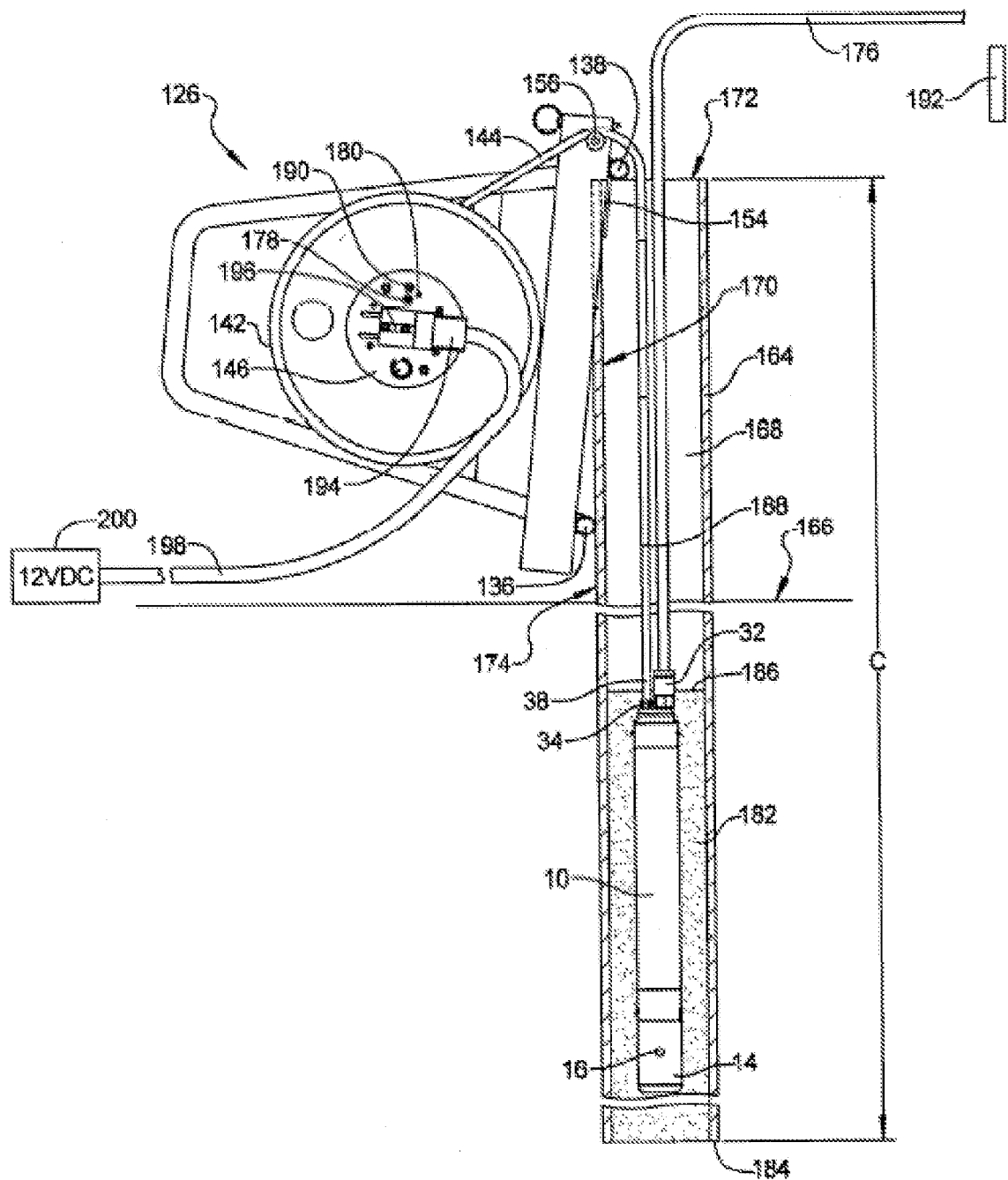


FIG 9

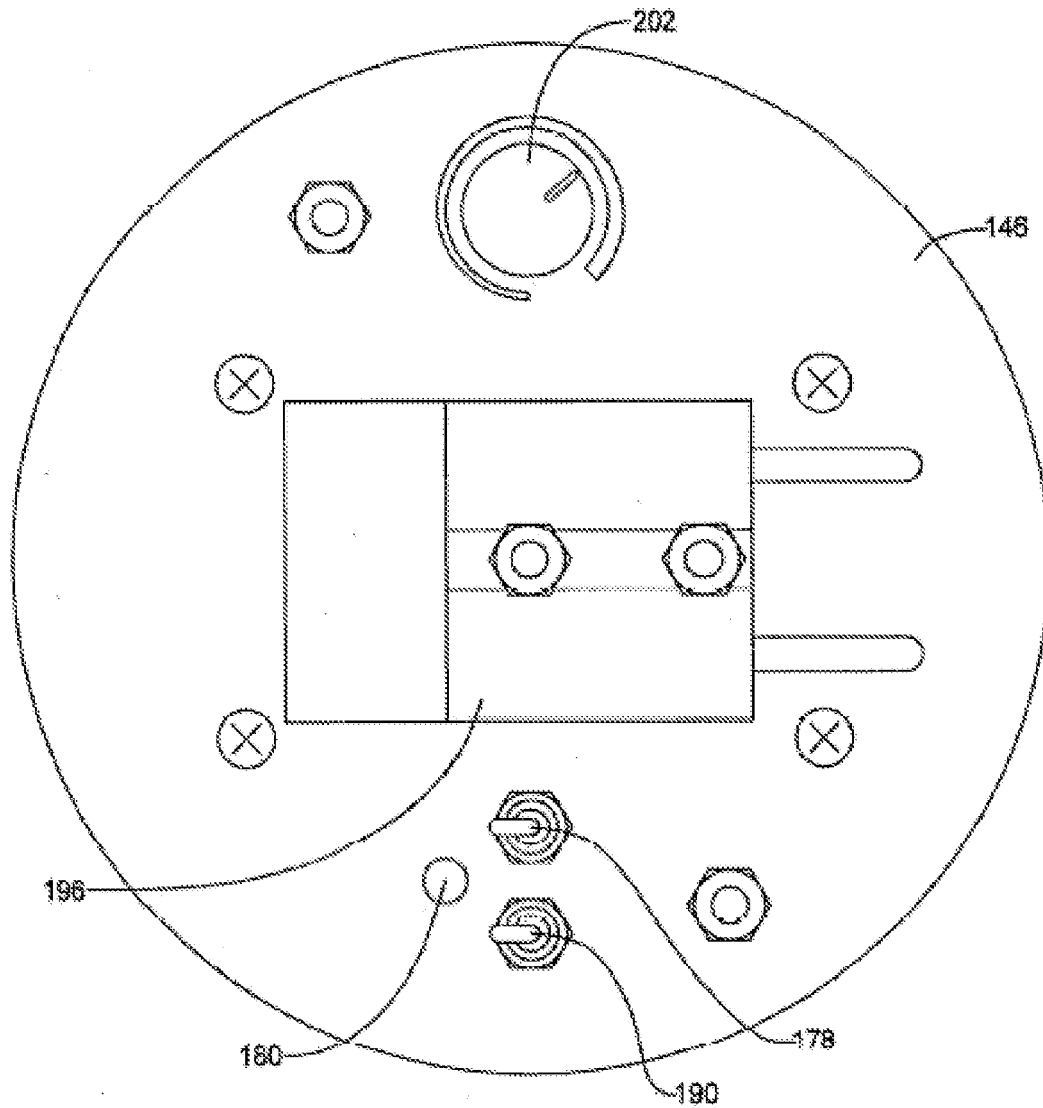
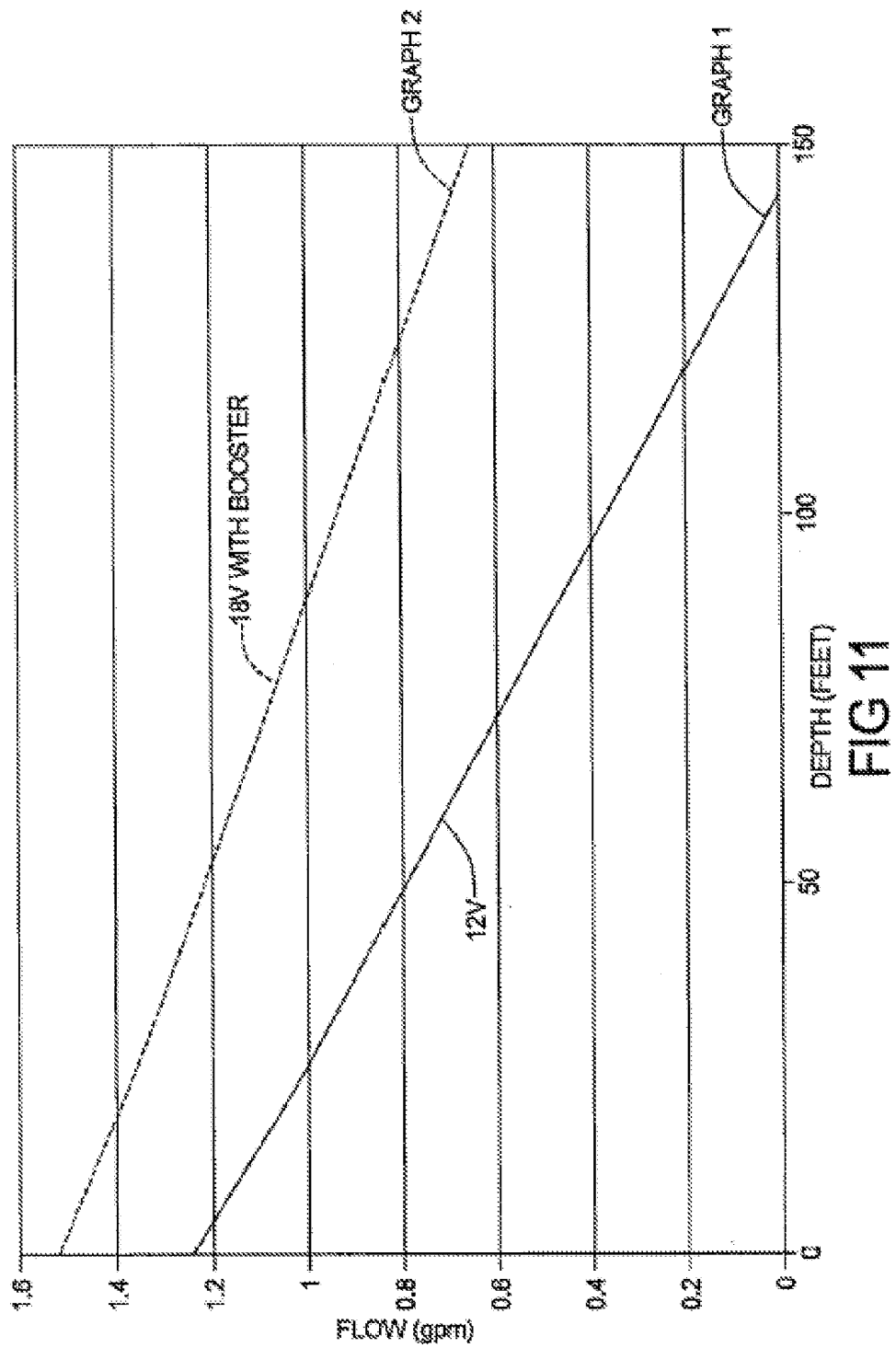


FIG 10



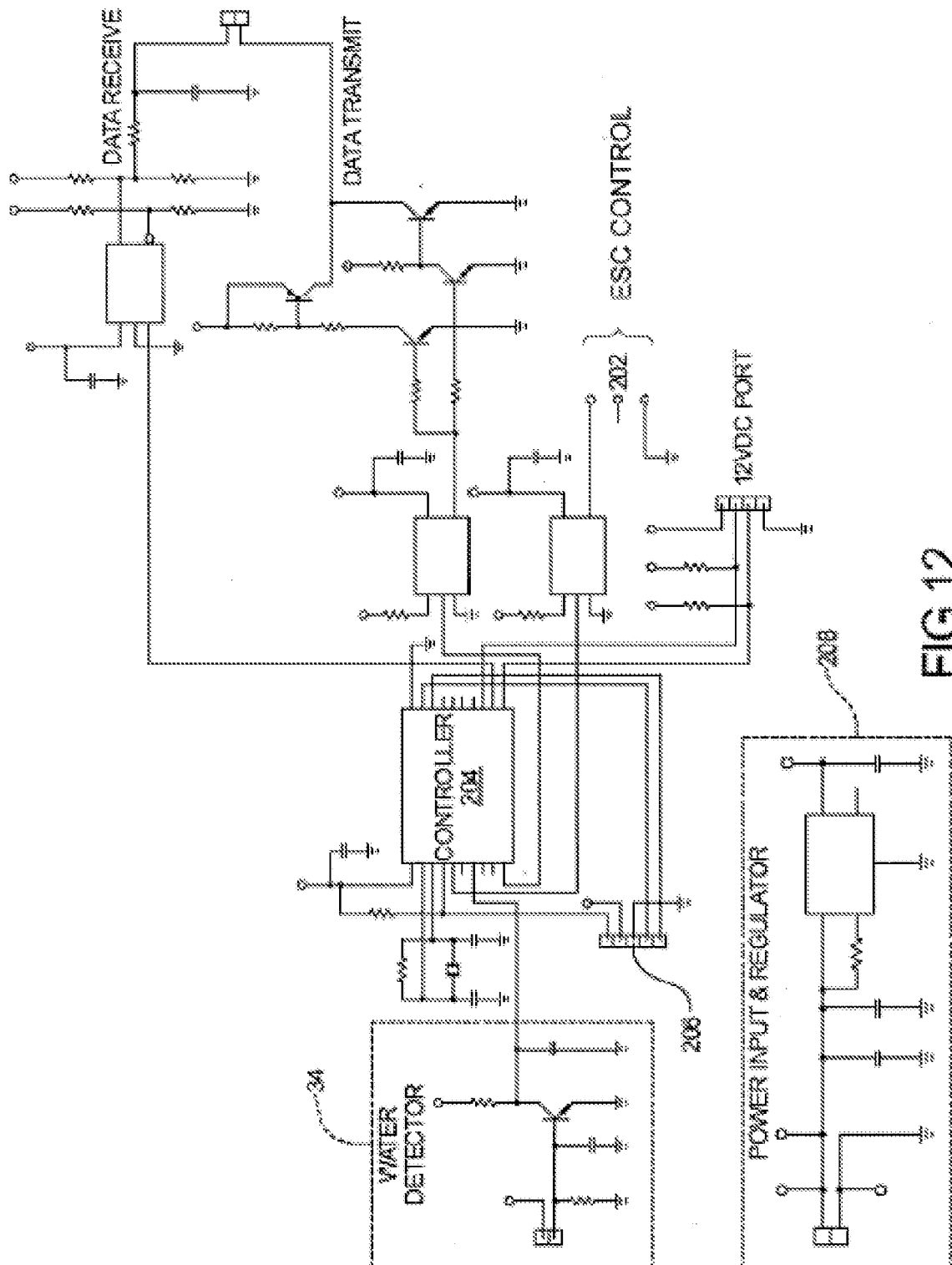


FIG 12

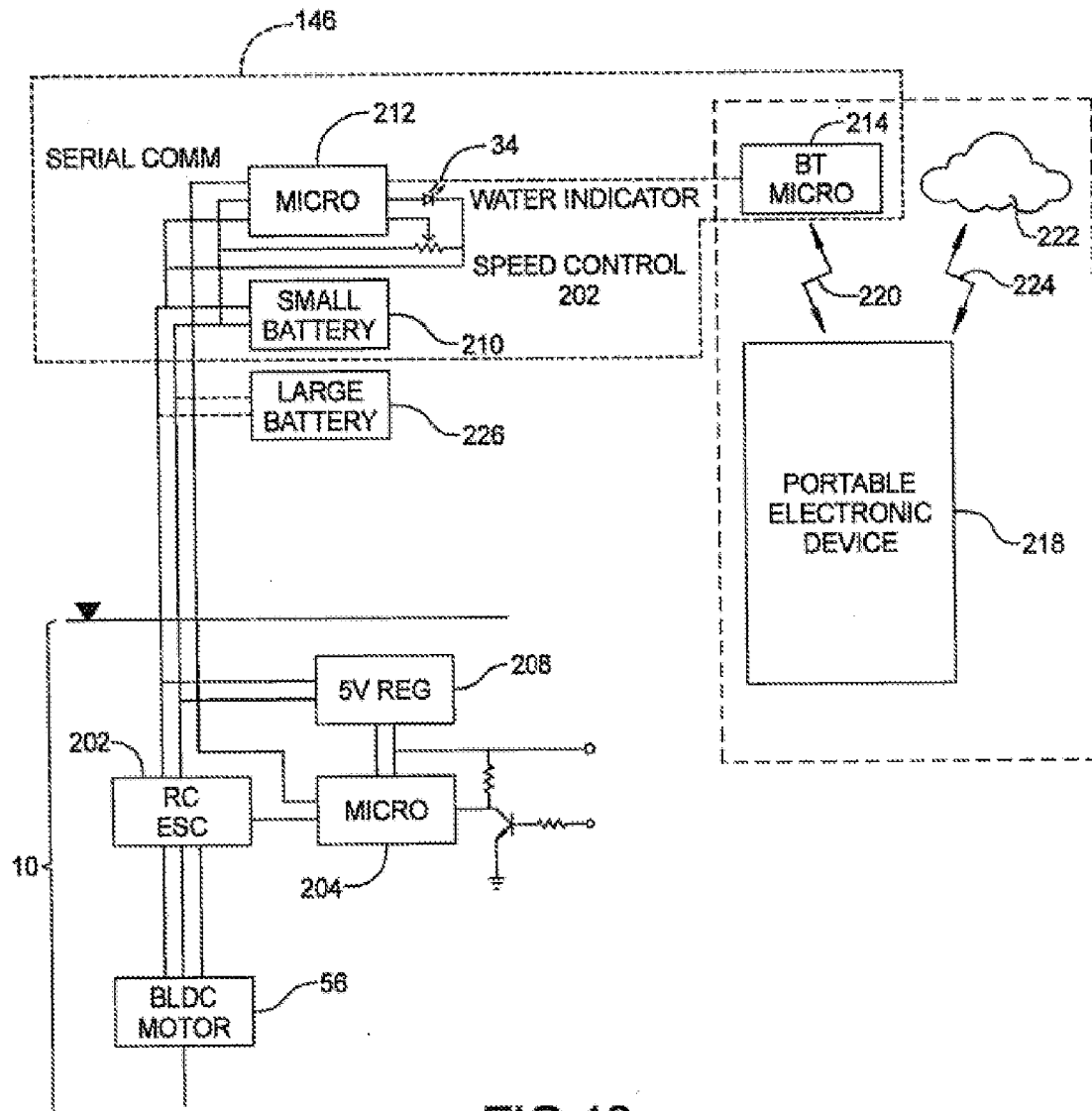


FIG 13

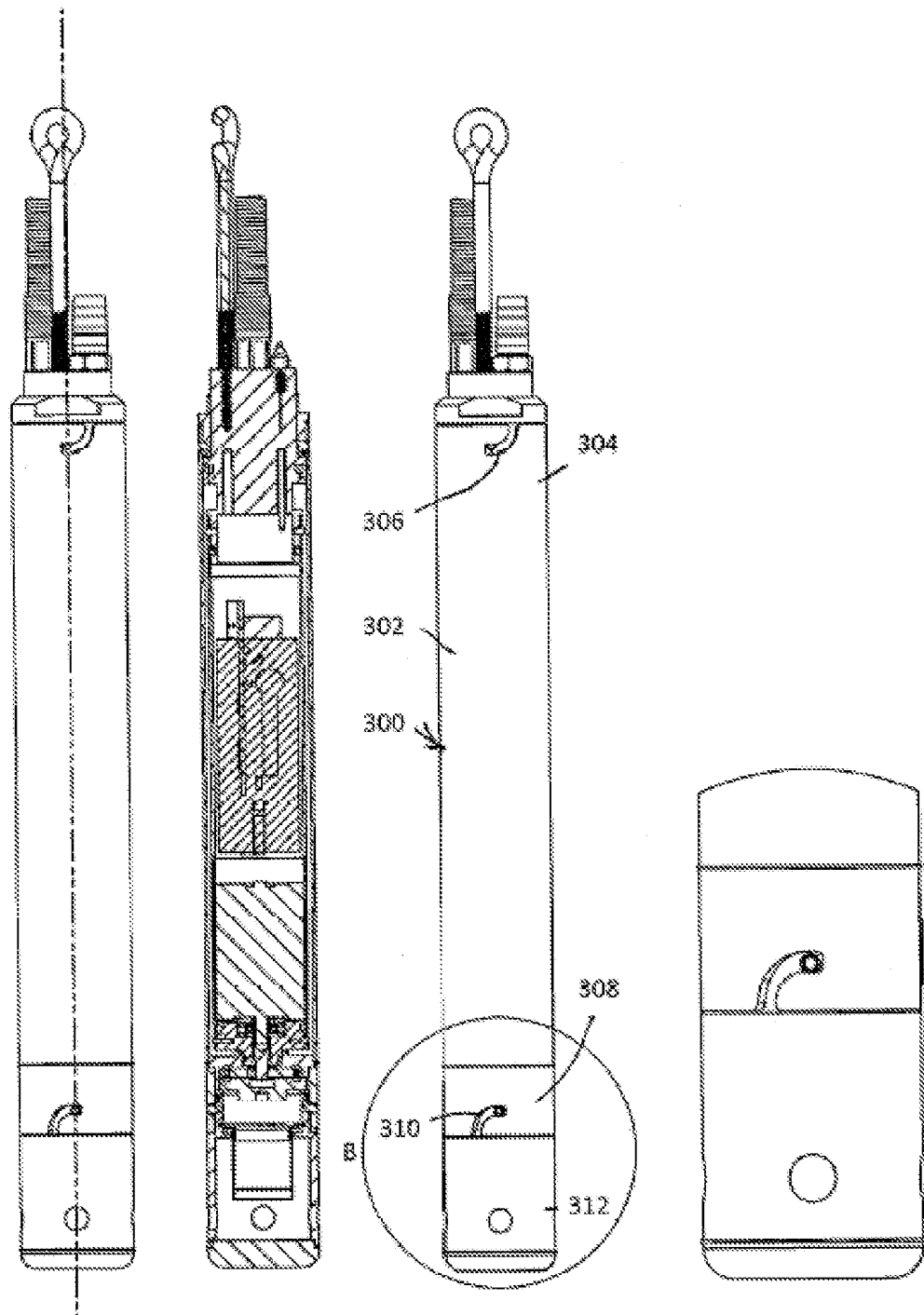
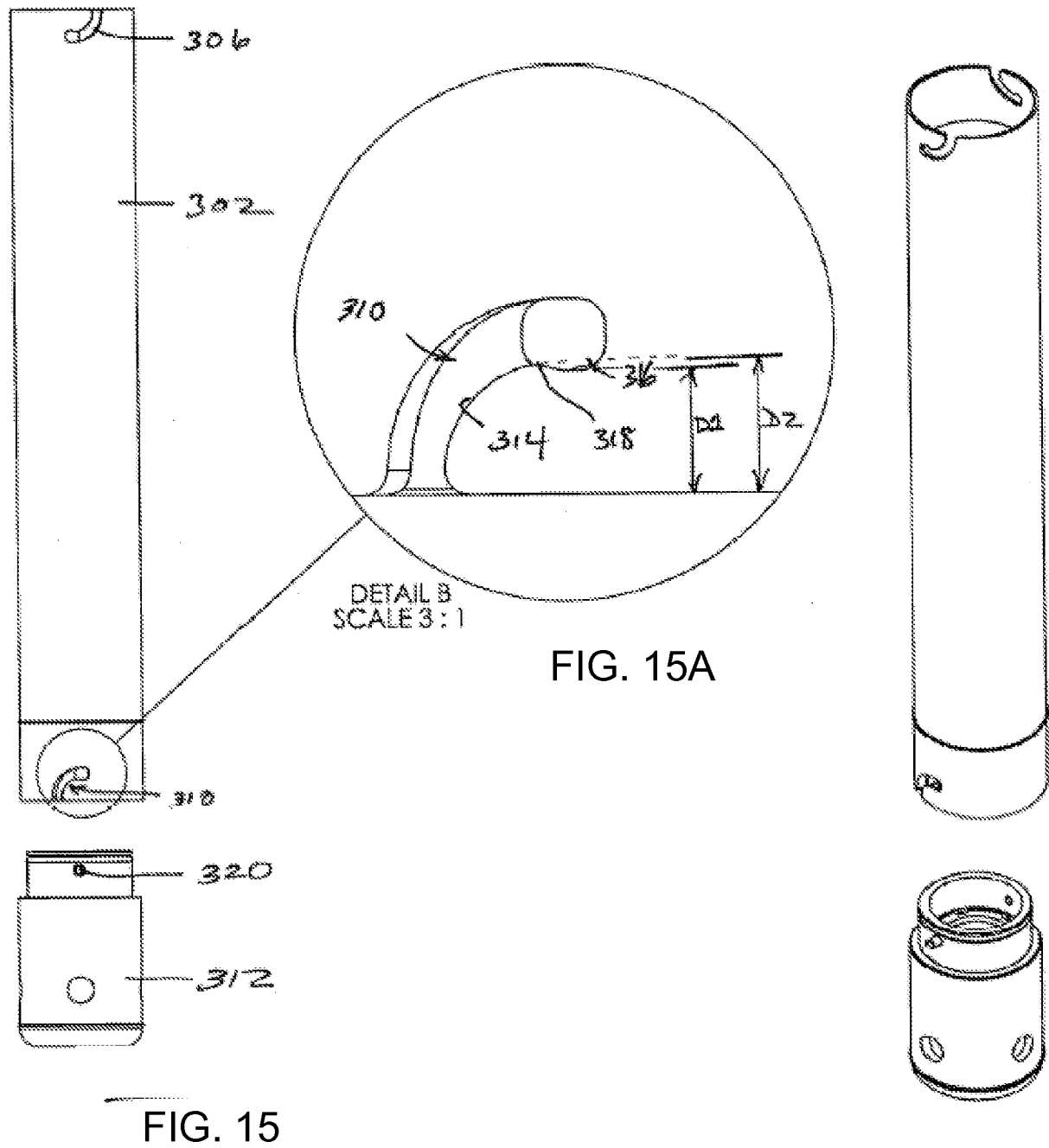


FIG. 14



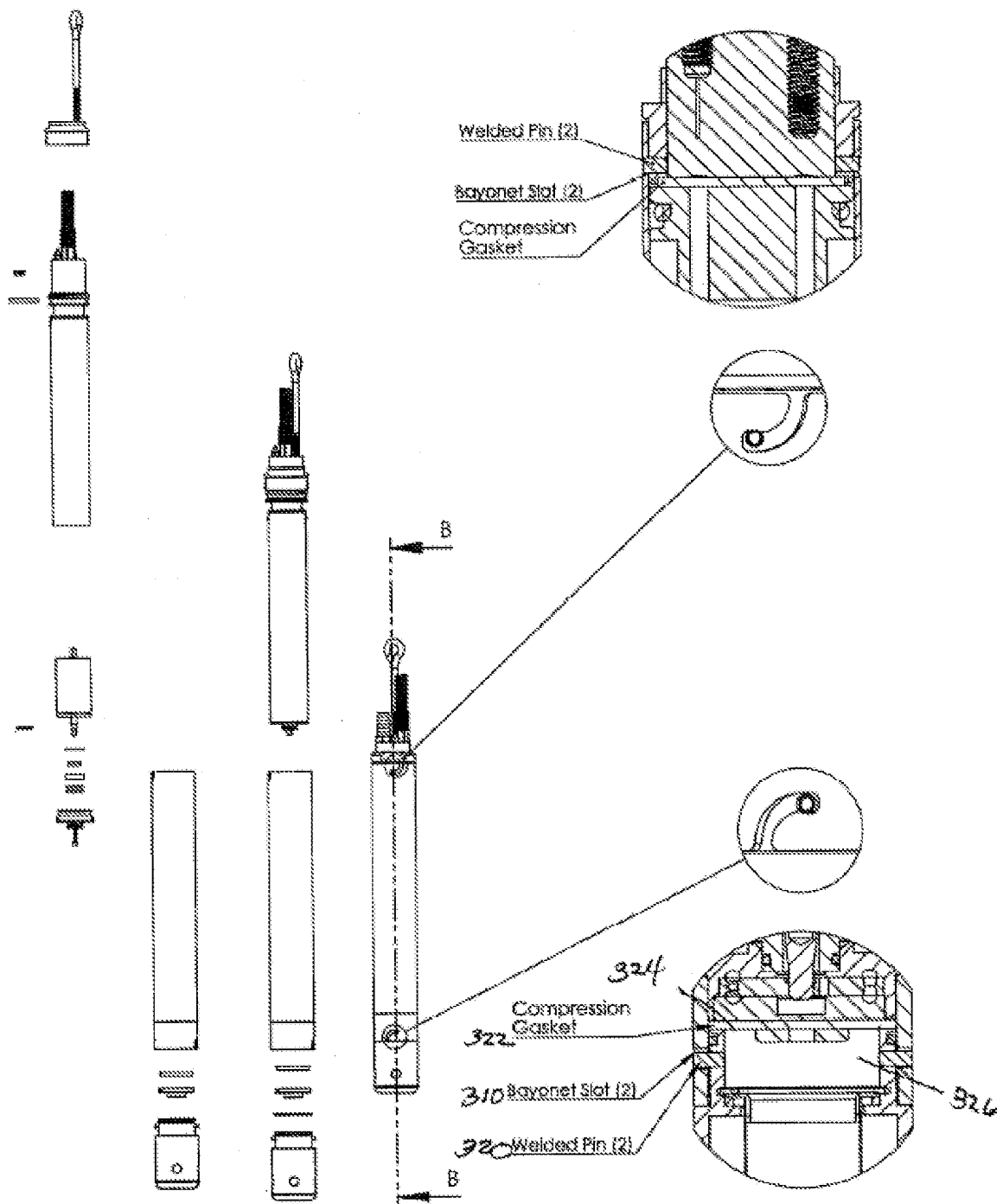
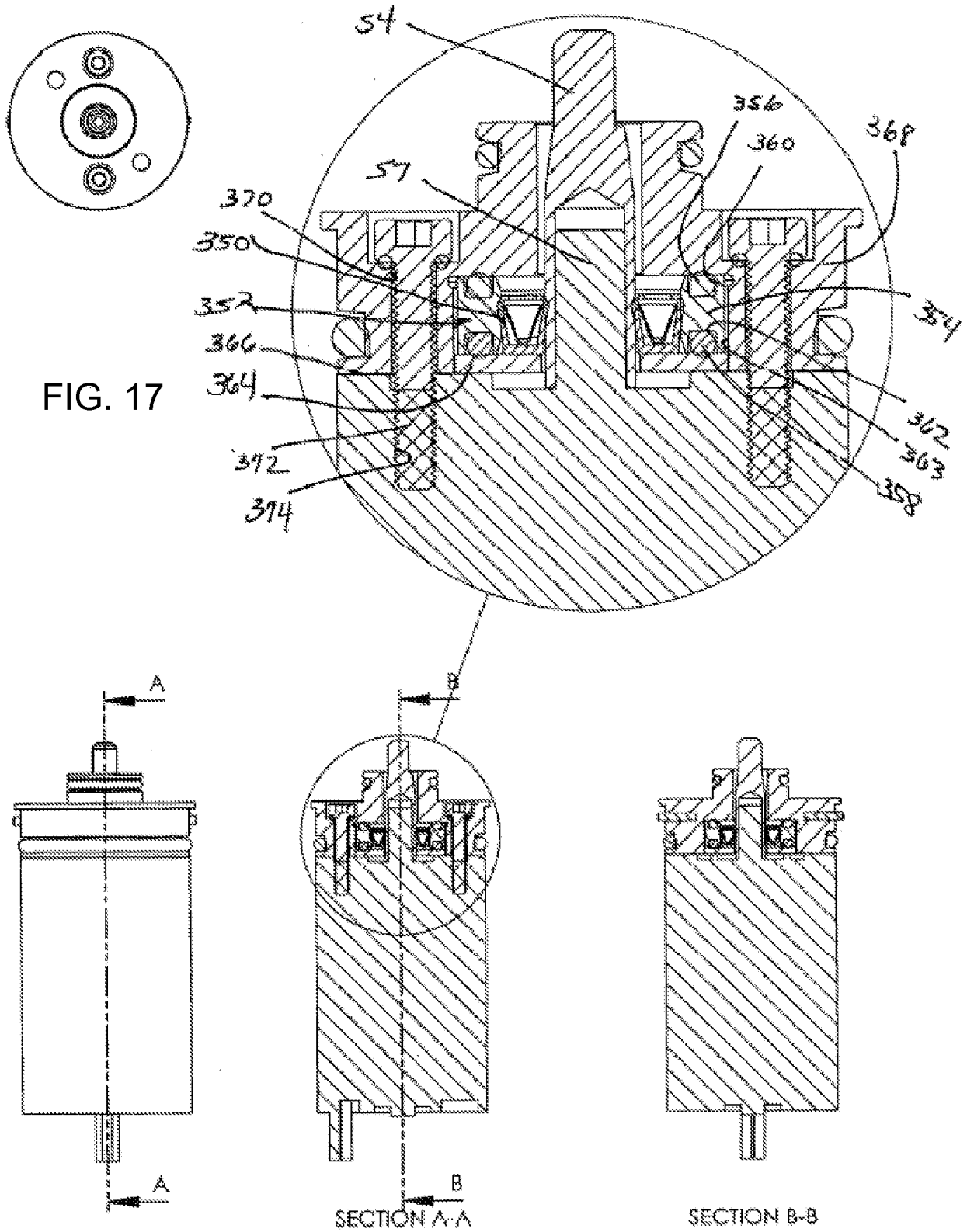


FIG. 16



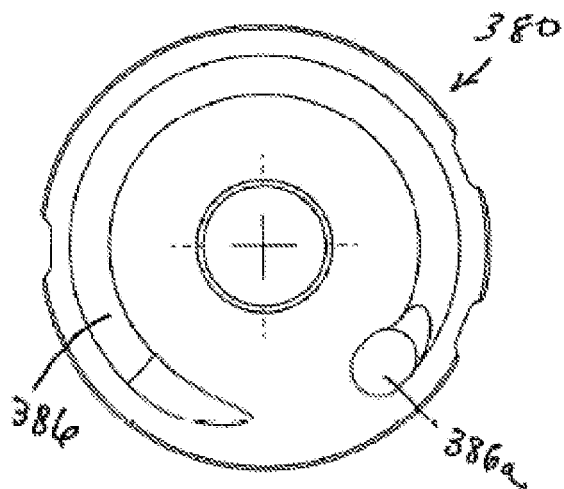


FIG. 18

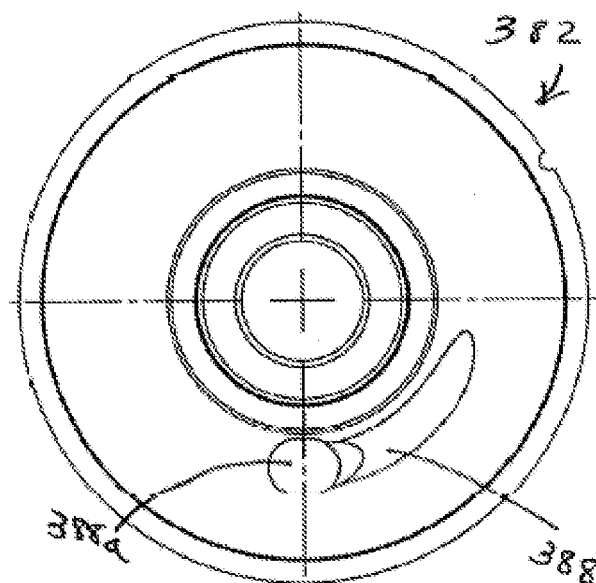


FIG. 21



FIG. 19

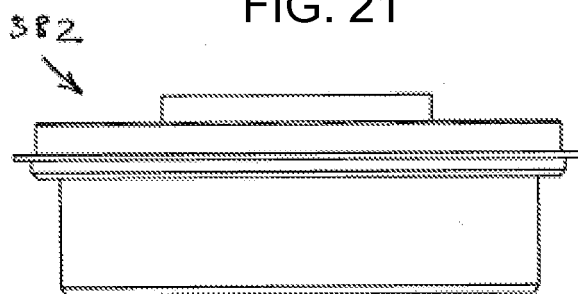


FIG. 22

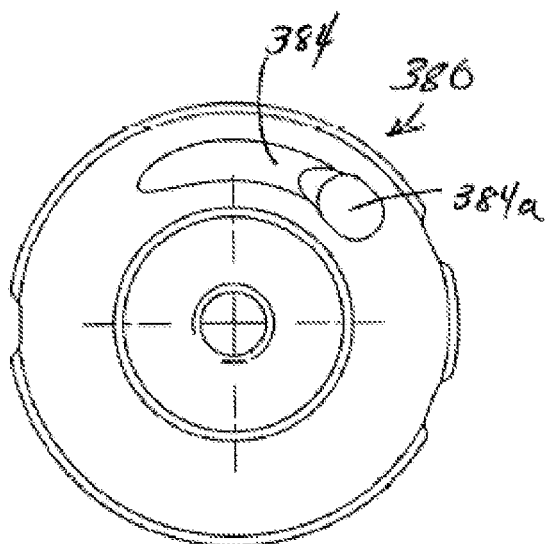


FIG. 20

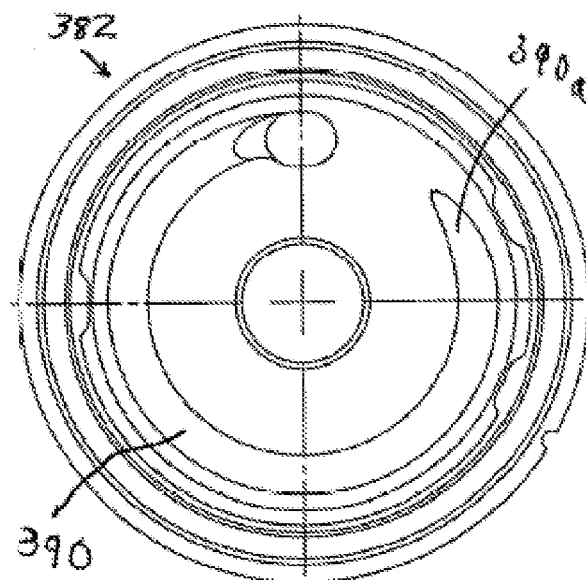


FIG. 23

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 61911273 A [0001]
- US 20070166178 A1 [0004]
- US 20060180302 A1 [0004]
- US 20100211226 A1 [0004]
- US 20020071759 A1 [0004]