(12) STANDARD PATENT (11) Application No. **AU 2011248832 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Replaceable probe head

(51) International Patent Classification(s)
G01D 11/24 (2006.01) ***G01R 1/067*** (2006.01)

(21) Application No: **2011248832** (22) Date of Filing: **2011.04.19**

(87) WIPO No: **WO11/139539**

(30) Priority Data

(31) Number	(32) Date	(33) Country
12/774,081	**2010.05.05**	**US**

(43) Publication Date: **2011.11.10**
(44) Accepted Journal Date: **2015.07.23**

(71) Applicant(s)
YSI Incorporated

(72) Inventor(s)
Palassis, Christopher J.;James, Michael T.

(74) Agent / Attorney
Phillips Ormonde Fitzpatrick, L 16 333 Collins St, Melbourne, VIC, 3000

(56) Related Art
US 2003/0148636

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 November 2011 (10.11.2011)

PCT

(10) International Publication Number
WO 2011/139539 A3

(51) International Patent Classification:
G01D 11/24 (2006.01) *G01R 1/067* (2006.01)

(21) International Application Number:
PCT/US2011/032943

(22) International Filing Date:
19 April 2011 (19.04.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/774,081 5 May 2010 (05.05.2010) US

(71) Applicant *(for all designated States except US)*: **YSI INCORPORATED** [US/US]; 1700/1725 Brannum Lane, P.O. Box 279, Yellow Springs, OH 45387 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **PALASSIS, Christopher, J.** [US/US]; 2625 US Route 68 N, Yellow Springs, OH 45387 (US). **JAMES, Michael, T.** [US/US]; 1616 Middle Park Drive, Dayton, OH 45414 (US).

(74) Agents: **LEVY, Mark, P.** et al.; Thompson Hine LLP, P.O. Box 8801, Dayton, Ohio 45401-8801 (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, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

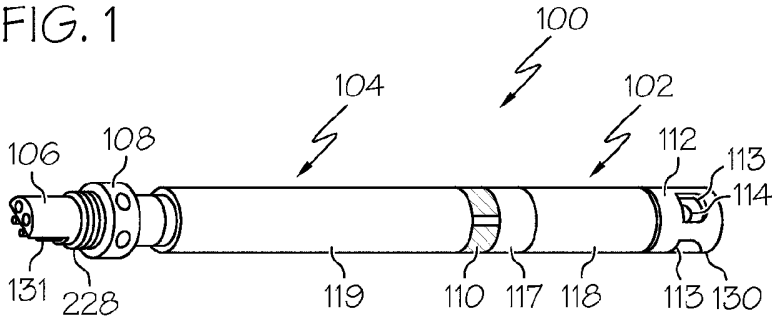
— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
23 February 2012

(54) Title: REPLACEABLE PROBE HEAD

FIG. 1



(57) Abstract: A probe head is disclosed that is detachable from a probe body containing electronics. The probe head including a housing enclosing a sensor and at least part of an electrical connector electrically coupled to the sensor. The housing has a coupling member positioned to detachably connect the housing to the probe body, and when the probe head and probe body are coupled, the electrical connector electrically couples the sensor to the electronics in the probe body.

WO 2011/139539 A3

REPLACEABLE PROBE HEAD

TECHNICAL FIELD

[0001] The present application relates to a replaceable probe head, and more particularly to a replaceable probe head having a sensor, such as an electrode, and having a connector for sealably connecting the probe head to a probe body.

BACKGROUND

[0002] Probes having sensors are known, but in the past once the sensor dies, in particular when a fluid reservoir of an electrode type sensor is spent, the entire probe was discarded. That may not have been too expensive prior to "smart probes," but now that probes, like those disclosed herein, carry an on-board circuit board with memory and numerous other functionalities, it is expensive to just throw away the entire probe.

[0003] To solve this problem and address this long-felt need, Applicants have developed a replaceable probe head that allows the body of the probe housing the circuit board to be reused. In the embodiment disclosed herein, only the probe head is discarded.

SUMMARY

[0004] Viewed from one aspect of the invention, there is provided a probe head that is detachable from a probe body that contains electronics. The probe head includes a housing that encloses an electrode as a sensor, a reagent reservoir therefor, and an electrical member connecting the sensor to an electrical connector, wherein at least part of the electrical connector protrudes from the housing. The housing includes a coupling member positioned to detachably connect the housing to the probe body at a junction where the electrical connector couples with the electronics in the probe body to electrically couple the sensor to the electronics of the probe body, thereby obviating such electronics from the probe head. Reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir while the probe body containing the electronics remains unchanged.

[0004a] In some embodiments, the coupling member includes a flexible, generally C-shaped open ring.

[0004b] When the probe head is detachably connected to the probe body, the electrical connector will electrically couple the sensor to the electronics in the probe body.

[0004c] In some embodiments, the coupling member is the flexible, generally C-shaped open ring having a snap-fit feature, for example, an annular ridge protruding from the exterior surface of the open ring for coupling the probe head to the probe body. The open ring may be compressible toward a closed ring position to couple the probe head to the probe body, expands to interconnect the two, and may be compressible again to uncouple the probe head.

[0004d] In some embodiments, the probe head is replaceable and/or disposable.

[0005] Viewed from another aspect of the invention, there is provided a probe for monitoring a parameter of an environment, wherein the probe includes a probe body enclosing electronics. The probe body has a first end and a second end, and a first electrical connector proximal the first end and electrically coupled to the electronics and a second electrical connector proximal to the second end and electrically coupled to the electronics, wherein each of the first electrical connector and the second electrical connector are at least partially enclosed by the probe body. The probe also includes a probe head enclosing an electrode as a sensor, a reagent reservoir therefor and at least part of a third electrical connector electrically coupled to the sensor. The probe also includes a coupling member positioned to detachably connect the probe head and the probe body to one another with the first electrical connector connected to the third electrical connector, thereby electrically coupling the sensor of the probe head with the electronics of the probe body and obviating such electronics from the probe head. The second electrical connector of the probe body connects the electronics in the probe body to a device capable of communicating with the sensor, via the electronics in the probe body, to monitor an environment surrounding the sensor. Reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir

while the probe body containing the electronics remains unchanged.

[0006] The third electrical connector may be connectable to a monitoring device, for example, a sonde, that can operate and/or communicate with the probe, in particular, with the electronics of the probe body and, hence, the sensor in the probe head. The third electrical connector may be a wet-mateable connector.

[0006a] Also described is a probe for connection to a sonde for monitoring a parameter of an environment, the probe comprising: a probe body defining an interior cavity and having a coupling member connectable to the sonde, the probe body comprising a circuit board housed within the interior cavity of the probe body in a water-tight sealed portion thereof, wherein the circuit board comprises a first electrical connector electrically coupled thereto and having a portion of the first electrical connector extending out of the water-tight sealed portion of the interior cavity; and a probe head defining an interior cavity and comprising a sensor housed within the interior cavity of the probe head in a water-tight sealed portion thereof, wherein the sensor is electrically coupled to a second electrical connector having a portion thereof extending out of the water-tight portion of the interior, wherein the portion of the first electrical connector extending out of the water-tight sealed portion of the probe body is mateable with the second electrical connector extending out of the water-tight sealed portion of the probe head, and a connector portion of the probe body proximate to the first electrical connector is mateable with a connector portion of the probe head proximate to the second electrical connector with a releasably attachable connection that provides a water-tight seal protecting the first and second electrical connectors.

[0006b] Viewed from another aspect of the present invention, there is provided a system for monitoring an environment, the system comprising: a sonde comprising at least one junction for coupling with a probe that monitors parameters of an environment using a sensor; and a probe couplable with the sonde for electrical communication therewith, the probe comprising: a probe body having a water-tight housing enclosing a circuit board having memory, a first electrical connector connected to the circuit board and having a portion thereof protruding from the water-tight housing, and a second electrical connector connected to the circuit board and having a portion thereof protruding from the housing; and a probe head having a

housing enclosing electrode, a reagent reservoir therefor, and a third electrical connector connected to the electrode, wherein a portion of the third electrical connector protrudes from the housing; wherein the third electrical connector of the probe head is detachably couplable with one of the first or second electrical connectors of the probe body and the other of the first or second electrical connectors of the probe body is electrically couplable with the sonde; and wherein the reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir while the probe body containing the circuit board having memory remains unchanged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a side view of one embodiment of a probe having a replaceable probe head.

[0008] FIG. 2 is an exploded assembly view of the probe of FIG. 1.

[0009] FIG. 3 is a side view of the replaceable probe head without the retaining clip.

[0010] FIG. 4 is a cross-sectional view of the replaceable probe head of FIG. 3 taken along line 4-4.

[0011] FIGS. 5-6 are connector end views of alternate embodiments of the replaceable probe head.

[0012] FIG. 7 is a top view of the retaining clip of the replaceable probe head.

[0013] FIG. 8 is a front view of the retaining clip of FIG. 7.

[0014] FIG. 9 is a cross-sectional view of the probe body.

[0015] FIG. 10 is a cross-sectional view of the probe of FIG. 1.

[0016] FIGS. 11-12 are distal end views of alternate embodiments of the probe body.

[0017] FIG. 13 is a front view of another embodiment of the replaceable probe head.

[0018] FIG. 14 is a top perspective view of a sonde that includes the probe of FIG. 1.

[0019] FIG. 15 is an exploded assembly view of one embodiment of a probe.

DETAILED DESCRIPTION

[0020] The following detailed description will illustrate the general principles of the invention, examples of which are additionally illustrated in the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0021] Referring to FIG. 1, a probe, generally designated 100, is shown that has a distal end 130 and a proximal end 131 and may include a removable probe head 102 removeably coupled to a probe body 104 by a coupling member 110, a connector 106, a connecting collar 108, and a guard 112 having one or more windows 113. The probe 100 can monitor parameters of an environment using a sensor 114 housed within the probe head 102, typically an environment surrounding the distal end 130 of the probe, i.e., the probe head, when connected to another device by connector 106 and, optionally, by the connecting collar 108. The connecting collar 108 may be threaded for connecting the probe to a port in the device. The connector 106 may include a stop ring 228 to retain the collar 108, i.e., to keep the collar from sliding off.

[0022] Referring to FIG. 14, in one embodiment, the probe 100 may be connected to a sonde 500, like the sonde described in U.S. Patent 6,779,383, modified to include the probe disclosed herein. The sonde 500 includes a plurality of probes having various sensing capabilities. For example, the sonde 500 may include a turbidity sensor 510, a dissolved oxygen sensor 512, the probe 100 having the replaceable probe head that in one embodiment includes a pH electrode and/or an ORP electrode, a temperature-conductivity sensor 516 and a sensor 518, which can be a chlorophyll or rhodamine sensor. The sonde 500 may also include a wiper element 520 about which a wiper media such as a foamed rubber wiper pad is wrapped and extending therefrom beyond the diameter of the sensor it is mounted on, the turbidity sensor 510 in FIG. 14 is a brush 524 for cleaning the surface of the sensors. In another embodiment, the probe 100 may be connected to a sensor adaptor, a datalogger, a computer, a handheld monitoring unit, or any other mobile or fixed data collection platform capable of connecting to the probe and communicating with the sensor therein to monitor the environment surrounding the sensor.

[0023] The probe 100 includes a sensor 114 housed within the housing 118 that defines at least part of the replaceable probe head 102. The sensor 114 has access to the environment surrounding the distal end 130 of the probe 100. In one embodiment, like that in FIG. 1, the sensor 114 may protrude from housing 118 and be surrounded by the guard 112. The replaceable probe head 102 may include a housing 118, which may be a hollow, generally cylindrical tube, with a sleeve 117 fixedly attached to one end thereof. The replaceable probe head 102 may also include a coupling member 110 positioned on the sleeve opposite the distal end 130. The coupling member removeably couples the replaceable probe head 102 to the probe body 104, in particular to second housing 119.

[0024] The replaceable probe head 102, in particular its housing 118, sleeve 117, and guard 112 may be a plastic material such as a suitable engineering thermoplastic material with good material strength that lends itself to having the windows 113, the tabs 129, 129', slots 182, 182' and/or annular grooves 116, 120, 122, described below, formed therein. The thermoplastic may be water, corrosion, and/or chemically resistant, and electrically insulating. The plastic material should

also be suitable for forming a watertight housing, in particular, having watertight bands between adjoining pieces. The watertight bond is important since the replaceable probe head 102 is often used under water at significant depths and experiences increased pressure as it descends. If a gap occurs, water may be able to enter the replaceable probe head 102 and damage its components.

[0025] The thermoplastic material may be an acetal, acrylic, acrylonitrile-butadiene-styrene terpolymer, a polyamide, a polycarbonate, a polyetherimide, a polyphenylene ether, a polyphenylene sulfide, a polysulfone, polyvinyl alcohol, or a thermoplastic polyester. In one embodiment, the thermoplastic material is an imide; preferably a non-filled imide, such as a polyetherimide. Polyetherimides are commercially available under the brand name Ultem® available from SABIC Innovative Plastics.

[0026] As shown in the assembly view of FIG. 2, the replaceable probe head 102 may be inserted into the probe body 104, preferably using linear force, to couple the replaceable probe head 102 to the probe body 104 with a watertight seal. The replaceable probe head 102 may need to be partially inserted into the probe body 104 and rotated to align means to key the replaceable probe head 102 to the probe body 104 for a proper connection before applying further force to push the replaceable probe head 102 into the probe body 104. The replaceable probe head 102 is removeably coupled to the probe body 104 by the coupling member 110 and may be removed by activating (e.g., compressing) the coupling member 110 and pulling with a linear force opposite of the force used to insert the replaceable probe head 102.

[0027] Now referring to FIGS. 1-4, the replaceable probe head 102 has a first end 184 and a second end 186, a housing 118 that houses a sensor 114 and at least part of an electrical connector 171 electrically coupled to the sensor 114, a coupling member 110 positioned to detachably connect the housing 118 to the probe body 104, and a guard 112 to protect the first end 184 where a portion of the sensor 114 may be positioned. In one embodiment, the housing 118 may be a monolithic body having the coupling member 110 integrally formed therewith or as a separate component. In another embodiment, the housing 118 may include a sleeve 117,

which may have the coupling member, again, integrally formed therewith or as a separate component.

[0028] The housing 118, best seen in FIGS. 3-4, has a first end 150 and a second end 158 and may be a generally cylindrical, hollow housing. The first end 150 defines a first opening 152 that may include one or more ports 199 (FIG. 10) and includes a first connecting means 156 on its exterior surface proximate to the first opening. The first connecting means 156 may be continuous or discontinuous protuberances such as clips, snap-fit feature(s), threading, or other connecting features that can fixedly attach the guard 112 to the housing 118. The first end 150 may have a smaller outer diameter than the central section 153 of the housing, which facilitates the guard 112 fitting over the first end 150. In an alternate embodiment, the protuberances may be on the interior of the guard 112 and the first end 150 will, instead, have appropriately positioned and shaped recesses proximate to the first opening 152. The first end 150 may also have a smaller inner diameter than the central section of the housing 118 such that an annular shoulder 154 is formed where the first end 150 transitions to the central section of the housing. The annular shoulder 154 may be used to mount one or more sensors 114 within the first end 150 of the housing. In another embodiment, the guard 112 could fit inside the first end 150 rather than over it, and both components would be shaped and configured accordingly.

[0029] The guard 112, as described above, is fixedly attachable to the first end 150 of the housing 118 of the replaceable probe head. The guard includes one or more windows 113 in the distal end of the guard 112. The guard 112 may be a generally cylindrical, hollow sleeve that fits at least partially over the first end 150 of the housing 118 to position the one or more windows 113 where the environment surrounding the guard 112 has access to the sensor 114 or electrode 114' of the replaceable probe head 102.

[0030] The second end 158 of the first housing 118 defines an opening 159 in the second end and includes a second connecting means 160 on its exterior surface proximate to the opening 159. The second connecting means 160 may be any of the same connecting means discussed above for the first connecting means 156 and may be the same or different as the first connecting means 156 on the housing 118.

The second end 158 may have a smaller outer diameter than the central section of the housing 118, which facilitates the second end 158 receiving the sleeve 117. The outer diameter of the second end 158 may be the same as the outer diameter of the first end 150 of the housing, but is not limited thereto. In another embodiment, the sleeve 117 could fit inside the second end 158, and both components would be shaped and configured accordingly.

[0031] The sleeve 117 has a distal end 162 and a proximal end 164. The distal end 162 defines a first opening 166 that has a larger inner diameter than the central section 176 of the sleeve 117. A first annular step 178 is formed in the interior of the sleeve 117 where the distal end 162 transitions to the central section 176. The first annular step 178 acts as a stop or seat for the second end 158 of the housing 118 when it is inserted into the open first end 166 of the sleeve 117. The distal end 162 may include an annular groove or appropriately shaped and position recesses just interior to the first end 166 indented into the wall thereof. The groove or recesses are to receive the connecting means 160 of the second end 158 of the first housing 118 for a watertight connection. The sleeve 117 and housing 118 are preferably fixedly attached together. In an alternate embodiment, the sleeve 117 may be integral with the housing 118. If so, the second connecting means 160 would be absent.

[0032] The exterior of sleeve 117 may include one or more annular groves 116, 120, 122 indented therein. A first annular groove 116 may be positioned most proximate to the housing 118 and may be wide enough to receive the coupling member 110. The sleeve 117 may include a second annular groove 120 between the first annular groove 116 and the proximal end 164 of the sleeve. The second annular groove 120 may be shaped to receive a first sealing member 124, for example, an O-ring or the like. In another embodiment, there may be a third annular groove 122 between the second annular groove 120 and the proximal end 164 of the sleeve 117 that is shaped to receive a second sealing member 126. While the embodiments herein have three annular grooves with two of the grooves for receiving sealing members, one of skill in the art will appreciate that any number of grooves and sealing members may be used. The sealing members 124, 126 (FIG. 2)

provide a watertight seal between the replaceable probe head 102 and the probe body 104.

[0033] The proximal end 164 of the sleeve 117 defines a second opening 168 that has a smaller inner diameter than the central section 176 of the sleeve 117. As such, a second annular step 179 is formed in the interior of the sleeve 117 at the transition of the central section 176 to the second opening 168. The second annular step 179 has seated thereon a circuit board 170, such as a printed circuit board , that has a electrical connector 171 extending from the circuit board 170 into or through the second opening 168. The electrical connector 171 may be a header with either pins or sockets extending from the second opening 168, a card edge connector, a printed circuit board connector, a USB connector, or any other known or later-developed connector that can connect the sensor 114 or electrode 114' to the circuit or circuit board 170 housed within the probe body 104. In the embodiment in FIGS. 3-6, the electrical connector 171 is a male header with at least one active pin. One of skill in the art will appreciate that not all the pins on a header need be connected to the circuit board 170 on the opposite side of the header. While the header shown has six pins, the electrical connector is not limited thereto.

[0034] The circuit board 170 may be adhered to the sleeve 117 to hold it in place and to form a watertight seal. Filler 180 may be present between the electrical connector 171 and the second opening 168. Suitable filler 180 seals the second opening 168 of the sleeve 117 so that water cannot enter and damage the components of the connector 171, the circuit board 170, or the sensor 114. The filler 180 may be an adhesive, polymer, or other resin that provides a watertight protective seal of the open second end 168. For example, filler 180 may be an epoxy resin, silicone RTV, potting compound, or any other suitable filler for forming a watertight seal. Connected to the circuit board 170 opposite the electrical connector 171 is at least one lead 174 that extends through the sleeve 117 into housing 118 and connects the sensor 114 and/or its components to the electrical connector 171.

[0035] The proximal end 164 of the sleeve 117 may also include a means to key the replaceable probe head 102 to the probe body 104. In the embodiment of FIGS. 3-5, the means to key the replaceable probe head 102 is one or more tabs 129, 129'

extending longitudinally from the proximal end 164 of the sleeve 117. The first tab 129 and the second tab 129' may have different shapes as shown in FIG. 5, such that there is only one orientation for insertion of the replaceable probe head 102 into the probe body 104 to correctly connect the electrical connector 171 to the circuit board 170 in the probe body 104. Accordingly, as seen in FIG. 11, the first opening 136 of the probe body 104 receiving the electrical connector 171 has a first slot 214 configured to receive the first tab 129 and a second slot 215 configured to receive the second tab 129'. In the embodiment of FIG. 6, the means to key the replaceable probe head 102 may be one or more slots 182, 182' cut into the proximal end 164' of the sleeve 117, with the slots preferably having different shapes. Accordingly, as seen in FIG. 12, the first opening 136 of the probe body 104 receiving the electrical connector 171 has a first tab 216 and a second tab 217 configured to be received in the slots 182, 182', respectively, of the replaceable probe head 102. Many other means to key two parts together are known and are equally applicable here. For example, the proximal end 164 of the sleeve 117 may have a protrusion on the outer surface thereof that fits into a slot indented and running longitudinally down the interior wall of the end of the probe body 104 receiving the sleeve 117.

[0036] The sensor 114 housed within the replaceable probe head 102 may include a plurality of components, including an electrode 114' (FIG. 10), window, membrane, or other surface positioned in or extending from the first end 150 of the housing 118, preferably in or extending from a port 199 in the first end 150. The electrode 114' may be an ion-selective electrode. Any suitable ion-selective electrode or a combination of such electrodes may be housed by the probe head 102. For example, a pH electrode, oxidation-reduction potential electrode, a dissolved oxygen electrode, an electrode selective toward nitrite ions, nitrate ions, ammonia, fluoride ions, sodium ions, chloride ions, potassium ions, calcium ions, bromide ions, or manganese(II) ions. In one embodiment, the probe head 102 houses a pH electrode. In another embodiment, the probe head 102 houses an oxidation reduction potential electrode. In yet another embodiment, the probe head 102 houses both a pH electrode and an oxidation-reduction potential electrode.

[0037] An embodiment of a probe 100 having two sensors, in particular two electrodes 114' extending from the first end 150 of housing 118, is represented in

FIG. 10. The electrodes 114' have their sensor components 198 housed within housing 118 and connected to electrical leads 174 by a sensor connector 200, for example, or electrical lead. The sensor components 198 are those typically needed for the particular sensor or electrode chosen for the parameter to be monitored. For a pH electrode, the sensor components 198 may include a sensor reservoir containing a reagent that is consumed in making measurements with the sensor, for example, an electrolyte filling solution such as KCl, a pH glass electrode in fluid communication with the reservoir, a wire such as a pure silver wire dipped in silver chloride to pass the signal from the solution to the sensor connector 200, and a reference electrode, either separate or built into the pH electrode itself. For an oxidation-reduction potential electrode, the sensor components 198 may include similar components to the pH electrode such as the pure silver wire dipped in silver chloride surrounded by a reservoir containing an electrolyte filling solution such as KCl, except that a nobel metal such as platinum, gold, or silver is used as the measuring element rather than pH glass. The sensor components 198 for other types of electrodes or sensors are known and may be housed within housing 118.

[0038] The coupling member 110 may be any connecting feature that allows the mating of the probe head 102 and the probe body 104 and the mating of their respective electrical connectors 171, 212 with a detachable, watertight connection.

[0039] Now referring to FIGS. 7-8, the coupling member 110 is a flexible open ring 110 having a slot 111. In one embodiment, the open ring 110 is generally C-shaped. The flexibility of the ring 110 and slot 111 render the open ring 110 compressible or pinchable at least to the extent that the slot 111 may be closed when pressure is applied to the ring 110 on both sides of the slot 111 and will return to its original position when the pressure is removed. Accordingly, the open ring 110 is compressible or pinchable toward a closed ring position as shown by arrows **A** in FIG. 7. The open ring 110 may also be expandable such that it may be expanded to widen slot 111, in particular, so that the open ring 110 may be slid over the sleeve 117 and into the first annular groove 116.

[0040] The exterior of the coupling member 110, best seen in FIG. 8, includes an upper portion 192 defining an open distal end 190 and a lower portion 193 defining an open proximal end 191. The upper portion 192 overall has a larger outer

diameter compared to the lower portion 193. An annular stop 196 is defined where the upper portion 192 transitions to the lower portion 193. The lower portion 193 includes a snap fit feature 128. The snap fit feature 128 is generally an annular snap fit feature, as it extends around the outer circumference of the open ring 110. The leading edge 194 of the snap fit feature 128 may be beveled at an angle less than 90° to aide in pushing the snap fit feature 128 into the probe body 104. The snap fit feature 128 is preferably an annular protuberance as shown in FIG. 8, but is not limited thereto. Inside and outside snap fit features and/or other cantilevered snap fit features are all well known and may be applicable here.

[0041] An advantage to the open ring 110 is that the replaceable probe head 102 can be removed and replaced easily by anyone. Such components are often referred to as "field replaceable," which eliminates sending the probe to the manufacturer for replacement of the probe head.

[0042] The flexible open ring 110 detachably locks the probe head 102 and the probe body 104 together upon insertion. The open ring 110 is compressed during insertion into the probe body 104 and, due to its flexibility, expands outward into engagement with the probe body 104 once inserted. In the embodiment of FIG. 10, the snap-fit feature 128 of the open ring 110 expands into engagement with, for example, an annular groove in the probe body 104. The user may make insertion of the probe head 102 easier by pinching the open ring 110 toward a closed ring position **A** while inserting or beginning to insert the probe head 102 into the probe body 104.

[0043] When the probe head 102 is ready to be replaced (i.e., when an on-board reservoir is used up, the probe head no longer works, etc.), the flexible open ring 110 is pinched toward a closed ring position **A** by the user to disengage the open ring 110 from the probe body 104. The user may pinch the open ring 110 between the thumb and at least one finger of the same hand. While pinching the open ring 110, the user pulls the probe head 102 and the probe body 104 apart thereby disengaging their respective electrical connectors 171, 212. Now the spent probe head 102 may be discarded and replaced with a new probe head.

[0044] An alternate embodiment for the coupling member 110 is shown on the replaceable probe head 302 in FIG. 13. The replaceable probe head 302 has an

integral housing 318 that has a distal end 384 defining a first opening 352 and a proximal end 386 defining a second opening 368. Here, the annular snap fit feature 328 is integrally formed on a coupling member 319 of the housing 318. The coupling member 319, overall, has a smaller outer diameter than the rest of housing 318, such that an annular step 378 is defined at the transition from the coupling portion 319 to the main body of housing 318. The exterior of coupling member 319 may also include one or more annular groves indented therein. A first annular groove 320 may be between the snap fit feature 328 and the proximal end 386. The first annular groove 320 may be shaped to receive a sealing member, for example, an O-ring or the like. The coupling member 319 may also include a second annular groove 322 between the first annular groove 320 and the proximal end 386 that is also shaped to receive a sealing member. While FIG. 13 illustrates two annular grooves in the coupling portion 319, the embodiment is not limited thereto. This embodiment has an effective coupling mechanism, but the probe head 302 may need to be replaced by the manufacturer or a trained technician.

[0045] In another embodiment, the coupling member 110 may be a clip, a push button-receiving aperture connection, threading, or other connecting features that facilitate a detachable connection between the probe head 102 and the probe body 104. These alternate coupling members may be used alone or in combination with the open ring 110 discussed above or with one another. Any of these embodiments may include an O-ring or other sealing member to provide a watertight seal between the probe head 102 and the probe body 104.

[0046] Now referring to FIG. 9, the probe body 104 has a second housing 119 that is preferably a hollow, generally cylindrical tube having a distal end 132 and a proximal end 134. The distal end 132 defines a first opening 136 and the proximal end 134 defines a second opening 137. The housing 119 has a substantially uniform outer diameter, but has three internal segments with different inner diameters. The interior of the housing 119 has a cavity 138 at the distal end 132, an enlarged opening 146 at the proximal end 134, and a chamber 144 therebetween.

[0047] The cavity 138 has a smaller inner diameter than the chamber 144 such that an annular shoulder 142 is defined at the transition between the cavity 138 and the chamber 144. The cavity 138 is generally sized to receive the second end 186

of the replaceable probe head 102 including the snap fit feature 128 of the coupling member 110. Just interior to the first opening 136 is an annular groove 140 indented into the wall of the cavity and extending around its periphery. The annular groove 140 is shaped and positioned so as to receive the snap fit feature 128 protruding from the coupling member 110 when the replaceable probe head 102 is connected to the probe body 104. It is appreciated that, while an annular groove is preferable, other indentation means are also possible. For example, the other indentation means may include a plurality of recesses formed in the cavity's wall arranged to coincide in alignment with a plurality of protuberances on the second end 186 of the replaceable probe head 102.

[0048] The enlarged opening 146 at the proximal end 134 of the second housing 119 extends generally uniformly into the interior of the housing 119 and is contiguous with the second opening 137 defined by the proximal end 134. The enlarged opening 146 has a larger inner diameter compared to the chamber 144 and may even have a larger inner diameter compared to the cavity 138. The benefits of the enlarged opening 146, in particular, in relation to assembling and welding the assembly, are explained in Applicants' U.S. Patent Application Serial No. 12/773,995 PROBE AND PROCESS OF ASSEMBLING SAID PROBE (the "Assembly Process application"), filed the same day as this application, and incorporated herein by reference in its entirety.

[0049] The second housing 119 may be a metal and/or an anti-biofouling material. The metal may be water resistant and corrosive resistant. For example, the second housing 119 may be titanium, stainless steel, nickel, copper, and alloys thereof. In one embodiment, the second housing 119 is titanium. In another embodiment, the second housing 119 is an antifouling copper-nickle alloy with a high copper content. For example, the antifouling copper-nickle alloy may be a 90-10 CuNi alloy or a 70-30 CuNi alloy. In another embodiment, the housing may be an antifouling plastic, for example, a polyethylene, polypropylene, or nylon that may include an anti-fouling compound such as capsaicin, capsicum, furan compounds, copper compounds, lactones, alkyl-phenols, organotin compounds, antibiotics, or mixtures thereof.

[0050] Now referring to FIG. 10, which is a cross-section of the embodiment in FIG.1, the probe 100 includes the features of the replaceable probe head 102 discussed above including the open ring as the coupling member 110 and a probe body 104 with housing 119 housing a circuit board 220, such as a printed circuit board. The circuit board 220 is mainly housed in chamber 144 and is connected to a platform 210 having a second electrical connector 212 extending therethrough. The platform 210 is seated on the annular shoulder 142, preferably the platform 210 is adhered thereto with a watertight seal, for example with an epoxy adhesive. The platform 210 and the second connector 212 are also shown in the end views of FIGS. 11-12 looking down into cavity 138 of the second housing 119 from the first opening 136.

[0051] The second electrical connector 212 may be the same as the first electrical connector 171 described above, but of a configuration that will mate with the first electrical connector 171. As shown in FIG. 10, the first connector 171 is a male header with six pins and the second electrical connector 212 is a female header with six receptacles receiving the pins.

[0052] Connector 106 is connected to the circuit board 220 at the end opposite of the platform 210 by leads 222. The connector 106 includes at least one male pin 224 and at least one female receptacle 225. Preferably, the male pin 224 and female receptacle 225 are wet mateable connectors. Connector 106 may also include a casing 226 surrounding at least part thereof, preferably, surrounding the part adjacent to the proximal end 134 of second housing 119 to provide a surface for affixing the connector 106 to the proximal end 134 with a watertight seal. The casing 226 may be a metal and/or an anti-biofouling material such as those discussed above for the second housing 119. In one embodiment, the second housing 119 and the casing 226 are composed of the same material and may be fixedly attached to one another, for example by laser welding as disclosed in the Weld Method application. To enhance the attachment between the second housing 119 and the casing 226, a reducing ring 148 may be inserted into the enlarged opening 146 of the second housing 119 to provide increased surface area for the weld.

[0053] Connector 106 may include a collar 108 on the casing 226 that is retained on the casing 226 by a stop ring 228 that fits within an annular groove indented into the end of the casing 226 opposite the second housing 119.

[0054] Referring now to FIG. 15, in another embodiment, a probe, generally designated 400, has a probe body 404 including an insertable male end 408 having a first electrical connector therein and a coupling member 410 positioned to detachably couple the probe body 404 to a probe head 402. The first electronic connector may be similar to those described above for FIGS. 3-6. The insertable male end 408 may be part of the probe body second housing 419', and, in one embodiment, is integral with the second housing 419. In another embodiment, the insertable male end 408 is a separate component attached to housing 419. The insertable male end 408 may also include one or more sealing members, such as O-rings 424 and an alignment tab 429. The coupling member 410, as shown, is an open flexible ring having a slot 411 and a snap-fit feature 428. The open flexible ring 410 may also have any of the features described above. The probe 400 may also include a connector 106 and threaded collar 108, similar to those described above. The probe body 404 also includes electronics, for example, a circuit board, housed within the second housing 419 to communicate with the sensor in the probe head 402.

[0055] The probe head 402 has a first housing 418 that houses a sensor and a second electrical connector. The first housing 418 includes a female end 459 for receiving the male end 408 of the probe body 404. The second electrical connector is preferably positioned in the female end 459 so that the sensor in the probe head 402 can be electrically coupled to the electronics in the probe body 404. The female end 459 and the second electrical connector may be similar to those described above for the probe body of FIGS. 10-12.

[0056] When comparing the embodiments of FIGS. 2 and 15, the embodiment of FIG. 2 may be preferable because it may be easier to replace the probe head having the coupling member and O-rings rather than replacing the O-rings on the probe body. The O-rings may wear or break after a plurality of uses. Wear on the O-rings may prevent the O-rings from providing a watertight seal. Accordingly, the

O-rings may need to be changed each time the probe head is replaced in the embodiment of FIG. 15.

[0057] In another embodiment, the probe may be mounted within a multi-probe assembly or sonde as illustrated in U.S. Patent 6,779,383 and wiped with a wiper element that cleans not only the disclosed probe 100, but other sensors in other probes.

[0058] It will be appreciated that while the invention has been described in detail and with reference to specific embodiments, numerous modifications and variations are possible without departing from the spirit and scope of the invention as defined by the following claims.

[0059] Where the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components, or group thereof.

2011248832 29 Jun 2015

The claims defining the invention are as follows:

1. A probe head that is detachable from a probe body that contains electronics, the probe head comprising:

a housing enclosing an electrode as a sensor, a reagent reservoir therefor, and an electrical member connecting the sensor to an electrical connector, wherein at least part of the electrical connector protrudes from the housing, the housing comprising a coupling member positioned to detachably connect the housing to the probe body at a junction where the electrical connector couples with the electronics in the probe body to electrically couple the sensor to the electronics of the probe body, thereby obviating such electronics from the probe head;

wherein reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir while the probe body containing the electronics remains unchanged.

2. The probe head of claim 1 wherein the coupling member includes a flexible, generally C-shaped open ring that is compressible to disengage the coupling member from the probe body such that the probe head is detachable from the probe body.

3. The probe head of claim 2 wherein compressing the flexible, generally C-shaped open ring reduces the ring's diameter.

4. The probe head of any one of claims 1 to 3 wherein the housing further comprises a first seat with the flexible, generally C-shaped open ring seated thereon.

5. The probe head of claim 4 wherein the housing includes a second seat having a sealing ring seated thereon.

6. The probe head of any one of claims 1 to 5 wherein the coupling member is integral with the housing.

7. A probe for monitoring a parameter of an environment, the probe comprising:

a probe body that encloses electronics, the probe body having a first and a second end, and having a first electrical connector proximal the first end and electrically coupled to

the electronics and a second electrical connector proximal to the second end and electrically coupled to the electronics, wherein each of the first electrical connector and the second electrical connector are at least partially enclosed by the probe body; and

a probe head enclosing an electrode as a sensor, a reagent reservoir therefor and at least part of a third electrical connector electrically coupled to the sensor,

a coupling member positioned to detachably connect the probe head and the probe body to one another with the first electrical connector connected to the third electrical connector, thereby electrically coupling the sensor of the probe head with the electronics of the probe body and obviating such electronics from the probe head;

wherein the second electrical connector of the probe body connects the electronics in the probe body to a device capable of communicating with the sensor, via the electronics in the probe body, to monitor an environment surrounding the sensor; and

wherein reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir while the probe body containing the electronics remains unchanged.

8. The probe of any one of claims 1 to 7 wherein the probe head is disposable.

9. The probe of any one of claims 1 to 8 wherein the probe head and probe body are detachably connected with a watertight seal.

10. The probe of any one of claims 1 to 9 wherein the coupling member includes a flexible open ring with a slot defining a discontinuous region therein, the open ring further including a snap-fit feature.

11. The probe of claim 10 wherein the flexible open ring is pinchable to narrow the slot and transition the ring toward a closed position to disengage the coupling member such that the probe head is detachable from the probe body.

12. The probe of claim 10 or claim 11 wherein the probe head includes the flexible open ring and the probe body includes an annular groove to receive the snap-fit feature of the flexible open ring, and wherein the snap-fit feature is received in the annular groove.

2011248832 29 Jun 2015

13. The probe of any one of claims 1 to 12 wherein the probe head further comprises a sleeve having a first seat with the flexible open ring seated thereon.

14. The probe of any one of claims 7 to 13 wherein the second electrical connector is a wet mateable connector connectable to a monitoring device.

15. The probe of any one of claims 7 to 14 wherein the probe head or the probe body includes an alignment member for unidirectional connection of the first electrical connector with the third electrical connector.

16. A system for monitoring an environment, the system comprising:

a sonde comprising at least one junction for coupling with a probe that monitors parameters of an environment using a sensor; and

a probe couplable with the sonde for electrical communication therewith, the probe comprising:

a probe body having a water-tight housing enclosing a circuit board having memory, a first electrical connector connected to the circuit board and having a portion thereof protruding from the water-tight housing, and a second electrical connector connected to the circuit board and having a portion thereof protruding from the housing; and

a probe head having a housing enclosing electrode, a reagent reservoir therefor, and a third electrical connector connected to the electrode, wherein a portion of the third electrical connector protrudes from the housing;

wherein the third electrical connector of the probe head is detachably couplable with one of the first or second electrical connectors of the probe body and the other of the first or second electrical connectors of the probe body is electrically couplable with the sonde; and

wherein the reagent within the reagent reservoir is consumable and once exhausted, the probe head is detachable from the probe body for replacement with a probe head comprising an unexhausted reagent reservoir while the probe body containing the circuit board having memory remains unchanged.

17. A probe head that is detachable from a probe body that contains electronics, the probe head substantially as hereinbefore described with reference to any one of the embodiments as illustrated in the accompanying drawings.

18. A probe for monitoring a parameter of an environment, the probe substantially as hereinbefore described with reference to any one of the embodiments as illustrated in the accompanying drawings.

19. A system for monitoring an environment, the system substantially as hereinbefore described with reference to any one of the embodiments as illustrated in the accompanying drawings.

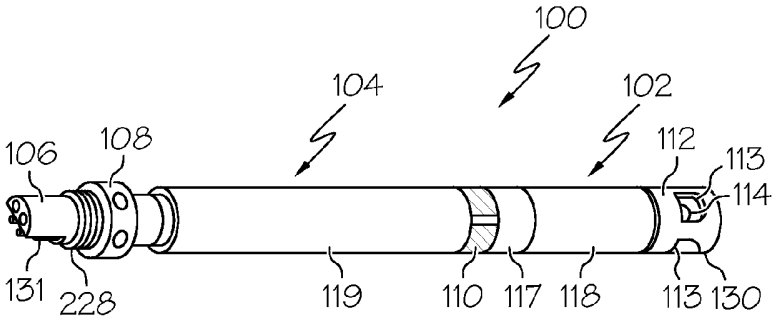

100
104
102
106
108
112
113
114
131
228
119
110
117
118
113
130

FIG. 1

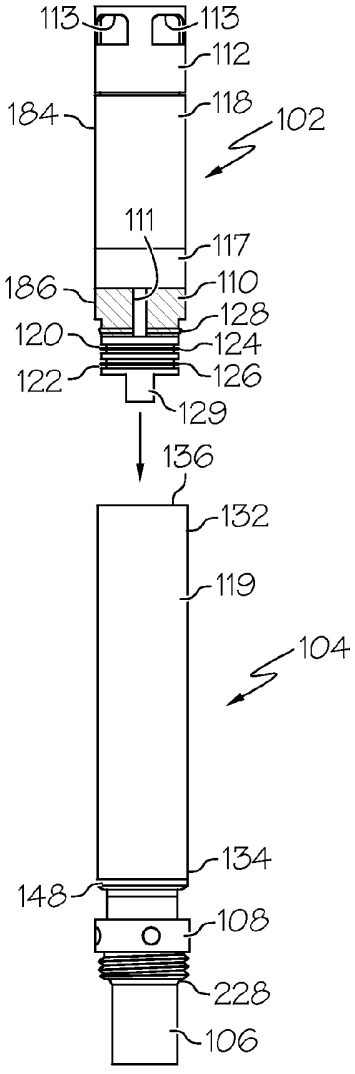

113
113
112
184
118
102
111
117
186
110
128
120
124
122
126
129
136
132
119
104
134
148
108
228
106

FIG. 2

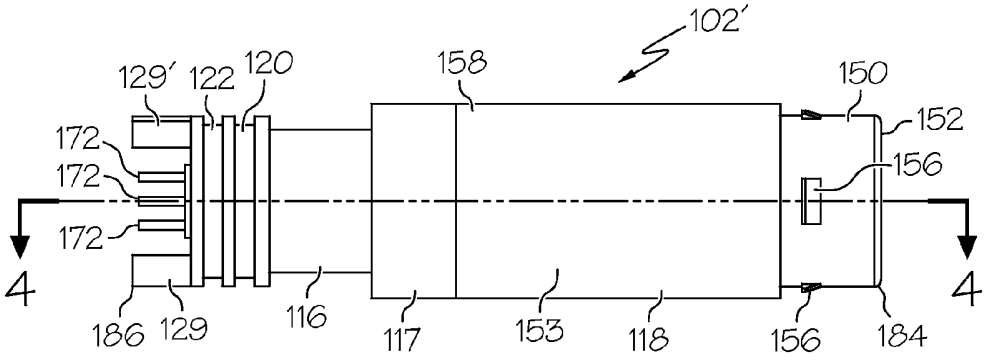


FIG. 3

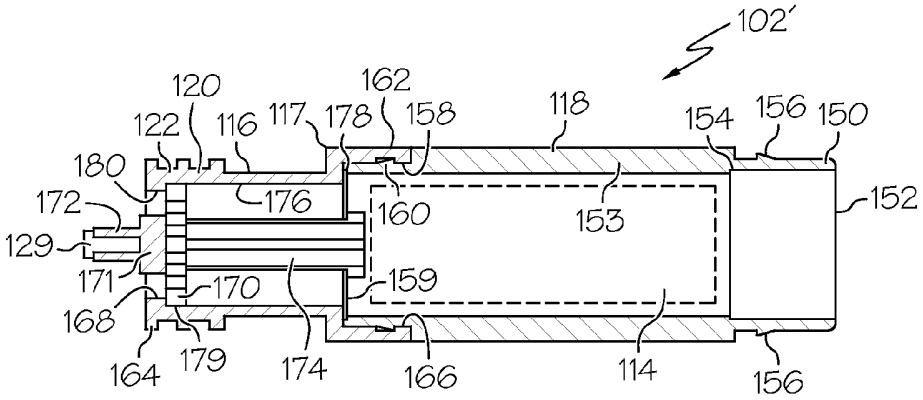


FIG. 4

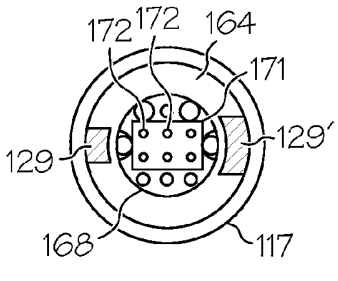


FIG. 5

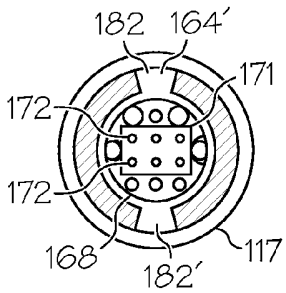


FIG. 6

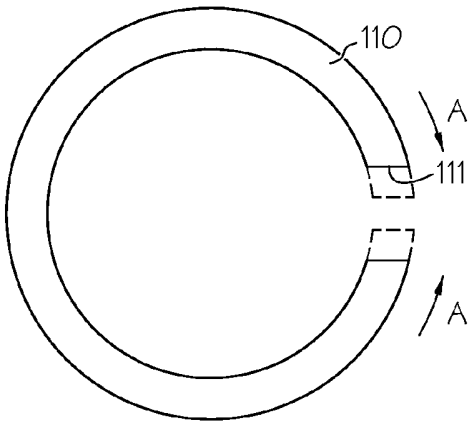


FIG. 7

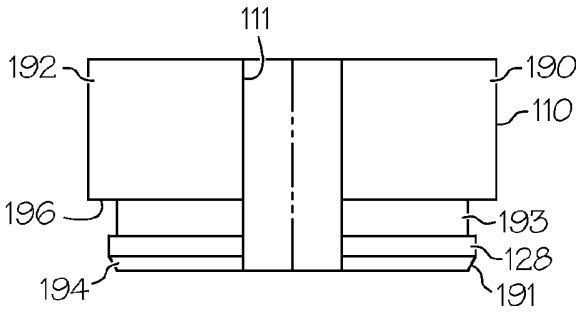


FIG. 8

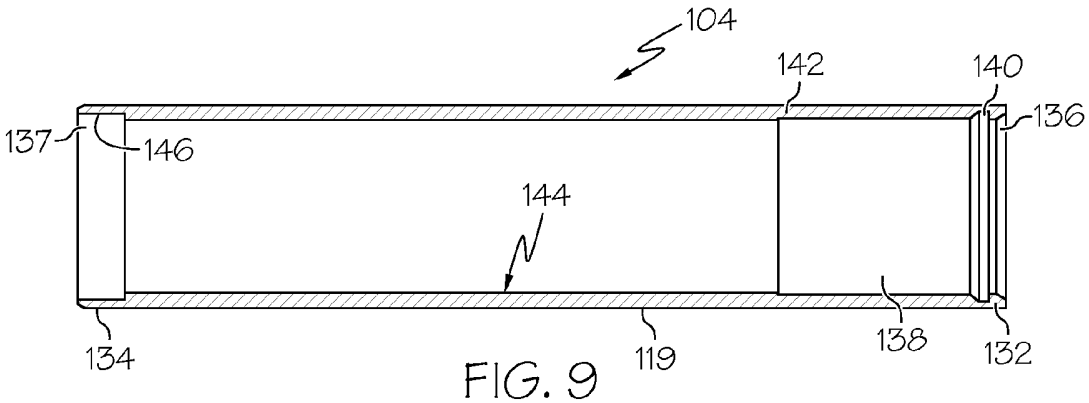


FIG. 9

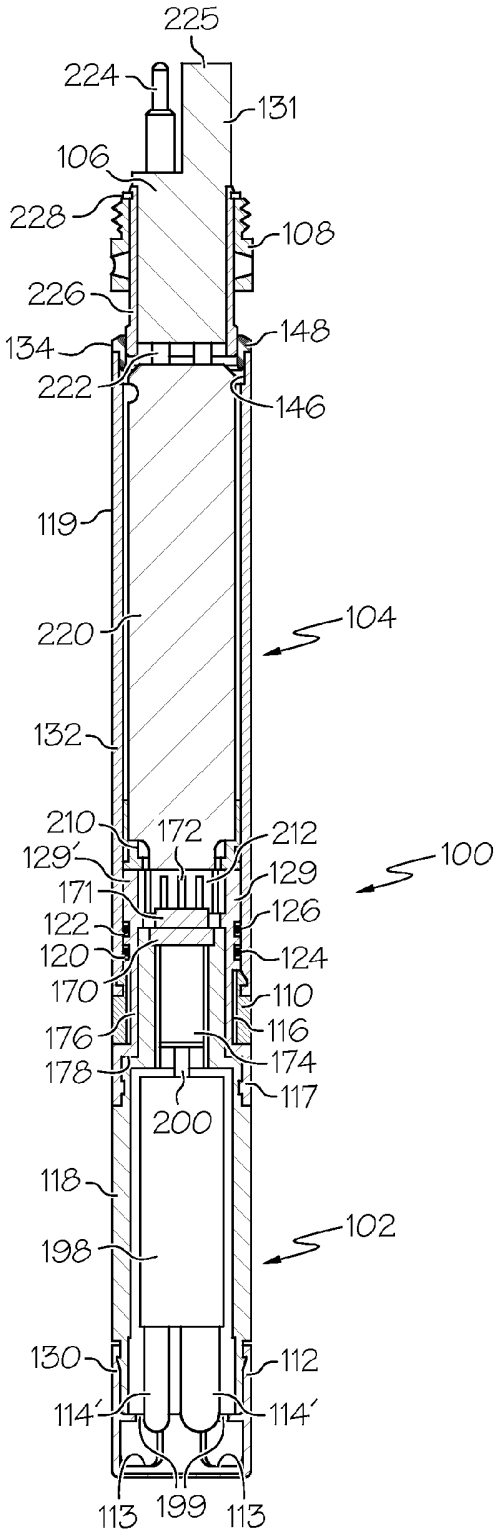

225
224
131
106
228
108
226
148
134
222
146
119
220
104
132
210
172
212
129'
129
100
171
126
122
120
124
170
110
176
116
178
174
117
200
118
102
198
130
112
114'
114'
113
199
113

FIG. 10

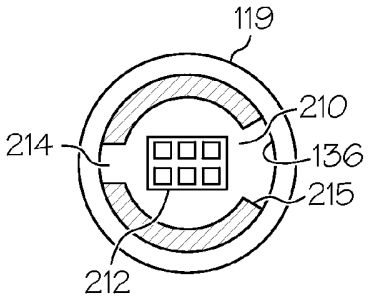


FIG. 11

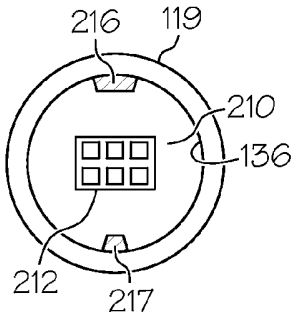


FIG. 12

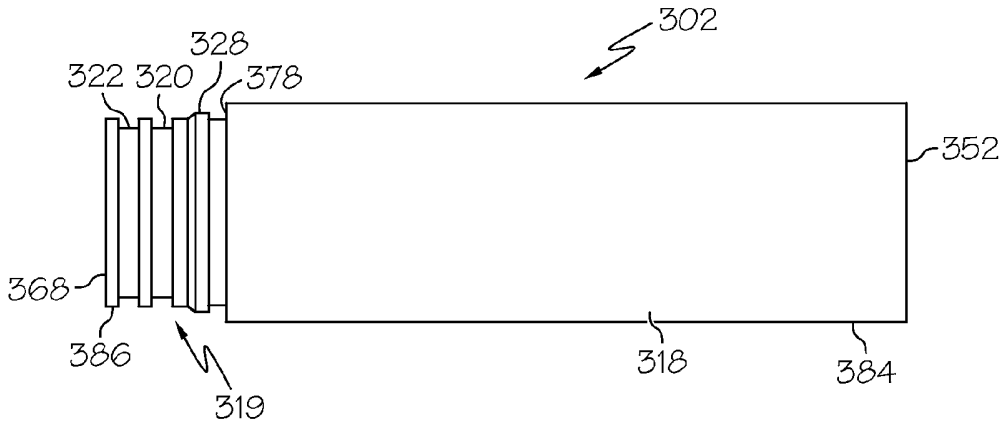


FIG. 13

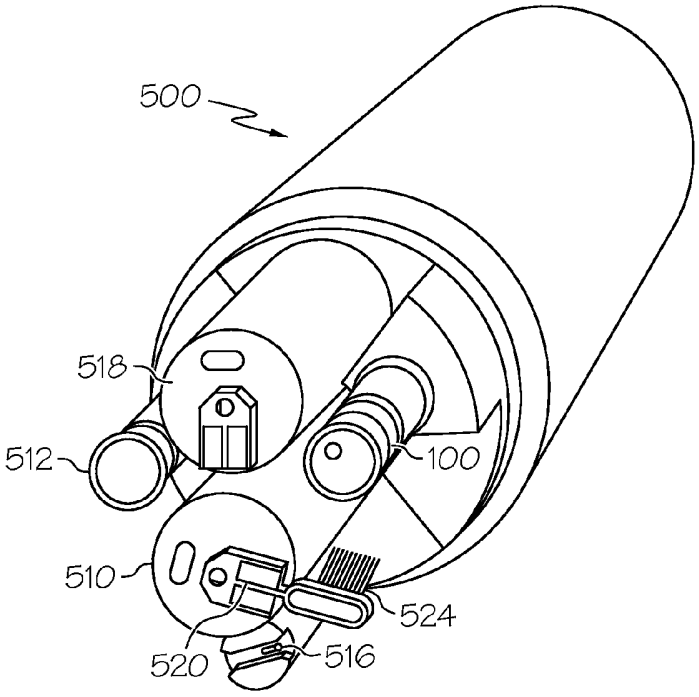

500
518
512
100
510
524
520
516

FIG. 14

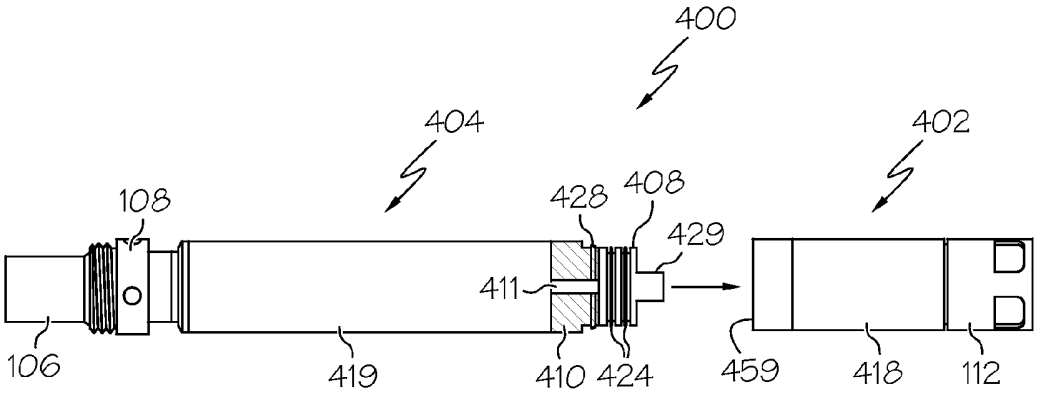

400
404
402
108
428
408
429
411
106
419
410
424
459
418
112

FIG. 15