(19) DANMARK

(10) DK/EP 2800960 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *G 01 L 19/06 (2006.01)* *G 01 L 21/30 (2006.01)* *G 01 L 21/32 (2006.01)* *H 01 J 1/52 (2006.01)* *H 01 J 41/02 (2006.01)* *H 01 J 41/04 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2019-01-28**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2018-10-31**

(86) Europæisk ansøgning nr.: **13746239.6**

(86) Europæisk indleveringsdag: **2013-02-07**

(87) Den europæiske ansøgnings publiceringsdag: **2014-11-12**

(86) International ansøgning nr.: **US2013025198**

(87) Internationalt publikationsnr.: **WO2013119851**

(30) Prioritet: **2012-02-08 US 201261596470 P**

(84) Designerede stater: **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**

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(54) Benævnelse: **Ioniseringsmåler til højtryksdrift**

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DESCRIPTION

BACKGROUND OF THE INVENTION

[0001] Ionization gauges, more specifically Bayard-Alpert (BA) ionization gauges, are the most common non-magnetic means of measuring very low pressures. The gauges have been widely used worldwide. These gauges were disclosed in 1952 in U.S. Patent No. 2,605,431. A typical ionization gauge includes an electron source, an anode, and an ion collector electrode. For the BA ionization gauge, the electron source is located outside of an ionization space or anode volume which is defined by a cylindrical anode screen. The ion collector electrode is disposed within the anode volume. Electrons travel from the electron source to and through the anode, cycle back and forth through the anode, and are consequently retained within, or nearby to, the anode.

[0002] In their travel, the electrons collide with molecules and atoms of gas that constitute the atmosphere whose pressure is desired to be measured. This contact between the electrons and the gas creates ions. The ions are attracted to the ion collector electrode, which is typically connected to ground. The pressure of the gas within the atmosphere can be calculated from ion and electron currents by the formula $P = (1/S)\ (I_{ion}/I_{electron})$, where S is a coefficient with the units of 1/Torr and is characteristic of a particular gauge geometry, electrical parameters, and pressure range.

[0003] The operational lifetime of a typical ionization gauge is approximately ten years when the gauge is operated in benign environments. However, these same gauges and electron sources (cathodes) fail in minutes or hours when operated at too high a pressure or during operation in gas types that degrade the emission characteristics of the electron source. Sputtering is a problem when operating the ionization gauge at high pressures, such as above 10^{-4} Torr. This is a problem at high pressure because there is more gas to ionize. This sputtering is caused by high energy impacts between ions and components of the ionization gauge. Ions with a high energy may impact a tungsten material that forms a collector post of the ionization gauge. These impacts result in atoms being ejected from the collector post and envelope surfaces with significant internal kinetic energies. Ejected material can travel freely to other surfaces within the line of sight of the sputtered surfaces, and can cause gauge failure by coating the cathode or by coating of the feed-through insulators of the gauge, which can result in electric leakages.

[0004] Therefore, there is a need for an ionization gauge design that minimizes or eliminates the above mentioned problems.

[0005] US2011/163754 describes an ionization gauge with emission current and bias potential control. US2005/028602 describes an ionization gauge comprising an electron-emitting cathode made by exploiting nanotube technology.

SUMMARY OF THE INVENTION

[0006] The present invention provides an ionization gauge according to claim 1, and a method of measuring pressure according to claim 7.

[0007] Coating of the electron source, such as a hot filament, is facilitated by the typical arrangement, shown in FIG. 1, of the filament and collector structures side by side to one another in a parallel arrangement, often with a large surface area of the filament facing the collector surface. The present ionization gauge minimizes the effects of self-sputtering on filament emission efficiency by inhibiting the sputtered atoms from finding straight paths from the collector to the electron source in the gauge.

[0008] The ionization gauge may be used to measure pressure while controlling the location of deposits resulting from sputtering when operating at high pressure.

[0009] The present ionization gauge has many advantages, including minimizing the exposure of the electron source to atom flux sputtered off the collector electrode and envelope surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

FIG. 1 is a schematic view of a generalized ionization gauge of the prior art.

FIG. 2 is a schematic view of an ionization gauge of the present disclosure having an electron source positioned at an end of the ionization volume.

FIG. 3A is a cross-section of the ionization gauge shown in FIG. 2 with an envelope surrounding the ionization volume.

FIG. 3B is an illustration of simulated electron paths within the ionization gauge shown in FIG. 3A.

FIG. 4A is a side view of an ionization gauge having a shade between the electron source and the collector electrode.

FIG. 4B is a side view of an ionization gauge having a shade between the electron source and the collector electrode, and having the collector electrode formed of two collector electrodes.

FIG. 5A is a top sectional view of an ionization gauge having a shade between the electron source and the collector electrode.

FIG. 5B is a top sectional view of an ionization gauge having a shade between the electron source and the collector electrode, and having the collector electrode formed of two collector electrodes.

FIG. 5C is a top sectional view of an ionization gauge having a shade between the electron source and the collector electrode, and having the collector electrode formed of two collector electrodes oriented in a plane parallel to the plane of the electron source.

FIG. 5D is a side view of an ionization gauge having a double loop electron source.

FIG. 6A is a side view of an ionization gauge having an envelope, a first shade between the electron source and the collector electrodes, a second shade between the envelope and the electron source, a second collector electrode inside the anode structure, and a third collector electrode outside the anode structure.

FIG. 6B is a side view of an ionization gauge having an envelope, a first shade between the electron source and the collector electrodes, a second shade between the envelope and the electron source, and a collector electrode outside the anode structure.

FIG. 7 is a top sectional view of an ionization gauge having a first shade between the electron source and the collector electrode, and a second shade between the envelope and the electron source.

DETAILED DESCRIPTION OF THE INVENTION

[0011] As mentioned above, coating of the electron source 105, such as a hot filament, is facilitated by the typical arrangement, shown in FIG. 1, of the filament 105 and collector 110 structures side by side to one another in a parallel arrangement, often with a large surface area of the filament 105 facing the collector surface 110.

[0012] A description of example embodiments of the invention follows.

[0013] In one embodiment, shown in FIG. 2, an ionization gauge 100 of the present disclosure has an anode structure comprising a cylindrical wire grid 120 around posts 112 and 114, defining an ionization volume 121 in which electrons impact gas molecules and atoms. Two end grids 111a and 111b define the ends of the ionization volume 121. A hot cathode electron source 105 emits electrons 125, the electron source 105 being positioned at an end of the ionization volume 121. A collector electrode 110 collects ions formed by collisions between the electrons 125 and gas molecules and atoms, to provide a gas pressure output. The collector electrode 110 extends along a collector axis through the ionization volume 121, the collector

axis extending through the ends of the ionization volume 121. At the other end of ionization volume 121 from the hot cathode electron source 105, the collector electrode 110 and support posts 112 and 114 protrude through the solid disk 116 that is displaced downward from end grid 111b. The electron source 105 can be, for example, a heated cathode filament, as shown in FIG. 2, or a disc cathode thermionic emitter (*e.g.*, Kimball Physics, Inc., Wilton, NH).

[0014] A cross-section of the upper portion of the ionization gauge 100 that includes the electron source 105 is schematically illustrated in FIGS. 3A and 3B. The ionization gauge 100 is based on the ionization of gas molecules and atoms in a measurement chamber 117 by a constant flow of electrons. The negatively charged electrons 125 shown in FIG. 3B (only shown on the left side in FIG. 3B, although electrons would similarly be on the right side) are emitted at a well-controlled selectable rate from, for example, a heated cathode 105, and can be released or accelerated toward a positively charged anode 120. The electrons 125 pass into and through the anode 120 and then cycle back and forth through the anode 120. The electrons 125 are then retained within the ionization volume of the anode 121, in part due to the potential bias on end grids 111a and 111b. In this space, the electrons 125 collide with the gas molecules and atoms to produce positively charged ions before colliding with a grid wire 120, or end grids 111a or 111b. During low pressure operation, significant ionization only occurs within the anode 120, and thus the volume 121 within the anode 120 is referred to as the ionization volume 121. Some ionization may occur outside the ionization volume 121, in particular during high pressure operation (*e.g.*, above about 10^{-4} Torr), when sufficient ionization may occur for collection. The ions are collected by the ion collector 110. Collector 110 is nearly at ground potential, which is negative with respect to the positively charged anode 120. However, this arrangement is not limiting and collector 110 may have various potential differences with respect to the anode 120. *See* Application No. 12/860,050 published as US 2011/0062961 A1. At a constant cathode to anode voltage and electron emission current, the rate that positive ions are formed is related to the density of the gas in the gauge 100. Turning back to FIG. 2, this signal from the collector electrode 110 is detected by an ammeter 135, which is calibrated in units of pressure, for all pressure readings.

[0015] In the embodiment shown in FIG. 2, sputtered atoms from collector 110, that are typically ejected along paths that are perpendicular to the collector 110, are unlikely to deposit on filament 105, because filament 105 is positioned at an end of the ionization volume 121, out of a line of sight perpendicular to the collector electrode 110, and no longer alongside collector 110, in contrast to the arrangement shown in FIG. 1. The use of a hot cathode filament as the electron source 105 in the geometry shown in FIG. 2 enables high pressure operation of the ionization gauge 100.

[0016] Alternative ionization gauges outside the scope of the claims are shown in FIGS. 4A, 4B, 5A, and 5B. A first shade 115 is located between the electron source 105 and the collector 110 to effectively shield the exposed filament surfaces from the effects of sputtered collector atoms. Electric fields direct the electrons produced by electron source 105 around the shade 115 and into the ionization volume 120. The electron source can, for example, be a hot cathode as shown in FIGS. 4A and 4B, or a microchannel plate. For the microchannel plate,

see Application No. 12/808,983 published as US 2011/0234233 A. The hot cathode 105 can be a cylindrical filament shown as a single loop in FIGS. 4A and 4B, or the filament can be a double loop, as shown in FIG. 5D (where the shade 115 is not shown for clarity), or a ribbon filament, shown as top sectional views in FIGS. 5A, 5B, and 5C, the ribbon filament 105 having flat surface oriented at about 90° with respect to the collector electrode 110, such that the surface area of the filament 105 facing the collector electrode 110 is minimized. One of the collector electrode 110 and the electron source 105 can be located inside the anode structure 120, and the other of the collector electrode 110 and the electron source 105 can be located outside the anode structure 120. As shown in FIG. 6A, if the source 105 that emits electrons is located outside the anode structure 120 and the collector electrode 110 is located inside the anode structure 120, then the ionization gauge 200 can include a first collector electrode 110a and a second collector electrode 110b located inside the anode structure 120, and, optionally, a third collector electrode 210 located outside the anode structure 120, in between the first shade 115 and the anode structure 120, for high pressure measurements of very short mean free path ions formed in measurement chamber 117. Alternatively, the ionization gauge 200 can include a single collector electrode 110 located inside the anode structure 120 and a collector electrode 210 located outside the anode structure 120, as shown in FIG. 6B. Here, the collector electrode 210 is outside the ionization volume defined by the anode structure 120, but, at high pressure, ionization also occurs outside this primary ionization volume.

[0017] FIGS. 4A, 4B, 5A, and 5B show a nude configuration of the ionization gauge 100, that is, without a surrounding gauge vessel. It is also envisioned that non-nude type ionization gauges are also possible, having an envelope 205 as shown in FIGS. 6A, 6B, discussed above and FIG. 7, that shows a top sectional view of the ionization gauge shown in FIG. 6B. At pressures greater than about 10^{-4} Torr, electrons emitted from the filament 105 have a high probability of colliding with gas atoms or molecules on the way to the anode 120. As ions are formed outside the anode 120, they are accelerated towards the envelope 205, typically made of stainless steel, and sputtering of stainless steel is now possible. Some of the component atoms of stainless steel sputtered from the envelope 205 coat the back surface of the filament 105. As the pressure continues to increase and approaches about 10^{-1} Torr, the majority of ionization occurs outside the anode 120 and stainless steel wall sputtering becomes the main source of material deposited on the filament 105. The resulting typical deposition pattern on the filament 105 is a coating of stainless steel component atoms on the side of the filament 105 facing the envelope 205 and a coating of tungsten on the side of the filament 105 facing the collector 110. FIGS. 6A, 6B, and 7 show specific non-nude type ionization gauges 200, wherein a second shade 119 is used to shield the electron source 105 from the effects of atoms sputtered off the envelope 205, that is, atoms sputtered off the envelope 205 are inhibited from depositing on the electron source 105. The first and second shades, 115 and 119, respectively, can be shaped metal plates, such as, for example, stainless steel. The electric potential of the shades can be the same as the cathode potential or slightly lower than the cathode potential, and therefore not subject to the sputtering problems discussed above.

[0018] A method of measuring pressure with an ionization gauge 100 described above and shown in FIG. 2 includes emitting electrons from a hot cathode electron source 105 positioned

at an end of an ionization volume 120, the electrons colliding with gas molecules and atoms inside an anode structure comprising a cylindrical mesh grid that defines the ionization volume 120. The method further includes collecting ions formed by collisions between the electrons and gas molecules and atoms on a collector electrode 110 to provide a gas pressure output. The collector electrode 110 extends along a collector axis through the ionization volume, the collector axis extending through the ends of the ionization volume.

[0019] An alternative method of measuring pressure with an ionization gauge 200 shown in FIGS. 6A, 6B, and 7 includes emitting electrons from an electron source 105, the electrons colliding with gas molecules and atoms inside an anode structure comprising a cylindrical mesh grid that defines an ionization volume 120. The method further includes locating a first shade 115 outside of the ionization volume between the electron source 105 and the collector electrode 110, one of the collector electrode 110 and the electron source 105 being located inside the anode structure 120, and the other of the collector electrode 110 and the electron source 105 being located outside the anode structure 120, and collecting ions formed by collisions between the electrons and gas molecules and atoms on the collector electrode 110 to provide a gas pressure output. If the source 105 that emits electrons is located outside the anode structure 120 and the collector electrode 110 is located inside the anode structure 120, then, optionally, the method can further include locating a first and a second collector electrode (110a and 110b, respectively) inside the anode structure 120 and, additionally, the method can further include locating a third collector electrode 210 outside the anode structure 120, in between the first shade 115 and the anode structure 120, as shown in FIG. 6A. The method can further include locating a second shade 119 between the envelope 205 and the electron source 105, such that atoms sputtered off the envelope 205 are inhibited from depositing on the electron source 105. The pressure can be in a range of between about 10^{-1} Torr and about 10^{-4} Torr.

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.

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- US20110062961A1 [0014]
- US12808983B [0016]
- US20110234233A [0016]

Patentkrav

1. Ioniseringsmåler til måling af tryk omfattende:
en anodestruktur omfattende et gitter (111, 120), der definerer et ioniseringsvolumen, i hvilket elektroner påvirker gasmolekyler og atomer;
en varm katodeelektronkilde (105), som udsender elektroner; og
en kollektorelektrode (110) til at samle ioner, der er dannet ved kollisioner mellem elektronerne og gasmolekylerne og atomerne, for at tilvejebringe en gastrykudgang, hvor kollektorelektroden strækker sig langs med en kollektorakse gennem ioniseringsvoluminet; **kendetegnet ved, at** elektronkilden er placeret ved en ende af ioniseringsvoluminet, gennem hvilket kollektoraksen strækker sig.

2. Ioniseringsmåler ifølge krav 1, hvor gitteret er et cylindrisk gitter.

3. Ioniseringsmåler ifølge krav 1 eller 2, indrettet til at arbejde inden for et trykområde på mellem ca. 10^{-1} Torr og 10^{-4} Torr.

4. Ioniseringsmåler ifølge krav 1, 2 eller 3, hvor den varme katodeelektronkilde er et opvarmet katodefilament.

5. Ioniseringsmåler ifølge krav 4, hvor det opvarmede katodefilament er dannet i en løkke.

6. Ioniseringsmåler ifølge krav 1, 2 eller 3, hvor den varme katodeelektronkilde er en termionisk pladekatodeemitter.

7. Ioniseringsmåler ifølge et af de foregående krav, yderligere omfattende en kappe (117), der omgiver anodestrukturen, elektronkilden og kollektorelektroden.

8. Fremgangsmåde til måling af tryk med en ioniseringsmåler omfattende:
at udsende elektroner fra en varm katodeelektronkilde (105), hvor elektronerne kolliderer med gasmolekyler og atomer inden i en anodestruktur omfattende et gitter (111, 120), som definerer et ioniseringsvolumen; og

at samle ioner, der er dannet ved kollisioner mellem elektronerne og gasmolekylerne og atomerne, på en kollektorelektrode (110) for at tilvejebringe en gastrykudgang, hvor kollektorelektroden strækker sig langs med en kollektorakse gennem ioniseringsvoluminet; **kendetegnet ved** at placere elektronkilden ved en ende af ioniseringsvoluminet, gennem hvilket kollektoraksen strækker sig.

9. Fremgangsmåde ifølge krav 8, hvor gitteret er et cylindrisk maskegitter.

10. Fremgangsmåde ifølge krav 8 eller 9, hvor trykket ligger inden for et område af mellem ca. 10^{-1} Torr og ca. 10^{-4} Torr.

11. Fremgangsmåde ifølge krav 8, 9 eller 10, hvor den varme katodeelektronkilde er et opvarmet katodefilament.

12. Fremgangsmåde ifølge krav 11, hvor det opvarmede katodefilament er dannet i en løkke.

13. Fremgangsmåde ifølge krav 8, 9 eller 10, hvor den varme katodeelektronkilde er en termionisk pladekatodeemitter.

14. Fremgangsmåde ifølge et af kravene 8, 9, 10, 11, 12 og 13, yderligere omfattende at omgive elektronkilden, anodestrukturen, elektronkilden og kollektorelektroden med en kappe (117).

DRAWINGS

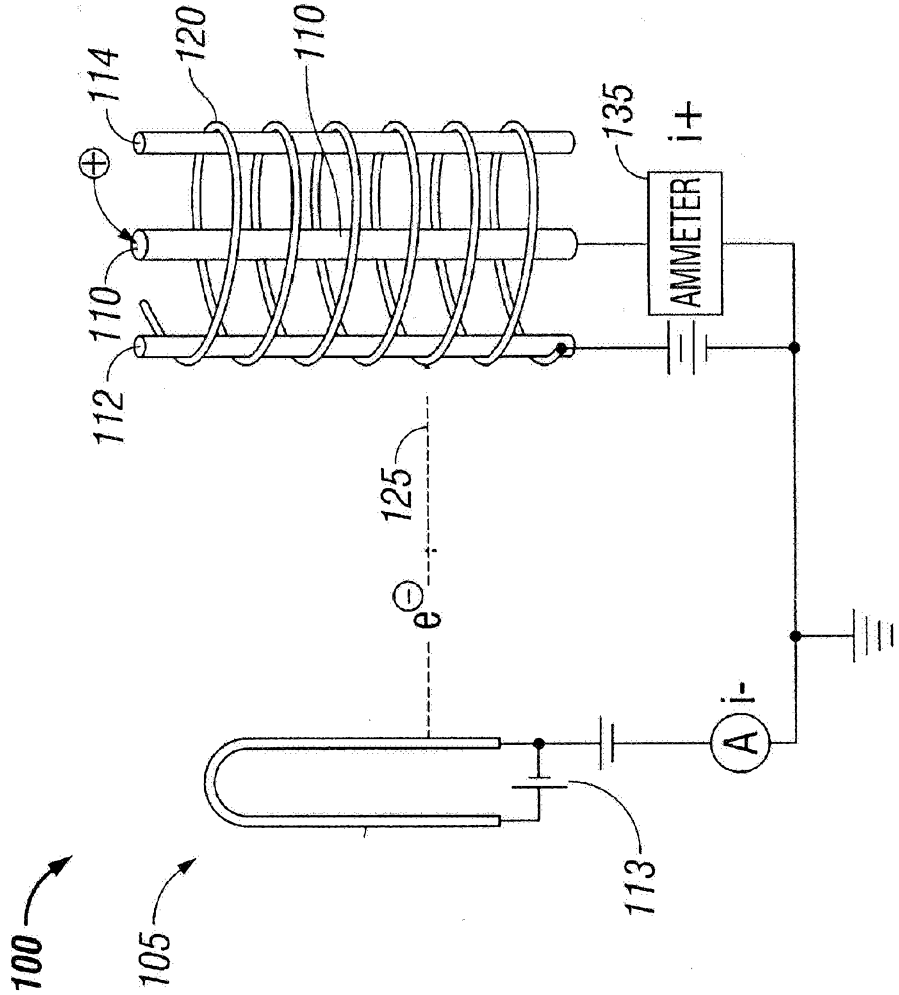

FIG. 1
PRIOR ART

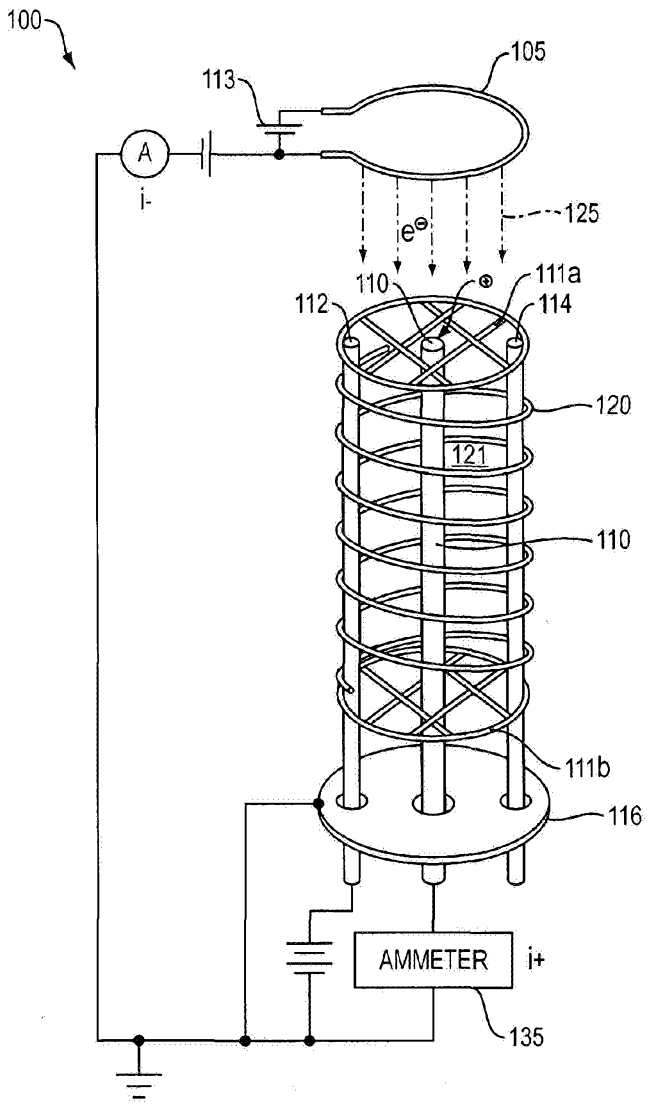
100
105
113
A
i-
125
e⊖
110
⊕
111a
112
114
120
121
110
111b
116
AMMETER
i+
135

FIG. 2

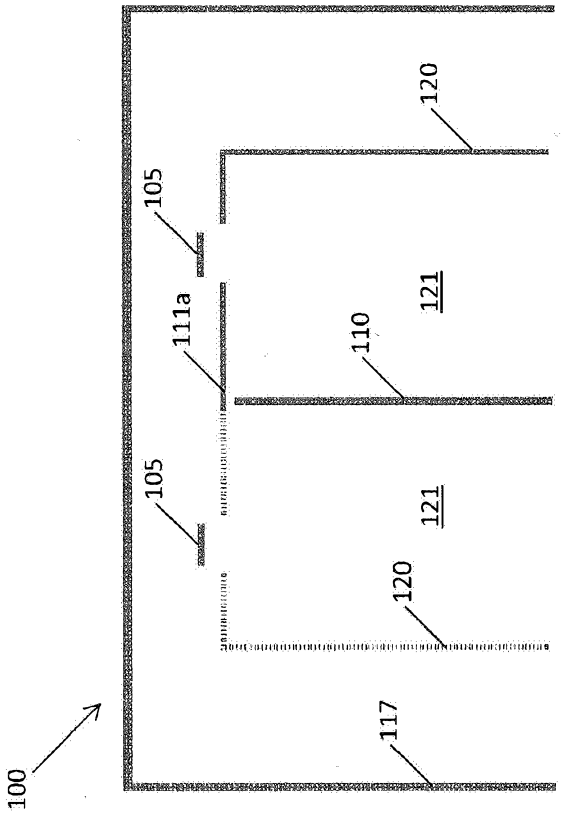

FIG. 3A

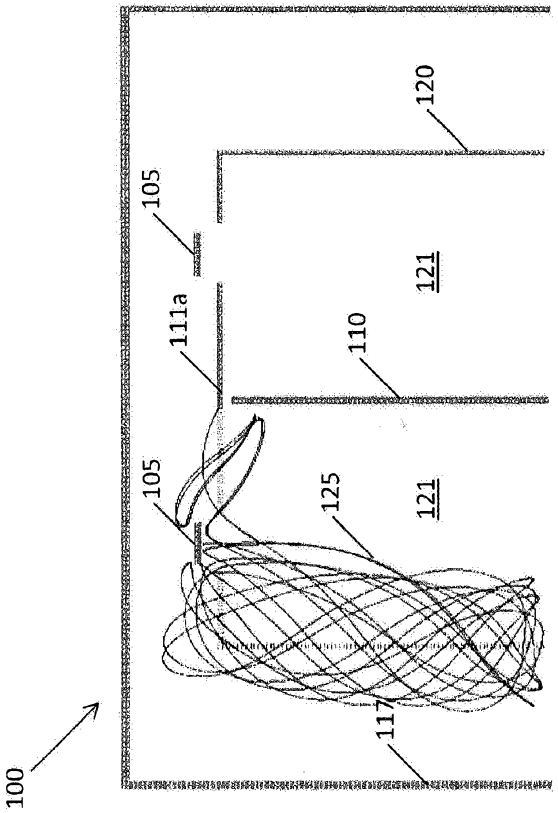

FIG. 3B

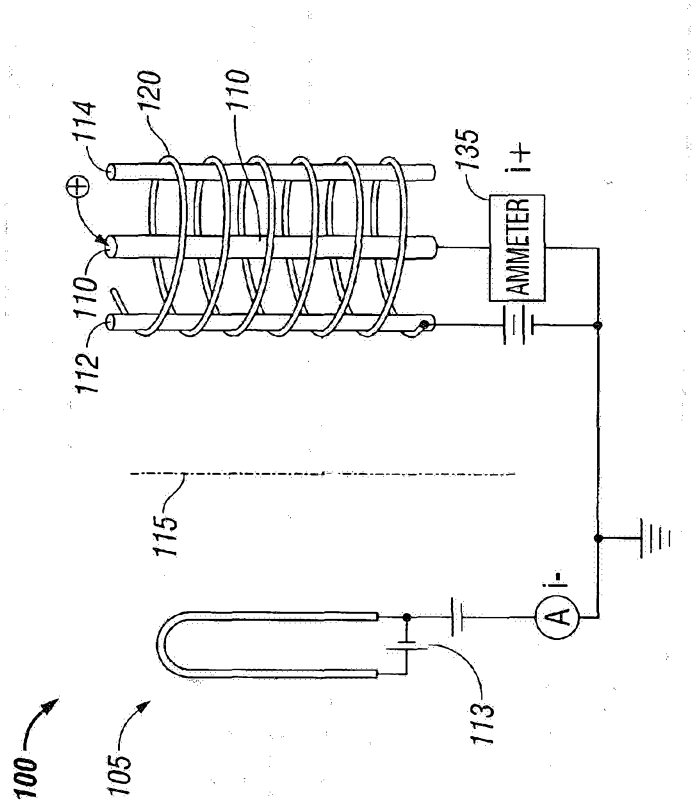

FIG. 4A

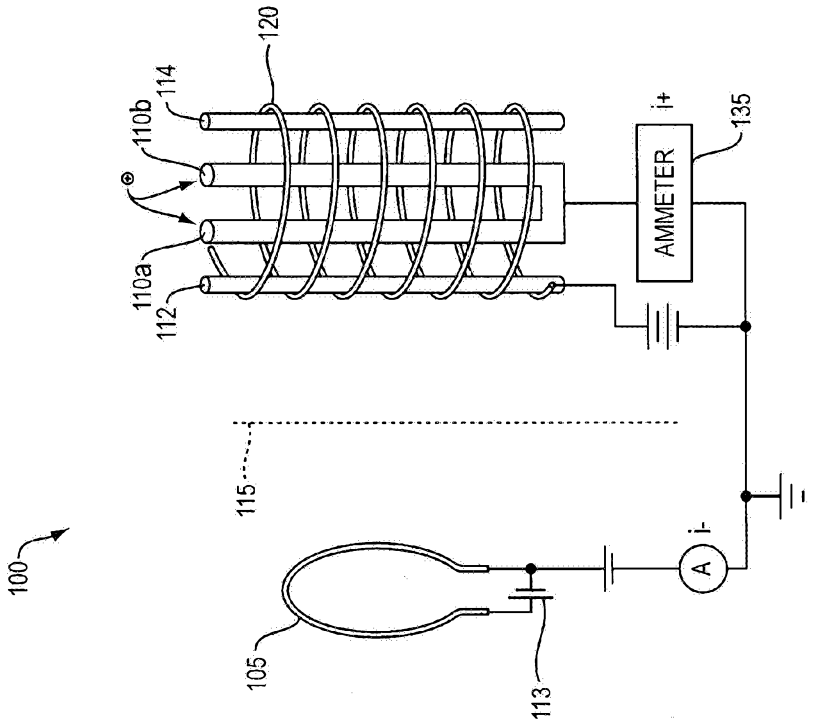

FIG. 4B

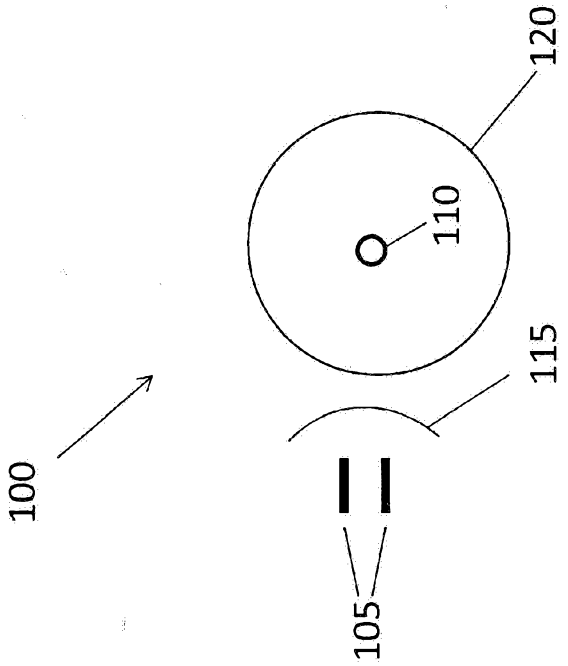

FIG. 5A

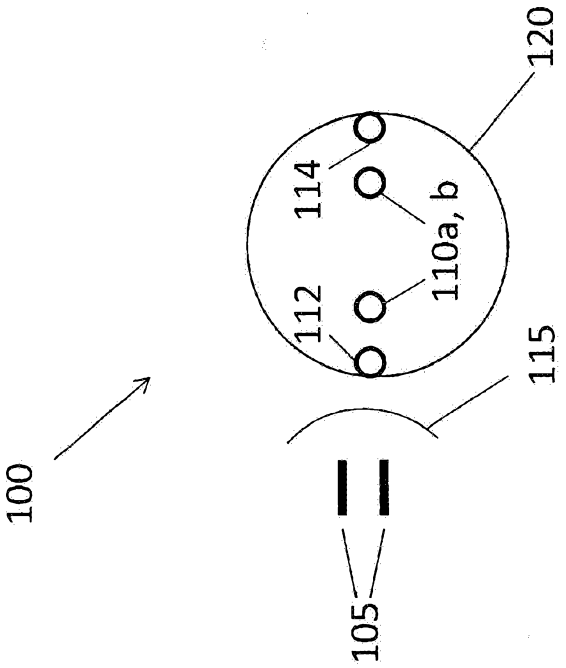

FIG. 5B

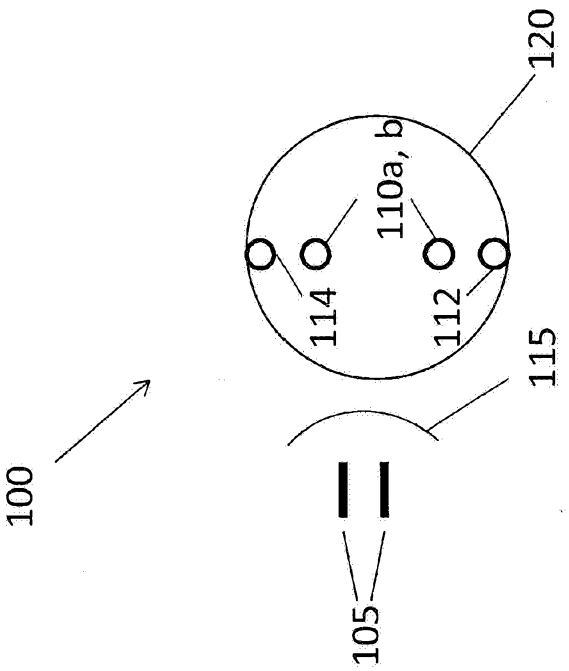

FIG. 5C

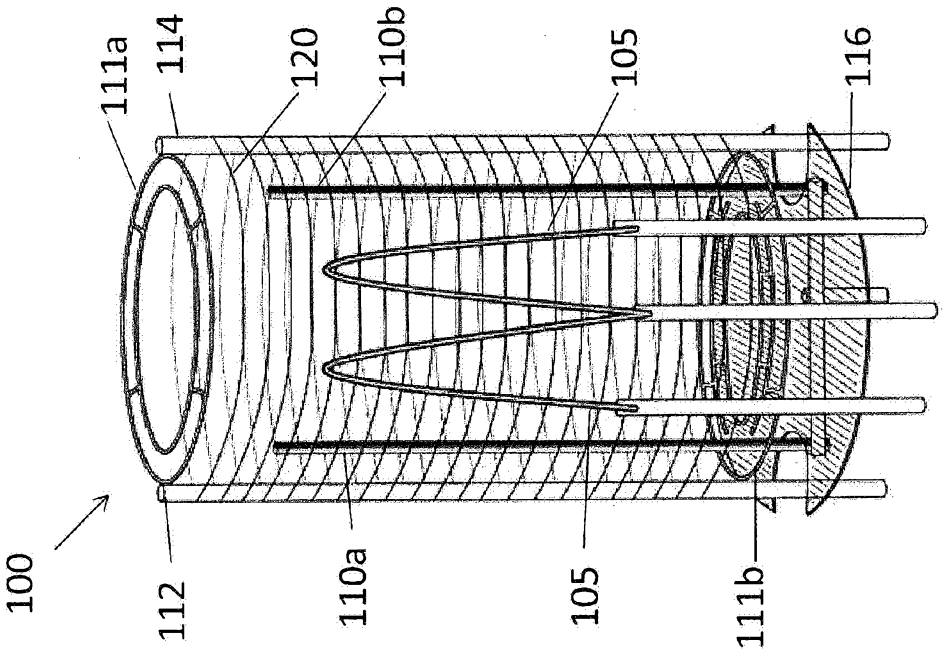

FIG. 5D

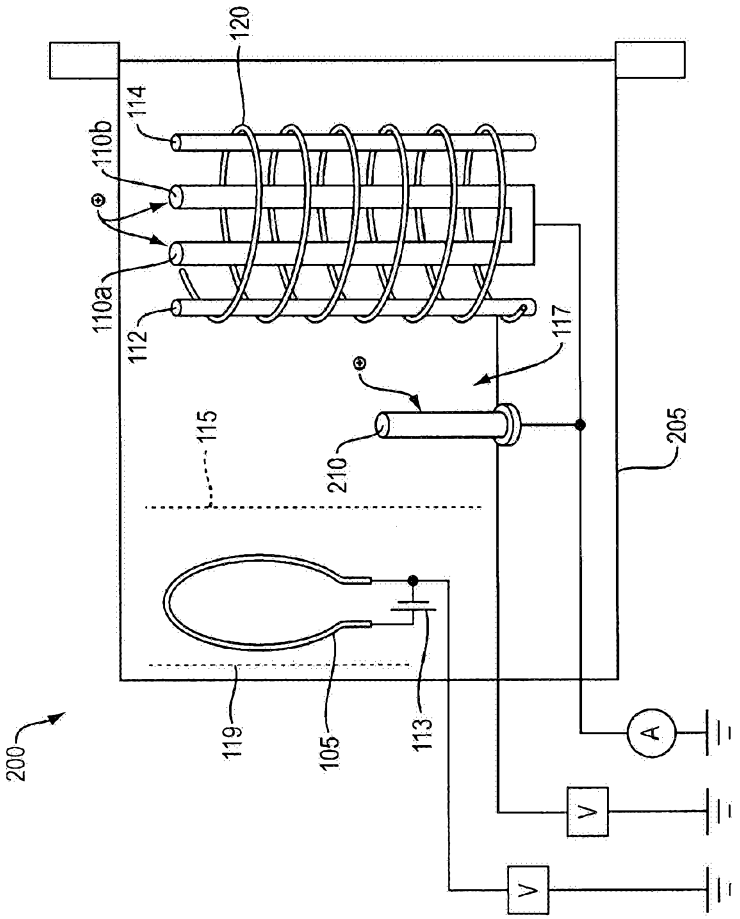

FIG. 6A

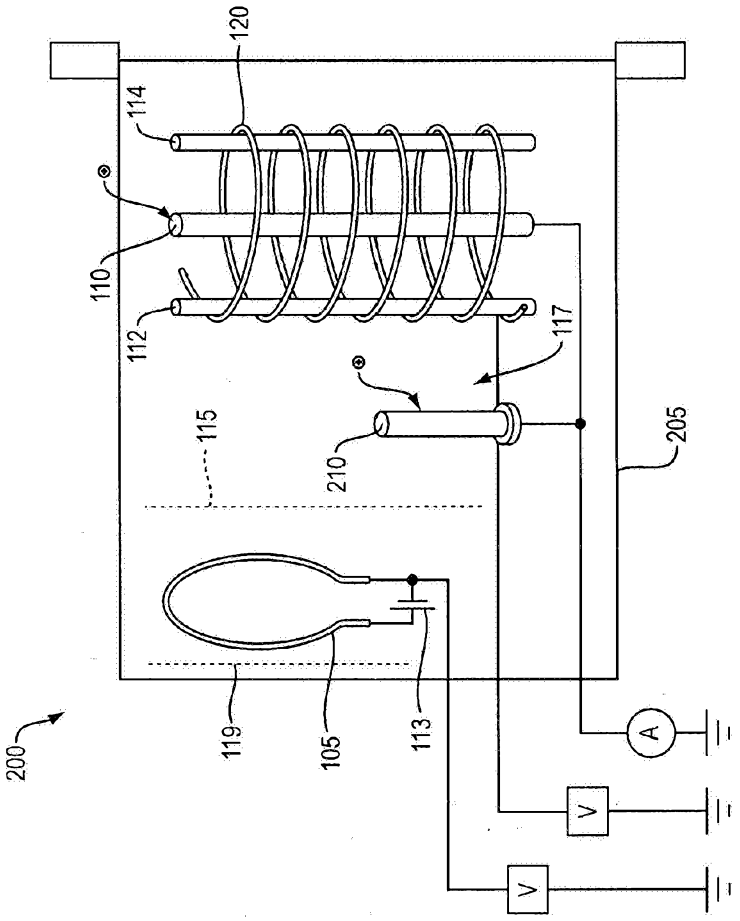

FIG. 6B

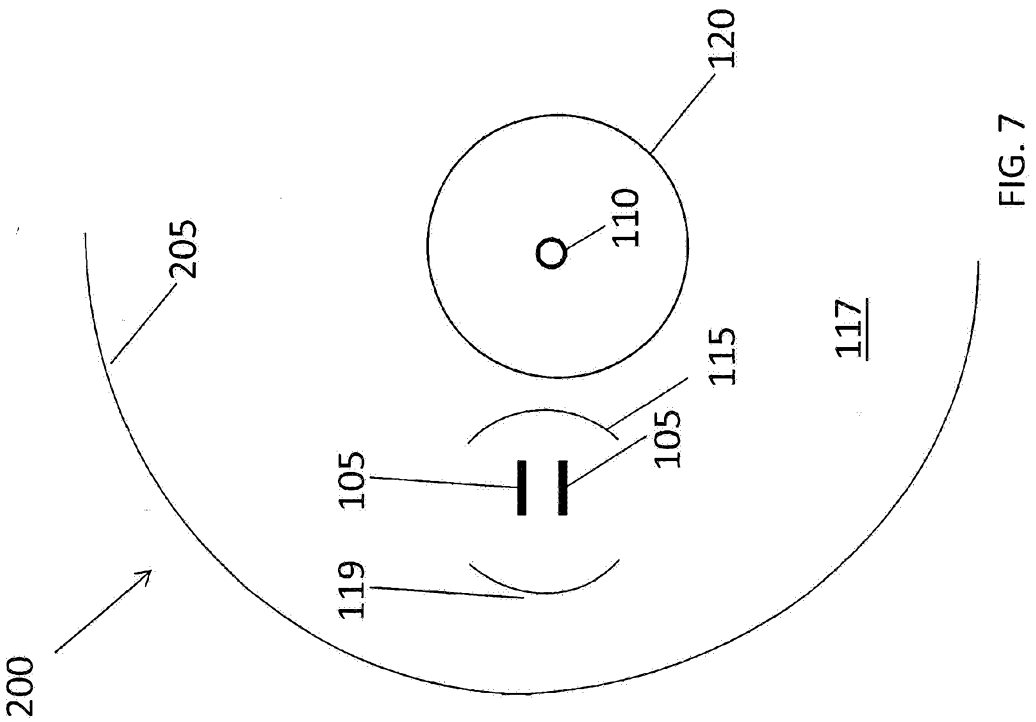

FIG. 7