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(54) **TWO-PHASE ISOLATION METHODS AND SYSTEMS FOR CONTROLLED DRILLING**

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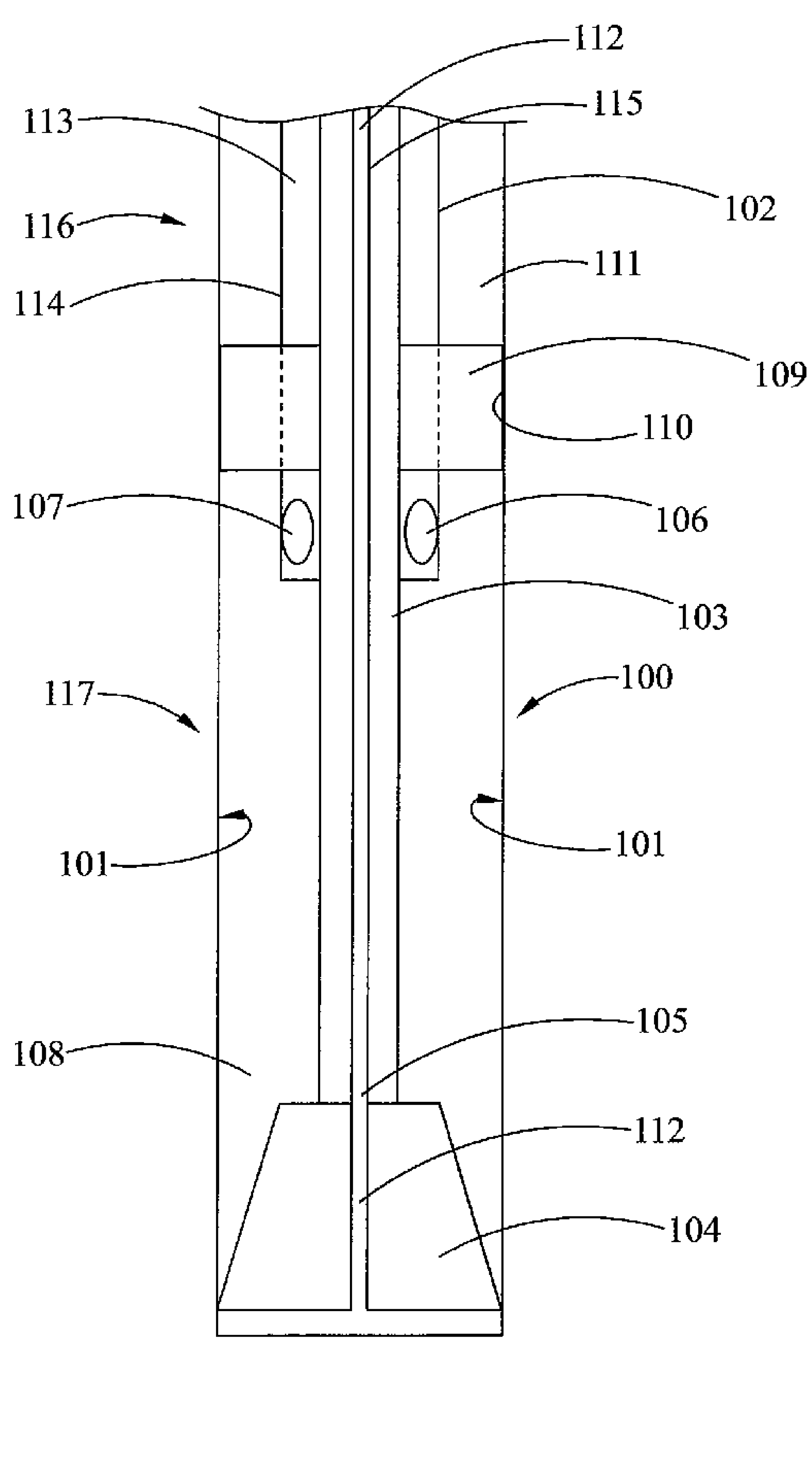
(57) **ABSTRACT**

There is provided a system and method for having multiple movable isolation zones within a borehole, to provide for zones having predetermined properties, such as pressure, flow or optical properties. These movable isolation zones provide advantages in downhole activities, such as, laser cutting and laser drilling to advance a borehole.



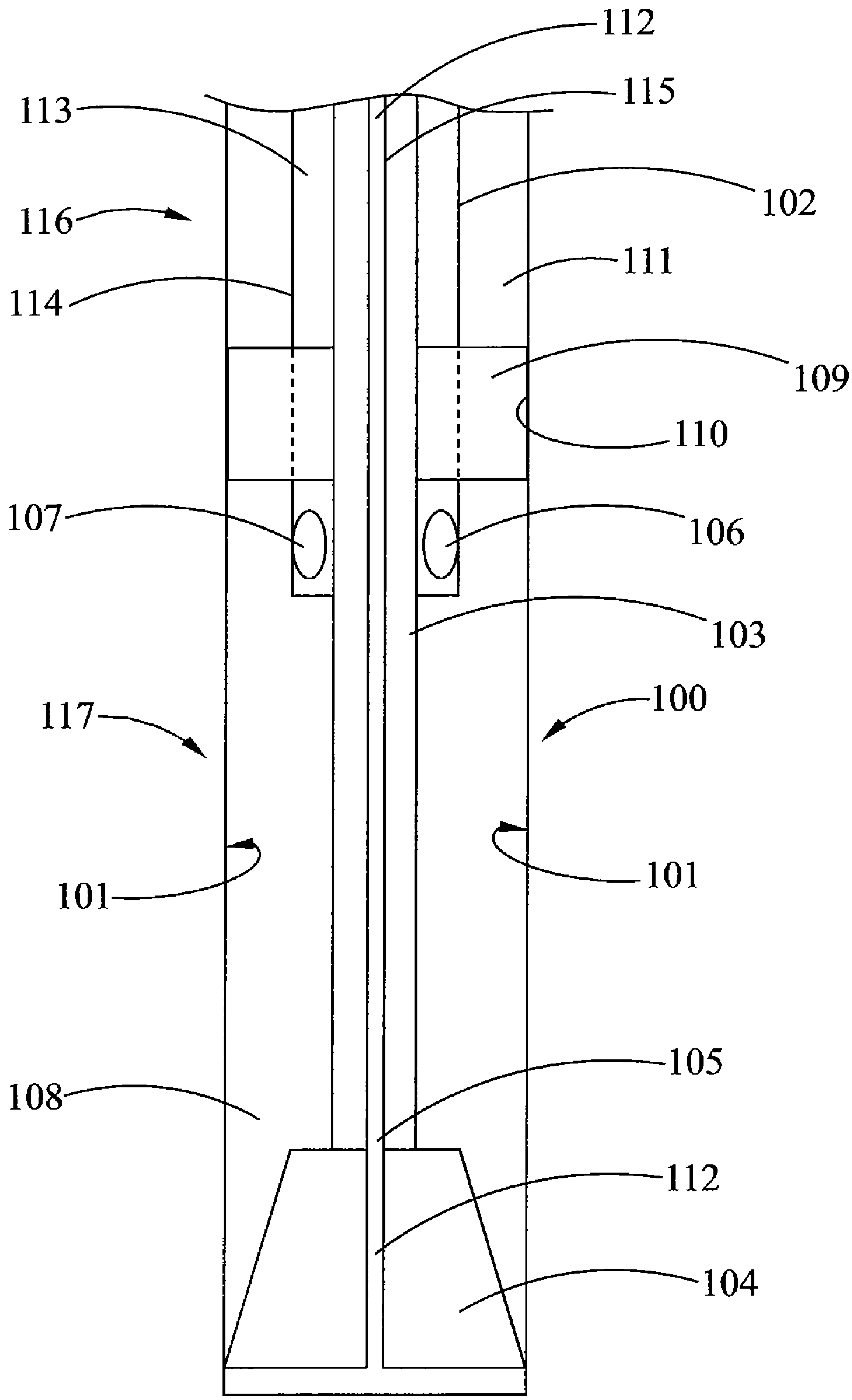

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Fig.1

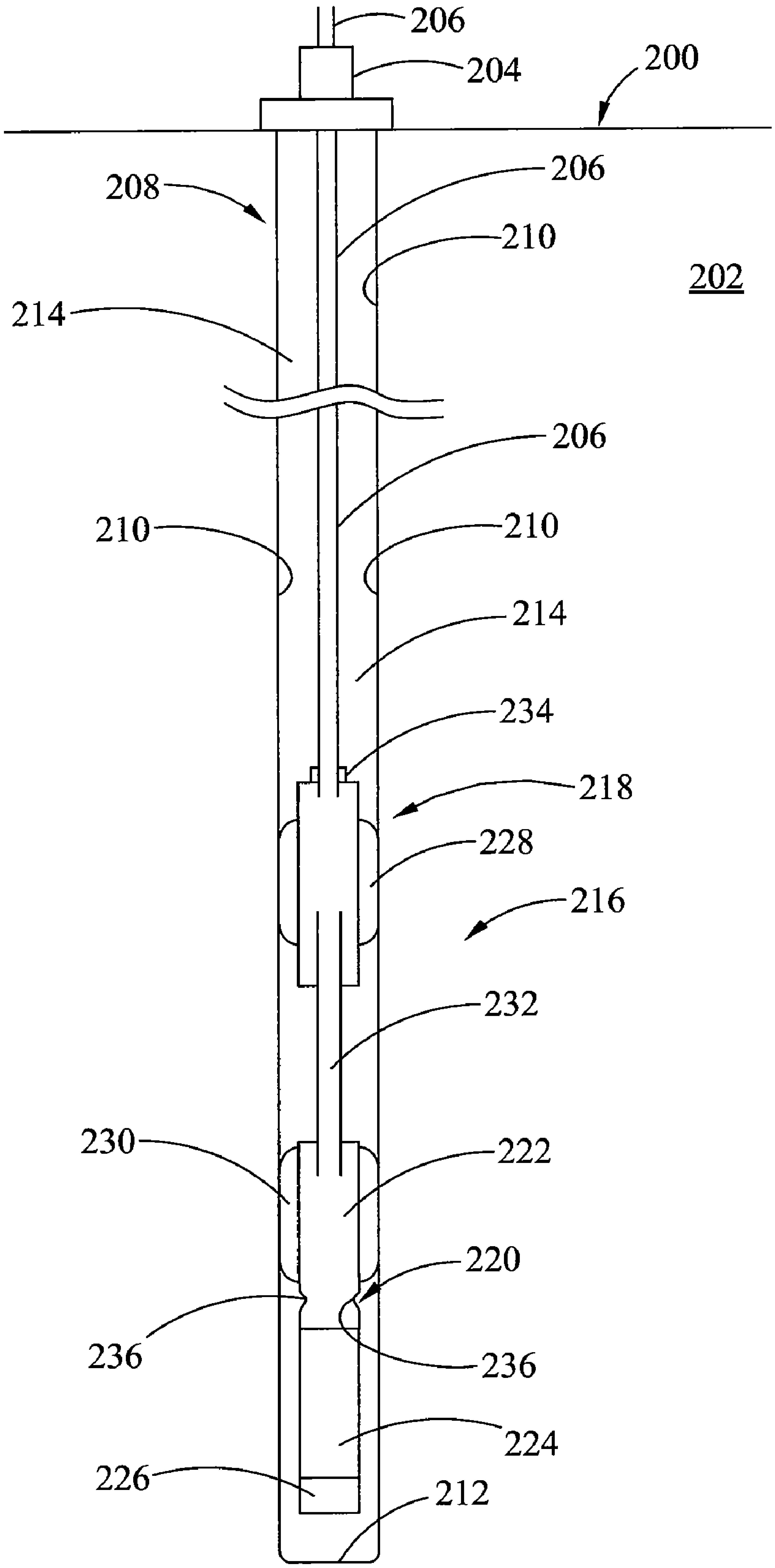
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Fig. 2

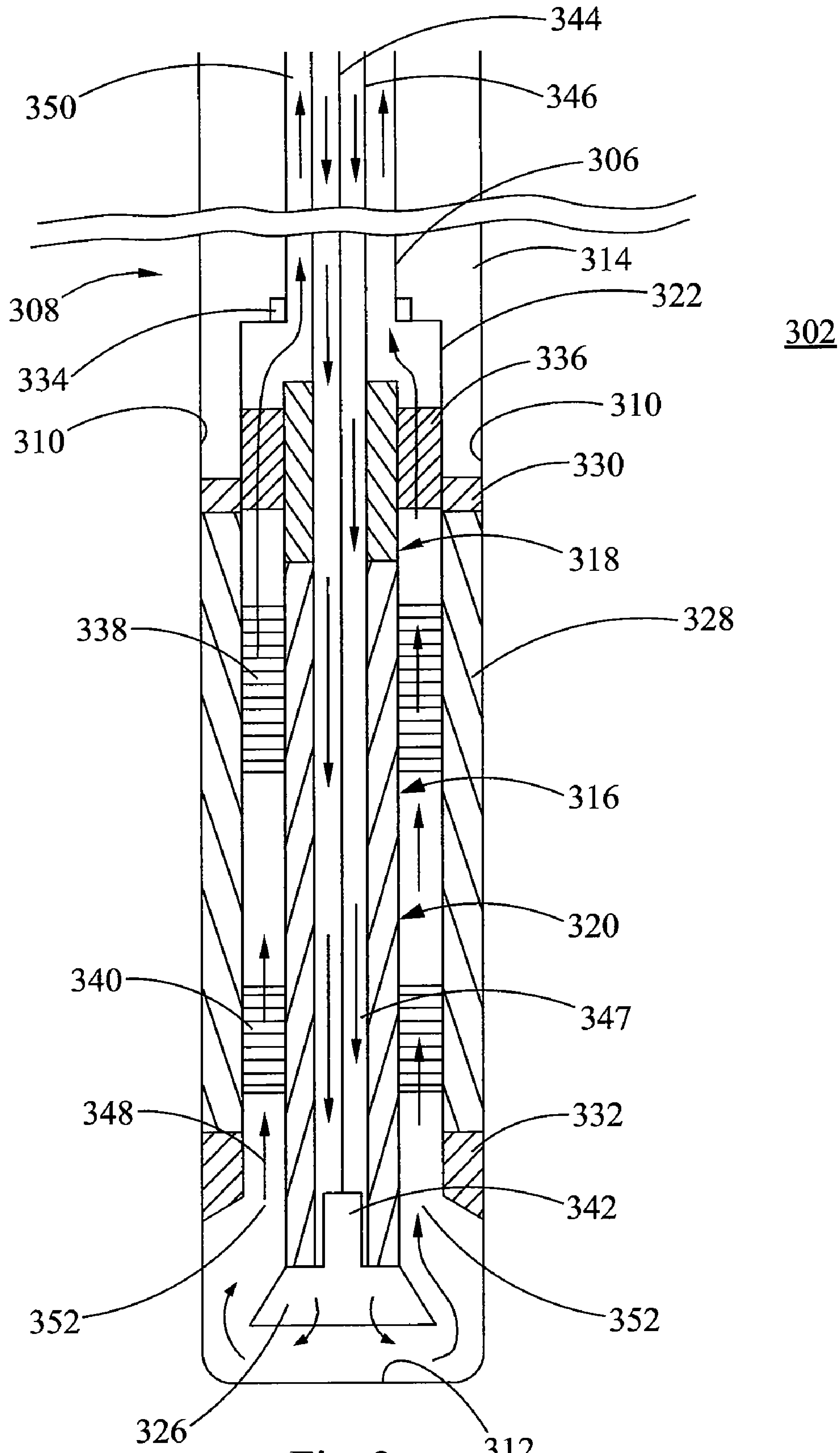
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Fig. 3

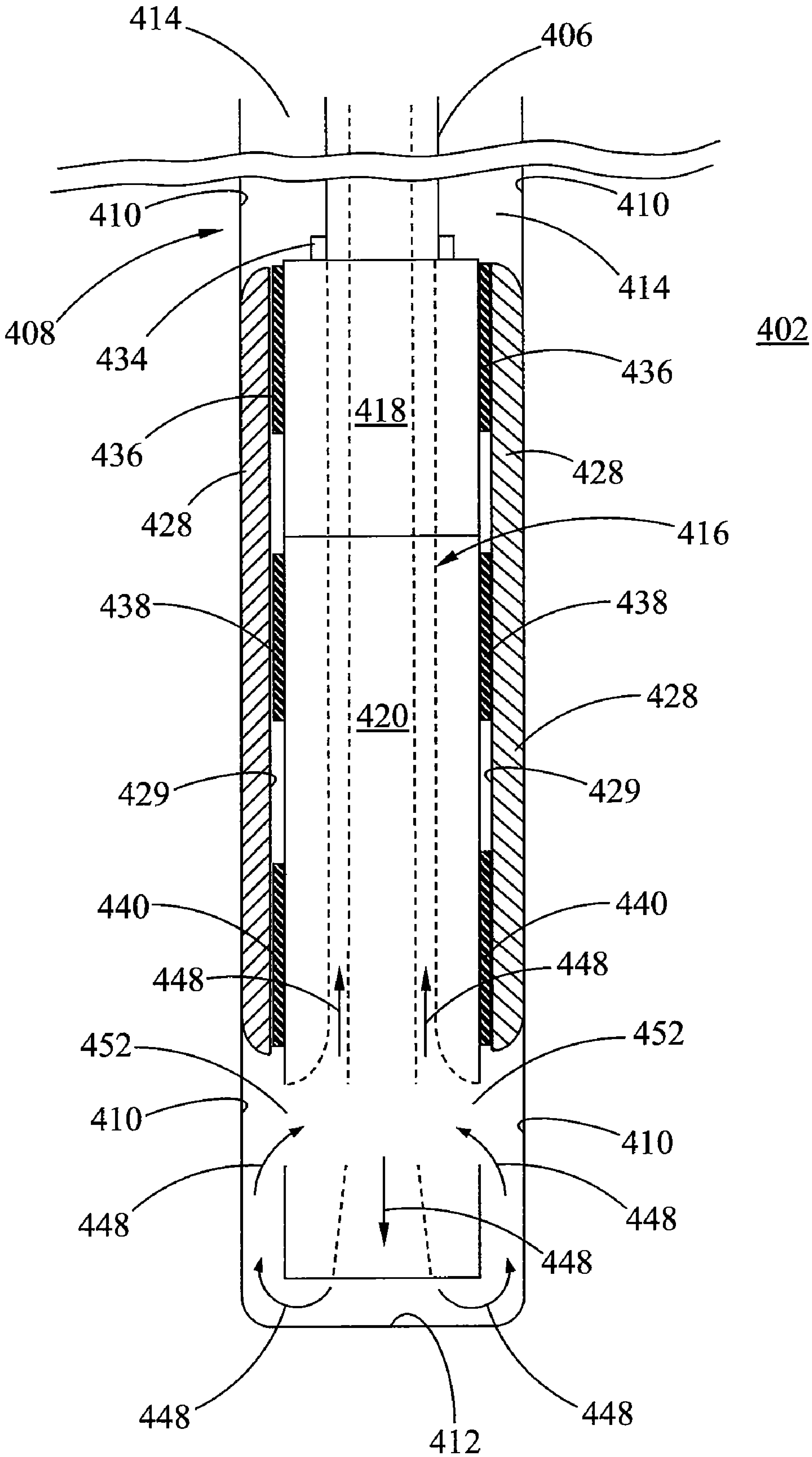
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Fig. 4

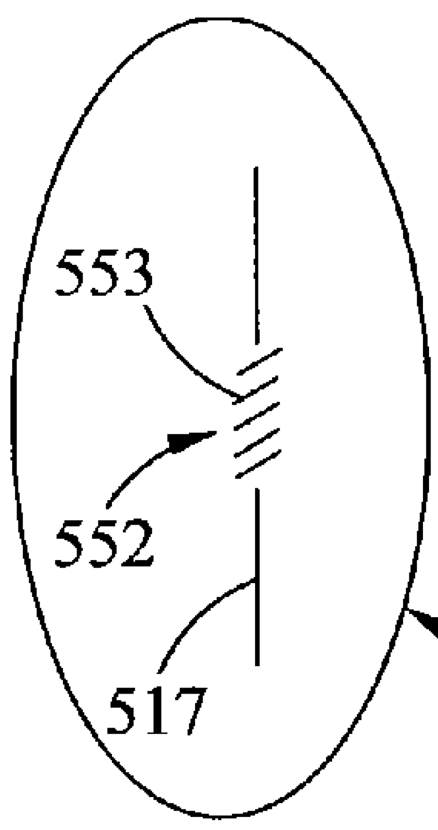

Fig. 5B

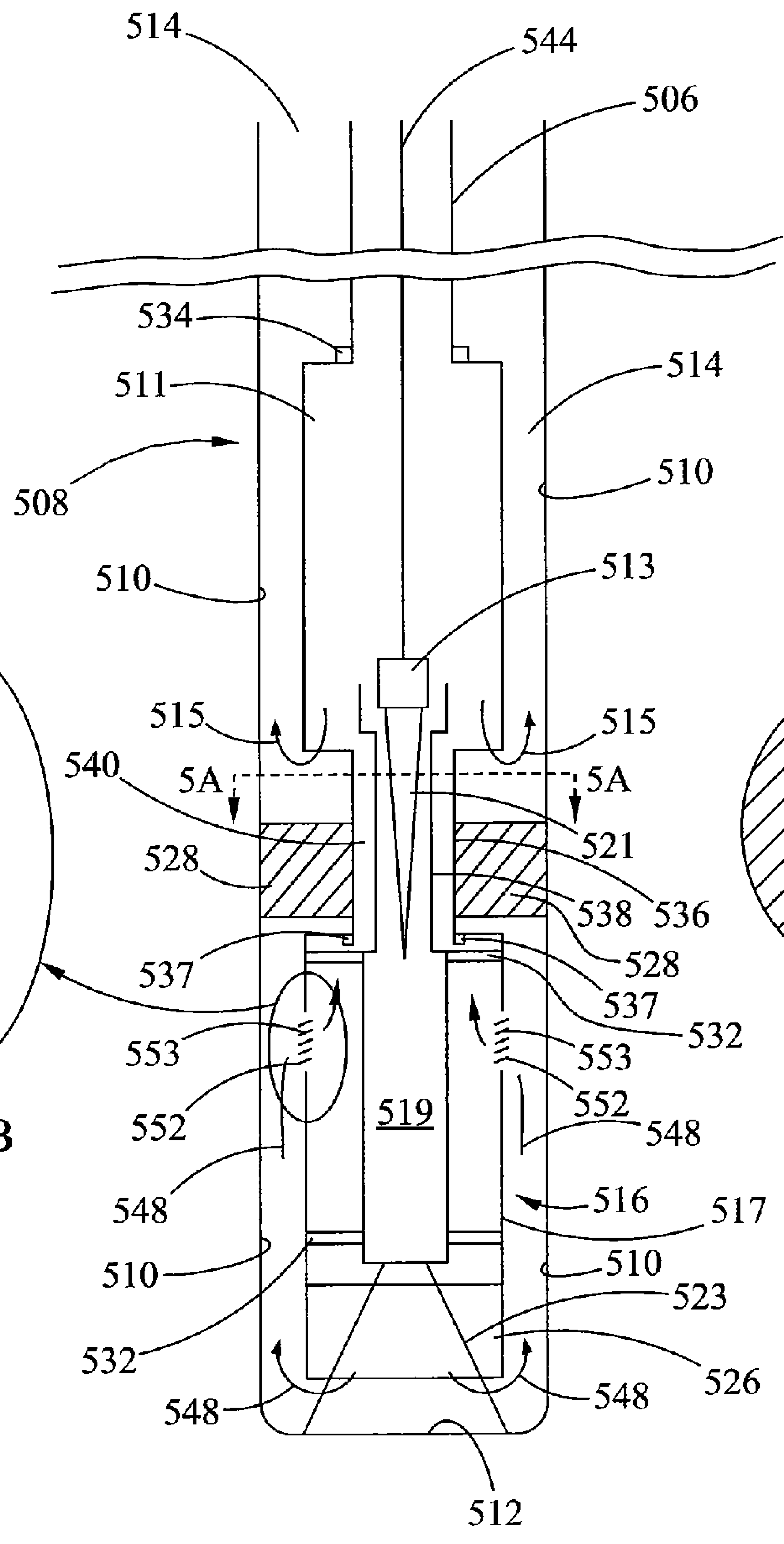

Fig. 5

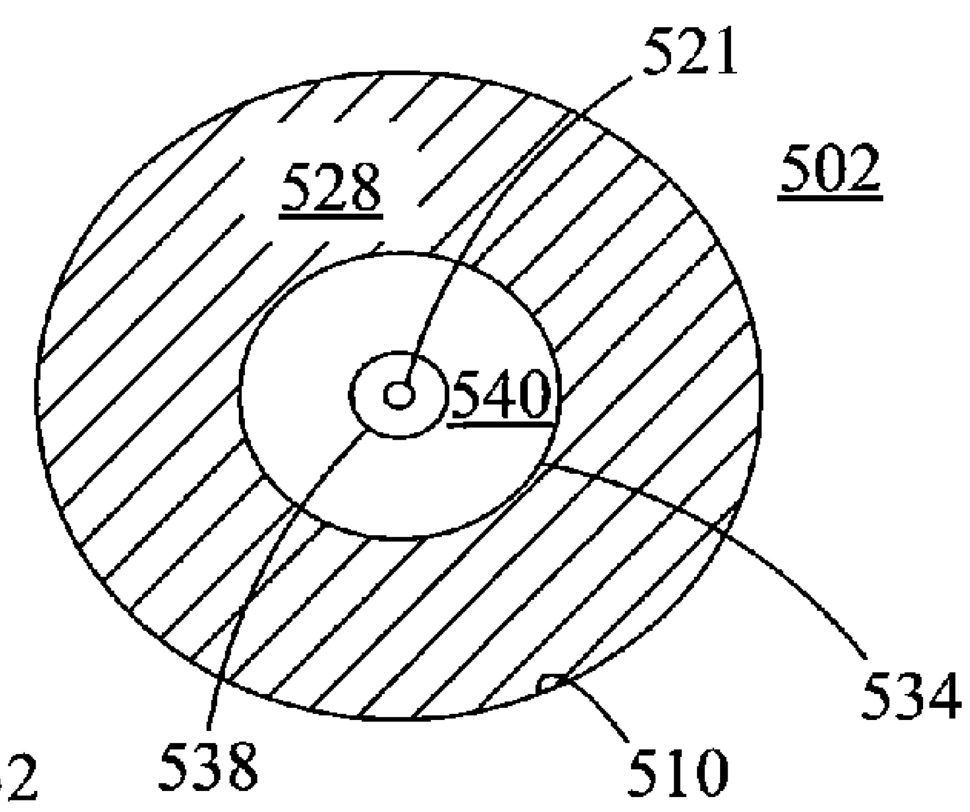

Fig. 5A

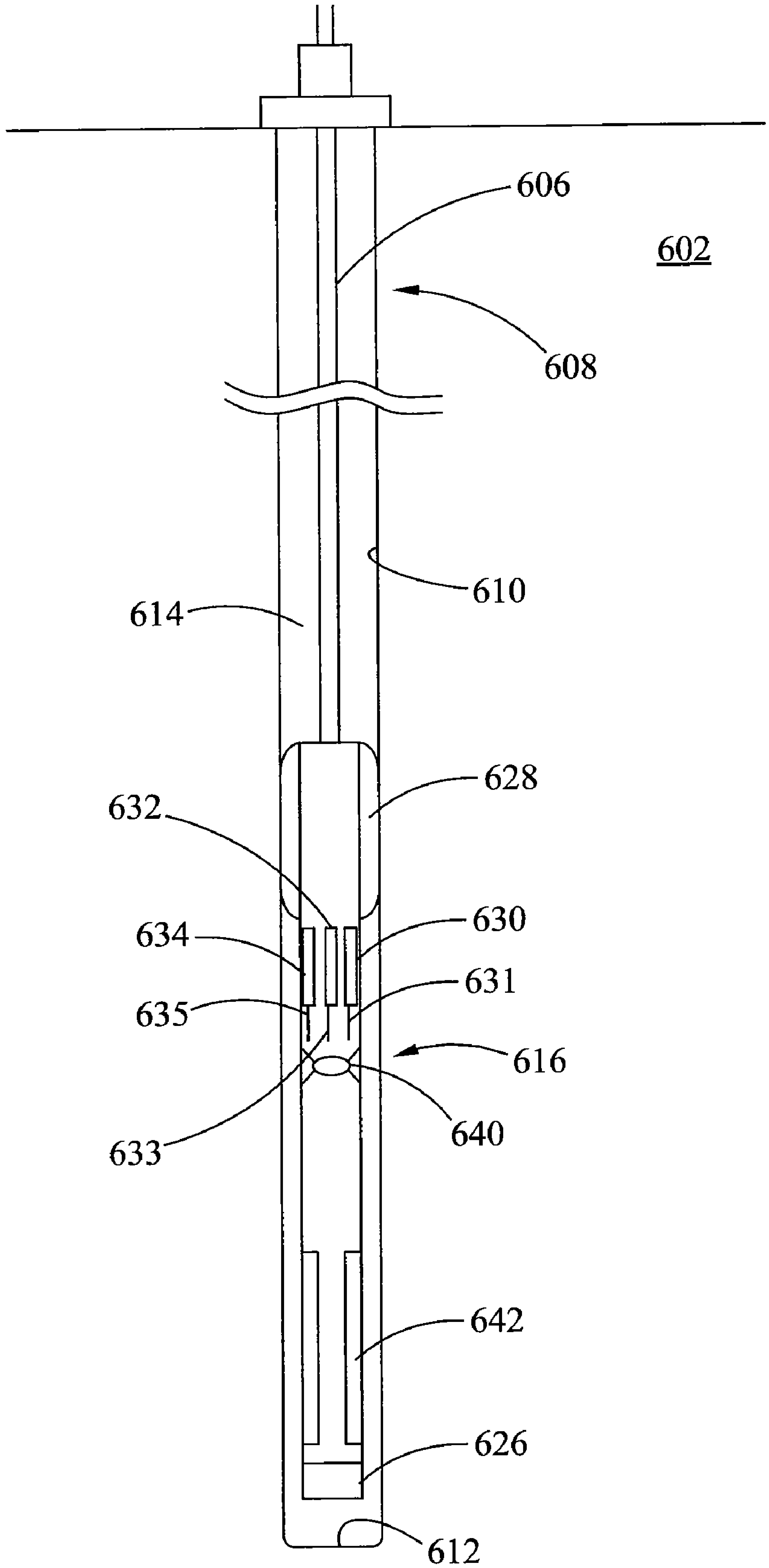
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Fig. 6

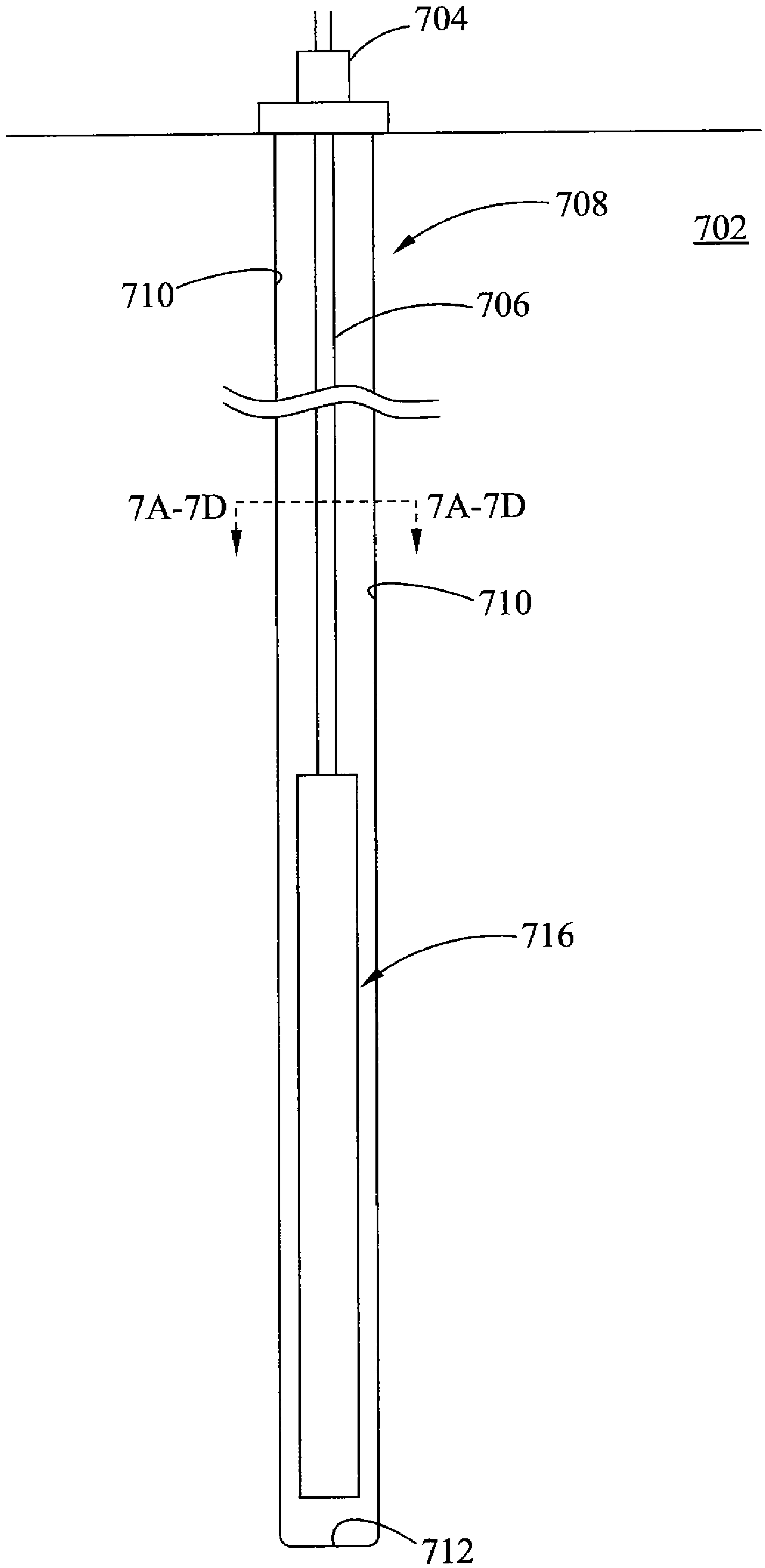

Fig. 7

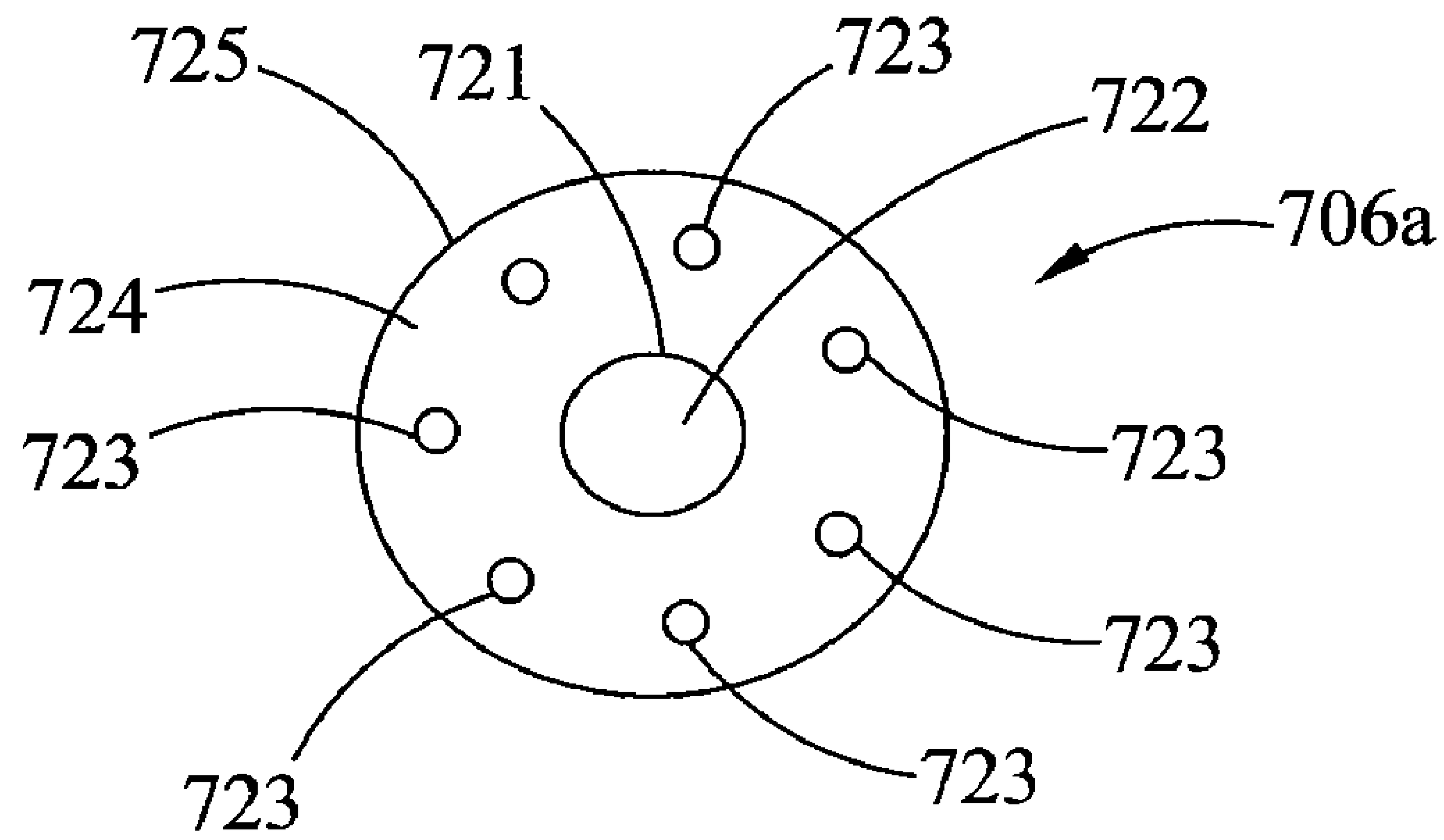

Fig. 7A

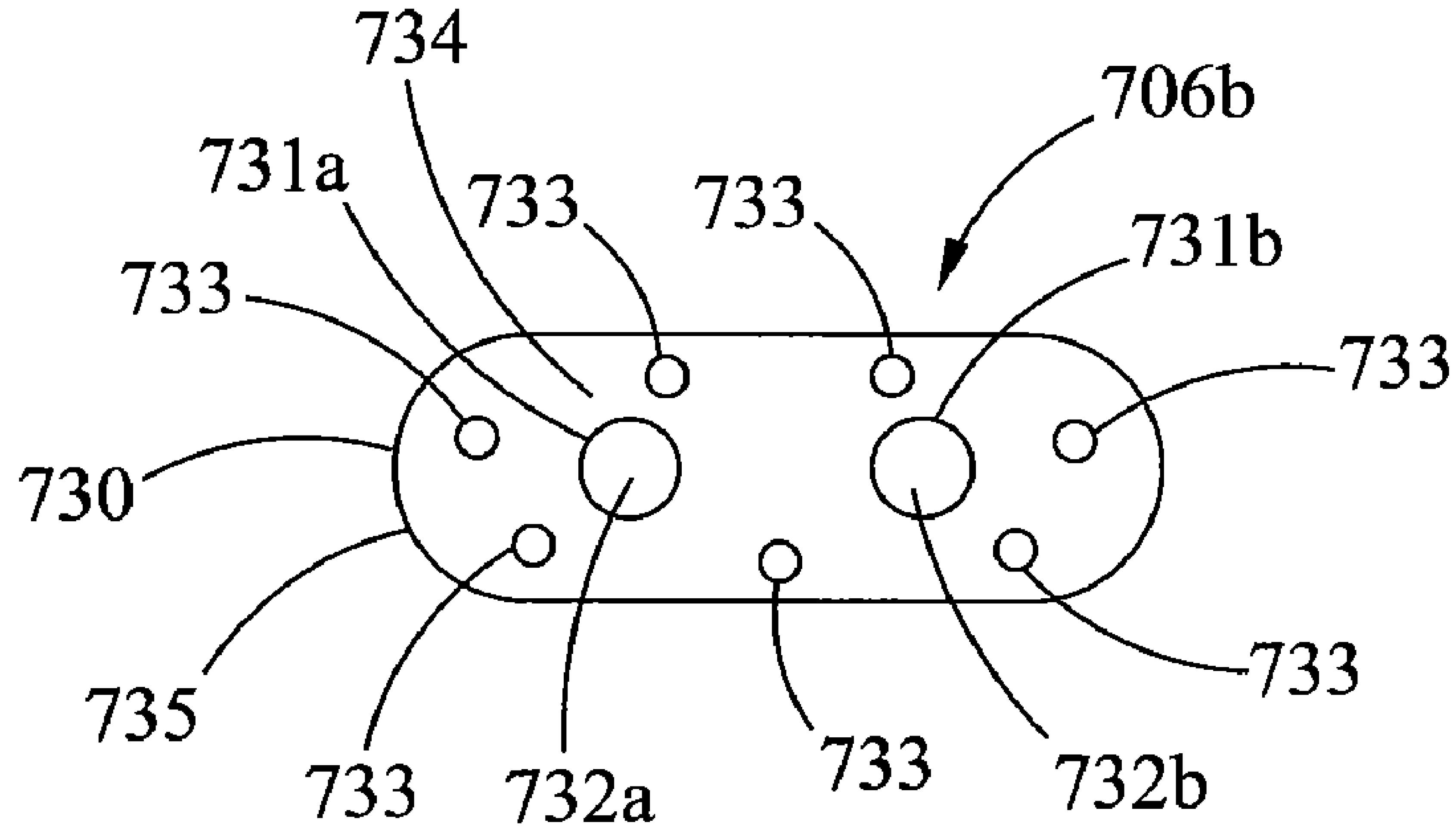

Fig. 7B

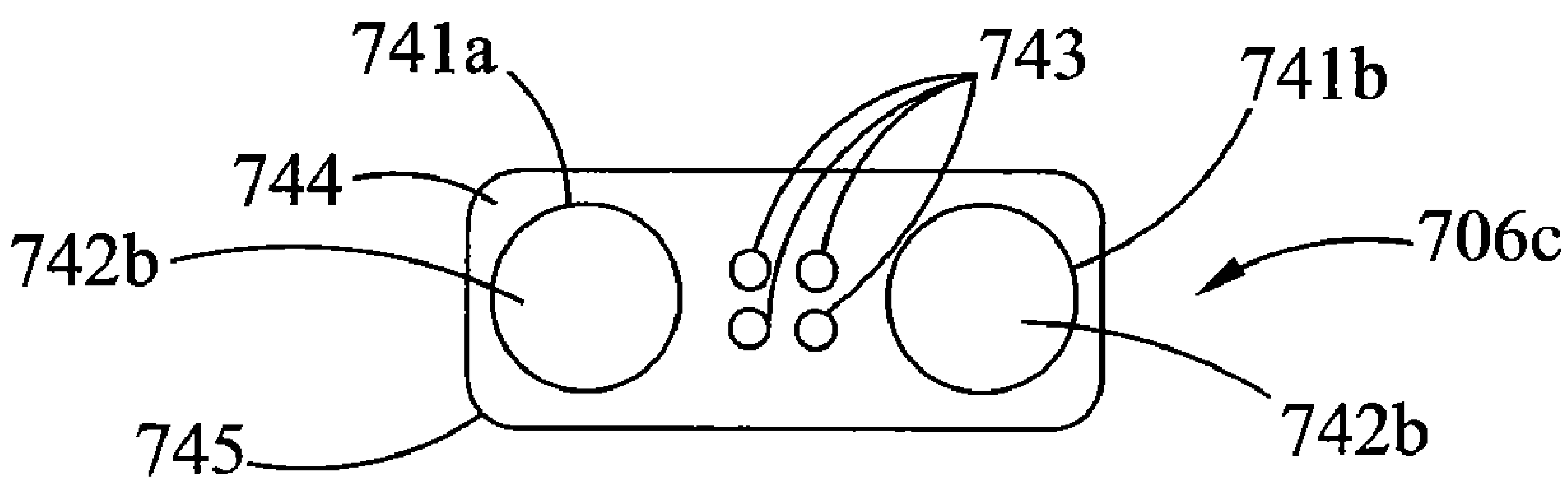

Fig. 7C

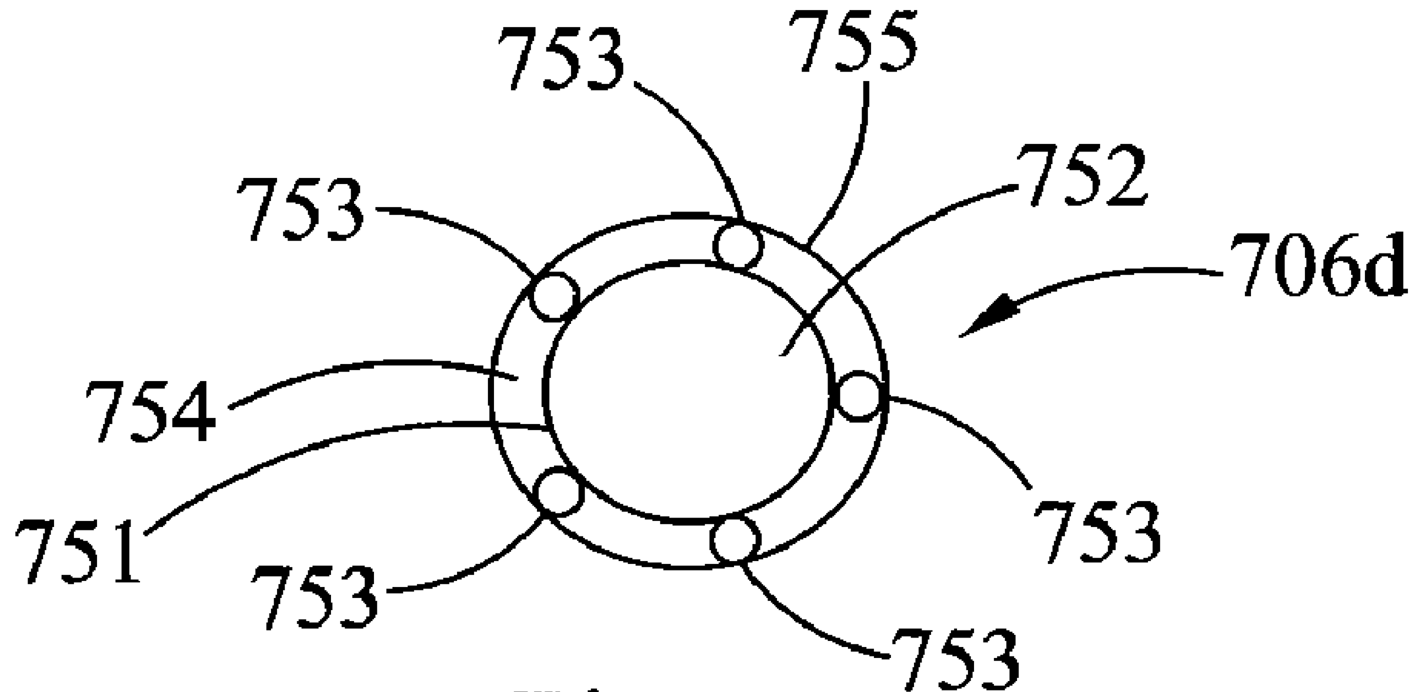

Fig. 7D

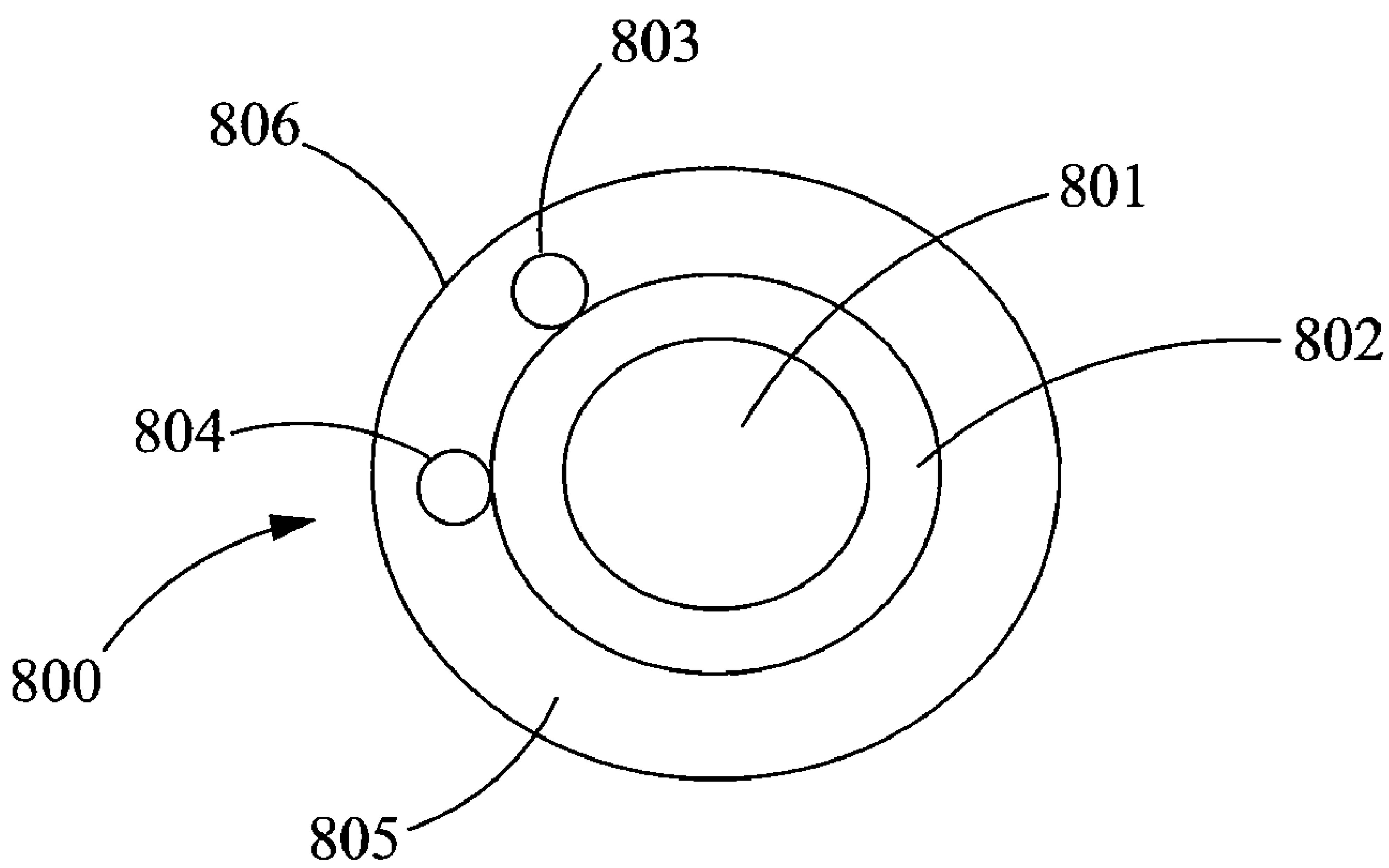

Fig. 8A

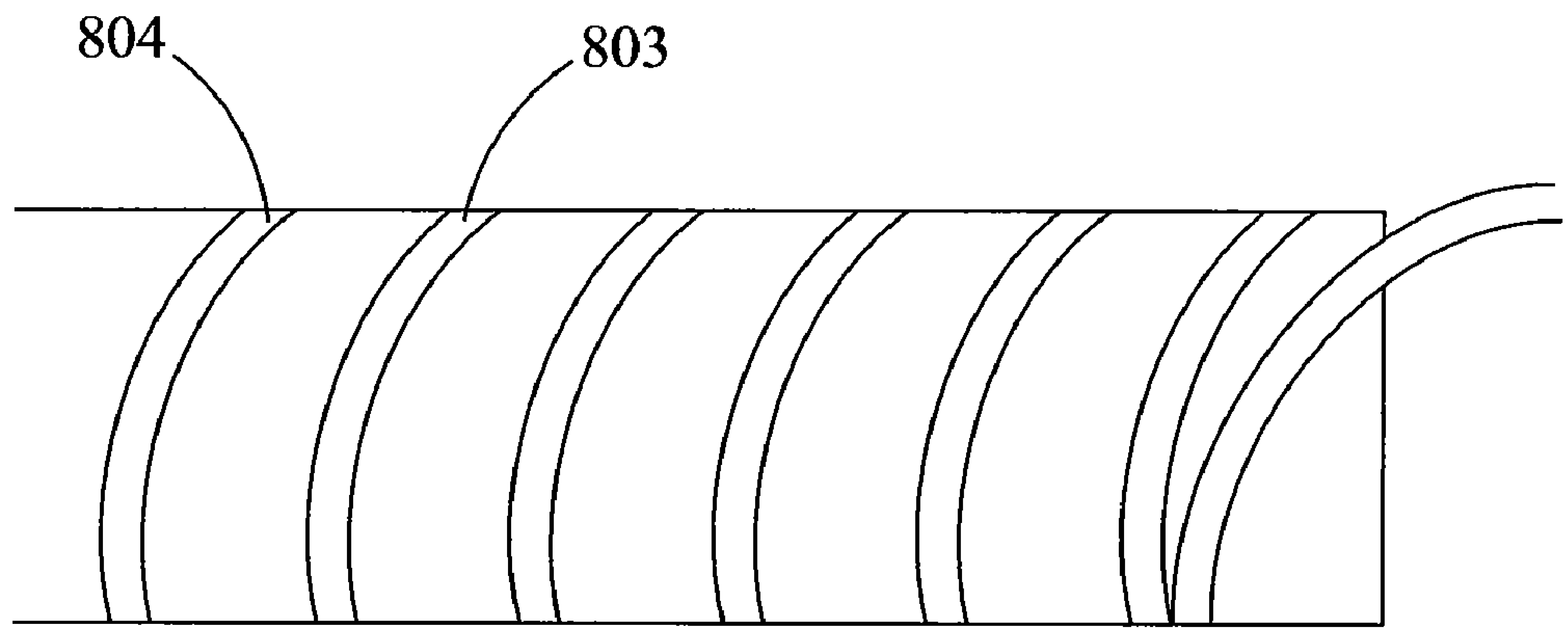

Fig. 8B

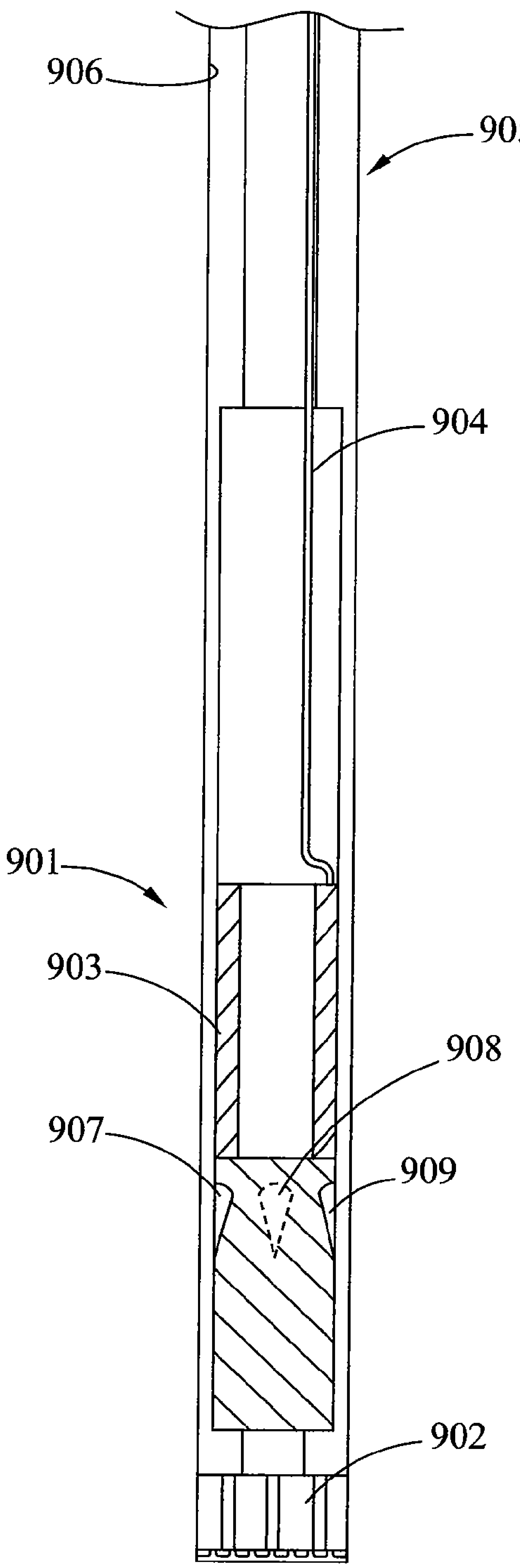
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Fig. 9A

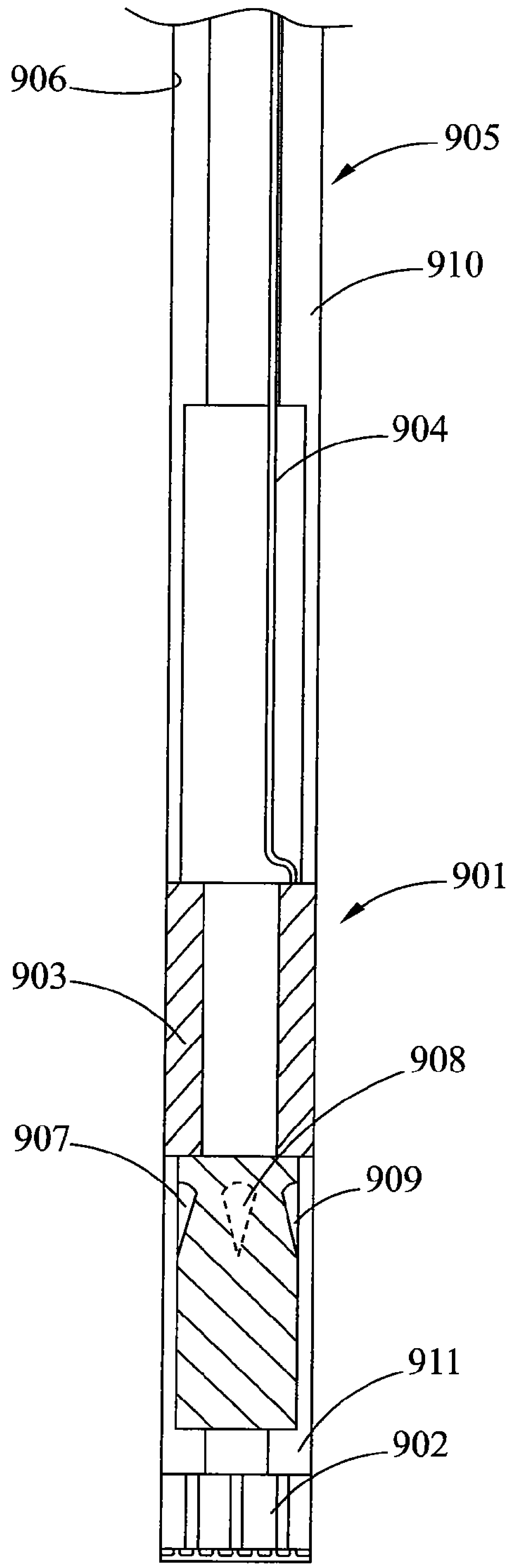
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Fig. 9B

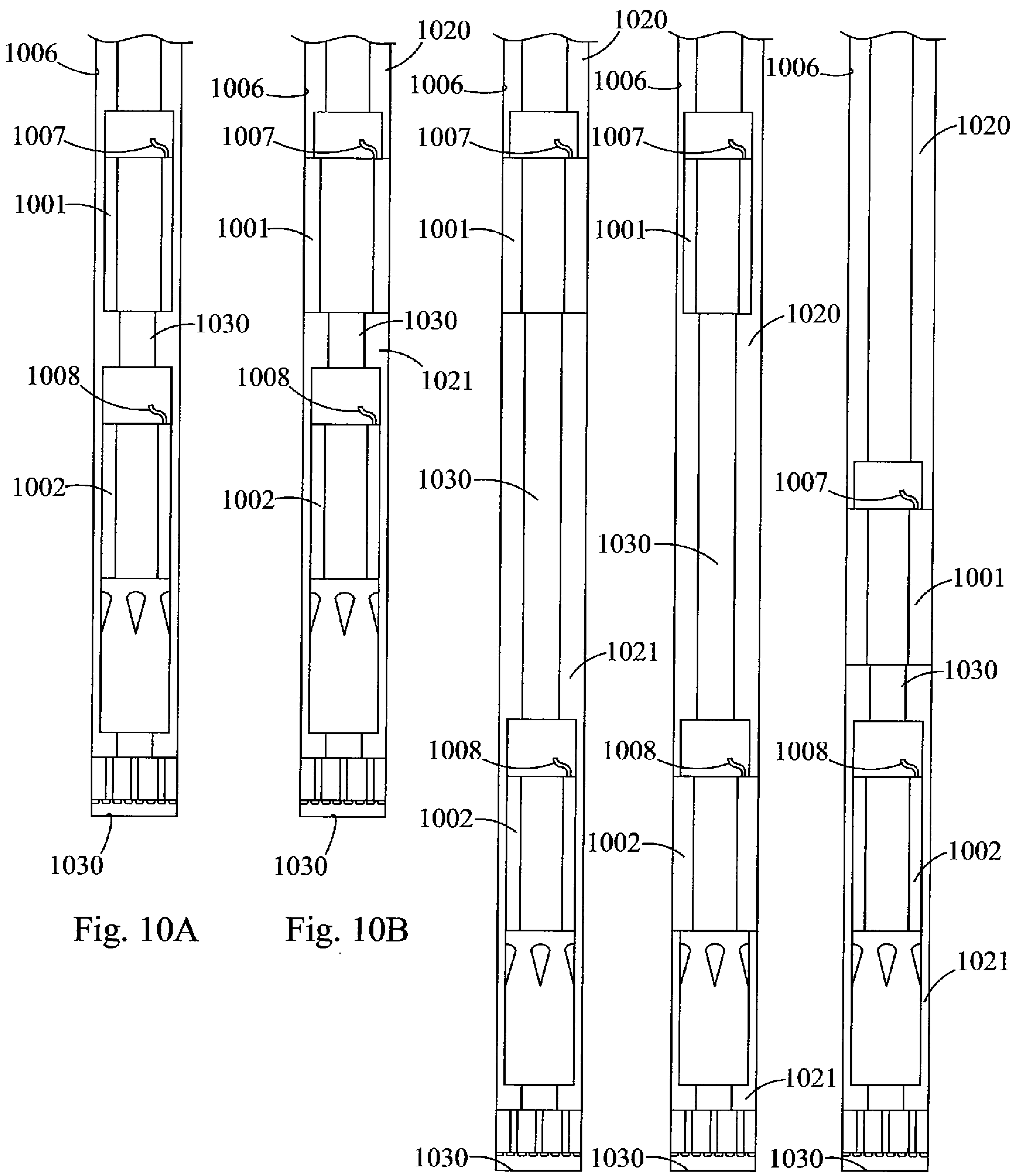

Fig. 10A   Fig. 10B

Fig. 10C   Fig. 10D   Fig. 10E

TWO-PHASE ISOLATION METHODS AND SYSTEMS FOR CONTROLLED DRILLING

[0001] This application: (i) claims, under 35 U.S.C. §119 (e)(1), the benefit of the filing date of Aug. 17, 2010 of provisional application Ser. No. 61/374,594; (ii) claims, under 35 U.S.C. §119(e)(1), the benefit of the filing date of Feb. 24, 2011 of provisional application Ser. No. 61/446,042; (iii) is a continuation-in-part of U.S. patent application Ser. No. 12/544,136, filed Aug. 19, 2009, which claims, under 35 U.S.C. §119(e)(1), the benefit of the filing date of Aug. 20, 2008 of provisional application Ser. No. 61/090,384, the benefit of the filing date of Oct. 3, 2008 of provisional application Ser. No. 61/102,730, the benefit of the filing date of Oct. 17, 2008 of provisional application Ser. No. 61/106,472 and the benefit of the filing date of Feb. 17, 2009 of provisional application Ser. No. 61/153,271; (iv) is a continuation-in-part of U.S. patent application Ser. No. 12/544,094, filed Aug. 19, 2009; (v) is a continuation-in-part of U.S. patent application Ser. No. 12/706,576, filed Feb. 16, 2010, which is a continuation-in-part of U.S. patent application Ser. No. 12/544,136, filed Aug. 19, 2009, and which claims, under 35 U.S.C. §119 (e)(1), the benefit of the filing date of Oct. 17, 2008 of provisional application Ser. No. **61/106,472**, the benefit of the filing date of Feb. 17, 2009 of provisional application Ser. No. 61/153,271, and the benefit of the filing date of Jan. 15, 2010 of provisional application Ser. No. 61/295,562; (vi) is a continuation-in-part of U.S. patent application Ser. No. 12/840,978 filed Jul. 21, 2010; (vii) is a continuation-in-part of U.S. patent application Ser. No. 12/543,986, filed Aug. 19, 2009; (viii) is a continuation-in-part of U.S. patent application Ser. No. 12/544,038, filed Aug. 19, 2009; (ix) is a continuation-in-part of U.S. patent application Ser. No. 12/544,094, filed Aug. 19, 2009; (x) claims, under 35 U.S.C. §119(e)(1), the benefit of the filing date of Feb. 24, 2011 of provisional application Ser. No. 61/446,043; and (xi) claims, under 35 U.S.C. §119(e)(1), the benefit of the filing date of Aug. 31, 2010 of provisional application Ser. No. 61/378,910, the entire disclosures of each of which are incorporated herein by reference.

[0002] This invention was made with Government support under Award DE-AR0000044 awarded by the Office of ARPA-E U.S. Department of Energy. The Government has certain rights in this invention.

BACKGROUND OF THE INVENTION

Field of the Invention

[0003] The present invention relates to methods and apparatus for the selective and predetermined management and control of downhole pressures while advancing a borehole or performing other operations within a borehole. In particular the present inventions relate to such methods and apparatus for laser assisted drilling of boreholes and for the directional control of laser assisted drilling of boreholes and for performing laser operations within a borehole. In particular, the present invention relates to unique and novel systems for, configurations of, and methods for utilizing, a liquid-gas Laser Bottom Hole Assembly ("LBHA").

[0004] As used herein, unless specified otherwise, the term "high power laser energy" means a laser beam having at least about 1 kW (kilowatt) of power. As used herein, unless specified otherwise, the term "great distances" means at least about 500 m (meter). As used herein, unless specified otherwise, the terms "substantial loss of power," "substantial power loss" and similar such phrases, mean a loss of power of more than about 3.0 dB/km (decibel/kilometer) for a selected wavelength. As used herein, unless specified otherwise, the term "substantial power transmission" means at least about 50% transmittance.

SUMMARY

[0005] It is desirable to have the ability to selectively and variably manage and control pressures in a borehole. It is further desirable the ability to use drilling liquids in conjunction with a laser-mechanical drilling process to advance a borehole while simultaneously isolating such liquids from the laser beam path and minimizing the inflow of any formation fluids that would interfere with the laser beam. The present invention, among other things, solves these needs by providing the articles of manufacture, devices and processes taught herein.

[0006] Thus there is provided herein a method of advancing a borehole using a two-phase isolation drilling system, the method having the steps of positioning a bottom hole assembly in association with a conveyance device in a borehole, the borehole having a sidewall surface, a bottom surface and a start, the conveyance device having an inflow path and a return path. The bottom hole assembly in this method has an isolation means, a bit, and an inflow path and a return path. So that the bottom hole assembly inflow path is in fluid communication with the conveyance device inflow path and the bottom hole assembly return path is in fluid communication with the conveyance device return path. Activating the isolation means into sealing engagement with the borehole sidewall surface, wherein the borehole is divided into a first and a second isolation zone, such that the second isolation zone includes the borehole bottom surface and filling the first isolation zone of the borehole with a first medium, such that a predetermined pressure on the borehole surfaces in the first isolation zone is maintained by the first medium and circulating a second medium through the input path of the conveyance device, the input path of the bottom hole assembly, through the bit, through the return path of the bottom hole assembly, and through the return path of the conveyance device and, engaging the bit against a surface of the borehole and while applying a pressure to the bit, rotating the bit against the borehole surface. So that material is removed from the borehole surface and the removed borehole material is transported by the circulating second medium through the return path of the bottom hole assembly and the return path of the conveyance device, such that removed borehole material does not substantially contact the borehole surfaces of the first isolation zone.

[0007] There is further provided such a method where a high power laser beam having at least about 15 kW of power, is directed through the bottom hole assembly and strikes the borehole surface; wherein the isolation means is a sealing engagement device; where the isolation means is an inflatable packer; wherein the isolation means is a slidable engagement device; where the first medium is a drilling liquid; where the drilling liquid is a drilling mud; where the second medium is a fluid transmissive to the laser beam; where the second medium is nitrogen; where thermal energy is directed by the bottom hole assembly toward the borehole surface; wherein a particle stream is directed by the bottom hole assembly

toward the borehole surface; where the bit is rotated by an electric motor and combinations of these.

[0008] Still further there is provided a method of controlled down hole cutting using liquids, gases and high power laser energy, including: providing a first isolation zone in a borehole, having a fluid; providing a second isolation zone adjacent a surface in the borehole to be cut, the second isolation zone movably associated with the first isolation zone; flowing a gas into the first isolation zone; and, directing a high power laser beam along a laser beam path to the surface in the borehole, whereby material is cut from the surface by the laser beam; and, moving an isolation zone in association with moving the laser cutting, so that the fluid does not substantially interfere with the laser beam.

[0009] There is additionally provided a system for advancing a borehole while simultaneously using a two-phase medium, the system including: a bottom hole assembly; a bottom hole assembly housing; a conveyance device affixed to the bottom hole assembly housing; the bottom hole assembly including a rotating section and a non-rotating section; a sealable engagement member; and, the bottom hole assembly including at least two isolated fluid paths. Such a system may also have the bottom hole assembly having high power laser optics and a high power laser beam path.

[0010] Moreover, there is provided a system for advancing a borehole while simultaneously using a two-phase medium, the system having: a laser bottom hole assembly; a laser bottom hole assembly housing; a conveyance device affixed to the laser bottom hole assembly housing; the bottom hole assembly comprising a rotating section and a non-rotating section; a sealable engagement member; and, the bottom hole assembly comprising at least two isolated fluid paths. This system may also include: the laser bottom hole assembly having an electric motor; the laser bottom hole assembly having a mud motor; and the laser bottom hole assembly includes a second sealable engagement member and a piston advancement means.

[0011] Additionally, there is provided a system for advancing a borehole having: a laser bottom hole assembly having at least two portions; a means for delivering a high power laser beam; a means for convey high power laser energy to the bottom hole assembly; the conveyance means in optical association with the laser bottom hole assembly; a means for rotating a portion of the laser bottom hole assembly; a means for maintaining the relative position of the laser bottom hole assembly within the borehole; the positioning means including a means for forming an isolation zone; and, a means for advancing the laser bottom hole assembly. Such a system may also have the advancing means selected from any of the following a tractor, a force from the weight of drilling collars, a piston means, or a force from the weight of a drilling fluid.

[0012] Yet further there is provided a method of particle drilling to advance a borehole including the steps of: setting a sealable engagement member in a borehole to create a first and second isolation zone; filling the first isolation zone with a drilling liquid; and, circulating through the second isolation zone a drilling fluid comprising particles; whereby the particle containing fluid impinges upon a borehole surface to in part advance the borehole, such that the particles are isolated from the second isolation zone.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a schematic view of an embodiment of a downhole assembly in accordance with the present invention.

[0014] FIG. **2** is a schematic view of an embodiment of a dual packer downhole assembly in accordance with the present invention.

[0015] FIG. **3** is cross-sectional view of another embodiment of a downhole assembly in accordance with the present invention.

[0016] FIG. **4** is a cross-sectional view of another embodiment of a downhole assembly in accordance with the present invention.

[0017] FIG. **5** is a cross-sectional view of an embodiment of a laser downhole assembly in accordance with the present invention.

[0018] FIG. **5**A is a cross-sectional view of the assembly of FIG. **5** taken along line A-A.

[0019] FIG. **5**B is an enlarged view of a section of FIG. **5**.

[0020] FIG. **6** is a schematic view of an embodiment of a steerable downhole assembly in accordance with the present invention.

[0021] FIG. **7** is a schematic view of another embodiment of a downhole assembly in accordance with the present invention.

[0022] FIGS. **7**A to **7**D, are cross-sectional view taken along line **7**A-**7**D, of different embodiments of conveyance devices in accordance with the present invention.

[0023] FIGS. **8**A and **8**B, are a cross-sectional view and a prospective view, respectively, of an embodiment of a conveyance device in accordance with the present invention.

[0024] FIGS. **9**A and **9**B, are schematic views of another embodiment of a laser downhole assembly in accordance with the present invention in operation.

[0025] FIGS. **10**A to **10**E, are schematic views of the embodiment of FIG. **2** showing various stages of its operation cycle.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] In general, the present inventions relate to configurations for advancing boreholes in the earth, for example sandstone, limestone, basalt, salt, granite, shale, etc., or in other materials, such as for example concrete. These inventions further relate to the use of drilling fluids or drilling muds and gas to manage and control pressures downhole, formation pressures and conditions, and to remove borehole cuttings, i.e., the debris that is created from the removal of borehole material created by advancing the borehole.

[0027] In general there is provided a laser bottom hole assembly ("LBHA") that is used in conjunction with engagement sealing devices, such as inflatable packers, bladders, pistons, wipers, rams or similar type devices for sealing against borehole wall surfaces. The LBHA and the laser-mechanical drilling processes, of U.S. Patent Application Ser. No. 61/247,796, U.S. patent application Ser. No. 12/896,021, U.S. Patent Applications Publication Nos. 2010/0044106, 2010/0044104, 2010/0044105, 2010/0044102, 2010/0044103, and U.S. Patent Applications Nos. 61/446,042 and 61/446,043, provide among other things, the ability to have borehole wall surfaces that are very smooth, and are believed to have a substantially higher level of smoothness than the walls of boreholes formed by conventional mechanical drilling. These laser-mechanical formed boreholes have surface smoothness that can be about ⅛ inch from peak-to-trough or smaller peak-to-trough values. This smoothness is obtained directly from the laser-mechanical advancement of the borehole, and without subsequent or additional reaming or similar type operations.

[0028] Packers, wipers and similar types of devices, thus, can seal against the borehole walls creating an isolated upper and lower borehole sections. These devices can further slide, due in part to the smoothness of the laser-mechanical borehole wall, or otherwise advance down, i.e., toward the end or bottom, of the borehole while maintaining a seal against the borehole wall surface. Although boreholes are generally depicted or illustrated as advancing from the surface vertically down into the earth, the present inventions are not limited to such vertical drilling, but also address horizontal drilling, directional drilling, and the advancement of boreholes in any direction relative to the surface. Thus, by using these devices to create isolation zones or isolation sections in the borehole allows pressures and conditions in those zones to be independently and variably controlled. This use of these devices further permits the use of a liquid in one zone and a gas in the other zone, different liquids in the zones, and/or different gases in the zones.

[0029] In general, and by way of example, there is provided a LBHA that is used in conjunction with inflatable packers, pistons or wiper seals or similar sealing devices. The packers can be inflated against, or the other devices can be extended against, the borehole walls and thus can form a seal that isolates the section of the borehole above the packer and the section of the borehole below the packer. The packers and other engagement-sealing devices are slidably engagable, reversibly engagable, moveably engagable and combinations and variation of these. That is, they can preferably be repeatedly extended and retracted or otherwise moved or slid along the borehole wall to maintain the isolation zone(s).

[0030] Accordingly, when the packers are inflated the upper section of the borehole can be filled with a drilling fluid, in particular a drilling liquid, for example water or a drilling mud. In this way the pressures in the borehole, such as formation pressures, can be managed by the weight and type of liquid used. The use of this static type liquid application in the borehole further has the ability to avoid, mitigate, or solve loss of circulation problems that can be encountered during drilling.

[0031] Loss of circulation of drilling liquid can occur when the drilling liquid that is pumped into the borehole, in part to carry the cuttings or debris that are formed by the advancement of the borehole to the surface, flows into the formation, i.e., into the earth and is thus lost and does not return to the surface. Using the configurations of the present inventions, should this condition be encountered when drilling, it can be overcome by additional liquid being pumped into the borehole to maintain the desired volume of fluid in the borehole above the inflated packer. Thus, in the present static liquid embodiment, the amount of liquid that needs to be added is only equal to the amount of liquid that is lost into the formation, rather than the additional amount that is needed to maintain circulation of the fluid, in other systems.

[0032] Further this system provides the ability to apply external pressure from the surface to the fluid, and particularly to apply external pressure to a lighter weight liquid, such as water, and in this way selectively control the pressure that the liquid is exerting in the borehole. Thus, this system provides the ability to exactly and precisely apply a predetermined or preselected pressures to a borehole and change those pressures as need or as conditions in the borehole change over time and/or over the length of the borehole.

[0033] Further, when the packers are inflated the portion of the borehole below the packers is isolated from the drilling fluid. In this lower section the LBHA, or at least a portion of the LBHA, can be located. Thus, the laser beam can be delivered from the laser optics through the laser drill bit (laser-mechanical bit), without having to pass through drilling mud or liquids, and assist in the removal of borehole material to advance the borehole. A gas, such as for example air, nitrogen, or argon is pumped down through the LBHA to exit the drill bit, and potentially other ports in the LBHA, to lift and remove the cuttings. The cuttings are lifted and advanced by the gas (at this point in the process the gas is at times referred to as return gas or return gas flow) up the borehole wall, into openings or ports in the LBHA and then up a conveyance device to the surface. In this manner, the cuttings or debris do not mix with the drilling liquid. The pressure and flow rate of the gas is based upon several factors and requirements including: (i) the amount of pressure that is need to maintain borehole integrity in the lower isolated section, i.e., the section below the packer; (ii) manage formation pressures in the lower isolated section; and, (iii) lift the cut borehole particles, i.e., the debris to the surface.

[0034] In some wells gas pressures of 10,000 psi and, as much as 15,000 psi, or more may be needed and flow rates from about 300 to about 1000 CFM (cubic feet per minute) may be needed. In particular the pressure of the gas in the lower isolation zone should be great enough to overcome and/or match the hydrostatic pressure that is exerted by the formation on the well bore in the isolation zone, and as the isolation zone is advanced in conjunction with the borehole. In this manner the gas pressure should be selected to meet both well control requirements and borehole stability requirements. Further, the gas pressure should be sufficient to prevent the inflow of any fluids that could interfere with or substantially reduce or stop the laser beam from weakening, softening, spalling or otherwise beneficially affecting the borehole surface, and for drilling the bottom surface of the borehole. Further, the size of the inlet gas flow, the openings in the drill bit, the size of the return gas flow openings, as well as, the area of the return channel can be predetermined to meet and optimize the pressure and flow rates needed for a particular drilling application.

[0035] A grating or screen may also be used in conjunction with the return ports to break up or otherwise manage and control the size of the particles returning up the conveyance device. This embodiment, however, may further require the application of scrapers or other means or methods to prevent the grating from plugging. However, depending upon the laser's effect on the borehole material, such cleaning may not be needed as the weakened borehole material will simply crumble, or otherwise break apart, upon impact with the grating.

[0036] For the foregoing, and as further provided herein, there is provided a system and a method that allows for the use of drilling fluids or drilling mud in the borehole during a laser-mechanical process, while simultaneously enabling the laser beam to be shot through a gas, without having to travel through a fluid, moving fluid or drilling mud and thus enabling the laser beam to avoid the fluids being used.

[0037] The conveyance device or conveying means may be any known tubular in the drilling industry that has the ability or capability to have additional tubes or annular spaces within it, or associated with it. Thus, for example, conventional drilling pipe with inserts added to it, coiled tubing with additional tubing contained therewith, wireline, and composite tubing may be used. Further illustrations of type of conveyance devices are provided in U.S. patent application Ser. No. 13/210,581, filed Aug. 16, 2011, the entire disclosure of which is incorporated herein by reference.

[0038] The systems and methods provided herein provide great levels of control over drilling parameters and conditions. Thus, for example, the control of WOB (weight-on-bit), ROP (rate-of-penetration), RPM (bit revolutions-per-minute), pressure in the borehole above the drilling location, and pressure in the borehole at the drilling location can be independently, variably and finely controlled. Thus, the systems and methods provided herein enable what in effect can be seen as push-button drilling. This system further allows for under pressure drilling, over pressure drilling and selected and predetermined varying of over and under pressure drilling as the borehole is advanced.

[0039] Turning to FIG. **1**, there is shown a cross sectional view of an embodiment of a drilling assembly in a borehole **100**. The borehole **100** has sidewalls **101**. A piston **109** with a wiper seal **110** forms a seal against borehole sidewall **101**. The borehole sidewall **101** being form by a laser-mechanical drilling process is very smooth and enables the wiper to seal against it, and maintain the seal as the wiper is slide downward.

[0040] The piston **109** is lowered by coiled tubing **102**. The coiled tubing **102** has an inner tubular **115** forming a channel **112** for transmitting a clearing gas to the bottom of the borehole or laser work area. This inner tubular **115** and the outer wall **114** of the coiled tubing **102** form an annulus **113**. The annulus **113** carries the cuttings, debris, e.g., returns out of the borehole. The cuttings enter annuls **113** though openings **106**, **107**. The LBHA **103** has a channel **105** through it for flowing a clearing gas, this channel is in fluid communication with a channel **112** in the laser-bit **104**. Thus, the clearing gas flows down inner channel **112**, to inner channel **105**, to inner channel **112** and out the laser-bit **104**. The returns are then carried up the lower section, e.g., the section of borehole below the piston **109** and enter openings **106**, **107**. An electric motor laser bottom hole assembly of U.S. Patent Application Ser. No. 61/446,042 and a laser-mechanical bit of U.S. Patent Application Ser. No. 61/446,043 may be utilized. The drilling assembly of U.S. Patent Application Ser. No. 12/986,021 may also be used. Drilling mud **111**, or other drilling fluid, is contained above the piston **109** by the seal formed between wiper **110** and the sidewall **101**. The clearing air flow through the channels **112**, **105**, **112** exits the bit **104** and carries cuttings and debris up and into the return openings **106**, **107**. In operation as the LBHA advances the borehole, the LBHA will also advance with the piston and wiper moving down, i.e., sliding, while maintaining the seal against the sidewall to prevent the drilling mud from moving around or below the piston. In this manner, this embodiment may be view as in slidable engagement with the sidewall. There is also created an advancing upper isolation zone **116** and an advancing lower isolation zone **117**.

[0041] FIG. **2** illustrates an example of a fluid-gas LBHA system in use in a borehole. Thus, there is provided in the earth **202** a borehole **208**. The borehole **208** has a sidewall surface **210** and a borehole bottom surface **212**. At the surface **200** of the earth there is provided the top, or start of the borehole. At the surface **200** of the earth, there is provided a surface assembly **204**, which may have a wellhead, a diverter, and a blow out preventer (BOP).

[0042] A conveyance device **206** is extended through the surface assembly **204** and into the borehole. For example, the conveyance devices can be coiled tubing, with tubes and lines contained therein, and thus a coiled tubing rig, as for example provided in the above incorporated by reference published patent applications, can be used with the conveyance device.

[0043] The conveyance device **206** extends down the borehole **208** and is attached to the LBHA **216** by attachment device **234**. The attachment device can be any means suitable for the purpose; it can be permanent, temporary or releasable. It can be a weld, a threaded member and a nut, a quick disconnect, a collet, or other attachment devices that are known to the art.

[0044] The LBHA **216** has a first section **218** and a second section **220**. The second section **220** of the LBHA has a first part **222** and a second part **224**. A laser-mechanical bit **226** is positioned at the distal end of the second part **224** of the second section **220** of the LBHA **216**. There is further provided an inflatable packer **228** on the first section **218** of the LBHA **216** and an inflatable packer **230** on the second section **220** of the LBHA **216**.

[0045] As shown in FIG. **2** the packers are shown as inflated, thus they are shown as extending from the LBHA to and engaging the surface of the sidewall of the borehole. In this way the inflatable packers engage the surface of the borehole wall and seal against the wall, or form a seal against the wall. Further by sealing against the borehole wall the packers isolate the upper section of the well, i.e., the section of the borehole wall from the packer to the start of the well, from the lower section of the well, i.e., the section of the well from the packer to the bottom of the borehole. As shown in FIG. **2** the packer **218** is inflated against the wall and isolates and prevents the drilling fluid or drilling mud **214** contained in the borehole from advancing toward the second section **220** of the LBHA; or the bottom of the borehole **212**; thus preventing the fluid from causing any potential interference with the laser beam or laser beam path.

[0046] The second or lower section **220** of the LBHA contains the laser optics that, for example, may form the beam profile and focus the beam, and the means for rotating the bit. The rotation means can be for example an electric motor or an air driven mud motor. Further, the lower section of the LBHA has ports or openings **236** for the air to return into the LBHA and carry the cuttings up the conveyance device to the surface.

[0047] The first **218** and second **220** sections of the LHBA **216** are connected by a piston **232**. Thus, in use the packer **228** is inflated and in addition to forming a seal, fixes and holds the first section **218** in position in the borehole. The piston **232** is then advance at a controlled rate and advances the second section **220** of the LBHA against the bottom of the borehole. In this way the borehole is advanced, as the piston is extended, and a high level of control can be maintained over rate-of-penetration (ROP), weight-on-bit (WOB) and revolutions-per-minute of the bit (RPM). Monitors and sensors can be located in the LBHA and connected to control devices at the surface by way of cables and/or fibers associated with the conveyance device.

[0048] When the piston has reached the end of its stroke, i.e., it is extended to its greatest practical length, the packer **230** is inflated, as shown in FIG. **2** and then the packer **228** is deflated, sufficiently so that the piston can be retracted and the upper or first section **218** is moved down toward the second section **222**. The packer **228** is then inflated and the piston extend. This process is repeated, in an inch-worm like fashion advancing the well bore. Alternatively, the upper packer **228** can be a retractable cleat or other fixing apparatus that releasably attaches to or engages the borehole wall. In this case the lower packer remains inflated and is slid along the borehole wall surface, maintaining the seal and isolating the drilling mud above the lower section, which contains the gas flow.

[0049] Gas is flowed down the conveyance means **206**, through the upper section **218**, the piston **232** and the lower section **224** and out the bit **216**. The gas after exiting the bit carries the cuttings up the borehole, into the return ports **236** and up through the LBHA **216** and the conveyance device **206** to the surface, where the cuttings are handled in manners known to those skilled in the art. The gas must have sufficient flow rate and pressure to manage the borehole pressures and remove the cuttings.

[0050] The inflatable packers that are preferred in the present inventions have a tubular member and an inflatable bladder like structure that can be controllably inflated and deflated to fill the annulus between tubular member and the bore wall. Further, the pressure that the bladder exerts against the bore wall can be controlled and regulated. Control lines and lines for providing the media to inflate and deflate the bladder are associated, with or contained within, the conveyance device.

[0051] FIG. **3** provides a further illustration of fluid-gas laser mechanical system in a borehole **308** located in the earth **302**. Thus, there is provided a conveyance device **306** extending into a borehole **308**, having a borehole sidewall surface **310** and a bottom surface **312**. The conveyance device is connected to LBHA **316** by attachment device **334**. The LBHA **316** has a housing **322**. Within the housing **322** is a non-rotating section **318** of the LBHA and a rotating section **320** of the LBHA. The non-rotating section **318** is secured to or affixed to the housing **322** by holding structure **336**. The rotating section **320** is attached to the housing **322** by bearing assemblies **338** and **340**. The rotation section of the LBHA may have an electric motor, an air driven motor or other means to rotate the bit. The holding structure and bearing assemblies are thus selected to work with and fit with, the arrangement of rotation and non-rotating sections of the LBHA. It further may contain the laser optics **342**. The bearing assemblies **338**, **340** and the holding structure **336** have openings, or ports, (not shown in the figure) that permit the return gas flow shown by arrow **348** to pass by, around, or through them. The flow paths around, by or through the bearing assembly may be outside of the bearings, for example a series of openings outside of the outer bearing race, or inside of the bearings, or otherwise provide for the passage of the fluid by the bearings without substantially interfering with the operation of the bearings.

[0052] An inflatable packer **328** is attached to the housing **322**. As shown in FIG. **3** the packer is inflated and isolates the drilling fluid **314**, preferably a drilling liquid, such as a drilling mud, above it. The packer may further have associated with it wipers or sealing members **330** and a sealing or directing device **332**. In use as the borehole is advanced the packer will slide along the borehole wall surface. The force to advance the packer and the LBHA down the borehole can be from a piston as shown in FIG. **2**, a tractor, weight from drilling collars or other means. Further, the weight of the drilling mud itself in the borehole may provide the force to advance the LBHA.

[0053] There is shown in FIG. **3** an example of the location of an optical fiber **344**, which is located in a tube **346**, which is located within the conveyance device **306**. The outer diameter of the tube **346** and the inner diameter of the conveyance device **306** form annulus **350**. The flow of the gas is also illustrated in FIG. **3**. Thus, there is shown the in-flow path of the gas by arrows **347** and the outflow or return flow of the gas shown by arrows **348**. Accordingly, the gas flows down the tube **346**, through the LBHA **316** and out the bit **326**. The gas then carries the cuttings or debris up the borehole and into openings or ports **352** following the return gas path shown by arrows **348** up the annulus **350** to the surface.

[0054] FIG. **4** provides an illustration of a fluid-gas laser mechanical system. Thus, there is provided a borehole **408** having sidewall surfaces **410** and bottom surface **412** in the earth **402**. A conveyance device **406** extends into the borehole and is attached by attachment means **434** to the LBHA **416**. The LBHA has a non-rotating section **418** and a rotating section **420**. Alternatively, the rotating section could be contained partially or completely within the non-rotating section. The position of bearings and seals with respect to the LBHA and the packers depends upon the positioning of the rotating and non-rotating components. The LBHA **416** is attached to the inner tube **429** of the packer **428** by seal **436**, a first bearing assembly **438** and a second bearing assembly **440**. The flow of the gas is shown by arrows **448**. Ports **452** are also shown in the LBHA. In FIG. **4** the packers are shown inflated and the upper section of the borehole is filled with drilling fluid **414**, which is preferably a drilling liquid. The term "fluid" would include liquid, gas, foams, solid material entrained in a liquid, gas or foam, and combinations of these. The flow paths down or into the LBHA and the return flow path up and out of the LBHA are shown by phantom lines in FIG. **4**. The flow paths around, by or through the bearing assembly may be outside of the bearings, for example a series of openings outside of the outer bearing race, or inside of the bearings, or otherwise provide for the passage of the fluid by the bearings without substantially interfering with the operation of the bearings.

[0055] FIGS. **5**, **5**A and **5**B illustrate a further fluid-gas laser mechanical system. In this system there is provided non-rotating optics **513**, which are optically associated with optical fiber **544**. The optics **513** launch the laser beam **521** through a rotating hollow shaft **538** and into a rotating optics **519**, which optics **519** are located in LBHA **516**. In this way a conventional mud motor **511** using circulating fluid **514**, e.g., a gas, a drilling liquid or drilling mud (arrow **515** shows flow) can be used to rotate the LBHA. In this embodiment the fluid is preferably a drilling liquid, such as drilling mud.

[0056] There is further provided a borehole **508** in the earth **502**. The borehole **508** having sidewall surfaces **510** and a bottom surface **512**. There is provided in the borehole a conveyance device **506** having an optical fiber **544** associated therewith. There is provided a mud motor **511** having non-rotating optics **513**. The mud motor turns hollow shaft **538**, which is contained within connecting housing **536**. Connecting housing **536** does not rotate and connects mud motor **511** via seal and bearing assembly **537** to rotating house **517** of the LBHA **516**. The LBHA optics **519** are held in place within the housing **517** by supports **532**. The laser beam is focused and directed by optics **519**, leaves the optics **519** as beam **523** having a predetermined energy profile and travels through open space in the beam guide or channel within the bit **526** to strike the bottom surface of the borehole **512**. The supports

532 have opening, or provisions, to permit the return gas to flow past them and out of the LBHA.

[0057] Packers **528** are located on, or associated with, the connecting housing **536**. In this way the packers can engage the borehole wall surface and isolate the circulating mud **514** that is used to drive the mud motor, while the rotational movement generated by the mud motor is transferred by the rotating hollow shaft **538** to the LBHA **516**.

[0058] The return flow of the gas is shown by arrows **548**. The return gas moves up the borehole **508** and enters the LBHA through return gas openings **552**. The return gas enters ports **552** through grating **553** associated with housing **517**. The grating **553** is designed to break or otherwise control the particle size of the debris or cuttings that are returned uphole. The return gas travels up through the annulus **540** between the housing **536** and the hollow shaft **538** and then up the conveyance device **506**. Although not shown in FIG. **5**, there would be three separate flow paths in the conveyance device **506**. There is one flow path for the motive fluid for mud motor **511**, which fluid would be returned up the borehole in the annulus formed between the outer surface of the conveyance device **506** and the borehole wall surface **510**. There is a second flow path down the conveyance device into motor **511**, for a clean fluid, e.g., gas, into the passage formed by **538** and into the LBHA **516** and out the bit **526**. The third flow path would be for returns and would start at openings **552** travel to the annulus **540** and up and into a separate return flow path in the conveyance device **506**. The three flow paths, e.g., motive fluid, clean fluid and returns, in the conveyance device **506**, could be side-by-side, concentric, or along the lines of the conveyance devices disclosed in U.S. patent application Ser. No. 13/210,581, filed Aug. 16, 2011, the entire disclosure of which is incorporated herein by reference, and combinations and variations of these. The flow paths around, by or through any bearing assembly may be outside of the bearings, for example a series of openings outside of the outer bearing race, or inside of the bearings, or otherwise provide for the passage of the fluid by the bearings without substantially interfering with the operation of the bearings.

[0059] FIG. **6** illustrates a directional drilling system utilizing the liquid-gas laser-mechanical drilling system. There is provided in the earth **602** a borehole **608**, having sidewall surfaces **610** and a bottom surface **612**. A conveyance device **606** extends from the surface to the LBHA **616**. The LBHA **616** has three steering motors **630**, **632** and **634**, which have arms **631**, **633** and **635** associated therewith. The motors and arms are used to bend the LBHA **616** about an articulation joint **640**. An electric motor **642** is located in the LBHA **616** in the lower section, i.e., below the joint **640**. The motor **642** is used to rotate bit **626** and optics (not shown). An inflatable packer **628** (shown as inflated) is associated with the LBHA **616**. Thus, the motor and arm assemblies can be used to bend the LBHA as far as 8 degrees from a straight axis of the LBHA, or more, in any direction. This system thus can provide for direction drilling and the formation of other than straight boreholes, as well as straight boreholes, and substantially straight boreholes. This LBHA, like the others disclosed herein can be advanced by a tractor, weighted collars, a piston, or the weight of the mud, or an external pressure applied to the drilling liquid or mud. The electric motor and the directional control motors may be configured below the bit drive motor, with a flexible drive shaft passing through the assembly. Thus, providing an assembly with a shorter component below the drive motor, allowing for a tighter turn of the assembly.

[0060] FIG. **7** and FIGS. **7**A to **7**D and **8**A to **8**B show various configurations for conveyance devices. Thus, there is shown the earth **702** having a surface assembly **704** positioned on top of a borehole **708** having sidewall surface **710** and bottom surface **712**. The conveyance device **706** is connected to a LBHA **716**. FIGS. **7**A to **7**D show various cross-sectional views of conveyance devices. Thus, in FIG. **7**A there is provided a conveyance device **706***a*, having an inner member **721**, e.g., a tube, the inner member **721** having an open area or open space **722**. A plurality of lines **723**, e.g., electric conductors, hydraulic lines, tubes, data lines, fiber optics, fiber optics data lines, high power optical fibers, and/or high power optical fibers in a metal tube. The device **706***a* has an outer member **725** and in the area between the outer member **725** and the inner member **721** is filled with and/or contains a supporting or filling medium **724**, e.g., an elastomer or the same or similar material that the inner member and/or outer member is made from.

[0061] In FIG. **7**B there is provided a conveyance device **706***b*, having an inner members, **731***a* and **731***b*, e.g., a tubes, the inner members **731***a* and **731***b* having an open area or open space **732***a*, **732***b* associated therewith. A plurality of lines **733**, e.g., electric conductors, hydraulic lines, tubes, data lines, fiber optics, fiber optics data lines, high power optical fibers, and/or high power optical fibers in a metal tube. The device **706***b* has an outer member **735** and the area between the outer member **735** and the inner members **731***a* and **731***b* is filled with and/or contains a supporting medium **734**, e.g., an elastomer or the same or similar material that the inner member and/or outer member is made from.

[0062] In FIG. **7**C there is provided a conveyance device **706***c*, having inner members, **741***a* and **741***b*, e.g., a tubes, the inner members **741***a* and **741***b* having an open area or open space **742***a*, **742***b* associated therewith. A plurality of lines **743**, e.g., electric conductors, hydraulic lines, tubes, data lines, fiber optics, fiber optics data lines, high power optical fibers, and/or high power optical fibers in a metal tube. The device **706***c* has an outer member **745** and the area between the outer member **745** and the inner members **741***a* and **741***b* is filled with and/or contains a supporting medium **744**, e.g., an elastomer or the same or similar material that the inner member and/or outer member is made from.

[0063] In FIG. **7**D there is provided a conveyance device **706***d*, having an inner member **751**, e.g., a tube, the inner member **751** having an open area or open space **752**. A plurality of lines **753**, e.g., electric conductors, hydraulic lines, tubes, data lines, fiber optics, fiber optics data lines, high power optical fibers, and/or high power optical fibers in a metal tube. The device **706***d* has an outer member **755** and in the area between the outer member **755** and the inner member **751** is filled with and/or contains a supporting medium **754**, e.g., an elastomer or the same or similar material that the inner member and/or outer member is made from.

[0064] FIGS. **8**A and **8**B show a cross section and side view of a composite tube conveyance device. In FIG. **8**A there is provided a cross-section of a composite tube conveyance device **800**. There is an extruded inner member **802**, having an open space **801**. Around the extruded core, preferably in a spiral fashion, lines **803** and **804** are positioned around and along the extruded inner member **802**. A high density polymer **805** then coats and encapsulates the lines and the extruded inner member. The high density polymer **805** forms an outer surface **806** of the composite tube **800**. FIG. **8**B shows the composite with the lines wrapped around the extruded tube but without the high density polymer so that the spiral arrangement can be seen.

[0065] In FIG. **9**A and **9**B there is provided an embodiment of a drilling assembly having an LBHA **901**. The LBHA **901** has a packer assembly **903** having a control line **904**. The LBHA has a laser-bit **902** and has return openings **907**, **908**, **909**. In FIG. **9**A the packer **903** is not expanded.

[0066] In FIG. **9**B the packer is inflated and expanded against the sidewall **906** of borehole **905** to form a seal. Thus, drilling mud **910** is held in the borehole **905** above the packer and gas **911**, under a predetermined pressure and flow rate, is flowed below the packer **903**.

[0067] Turning to FIGS. **10**A to **10**E, there is illustrated snapshots of the advancement of a borehole using the two-packer embodiment of FIG. **2**. In FIG. **10**A the assembly is positioned in a borehole having a borehole sidewall **106** and a bottom surface **1030**. The upper packer **1001** has a control line **1007** and lower packer **1002** has a control line **1008**. The LBHA has a piston **1030** between the upper packer **1001** and the lower packer **1002**. In FIG. **10**A both packers are not extended.

[0068] In FIG. **10**B the upper packer **1001** is inflated and extended against the sidewall **1006** forming a seal. The lower packer **1002** is not inflated. Drilling fluid **1020**, e.g., mud, is held in the borehole above the packer **1001**. Gas **1021** is circulated below the packer **1001** to remove cuttings.

[0069] In FIG. **10**C the upper packer **1001** remains inflated, holding mud **1020** above it. The piston **1030** has been extended to follow the advancement of the borehole and the bottom surface **1030** of the borehole. The lower packer **1002** is not inflated. Gas **1021** is circulated below the packer **1001** to remove cuttings.

[0070] In FIG. **10**D the upper packer **1001** is deflated and retracted from the sidewall **1006**. The lower packer **1002** is inflated and extended into sealing engagement with the sidewall **1006**. The drilling fluid **1020** is held in the borehole above the lower packer **1002**. Gas **1021** is circulated below the packer **1002** to remove cuttings.

[0071] Between the snapshots of FIG. **10**D and FIG. **10**E the piston **1030** has been retracted, while the packer **1002** is engaged against the sidewall **1006**, thus moving the upper packer **1001** down the borehole toward the lower packer **1002**. Upon completion of this movement, as seen in FIG. **10**E, the upper packer **1001** is inflated and extended against the sidewall **1006** forming a seal that holds back the drilling mud **1020**. The lower packer **1002** is deflated and retracted from the sidewall **1006**. Gas **1021** is circulated below packer **1001** to remove cuttings. In this manner the movement illustrated in FIGS. **10**A to **10**E is repeated as the borehole is advanced.

[0072] Moreover, the presences of two or more movable isolation zones, such as in the forgoing examples and illustrations has significant applications in non-laser mechanical processes. Thus, the use of an inflatable packer, or similar device, in association with a conventional, i.e. mechanical, bottom hole assembly provides many advantages. Thus, the forgoing examples and illustrations of isolation systems and methods may be used with a conventional, i.e., mechanical bottom hole assembly. Further, the forgoing examples and illustrations of isolation systems and methods may be used with a non-laser thermal and/or thermal-mechanical bottom hole assembly, such as for example one that employs a flame jet, flame spallation, a plasma jet, a particle jet, particle drilling or an electric arc, or they may be used with a both the forging non-laser systems and a laser system.

[0073] These movable isolation zones may also have significant applications and provide advantages in other down hole activities such as pipe cutting, perforating, window milling, and flow assurance, performed by for example laser, laser-mechanical, laser fluid jet, flame jet, flame spallation, plasma jet, particle jet, particle drilling or electric arc methodologies. Thus, the isolation zones and in particular the movable isolation zones may be employed with cutting, perforating and milling equipment, such as disclosed in U.S. Patent Application Ser. No. 61/378,910, filed Aug. 31, 3010, the entire disclosure of which is incorporated herein by reference.

[0074] Additionally, multiple isolation systems of the present invention may be used in a single borehole, providing the ability to isolate and selectively manage well and borehole pressures and conditions while simultaneously advancing the borehole. This configuration would permit the isolation zones to individually underbalanced, balanced or overbalanced. It would further provide for the ability to precisely manage and control the pressure in each individual isolation zone.

[0075] Moreover, in addition to electric motors, turbines, liquid driven mud motors, air driven mud motors, top drives, a kelly, a rotary table and similar or equivalent means to rotate a drill bit and tubulars associated with a drill bit may be utilized.

[0076] In these embodiments the ability to isolate a medium above an isolation means, which can be advanced in conjunction with the advancement of the borehole, such as an inflatable slidable packer, and to have a second medium that is below the isolation means and preferably circulated and used inter alia to remove cuttings has considerable benefits. For example, for all types of drilling this system provides the ability to isolate and test intervals while drilling. Further, in all types of drilling, e.g., laser-mechanical, thermal-mechanical, laser, thermal, mechanical, etc., the first medium can be a fluid, a liquid, drilling mud, a liquid containing chemicals, heated, steam, a gas, a foam, or other medium that have been or may be useful in a downhole environment. Similarly, the second medium, can be the same as or different from the first media.

[0077] The invention may be embodied in other forms than those specifically disclosed herein without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive, and the scope of the invention is commensurate with the appended claims rather than the foregoing description.

What is claimed:

1. A method of advancing a borehole using a two-phase isolation drilling system, the method comprising:

a. positioning a bottom hole assembly in association with a conveyance device in a borehole, the borehole having a sidewall surface, a bottom surface and a start, the conveyance device having an inflow path and a return path;

b. the bottom hole assembly comprising:

  i. an isolation means;

  ii. a bit, and

  iii. an inflow path and a return path;

c. wherein, the bottom hole assembly inflow path is in fluid communication with the conveyance device inflow path and the bottom hole assembly return path is in fluid communication with the conveyance device return path;

d. activating the isolation means into sealing engagement with the borehole sidewall surface, wherein the borehole

is divided into a first and a second isolation zone, such that the second isolation zone includes the borehole bottom surface;
e. filling the first isolation zone of the borehole with a first medium, such that a predetermined pressure on the borehole surfaces in the first isolation zone is maintained by the first medium;
f. circulating a second medium through the input path of the conveyance device, the input path of the bottom hole assembly, through the bit, through the return path of the bottom hole assembly, and through the return path of the conveyance device; and,
g. engaging the bit against a surface of the borehole and while apply a pressure to the bit, rotating the bit against the borehole surface;
h. whereby, material is removed from the borehole surface and the removed borehole material is transported by the circulating second medium through the return path of the bottom hole assembly and the return path of the conveyance device, such that removed borehole material does not substantially contact the borehole surfaces of the first isolation zone.

2. The method of claim **1**, wherein a high power laser beam having at least about 15 kW of power, is directed through the bottom hole assembly and strikes the borehole surface.

3. The method of claim **2**, wherein the isolation means is a sealing engagement device.

4. The method of claim **2**, wherein the isolation means is an inflatable packer.

5. The method of claim **2**, wherein the isolation means is a slidable engagement device.

6. The method of claim **2**, wherein the first medium is a drilling liquid.

7. The method of claim **6**, wherein the drilling liquid is a drilling mud.

8. The method of claim **2**, wherein the second medium is a fluid transmissive to the laser beam.

9. The method of claim **2**, wherein the second medium is nitrogen.

10. The method of claim **1**, wherein thermal energy is direct by the bottom hole assembly toward the borehole surface.

11. The method of claim **1**, wherein a particle stream is directed by the bottom hole assembly toward the borehole surface.

12. The method of claim **2**, wherein the bit is rotated by an electric motor.

13. The method of claim **5**, wherein the bit is rotated by an electric motor.

14. A method of controlled down hole cutting using liquids, gases and high power laser energy, the method comprising:
a. providing a first isolation zone in a borehole, having a fluid;
b. providing a second isolation zone adjacent a surface in the borehole to be cut, the second isolation zone movably associated with the first isolation zone;
c. flowing a gas into the first isolation zone; and,
d. directing a high power laser beam along a laser beam path to the surface in the borehole, whereby material is cut from the surface by the laser beam; and,
e. moving an isolation zone in association with moving the laser cutting, so that the fluid does not substantially interfere with the laser beam.

15. A system for advancing a borehole while simultaneously using a two-phase medium, the system comprising:
a. a bottom hole assembly;
b. a bottom hole assembly housing;
c. a conveyance device affixed to the bottom hole assembly housing;
d. the bottom hole assembly comprising a rotating section and a non-rotating section;
e. a sealable engagement member; and,
f. the bottom hole assembly comprising at two isolated fluid paths.

16. The system of claim **15**, wherein the bottom hole assembly comprises high power laser optics and a high power laser beam path.

17. A system for advancing a borehole while simultaneously using a two-phase medium, the system comprising:
a. a laser bottom hole assembly;
b. a laser bottom hole assembly housing;
c. a conveyance device affixed to the laser bottom hole assembly housing;
d. the bottom hole assembly comprising a rotating section and a non-rotating section;
e. a sealable engagement member; and,
f. the bottom hole assembly comprising at least two isolated fluid paths.

18. The system of claim **17**, wherein the laser bottom hole assembly comprises an electric motor.

19. The system of claim **17**, wherein the laser bottom hole assembly comprises a mud motor.

20. The system of claim **17**, wherein the laser bottom hole assembly comprises a second sealable engagement member and a piston advancement means.

21. A system for advancing a borehole comprising:
a. a laser bottom hole a assembly having at least two portions;
b. a means for delivering a high power laser beam;
c. a means for convey high power laser energy to the bottom hole assembly; the conveyance means in optical association with the laser bottom hole assembly;
d. a means for rotating a portion of the laser bottom hole assembly;
e. a means for maintaining the relative position of the laser bottom hole assembly within the borehole;
f. the positioning means comprising a means for forming an isolation zone; and,
g. a means for advancing the laser bottom hole assembly.

22. The system of claim **18**, whereby the advancing means is selected from the group constitutes a tractor, a force from the weight of drilling collars, a piston means, or a force from the weight of a drilling fluid.

23. A method of particle drilling to advance a borehole comprising the steps of:
a. setting an sealable engagement member in a borehole to create a first and second isolation zone;
b. filling the first isolation zone with a drilling liquid; and,
c. circulating through the second isolation zone a drilling fluid comprising particles;
d. whereby the particle containing fluid impinges upon a borehole surface to in part advance the borehole, such that the particles are isolated from the second isolation zone.

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