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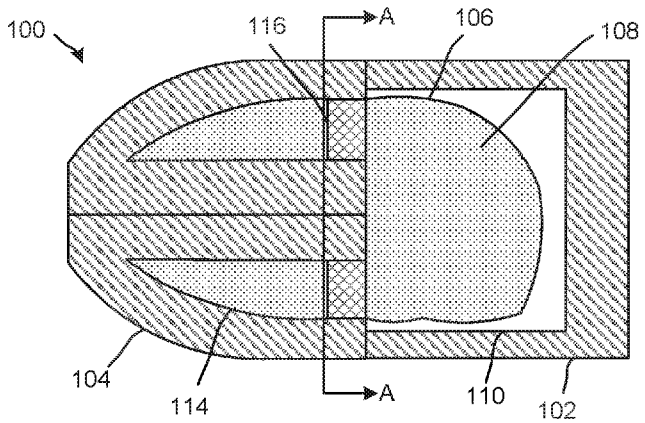

FIG. 1A

(57) Abstract: According to examples, an in-ear device may include a base member having a reservoir that contains a fluid material and an expandable member to be inserted inside an ear canal, in which the expandable member may be attached to the base member. The in-ear device may also include a bladder formed inside the expandable member and an electrically activated pump positioned between the reservoir and the bladder, in which the electrically activated pump may pump fluid material from the reservoir into the bladder to expand the bladder and the expandable member.

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IN-EAR DEVICES

BACKGROUND

[0001] In-ear devices such as earbuds, hearing aids, ear plugs, etc., that are manufactured to fit inside of a human ear canal of one size typically does not fit well within other human ear canal sizes. This is because there is a relatively large natural variation in the sizes of human ear canals. For instance, human ear canals may range in size from about 7 millimeters to more than about 14 millimeters. As such, users are often required to find in-ear devices having the correct sizes to fit comfortably and securely within their ear canals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Features of the present disclosure are illustrated by way of example and not limited in the following figure(s), in which like numerals indicate like elements, in which:

[0003] FIGS. 1A and 1B, respectively, show cross-sectional side views of an example in-ear device during two stages of operation;

[0004] FIG. 1C shows a cross-sectional view of the in-ear device depicted in FIG. 1A taken along lines A-A;

[0005] FIGS. 2A and 2B, respectively, show cross-sectional views of another example in-ear device during two-stages of operation;

[0006] FIGS. 2C and 2D, respectively, show cross-sectional side views of the another example in-ear device depicted in FIGS. 2A and 2B taken along lines B-B and C-C;

[0007] FIG. 3 shows a block diagram of an example in-ear device;

[0008] FIG. 4 shows a block diagram of an example electroosmotic pump;

[0009] FIG. 5 shows a flow diagram of an example method for shifting a shape of an in-ear device; and

[0010] FIG. 6 depicts a flow diagram of an example method for determining a pressure level at a location inside of an expandable member using an electroosmotic pump.

DETAILED DESCRIPTION

[0011] Disclosed herein are in-ear devices that include expandable members that may be expanded to better fit within a user's ear canal and methods for shifting shapes of the in-ear devices. The in-ear devices disclosed herein may include a reservoir containing a fluid material and an electrically activated pump positioned to pump the fluid material from the reservoir into a bladder to cause the bladder and the section of the expandable member in which the bladder is located to expand. A plurality of bladders may be provided around the expandable member and a plurality of electrically activated pumps may be provided to independently pump the fluid material into the plurality of bladders. In this regard, the shape of the expandable member may be varied in multiple locations by varying the amount of the fluid material that is pumped into the plurality of bladders.

[0012] The in-ear devices disclosed herein may also include sensor components that may detect contact and/or pressure levels of contact between the sensor components and surfaces of the ear canal. The sensor components may also detect physiological signals of a user through the ear canal. A controller may control the pumping of fluid material into the plurality of bladders based upon the detected contact by the sensor components. For instance, the electrically activated pumps, which may be electroosmotic pumps, may continue to pump the fluid material into the bladders until it is determined that the sections of the expandable member affected by the bladders are in desired contact with the ear canal. Particularly, a sensor component may be correlated to a bladder and when the sensor component detects that desired contact has been made, flow of the fluid material to that bladder may be stopped. The desired contact may be achieved when the sensor component detects a certain level of pressure and/or when a signal level of the sensor component is improved or maximized.

[0013] Through implementation of the in-ear devices disclosed herein, in-ear devices may be shifted in shape to better conform with an ear canal shape. The shift in the in-ear device shape may enhance comfort and fit within the ear canal as well as improve sound quality by increasing sound isolation and

reducing environmental noise. The shift in the in-ear device shape may also enable sensor components that detect physiological signals to be placed in direct contact with the ear canal, which may improve signal to noise ratios in the signals collected by the sensor components.

[0014] As used herein, the terms "a" and "an" are intended to denote at least one of a particular element, the term "includes" means includes but not limited to, the term "including" means including but not limited to, and the term "based on" means based at least in part on.

[0015] With reference first to FIGS. 1A and 1B, there are respectively shown cross-sectional side views of an example in-ear device 100 during two stages of operation. It should be understood that the in-ear device 100 depicted in FIGS. 1A and 1B may include additional components and that some of the components described herein may be removed and/or modified without departing from a scope of the in-ear device 100 disclosed herein. Generally speaking, the in-ear device 100 may be an ear plug, e.g., a plug that is to be inserted into a user's ear canal to block and/or reduce transmission of sound through the user's ear canal. In addition, the in-ear device 100 may improve the fit within the user's ear canal and thus may reduce transmission of sound through the user's ear canal by increasing in size as discussed herein.

[0016] The in-ear device 100 may include a base member 102 and an expandable member 104 (which is also referenced herein as an ear insert member). The base member 102 and the expandable member 104 may be formed of a resilient material, such as silicone, pliable foam, rubber, or the like. The expandable member 104 may be sized to fit within an ear canal and may have a diameter that is between about 7 mm to about 10 mm. In addition, the expandable member 104 may be integrally formed with the base member 102 or may be attached to the base member 102 through any suitable mechanism, including adhesives, mechanical fasteners, etc. In any regard, as discussed herein, the expandable member 104 may be separately expandable from the base member 102 such that the expandable member 104 may expand inside of a user's ear canal.

[0017] The base member 102 may include a reservoir 106 containing a fluid material 108, such as a liquid, a gel, or the like. The fluid material 108 may be any fluid material 108 that may remain in a fluid state inside the reservoir 106 for at least a certain length of time. By way of particular example, the fluid material 108 may be water or a water-based solution. The reservoir 106 may be composed of a flexible membrane that may reduce in size as the fluid material 108 is expelled from the reservoir 106 and that may expand in size as the fluid material 108 is supplied into the reservoir 106. The reservoir 106 may be made of a rubber material, a plastic material, or the like. In addition, the reservoir 106 may be housed within a cavity 110 inside the base member 102.

[0018] The reservoir 106 may be in fluid communication with a bladder 114 formed in the expandable member 104. The bladder 114 may be formed in a cavity in the expandable member 104. In some examples, the bladder 114 may be part of the reservoir 106, e.g., the membrane of the reservoir 106 may extend into the bladder 114 such that leakage of the fluid material 108 may be prevented. The bladder 114 may also be filled with the fluid material 108. As shown in FIG. 1C, which is a cross-sectional view of the in-ear device 100 taken along lines A-A in FIG. 1A, the expandable member 104 and the bladder 114 may have circular cross-sectional shapes. Additionally, the bladder 114 may extend around a central section of the expandable member 104.

[0019] The in-ear device 100 may also include an electrically activated pump 116 positioned at a conduit between the reservoir 106 and the bladder 114. The electrically activated pump 116, when activated, may apply a sufficient amount of pressure onto the fluid material 108 to flow from the reservoir 106 and into the bladder 114. The amount of pressure applied onto the fluid material 108 may also cause the bladder 114 and the expandable member 104 to expand as shown in FIG. 1B. The movement of the fluid material 108 out of the reservoir 106 may cause the reservoir 106 to shrink as also shown in FIG. 1B. In one regard, the expansion of the expandable membrane 104 may cause the expandable membrane 104 to expand inside the user's ear canal to thus enable the in-ear device 100 to have a tighter fit.

[0020] Depending on the type and configuration of the electrically activated pump 116, the electrically activated pump 116 may be deactivated or operated in a reverse flow to cause the fluid material 108 to be moved from the bladder 114 to the reservoir 106. As discussed herein, the expandable member 104 may be formed of a resilient material and thus, as the fluid material 108 is expelled from the bladder 114 and supplied into the reservoir 106, the expandable member 104 may return to an original size, e.g., as shown in FIG. 1A. The in-ear device 100 may thus be more readily removed from the user's ear canal.

[0021] With reference now to FIGS. 2A and 2B, there are respectively shown cross-sectional side views of another example in-ear device 200 during two stages of operation. It should be understood that the in-ear device 200 depicted in FIGS. 2A and 2B may include additional components and that some of the components described herein may be removed and/or modified without departing from a scope of the in-ear device 200 disclosed herein. Generally speaking, the in-ear device 200 may be an earbud, a hearing aid, or the like. The in-ear device 200 may include some of the same features as the in-ear device 100 depicted in FIGS. 1A and 1B and thus, the same features are not described in detail with respect to FIGS. 2A and 2B.

[0022] The in-ear device 200 may include a base member 102 and an expandable member 104. As discussed above, the base member 102 and the expandable member 104 may be formed of a resilient material and the expandable member 104 may be sized to fit within an ear canal. The base member 102 may also include multiple reservoirs 106 containing the fluid material 108. The reservoirs 106 may each be composed of a flexible membrane that may reduce in size as the fluid material 108 is expelled from the reservoirs 106 and may expand in size as the fluid material 108 is introduced into the reservoirs 106. In addition, the reservoirs 106 may be housed within cavities 110 inside the base member 102. The cavities 110 may be in fluid communication with an ambient environment via air exhaust holes 112 to enable the reservoirs 106 to expand and contract.

[0023] Each of the reservoirs 106 may be in fluid communication with a

respective bladder 114 formed in the expandable member 104. In some examples, the bladders 114 may be parts of the reservoirs 106, e.g., a reservoir 106 may extend into a bladder 114. The bladders 114 may also be filled with the fluid material 108. As shown in FIG. 2C, which is cross-sectional view of the in-ear device 200 taken along lines B-B in FIG. 2A, the bladders 114 may be positioned around multiple locations of the expandable member 104. Although the bladders 114 are depicted as being in fluid communication with respective reservoirs 106, it should be understood that that a reservoir 106 may be in fluid communication with multiple ones of the bladders 114.

[0024] The in-ear device 100 may also include electrically activated pumps 116 positioned at conduits between the reservoirs 106 and the bladders 114, a power source 118, and a controller 120 to control delivery of power to the electrically activated pumps 116. The power source 118 may be a removable battery and/or a rechargeable battery and the controller 120 may be circuitry, e.g., a logic component, that may control delivery of power from the power source 118 to the electrically activated pumps 116. When supplied with power, e.g., voltage, the electrically activated pumps 116 may apply a sufficient amount of pressure on the fluid material 108 to cause the bladders 114 to expand. The expansion of the bladders 114 may cause the expandable member 104 to also expand. Although four bladders 114 and four electrically activated pumps 116 are depicted, it should be understood that the in-ear device 200 may include additional bladders 114 and pumps 116, which may enable greater control in the shifting of the shape of the expandable member 104.

[0025] In some examples, the controller 120 may control the electrically activated pumps 116 as a group such that the electrically activated pumps 116 are activated together. In some examples, the controller 120 may independently control the electrically activated pumps 116 to pump fluid material 108 individually into the bladders 114. An example of the controller 120 independently controlling an electrically activated pump 116 is depicted in FIGS. 2B and 2D. FIG. 2D shows a cross-sectional side view of the in-ear device 200 taken along lines C-C in FIG. 2B. As shown in FIGS. 2B and 2D, one of the electrically activated pumps 116 is supplied with voltage while the other electrically activated pumps 116

remain inactive. In this regard, one section of the expandable member 104 may expand while the other sections of the expandable member 104 remain in a normal or collapsed state. It is therefore contemplated that the controller 120 may vary the shape and the size of the expandable member 104 by varying the supply of power to the electrically activated pumps 116.

[0026] In any regard, an opening 122 may extend laterally through a central portion of the expandable member 104. A support element 124 may be provided around the periphery of the opening 122 to prevent or minimize expansion of the bladder 114 and the expandable member 104 into the opening 122. The support element 124 may thus be formed of a rigid material, e.g., metal, plastic, or the like, that may provide a support upon which the expandable member 104 may expand outwardly as shown in FIGS. 2B and 2D.

[0027] The in-ear device 200 may also include sensor components 126 located around the periphery of the expandable member 104. For instance, a sensor component 126 may be provided in line with a respective one of the bladders 114. In other examples, a single sensor component 126 may be provided on the expandable member 104. Each of the sensor components 126 may be attached one end thereof to the expandable member 104 to enable the sensor components 126 to remain attached to the expandable member 104 as the expandable member 104 expands or contracts. The sensor components 126 may additionally or in other examples, be attached in other manners to the expandable member 104 without restricting the expansion and contraction of the expandable member 104. By way of example, the sensors components 126 may be attached through use of adhesives, welds, or the like.

[0028] The sensor components 126 may include electrodes and may thus be formed of a metallic material. The sensor components 126 may detect, for instance, when the sensor components 126 have come into contact with a surface and/or the amount of pressure being applied onto the sensor components 126 by a surface, such as the surface of an ear canal. The sensor components 126 may detect these conditions through, for instance, capacitive sensing, pressure sensing, or the like.

[0029] The sensor components 126 may be in communication with the controller 120 and thus, the controller 102 may determine which of the sensor components 126 is in contact with the ear canal. In some examples, the controller 120 may supply power to respective ones of the electrically activated pumps 116 to cause certain sections of the expandable member 104 to expand and thus change the shape of the expandable member 104 based upon which of the sensor components 126 detected contact with the ear canal. That is, for instance, if a particular sensor component 126 does not detect that there is contact, the controller 120 may supply power to the electrically activated pump 116 of the bladder 114 that is in-line with the particular sensor component 126. Additionally, the controller 120 may continue to supply power to that electrically activated pump 116 until the controller 120 determines that the particular sensor component 126 has detected that there is contact and/or that the amount of detected pressure exceeds a certain threshold value. The controller 120 may cause the shape of the expandable member 104 to be modified until each of the sensor components 126 has detected that there is contact and/or that the amount of detected pressure exceeds a certain threshold value. In this manner, the shape of the expandable member 104 may match the shape of the section of the ear canal into which the expandable member 104 is inserted.

[0030] The sensor components 126 may additionally or in other examples make physiological sensor readings. The physiological sensor readings may include any of, for instance, electrocardiogram (ECG) readings, electroencephlagram (EEG) readings, blood pressure readings, heart rate readings, or the like. The sensor components 126 may communicate the physiological sensor readings to the controller 120 and the controller 120 may communicate the received readings to a computing device (not shown), such as a smartphone, a laptop computer, a smartwatch, or the like. The controller 120 may communicate with the computing device through a wired or a wireless connection, such as via a Bluetooth™ connection. The in-ear device 200 may include an aperture 128 through which an antenna and/or a cable may be inserted into the interior of the base member 102.

[0031] According to examples, the controller 120 may vary the supply of

power to the electrically activated pumps 116 to vary the contact between the sensor components 126 and the ear canal wall. For instance, the controller 120 may vary the contact to improve the readings collected by the sensor components 126. In other words, the controller 120 may vary the shape of the expandable membrane 104 until the sensor components 126 are determined to have maximal contact with the ear canal wall, which may result in improved signal-to-noise ratios of the readings that the sensor components 126 have collected. The controller 120 may thus track the readings by the sensor components 126 as the shape of the expandable member 104 is modified to determine the shape that results in the highest readings.

[0032] In some examples, the sensor components 126 may be integrated into the expandable membrane 104. In these examples, conductive filaments may be provided on the surface and/or within the expandable membrane 104. In addition, or in other examples, the expandable membrane 104 may be formed of a conductive polymer material, such as polyaniline.

[0033] The in-ear device 200 may also include audio components 130. The audio components 130 may include any of a speaker, a microphone, a digital signal processor (DSP), a radio for receiving wireless signals, and the like. The speaker may be implemented to output audio, e.g., speech, music, etc., through the opening 122. The microphone may be used to capture a user's speech or other external noises. The DSP may perform noise suppression of signals received from the sensor components 126, classification and contextual analysis of the data acquired by the sensor components 126 and the microphone, noise suppression from an external microphone acquired signal and desired signal, playback enhancement of a desired signal, or the like. The radio may receive and enhance WiFi and/or Bluetooth™ signals.

[0034] Turning now to FIG. 3, there is shown a block diagram of an example in-ear device 300. It should be understood that the in-ear device 300 depicted in FIG. 3 may include additional components and that some of the components described herein may be removed and/or modified without departing from a scope of the in-ear device 300 disclosed herein.

[0035] The in-ear device 300 may be equivalent to the in-ear device 200 depicted in FIGS. 2A-2D and the in-ear device 300 is described with respect to the components described above with respect to the in-ear device 200. As shown, the in-ear device 300 may include a controller 302, which may be equivalent to the controller 120. The in-ear device 300 may also include a power source 304 and a plurality of electrically activated pumps 306-1 to 306-N, in which the variable "N" may represent an integer value greater than one. The power source 304 may be equivalent to the power source 118 and the electrically activated pumps 306-1 to 306-N may be equivalent to the electrically activated pumps 116 depicted in FIGS. 2A and 2B. The in-ear device 300 may further include audio components 308 and sensors 308-1 to 308-M, in which the variable "M" may represent an integer value greater than one. The audio components 308 may be equivalent to the audio components 130 and the sensors 308-1 to 308-M may be equivalent to the sensor components 126 depicted in FIGS. 2A and 2B.

[0036] The in-ear device 300 may further include an input device 312 through which a user may input commands to the controller 302. The input device 312 may be a user interface on base member 102, such as a button, a touchpad, a switch, or the like. The input device 312 may also be an interface through which the controller 302 may receive commands from a computing device, such as a smartwatch, a smartphone, a tablet computer, a laptop computer, or the like. In any regard, in response to receipt of a command from the input device 312, the controller 302 may control the supply of power from the power source 304 to the pumps 306-1 to 306-N. According to examples, the pumps 306-1 to 306-N may each be an electroosmotic pump as shown, for instance, in FIG. 4. One electroosmotic pump 306-1 is depicted in FIG. 4, but is should be understood that the remaining electroosmotic pumps 306-2 to 306-N may be similarly configured to the electroosmotic pump 306-1.

[0037] The electroosmotic pump 306-1 may include a first electrode layer 402 and a second electrode layer 404. Each of the layers 402 and 404 may be formed of a porous material and/or may include a porous structure. The electroosmotic pump 306-1 may also include a porous media 406 sandwiched between the first electrode layer 402 and the second electrode layer 404. The

first electrode layer 402 and the second electrode layer 404 may be coupled to the power source 304, which may supply a voltage differential between the first electrode layer 402 and the second electrode layer 404. The voltage differential may drive fluid material 108 from one side of the electroosmotic pump 306-1 to the other side of the electroosmotic pump 306-1. The controller 302 may control the voltage differential level across the first electrode layer 402 and the second electrode layer 404 to thus control the flow rate at which the fluid material 108 flows across the electroosmotic pump 306-1. That is, the greater the voltage differential level, the greater the flow rate.

[0038] As discussed above, the flow of the fluid material 108 may be from a reservoir 106 to a bladder 114 to expand a section of the expandable member 104. As also discussed herein, the controller 302 may continue to supply power to the electroosmotic pump 306-1 until a maximum condition is reached, until a feedback indicating that the pumping is to stop is received, until a command to stop pumping is received, or the like. Additionally, the controller 302 may reverse the polarity of the voltage differential between the first electrode layer 402 and the second electrode layer 404 to cause the fluid material 108 to flow in the opposite direction, e.g., from the bladder 114 to the reservoir 106. In other examples, the fluid material 108 may flow back from the bladder 114 to the reservoir 106 when voltage to the first and second electrode layer 402, 404 due to the compression of the expandable member 104 caused by the resiliency of the expandable member 104.

[0039] Various manners in which the in-ear device 300 may be implemented are discussed in greater detail with respect to the method 500 depicted in FIG. 5. Particularly, FIG. 5 depicts an example method 500 for shifting a shape of an in-ear device 300. It should be apparent to those of ordinary skill in the art that the method 500 may represent generalized illustrations and that other operations may be added or existing operations may be removed, modified, or rearranged without departing from the scope of the method 500.

[0040] The description of the method 500 is made with reference to the in-ear device 300 illustrated in FIG. 3 for purposes of illustration. It should, therefore, be understood that in-ear devices having other configurations may be implemented to perform the method 500 without departing from a scope of the method 500.

[0041] At block 502, a voltage may be supplied to an electroosmotic pump 306-1 to cause a fluid material 108 to be pumped from a reservoir 106 in a base member 102 to a bladder 114 in an expandable member 104. The pumping of the fluid material 108 may cause the bladder 114 and the expandable member 104 to expand as discussed above. As also discussed above, the controller 302 may control the power source 304 to apply a voltage differential across the electrode layers 402 and 404 of the electroosmotic pump 306-1 in order to pump the fluid material 108.

[0042] At block 504, the pressure level at a location inside of or on the expandable member 104 may be determined. According to examples, the sensors 310-1 to 310-M may be implemented to detect the pressure level, e.g., the amount of pressure applied to an exterior surface of the expandable member 104. In addition or in other examples, a pressure sensor (not shown) may be provided inside of a bladder 114 and may detect the pressure level inside of the expandable member 104. In still other examples, the electroosmotic pump 306-1 may be implemented to detect the pressure level as discussed in greater detail herein below with respect to the flow diagram 600 depicted in FIG. 6. In any regard, the pressure level inside of or on the expandable member 104 may increase as the electroosmotic pump 306-1 continues to pump the fluid material 108 into the bladder 114.

[0043] At block 506, the controller 302 may determine whether the pressure level determined at block 504 is equal to or exceeds a certain threshold. The certain threshold may be a pressure level that corresponds to an outer surface or multiple outer surfaces of the expandable member 104 contacting the ear canal. The certain threshold may be user defined and/or may be determined through testing.

[0044] In response to a determination that the determined pressure level does not equal or exceed the certain threshold, voltage may continue to be supplied to the electroosmotic pump 306-1 as indicated at block 502. In addition, blocks 502-506 may be repeated until the controller 302 determines that the determined pressure level equals or exceeds the certain threshold at block 506. In response to a determination at block 506 that the determined pressure level equals or exceeds the certain threshold, the controller 302 may cease flow of the fluid material 108 from the reservoir 106 to the bladder 114 as indicated at block 508. For instance, the controller 302 may cease the supply of the voltage to the electroosmotic pump 306-1. In other examples, the controller 302 may supply voltage at a certain level to the electroosmotic pump 306-1 to stop the fluid material 108 from flowing into or out of the bladder 114. That is, for instance, application of the voltage at the certain level may counteract the pressure applied by the expandable member 104 as the expandable member 104 contracts, which may cause the fluid material 108 to be forced back into the reservoir 106. The certain level may be an appropriate level that that sufficiently counteracts the pressure applied by the expandable member 104.

[0045] According to examples in which the in-ear device 300 includes multiple electroosmotic pumps 306-1 to 306-N, multiple sensors 310-1 to 310-M, and multiple bladders 114, the controller 302 may control the application of voltage to each of the electroosmotic pumps 306-1 to 306-N separately according to the method 500. For instance, the controller 302 may supply voltage to each of the electroosmotic pumps 306-1 to 306-N and may cease the supply of the voltage at different times, e.g., when the sensors 310-1 to 310-M respectively corresponding to the electroosmotic pumps 306-1 to 306-N individually detects that the pressure levels have reached or exceeded the certain threshold.

[0046] Turning now to FIG. 6, there is shown a flow diagram of an example method 600 for determining a pressure level at a location inside of an expandable member 104 using an electroosmotic pump 306-1. The method 600 may be implemented, for instance, at block 504 in FIG. 5.

[0047] At block 602, the controller 302 may cease supply of voltage to an

electroosmotic pump 306-1. When the supply of voltage is ceased, the fluid material 108 in the bladder 114 may flow back through the electroosmotic pump 306-1 from the bladder 114 and into the reservoir 106. As the fluid material 108 flows across the electroosmotic pump 306-1, e.g., in the opposite direction than as shown in FIG. 4, a voltage may be generated between the second electrode layer 404 and the first electrode layer 402. The controller 302 may detect the voltage, e.g., the return voltage, as indicated at block 604. The amount of voltage generated may vary depending upon the rate at which the fluid material 108 flows across the electroosmotic pump 306-1. In addition, the rate at which the fluid material 108 flows across the electroosmotic pump 306-1 may depend upon the amount of pressure being applied on the bladder 114, e.g., the greater the pressure, the greater the flow rate. Thus, correlations between detected voltages and pressure levels inside the expandable member 104, and particularly, within a bladder 114, may be determined through testing and/or calculations and stored in a data store.

[0048] At block 606, the controller 302 may correlate the detected return voltage to a pressure level inside the expandable member. For instance, the controller 302 may access a data store containing the correlations between the detected voltages and the pressure levels inside the expandable member 104 to correlate the detected return voltage to the pressure level. The controller 302 may determine the correlated pressure level as the determined pressure level inside of the expandable member 104.

[0049] Although described specifically throughout the entirety of the instant disclosure, representative examples of the present disclosure have utility over a wide range of applications, and the above discussion is not intended and should not be construed to be limiting, but is offered as an illustrative discussion of aspects of the disclosure.

[0050] What has been described and illustrated herein is an example of the disclosure along with some of its variations. The terms, descriptions and figures used herein are set forth by way of illustration only and are not meant as limitations. Many variations are possible within the spirit and scope of the

disclosure, which is intended to be defined by the following claims -- and their equivalents -- in which all terms are meant in their broadest reasonable sense unless otherwise indicated.

What is claimed is:

1. An in-ear device comprising:

a base member having a reservoir that contains a fluid material;

an expandable member to be inserted inside an ear canal, the expandable member being attached to the base member;

a bladder formed inside the expandable member; and

an electrically activated pump positioned between the reservoir and the bladder, the electrically activated pump to pump fluid material from the reservoir into the bladder to expand the bladder and the expandable member.

2. The in-ear device according to claim 1, further comprising:

a plurality of bladders formed at multiple locations inside the expandable member;

a plurality of electrically activated pumps positioned between the reservoir and the plurality of bladders; and

a controller to control the plurality of electrically activated pumps to control the flow of fluid from the reservoir into the plurality of bladders.

3. The in-ear device according to claim 2, further comprising:

a plurality of sensor components to detect contact with an external surface; and

wherein the controller is to independently control the plurality of electrically activated pumps to pump the fluid material into the plurality of bladders according to the detected contact by the plurality of sensor components.

4. The in-ear device according to claim 1, wherein the expandable member comprises an opening extending laterally through the expandable member, the in-ear device further comprising:

a support element provided within the opening to restrict expansion of the expandable member into the opening.

5. The in-ear device according to claim 1, wherein the electrically activated pump is an electroosmotic pump that includes:

a porous media having a first side and a second side;

a first electrode layer in contact with the first side of the porous media;

a second electrode layer in contact with a second side of the porous media, wherein the first electrode layer and the second electrode layer are porous; and

wherein a voltage is to be supplied to the first electrode layer and the second electrode layer to operate the electroosmotic pump at a certain flow rate..

6. The in-ear device according to claim 5, further comprising:

a power source coupled to the first electrode layer and a second electrode layer;

a controller to control the power source; and

at least one of a speaker, a microphone, a digital signal processor (DSP), and a radio for receiving wireless signals.

7. The in-ear device according to claim 6, wherein the DSP is to at least one of:

perform signal noise suppression;

classify signals acquired by an electrode;

suppress noise from an external microphone acquired signal that includes noise and a desired signal; and

perform contextual analysis.

8. The in-ear device according to claim 1, further comprising:

a plurality of sensor components attached to an outer surface of the expandable member, the sensor components to detect a physiological state inside the ear canal;

a plurality of electrically activated pumps positioned in relation to the plurality of sensor components; and

a controller to control the plurality of electrically activated pumps to expand

the expandable member to position the plurality of sensor components in contact with the ear canal.

9. An ear bud comprising:

a base member comprising a cavity housing a reservoir, the reservoir containing a fluid material;

an ear insert member attached to the base member, wherein the ear insert member is to be inserted inside an ear canal;

a plurality of bladders provided inside the ear insert member;

a plurality of electroosmotic pumps, wherein each of the plurality of electroosmotic pumps is positioned between the reservoir and a respective bladder of the plurality of bladders; and

a controller to control the plurality of electroosmotic pumps to individually control the flow of the fluid material from the reservoir into the plurality of bladders and vary a shape of the ear insert member.

10. The ear bud according to claim 9, wherein the electroosmotic pump includes:

a porous media having a first side and a second side;

a first electrode layer in contact with the first side of the porous media;

a second electrode layer in contact with a second side of the porous media, wherein the first electrode layer and the second electrode layer are porous; and

wherein the ear bud further comprises a power source coupled to the first electrode layer and a second electrode layer.

11. The ear bud according to claim 10, wherein the controller is to receive a detected voltage level across an electroosmotic pump of the plurality of electroosmotic pumps and to calculate a pressure inside the bladder that is fluid communication with the electroosmotic pump based upon detected voltage, wherein the detected voltage level corresponds to a flow of fluid through the electroosmotic pump from the bladder to the reservoir.

12. The ear bud according to claim 11, wherein the controller is further to:

determine whether the pressure inside the bladder has reached a certain threshold;

in response to a determination that the pressure inside the bladder has not reached the certain threshold, continue to supply voltage to the electroosmotic pump to cause the fluid material to continue to flow from the reservoir to the bladder; and

in response to a determination that the pressure inside the bladder has reached the certain threshold, supply voltage at a certain level to the electroosmotic pump to prevent the fluid material from flowing back from the bladder to the reservoir.

13. A method comprising:

supplying a voltage to an electroosmotic pump positioned between a reservoir in a base member and a bladder in an expandable member to be inserted into an ear canal, wherein the supply of the voltage to the electroosmotic pump causes the electrostatic pump to pump a fluid material from the reservoir to the bladder to expand the expandable member;

determining a pressure level at a location inside of or on the expandable member;

determining whether the pressure level at the location equals or exceeds a certain threshold; and

ceasing flow of the fluid material from the reservoir to the bladder in response to the determined pressure level equaling or exceeding the certain threshold.

14. The method according to claim 13, further comprising:

supplying the voltage to a plurality of electroosmotic pumps positioned between the reservoir and a plurality of bladders;

determining whether a pressure level at multiple locations inside of or on the expandable member equals or exceeds a certain threshold; and

for each of the multiple locations having a pressure level that equals or exceeds the certain threshold, ceasing flow of the fluid material from the reservoir to the bladder in that location.

15. The method according to claim 13, wherein determining the pressure level at a location of the expandable member further comprises:

ceasing supply of the voltage to the electroosmotic pump to cause the fluid material to flow from the bladder to the reservoir, wherein the flow of the fluid material from the bladder to the reservoir causes a return voltage to be generated across the electroosmotic pump;

detecting a return voltage level across the electroosmotic pump; and

correlating the detected return voltage level to the pressure level at the location inside of or on the expandable member.

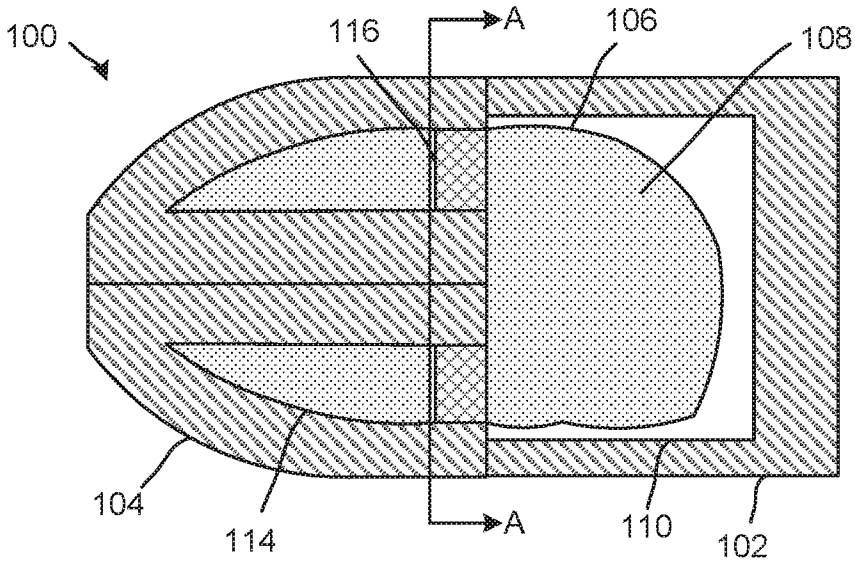


FIG. 1A

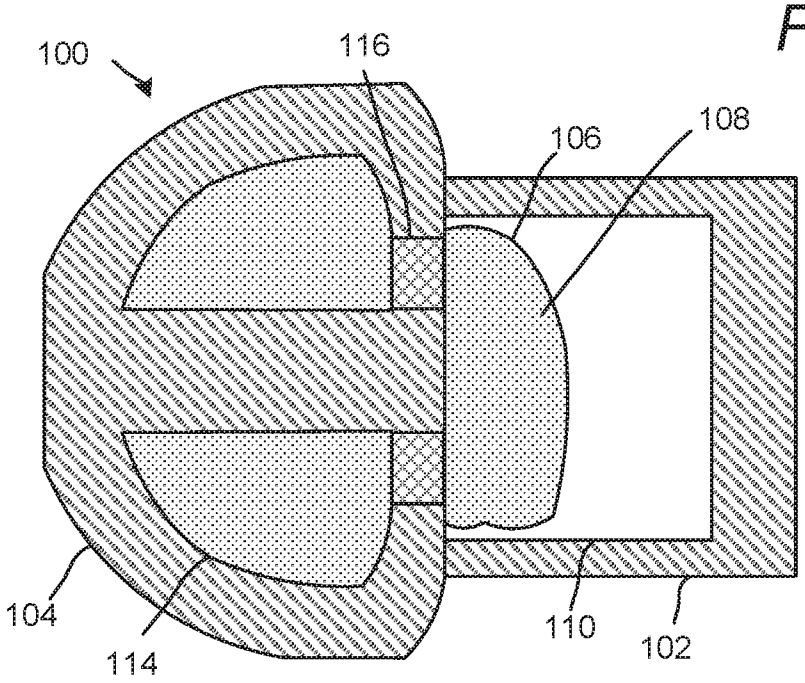


FIG. 1B

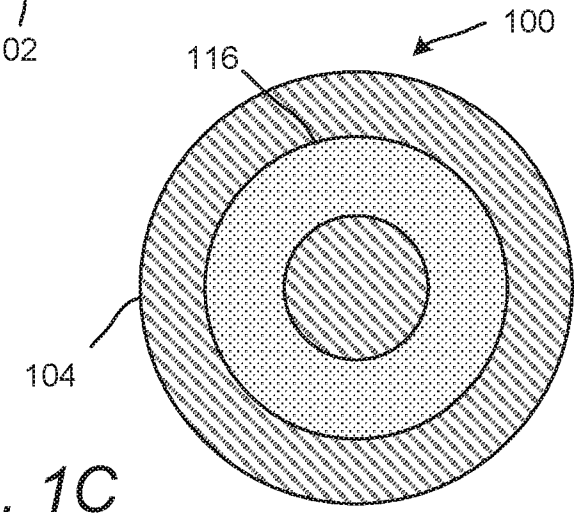
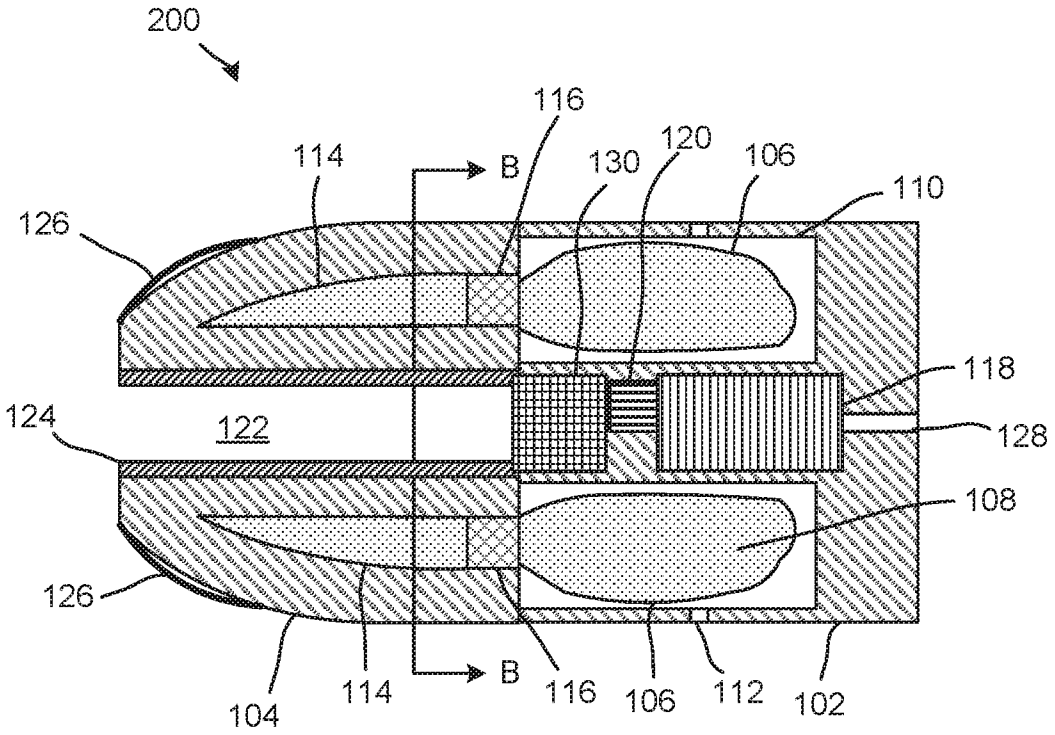


FIG. 1C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116
114
B
130
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122
128
108
126
B
104
114
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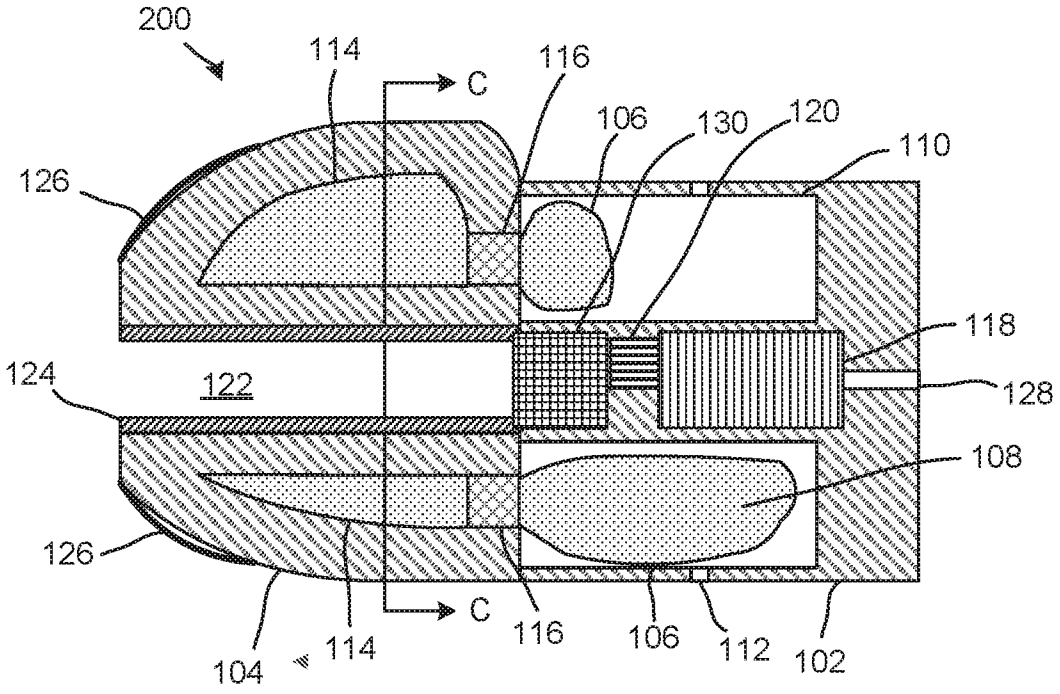
106
112
102

FIG. 2A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114
C
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126
C
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106
112
102

FIG. 2B

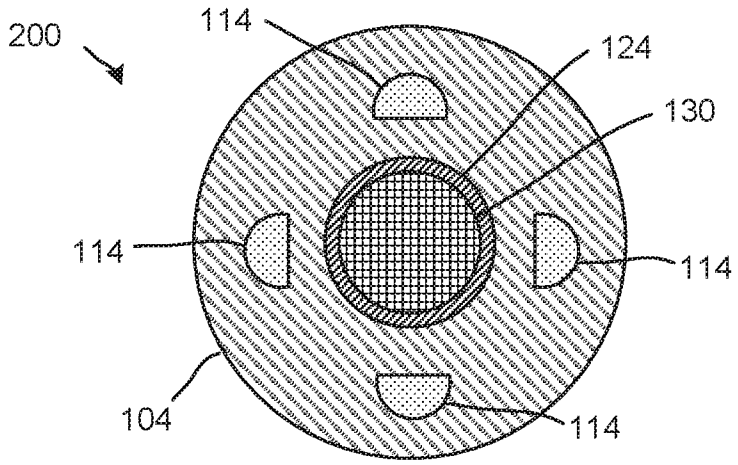


FIG. 2C

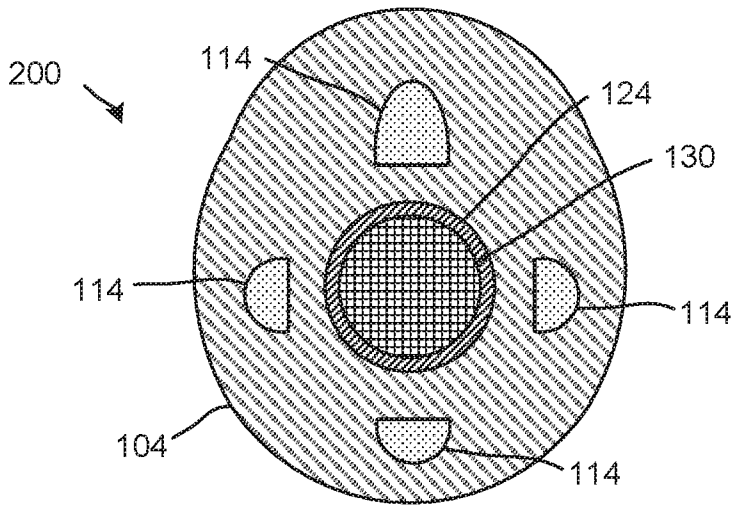
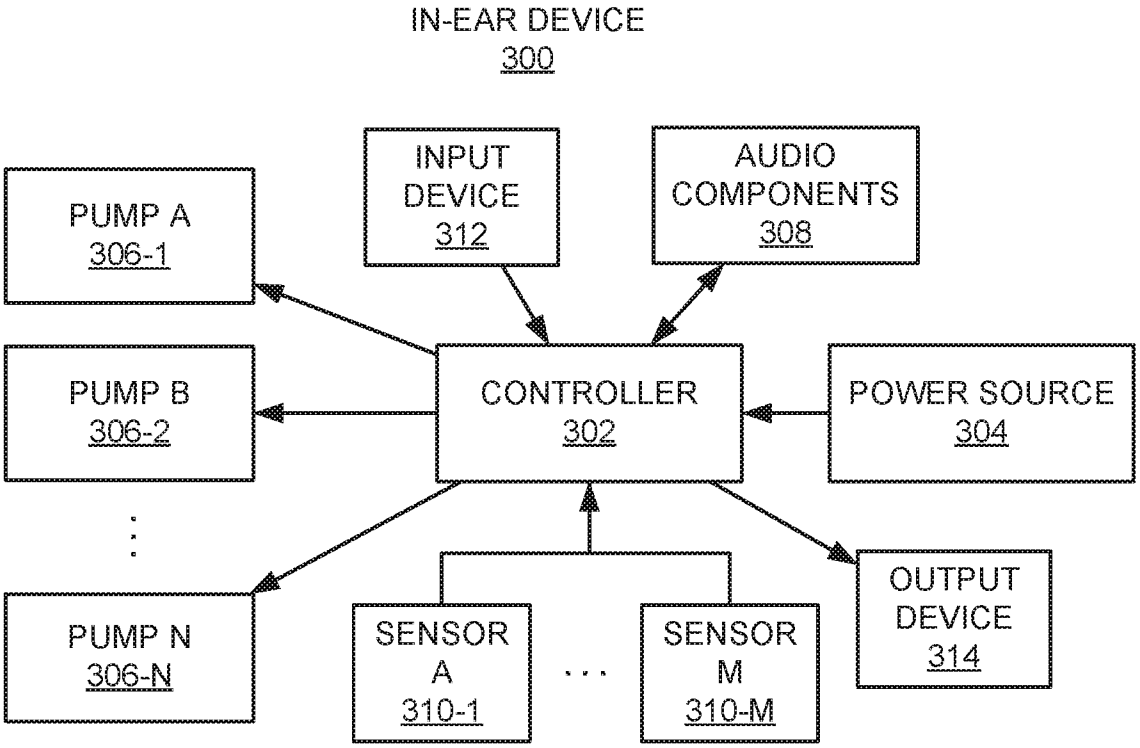


FIG. 2D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300
INPUT DEVICE
312
AUDIO COMPONENTS
308
PUMP A
306-1
PUMP B
306-2
CONTROLLER
302
POWER SOURCE
304
PUMP N
306-N
SENSOR A
310-1
SENSOR M
310-M
OUTPUT DEVICE
314

FIG. 3

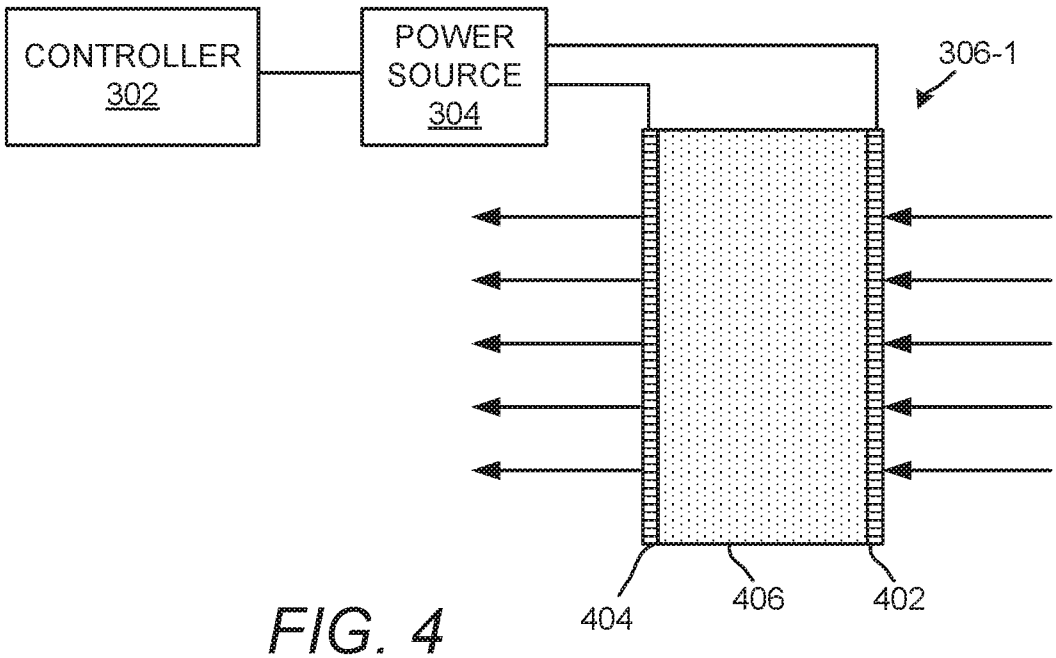
CONTROLLER
302
POWER SOURCE
304
306-1
404
406
402

FIG. 4

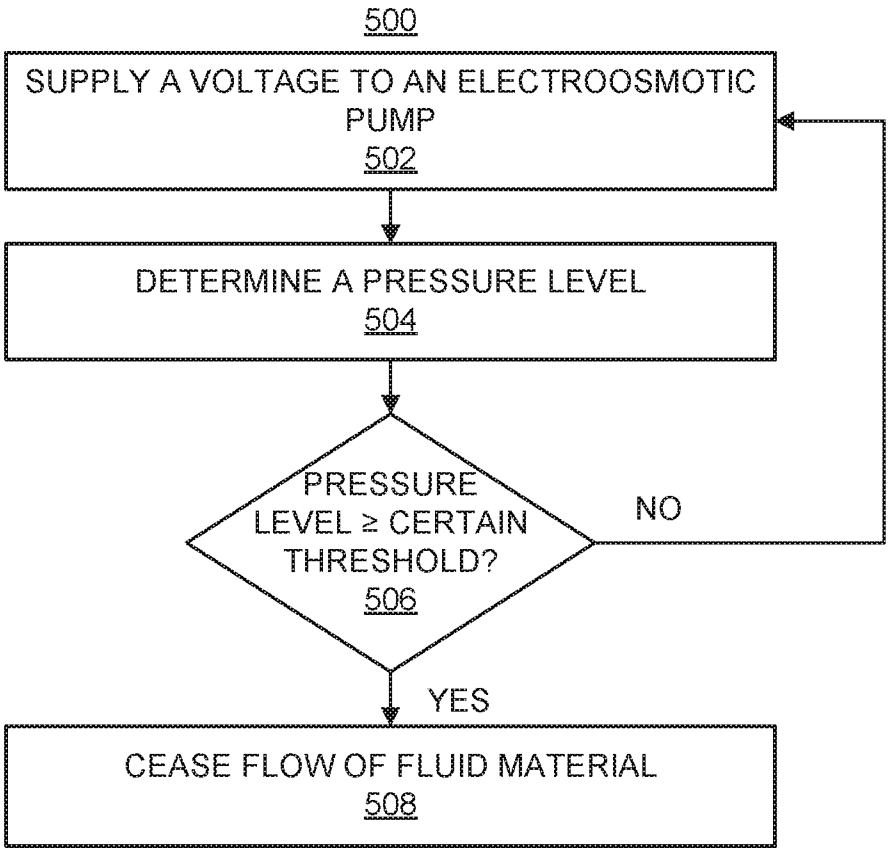
500
SUPPLY A VOLTAGE TO AN ELECTROOSMOTIC PUMP
502
DETERMINE A PRESSURE LEVEL
504
PRESSURE LEVEL ≥ CERTAIN THRESHOLD?
506
NO
YES
CEASE FLOW OF FLUID MATERIAL
508

FIG. 5

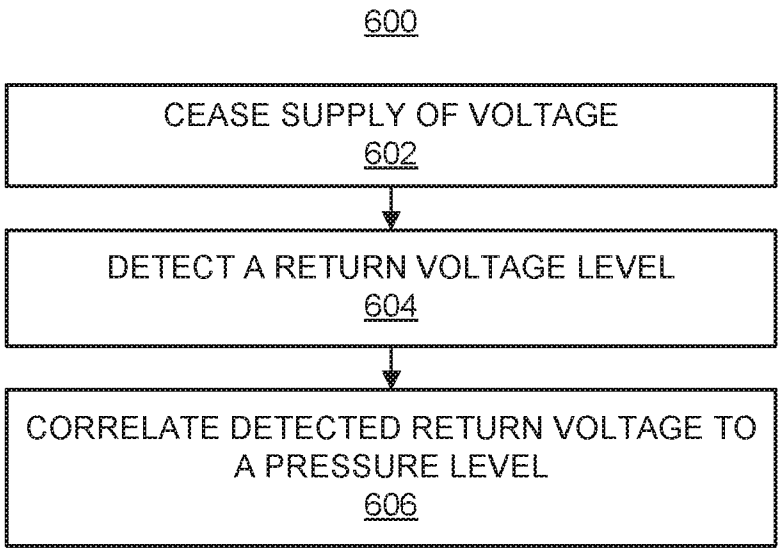
600
CEASE SUPPLY OF VOLTAGE
602
DETECT A RETURN VOLTAGE LEVEL
604
CORRELATE DETECTED RETURN VOLTAGE TO A PRESSURE LEVEL
606

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/029962

A. CLASSIFICATION OF SUBJECT MATTER

A61F 11/00 *(2006.01)*
A61F 11/10 *(2006.01)*

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B 17/00, A61F 2/00, 11/00, H04R 1/00, A61F 11/06, 11/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), DWPI, Esp@cenet, Google, Yandex, Patentscope

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2017/0026732 A1 (HARMAN INTERNATIONAL INDUSTRIES, INC.) 26.01.2017, paragraphs [0002], [0009], [0027], [0031] - [0033], [0037] - [0038], [0042], fig. 2	1-8, 11-15
Y	US 2004/0215053 A1 (MATIN BONDO JORGENSEN et al.) 28.10.2004, fig. 1, paragraphs [0016] - [0017], [0022]	1-12
Y	US 2016/0025083 A1 (SOGANG UNIVERSITY RESEARCH FOUNDATION) 28.01.2016, fig. 4, abstract, paragraphs [0002], [0020], [0045]	1-15
Y	US 2016/0058619 A1 (OIDO NOVA LTD) 03.03.2016, paragraphs [0042], [0050], [0090]	3, 9-12, 14
Y	US 4133984 A (KOKEN CO., LTD.) 09.01.1979, fig. 1	4

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2017 (28.09.2017)	21 December 2017 (21.12.2017)

Name and mailing address of the ISA/RU:	Authorized officer
Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Y. Skvortsova Telephone No. (495)531-64-81