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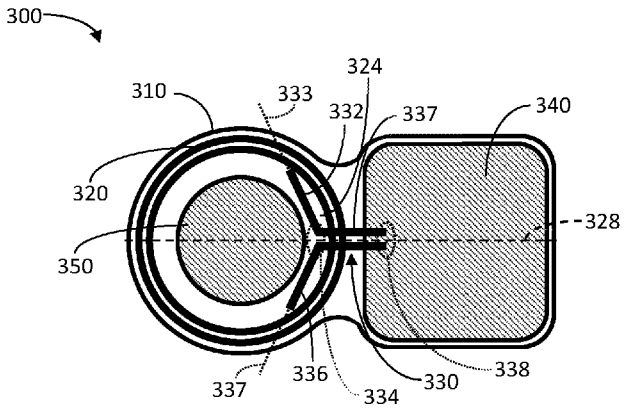
(54) **Title:** IMPLANT WITH INDUCTION COIL AND ANTENNA WITH VERTEX

FIG. 2A:



(57) **Abstract:** An apparatus includes a casing configured to be implanted on or within a recipient's body, an electrically conductive and substantially planar coil within the casing and configured to inductively receive power signals from a device external to the recipient's body, and an antenna within the casing and configured to receive and/or transmit data signals. The antenna includes an electrically conductive first portion extending from a vertex in a first direction and an electrically conductive second portion extending from the vertex in a second direction different from the first direction. The vertex is within a volume encircled by the coil and extending above and below the coil along a direction substantially perpendicular to the coil.

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[Continued on next page]

Declarations under Rule 4.17:

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

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

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IMPLANT WITH INDUCTION COIL AND ANTENNA WITH VERTEX

BACKGROUND

Field

[0001] The present application relates generally to systems and methods for wirelessly communicating data to and/or from a device implanted on or within a recipient's body.

Description of the Related Art

[0002] Medical devices have provided a wide range of therapeutic benefits to recipients over recent decades. Medical devices can include internal or implantable components/devices, external or wearable components/devices, or combinations thereof (e.g., a device having an external component communicating with an implantable component). Medical devices, such as traditional hearing aids, partially or fully-implantable hearing prostheses (e.g., bone conduction devices, mechanical stimulators, cochlear implants, etc.), pacemakers, defibrillators, functional electrical stimulation devices, and other medical devices, have been successful in performing lifesaving and/or lifestyle enhancement functions and/or recipient monitoring for a number of years.

[0003] The types of medical devices and the ranges of functions performed thereby have increased over the years. For example, many medical devices, sometimes referred to as "implantable medical devices," now often include one or more instruments, apparatus, sensors, processors, controllers or other functional mechanical or electrical components that are permanently or temporarily implanted in a recipient. These functional devices are typically used to diagnose, prevent, monitor, treat, or manage a disease/injury or symptom thereof, or to investigate, replace or modify the anatomy or a physiological process. Many of these functional devices utilize power and/or data received from external devices that are part of, or operate in conjunction with, implantable components.

SUMMARY

[0004] In one aspect disclosed herein, an apparatus comprises a casing configured to be implanted on or within a recipient's body. The apparatus further comprises an electrically conductive and substantially planar coil within the casing. The coil is configured to inductively receive power signals from a device external to the recipient's body. The apparatus further

comprises an antenna within the casing and configured to receive and/or transmit data signals. The antenna comprises an electrically conductive first portion extending from a vertex in a first direction. The vertex is within a volume encircled by the coil and extending above and below the coil along a direction substantially perpendicular to the coil. The antenna further comprises an electrically conductive second portion extending from the vertex in a second direction different from the first direction.

[0005] In another aspect disclosed herein, an apparatus comprises an electrically insulative body configured to be implanted on or within a recipient. The apparatus further comprises an antenna coil within the body and at least partially bounding a region. The antenna coil is configured to inductively receive first signals transmitted transcutaneously. The apparatus further comprises a monopole or dipole antenna within the body and configured to receive transcutaneously transmitted second signals and/or to transcutaneously transmit third signals. The monopole or dipole antenna comprises a pair of branches each extending from a vertex in different directions, the vertex and the region overlapping one another.

[0006] In another aspect disclosed herein, a method comprises providing a substantially planar inductive coil. The method further comprises providing an antenna comprising an electrically conductive first portion and an electrically conductive second portion. The first and second portions extend in different directions from one another. The method further comprises placing the antenna relative to the inductive coil with the first and second portions of the antenna extending at least partially within or superimposed with a region substantially bounded by the inductive coil. The method further comprises hermetically sealing at least a portion of the inductive coil and the first and second portions of the antenna within an electrically insulating dielectric casing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Implementations are described herein in conjunction with the accompanying drawings, in which:

[0008] FIG. 1A is a perspective view of an example cochlear implant auditory prosthesis implanted in a recipient in accordance with certain implementations described herein;

[0009] FIG. 1B is a perspective view of an example fully implantable middle ear implant auditory prosthesis implanted in a recipient in accordance with certain implementations described herein;

[0010] FIG. 2A schematically illustrates a top view of an example apparatus in accordance with certain implementations described herein;

[0011] FIG. 2B is a top view photograph of an example apparatus in accordance with certain implementations described herein;

[0012] FIG. 2C schematically illustrates a cross-sectional view of the example apparatus in accordance with certain implementations described herein and a device external to the recipient's body;

[0013] FIGs. 3A-3E schematically illustrate top views of various example antennas in accordance with certain implementations described herein;

[0014] FIG. 4 schematically illustrates a top view of a portion of an example apparatus in which the antenna in electrical communication with the coil in accordance with certain implementations described herein;

[0015] FIGs. 5A-5C schematically illustrate side views of example antennas within the casing with the vertex in the region surrounded by the coil in accordance with certain implementations described herein;

[0016] FIG. 6 is a plot of a simulation of the gain spatial distribution of an antenna as a function of tilt angle φ for an example apparatus implanted on a surface of the recipient's mastoid bone in accordance with certain implementations described herein; and

[0017] FIG. 7 is a flow diagram of an example method in accordance with certain implementations described herein.

DETAILED DESCRIPTION

[0018] Certain implementations described herein provide a medical implant having a first antenna (e.g., radio frequency (RF) coil) configured to receive power from a source external to the recipient's body and having a second antenna with two portions extending in different directions from a vertex (e.g., "Y-shaped"), the second antenna configured to be in wireless communication with at least one external device (e.g., for receiving/transmitting data and/or control signals). The second antenna can be embedded within the same casing as the

coil antenna. In addition, the second antenna can have a radiation pattern that is weighted towards the front of the recipient's head.

[0019] The teachings detailed herein are applicable, in at least some implementations, to any type of implantable or non-implantable stimulation system or device (e.g., implantable or non-implantable auditory prosthesis device or system). Implementations can include any type of medical device that can utilize the teachings detailed herein and/or variations thereof. Furthermore, while certain implementations are described herein in the context of auditory prosthesis devices, certain other implementations are compatible in the context of other types of devices or systems.

[0020] Merely for ease of description, apparatus and methods disclosed herein are primarily described with reference to an illustrative medical device, namely an implantable transducer assembly including but not limited to: electro-acoustic electrical/acoustic systems, cochlear implant devices, implantable hearing aid devices, middle ear implant devices, bone conduction devices (e.g., active bone conduction devices; passive bone conduction devices, percutaneous bone conduction devices; transcutaneous bone conduction devices), Direct Acoustic Cochlear Implant (DACI), middle ear transducer (MET), electro-acoustic implant devices, other types of auditory prosthesis devices, and/or combinations or variations thereof, or any other suitable hearing prosthesis system with or without one or more external components. Implementations can include any type of auditory prosthesis that can utilize the teachings detailed herein and/or variations thereof. Certain such implementations can be referred to as "partially implantable," "semi-implantable," "mostly implantable," "fully implantable," or "totally implantable" auditory prostheses. In some implementations, the teachings detailed herein and/or variations thereof can be utilized in other types of prostheses beyond auditory prostheses.

[0021] FIG. 1A is a perspective view of an example cochlear implant auditory prosthesis 100 implanted in a recipient in accordance with certain implementations described herein. The example auditory prosthesis 100 is shown in FIG. 1A as comprising an implanted stimulator unit 120 and a microphone assembly 124 that is external to the recipient (e.g., a partially implantable cochlear implant). An example auditory prosthesis 100 (e.g., a totally implantable cochlear implant; a mostly implantable cochlear implant) in accordance with certain implementations described herein can replace the external microphone assembly 124

shown in FIG. 1A with a subcutaneously implantable microphone assembly, as described more fully herein. In certain implementations, the example cochlear implant auditory prosthesis 100 of FIG. 1A can be in conjunction with a reservoir of liquid medicament as described herein.

[0022] As shown in FIG. 1A, the recipient has an outer ear 101, a middle ear 105, and an inner ear 107. In a fully functional ear, the outer ear 101 comprises an auricle 110 and an ear canal 102. An acoustic pressure or sound wave 103 is collected by the auricle 110 and is channeled into and through the ear canal 102. Disposed across the distal end of the ear canal 102 is a tympanic membrane 104 which vibrates in response to the sound wave 103. This vibration is coupled to oval window or fenestra ovalis 112 through three bones of middle ear 105, collectively referred to as the ossicles 106 and comprising the malleus 108, the incus 109, and the stapes 111. The bones 108, 109, and 111 of the middle ear 105 serve to filter and amplify the sound wave 103, causing the oval window 112 to articulate, or vibrate in response to vibration of the tympanic membrane 104. This vibration sets up waves of fluid motion of the perilymph within cochlea 140. Such fluid motion, in turn, activates tiny hair cells (not shown) inside the cochlea 140. Activation of the hair cells causes appropriate nerve impulses to be generated and transferred through the spiral ganglion cells (not shown) and auditory nerve 114 to the brain (also not shown) where they are perceived as sound.

[0023] As shown in FIG. 1A, the example auditory prosthesis 100 comprises one or more components which are temporarily or permanently implanted in the recipient. The example auditory prosthesis 100 is shown in FIG. 1A with an external component 142 which is directly or indirectly attached to the recipient's body, and an internal component 144 which is temporarily or permanently implanted in the recipient (e.g., positioned in a recess of the temporal bone adjacent auricle 110 of the recipient). The external component 142 typically comprises one or more sound input elements (e.g., an external microphone 124) for detecting sound, a sound processing unit 126 (e.g., disposed in a Behind-The-Ear unit), a power source (not shown), and an external transmitter unit 128. In the illustrative implementations of FIG. 1A, the external transmitter unit 128 comprises an external coil 130 (e.g., a wire antenna coil comprising multiple turns of electrically insulated single-strand or multi-strand platinum or gold wire) and, preferably, a magnet (not shown) secured directly or indirectly to the external coil 130. The external coil 130 of the external transmitter unit 128 is part of an inductive radio frequency (RF) communication link with the internal component 144. The sound processing

unit 126 processes the output of the microphone 124 that is positioned externally to the recipient's body, in the depicted implementation, by the recipient's auricle 110. The sound processing unit 126 processes the output of the microphone 124 and generates encoded signals, sometimes referred to herein as encoded data signals, which are provided to the external transmitter unit 128 (e.g., via a cable). As will be appreciated, the sound processing unit 126 can utilize digital processing techniques to provide frequency shaping, amplification, compression, and other signal conditioning, including conditioning based on recipient-specific fitting parameters.

[0024] The power source of the external component 142 is configured to provide power to the auditory prosthesis 100, where the auditory prosthesis 100 includes a battery (e.g., located in the internal component 144, or disposed in a separate implanted location) that is recharged by the power provided from the external component 142 (e.g., via a transcutaneous energy transfer link). The transcutaneous energy transfer link is used to transfer power and/or data to the internal component 144 of the auditory prosthesis 100. Various types of energy transfer, such as infrared (IR), electromagnetic, capacitive, and inductive transfer, may be used to transfer the power and/or data from the external component 142 to the internal component 144. During operation of the auditory prosthesis 100, the power stored by the rechargeable battery is distributed to the various other implanted components as needed.

[0025] The internal component 144 comprises an internal receiver unit 132, a stimulator unit 120, and an elongate electrode assembly 118. In some implementations, the internal receiver unit 132 and the stimulator unit 120 are hermetically sealed within a biocompatible housing. The internal receiver unit 132 comprises an internal coil 136 (e.g., a wire antenna coil comprising multiple turns of electrically insulated single-strand or multi-strand platinum or gold wire), and preferably, a magnet (also not shown) fixed relative to the internal coil 136. The internal receiver unit 132 and the stimulator unit 120 are hermetically sealed within a biocompatible housing, sometimes collectively referred to as a stimulator/receiver unit. The internal coil 136 receives power and/or data signals from the external coil 130 via a transcutaneous energy transfer link (e.g., an inductive RF link). The stimulator unit 120 generates electrical stimulation signals based on the data signals, and the stimulation signals are delivered to the recipient via the elongate electrode assembly 118.

[0026] The elongate electrode assembly 118 has a proximal end connected to the stimulator unit 120, and a distal end implanted in the cochlea 140. The electrode assembly 118 extends from the stimulator unit 120 to the cochlea 140 through the mastoid bone 119. In some implementations, the electrode assembly 118 may be implanted at least in the basal region 116, and sometimes further. For example, the electrode assembly 118 may extend towards apical end of cochlea 140, referred to as cochlea apex 134. In certain circumstances, the electrode assembly 118 may be inserted into the cochlea 140 via a cochleostomy 122. In other circumstances, a cochleostomy may be formed through the round window 121, the oval window 112, the promontory 123, or through an apical turn 147 of the cochlea 140.

[0027] The elongate electrode assembly 118 comprises a longitudinally aligned and distally extending array 146 of electrodes or contacts 148, sometimes referred to as electrode or contact array 146 herein, disposed along a length thereof. Although the electrode array 146 can be disposed on the electrode assembly 118, in most practical applications, the electrode array 146 is integrated into the electrode assembly 118 (e.g., the electrode array 146 is disposed in the electrode assembly 118). As noted, the stimulator unit 120 generates stimulation signals which are applied by the electrodes 148 to the cochlea 140, thereby stimulating the auditory nerve 114.

[0028] While FIG. 1A schematically illustrates an auditory prosthesis 100 utilizing an external component 142 comprising an external microphone 124, an external sound processing unit 126, and an external power source, in certain other implementations, one or more of the microphone 124, sound processing unit 126, and power source are implantable on or within the recipient (e.g., within the internal component 144). For example, the auditory prosthesis 100 can have each of the microphone 124, sound processing unit 126, and power source implantable on or within the recipient (e.g., encapsulated within a biocompatible assembly located subcutaneously), and can be referred to as a totally implantable cochlear implant ("TICI"). For another example, the auditory prosthesis 100 can have most components of the cochlear implant (e.g., excluding the microphone, which can be an in-the-ear-canal microphone) implantable on or within the recipient, and can be referred to as a mostly implantable cochlear implant ("MICI").

[0029] FIG. 1B schematically illustrates a perspective view of an example fully implantable auditory prosthesis 200 (e.g., fully implantable middle ear implant or totally

implantable acoustic system), implanted in a recipient, utilizing an acoustic actuator in accordance with certain implementations described herein. The example auditory prosthesis 200 of FIG. 1B comprises a biocompatible implantable assembly 202 (e.g., comprising an implantable capsule) located subcutaneously (e.g., beneath the recipient's skin and on a recipient's skull). While FIG. 1B schematically illustrates an example implantable assembly 202 comprising a microphone, in other example auditory prostheses 200, a pendant microphone can be used (e.g., connected to the implantable assembly 202 by a cable). The implantable assembly 202 includes a signal receiver 204 (e.g., comprising a coil element) and an acoustic transducer 206 (e.g., a microphone comprising a diaphragm and an electret or piezoelectric transducer) that is positioned to receive acoustic signals through the recipient's overlying tissue. The implantable assembly 202 may further be utilized to house a number of components of the fully implantable auditory prosthesis 200. For example, the implantable assembly 202 can include an energy storage device and a signal processor (e.g., a sound processing unit). Various additional processing logic and/or circuitry components can also be included in the implantable assembly 202 as a matter of design choice.

[0030] For the example auditory prosthesis 200 shown in FIG. 1B, the signal processor of the implantable assembly 202 is in operative communication (e.g., electrically interconnected via a wire 208) with an actuator 210 (e.g., comprising a transducer configured to generate mechanical vibrations in response to electrical signals from the signal processor). In certain implementations, the example auditory prosthesis 100, 200 shown in FIGs. 1A and 1B can comprise an implantable microphone assembly, such as the microphone assembly 206 shown in FIG. 1B. For such an example auditory prosthesis 100, the signal processor of the implantable assembly 202 can be in operative communication (e.g., electrically interconnected via a wire) with the microphone assembly 206 and the stimulator unit of the main implantable component 120. In certain implementations, at least one of the microphone assembly 206 and the signal processor (e.g., a sound processing unit) is implanted on or within the recipient.

[0031] The actuator 210 of the example auditory prosthesis 200 shown in FIG. 1B is supportably connected to a positioning system 212, which in turn, is connected to a bone anchor 214 mounted within the recipient's mastoid process (e.g., via a hole drilled through the skull). The actuator 210 includes a connection apparatus 216 for connecting the actuator 210 to the ossicles 106 of the recipient. In a connected state, the connection apparatus 216 provides

a communication path for acoustic stimulation of the ossicles 106 (e.g., through transmission of vibrations from the actuator 210 to the incus 109).

[0032] During normal operation, ambient acoustic signals (e.g., ambient sound) impinge on the recipient's tissue and are received transcutaneously at the microphone assembly 206. Upon receipt of the transcutaneous signals, a signal processor within the implantable assembly 202 processes the signals to provide a processed audio drive signal via wire 208 to the actuator 210. As will be appreciated, the signal processor may utilize digital processing techniques to provide frequency shaping, amplification, compression, and other signal conditioning, including conditioning based on recipient-specific fitting parameters. The audio drive signal causes the actuator 210 to transmit vibrations at acoustic frequencies to the connection apparatus 216 to affect the desired sound sensation via mechanical stimulation of the incus 109 of the recipient.

[0033] The subcutaneously implantable microphone assembly 202 is configured to respond to auditory signals (e.g., sound; pressure variations in an audible frequency range) by generating output signals (e.g., electrical signals; optical signals; electromagnetic signals) indicative of the auditory signals received by the microphone assembly 202, and these output signals are used by the auditory prosthesis 100, 200 to generate stimulation signals which are provided to the recipient's auditory system. To compensate for the decreased acoustic signal strength reaching the microphone assembly 202 by virtue of being implanted, the diaphragm of an implantable microphone assembly 202 can be configured to provide higher sensitivity than are external non-implantable microphone assemblies. For example, the diaphragm of an implantable microphone assembly 202 can be configured to be more robust and/or larger than diaphragms for external non-implantable microphone assemblies.

[0034] The example auditory prostheses 100 shown in FIG. 1A utilizes an external microphone 124 and the auditory prosthesis 200 shown in FIG. 1B utilizes an implantable microphone assembly 206 comprising a subcutaneously implantable acoustic transducer. In certain implementations described herein, the auditory prosthesis 100 utilizes one or more implanted microphone assemblies on or within the recipient. In certain implementations described herein, the auditory prosthesis 200 utilizes one or more microphone assemblies that are positioned external to the recipient and/or that are implanted on or within the recipient, and utilizes one or more acoustic transducers (e.g., actuator 210) that are implanted on or within

the recipient. In certain implementations, an external microphone assembly can be used to supplement an implantable microphone assembly of the auditory prosthesis 100, 200. Thus, the teachings detailed herein and/or variations thereof can be utilized with any type of external or implantable microphone arrangement, and the acoustic transducers shown in FIGs. 1A and 1B are merely illustrative.

[0035] FIG. 2A schematically illustrates a top view of an example apparatus 300 in accordance with certain implementations described herein. FIG. 2B is a top view photograph of an example apparatus 300 in accordance with certain implementations described herein. FIG. 2C schematically illustrates a cross-sectional view of the example apparatus 300 in accordance with certain implementations described herein and a device 400 external to the recipient's body. The apparatus 300 comprises a casing 310 configured to be implanted on or within a recipient's body. The apparatus 300 further comprises an electrically conductive and substantially planar coil 320 (e.g., defining a plane 322) within the casing 310, the coil 320 configured to inductively receive power signals from a device 400 external to the recipient's body. The apparatus 300 further comprises an antenna 330 within the casing 310 and configured to receive and/or transmit data signals. The antenna 330 comprises an electrically conductive first portion 332 extending from a vertex 334 in a first direction 333 and an electrically conductive second portion 336 extending from the vertex 334 in a second direction 337 different from the first direction 333. The vertex 334 is within a volume 326 encircled by the coil 320 and extending above and below the coil 320 in a direction substantially perpendicular to the coil 320.

[0036] In certain implementations, the apparatus 300 is part of a transcutaneous system (e.g., auditory prosthesis system) comprising the apparatus 300 (e.g., an implanted portion of an acoustic prosthesis system) and the device 400 (e.g., an external portion of the acoustic prosthesis system). For example, the apparatus 300 can be configured to be implanted on and substantially parallel to a bone surface 510 (e.g., a surface of a portion of the skull 520; a surface of the mastoid bone 119) within a recipient and the external device 400 can be configured to be worn on the recipient's skin 530 over the apparatus 300. The device 400 can comprise a housing 410 (e.g., biocompatible; skin-friendly) and an electrically conductive coil 420 configured to provide power and/or data to the apparatus 300 and/or to receive data from the apparatus 300 via magnetic induction with the electrically conductive coil 320 of the

apparatus 300. For example, the coil 320 can be configured to inductively receive power signals transmitted transcutaneously (e.g., from the device 400) and the antenna 330 can be configured to receive transcutaneously transmitted data and/or control signals (e.g., from the device 400 and/or another external device) and/or to transcutaneously transmit data and/or control signals (e.g., to the device 400 and/or another external device). The apparatus 300 can be configured to use the antenna 330 for various wireless links, including but not limited to: 2.4 GHz wireless links (e.g., for a MICI or a TICI); Bluetooth Low-Energy (BLE) links; medical implant communication system (MICS) bands (e.g., 401-406 MHz); short range device (SRD) bands (e.g., 863 MHz; 915 MHz).

[0037] The apparatus 300 can further comprise circuitry 340 in electrical communication with the coil 320 and the antenna 330, the circuitry 340 configured to receive power from the coil 320 and to receive and/or transmit data signals via the antenna 330. For example, the circuitry 340 can comprise one or more active elements (e.g., stimulator unit 120; assembly 202; vibrating actuator) configured to deliver stimuli (e.g., stimulation signals) to a portion of the recipient's body and/or to detect an attribute or condition of the recipient's body. The circuitry 340 can be in electrical communication with the portion of the recipient's body via electrical conduits 342 (e.g., electrode assembly 118; return electrode) in electrical communication with the circuitry 340 and extending from the casing 310 to a region of the recipient's body. In certain implementations, the circuitry 340 and the coil 320 are within the same casing 310 (see, e.g., FIGs. 2A-2C), while in certain other implementations, the circuitry 340 and the coil 320 are in two casings that are attached to one another (e.g., electrically connected by at least one electrical conductor).

[0038] For example, the circuitry 340 can comprise one or more microprocessors (e.g., application-specific integrated circuits; generalized integrated circuits programmed by software with computer executable instructions; microelectronic circuitry; microcontrollers) and at least one storage device (e.g., at least one tangible or non-transitory computer readable storage medium; read only memory; random access memory; flash memory) configured to store information (e.g., data; commands) accessed by the one or more microprocessors during operation. The at least one storage device can be encoded with software (e.g., a computer program downloaded as an application) comprising computer executable instructions for instructing the one or more microprocessors (e.g., executable data access logic, evaluation

logic, and/or information outputting logic). In certain implementations, the one or more microprocessors execute the instructions of the software to provide functionality as described herein. The circuitry 340 can be configured to receive power signals, data signals, and/or control signals wirelessly communicated from the device 400 via the coil 420 and the coil 320. In addition, the circuitry 340 can be configured to receive and/or transmit data and/or control signals wirelessly communicated via the antenna 330 between the apparatus 300 and the device 400 or another separate external device.

[0039] In certain implementations, the casing 310 (e.g., body of the apparatus 300) comprises an electrically insulative and biocompatible material (e.g., silicone rubber; polymer; polyether-etherketone (PEEK); ceramic; titanium oxide; glass; glycerine) that is configured to improve impedance matching of the antenna 340 so as to reduce signal losses in dissipative body tissue, thereby increasing the efficiency and/or the bandwidth of the antenna 340, as compared to the antenna 340 being outside the casing 310. For example, the casing 310 can have a dielectric constant of about 3.5 at the 2.4 GHz industrial, scientific, and medical (ISM) frequency band.

[0040] In certain implementations, the casing 310 is configured to be positioned beneath the skin 530 and other tissue (e.g., fat and/or muscular 408 layers) and above and on the bone surface 510 in a portion of the recipient's body (e.g., the head). For example, the casing 310 can be substantially parallel to the bone surface 510 (e.g., schematically illustrated in FIG. 2C). In certain implementations, the casing 310 can be bent to be compatible with (e.g., conforms to; follows) a curvature of the bone surface 510, while in certain other implementations, the bone surface 510 can be altered (e.g., machined) to provide a portion with which the casing 310 is compatible. In certain implementations, the casing 310 can be configured to be affixed to the bone surface 510 using at least one biocompatible anchor, screw, or adhesive. The casing 310 of certain implementations is configured to hermetically seal the coil 320 and the antenna 330 from an environment surrounding the casing 310. The casing 310 can also be substantially transparent to the electromagnetic or magnetic fields between the apparatus 300 and the device 400 (e.g., such that the casing 310 does not substantially interfere with power transmission from the device 400 to the apparatus 300 and/or data transmission to and/or from the apparatus 300).

[0041] In certain implementations, the apparatus 300 further comprises a magnetic element 350 (e.g., magnetic cassette) within the casing 310 (e.g., the casing 310 is configured to hermetically seal the magnetic element 350 from the environment surrounding the casing 310). The magnetic element 350 can be configured to generate a magnetic force with the device 400 external to the recipient's body. In certain implementations, the magnetic element 350 comprises at least one magnetic material (e.g., ferromagnetic; ferrimagnetic; permanent magnet; diamagnetic magnet) and has a substantially planar shape (e.g., disk; plate; substantially circular, oval, or rectangular). The magnetic element 350 can be configured to interact with a portion of the device 400 (e.g., a magnetic element 450) when the device 400 is positioned on or over the skin 530 of the recipient above the apparatus 300. The interaction can generate a magnetic attraction force with sufficient strength to hold the device 400 onto the recipient's skin 530 such that the coil 420 is in operative wireless communication with the coil 320 of the apparatus 300 to wirelessly and transcutaneously transfer energy from the device 400 to the apparatus 300 (e.g., via magnetic induction; via a radio-frequency or RF link).

[0042] In certain implementations, as shown in FIGs. 2A-2C, at least a portion of the magnetic element 350 can be positioned within the volume 326 (e.g., within a region 324 at least partially bounded or surrounded by the coil 320). For example, the magnetic element 350 and the coil 320 can both be substantially circular in the plane 322, substantially coplanar with one another, and/or substantially concentric with one another. In certain implementations, as shown in FIGs. 2A and 2B, the vertex 334 and the region 324 at least partially bounded by the coil 320 overlap one another. For example, the coil 320 surrounds the magnetic element 350 and the vertex 334 of the antenna 330 is between the magnetic element 350 and the coil 320 (see, e.g., FIGs. 2A-2C).

[0043] In certain implementations, the coil 320 substantially planar (e.g., defining the plane 322 and comprises multiple turns of electrically insulated single-strand or multi-strand wire (e.g., a planar electrically conductive wire with multiple windings having a substantially circular, rectangular, spiral, or oval shape or other shape) or metal traces on epoxy of a printed circuit board. For example, the wires of the coil 320 can extend substantially parallel to the plane 322 and can have a diameter, length, and/or width (e.g., along a lateral direction substantially parallel to the bone surface 510) less than or equal to 60 millimeters

(e.g., in a range of 15 millimeters to 40 millimeters; in a range of 25 millimeters to 50 millimeters; in a range of less than 30 millimeters; in a range of 20 millimeters to 60 millimeters; in a range greater than 60 millimeters). In certain implementations, the coil 320 is configured to inductively receive signals (e.g., power signals) generated externally to the recipient (e.g., by the device 400).

[0044] In certain implementations, the antenna 330 is configured to receive data signals from the device 400 and/or to transmit data signals to the device 400. For example, the device 400 can be an external portion of a system (e.g., acoustic prosthesis system) comprising an internal portion comprising the apparatus 300. In certain implementations, the antenna 330 is configured to receive data signals from another external device (not shown) and/or to transmit data signals to another external device. For example, the other external device can be a smartphone, smart tablet, or other computing device that is separate from the device 400 and configured to be held (e.g., not worn) by the recipient.

[0045] In certain implementations, the antenna 330 is sufficiently small to fit within the casing 310. For example, the length of the first portion 332 (e.g., from the vertex 334 to an end of the first portion 332) and/or the length of the second portion 336 (e.g., from the vertex 334 to an end of the second portion 336) can be in a range of 4 millimeters to 15 millimeters (e.g., in a range of 6 millimeters to 10 millimeters). In certain implementations, the first and second portions 332, 336 can comprise electrically conductive wires (e.g., flexible; inflexible) or traces on a printed-circuit board (e.g., flexible; inflexible). In certain implementations, the antenna 330 comprises a lossless dielectric coating (e.g., 1 mm thick) on the electrically conductive first and second portions 332, 336, which can improve performance and stability of the antenna 330.

[0046] FIGs. 3A-3E schematically illustrate top views of various example antennas 330 in accordance with certain implementations described herein. Other shapes of the antenna 330 (e.g., meander-shaped; helix-shaped; fractal-shaped; polarized patch; planar inverted F-antenna) are also compatible with certain implementations described herein. The example antennas 330 of FIGs. 3A and 3B comprise a substantially straight first portion 332 (e.g., branch) and a substantially straight second portion 336 (e.g., branch) and can be described as "Y-shaped" or "V-shaped." The example antennas 330 of FIGs. 3C and 3D comprise a curved first portion 332 (e.g., branch) and a curved second portion 336 (e.g., branch) and can be

described as "U-shaped." While the first and second portions 332, 336 extend from the vertex 334 in the first and second directions 333, 337, respectively, due to their curvature, the first and second portions 332, 336 of FIGs. 3C and 3D deviate from the first and second directions 333, 337 farther from the vertex 334. In certain implementations, the antenna 330 comprises at least one electrically conductive third portion 338 in electrical communication with the first and second portions 332, 336 at the vertex 334 and having an antenna feed point 339 configured to be in electrical communication with the circuitry 340. In certain implementations, the at least one electrically conductive third portion 338 is substantially straight, while in certain other implementations, the at least one electrically conductive third portion 338 is bent or curved.

[0047] In FIGs, 3A-3D, the vertex angle θ between the first direction 333 and the second direction 337 is in a range of 90 degrees to 180 degrees (e.g., 90 degrees to 130 degrees; 100 degrees to 140 degrees). In certain implementations, the antenna 330 is a dipole antenna (e.g., Hertzian) which has the first portion 332 and the second portion 336 electrically insulated from one another at the vertex 336 (see, e.g., FIGs. 3A and 3C), while in certain other implementations, the antenna 330 is a monopole antenna which has the first portion 332 and the second portion 336 in electrical communication with one another at the vertex 336 (see, e.g., FIGs. 3B and 3D).

[0048] In certain implementations, the antenna 330 is positioned substantially symmetrically relative to the coil 320. For example, as schematically illustrated by FIG. 2A, the at least one electrically conductive third portion 337 can extend along a direction 328 through a center of the coil 320 (e.g., substantially perpendicularly to the wires of the coil 320). In certain other implementations, the antenna 330 is positioned substantially non-symmetrically relative to the coil 320. For example, as schematically illustrated by FIG. 3E, the at least one electrically conductive third portion 337 can be offset laterally relative to the direction 328 through the center of the coil 320. As with the example apparatus 300 of FIGs. 2A and 2B, the vertex 334 and the region 324 at least partially bounded by the coil 320 overlap one another.

[0049] FIG. 4 schematically illustrates a top view of a portion of an example apparatus 300 in which the antenna 330 in electrical communication with the coil 320 in accordance with certain implementations described herein. In certain implementations, the

coil 320 and the antenna 330 have a common feedthrough connection at the antenna feed point 339 that is in electrical communication with the circuitry 340. In certain other implementations, the coil 320 and the antenna 330 have separate feedthrough connections (e.g., separate antenna feed points for the coil 320 and the antenna 330 with separate electrical paths configured to be excited separately) in electrical communication with the circuitry 340.

[0050] FIGs. 5A-5C schematically illustrate side views of example antennas 330 within the casing 310 with the vertex 334 in the region 322 surrounded by the coil 320 (e.g., between the magnetic element 350 and the coil 320) in accordance with certain implementations described herein. As shown in FIG. 5A, the vertex 334 can be substantially coplanar with the coil 320 (e.g., with the plane 322), and as shown in FIGs. 5B and 5C, respectively, the vertex 334 can be spaced above or below the plane 322. In certain implementations (see, e.g., FIGs. 5A-5C), the first portion 332 and the second portion 336 are substantially coplanar with one another, while in certain other implementations, the first portion 332 and the second portion 336 are not coplanar with one another. In certain implementations, the first portion 332 and the second portion 336 are tilted relative to the coil 320 (e.g., relative to the plane 322) by a substantially non-zero tilt angle φ (see, e.g., FIGs. 5A-5C). For example, the tilt angle φ can be in a range of 3 degrees to 60 degrees (e.g., 5 degrees to 19 degrees). In certain other implementations, the first portion 332 and the second portion 336 are not tilted relative to the plane 322 (e.g., the first portion 332 and the second portion 336 are substantially coplanar with the coil 320).

[0051] FIG. 6 is a plot of a simulation of the gain spatial distribution of an antenna 330 as a function of tilt angle φ for an example apparatus 300 implanted on a surface of the recipient's mastoid bone 119 (e.g., with a simulated skin flap thickness of 10 mm) in accordance with certain implementations described herein. The gain spatial distribution is shown for various azimuthal angles around the recipient's head, with azimuthal angle of 180 degrees corresponding to a direction towards the recipient's brain. As shown in FIG. 6, the gain spatial distribution can be modified by adjusting (e.g., optimizing) the geometry of the antenna 330. For example, the tilt angle can be increased from zero (e.g., so that the first and second portions 332, 336 are not substantially parallel to the coil 320) which can increase the gain (e.g., by 2.2 dB) and/or the angular width (e.g., by 5 degrees) of a distribution lobe in a specific direction (e.g., towards the front of the head at an azimuthal angle of 110 degrees).

The values of the gain and the angular width can be dependent on the distance between the antenna 340 and the lossy human tissue layers. The gain spatial distribution is also dependent on the vertex angle θ of the antenna 330. FIG. 6 further illustrates that the gain spatial distribution of the antenna 330 can be substantially uniform and bidirectional.

[0052] Table 1 compares simulated coupling coefficient values for an electrically conductive coil 420 of an external device 400 with (i) an implanted coil (e.g., loosely coupled RF link) without an antenna 330 and with (ii) a coil 320 with a "Y-shaped" antenna 330 with a vertex 344 in the volume 326 for various skin flap thicknesses in accordance with certain implementations described herein.

Table 1:

Skin Flap Thickness (millimeters)	Simulated coupling coefficient at frequency of the loosely coupled RF link	
	Coil only	Coil 320 with "Y-shaped" antenna 330
0	0.376	0.376
1	0.326	0.326
2	0.284	0.284
3	0.250	0.250
4	0.221	0.221
5	0.196	0.196
6	0.175	0.175
7	0.157	0.157
8	0.141	0.141
9	0.128	0.127
10	0.115	0.115
11	0.105	0.105
12	0.095	0.095
13	0.087	0.087

As shown in Table, 1, placing the antenna 340 with the vertex 344 inside the volume 326 has substantially no impact on the coupling coefficient between the coil 320 and the coil 420 for a range of SFT from zero to 13 millimeters.

[0053] The antenna 330 of certain implementations is configured to avoid various effects resulting from use of the coil 320 alone for both wireless power transmission and wireless data/control transmission. For example, use of the antenna 330 for transcutaneous wireless transmission of RF data signals (e.g., 2.4 GHz) can allow the coil 320 to be used solely for transcutaneous wireless transmission of power signals (e.g., 5 MHz), thereby avoiding possible undesirable interactions (e.g., reduced coexistence) concomitant with the coil 320 being in electrical communication with the front ends of both the power transfer circuitry and the data transfer circuitry. In certain implementations, the coil 320 and the antenna 330 can have separate feedthrough connections to the circuitry 340, which can significantly improve coexistence between a loosely coupled RF link and a 2.4 GHz wireless link, as compared to the coil 320 solely being used for both links. For another example, while the relatively large surface area of the coil 320 at the vicinity of human tissue can effectively detune the coil 320 for the RF link, the antenna 330 can have a significantly smaller surface area so the detuning by the human tissue is lessened (e.g., the performance of the antenna 330 is substantially less susceptible to impedance variations from the skin effect because the effective antenna surface area is substantially less than that of the coil 320). For another example, the impedance matching solution using only the coil 320 can be more difficult than using the antenna 330. Since the RF coil resistance can be low (e.g., below 50 ohms), loss control can be difficult and any component residing on the coil affects the impedance matching solution. In contrast, the antenna 330 can be electrically isolated from the coil 320 and can have a significantly higher resistance, simplifying the impedance matching solution.

[0054] Table 2 lists simulations of various radiation properties of a conventional apparatus having only a substantially planar antenna coil and of an apparatus 300 having both a substantially planar antenna coil 320 and a "Y-shaped" antenna 330 in accordance with certain implementations described herein. The simulations used for Table 2 had the apparatus implanted on a human head phantom model and under human tissue layers having a thickness (e.g., skin flap thickness or SFT) of 10 millimeters and were made at 2.4 GHz (e.g., frequency range of Bluetooth). The maximum operating range at the line-of-sight (LOS) from the front

of the head using only a substantially planar antenna coil in a dipole configuration was measured to be about 1.8 meters. In contrast, the maximum operating range at the LOS from the front of the head using the "Y-shaped" antenna 330 with separate feedthrough connections was estimated to be about 4.4 meters. In addition, while the radiation pattern of the antenna coil only was larger towards the back of the head than towards the front of the head (e.g., due to limitations of the positioning of the antenna coil relative to the human head), the radiation pattern of the "Y-shaped" antenna 330 was substantially uniform between the front of the head and the back of the head (e.g., bidirectional).

Table 2:

	Antenna Gain (max) at back of head	Antenna Gain (max) at front of head	Radiation efficiency	Max. range (at LOS from front of head)
Antenna coil only	-24.1 dBi	-33.4 dBi	3.2×10^{-3}	1.8 meters (measured)
Coil 320 and "Y-shaped" antenna 330 with common feedthrough connections	-24.6 dBi	-28.9 dBi	3.9×10^{-3}	3.1 meters (estimated)
Coil 320 and "Y-shaped" antenna 330 with separate feedthrough connections	-22.5 dBi	-25.6 dBi	4.9×10^{-3}	4.4 meters (estimated)

[0055] FIG. 7 is a flow diagram of an example method 700 in accordance with certain implementations described herein. While the method 700 is described by referring to some of the structures of the example apparatus 300 of FIGs. 2A-2C, 3A-3E, 4, and 5A-5C, other apparatus and systems with other configurations of components can also be used to perform the method 700 in accordance with certain implementations described herein.

[0056] In an operational block 710, the method 700 comprises providing a substantially planar inductive coil 320. In an operational block 720, the method 700 further

comprises providing an antenna 330 comprising an electrically conductive first portion 332 and an electrically conductive second portion 336, the first and second portions 332, 336 extending in different directions from one another. In an operational block 730, the method 700 further comprises placing the antenna 330 relative to the inductive coil 320 with the first and second portions 332, 336 of the antenna 330 extending at least partially within or superimposed with a region 324 substantially bounded by the inductive coil 320. In an operational block 740, the method 700 further comprises hermetically sealing at least a portion of the inductive coil 320 and the first and second portions 332, 336 of the antenna 330 within an electrically insulating dielectric casing 310. In certain implementations, the method 700 further comprises tilting the first and second portions 332, 336 of the antenna 330 relative to a plane 322 of the inductive coil 320 by a non-zero tilt angle φ.

[0057] Although commonly used terms are used to describe the systems and methods of certain implementations for ease of understanding, these terms are used herein to have their broadest reasonable interpretations. Although various aspects of the disclosure are described with regard to illustrative examples and implementations, the disclosed examples and implementations should not be construed as limiting. Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain implementations include, while other implementations do not include, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more implementations or that one or more implementations necessarily include logic for deciding, with or without user input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular implementation. In particular, the terms “comprises” and “comprising” should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

[0058] It is to be appreciated that the implementations disclosed herein are not mutually exclusive and may be combined with one another in various arrangements. In addition, although the disclosed methods and apparatuses have largely been described in the

context of various devices, various implementations described herein can be incorporated in a variety of other suitable devices, methods, and contexts. More generally, as can be appreciated, certain implementations described herein can be used in a variety of implantable medical device contexts that can benefit from certain attributes described herein.

[0059] Language of degree, as used herein, such as the terms "approximately," "about," "generally," and "substantially," represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms "approximately," "about," "generally," and "substantially" may refer to an amount that is within ± 10% of, within ± 5% of, within ± 2% of, within ± 1% of, or within ± 0.1% of the stated amount. As another example, the terms "generally parallel" and "substantially parallel" refer to a value, amount, or characteristic that departs from exactly parallel by ± 10 degrees, by ± 5 degrees, by ± 2 degrees, by ± 1 degree, or by ± 0.1 degree, and the terms "generally perpendicular" and "substantially perpendicular" refer to a value, amount, or characteristic that departs from exactly perpendicular by ± 10 degrees, by ± 5 degrees, by ± 2 degrees, by ± 1 degree, or by ± 0.1 degree. The ranges disclosed herein also encompass any and all overlap, sub-ranges, and combinations thereof. Language such as "up to," "at least," "greater than," less than," "between," and the like includes the number recited. As used herein, the meaning of "a," "an," and "said" includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein, the meaning of "in" includes "into" and "on," unless the context clearly dictates otherwise.

[0060] While the methods and systems are discussed herein in terms of elements labeled by ordinal adjectives (e.g., first, second, etc.), the ordinal adjective are used merely as labels to distinguish one element from another (e.g., one signal from another or one circuit from one another), and the ordinal adjective is not used to denote an order of these elements or of their use.

[0061] The invention described and claimed herein is not to be limited in scope by the specific example implementations herein disclosed, since these implementations are intended as illustrations, and not limitations, of several aspects of the invention. Any equivalent implementations are intended to be within the scope of this invention. Indeed, various modifications of the invention in form and detail, in addition to those shown and

described herein, will become apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the claims. The breadth and scope of the invention should not be limited by any of the example implementations disclosed herein but should be defined only in accordance with the claims and their equivalents.

WHAT IS CLAIMED IS:

1. An apparatus comprising:

a casing configured to be implanted on or within a recipient's body;

an electrically conductive and substantially planar coil within the casing, the coil configured to inductively receive power signals from a device external to the recipient's body; and

an antenna within the casing and configured to receive and/or transmit data signals, the antenna comprising:

an electrically conductive first portion extending from a vertex in a first direction, the vertex within a volume encircled by the coil and extending above and below the coil along a direction substantially perpendicular to the coil; and

an electrically conductive second portion extending from the vertex in a second direction different from the first direction.

2. The apparatus of claim 1, wherein the vertex is substantially coplanar with the coil.

3. The apparatus of claim 1 or claim 2, wherein the first portion and the second portion are in electrical communication with one another at the vertex.

4. The apparatus of claim 1 or claim 2, wherein the first portion and the second portion are electrically insulated from one another at the vertex.

5. The apparatus of any preceding claim, wherein the first portion and the second portion are substantially coplanar with one another.

6. The apparatus of claim 5, wherein the first portion and the second portion are substantially coplanar with the coil.

7. The apparatus of claim 5, wherein the first portion and the second portion are tilted relative to the coil by a substantially non-zero tilt angle.

8. The apparatus of any preceding claim, wherein the first direction and the second direction have a vertex angle therebetween, the vertex angle in a range of 90 degrees to 180 degrees.

9. The apparatus of any preceding claim, wherein the first portion and the second portion are substantially straight.

10. The apparatus of any of claims 1 to 8, wherein the first portion and the second portion are substantially curved.

11. The apparatus of any preceding claim, further comprising a magnetic element within the casing, the magnetic element configured to generate a magnetic force with the device.

12. The apparatus of claim 11, wherein the coil surrounds the magnetic element and the vertex is between the magnetic element and the coil.

13. The apparatus of claim 11 or claim 12, wherein the magnetic element comprises at least one ferromagnetic or ferrimagnetic material and the magnetic force is sufficient to hold the device onto the recipient's body.

14. The apparatus of any of claims 11 to 13, wherein the magnetic element and the coil are substantially circular, and the magnetic element is substantially coplanar with the coil.

15. The apparatus of any of claims 11 to 14, wherein the magnetic element and the coil are substantially concentric with one another.

16. The apparatus of any preceding claim, wherein the antenna is configured to receive the data signals from the device and/or to transmit the data signals to the device.

17. The apparatus of any of claims 1 to 16, wherein the antenna is configured to receive the data signals from at least one second device and/or to transmit the data signals to the at least one second device.

18. The apparatus of any preceding claim, further comprising a stimulation assembly in electrical communication with the coil and with the antenna, the stimulation assembly configured to deliver stimulation signals to a portion of the recipient's body.

19. An apparatus comprising:

an electrically insulative body configured to be implanted on or within a recipient;

an antenna coil within the body and at least partially bounding a region, the antenna coil configured to inductively receive first signals transmitted transcutaneously; and

a monopole or dipole antenna within the body and configured to receive transcutaneously transmitted second signals and/or to transcutaneously transmit third

signals, the monopole or dipole antenna comprising a pair of branches each extending from a vertex in different directions, the vertex and the region overlapping one another.

20. The apparatus of claim 19, wherein the monopole or dipole antenna is Y-shaped, V-shaped, U-shaped, meander-shaped, or fractal-shaped.

21. The apparatus of claim 19 or claim 20, further comprising circuitry in electrical communication with the antenna coil and the monopole or dipole antenna, the circuitry configured to receive power from the antenna coil and to receive and/or transmit data signals via the antenna.

22. The apparatus of claim 21, wherein the antenna coil and the monopole or dipole antenna have a common feedthrough connection in electrical communication with the circuitry.

23. The apparatus of claim 21, wherein the antenna coil and the monopole or dipole antenna have separate feedthrough connections in electrical communication with the circuitry.

24. The apparatus of any of claims 19 to 23, wherein the apparatus is an implanted portion of an acoustic prosthesis system that further comprises an external component configured to generate the first signals.

25. A method comprising:

providing a substantially planar inductive coil;

providing an antenna comprising an electrically conductive first portion and an electrically conductive second portion, the first and second portions extending in different directions from one another;

placing the antenna relative to the inductive coil with the first and second portions of the antenna extending at least partially within or superimposed with a region substantially bounded by the inductive coil; and

hermetically sealing at least a portion of the inductive coil and the first and second portions of the antenna within an electrically insulating dielectric casing.

26. The method of claim 25, further comprising tilting the first and second portions of the antenna relative to a plane of the inductive coil by a non-zero tilt angle.

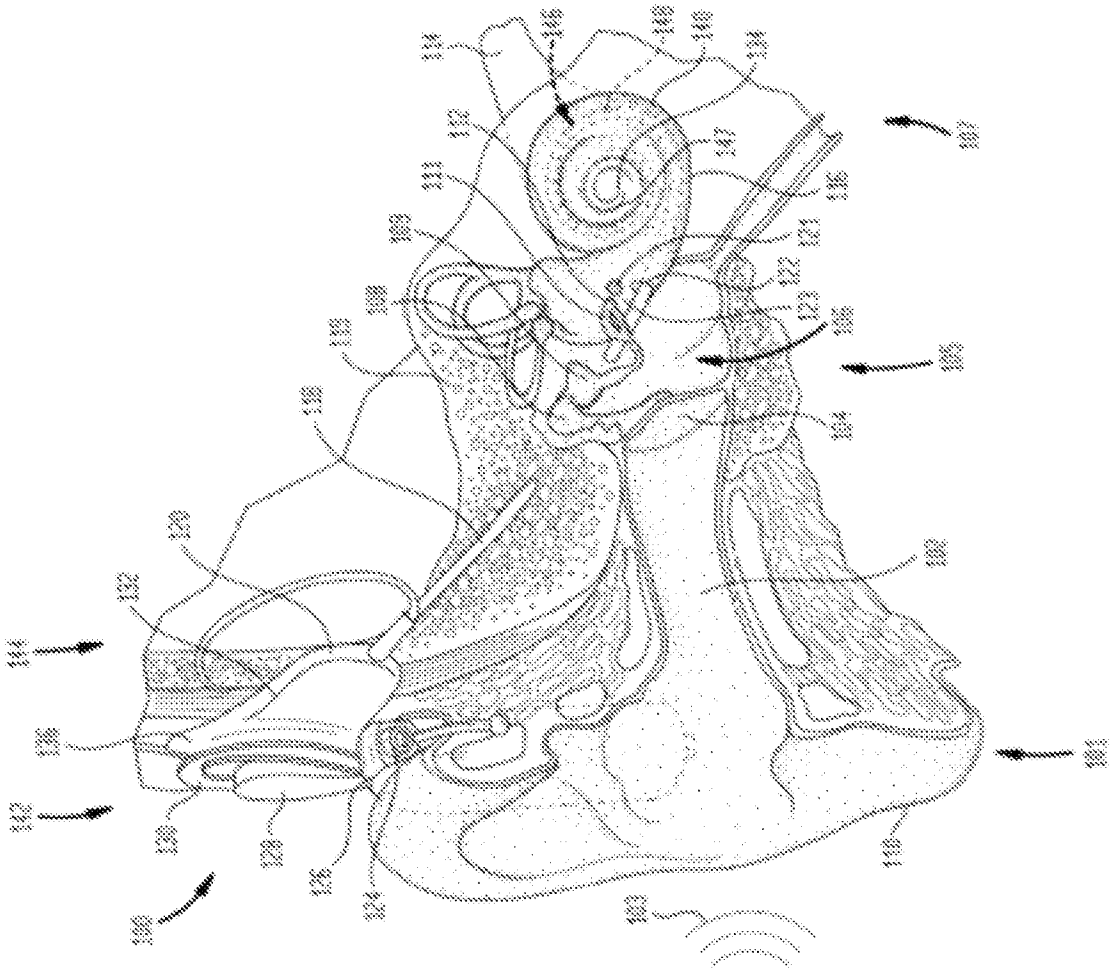


FIG. 1A:

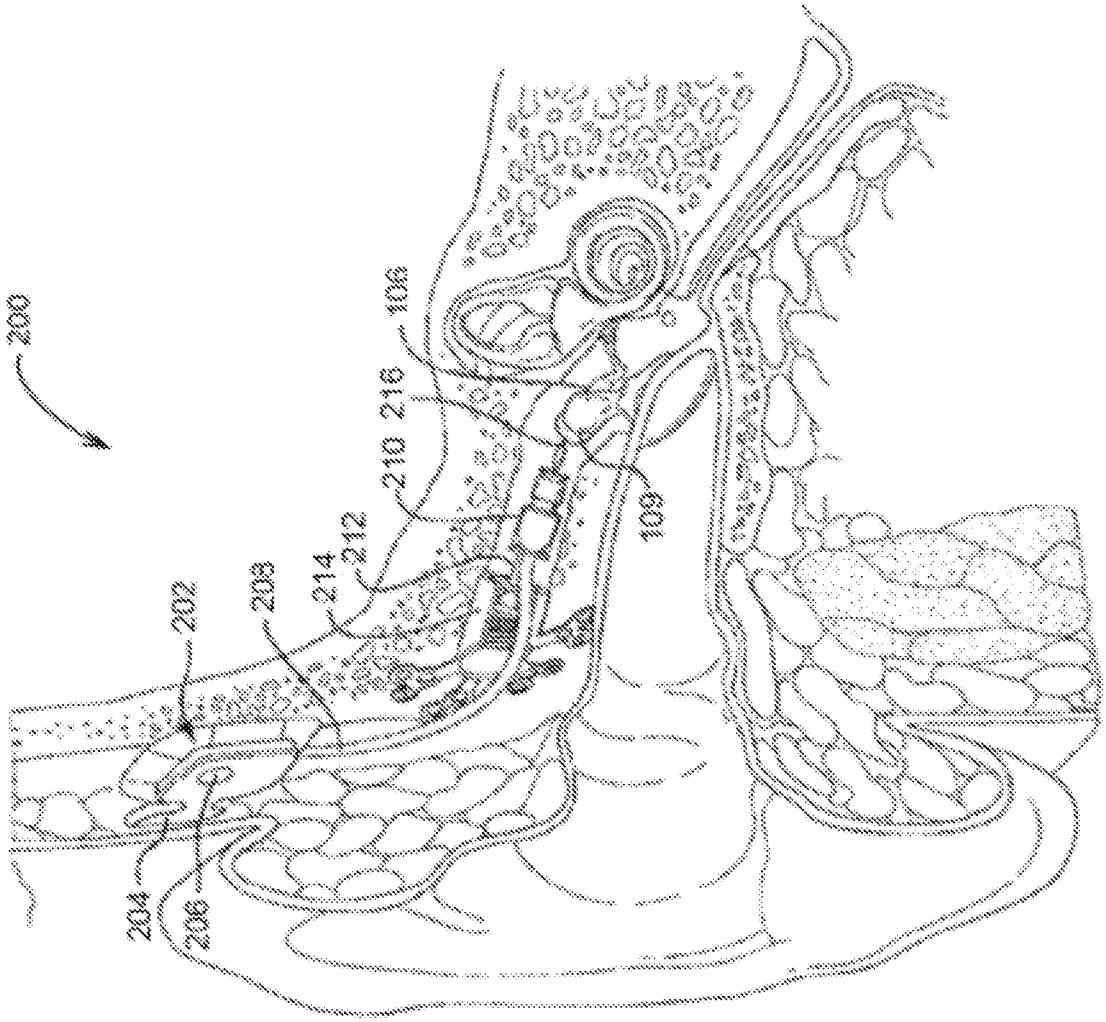


FIG. 1B:

FIG. 2A:

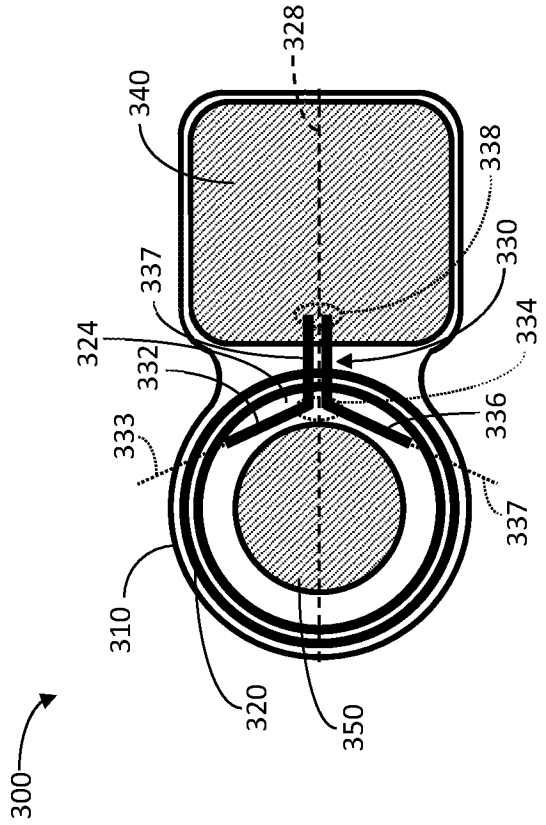


FIG. 2B:

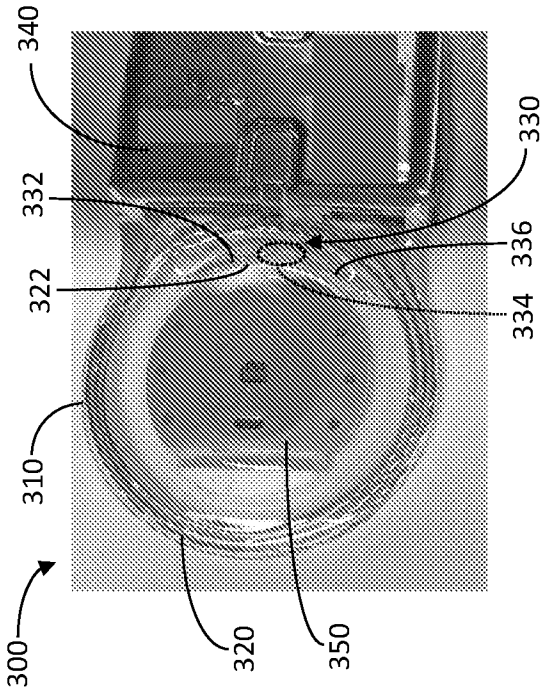


FIG. 2C:

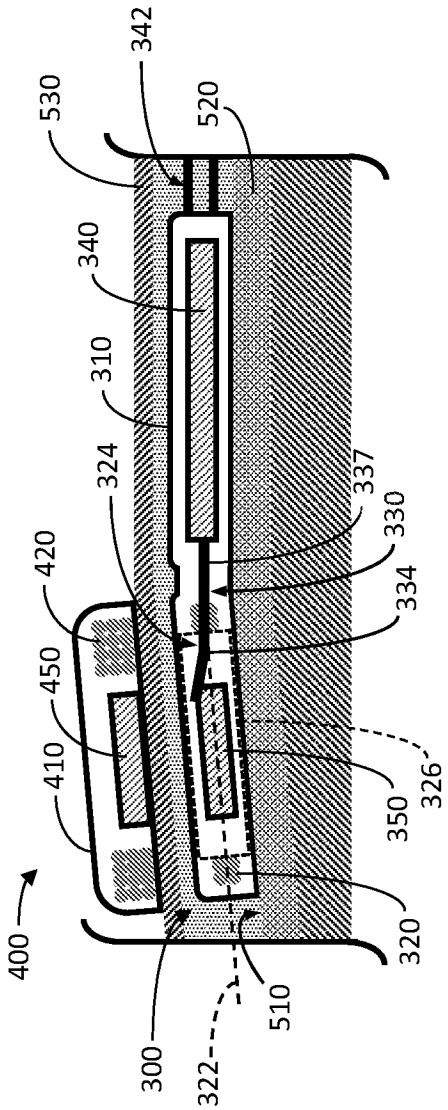


FIG. 3A:

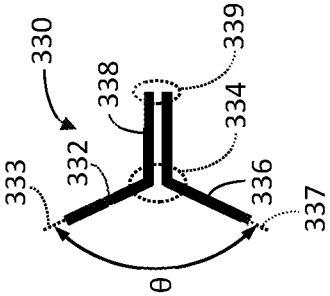


FIG. 3B:

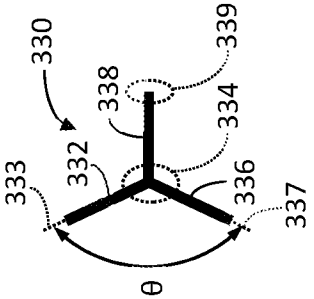


FIG. 3C:

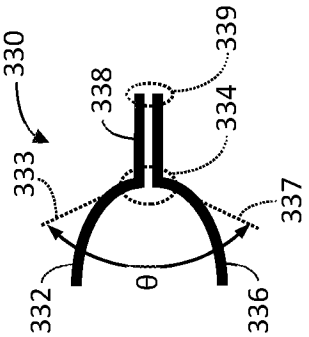


FIG. 3D:

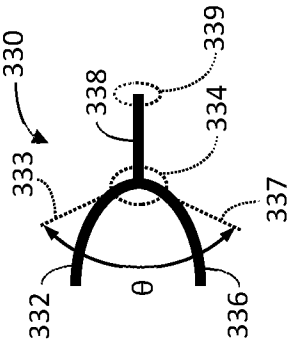


FIG. 3E:

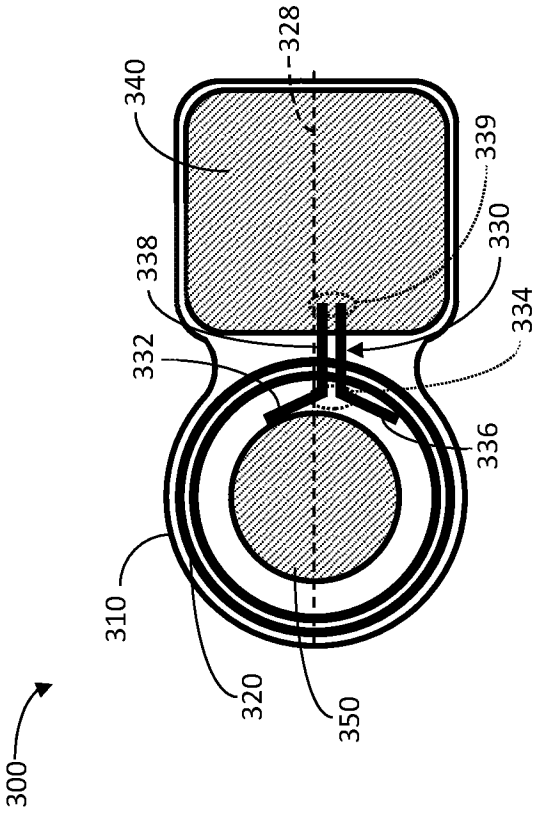


FIG. 4:

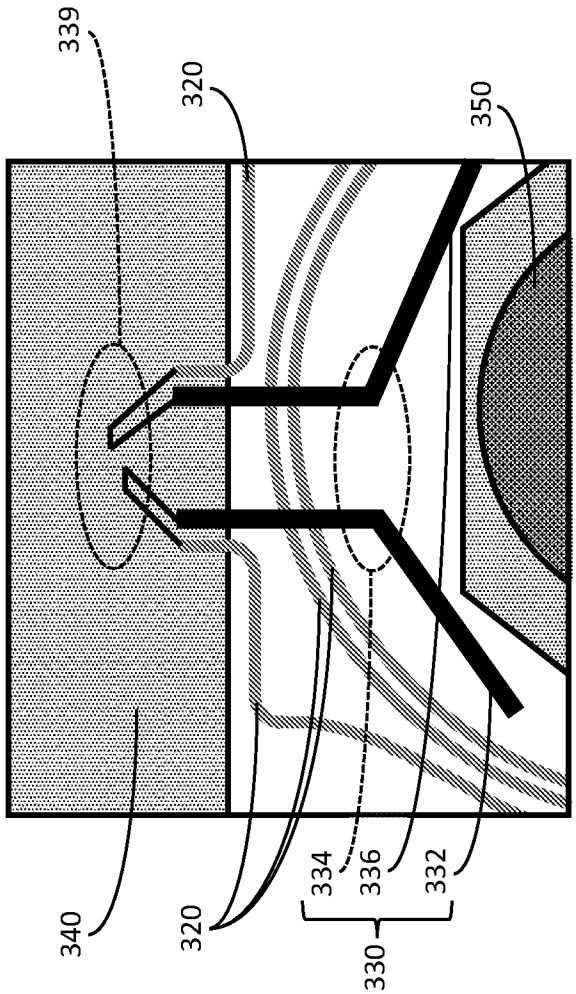


FIG. 5A:

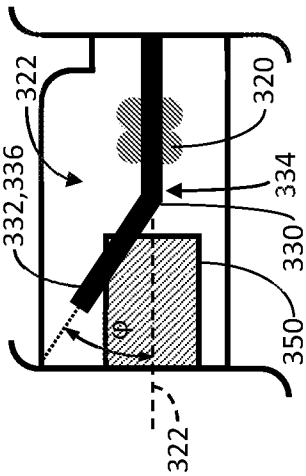


FIG. 5B:

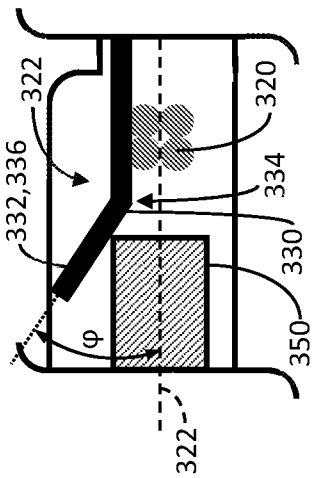


FIG. 5C:

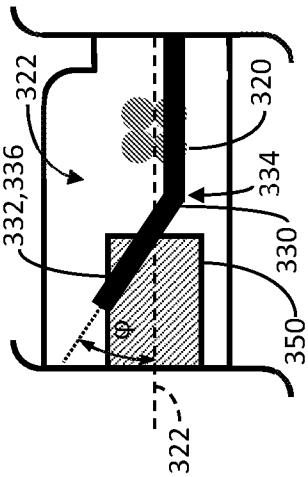
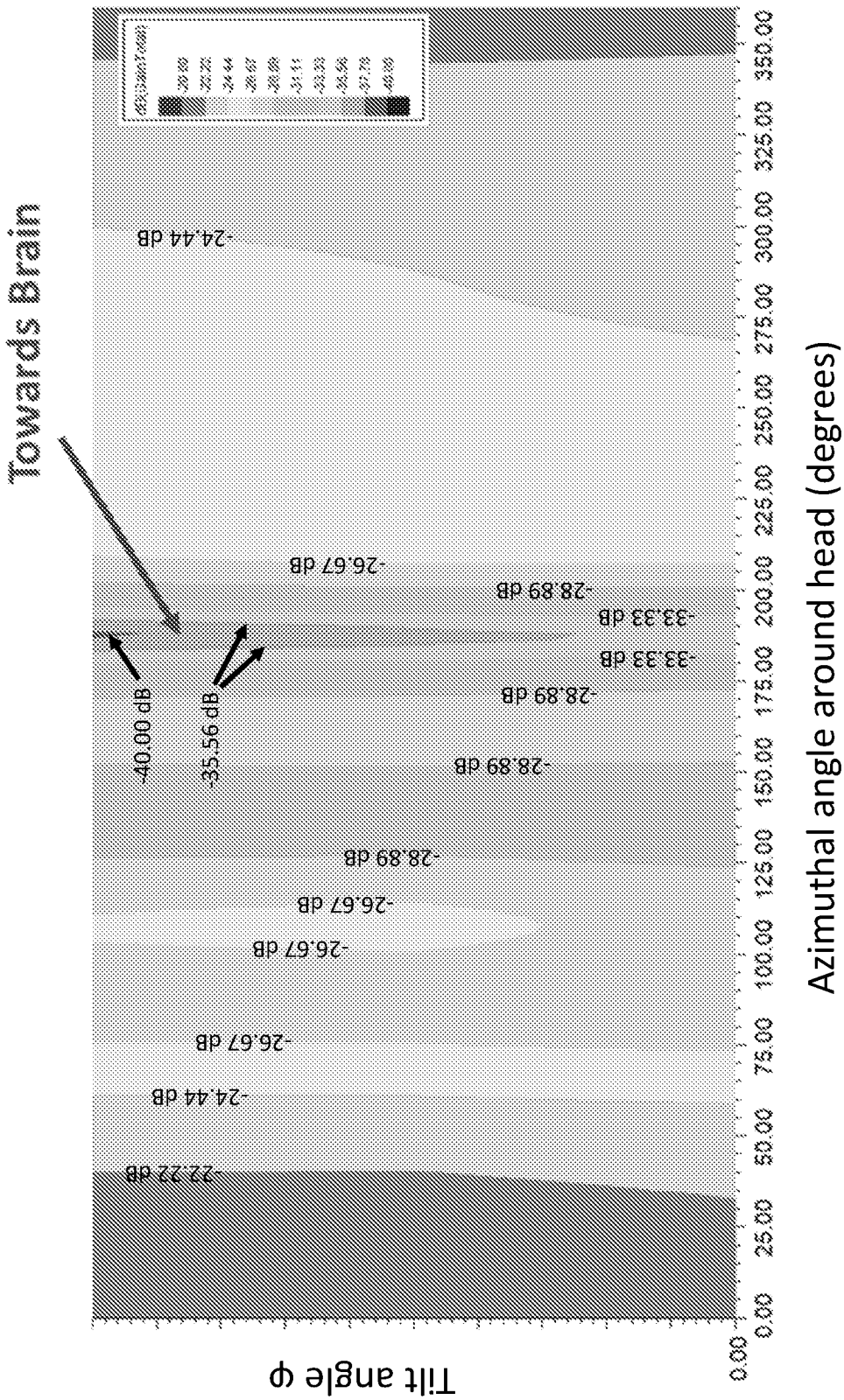


FIG. 6:


Towards Brain
-40.00 dB
-35.56 dB
-22.22 dB
-24.44 dB
-26.67 dB
-26.67 dB
-26.67 dB
-28.89 dB
-28.89 dB
-28.89 dB
-33.33 dB
-33.33 dB
-28.89 dB
-26.67 dB
-24.44 dB
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
250.00
275.00
300.00
325.00
350.00
Tilt angle φ
Azimuthal angle around head (degrees)

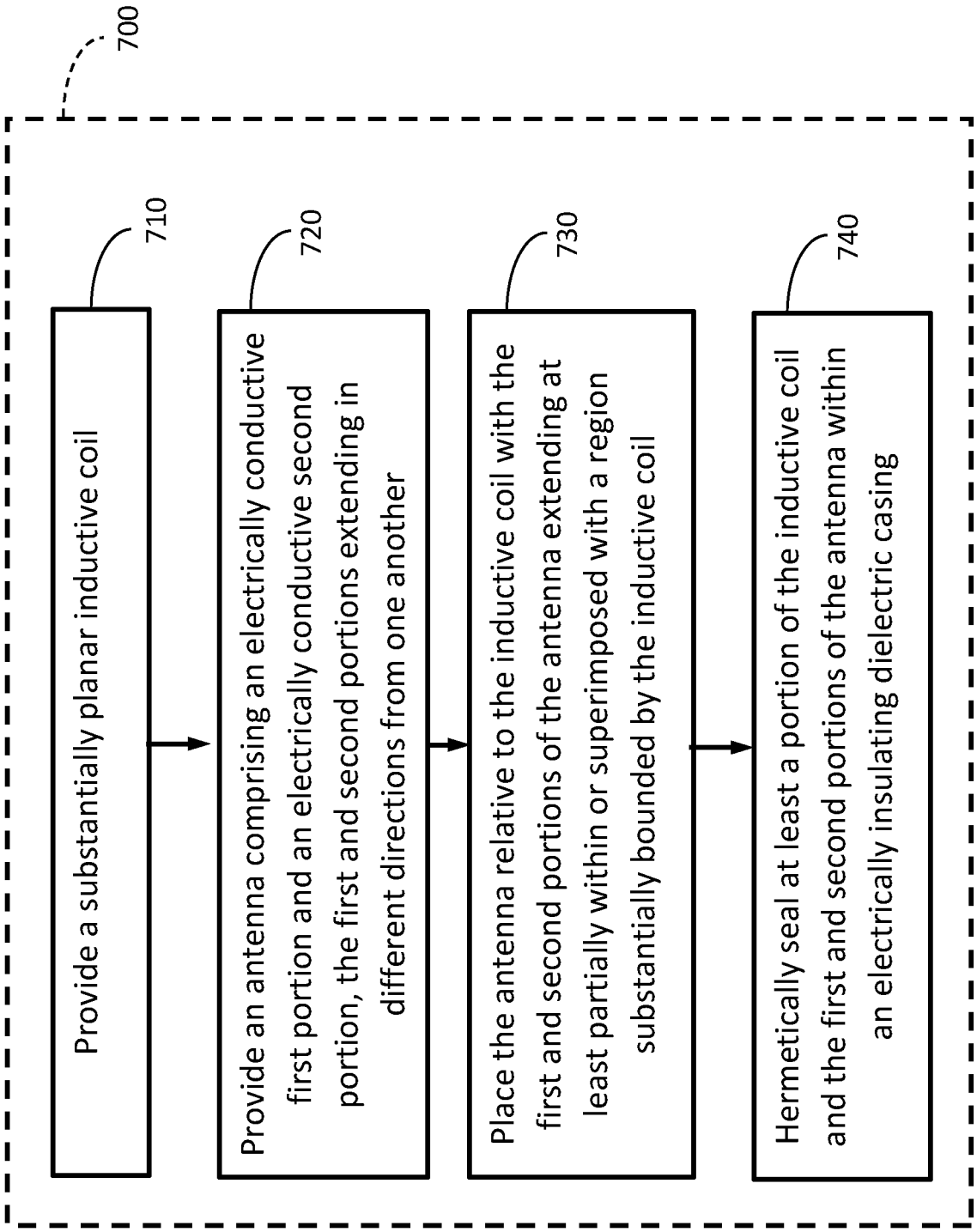

700
710
Provide a substantially planar inductive coil
720
Provide an antenna comprising an electrically conductive first portion and an electrically conductive second portion, the first and second portions extending in different directions from one another
730
Place the antenna relative to the inductive coil with the first and second portions of the antenna extending at least partially within or superimposed with a region substantially bounded by the inductive coil
740
Hermetically seal at least a portion of the inductive coil and the first and second portions of the antenna within an electrically insulating dielectric casing

FIG. 7:

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/053721

A. CLASSIFICATION OF SUBJECT MATTER

A61N 1/372(2006.01)i; **A61N 1/378**(2006.01)i; **H04B 5/79**(2024.01)i; **H04B 5/43**(2024.01)i; **A61N 1/36**(2006.01)i; **A61N 1/05**(2006.01)i

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)

A61N 1/372(2006.01); A61N 1/00(2006.01); A61N 1/05(2006.01); A61N 1/08(2006.01); A61N 1/36(2006.01); A61N 1/375(2006.01); A61N 1/378(2006.01); H01Q 1/27(2006.01)

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: implant, coil, antenna, transmit, signals, vertex, coil, monopole, dipole, branches, feedthrough

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017-091299 A1 (BOSTON SCIENTIFIC NEUROMODULATION CORPORATION) 01 June 2017 (2017-06-01) paragraphs [0023]-[0033]; claims 1-15; figures 3A-6D	1-4,19-23,25-26
A	US 8825171 B1 (ADVANCED BIONICS LLC) 02 September 2014 (2014-09-02) whole document	1-4,19-23,25-26
A	US 2014-0266933 A1 (NEUROPACE, INC.) 18 September 2014 (2014-09-18) whole document	1-4,19-23,25-26
A	US 8862235 B1 (STOVER, H. H. et al.) 14 October 2014 (2014-10-14) whole doucment	1-4,19-23,25-26
A	US 11090484 B2 (COCHLEAR LIMITED) 17 August 2021 (2021-08-17) whole document	1-4,19-23,25-26

☑ 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
"D" document cited by the applicant in the international application
"E" earlier application or patent 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
15 July 2024	**15 July 2024**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/053721

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2022-0088396 A1 (BOSTON SCIENTIFIC NEUROMODULATION CORPORATION) 24 March 2022 (2022-03-24) whole document	1-4,19-23,25-26

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/053721

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☑ Claims Nos.: **6-7,12**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

As claims 6-7, 12 refer to one of the unsearchable claims which does not comply with PCT Rule 6.4(a), claims 6-7, 12 are unclear (PCT Article 6).

3. ☑ Claims Nos.: **5,8-11,13-18,24**
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2024/053721

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		EP 1614443 B1	19 September 2007
		US 2006-0009814 A1	12 January 2006
		US 9622677 B1	18 April 2017
US 11090484 B2	17 August 2021	US 2014-0163626 A1	12 June 2014
		US 2015-0165192 A1	18 June 2015
		US 2021-0330964 A1	28 October 2021
US 2022-0088396 A1	24 March 2022	None	