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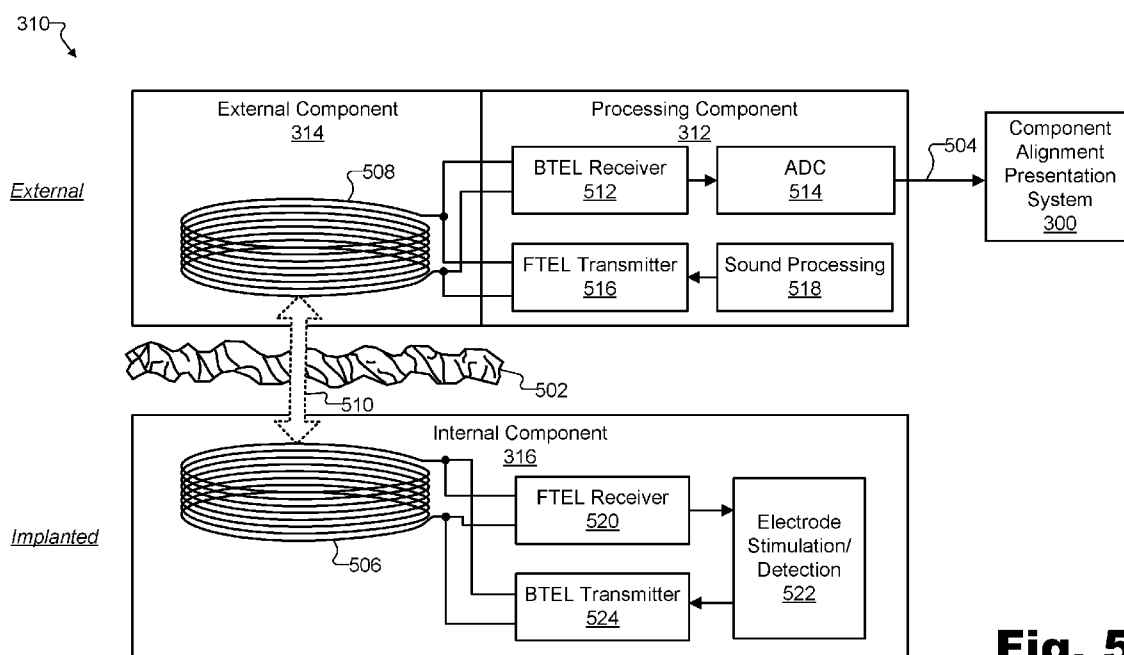


Fig. 5

(57) Abstract: An exemplary component alignment presentation system receives a Received Signal Strength Indicator ("RSSI") signal from a cochlear implant system. The cochlear implant system includes an external component configured to detect a wireless back telemetry signal generated by an internal component and having a detected signal strength indicative of how optimally the external component is aligned with the internal component. The cochlear implant system further includes a processing component configured to generate the RSSI signal based on the signal strength of the detected back telemetry signal and to provide the RSSI signal to the component alignment presentation system. The component alignment presentation system presents, based on the RSSI signal and by way of a user interface, an indication of how optimally the external component is aligned with the internal component to assist a user in optimally aligning the external component with the internal component. Corresponding methods are also disclosed.

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SYSTEMS FOR FACILITATING OPTIMAL ALIGNMENT OF COCHLEAR IMPLANT SYSTEM COMPONENTS

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BACKGROUND INFORMATION

[0001] Cochlear implant systems are used to provide, restore, and/or improve hearing loss suffered by cochlear implant patients who use the cochlear implant systems. In operation, typical cochlear implant systems include one or more internal components implanted within the patient (e.g., including a cochlear implant that applies electrical stimulation to the patient by way of an electrode lead inserted in the patient's cochlea), as well as one or more external components operating external to the patient (e.g., including a sound processor, a headpiece, etc.). In order for external and internal components to properly interoperate, communication between the external and internal components is commonly carried over a transcutaneous wireless link. For example, an external sound processor may transmit operating power and/or data (e.g., stimulation parameters and/or other instructions) to an internal cochlear implant by way of an external headpiece that is aligned on the head with the cochlear implant and includes a communication component (e.g., an antenna coil or the like) for transmitting the power and data through the skin to the cochlear implant.

[0002] In some examples, optimal alignment of external and internal components may be facilitated by magnets associated with the external and/or internal components. However, particularly in circumstances where such magnets are absent or insufficiently effective, it may be difficult and/or inconvenient to optimally align external and internal components. For example, during a surgical procedure in which the internal components are being implanted, various obstructions (e.g., bandages, surgical drapes and coverings, etc.) may obstruct a surgeon's view of the patient's head and blunt a magnetic attraction between the external and internal components. As another example, cochlear implant systems with weak magnets or no magnets may be used by patients who are unable to tolerate strong magnetic forces for various reasons (e.g., discomfort, magnetic interference with other devices, etc.).

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The accompanying drawings illustrate various embodiments and are a part of the specification. The illustrated embodiments are merely examples and do not limit the

scope of the disclosure. Throughout the drawings, identical or similar reference numbers designate identical or similar elements.

[0004] FIG. 1 illustrates an exemplary cochlear implant system according to principles described herein.

5 **[0005]** FIG. 2 illustrates a schematic structure of the human cochlea according to principles described herein.

[0006] FIG. 3 illustrates a block diagram of exemplary components of a cochlear implant system communicatively coupled with a component alignment presentation system configured to facilitate optimal alignment of components of the cochlear implant system according to principles described herein.

[0007] FIG. 4 illustrates exemplary aspects of how the component alignment presentation system of FIG. 3 may facilitate optimal alignment of an external component of the cochlear implant system of FIG. 3 with an internal component of the cochlear implant system according to principles described herein.

15 **[0008]** FIG. 5 illustrates exemplary aspects of the cochlear implant system of FIG. 3 during operation with the component alignment presentation system of FIG. 3 according to principles described herein.

[0009] FIGS. 6A through 6C illustrate exemplary implementations and configurations of the cochlear implant system and the component alignment presentation system of FIG. 3 according to principles described herein.

[0010] FIG. 7 illustrates an exemplary method for facilitating optimal alignment of cochlear implant system components according to principles described herein.

[0011] FIG. 8 illustrates an exemplary computing device according to principles described herein.

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DETAILED DESCRIPTION

30 **[0012]** Systems and methods for facilitating optimal alignment of cochlear implant system components are described herein. For example, an external component and an internal component of a cochlear implant system may be most optimally aligned when a communication component included within the external component (e.g., an antenna coil or the like) is positioned so as to be disposed directly over a corresponding

communication component included within the internal component. In contrast, the external and internal components may be less optimally aligned when the communication components are near one another, but are offset to some degree from the most optimal position. While certain transmission (e.g., data communication, power transmission, etc.) may be performed with a suboptimal alignment between the external and internal components, it may be desirable to achieve the most optimal alignment possible to promote reliable, effective, and power-efficient operation of the cochlear implant system.

[0013] To this end, disclosed systems and methods may be used to facilitate optimal alignment of cochlear implant system components. For instance, an exemplary component alignment presentation system may be implemented by at least one physical computing device (e.g., by a computing system coupled to a cochlear implant system, by one or more components included within a cochlear implant system, by a combination of a computing system and components included within a cochlear implant system, etc.). The component alignment presentation system (e.g., the at least one physical computing device) may receive a Received Signal Strength Indicator (“RSSI”) signal from a cochlear implant system.

[0014] In some examples, the cochlear implant system from which the RSSI signal is received may include an external component configured to operate external to a patient associated with the cochlear implant system and configured to detect a wireless back telemetry signal generated by an internal component configured to be implanted within the patient. The detected back telemetry signal may have a signal strength indicative of how optimally the external component is aligned with the internal component. For instance, if the back telemetry signal is transmitted at a known, fixed signal strength, then the signal strength that the back telemetry signal has when it is detected (i.e., received) may indicate whether the transmitter of the back telemetry signal included within the internal component is well aligned with (i.e., relatively nearby, as indicated by a relatively strong signal) or poorly aligned with (i.e., relatively far away from, as indicated by a relatively weak signal) the receiver of the back telemetry signal included within the external component. The cochlear implant system may further include a processing component configured to generate the RSSI signal based on the signal strength of the detected back telemetry signal, as well as to provide the RSSI signal to the component alignment presentation system.

[0015] Based on the RSSI signal, the component alignment presentation system may present an indication of how optimally the external component is aligned with the internal component. For example, the component alignment presentation system may present graphics, sounds, haptic feedback, etc., to a user by way of a user interface (e.g., on a computer, on a mobile device, on an external component of the cochlear implant system, etc.). The user may be a surgeon or a member of a surgical team performing a surgical procedure to implant the internal components of the cochlear implant system, the patient or a caregiver who provides assistance to the patient (e.g., a parent of a pediatric patient, a nurse, a clinician, etc.), or any other user who may wish to optimally align (e.g., by manual placement) the external component with the internal component. The component alignment presentation system may assist the user in optimally aligning the external component with the internal component in various ways as will be described in more detail below.

[0016] Systems and methods for facilitating optimal alignment of cochlear implant system components may provide various benefits. For example, disclosed methods and systems may assist users in optimally aligning an external component of a cochlear implant system with an internal component of the cochlear implant system without visibility of the patient's head, without help from magnetic attraction forces pulling the components into place, or the like. Such assistance may be helpful and convenient in examples where visibility is poor, magnetic attraction forces are blunted or nonexistent, or in other such circumstances.

[0017] As one example, surgeons and others assisting the surgeon in implanting cochlear implant system components within patients may have various reasons to communicatively couple an external component with an internal component during the surgery. For example, by communicatively coupling an external sound processor (e.g., by way of an external headpiece) with an internal cochlear implant, the sound processor may direct the cochlear implant to apply stimulation and/or detect voltages to indicate to the surgical team whether an electrode lead has been or is being inserted properly (e.g., based on detected impedances, evoked responses from the patient, etc.). Unfortunately, operations in which data is obtained from internal components may use a relatively large amount of power, thereby requiring a relatively optimal alignment between the external and internal components to be performed successfully and reliably. Because various obstructions (e.g., surgical drapes, bandages, gauze, etc.) may limit visibility of and/or obstruct access to a location on the patient's head where

the cochlear implant is implanted, it has been inconvenient and frustrating for surgeons to try to achieve an optimal alignment during surgery without significant tactile (e.g., magnetic) or visual feedback. Even if magnets are included on the external and/or the internal components to help facilitate the alignment, the magnetic attraction force may be blunted by the various layers of cloth, gauze, etc. between the external component (e.g., the headpiece) and the internal component (e.g., the cochlear implant). As such, systems and methods for facilitating optimal alignment may be beneficial during surgery to make it easier to achieve the most optimal alignment possible.

[0018] As another example, certain cochlear implant systems may not provide significant magnetic alignment forces for a variety of reasons. For instance, magnets may be excluded from systems intended for patients who find the attraction (e.g., the pinch) of an external and an internal component to be painful or uncomfortable, for patients who have other medical devices which the magnets could interfere with, or for patients who otherwise are unable or prefer not to use magnets. In other examples, magnets may lose their effectiveness over time such that the magnetic attraction force becomes too weak to hold the external component onto the head and/or to help guide the external component into place in alignment with the internal component. Regardless of the reason, certain patients may use means other than magnets to hold external components of their cochlear implant systems in place during normal, day-to-day operation. For example, a headpiece of a cochlear implant system may be held in place on the patient's head with a hair clip, a headband, an adhesive, or the like. In these examples, users such as the patient himself or herself and/or a caretaker assisting the patient in positioning the external component may benefit from systems and methods described herein by receiving assistance in achieving and maintaining the most optimal alignment possible to thereby ensure reliable, power-efficient operation of the cochlear implant system.

[0019] Systems and methods for facilitating optimal alignment of cochlear implant system components may also be beneficial in that no additional circuitry may need to be added to cochlear implant systems for component alignment presentation systems to facilitate the optimal alignment. Moreover, disclosed systems and methods may accomplish the ends described above without use of stronger magnets, without increasing transmission power levels, without increasing battery usage (i.e., to decrease battery time), and so forth.

[0020] Various embodiments will now be described in more detail with reference to the figures. The disclosed systems and methods may provide one or more of the benefits mentioned above and/or various additional and/or alternative benefits that will be made apparent herein.

5 **[0021]** FIG. 1 illustrates an exemplary cochlear implant system 100. As shown, cochlear implant system 100 may include a microphone 102, a sound processor 104, a headpiece 106 having a coil disposed therein, a cochlear implant 108, and an electrode lead 110. Electrode lead 110 may include an array of electrodes 112 disposed on a distal portion of electrode lead 110 and that are configured to be inserted into the
10 cochlea to stimulate the cochlea after the distal portion of electrode lead 110 is inserted into the cochlea. It will be understood that one or more other electrodes (e.g., including a ground electrode, not explicitly shown) may also be disposed on other parts of electrode lead 110 (e.g., on a proximal portion of electrode lead 110) to, for example, provide a current return path for stimulation current generated by electrodes 112 and to
15 remain external to the cochlea after electrode lead 110 is inserted into the cochlea. As shown, electrode lead 110 may be pre-curved so as to properly fit within the spiral shape of the cochlea. Additional or alternative components may be included within cochlear implant system 100 as may serve a particular implementation.

[0022] As shown, cochlear implant system 100 may include various components
20 configured to be located external to a patient including, but not limited to, microphone 102, sound processor 104, and headpiece 106. Cochlear implant system 100 may further include various components configured to be implanted within the patient including, but not limited to, cochlear implant 108 and electrode lead 110.

[0023] Microphone 102 may be configured to detect audio signals presented to the
25 user. Microphone 102 may be implemented in any suitable manner. For example, microphone 102 may include a microphone that is configured to be placed within the concha of the ear near the entrance to the ear canal, such as a T-MIC™ microphone from Advanced Bionics. Such a microphone may be held within the concha of the ear near the entrance of the ear canal by a boom or stalk that is attached to an ear hook
30 configured to be selectively attached to sound processor 104. Additionally or alternatively, microphone 102 may be implemented by one or more microphones disposed within headpiece 106, one or more microphones disposed within sound processor 104, one or more beam-forming microphones, and/or any other suitable microphone as may serve a particular implementation.

[0024] Sound processor 104 (i.e., one or more components included within sound processor 104) may be configured to direct cochlear implant 108 to generate and apply electrical stimulation (also referred to herein as “stimulation current”) representative of one or more audio signals (e.g., one or more audio signals detected by microphone 102, input by way of an auxiliary audio input port, input by way of a clinician’s programming interface (“CPI”) device, etc.) to one or more stimulation sites associated with an auditory pathway (e.g., the auditory nerve) of the patient. Exemplary stimulation sites include, but are not limited to, one or more locations within the cochlea, the cochlear nucleus, the inferior colliculus, and/or any other nuclei in the auditory pathway. To this end, sound processor 104 may process the one or more audio signals in accordance with a selected sound processing strategy or program to generate appropriate stimulation parameters for controlling cochlear implant 108. Sound processor 104 may be housed within any suitable housing (e.g., a behind-the-ear (“BTE”) unit, a body worn device, headpiece 106, and/or any other sound processing unit as may serve a particular implementation).

[0025] In some examples, sound processor 104 may wirelessly transmit stimulation parameters (e.g., in the form of data words included in a forward telemetry sequence) and/or power to cochlear implant 108 by way of a wireless communication link 114 between headpiece 106 and cochlear implant 108 (e.g., a wireless link between a coil disposed within headpiece 106 and a coil included within or coupled to cochlear implant 108). Wireless communication link 114 may be most reliable, effective, power efficient, and so forth, when headpiece 106 is as optimally aligned with cochlear implant 108 as possible. In particular, wireless communication link 114 may be strongest when a communication component such as a coil disposed within headpiece 106 is aligned with and positioned as closely as possible to a communication component such as a coil disposed within cochlear implant 108 (e.g., positioned directly over the communication component of cochlear implant 108 on the other side of the skin of the patient). It will be understood that communication link 114 may include a bi-directional communication link and/or one or more dedicated uni-directional communication links.

[0026] Headpiece 106 may be communicatively coupled to sound processor 104 and may include an antenna (e.g., a coil and/or one or more wireless communication components) configured to facilitate selective wireless coupling of sound processor 104 to cochlear implant 108. Additionally or alternatively, headpiece 106 may be used to selectively and wirelessly couple any other external device (e.g., a battery charger, etc.)

to cochlear implant 108. To this end, headpiece 106 may be configured to be affixed to the patient's head and positioned or aligned such that an antenna housed within headpiece 106 is communicatively coupled to a corresponding implantable antenna (which may also be implemented by a coil and/or one or more wireless communication components) included within or otherwise associated with cochlear implant 108. In this manner, stimulation parameters and/or power signals may be wirelessly transmitted between sound processor 104 and cochlear implant 108 via a communication link 114 (which may include a bi-directional communication link and/or one or more dedicated uni-directional communication links as may serve a particular implementation).

[0027] Cochlear implant 108 may include any type of implantable stimulator that may be used in association with the systems and methods described herein. For example, cochlear implant 108 may be implemented by an implantable cochlear stimulator. In some alternative implementations, cochlear implant 108 may include a brainstem implant and/or any other type of cochlear implant that may be implanted within a patient and configured to apply stimulation to one or more stimulation sites located along an auditory pathway of a patient.

[0028] In some examples, cochlear implant 108 may be configured to generate electrical stimulation representative of an audio signal processed by sound processor 104 (e.g., an audio signal detected by microphone 102) in accordance with one or more stimulation parameters transmitted thereto by sound processor 104. Cochlear implant 108 may be further configured to apply the electrical stimulation to one or more stimulation sites (e.g., one or more intracochlear regions) within the patient via electrodes 112 disposed along electrode lead 110. In some examples, cochlear implant 108 may include a plurality of independent current sources each associated with a channel defined by one or more of electrodes 112. In this manner, different stimulation current levels may be applied to multiple stimulation sites simultaneously by way of multiple electrodes 112.

[0029] Along with receiving stimulation parameters and/or other instruction from sound processor 104 in a forward telemetry ("FTEL") signal, cochlear implant 108 may also transmit data back to sound processor 104 (e.g., by way of wireless communication link 114). For example, cochlear implant 108 may transmit a back telemetry ("BTEL") signal representative of measurements (e.g., impedance measurements, evoked response measurements, etc.) detected by cochlear implant

108 or representative of any other data that cochlear implant 108 may communicate with sound processor 104 in a particular implementation.

[0030] As shown, FIG. 1 illustrates that certain components of cochlear implant system 100 (i.e., microphone 102, sound processor 104, and headpiece 106) may be external components, while other components (i.e., cochlear implant 108, and lead 110 with electrodes 112) may be internal components. It will be understood, however, that in certain implementations of system 100, certain external components may be combined, omitted, and/or implanted within the patient. For instance, in certain examples, cochlear implant system 100 may omit headpiece 106 and a wireless communication component such as a coil may be included within sound processor 104. As another example, sound processor 104 (e.g., including a rechargeable battery for powering sound processor 104) may be integrated within cochlear implant 108 as a fully-implantable cochlear implant system implanted within the patient. In this example, a headpiece such as headpiece 106 may be used to provide power to the cochlear implant to charge a battery of the fully-implantable cochlear implant system. Regardless of how cochlear implant system 100 is configured, however, systems and methods for facilitating optimal alignment of cochlear implant system components may be equally applicable as long as there is at least one external component of cochlear implant system 100 that is to be aligned with an internal component of cochlear implant system 100.

[0031] FIG. 2 illustrates a schematic structure of the human cochlea 200 into which electrode lead 110 may be inserted. As shown in FIG. 2, cochlea 200 is in the shape of a spiral beginning at a base 202 and ending at an apex 204. Within cochlea 200 resides auditory nerve tissue 206, which is denoted by Xs in FIG. 2. The auditory nerve tissue 206 is organized within the cochlea 200 in a tonotopic manner. Relatively low frequencies are encoded at or near the apex 204 of the cochlea 200 (referred to as an “apical region”) while relatively high frequencies are encoded at or near the base 202 (referred to as a “basal region”). Hence, electrical stimulation applied by way of electrodes disposed within the apical region (i.e., “apical electrodes”) may result in the patient perceiving relatively low frequencies and electrical stimulation applied by way of electrodes disposed within the basal region (i.e., “basal electrodes”) may result in the patient perceiving relatively high frequencies. The delineation between the apical and basal electrodes on a particular electrode lead may vary depending on the insertion

depth of the electrode lead, the anatomy of the patient's cochlea, and/or any other factor as may serve a particular implementation.

[0032] FIG. 3 illustrates a block diagram of exemplary components of a cochlear implant system communicatively coupled with a component alignment presentation system configured to facilitate optimal alignment of components of the cochlear implant system. Specifically, as shown, a component alignment presentation system 300 ("system 300") that includes a communication facility 302, a presentation facility 304, and a storage facility 306 that stores management data 308 is communicatively coupled with a cochlear implant system 310 that includes a processing component 312, an external component 314, and an internal component 316. System 300 and/or cochlear implant system 310 may interoperate with one another to perform any of the operations described herein for facilitating optimal alignment of cochlear implant system components. To this end, as shown, communication facility 302, presentation facility 304, and storage facility 306 within system 300 may be selectively and communicatively coupled to one another, as may processing component 312, external component 314, and internal component 316 within cochlear implant system 310. Moreover, as illustrated by arrow 318, certain components of system 300 and cochlear implant system 310 (e.g., communication facility 302 and processing component 312) may also be communicatively coupled with one another to implement intersystem communications as will be described below.

[0033] It will be recognized that although facilities 302 through 306 are shown to be separate facilities in FIG. 3, facilities 302 through 306 may be combined into fewer facilities, such as into a single facility, or divided into more facilities as may serve a particular implementation. Similarly, although components 312 through 316 are shown to be separate components in FIG. 3, components 312 through 316 may be combined into fewer components or divided into more components as may serve a particular implementation. Moreover, in certain examples, system 300 and cochlear implant system 310 may be integrated together into a single system such that arrow 318, rather than representing a communicative coupling between separate systems, may represent the integration of a single system that performs all of the operations described below as being associated with both system 300 and cochlear implant system 310. Each of facilities 302 through 306 and components 312 through 316 will now be described in more detail.

[0034] Communication facility 302 may include or be implemented by one or more physical computing devices (e.g., including hardware and/or software such as processors, memories, communication interfaces, instructions stored in memory for execution by the processors, etc.) that perform various operations associated with communicating with cochlear implant system 310 and/or components thereof. For example, communication facility 302 may receive an RSSI signal from cochlear implant system 310 that is based on a signal strength of a detected back telemetry signal, making the RSSI signal indicative of how optimally external component 314 is aligned with internal component 316. Communication facility 302 may also transmit data to cochlear implant system 310 (e.g., data requesting or acknowledging the RSSI signal, etc.) and/or perform any other operations to communicate with cochlear implant system 310 or other systems, or with a user of system 300, as may serve a particular implementation.

[0035] Presentation facility 304 may include or be implemented by one or more physical computing devices such as the same computing devices or similar (but separate) computing devices described above in relation to communication facility 302. Presentation facility 304 may generate and maintain a user interface by way of which a user of system 300 may provide input to or receive information from system 300. For example, based on the RSSI signal received by communication facility 302, presentation facility 304 may present to the user (e.g., by way of the user interface) an indication of how optimally the external component is aligned with the internal component to assist the user in optimally aligning the external component with the internal component. As will be described in more detail below, the user interface presented by presentation facility 304 may include graphics or text displayed on a screen, sounds presented by way of a loudspeaker, haptic or tactile feedback presented by way of an input/output device that the user may touch, and/or in any other suitable way.

[0036] Storage facility 306 may maintain management data 308 and/or any other data received, generated, managed, maintained, used, and/or transmitted by facilities 302 and 304 in a particular implementation. Management data 308 may include data representative of RSSI signals received from cochlear implant system 310, data used to request such a signal, or the like. Additionally, management data 308 may include data representative of the user interface (e.g., including graphical data, sound data, etc.) that may be used to present the user interface and to thereby assist a user in optimally

aligning external component 314 with internal component 316. Storage facility 306 may further include any other data as may serve a particular implementation of system 300 to facilitate performing one or more of the operations described herein.

[0037] Within cochlear implant system 310, processing component 312 may be implemented by any component configured to perform basic signal processing such as to generate the RSSI signal based on a signal strength of a detected back telemetry signal, and to provide (i.e., communicate) the RSSI signal to communication facility 302 of system 300. For example, processing component 312 may be implemented by a sound processor of cochlear implant system 310 (e.g., a sound processor similar to sound processor 104, described above) or a component thereof. In some examples, processing component 312 may receive the detected back telemetry signal having the signal strength indicative of how optimally external component 314 is aligned with internal component 316, amplify the back telemetry signal, filter and/or otherwise process the back telemetry signal, and then convert the back telemetry signal from an analog signal to a digital RSSI signal that represents the signal strength of the detected back telemetry signal. Processing component 312 may also perform various other operations such as those described above in relation to sound processor 104.

[0038] External component 314 may be implemented by a component configured to operate external to the patient and that is to be optimally aligned with internal component 316 in order to facilitate communication with internal component 316. For example, external component 314 may be implemented by a headpiece similar to headpiece 106 described above in relation to cochlear implant system 100. External component 314 may be configured to detect the back telemetry signal generated by internal component 316 and to provide the back telemetry signal (e.g., or at least a signal representative of the detected signal strength of the detected back telemetry signal) to processing component 312. As such, external component 314 may include a wireless communication component such as an antenna coil and may be communicatively coupled (e.g., by way of a cable) to processing component 312. External component 314 may also perform various other operations such as those described herein in relation to headpiece 106.

[0039] Internal component 316 may be implemented by a component configured to be implanted within the patient and that communicates with (e.g., receives forward telemetry signals from and/or sends back telemetry signals to) external component 314 when external component 314 and internal component 316 are suitably aligned. For

example, internal component 316 may be implemented by a cochlear implant similar to cochlear implant 108 described above in relation to cochlear implant system 100. As described above, wireless transcutaneous communication may be most effective when the alignment of external component 314 and internal component 316 is optimized (i.e., by bringing the components as close together as possible). Thus, internal component 316 may generate and transmit a back telemetry signal with a known, fixed signal strength such that, when the back telemetry signal is detected by external component 314, the detected signal strength will be indicative of how optimally external component 314 is aligned with internal component 316. Internal component 316 may also perform various other operations such as those described herein in relation to cochlear implant 108.

[0040] FIG. 4 illustrates exemplary aspects of how system 300 may facilitate optimal alignment of external component 314 of cochlear implant system 310 with internal component 316 of cochlear implant system 310. Specifically, as shown in FIG. 4, beneath the skin on a particular part of a head of a patient 400, internal component 316 may be implanted (i.e., illustrated by dashed lines to indicate that internal component 316 is beneath the skin and may not actually be visible from the external perspective shown in FIG. 4). A user of system 300 may wish to determine where internal component 316 is located so as to align external component 314 with internal component 316 as optimally as possible. While external component 314 is shown to be “floating” on the surface of the head of patient 400 (i.e., so as to have complete freedom of movement in any direction), it will be understood that external component 314 may actually be somewhat limited in its movement as a result of being tethered (e.g., by a communication cable) to other components of cochlear implant system 310 such as processing component 312 (e.g., a sound processor or the like), which is not explicitly shown in FIG. 4 but which may be disposed, for example, behind the ear of patient 400.

[0041] In order to achieve an optimal alignment, the user of system 300 may manually attempt to move external component 314 into alignment with internal component 316. As such, the user may bring external component 314 into the general vicinity of internal component 316. For example, as shown, the user may bring external component 314 into a region 402 which may cover a relatively large portion of the head of patient 400 (i.e., making the region easy to locate), but which may encompass areas that are not particularly well-aligned with internal component 316. Region 402 may

represent a region in which internal component 316 is capable of receiving, to a least a certain degree, a forward telemetry signal generated by external component 314. For example, when cochlear implant system 310 is being initiated and external component 314 has not yet made a strong connection with internal component 316, cochlear
5 implant system 310 may cause a relatively large amount of power to be emitted from external component 314 to allow internal component 316 to receive power and begin powering up and transmitting a back telemetry signal.

[0042] As such, when external component 314 is located within an outer portion of region 402, internal component 316 may not be very optimally aligned with external
10 component 314, but may be aligned well enough to receive power from the forward telemetry signal and begin operating to generate and transmit the back telemetry signal. However, while external component 314 remains along the outer portion of region 402, the detected signal strength that external component 314 detects for the back telemetry signal may indicate that the alignment is still suboptimal. As a result, as
15 will be described in more detail below, a processing component communicatively coupled with external component 314 (e.g., processing component 312) may generate and provide an RSSI signal indicating that the alignment is suboptimal, which may be presented to the user in any of a variety of ways described herein. Based on the presentation of the indication that the alignment is currently suboptimal, the user may
20 continue moving external component 314 around on the head of patient 400 and monitoring the user interface to determine if external component 314 is becoming more optimally or less optimally aligned with internal component 316.

[0043] For example, if the user moves external component 314 into a region 404 that is more optimally aligned than the outer portion of region 402, the back telemetry
25 signal detected by external component 314 may have a stronger signal strength, indicating that the alignment is becoming more optimal. This improvement in the alignment may be communicated to the user by a similar chain of operations as described above (i.e., by way of the RSSI signal, the user interface, etc.) so that the user knows that the external component 314 is getting closer to a highly optimized
30 alignment. It will be understood that, while discrete regions 402 and 406 are shown in FIG. 4, that the proximity of external component 314 to internal component 316 (i.e., how optimal the alignment of the components is) may, in some examples, be represented by a different (e.g., larger) number of discrete regions, or by a continuum. By presenting feedback with a more fine resolution in this way, the user may more

quickly and easily determine how to move external component 314 to achieve the most optimal alignment possible.

[0044] Based on feedback presented by system 300 as described above, the user may eventually move external component 314 directly over internal component 316 within a region 406. Within region 406, the alignment between external component 314 and internal component 316 may be sufficiently optimal for cochlear implant system 310 to perform operations to finalize an initialization process and to lock the communication between the components, as will be described below. Additionally, system 300 may indicate to the user that a sufficiently optimal alignment has been achieved so that the user may cease moving external component 314 around and may fix external component 314 at the aligned location over internal component 316 (e.g., by holding external component 314 in place, fixing it using mechanical or adhesive means, or the like). In some examples, when external component 314 is moved into place within region 406, a magnetic attraction force between components 314 and 316 may be strong enough to pull the components together and hold external component 314 in place.

[0045] System 300 may be used in conjunction with cochlear implant system 310 to facilitate optimal alignment of cochlear implant system components in various situations and circumstances. For instance, in one example as mentioned above, the user optimally aligning external component 314 with internal component 316 by assistance of system 300 may be associated with performing a surgical procedure whereby internal component 316 is implanted within patient 400. For example, the user may be a surgeon who has implanted internal component 316 (e.g., a cochlear implant) and is now working on inserting another internal component (e.g., a lead coupled to the cochlear implant) into the cochlea of patient 400. The surgeon may have poor visibility and/or access to the area of the head where of internal component 316 is implanted due to various obstructions (e.g., bandages, drapes, etc.) that are located around that area. Thus, as the surgeon moves external component 314 around to attempt to achieve alignment with internal component 316, system 300 may receive the RSSI signal from cochlear implant system 310 and may present an indication (i.e., live, real-time, updated indication) to the surgeon of how optimally external component 314 is aligned with internal component 316 while the surgical procedure is underway.

[0046] As another example, also mentioned above, the user optimally aligning external component 314 with internal component 316 by assistance of system 300 may

be patient 400 or a caregiver assisting patient 400. For example, if cochlear implant system 310 is not implemented with magnets in components 314 and/or 316 due to a sensitivity of patient 400 or the like, or if magnets are (or have become) too weak to be particularly helpful to patient 400 in achieving an optimal alignment of components 314 and 316, system 300 may assist patient 400 in optimally aligning external component 314 with internal component 316 in any of the ways described above. Specifically, system 300 may receive the RSSI signal from cochlear implant system 310 and may present the indication of how optimally external component 314 is aligned with internal component 316 to patient 400 when cochlear implant system 310 is under control of patient 400 subsequent to the surgical procedure whereby internal component 316 is implanted within patient 400.

[0047] FIG. 5 illustrates exemplary aspects of cochlear implant system 310 during operation with system 300. Specifically, as shown, external component 314 is located external to a patient on the other side of a skin flap 502 from internal component 316, which is implanted within the patient. External component 314 is communicatively coupled with processing component 312, which is also external to the patient in this configuration, and which generates and provides an RSSI signal 504 to system 300. The providing of RSSI signal 504 may allow system 300 to present an indication, based on RSSI signal 504, of how optimally external component 314 is aligned with internal component 316 to assist a user in optimally aligning components 314 and 316.

[0048] Components 312 through 316 of cochlear implant system 310 may be implemented as any suitable components as may serve a particular implementation. For example, internal component 316 may be a cochlear implant (e.g., similar to cochlear implant 108) configured to be implanted within the patient's head under skin flap 502 and to communicate with external component 314 by way of a first communication component 506 (e.g., an antenna coil or the like) included within the cochlear implant when external component 314 is aligned with the cochlear implant. In this example, external component 314 may be a headpiece (e.g., similar to headpiece 106) configured to be disposed on the patient's head on an opposite side of skin flap 502 from the cochlear implant and to communicate with the cochlear implant by way of a second communication component 508 (e.g., another antenna coil or the like) included within the headpiece when the headpiece is aligned with the cochlear implant. Accordingly, in this example, processing component 312 may be a sound processor (e.g., similar to sound processor 104) communicatively coupled with the headpiece

(e.g., by way of a cable or the like) and with system 300. The sound processor may be configured to communicate with the cochlear implant by way of the headpiece.

[0049] In other examples, components 312 through 316 may be implemented by other components or in other ways. For instance, as mentioned above, in certain

5 examples, processing component 312 and external component 314 may be integrated together into a sound processor in a cochlear implant system that does not employ a discrete headpiece. In other words, the integrated sound processor may include communication component 508 as well as the circuitry and functionality of processing component 312 such that no separate headpiece is required. In still other examples, 10 internal component 316 may incorporate all the functionality of both cochlear implant 108 and sound processor 104, which may all be implanted within the patient. Such a system may be referred to as a fully implantable cochlear implant system. The internal sound processor/cochlear implant combination of such a fully implantable cochlear implant system may be recharged by a battery charger or the like, which may 15 implement (e.g., in separate components or as one integrated component) external component 314, processing component 312, and all the circuitry and functionality included therein.

[0050] Regardless of how components 312 through 316 are implemented and/or what roles these components take in a particular implementation of cochlear implant 20 system 310, certain circuitry and/or functionality may be included within each of the components to allow the components to facilitate optimal alignment along with system 300. For example, as shown, communication component 506 may be included within internal component 316 and communication component 508 may be included within external component 314. By way of these communication components, external 25 component 314 and internal component 316 may transmit and receive both forward telemetry signals and back telemetry signals over a wireless communication link 510 (e.g., similar to wireless communication link 114). Moreover, as shown, processing component 312 may include a back telemetry receiver 512 ("BTEL receiver 512"), an analog-to-digital conversion facility 514 ("ADC 514"), a forward telemetry transmitter 30 516 ("FTEL transmitter 516"), and a sound processing facility 518 ("sound processing 518"). Internal component 316 may include a forward telemetry receiver 520 ("FTEL receiver 520"), electrode stimulation and detection circuitry 522 ("electrode circuitry 522"), and a back telemetry transmitter 524 ("BTEL transmitter 524").

[0051] In operation, once external component 314 and internal component 316 are closely enough aligned that internal component 316 receives operating power from external component 314 (e.g., once external component 314 is approximately located within region 402) BTEL transmitter 524 may generate and transmit a back telemetry signal over wireless communication link 510 (e.g., by way of communication component 506). The back telemetry signal, as generated by BTEL transmitter 524, may be transmitted at a signal strength that is fixed (i.e., at a constant, known, and/or expected magnitude). BTEL receiver 512 may receive the back telemetry signal and perform amplification operations, filtering operations, and/or other suitable signal processing on the back telemetry signal. As detected by BTEL receiver 512, the signal strength of the detected back telemetry signal may be indicative of how optimally the external component is aligned with the internal component as a result of the back telemetry signal being generated (e.g., by BTEL transmitter 524) at the transmitted signal strength that is fixed.

[0052] Once the back telemetry signal has been suitably processed by BTEL receiver 512, ADC 514 may generate RSSI signal 504 as a digital signal by performing an analog-to-digital conversion of an analog signal representative of the signal strength of the detected back telemetry signal. As shown, ADC 514 (e.g., or a communication facility included within cochlear implant system 310, not explicitly shown) may then provide RSSI signal 504 to system 300 so that the alignment indication may be presented, by system 300, to a user attempting to optimize the alignment between external component 314 and internal component 316.

[0053] Along with the back telemetry communication specifically employed to facilitate the optimal alignment of cochlear implant system components described above, it will be understood that forward telemetry communication may also take place in order for cochlear implant system 310 to properly function as a cochlear implant system (e.g., similar to cochlear implant system 100 described above). For example, along with receiving the back telemetry signal from internal component 316, external component 314 may be further configured to transmit a wireless forward telemetry signal to internal component 316 concurrently with the detection of the back telemetry signal generated by internal component 316. Specifically, sound processing 518 may represent various operations performed by a sound processor such as sound processor 108, described above. Based on instruction from sound processing 518, FTEL transmitter 516 may transmit power (e.g., operating power) and/or data (e.g.,

stimulation parameters and instructions) over wireless communication link 510 for use by internal component 316. The forward telemetry signal transmitted by FTEL transmitter 516 may be received within internal component 316 by FTEL receiver 520. The power received may be used as operating power for internal component 316 (e.g., which may not have a battery or other power supply and may rely on power within the forward telemetry signal as its only source of power). The data received within the forward telemetry signal may be used by electrode circuitry 522 to apply stimulation to the patient (e.g., by way of an electrode lead as described above in relation to cochlear implant 108). Electrode circuitry 522 may also use the electrode lead to detect data (e.g., evoked responses, impedances, etc.) which may be included within the back telemetry signal transmitted back to processing component 312 by way of external component 314.

[0054] In order for the forward telemetry signal and the back telemetry signal to be transmitted concurrently (e.g., simultaneously using full-duplex communication) by way of communication components 506 and 508, the forward telemetry signal may be transmitted at a different frequency than the back telemetry signal. For example, the forward telemetry signal may be transmitted at a frequency such as 49 MHz, while the back telemetry signal may be transmitted at a different frequency such as 10.7 MHz in one particular example.

[0055] As described above, the quality of the alignment between components 314 and 316 (i.e., how optimally the components are aligned) may be determined based on a detected signal strength of a back telemetry signal transmitted by internal component 316. However, in certain examples, it may be possible to determine how optimally the components are aligned in a similar way using a detected signal strength of the forward telemetry signal. For example, internal component 316 could detect the signal strength of a forward telemetry signal sent by external component 314, process and convert the detected signal strength to a digital RSSI signal in a similar way as described above for processing component 312, and transmit the RSSI signal to external component 314. It will be understood that, while this exemplary implementation or one similar to it may be possible, it may be preferable in certain examples to detect the signal strength of a back telemetry signal rather than a forward telemetry signal because, as described above, the forward telemetry signal may have a variable signal strength (e.g., to transmit more power before optimal alignment has been achieved than after), while the

back telemetry signal may be transmitted with a fixed signal strength that is more directly correlated with how optimal the alignment is.

[0056] One reason that the signal strength of the forward telemetry signal may be variable, rather than fixed (as may be the case with the back telemetry signal), is that more transmission power may be called for while external component 314 is still being moved around in search of an optimal alignment than when the optimal alignment has been achieved. For example, while optimal alignment is being pursued (e.g., while external component 314 is being moved around within region 402 to try to find region 406 in the center), processing component 312 may be configured to perform an initial system communication characterization. Specifically, the communication characterization may be performed when processing component 312 determines that alignment has reached an optimal level by, for instance, detecting that a signal strength of the back telemetry signal is at a high level, detecting that a user has manually indicated (e.g., by a button press or the like) that the components cannot be aligned any better, or the like. Once processing component 312 determines that the optimal alignment level is reached, processing component 312 may characterize the forward telemetry signal levels being transmitted to determine power levels at which intersystem communications (e.g., over wireless communication link 510) will be made during operation of cochlear implant system 310.

[0057] In conventional systems, this system communication characterization may only be performed once at the initialization (e.g., power on, link startup, etc.) of the processing component. For configurations in which magnetic forces automatically maintain the alignment between components 314 and 316, such a one-time characterization may be appropriate. However, in configurations in which magnetic forces are absent or less capable of maintaining the initial alignment (e.g., configurations of magnet-less systems, surgical configurations where obstructions blunt the magnetic forces, etc.), it may be desirable to track whether the initial system communication characterization remains accurate (e.g., whether the alignment drifts or the like) and to recharacterize the system at a time other than during the initialization if it is detected that the initial system characterization is no longer accurate. To this end, processing component 312 may determine (e.g., during the operation of cochlear implant system 310) that the determined power levels are non-optimal based on RSSI signal 504. Processing component 312 may then perform a system communication recharacterization to determine optimal power levels at which intersystem

communications will be made during subsequent operation of cochlear implant system 310.

[0058] Just as RSSI signal 504 may be used to help optimize power usage by facilitating system recharacterization when needed, as described above, various examples may further use RSSI signal 504 for other purposes besides assisting users in optimally aligning external component 314 with internal component 316. For example, in certain implementations, RSSI signal 504 may be used to monitor and track the thickness of skin flap 502 over time. For example, by periodically logging a value of RSSI signal 504 (e.g., even in a standard system in which external component 314 is aligned and held in place using magnetic forces), the relative thickness of skin flap 502 may be tracked. For example, if it is determined that RSSI signal 504 has gradually indicated a less optimal alignment in a system where magnets have held external component 314 in place, this may indicate that scar tissue or the like has caused skin flap 502 to thicken such that external component 314 no longer has as strong of a connection with internal component 316. Similarly, the gradual decrease of RSSI signal 504 may indicate that a cable between processing component 312 and external component 314 has degraded or been damaged such that some of the power generated by FTEL transmitter 516 is being lost in the cable rather than being transmitted to internal component 316 by way of external component 314. In these and other suitable applications of RSSI signal 504, the information determined by tracking signal 504 may be useful for patients and/or their caregivers and doctors to diagnose problems with cochlear implant system 310 that may be remedied to improve the functionality of cochlear implant system 310.

[0059] As mentioned above, system 300 may be implemented in a variety of different ways, including as a system entirely integrated within a cochlear implant system, an entirely separate and distinct system from the cochlear implant system, or as a hybrid approach in which certain functionality of system 300 is integrated with the cochlear implant system and other functionality is performed separately. Accordingly, to illustrate a few specific ways that system 300 may be implemented, FIGS. 6A through 6C show exemplary implementations and configurations of system 300 and how it may integrate and/or interact with cochlear implant system 310.

[0060] Specifically, as shown in FIG. 6A, system 300 may be completely integrated with (e.g., implemented within) cochlear implant system 310. For example, system 300 may be implemented within a processing component of cochlear implant system 310

such as a BTE sound processor 602. As such, the user interface by way of which system 300 presents the indication of how optimally external component 314 is aligned with internal component 316 may be implemented by components of the cochlear implant system (e.g., components of sound processor 602) including a loudspeaker 604 (e.g., a loudspeaker 604-1 that emits sounds to be heard not only by the patient but also, for example, by a caretaker associated with the patient; a loudspeaker 604-2 that emits sounds directly to the patient to be heard by the patient using residual hearing that the patient retains; etc.) and including one or more visual indicators 606 (e.g., implemented by light-emitting diodes (“LEDs”) or the like) associated with the processing component. As shown in FIG. 6A, system 300 may receive RSSI signal 504 from ADC 514 as described above, and may use one or both of loudspeakers 604 and/or visual indicators 606 to indicate how optimal the alignment is based on RSSI signal 504. It will be understood that, while ADC 514 is shown as being included within cochlear implant system 310 along with sound processor 602 in FIG. 6A, ADC 514 may actually be integrated into sound processor 602 and may provide RSSI signal 504 to system 300 by providing the signal to other components included within sound processor 602 (e.g., a microprocessor or the like).

[0061] As additional examples, FIGS. 6B and 6C show implementations of system 300 where the user interface by way of which system 300 presents the indication of how optimally external component 314 is aligned with internal component 316 is implemented, respectively, by communication devices 608 and 610, which are each separate from and communicatively coupled with cochlear implant system 310. Communication devices 608 and 610 may be any suitable devices capable of communicating with cochlear implant system 310 (e.g., by way of a cable or wireless means, directly or by way of another intermediary device, etc.) and presenting some type of information (e.g., graphically, audibly, haptically, etc.) to a user by way of a user interface.

[0062] For example, communication device 608 in FIG. 6B may represent a personal computer, a CPI device, a combination thereof, or another suitable computing device configured to communicate with cochlear implant system 310 and to interface with a user. Similarly, communication device 610 in FIG. 6C may represent a mobile device such as a smartphone, a tablet device, a custom remote control configured to facilitate interaction with cochlear implant system 310, or the like. In certain examples, communication devices 608 and/or 610 may be general purpose computing devices

upon which specialized software (e.g., a downloadable application (“app”) or the like) has been loaded to implement system 300. Communication device 608 and 610 may each include screens for presenting graphical representations, as well as audio output means (e.g., loudspeakers, headphone jacks, etc.) for presenting audio.

5 Communication devices 608 and 610 may use such interfaces to present graphics such as graphic 612 illustrated on the screens of both communications devices, and to present audio. In some examples, communications devices 608 and/or 610 may also have additional ways of outputting information to a user, such as haptic feedback (e.g., vibrations, etc.), alert LEDs separate from the screen, and the like. These interfaces
10 may also be used to indicate to a user how optimal an alignment is in any way as may serve a particular implementation.

[0063] As used herein, a “user interface” may refer to any system, component, or other means by which information may be communicated to and/or received from a user. For example, certain user interfaces may be audiovisual user interfaces that
15 include graphical elements (e.g., visual indicators 606, the screens of communication devices 608 and 610, etc.), audio elements (e.g., loudspeakers 604, the audio interfaces of communication devices 608 and 610), and/or other suitable elements (e.g., haptic interfaces that may cause sound processor 602 and/or communication devices 608 and/or 610 to vibrate). In other examples, user interfaces may not be so
20 comprehensive. For instance, a graphical-only user interface may be configured to only present graphical representations of how optimally aligned the components are and may not present information using sound. Similarly, an audible-only user interface may be configured to only present sounds and may not include a screen to present information graphically. Regardless of what type of user interface is used to present
25 information to a user, however, system 300 may present the indication of how optimal the component alignment is by first detecting, based on a change in RSSI signal 504, a change in how optimally external component 314 is aligned with internal component 316. Then, depending on the type of user interface employed in a particular implementation, system 300 may represent the change in how optimally external
30 component 314 is aligned with internal component 316 in any of several different ways.

[0064] As one example, system 300 may graphically represent the change by way of a color and/or a status-indicating graphic displayed on a graphical display upon which the user interface is presented. For instance, a graphic such as graphic 612 may be displayed as red while alignment is relatively non-optimal (e.g., while external

component 314 is located on outer portions of region 402 in FIG. 4), as yellow (or a particular shade of yellow that may vary) as alignment becomes more optimal (e.g., while external component 314 is located within outer portions of region 404), and as green when the alignment reaches a particular level that is considered to be suitably optimal for reliable and efficient communications (e.g., when external component 314 is located within region 406).

[0065] Additionally, along with using color in this or a similar way, the size, shape, and/or other qualities of a status-indicating graphic may further help indicate how optimal the alignment is. For instance, as shown, graphic 612 may be implemented as a status bar with various portions that are filled in or blanked out, or that is continuous without discrete portions, or the like. The status bar may grow (e.g., portions currently blanked out toward the top may be filled in) as alignment becomes more optimal, and may shrink (e.g., portions currently filled in toward the bottom may be blanked out) as alignment becomes less optimal. It will be understood that a status bar illustrated by graphic 612 is only one of many examples of status-indicating graphics that could be used, and that any graphic capable of indicating relative status may also be used in various implementations. Additionally, it will be understood that visual indicators 606 of sound processor 602 may be used in a similar way as graphic 612 (e.g., changing colors, growing, shrinking, etc., according to how optimal the alignment is, etc.).

[0066] As another example of how system 300 may represent the detected change in how optimally external component 314 is aligned with internal component 316, system 300 may audibly represent the change in how optimally the components are aligned by way of a volume and/or a pitch of sound emitted by a loudspeaker by way of which the user interface is presented. For example, using one or both of loudspeakers 604 and/or using similar audio output means included within communication devices 608 and 610, system 300 may play a sound (e.g., a continuous tone or any other sound as may serve a particular implementation) that has a certain pitch (e.g., a relatively low-frequency pitch) and/or a certain volume (e.g., a relatively low volume) when the alignment is suboptimal. The sound may then change to a different pitch (e.g., a higher-frequency pitch) and/or a different volume (e.g., a higher volume) as the alignment becomes more optimal. In other examples, the pitch and/or volume may get lower, rather than higher, as alignment become more optimal, other aspects of sound may be employed (e.g., the timbre, type of sound, or other qualities may be altered) to indicate the alignment, or sound may be used in other ways as may serve a particular

implementation (e.g., an artificial voice may verbally indicate how optimal the alignment is or the like).

[0067] In certain examples, when system 300 detects (e.g., based on the change in RSSI signal 504) the change in how optimally external component 314 is aligned with internal component 316, system 300 may determine, based on the detected change in how optimal the alignment is, that external component 314 is optimally aligned with internal component 316 to at least a threshold level. For example, as described above, system 300 may determine that the alignment is optimal enough for a strong, reliable, efficient link to be made between the components such that it may not be necessary for internal component 316 to continue using power to generate and transmit the back telemetry signal.

[0068] When this threshold level of alignment is detected to be reached, system 300 may indicate this to the user by way of the user interface in any way as may serve a particular implementation. For example, system 300 may represent the determination that external component 314 is optimally aligned with internal component 316 to at least the threshold level by way of a change to at least one of a graphical representation presented on a graphical display and an audible representation presented by way of a loudspeaker. Specifically, for instance, the graphical representation may be changed from a color such as yellow to a color such as green, may begin to flash, may change shape or size, and/or may undergo any other suitable change to indicate that the threshold alignment level has been reached. Similarly, the audible representation may be changed from one type of sound to another, may change in pitch or volume more dramatically than it has changed previously (e.g., as external component 314 was moved around in search of the most optimal alignment), or may undergo any other suitable change as may serve a particular implementation.

[0069] FIG. 7 illustrates a method 700 for facilitating optimal alignment of cochlear implant system components. As illustrated, certain operations of method 700 (i.e., operations 702 through 706 on the right-hand side of FIG. 7) may be performed by a cochlear implant system such as cochlear implant system 310 and/or any implementation thereof. As further shown, other operations of method 700 (i.e., operations 708 through 710 on the left-hand side of FIG. 7) may be performed by a component alignment presentation system such as system 300 and/or any implementation thereof. While operations are shown and described in FIG. 7 as being performed by either a cochlear implant system or a component alignment presentation

system, it will be understood that, as described above, the cochlear implant system and the component alignment presentation system may be integrated together in any way as may serve a particular implementation. By the same token, one or more operations illustrated as being performed by one system may be performed by the other system or
5 by both systems in certain implementations. Additionally, while FIG. 7 illustrates exemplary operations according to one embodiment, other embodiments may omit, add to, reorder, and/or modify any of the operations shown in FIG. 7.

[0070] In operation 702, an external component of a cochlear implant system that operates external to a patient may detect a wireless back telemetry signal. For
10 example, the back telemetry signal may be generated by an internal component of the cochlear implant system implanted within the patient. The detected back telemetry signal may have a signal strength indicative of how optimally the external component is aligned with the internal component. Operation 702 may be performed in any of the ways described herein.

[0071] In operation 704, a processing component of the cochlear implant system may generate an RSSI signal based on the signal strength of the back telemetry signal detected by the external component in operation 702. Operation 704 may be performed
15 in any of the ways described herein.

[0072] In operation 706, the processing component may provide the RSSI signal generated in operation 704 to a component alignment presentation system. Operation
20 706 may be performed in any of the ways described herein.

[0073] In operation 708, the component alignment presentation system may receive the RSSI signal provided by the processing component of the cochlear implant system in operation 706. Operation 708 may be performed in any of the ways described herein.

[0074] In operation 710, the component alignment presentation system may present an indication of how optimally the external component is aligned with the internal component. For instance, the component alignment presentation system may present the alignment indication to a user based on the RSSI signal and by way of a user interface. In this way, operation 710 may assist the user in optimally aligning the
25 external component with the internal component in any manner described herein. Operation 710 may be performed in any of the ways described herein.

[0075] In certain embodiments, one or more of the processes described herein may be implemented at least in part as instructions embodied in a non-transitory computer-readable medium and executable by one or more computing devices. In general, a
30

processor (e.g., a microprocessor) receives instructions, from a non-transitory computer-readable medium (e.g., a memory, etc.) and executes the instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions may be stored and/or transmitted using any of a variety of known computer-readable media.

[0076] A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media, and/or volatile media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include, for example, dynamic random access memory ("DRAM"), which typically constitutes a main memory. Common forms of computer-readable media include, for example, a disk, hard disk, magnetic tape, any other magnetic medium, a compact disc read-only memory ("CD-ROM"), a digital video disc ("DVD"), any other optical medium, random access memory ("RAM"), programmable read-only memory ("PROM"), erasable programmable read-only memory ("EPROM"), electrically erasable programmable read-only memory ("EEPROM"), a Flash EEPROM device, any other memory chip or cartridge, or any other tangible medium from which a computer can read.

[0077] FIG. 8 illustrates an exemplary computing device 800 that may be specifically configured to perform one or more of the processes described herein. As shown in FIG. 8, computing device 800 may include a communication interface 802, a processor 804, a storage device 806, and an input/output ("I/O") module 808 communicatively connected via a communication infrastructure 810. While an exemplary computing device 800 is shown in FIG. 8, the components illustrated in FIG. 8 are not intended to be limiting. Additional or alternative components may be used in other embodiments. Components of computing device 800 shown in FIG. 8 will now be described in additional detail.

[0078] Communication interface 802 may be configured to communicate with one or more computing devices. Examples of communication interface 802 include, without limitation, a wired network interface (such as a network interface card), a wireless network interface (such as a wireless network interface card), a modem, an audio/video connection, and any other suitable interface.

[0079] Processor 804 generally represents any type or form of processing unit capable of processing data or interpreting, executing, and/or directing execution of one or more of the instructions, processes, and/or operations described herein. Processor 804 may direct execution of operations in accordance with one or more applications 812 or other computer-executable instructions such as may be stored in storage device 806 or another computer-readable medium.

[0080] Storage device 806 may include one or more data storage media, devices, or configurations and may employ any type, form, and combination of data storage media and/or device. For example, storage device 806 may include, but is not limited to, a hard drive, network drive, flash drive, magnetic disc, optical disc, RAM, dynamic RAM, other non-volatile and/or volatile data storage units, or a combination or sub-combination thereof. Electronic data, including data described herein, may be temporarily and/or permanently stored in storage device 806. For example, data representative of one or more executable applications 812 configured to direct processor 804 to perform any of the operations described herein may be stored within storage device 806. In some examples, data may be arranged in one or more databases residing within storage device 806.

[0081] I/O module 808 may be configured to receive user input and provide user output and may include any hardware, firmware, software, or combination thereof supportive of input and output capabilities. For example, I/O module 808 may include hardware and/or software for capturing user input, including, but not limited to, a keyboard or keypad, a touch screen component (e.g., touch screen display), a receiver (e.g., an RF or infrared receiver), and/or one or more input buttons.

[0082] I/O module 808 may include one or more devices for presenting output to a user, including, but not limited to, a graphics engine, a display (e.g., a display screen), one or more output drivers (e.g., display drivers), one or more audio speakers, and one or more audio drivers. In certain embodiments, I/O module 808 is configured to provide graphical data to a display for presentation to a user. The graphical data may be representative of one or more graphical user interfaces and/or any other graphical content as may serve a particular implementation.

[0083] In some examples, any of the facilities or systems described herein may be implemented by or within one or more components of computing device 800. For example, one or more applications 812 residing within storage device 806 may be configured to direct processor 804 to perform one or more processes or functions

associated with communication facility 302 or presentation facility 304 within system 300. Likewise, storage facility 306 within system 300 may be implemented by or within storage device 806.

[0084] In the preceding description, various exemplary embodiments have been
5 described with reference to the accompanying drawings. It will, however, be evident
that various modifications and changes may be made thereto, and additional
embodiments may be implemented, without departing from the scope of the invention
as set forth in the claims that follow. For example, certain features of one embodiment
described herein may be combined with or substituted for features of another
10 embodiment described herein. The description and drawings are accordingly to be
regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

- 5 1. A component alignment presentation system comprising:
 at least one physical computing device that
 receives a Received Signal Strength Indicator (RSSI) signal from a
 cochlear implant system that includes
 an external component configured to operate external to a patient
10 associated with the cochlear implant system and to detect a wireless back telemetry
 signal generated by an internal component configured to be implanted within the
 patient, the detected back telemetry signal having a signal strength indicative of how
 optimally the external component is aligned with the internal component, and
 a processing component configured to generate the RSSI signal
15 based on the signal strength of the detected back telemetry signal and to provide the
 RSSI signal to the component alignment presentation system; and
 presents, based on the RSSI signal and by way of a user interface, an
 indication of how optimally the external component is aligned with the internal
 component to assist a user in optimally aligning the external component with the
20 internal component.
2. The component alignment presentation system of claim 1, wherein:
 the internal component is a cochlear implant configured to be implanted within
 the patient's head under a skin flap and to communicate with the external component
25 by way of a first communication component included within the cochlear implant when
 the external component is aligned with the cochlear implant;
 the external component is a headpiece configured to be disposed on the
 patient's head on an opposite side of the skin flap from the cochlear implant and to
 communicate with the cochlear implant by way of a second communication component
30 included within the headpiece when the headpiece is aligned with the cochlear implant;
 and
 the processing component is a sound processor communicatively coupled with
 the headpiece and with the component alignment presentation system, the sound
 processor configured to communicate with the cochlear implant by way of the
35 headpiece.

3. The component alignment presentation system of claim 1, wherein:
the user optimally aligning the external component with the internal component
by assistance of the component alignment presentation system is associated with
5 performing a surgical procedure whereby the internal component is implanted within the
patient; and

the at least one physical computing device receives the RSSI signal from the
cochlear implant system and presents the indication of how optimally the external
component is aligned with the internal component to the user while the surgical
10 procedure is underway.

4. The component alignment presentation system of claim 1, wherein:
the user optimally aligning the external component with the internal component
by assistance of the component alignment presentation system is the patient or a
15 caregiver assisting the patient; and

the at least one physical computing device receives the RSSI signal from the
cochlear implant system and presents the indication of how optimally the external
component is aligned with the internal component to the user when the cochlear
implant system is under control of the user subsequent to a surgical procedure whereby
20 the internal component is implanted within the patient.

5. The component alignment presentation system of claim 1, wherein the
user interface by way of which the at least one physical computing device presents the
indication of how optimally the external component is aligned with the internal
25 component is implemented by a communication device separate from and
communicatively coupled with the cochlear implant system.

6. The component alignment presentation system of claim 1, wherein:
the component alignment presentation system is implemented within the
30 cochlear implant system; and

the user interface by way of which the at least one physical computing device
presents the indication of how optimally the external component is aligned with the
internal component is implemented by components of the cochlear implant system

including a loudspeaker and one or more visual indicators associated with the processing component.

7. The component alignment presentation system of claim 1, wherein the at least one physical computing device presents the indication of how optimally the external component is aligned with the internal component by:

detecting, based on a change in the RSSI signal, a change in how optimally the external component is aligned with the internal component; and

graphically representing the change in how optimally the external component is aligned with the internal component by way of at least one of a color and a status-indicating graphic displayed on a graphical display upon which the user interface is presented.

8. The component alignment presentation system of claim 1, wherein the at least one physical computing device presents the indication of how optimally the external component is aligned with the internal component by:

detecting, based on a change in the RSSI signal, a change in how optimally the external component is aligned with the internal component; and

audibly representing the change in how optimally the external component is aligned with the internal component by way of at least one of a volume and a pitch of sound emitted by a loudspeaker by way of which the user interface is presented.

9. The component alignment presentation system of claim 1, wherein the at least one physical computing device presents the indication of how optimally the external component is aligned with the internal component by:

detecting, based on a change in the RSSI signal, a change in how optimally the external component is aligned with the internal component;

determining, based on the change in how optimally the external component is aligned with the internal component, that the external component is optimally aligned with the internal component to at least a threshold level; and

representing the determination that the external component is optimally aligned with the internal component to at least the threshold level by way of a change to at least one of a graphical representation presented on a graphical display and an audible representation presented by way of a loudspeaker.

10. A cochlear implant system comprising:

an external component configured to operate external to a patient associated with the cochlear implant system and to detect a wireless back telemetry signal

5 generated by an internal component configured to be implanted within the patient, the detected back telemetry signal having a signal strength indicative of how optimally the external component is aligned with the internal component; and

a processing component configured to

10 generate, based on the signal strength of the detected back telemetry signal, a Received Signal Strength Indicator (RSSI) signal, and

provide the RSSI signal to a component alignment presentation system configured to receive the RSSI signal and to present, based on the RSSI signal and by way of a user interface, an indication of how optimally the external component is aligned with the internal component to assist a user in optimally aligning the external
15 component with the internal component.

11. The cochlear implant system of claim 10, wherein:

the internal component is a cochlear implant configured to be implanted within the patient's head under a skin flap and to communicate with the external component
20 by way of a first communication component included within the cochlear implant when the external component is aligned with the cochlear implant;

the external component is a headpiece configured to be disposed on the patient's head on an opposite side of the skin flap from the cochlear implant and to communicate with the cochlear implant by way of a second communication component
25 included within the headpiece when the headpiece is aligned with the cochlear implant; and

the processing component is a sound processor communicatively coupled with the headpiece and with the component alignment presentation system, the sound processor configured to communicate with the cochlear implant by way of the
30 headpiece.

12. The cochlear implant system of claim 10, wherein:

the user optimally aligning the external component with the internal component by assistance of the component alignment presentation system is associated with

performing a surgical procedure whereby the internal component is implanted within the patient; and

the component alignment presentation system to which the processing component provides the RSSI signal is configured to receive the RSSI signal from the processing component and to present the indication of how optimally the external component is aligned with the internal component to the user while the surgical procedure is underway.

13. The cochlear implant system of claim 10, wherein:

the user optimally aligning the external component with the internal component by assistance of the component alignment presentation system is the patient or a caregiver assisting the patient; and

the component alignment presentation system to which the processing component provides the RSSI signal is configured to receive the RSSI signal from the processing component and to present the indication of how optimally the external component is aligned with the internal component to the user when the cochlear implant system is under control of the user subsequent to a surgical procedure whereby the internal component is implanted within the patient.

14. The cochlear implant system of claim 10, wherein the external component is further configured to transmit a wireless forward telemetry signal to the internal component concurrently with the detection of the back telemetry signal generated by the internal component, the forward telemetry signal transmitted at a different frequency than the detected back telemetry signal and including data and power based upon which the internal component operates.

15. The cochlear implant system of claim 10, wherein the signal strength of the detected back telemetry signal is indicative of how optimally the external component is aligned with the internal component as a result of the wireless back telemetry signal being generated by the internal component at a transmitted signal strength that is fixed.

16. The cochlear implant system of claim 10, wherein the processing component is further configured to:

perform an initial system communication characterization to determine power levels at which intersystem communications will be made during operation of the cochlear implant system;

5 determine, during the operation of the cochlear implant system, that the determined power levels are non-optimal based on the RSSI signal; and

perform a system communication recharacterization to determine optimal power levels at which intersystem communications will be made during subsequent operation of the cochlear implant system.

10 17. The cochlear implant system of claim 10, wherein the processing component is configured to generate the RSSI signal as a digital signal by performing an analog-to-digital conversion of an analog signal representative of the signal strength of the detected back telemetry signal.

15 18. A method comprising:

receiving, by a component alignment presentation system, a Received Signal Strength Indicator (RSSI) signal from a cochlear implant system that includes an external component configured to operate external to a patient associated with the cochlear implant system and to detect a wireless back telemetry signal generated by an internal component configured to be implanted within the patient, the detected back telemetry signal having a signal strength indicative of how optimally the external component is aligned with the internal component, and

20 a processing component configured to generate the RSSI signal based on the signal strength of the detected back telemetry signal and to provide the RSSI signal to the component alignment presentation system; and

25 presenting, by the component alignment presentation system based on the RSSI signal and by way of a user interface, an indication of how optimally the external component is aligned with the internal component to assist a user in optimally aligning the external component with the internal component.

30

19. The method of claim 18, wherein:

the user optimally aligning the external component with the internal component by assistance of the component alignment presentation system is associated with

performing a surgical procedure whereby the internal component is implanted within the patient; and

the receiving of the RSSI signal from the cochlear implant system and the presenting of the indication of how optimally the external component is aligned with the
5 internal component are performed while the surgical procedure is underway.

20. The method of claim 18, wherein:

the user optimally aligning the external component with the internal component by assistance of the component alignment presentation system is the patient or a
10 caregiver assisting the patient; and

the receiving of the RSSI signal from the cochlear implant system and the presenting of the indication of how optimally the external component is aligned with the internal component are performed when the cochlear implant system is under control of the user subsequent to a surgical procedure whereby the internal component is
15 implanted within the patient.

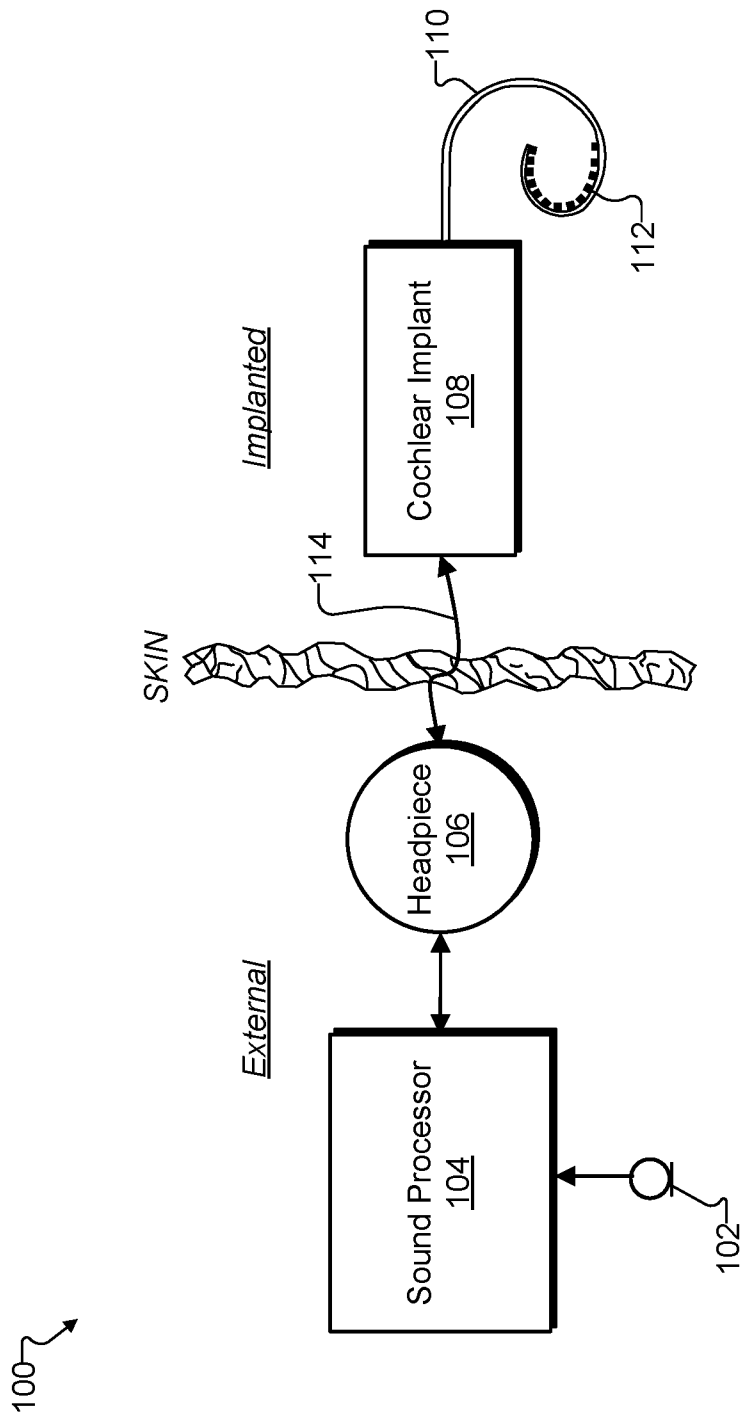


Fig. 1

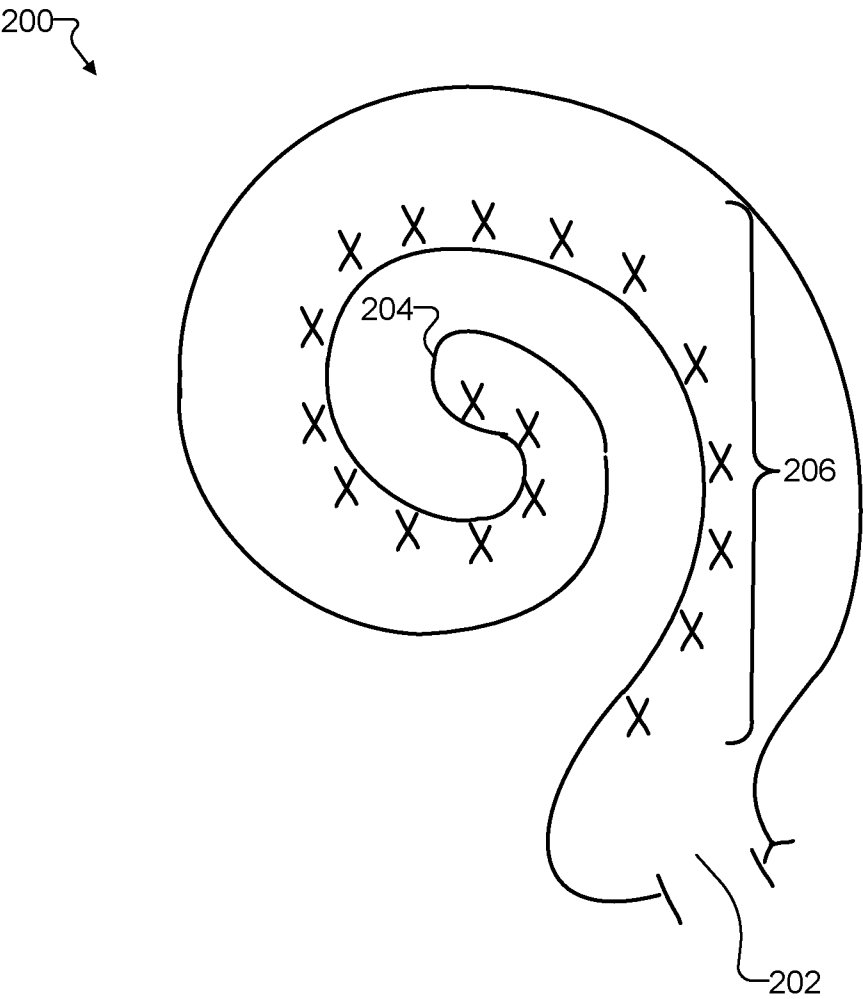
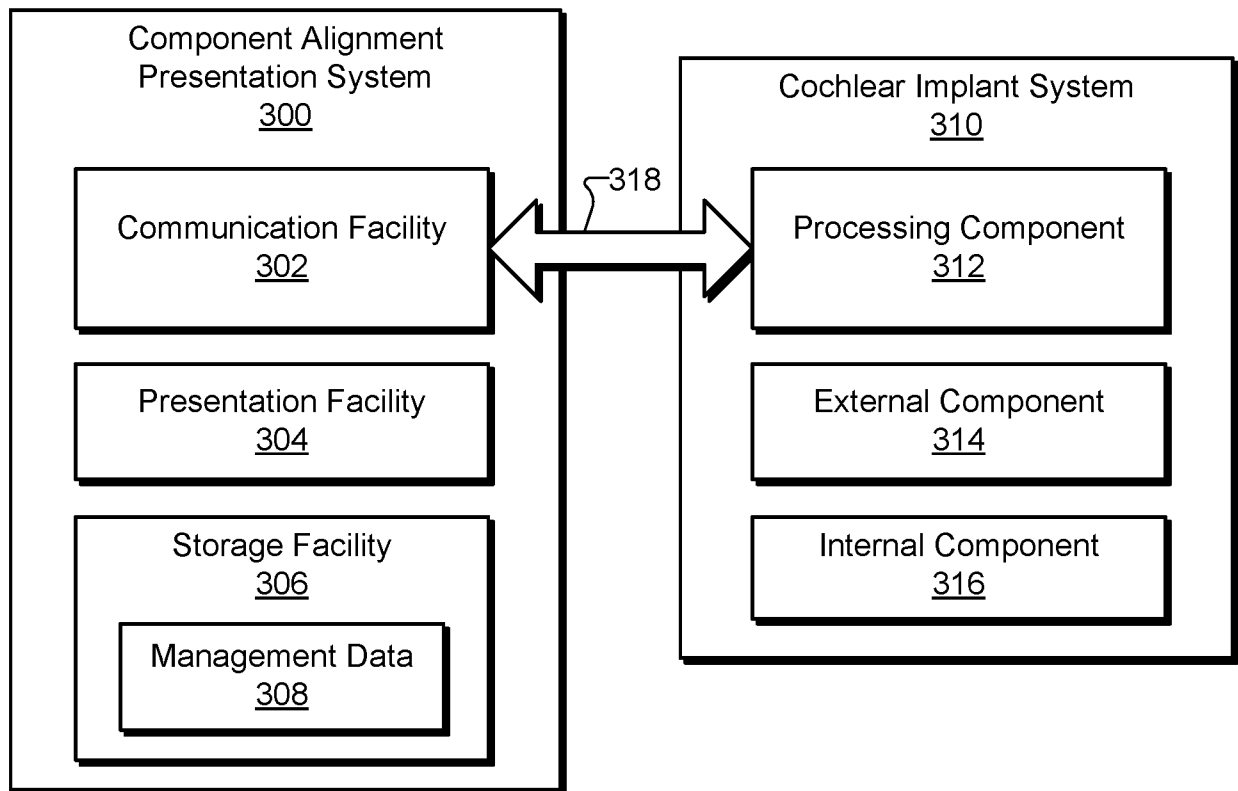


Fig. 2

3/8

**Fig. 3**

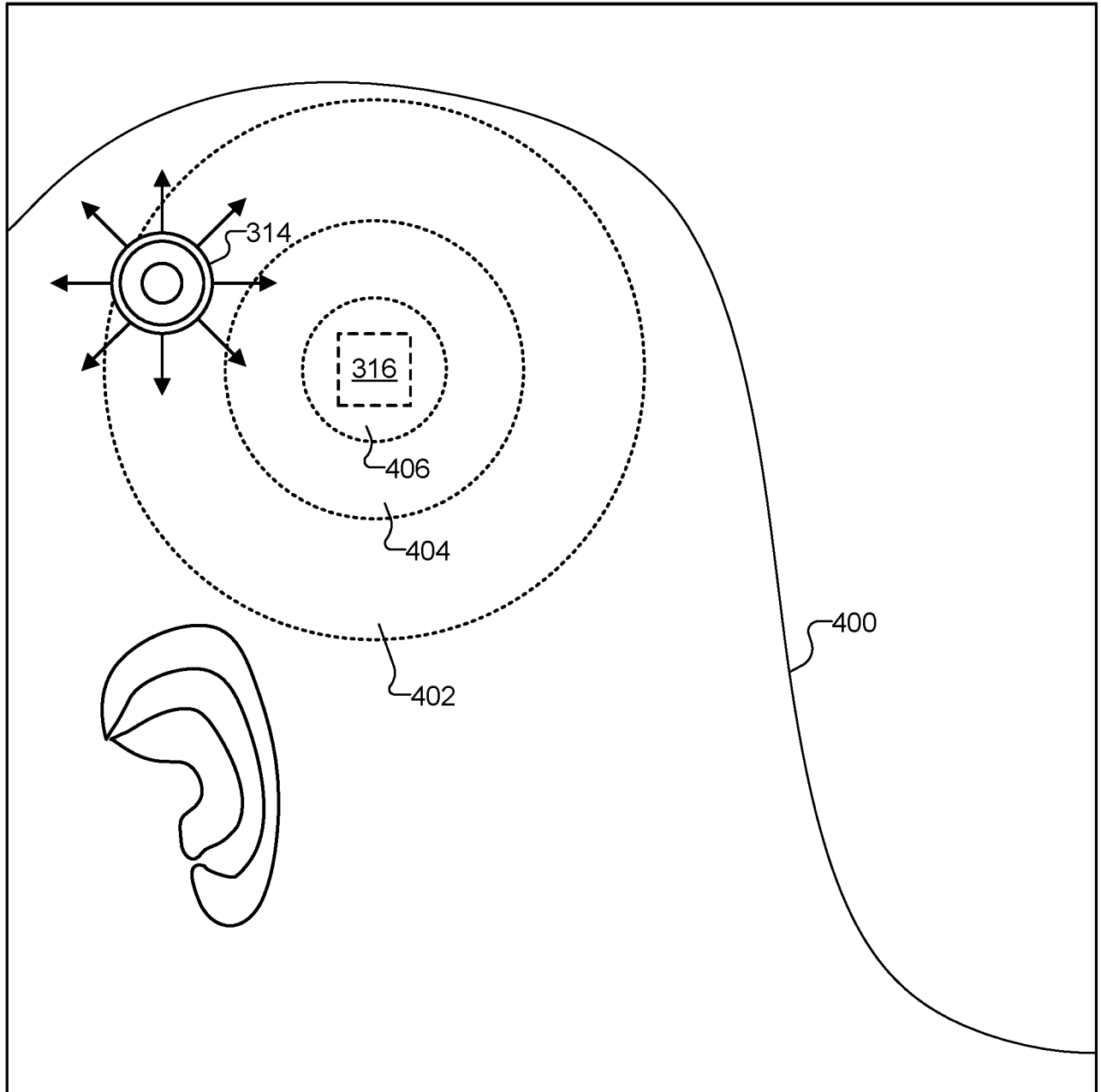


Fig. 4

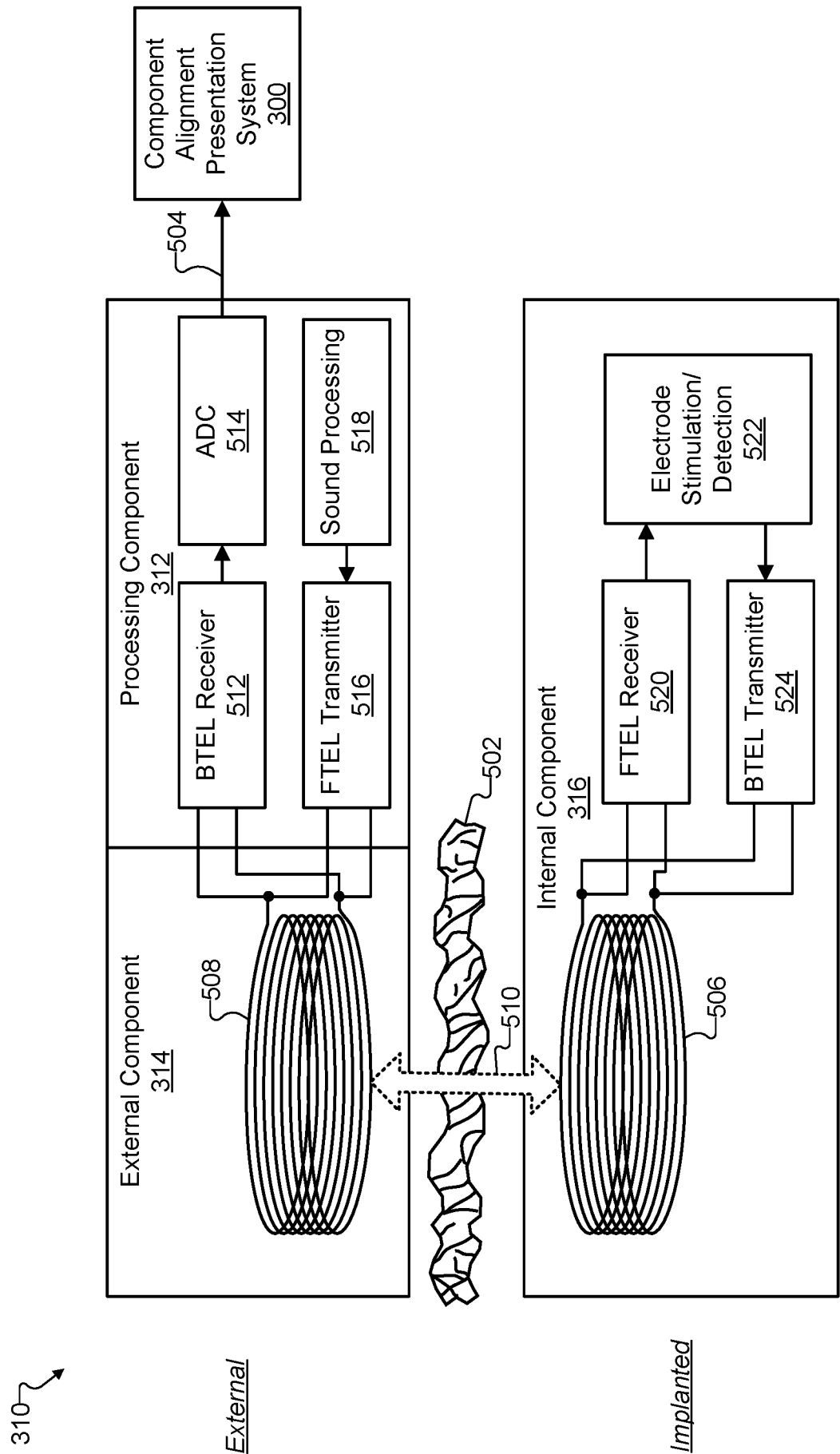
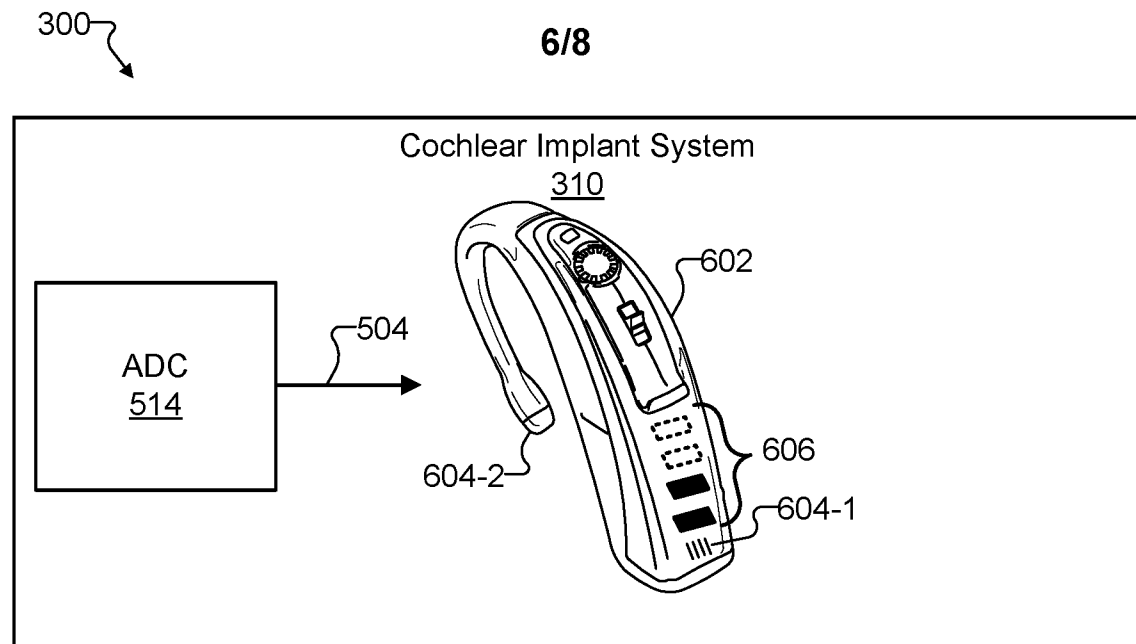
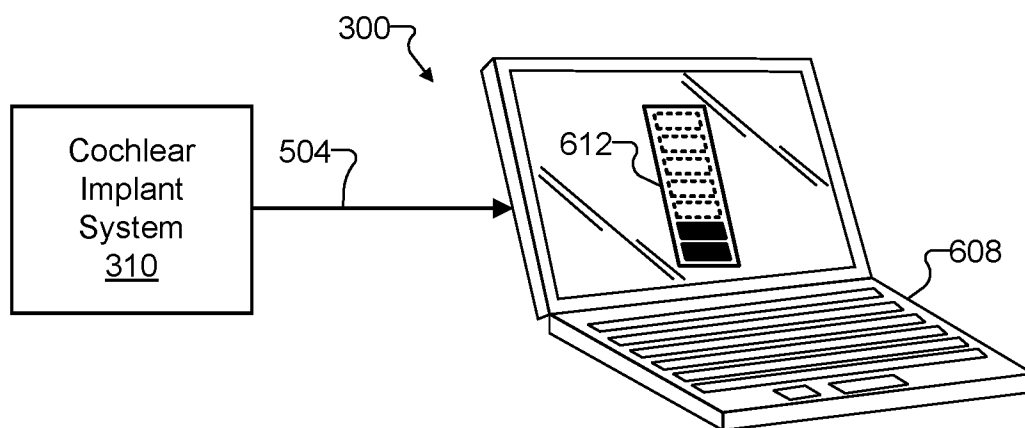
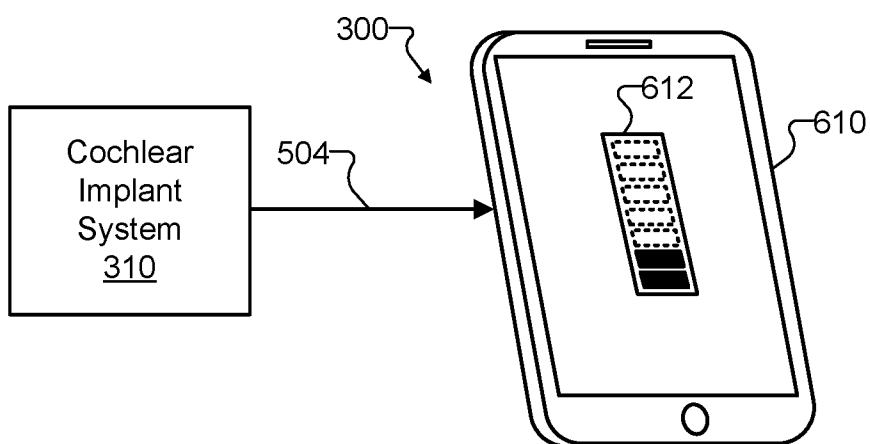
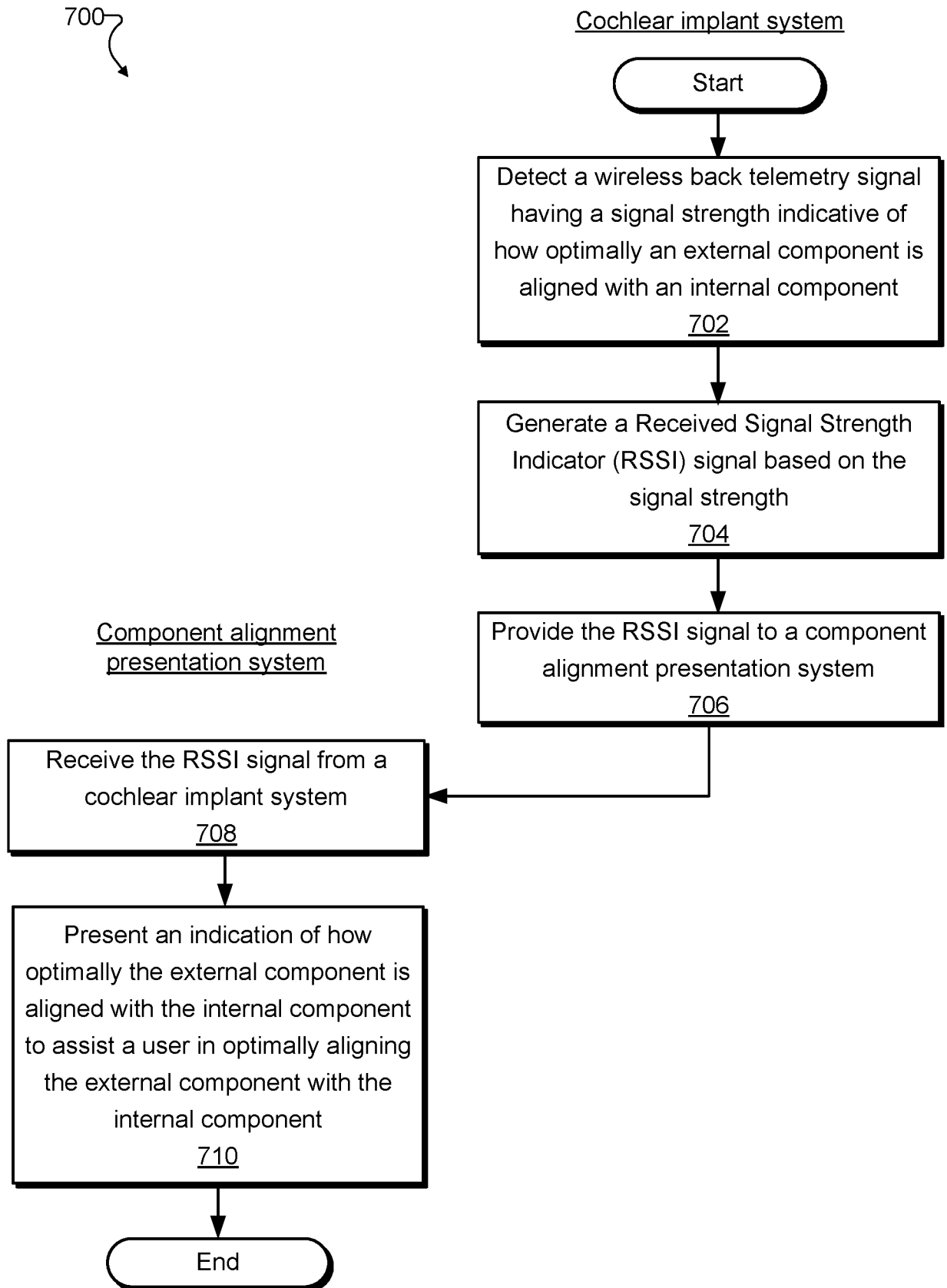


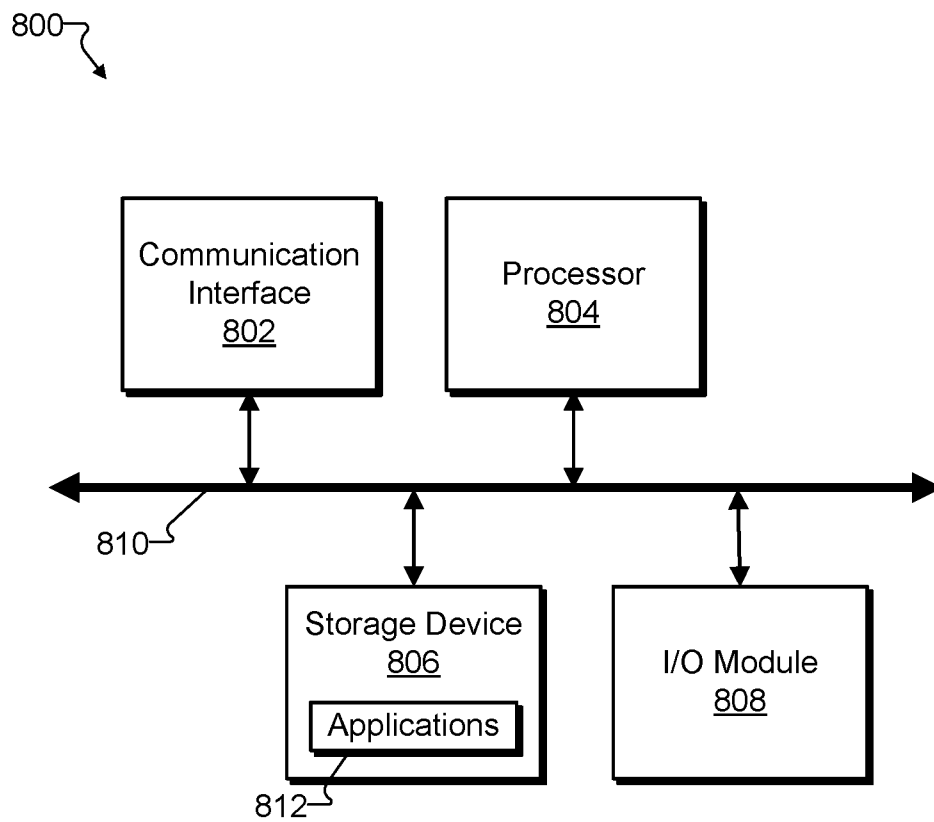
Fig. 5

**Fig. 6A****Fig. 6B****Fig. 6C**

7/8

**Fig. 7**

8/8

**Fig. 8**

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/048974

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61N1/378 A61N1/372 H02J50/90 A61N1/05
ADD.

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 H02J

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 279 025 A1 (MEDTRONIC INC [US]) 2 February 2011 (2011-02-02) abstract; claim *; figure * paragraphs [0065] - [0181] -----	1-17
A	US 2014/088665 A1 (MARSH DAVID [US] ET AL) 27 March 2014 (2014-03-27) the whole document -----	1-17
A	EP 2 388 043 A1 (SORIN CRM SAS [FR]) 23 November 2011 (2011-11-23) the whole document -----	1-17
A	US 6 073 050 A (GRIFFITH GLEN A [US]) 6 June 2000 (2000-06-06) the whole document -----	1-17



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 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

25 April 2018

Date of mailing of the international search report

04/05/2018

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/048974

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.: 18-20
because they relate to subject matter not required to be searched by this Authority, namely:
see FURTHER INFORMATION sheet PCT/ISA/210
2. ☒ Claims Nos.: 18-20
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:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claims Nos.: 18-20

The method of performing a surgical procedure as defined in claims 18-20 is regarded to be a method for treatment of the human or animal body by therapy/surgery. Therefore, the subject-matter of claims 18-20 has not been searched (Art.17(2)(a)(i) and Rule 39.1). Moreover, according to Article 34(4)(a)(i) PCT and Rule 67.1(iv) PCT, no international preliminary examination is required to be carried out on the subject-matter of these claims.

Continuation of Box II.2

Claims Nos.: 18-20

The method of performing a surgical procedure as defined in claims 18-20 is regarded to be a method for treatment of the human or animal body by therapy/surgery. Therefore, the subject-matter of claims 18-20 has not been searched (Art.17(2)(a)(i) and Rule 39.1).

Moreover, according to Article 34(4)(a)(i) PCT and Rule 67.1(iv) PCT, no international preliminary examination is required to be carried out on the subject-matter of these claims.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/048974

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2279025	A1	02-02-2011	EP 2279025 A1 02-02-2011
			US 2009259273 A1 15-10-2009
			WO 2009126354 A1 15-10-2009

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			US 2014370926 A1 18-12-2014

US 6073050	A	06-06-2000	NONE
