US 20240357298A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2024/0357298 A1**

Vardfjäll et al. (43) **Pub. Date: Oct. 24, 2024**

(54) **COUPLER FOR BONE CONDUCTION HEARING PROSTHESIS**

(71) Applicant: **Cochlear Limited**, Macquarie University, NSW (AU)

(72) Inventors: **Marcus Vardfjäll**, Askim (SE); **Stefan Magnander**, Göteborg (SE); **Tommy Bergs**, Härryda (SE)

(21) Appl. No.: **18/290,971**

(22) PCT Filed: **Aug. 8, 2022**

(86) PCT No.: **PCT/IB2022/057378**

§ 371 (c)(1),
(2) Date: **Jan. 22, 2024**

Related U.S. Application Data

(60) Provisional application No. 63/268,768, filed on Mar. 2, 2022, provisional application No. 63/235,943, filed on Aug. 23, 2021.

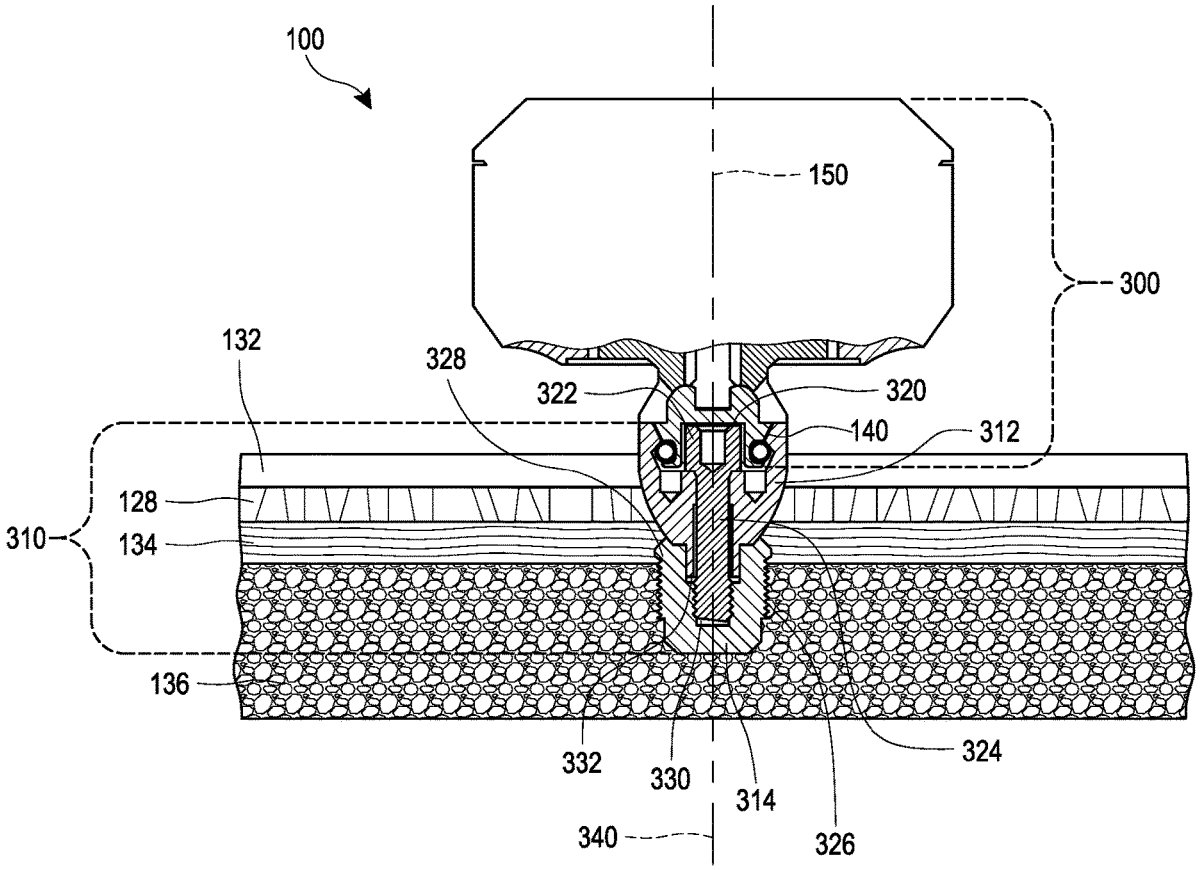
Publication Classification

(51) **Int. Cl.**
H04R 25/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 25/606*** (2013.01); *H04R 2460/13* (2013.01)

(57) **ABSTRACT**

An apparatus includes a coupling portion configured to be releasably coupled to an abutment affixed to a recipient's body. The coupling portion includes a substantially cylindrically symmetric body portion extending along a symmetry axis, the body portion including an outer body surface having a recess extending around the symmetry axis. The coupling portion further includes a resilient member in the recess and extending around the symmetry axis. The resilient member extends outwardly past the outer body surface and is configured to contact an inner abutment surface of the abutment. The resilient member is configured to undergo compression by the inner abutment surface and an inner surface of the recess upon being releasably coupled to the abutment. The compression has a component substantially perpendicular to the symmetry axis.



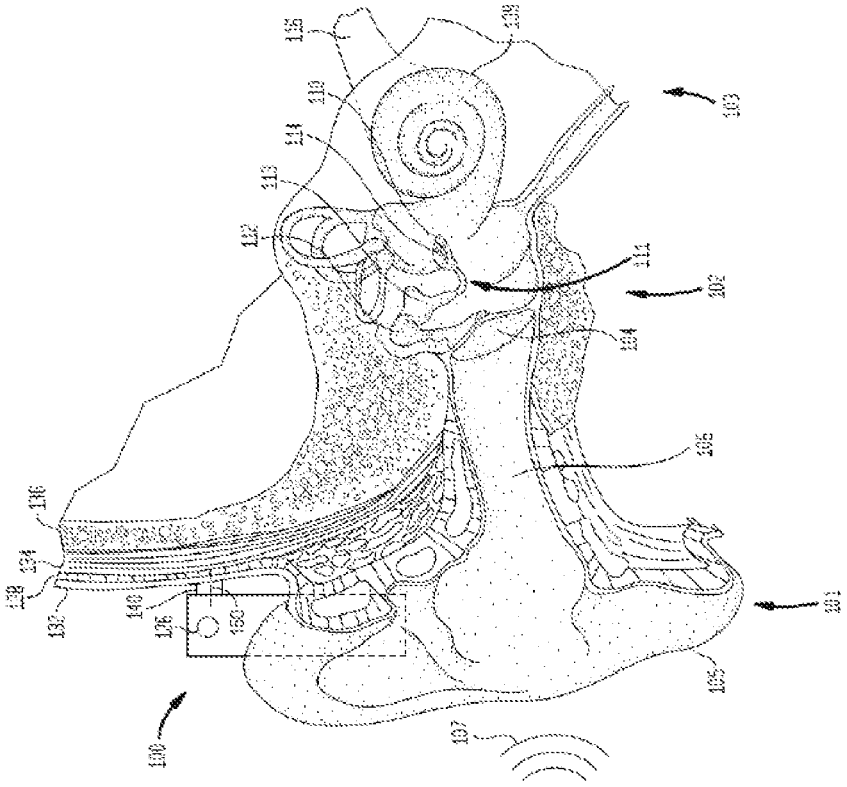

125
118
103
114
115
112
111
102
104
106
136
134
138
132
140
126
150
101
105
107
130

FIG. 1A

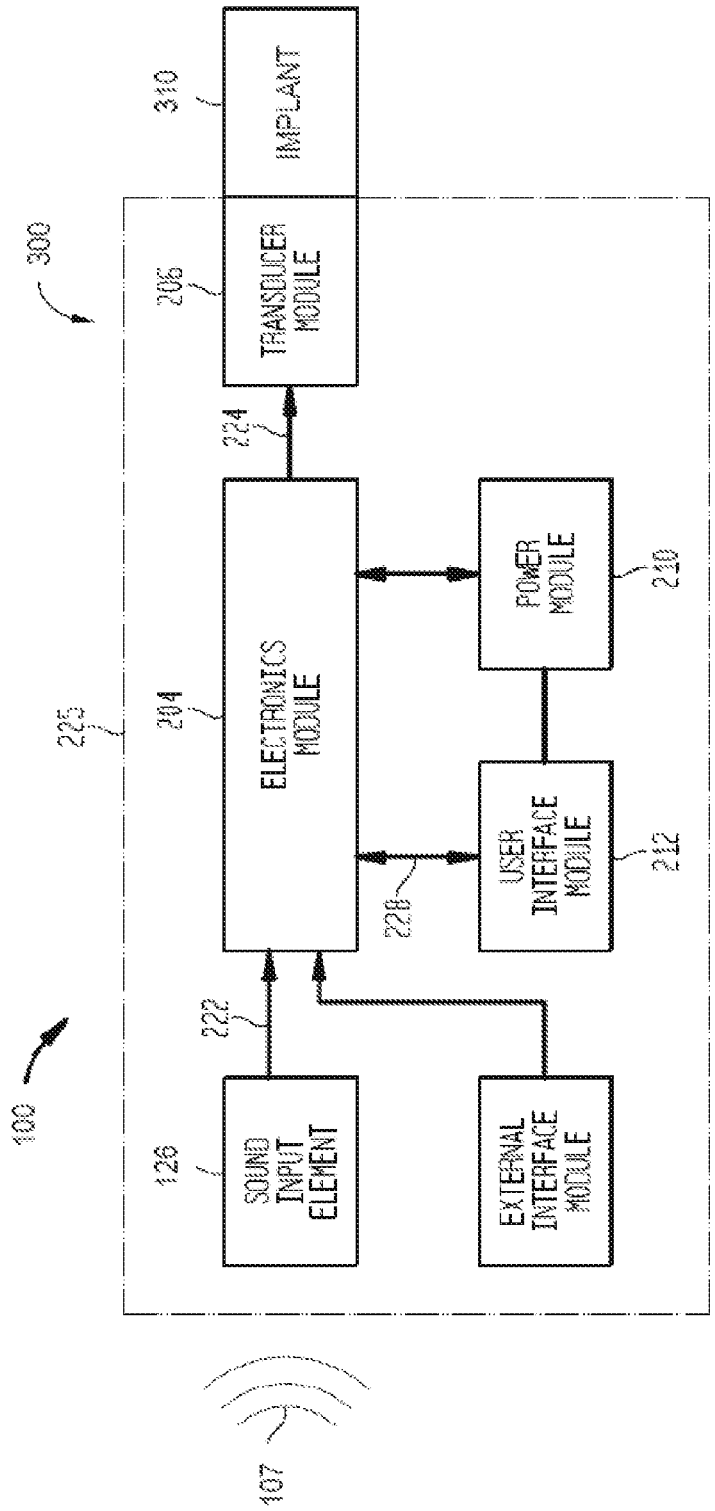

100
107
300
310
IMPLANT
206
TRANSDUCER MODULE
224
204
ELECTRONICS MODULE
225
226
210
POWER MODULE
212
USER INTERFACE MODULE
222
126
SOUND INPUT ELEMENT
EXTERNAL INTERFACE MODULE

FIG. 1B

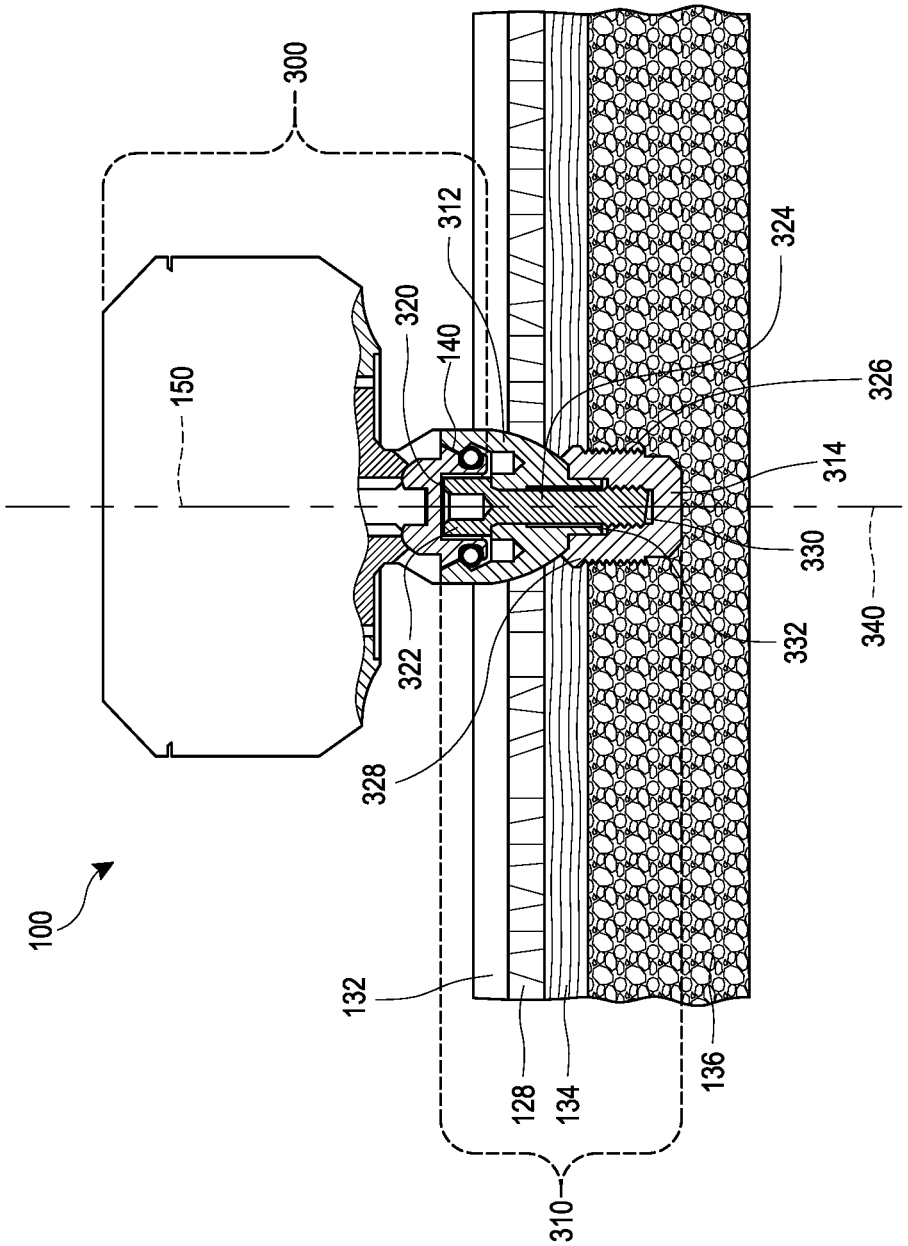

300
312
324
320
140
326
150
314
330
340
322
332
328
100
132
128
134
136
310

FIG. 1C

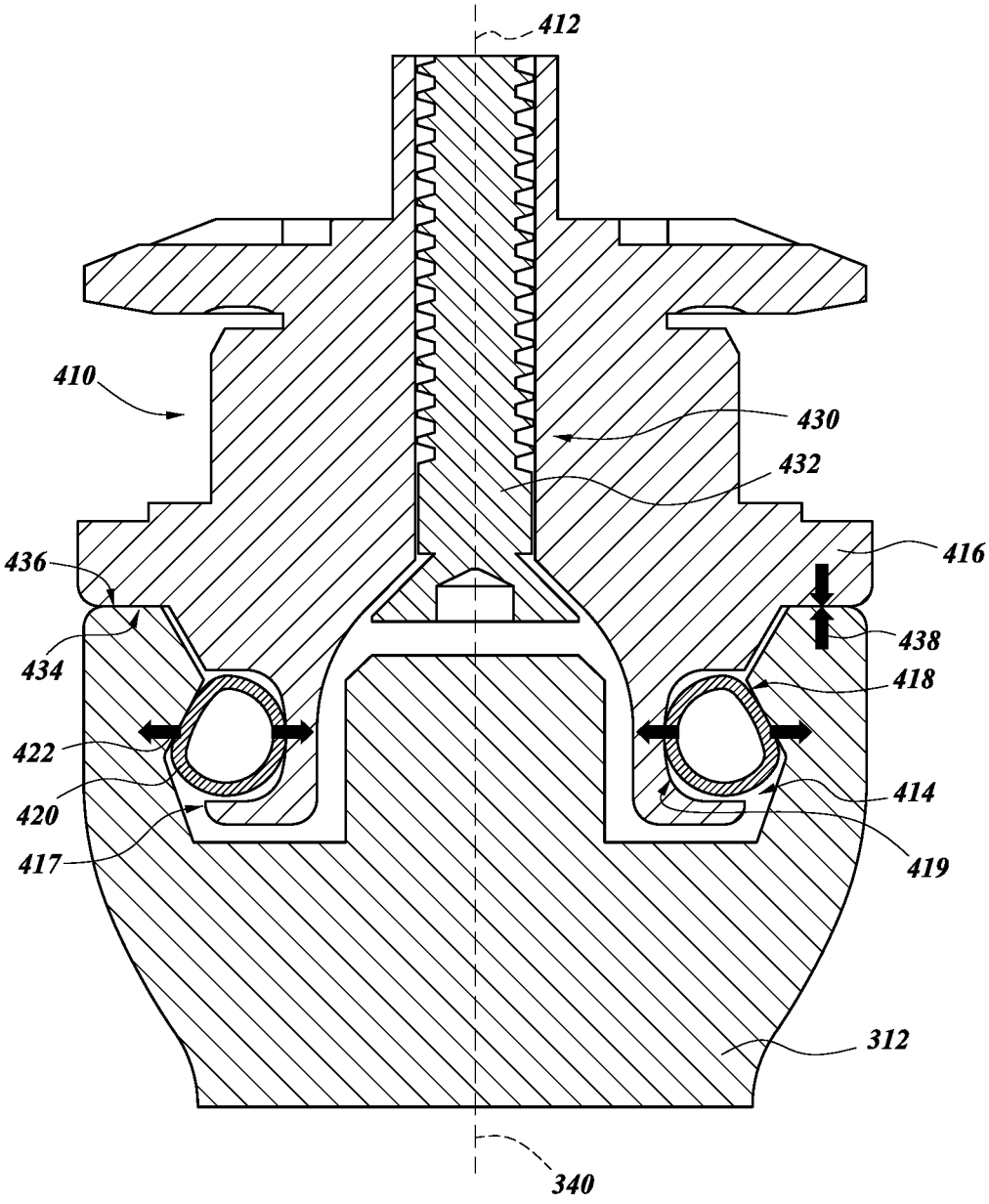


FIG. 2

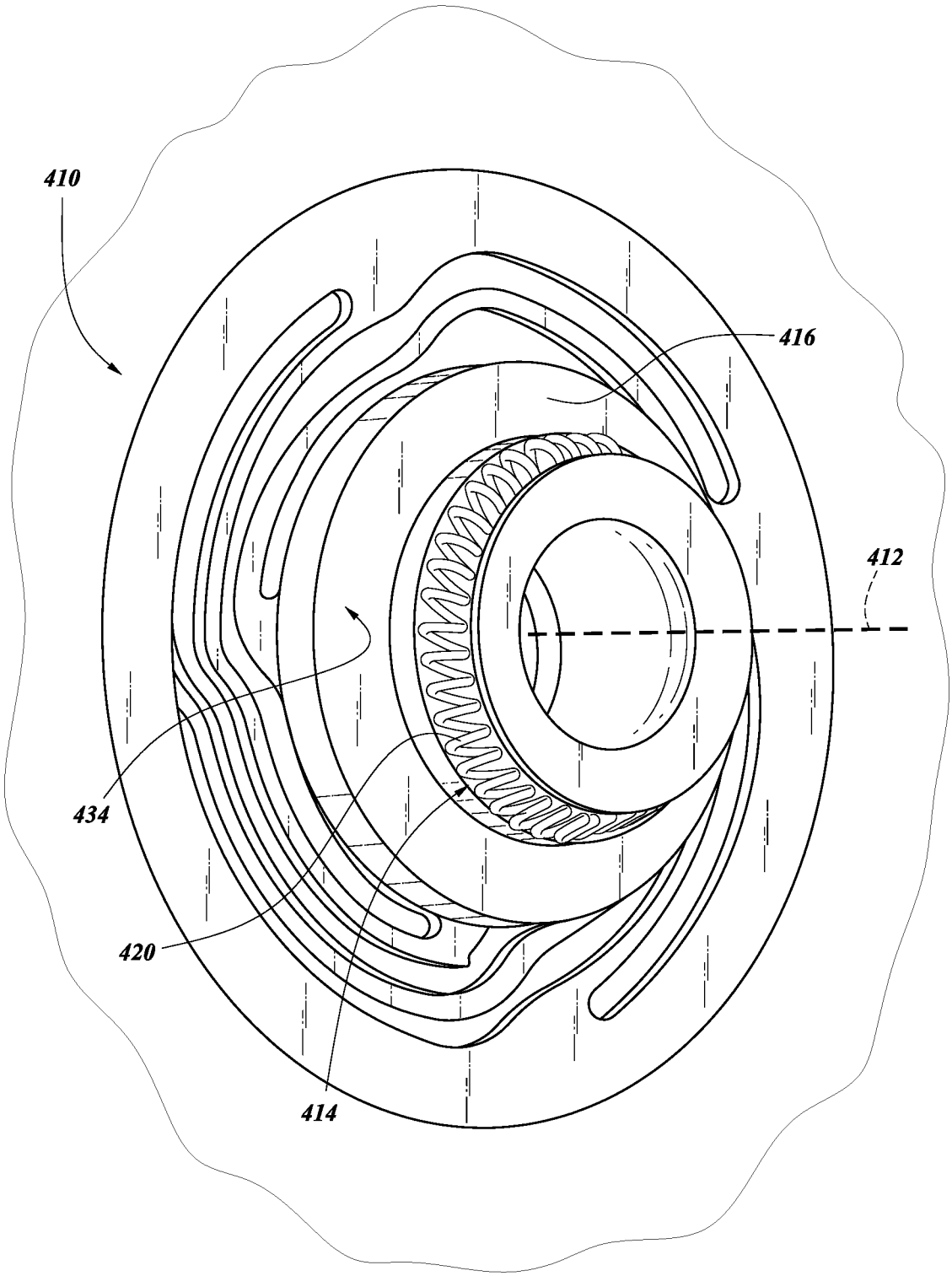


FIG. 3A

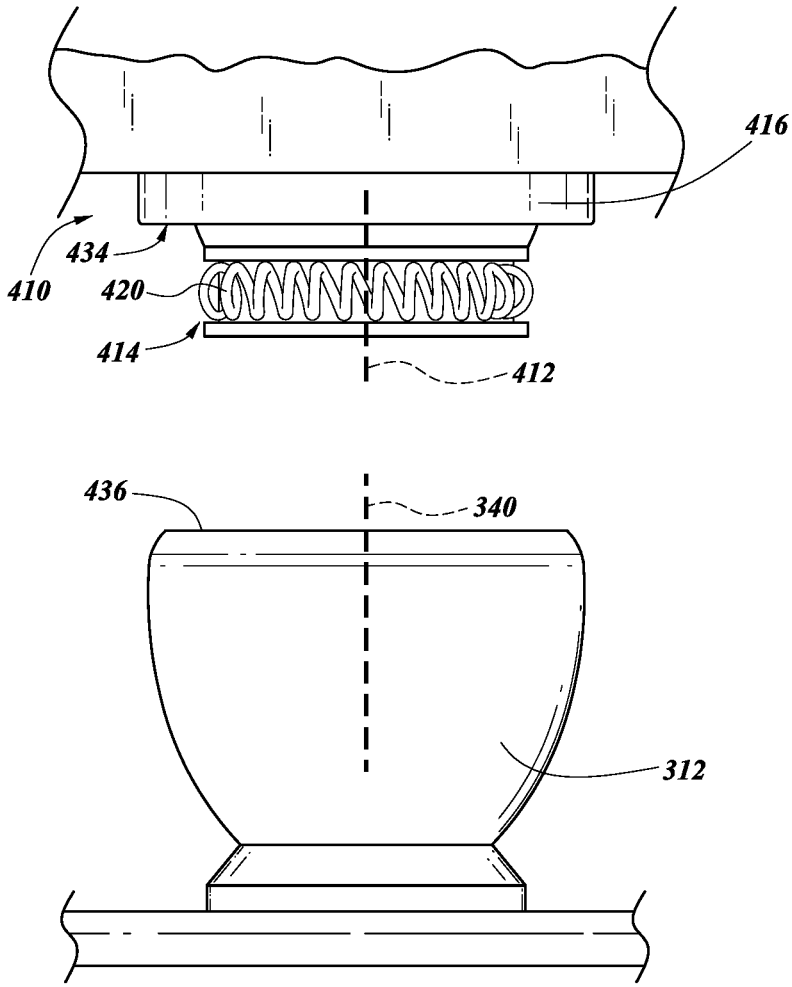


FIG. 3B

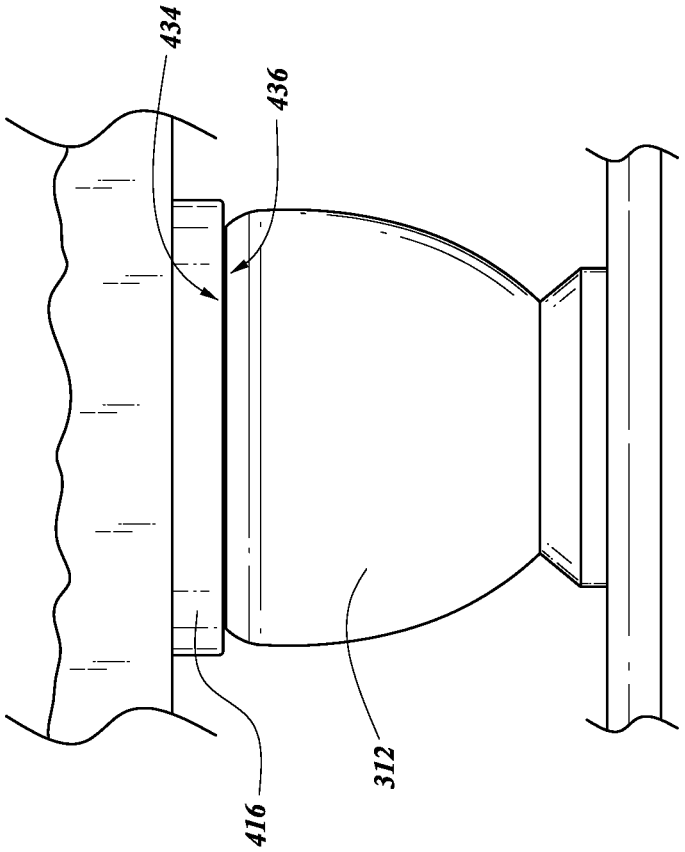


FIG. 3D

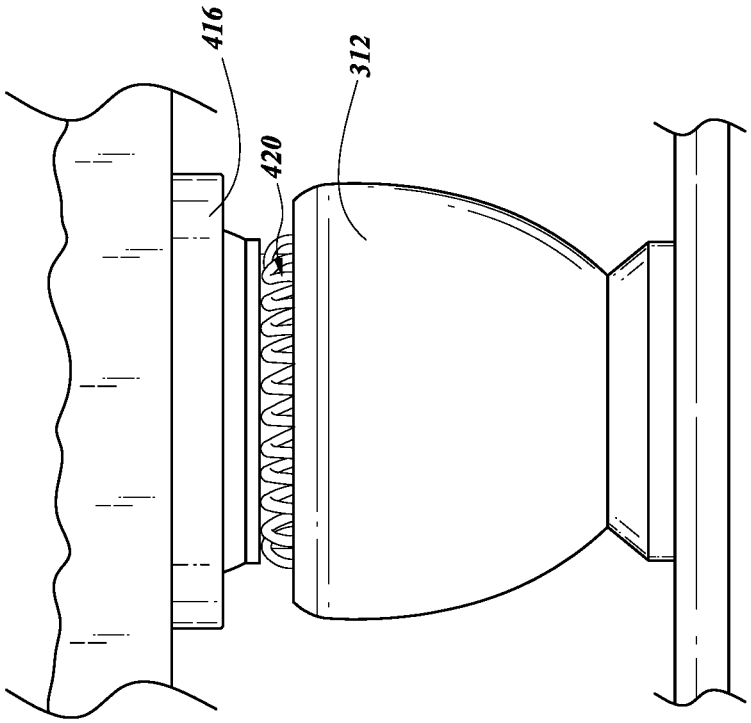


FIG. 3C

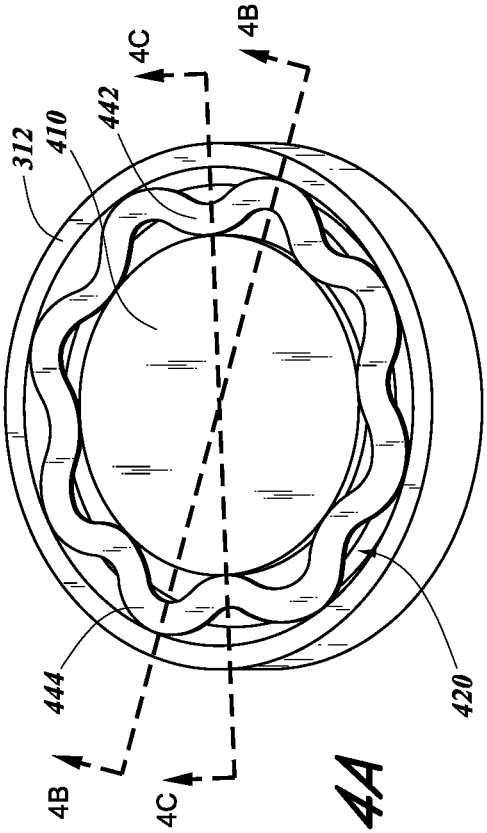


FIG. 4A

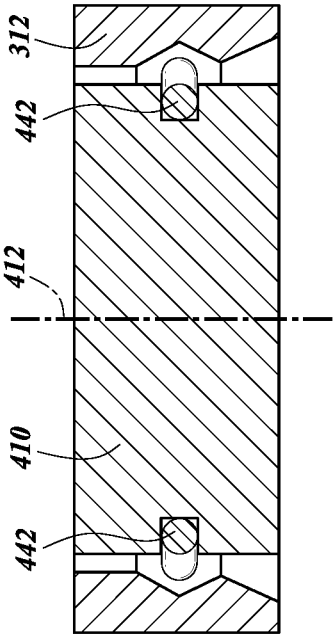


FIG. 4C

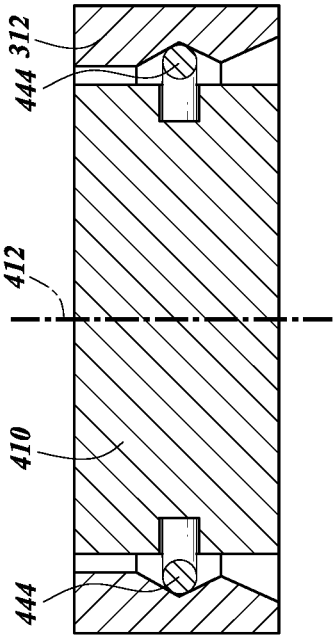


FIG. 4B

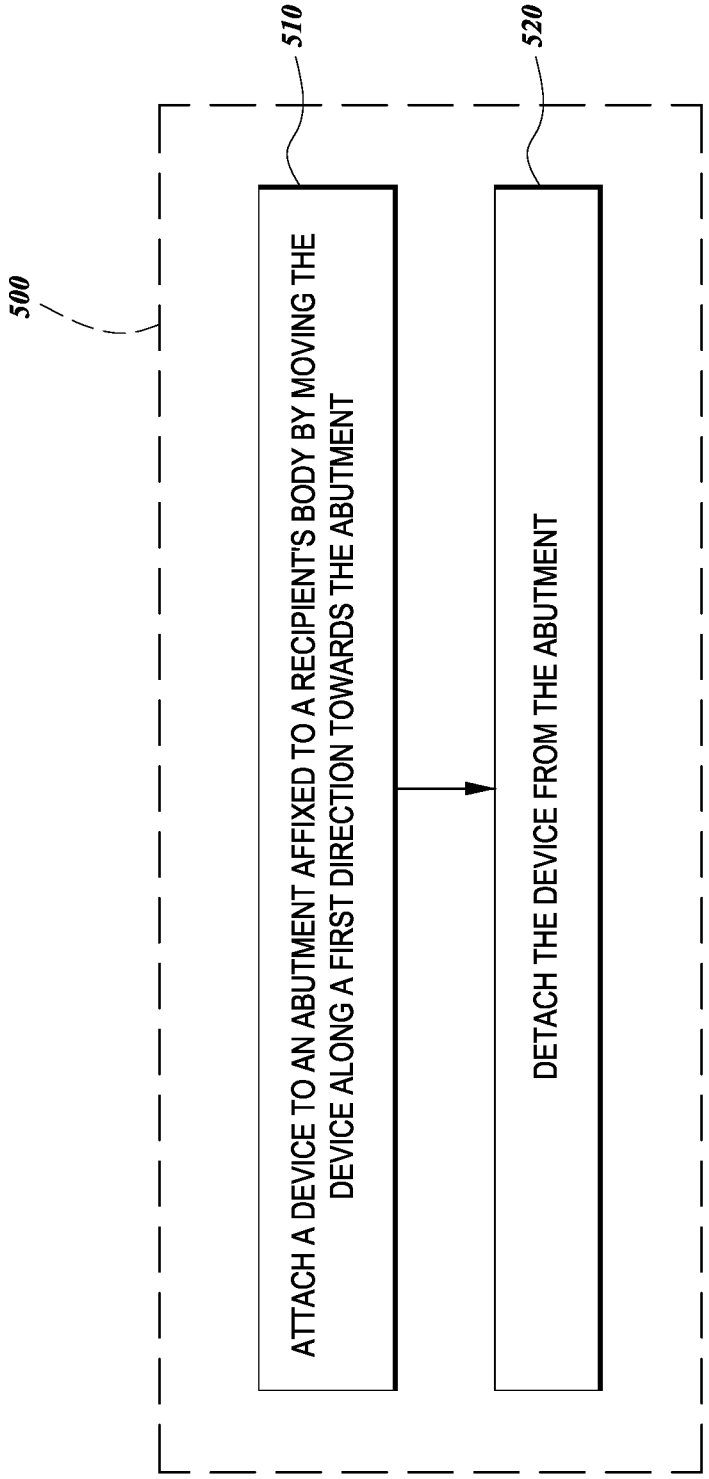

500
510
520
ATTACH A DEVICE TO AN ABUTMENT AFFIXED TO A RECIPIENT'S BODY BY MOVING THE DEVICE ALONG A FIRST DIRECTION TOWARDS THE ABUTMENT
DETACH THE DEVICE FROM THE ABUTMENT

FIG. 5

COUPLER FOR BONE CONDUCTION HEARING PROSTHESIS

BACKGROUND

Field

[0001] The present application relates generally to systems and methods for releasably coupling an external portion of a medical device system to an implanted portion affixed to a recipient's body.

Description of the Related Art

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

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

SUMMARY

[0004] In one aspect disclosed herein, an apparatus comprises a coupling portion configured to be releasably coupled to an abutment affixed to a recipient's body. The coupling portion comprises a substantially cylindrically symmetric body portion extending along a symmetry axis, the body portion comprising an outer body surface having a recess extending around the symmetry axis. The coupling portion further comprises a resilient member in the recess and extending around the symmetry axis. The resilient member extends outwardly past the outer body surface and is configured to contact an inner abutment surface of the abutment. The resilient member is configured to undergo compression by the inner abutment surface and an inner surface of the recess upon being releasably coupled to the abutment. The compression has a component substantially perpendicular to the symmetry axis.

[0005] In another aspect disclosed herein, an apparatus comprises a rigid body portion having a center axis and configured to be releasably attached to an abutment affixed to a recipient's body by moving the rigid body portion along the center axis towards the recipient's body. The rigid body portion or the abutment comprises a channel completely encircling the center axis. The apparatus further comprises an elastically compressible element in the channel and completely encircling the center axis. The elastically compressible element is configured to, upon the rigid body portion being releasably attached to the abutment, apply forces having substantially radial force components to both the rigid body portion and the abutment.

[0006] In another aspect disclosed herein, a method comprises attaching a device to an abutment affixed to a recipient's body by moving the device along a first direction towards the abutment such that a ring-shaped elastically compressible member is compressed between an inner perimeter of the ring-shaped elastically compressible member and an outer perimeter of the ring-shaped elastically compressible member. The method further comprises detaching the device from the abutment without damaging the device and/or the abutment.

BRIEF DESCRIPTION OF THE DRAWINGS

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

[0008] FIG. **1**A schematically illustrates a portion of an example percutaneous bone conduction device implanted in a recipient in accordance with certain implementations described herein:

[0009] FIG. **1**B is a functional block diagram of an example percutaneous bone conduction auditory prosthesis in accordance with certain implementations described herein;

[0010] FIG. **1**C depicts a side view of a portion of an example percutaneous bone conduction device in accordance with certain implementations described herein;

[0011] FIG. **2** schematically illustrates a cross-sectional view of a portion of an example apparatus in accordance with certain implementations described herein;

[0012] FIG. **3**A is a perspective view of an example coupling portion in accordance with certain implementations described herein;

[0013] FIGS. **3**B-**3**D are side views of the example coupling portion of FIG. **3**A during an example process of being releasably coupled to an example abutment in accordance with certain implementations described herein;

[0014] FIGS. **4**A-**4**C schematically illustrate various cross-sectional views of an example apparatus in accordance with certain implementations described herein; and

[0015] FIG. **5** is a flow diagram of an example method in accordance with certain implementations described herein.

DETAILED DESCRIPTION

[0016] Certain implementations described herein provide a mechanical coupler between an external device and an abutment implanted on or within a recipient's body. The coupler can comprise a flexible ring (e.g., garter spring; C-clip; O-ring) that is part of the external device or an external portion of the abutment and is compressed upon the external device being mated with (e.g., snapped onto; latched onto) the abutment. The mechanical coupler can be more easily fabricated than other couplers (e.g., fewer parts; more robust; less manufacturing variation; less wear) and/or can be more space efficient (e.g., smaller distance between the external device and the recipient's body) than other couplers. The mechanical coupler can also avoid using

thread locking to mate the mechanical coupler to the external device and/or can provide shock protection by detaching from the abutment in response to unexpected impacts or other forces without damage to the device and/or the abutment.

[0017] The teachings detailed herein are applicable, in at least some implementations, to any type of implantable or non-implantable vibration stimulation system or device (e.g., implantable or non-implantable bone conduction auditory prosthesis device or system). Implementations can include any type of medical device that can utilize the teachings detailed herein and/or variations thereof. Furthermore, while certain implementations are described herein in the context of auditory prosthesis devices, certain other implementations are compatible in the context of other types of devices or systems (e.g., bone conduction headphones; bone conduction speakers; bone conduction microphones; ultrasonic imaging).

[0018] Merely for ease of description, apparatus and methods disclosed herein are primarily described with reference to illustrative medical systems, namely active transcutaneous or percutaneous bone conduction auditory prosthesis systems. However, the teachings detailed herein and/or variations thereof may also be used with a variety of other medical or non-medical systems that provide a wide range of therapeutic benefits to recipients, patients, or other users. In some implementations, the teachings detailed herein and/or variations thereof can be utilized in other types of devices beyond auditory prostheses that may benefit from improvement of hearing percepts at vibrational frequency ranges generated by electromagnetic transducers and piezoelectric transducers. Implementations can include any type of auditory prosthesis that can utilize the teachings detailed herein and/or variations thereof. Certain such implementations can be referred to as "partially implantable," "semi-implantable," "mostly implantable," "fully implantable," or "totally implantable" auditory prostheses. In some implementations, the teachings detailed herein and/or variations thereof can be utilized in other types of prostheses beyond auditory prostheses.

[0019] FIG. **1**A schematically illustrates a perspective view of a portion of an example percutaneous bone conduction device **100** (e.g., auditory prosthesis) implanted in a recipient in accordance with certain implementations described herein. FIG. **1**B is a functional block diagram of an example percutaneous bone conduction device **100** in accordance with certain implementations described herein. FIG. **1**C schematically illustrates a side view of a portion of an example percutaneous bone conduction implant **310** in accordance with certain implementations described herein configured to be coupled to an operationally removable component **300** of the percutaneous bone conduction device **100**.

[0020] As shown in FIG. **1**A, the recipient has an outer ear **101**, a middle ear **102**, and an inner ear **103**. Elements of the outer ear **101**, the middle ear **102**, and the inner ear **103** are described below, followed by a description of the auditory prosthesis **100**. In a fully functional human hearing anatomy, the outer ear **101** comprises an auricle **105** and an ear canal **106**. A sound wave or acoustic pressure **107** is collected by the auricle **105** and channeled into and through the ear canal **106**. Disposed across the distal end of the ear canal **106** is a tympanic membrane **104** which vibrates in response to the acoustic wave **107**. This vibration is coupled to the oval window or fenestra ovalis **110** through three bones of the middle ear **102**, collectively referred to as the ossicles **111** and comprising the malleus **112**, the incus **113**, and the stapes **114**. The ossicles **111** of the middle ear **102** serve to filter and amplify the acoustic wave **107**, causing the oval window **110** to vibrate. Such vibrations set up waves of fluid motion within the cochlea **139**. Such fluid motion, in turn, activates hair cells (not shown) that line the inside of the cochlea **139**. Activation of the hair cells causes appropriate nerve impulses to be transferred through the spiral ganglion cells and the auditory nerve **116** to the brain (not shown), where they are perceived as sound.

[0021] FIG. **1**A also illustrates an example positioning of the device **100** relative to the outer ear **101**, the middle ear **102**, and the inner ear **103** of a recipient of the device **100**. As shown in FIG. **1**A, the device **100** is positioned behind the outer ear **101** of the recipient and comprises a sound input element **126** to receive sound signals **107**. The sound input element **126** can comprise, for example, a microphone, telecoil, etc. and can be located, for example, on or in the device **100**, or on a cable extending from the device **100**.

[0022] In certain implementations, the device **100** comprises an operationally removable component **300** and a bone conduction implant **310**, as schematically illustrated by FIG. **1**C. The operationally removable component **300** is operationally releasably coupled to the bone conduction implant **310**. By operationally releasably coupled, it is meant that it is releasable in such a manner that the recipient can relatively easily attach and remove the operationally removable component **300** during normal use of the device **100**, repeatedly if desired. Such releasable coupling is accomplished via a coupling apparatus of the operationally removable component **300** and a corresponding mating apparatus of the bone conduction implant **310**, as will be detailed below. This operationally releasable coupling is contrasted with how the bone conduction implant **310** is attached to the skull, as will also be detailed below.

[0023] The operationally removable component **300** includes the sound input element **126**, a sound processor (e.g., an electronics module **204** as shown in FIG. **1**B), and an actuator **206** (e.g., a transducer module, as shown in FIG. **1**B) configured to generate acoustic vibrations. The actuator **206** can comprise a vibrator (e.g., a vibrating electromagnetic actuator; a vibrating piezoelectric actuator; other type of vibrating actuator), and the operationally removable component **300** is sometimes referred to herein as a vibrator unit. More particularly, the sound input element **126** (e.g., a microphone) converts received sound signals **107** into electrical signals **222**. Alternatively, sound signals **107** are received by the sound input element **126** as electrical signals (e.g., via a cable or wireless connection, such as from an audiovisual device). The electrical signals **222** from the sound input element **126** are processed by the electronics module **204**, which can include a sound processing circuit, control electronics, transducer drive components, and a variety of other elements.

[0024] The electronics module **204** is configured to respond to the electrical signals **222** by generating control signals **224** which cause the actuator **206** to vibrate, generating a mechanical output force in the form of acoustic vibrations that is delivered to the skull of the recipient via the bone conduction implant **310**. In other words, the operationally removable component **300** converts the received sound signals **107** into mechanical motion using the

actuator **206** to impart vibrations to the recipient's skull. Delivery of this output force causes motion or vibration of the recipient's skull, thereby activating the hair cells in the recipient's cochlea **139** via cochlea fluid motion.

[0025] As shown in FIG. **1**B, the operationally removable component **300** can further comprise a power module **210** configured to provide electrical power to one or more components of the device **100**. For ease of illustration, the power module **210** has been shown connected only to user interface module **212** and the electronics module **204**. However, it should be appreciated that the power module **210** can be used to supply power to any electrically powered circuits/components of the device **100**. The user interface module **212** is configured to allow the recipient to interact with the device **100**. For example, the user interface module **212** can allow the recipient to adjust the volume, alter the speech processing strategies, power on/off the device, etc. In the example of FIG. **1**B, the user interface module **212** communicates with the electronics module **204** via the signal line **228**. The device **100** of certain implementations further includes an external interface module **214** configured to connect the electronics module **204** to an external device, such as a fitting system. Using the external interface module **214**, the operationally removable component **300** can obtain information from the device **100** (e.g., the current parameters, data, alarms, etc.) and/or modify the parameters of the device **100** used in processing received sounds and/or performing other functions.

[0026] In the example of FIG. **1**B, the sound input element **126**, the electronics module **204**, the actuator **206** (e.g., transducer module), the power module **210**, the user interface module **212**, and the external interface module **214** have been shown as integrated in a single housing **225**. However, it should be appreciated that in certain examples, one or more of the illustrated components can be housed in separate or different housings. For example, in some implementations, the actuator **206** and the sound input element **126** are housed in separate housings to eliminate a potential pathway for feedback. The sound input element **126**, the electronics module **204**, the power module **210**, the user interface module **212**, and the external interface module **214** can be housed in a behind-the-ear (BTE) component that is suspended from the pinna (e.g., by an ear hook). Similarly, it should also be appreciated that in certain such implementations, direct connections between the various modules and devices are not necessary and that the components can communicate, for example, via wireless connections.

[0027] As schematically illustrated in FIG. **1**A, the operationally removable component **300** of the device **100** further includes a coupling apparatus **140** configured to operationally removably attach the operationally removable component **300** to a bone conduction implant **310** (also referred to as an anchor system and/or a fixation system) which is implanted in the recipient. In the example device **100** of FIG. **1**A, the coupling apparatus **140** has a longitudinal axis **150** and is coupled to the bone conduction implant **310** (not shown in FIG. **1**A).

[0028] FIG. **1**C depicts a side view of a portion of an example percutaneous bone conduction implant **310** in accordance with certain implementations described herein. The example implant **310** of FIG. **1**C comprises a percutaneous abutment **312**, a bone fixture **314** (hereinafter sometimes referred to as the fixture **314**), and an abutment screw **320**. While FIG. **1**C illustrates one example implant **310** in accordance with certain implementations described herein, other implants **310** (e.g., comprising abutments **312**, fixtures **314**, and/or abutment screws **320** of any type, size/having any geometry) are also compatible with certain implementations described herein.

[0029] The implant **310** is configured to be repeatedly coupled to and decoupled from the coupling apparatus **140** of the operationally removable component **300**, as shown in FIG. **1**C. The coupling apparatus **140** comprises a longitudinal axis **150** (e.g., an axis along a length of the coupling apparatus **140**; an axis about which the coupling apparatus **140** is at least partially symmetric). For example, the coupling apparatus **140** can be configured to be removably attached to the bone conduction implant **310** by pressing the coupling apparatus **140** against the abutment **312** in a direction along (e.g., substantially parallel to) the longitudinal axis **150** of the coupling apparatus **140** and/or along (e.g., substantially parallel to) the longitudinal axis **340** of the abutment **312**. In certain such implementations, the coupling apparatus **140** can be configured to be snap-coupled to the abutment **312**. In certain implementations, as depicted by FIG. **1**C, the coupling apparatus **140** comprises a male component and the abutment **312** comprises a female component configured to mate with the male component of the coupling apparatus **140**. In certain implementations, this configuration can be reversed, with the coupling apparatus **140** comprises a female component and the abutment **312** comprises a male component configured to mate with the female component of the coupling apparatus **140**.

[0030] The operationally removable component **300** comprises the actuator **206**, with the operationally removable component **300** vibrationally connected to and removably coupled to the implant **310** via the coupling apparatus **140**. More particularly, the actuator **206** of the operationally removable component **300** is in vibrational communication with the coupling apparatus **140** such that vibrations generated by the actuator **206**, in response to a sound captured by the sound input element **126**, are transmitted to the coupling apparatus **140** and then to the implant **310** in a manner that at least effectively evokes a hearing percept. By "effectively evokes a hearing percept," it is meant that the vibrations are such that a typical human between 18 years old and 40 years old having a fully functioning cochlea receiving such vibrations, where the vibrations communicate speech, would be able to understand the speech communicated by those vibrations in a manner sufficient to carry on a conversation provided that those adult humans are fluent in the language forming the basis of the speech. In certain implementations, the vibrational communication effectively evokes a hearing percept, if not a functionally utilitarian hearing percept.

[0031] The abutment **312** of certain implementations is symmetrical with respect to at least those portions of the abutment **312** above the top portion of the fixture **314**. For example, the exterior surfaces of the abutment **312** can form concentric outer profiles about a longitudinal axis **340** of the abutment **312** (e.g., an axis along a length of the abutment **312**; an axis about which the abutment **312** is at least partially symmetric). As shown in FIG. **1**C, the exterior surfaces of the abutment **312** establish diameters lying on planes normal to the longitudinal axis **340** that vary along the length of the longitudinal axis **340**. For example, the abutment **312** can include outer diameters that progressively

become larger with increased distance from the fixture **314**. In certain other implementations, the outer diameters can have other outer profiles.

[0032] In certain implementations, the abutment **312** is configured for integration between the skin and the abutment **312**. Integration between the skin and the abutment **312** can be considered to occur when the soft tissue of the skin **132** encapsulates the abutment **312** in fibrous tissue and does not readily dissociate itself from the abutment **312**. This too inhibits the entrapment and/or growth of microbes proximate the implant **310**. For example, the abutment **312** can have a surface having features which are configured to reduce certain adverse skin reactions. In certain implementations, the abutment **312** is coated to reduce the shear modulus, which can also encourage skin integration with the abutment **213**. For example, at least a portion of the abutment **312** can be coated with or otherwise contain a layer of hydroxyapatite that enhances the integration of skin with the abutment **312**.

[0033] The abutment **312** is configured to be attached to the fixture **314** via the abutment screw **320**, and the fixture **314** is configured to be fixed to (e.g., screwed into) the recipient's skull bone **136**. The abutment **312** is affixed to the bone fixture **314** and extends from the fixture **314**, through muscle **134**, fat **128**, and skin **132** so that the coupling apparatus **140** can be attached thereto. The abutment screw **320** (e.g., comprising a screw head **322** and an elongate coupling shaft **324** connected to the screw head **322**) connects and holds the abutment **312** to the fixture **314**, thereby rigidly attaching the abutment **312** to the fixture **314**. The rigid attachment is such that the abutment **312** is vibrationally connected to the fixture **314** such that at least some of the vibrational energy transmitted to the abutment **312** is transmitted to the fixture **314** in a sufficient manner to effectively evoke a hearing percept. The percutaneous abutment **312** provides an attachment location for the coupling apparatus **140** that facilitates efficient transmission of mechanical force.

[0034] The fixture **314** can be made of any material that has a known ability to integrate into surrounding bone tissue (e.g., comprising a material that exhibits acceptable osseointegration characteristics). In certain implementations, the fixture **314** is formed from a single piece of material (e.g., titanium) and comprises outer screw threads **326** forming a male screw which is configured to be installed into the skull bone **136** and a flange **328** configured to function as a stop when the fixture **314** is implanted into the skull bone **136**. The screw threads **326** have can have a maximum diameter of about 3.5 mm to about 5.0 mm, and the flange **328** can have a diameter which exceeds the maximum diameter of the screw threads **326** (e.g., by approximately 10%-20%). The flange **328** has a planar bottom surface for resting against the outer bone surface, when the fixture **314** has been screwed down into the skull bone **136**. The flange **328** prevents the fixture **314** in general, and, in particular, screw threads **326**, from potentially completely penetrating completely through the bone **136**.

[0035] The body of the fixture **314** can have a length sufficient to securely anchor the fixture **314** to the skull bone **136** without penetrating entirely through the skull bone **136**. The length of the body can therefore depend on the thickness of the skull bone **136** at the implantation site. For example, the fixture **314** can have a length, measured from the planar bottom surface of the flange **328** to the end of the distal region (e.g., the portion farthest from the flange **328**), that is no greater than 5 mm or between about 3.0 mm to about 5.0 mm, which limits and/or prevents the possibility that the fixture **314** might go completely through the skull bond **136**.

[0036] The interior of the fixture **314** further includes an inner lower bore **330** having female screw threads configured to mate with male screw threads of the elongate coupling shaft **324** to secure the abutment screw **320** and the abutment **312** to the fixture **314**. The fixture **314** further includes an inner upper bore **332** that receives a bottom portion of the abutment **312**. While FIG. **1**C shows the coupling apparatus **140** directly engaging with (e.g., directly contacting) the abutment screw **320** (e.g., the screw head **322**), in certain other implementations, the coupling apparatus **140** engages with the abutment **312** without directly engaging with (e.g., without directly contacting) the abutment screw **320**.

[0037] In certain implementations, the bottom of the abutment **312** includes a fixture connection section extending below a reference plane extending across the top of the fixture **314** and that interfaces with the fixture **314**. Upon sufficient tensioning of the abutment screw **320**, the abutment **312** sufficiently elastically and/or plastically stresses the fixture **314**, and/or visa-versa, so as to form a tight seal at the interface of surfaces of the abutment **312** and the fixture **314**. Certain such implementations can reduce (e.g., eliminate) the chances of micro-leakage of microbes into the gaps between the abutment **312**, the fixture **314** and the abutment screw **320**.

[0038] FIG. **2** schematically illustrates a cross-sectional view of a portion of an example apparatus **400** (e.g., coupling apparatus **140**; operationally removable component **300**) in accordance with certain implementations described herein. The apparatus **400** comprises a coupling portion **410** having a center axis **412** (e.g., longitudinal axis **150**) and configured to be releasably attached to an abutment **312** affixed to a recipient's body (e.g., reversibly affixed to and detached from the abutment **312**) by moving the coupling portion **410** along the center axis **412** towards the recipient's body. The coupling portion **410** comprises a recess **414** (e.g., channel) extending around (e.g., completely encircling) the center axis **412**. The apparatus **400** further comprises a resilient (e.g., elastically compressible) element **420** in the recess **414** and extending around (e.g., completely encircling) the center axis **412**. The resilient element **420** is configured to, upon the coupling portion **410** being releasably attached to the abutment **312**, apply forces having substantially radial force components **422** to both the coupling portion **410** and the abutment **312**.

[0039] In certain implementations, the coupling portion **410** comprises a rigid body **416** having an outer body surface **417**. In certain implementations, the coupling portion **410** comprises a solid material (e.g., metal; plastic such as polyether ether ketone or PEEK) that is in mechanical communication with an actuator **206** (e.g., transducer; sensor) of the operationally removable component **300**. For example, as schematically illustrated by FIG. **2**, the coupling portion **410** comprises at least one through hole **430** and is attached to the actuator **206** by at least one screw **432**. In certain implementations, the coupling portion **410** is a unitary (e.g., single; monolithic) component, while in certain other implementations, the coupling portion **410** comprises two or more separate components that can be assembled

together (e.g., affixed to one another; screwed into one another) to form the coupling portion **410**.

[0040] In certain implementations, the resilient element **420** comprises a garter spring comprising a wire (e.g., metal; carbon steel; stainless steel) coiled around a coil axis, the coil axis substantially planar and surrounding a center axis that is substantially perpendicular to the coil axis. Example garter springs compatible with certain implementations described herein are available from Bal-Seal Engineering of Foothill Ranch, California. In certain other implementations, the resilient element **420** comprises a C-clip (e.g., a substantially planar circular ring having a substantially incompressible cross-section and two ends spaced from one another with an opening therebetween) that is elastically expandable and/or compressible to change the overall diameter of the C-clip. In certain other implementations, the resilient element **420** comprises an O-ring comprising an elastically compressible material (e.g., elastomer; rubber; Viton™ fluoroelastomer). In certain implementations, the resilient element **420** can be ring-shaped (e.g., substantially circular, oval, polygonal, symmetric, non-symmetric, or non-regular) in a plane perpendicular to the center axis **412**. For example, the resilient element **420** can be ring-shaped and substantially circular with an inner diameter in a range of 2 millimeters to 5 millimeters, an outer diameter in a range of 3 millimeters to 7 millimeters, and a width between the inner diameter and outer diameter in a range of less than 1 millimeter (e.g., 0.7 millimeter; 0.8 millimeter).

[0041] In certain implementations in which the effects of moisture, grease, or other materials potentially affecting the coupling between the coupling portion **410** and the abutment **312** are a concern, a metal garter spring (e.g., steel) and a metal abutment **312** (e.g., titanium) can be used to provide a metal-to-metal contact that not significantly affected by such effects. In other implementations in which wear between a metal garter spring and a metal abutment from repeated attachment and detachment and/or particles interfering with the coils of the garter spring are concerns, an O-ring can be used with the metal abutment **312** to inhibit such effects.

[0042] In certain implementations, as schematically illustrated by FIG. **2**, the resilient element **420** is in the recess **414**, extends outwardly past the outer body surface **417**, and is configured to contact an inner abutment surface **418** of the abutment **312**. The resilient element **420** is configured to undergo compression by the inner abutment surface **418** and an inner recess surface **419** of the recess **414** upon being releasably coupled to the abutment **312**, the compression having a component substantially perpendicular to the center axis **412** (e.g., the compressive force having a component equal and opposite to the substantially radial force components **422** denoted in FIG. **2**). In certain implementations in which the resilient element **420** comprises a garter spring, the compression of the resilient element **420** can comprise an elastic bending of the spring coils such that the spring coils are canted to reduce the outer diameter of the garter spring and/or an elastic deformation of the coils (e.g., from their substantially circular shape) to reduce the outer diameter of the garter spring. While FIG. **2** schematically illustrates the coupling portion **410** comprising the recess **414** and the resilient element **420**, in certain other implementations, the abutment **312** comprises the recess **414** and the resilient element **420**, and the resilient element **420** is configured to undergo compression by respective surfaces of the abutment **312** and the coupling portion **410**, the compression having a component substantially perpendicular to the center axis **412**. In certain implementations, the coupling portion **410** and the abutment **312** are configured to be snap-coupled (e.g., latched; mated) to one another.

[0043] In certain implementations, the center axis **412** is a symmetry axis of the rigid body **416** of the coupling portion **410** and the rigid body **416** extends along and is substantially cylindrically symmetric about the center axis **412**. For example, the coupling portion **410** (e.g., the rigid body **416**, the recess **414**, and the resilient element **420**) can be substantially circularly symmetric about the center axis **412** (e.g., have a circular cross-sectional shape in a plane perpendicular to the center axis **412**) and the abutment **312** can be substantially circularly symmetric about a center axis of the abutment **312**. In certain such implementations, the coupling portion **410** can be coupled to the abutment **312** with any rotational orientation about the center axis **412** and/or the apparatus **400** can be rotated around the center axis **412** relative to the abutment **312** while the coupling portion **410** is releasably coupled to the abutment **312**.

[0044] The coupling portion **410** and the abutment **312** of other certain implementations have other cross-sectional shapes (e.g., oval; polygonal) in a plane perpendicular to the center axis **412**, such that the apparatus **400** and the abutment **312** can only be releasably coupled to one another with a finite number of rotational orientations about the center axis **412** (e.g., one, two, or more). The coupling portion **410** and the abutment **312** of still other certain implementations have non-symmetry or non-regular shapes (e.g., keyed) in a plane perpendicular to the center axis **412** such that the apparatus **400** and the abutment **312** can only be releasably coupled to one another with a single rotational orientation about the center axis **412**. Certain implementations with a finite number of rotational orientations (e.g., a single rotational orientation) between the apparatus **400** and the abutment **312** inhibit (e.g., prevent) rotation of the apparatus **400** about the center axis **412** relative to the abutment **312** while the coupling portion **410** is releasably coupled to the abutment **312**.

[0045] In certain implementations, the coupling portion **410** is sufficiently rigid to provide a pathway for vibration propagation between the actuator **206** and the recipient's body. For example, the coupling portion **410** can comprise a first rigid surface **434** configured to contact and be in mechanical communication with a corresponding second rigid surface **436** of the abutment **312** when the coupling portion **410** is releasably coupled to the abutment **312**.

[0046] In certain implementations, the coupling portion **410** is sufficiently rigid such that the inner recess surface **419** does not appreciably deflect or deform relative to the inner abutment surface **418** while the coupling portion **410** is releasably coupled to the abutment **312** (e.g., such that the compression of the resilient element **420** is not substantially reduced or inhibited by movement of the inner recess surface **419**).

[0047] In certain implementations in which the actuator **206** generates the vibrations, the vibrations transmitted by the apparatus **300** are within a range of vibrational frequencies that are perceptible by the recipient as sound (e.g., a range of 20 Hz to 20 kHz), which are referred to herein as auditory vibrations. These auditory vibrations propagate along the transmission path comprising the first and second rigid surfaces **434**, **436** to the bone fixture **314** and propagate

via bone conduction from the bone fixture **314** to an inner ear region (e.g., within the temporal bone and comprising the vestibule, the cochlea **139**, and the semicircular canals) and/or a middle ear region (e.g., within the recipient's head, partially bounded by the tympanic membrane and comprising the ossicles **111**, the round window, the oval window **110**, and the Eustachian tube) to be detected as sound.

[0048] In certain implementations, the shape and/or orientation of the resilient element **420**, the rigid body **416**, and the abutment **312** are configured such that the compression of the resilient element **420** between the rigid body **416** and the abutment **312** generates forces on the rigid body **416** and the abutment **312** having first force components (e.g., substantially radial force components **422**) that are substantially perpendicular to the center axis **412** and second force components **438** that are substantially parallel to the center axis **412**. For example, as schematically illustrated by FIG. **2**, the inner abutment surface **418** and the inner recess surface **419** are configured such that compression of the resilient element **420** between the inner abutment surface **418** and the inner recess surface **419** generates the substantially radial force components **422** that are substantially perpendicular to the center axis **412** and that press the resilient element **420** against the inner abutment surface **418** and the inner recess surface **419**. These substantially radial force components **422** can substantially hold the apparatus **400** in place relative to the abutment **312**.

[0049] In certain implementations, the inner abutment surface **418** and the inner recess surface **419** are further configured such that compression of the resilient element **420** between the inner abutment surface **418** and the inner recess surface **419** also generates the second force components **438** that press the first rigid surface **434** against the second rigid surface **436** (e.g., press the first and second rigid surface **434**, **436** together such that the first and second rigid surfaces **434**, **436** provide a portion of a propagation path for vibrations between the actuator **206** and the recipient's body). For example, for an apparatus **400** comprising an actuator **206** (e.g., transducer) configured to generate vibrations (e.g., vibrational energy), the first and second rigid surfaces **434**, **436** can be configured to provide a portion of a transmission path for the vibrations from the actuator **206** to the recipient's body (e.g., via the fixture **314**).

[0050] FIG. **3**A is a perspective view of an example coupling portion **410** in accordance with certain implementations described herein. FIGS. **3**B-**3**D are side views of the example coupling portion **410** of FIG. **3**A during an example process of being releasably coupled to an example abutment **312** in accordance with certain implementations described herein. The example coupling portion **410** of FIG. **3**A comprises a resilient element **420** comprising a garter spring in a recess **414** of the rigid body **416**, the garter spring and the recess **414** extending around a center axis **412** of the coupling portion **410** (e.g., around a longitudinal symmetry axis of the rigid body **416**).

[0051] In certain implementations, the apparatus **400** and the abutment **312**, initially separate from one another, can be coupled to one another by aligning the center axis **412** of the coupling portion **410** with the longitudinal axis **340** of the abutment **312**, as schematically illustrated by FIG. **3**B. Coupling the apparatus **400** and the abutment **312** to one another can further comprise moving the coupling portion **410** towards the abutment **312** in a direction along the center axis **412** and pressing the coupling portion **410**, including the resilient element **420**, into the abutment **312** in the direction along the center axis **412** (see, e.g., FIG. **3**C) such that the apparatus **400** and the abutment **312** snap together (e.g., with the resilient element **420** compressed by the inner abutment surface **418** and the inner recess surface **419**) with the first and second rigid surfaces **434**, **436** pressed against one another (see, e.g., FIG. **3**D). In certain implementations, the apparatus **400** and the abutment **312**, initially coupled together, can be released (e.g., separated) from one another by moving the coupling portion **410** away from the abutment **312** in a direction along the center axis **412**, thereby pulling the coupling portion **410**, including the resilient element **420**, out of the abutment **312** (see, e.g., FIGS. **3**C and **3**B) such that the apparatus **400** and the abutment **312** snap apart from one another.

[0052] In certain implementations, the coupling portion **410** is configured to release from being coupled to the abutment **312** upon tilting of the apparatus **400** relative to the abutment by a predetermined angle of the center axis **412** (e.g., symmetry axis) relative to the longitudinal axis **340** of the abutment **312**. For example, a torque applied to the apparatus **400** while the apparatus **400** is coupled to the abutment **312** can tilt the center axis **412** of the coupling portion **410** to be non-parallel to the longitudinal axis **340** of the abutment **312**. Upon the angle between the center axis **412** of the coupling portion **410** and the longitudinal axis **340** of the abutment becoming greater than or equal to a predetermined value (e.g., in a range of 5 degrees to 20 degrees), the resilient element **420** can slide away from the inner abutment surface **418** resulting in the coupling portion **410** snapping away from the abutment **312** but without significant damage to the apparatus **400** and/or the abutment **312**. In certain such implementations, the apparatus **400** provides a safety feature by allowing the apparatus **400** to detach from the abutment **312** upon an impact or other force unexpectedly applied to the apparatus **400** (e.g., shock protection).

[0053] In certain implementations, the resilient element **420** has an elastically compressible cross-section (e.g., O-ring) which provides a spring force that couples the coupling portion **410** with the abutment **312**. For example, FIGS. **3**A-**3**D schematically illustrate a substantially circular and substantially planar resilient element **420** encircling the longitudinal axis **412** of the coupling portion **410** with the resilient element **420** contacting both the coupling portion **410** and the abutment **312** substantially continuously along the resilient element **420**. In certain other implementations, the resilient element **420** comprises a substantially planar ring-like portion with two ends spaced from one another with an opening therebetween (e.g., C-clip) such that elastically changing the overall width (e.g., diameter) provides the spring force.

[0054] In certain implementations, the spring force of the resilient element **420** can be provided by elastic deformation of the overall shape of the resilient element **420**. For example, the resilient element **420** can have a substantially non-circular shape that does not contact both the coupling portion **410** and the abutment **312** substantially continuously along the resilient element **420**. The material (e.g., plastic; metal) of the resilient element **420** (e.g., garter spring; C-clip; O-ring) can extend around (e.g., encircle) the longitudinal axis **412** and can have a substantially elliptical or polygonal shape (e.g., substantially triangular; substantially

square; substantially pentagonal; substantially hexagonal; substantially heptagonal; substantially octagonal) and/or a wave-like perimeter (e.g., differing radial distances from a center of the resilient element **420** along the perimeter). Examples of such resilient elements **420** are available from Smalley Steel Ring Company of Lake Zurich, Illinois. The resilient element **420** can provide fixation along the axial direction (e.g., along the longitudinal axis **412** of the coupling portion **410** and/or the longitudinal axis **340** of the abutment **312**), as well as fixation along the radial direction (e.g., perpendicular to the axial direction).

[0055] FIGS. **4**A-**4**C schematically illustrate various cross-sectional views of an example apparatus **400** in accordance with certain implementations described herein. FIG. **4**A shows a cross-sectional view of a substantially planar resilient element **420** in a plane substantially perpendicular to the longitudinal axis **412**, and FIGS. **4**B and **4**C show cross-sectional views of the resilient element **420** of FIG. **4**A in two different planes substantially perpendicular to the resilient element **420**. The resilient element **420** of FIG. **4**A is substantially octagonal and has a wave-like perimeter that varies in the radial direction relative to the symmetry axis (e.g., the longitudinal axis **412**, the longitudinal axis **340**). The resilient element **420** comprises multiple portions **442** configured to contact an outer surface of the coupling portion **410** (e.g., while spaced from the inner surface of the abutment **312**) and multiple portions **444** configured to contact an inner surface of the abutment **312** (e.g., while spaced from the outer surface of the coupling portion **410**). While the resilient element **420** of FIGS. **4**A-**4**C is substantially planar, in certain other implementations, the resilient element **420** has a substantially non-planar shape (e.g., a wave-like perimeter that varies in the axial direction relative to the symmetry axis).

[0056] In certain implementations, the resilient element **420** has a substantially circular cross-section (see, e.g., FIGS. **4**B and **4**C) in a plane substantially perpendicular to the resilient element **420** with a substantially constant thickness along the circumference of the resilient element **420**, while in certain other implementations, the cross-section in a plane substantially perpendicular to the resilient element **420** is non-circular (e.g., rectangular). In certain implementations, the resilient element **420** is configured to fit within grooves of the coupling portion **410** and the abutment **312**, and the grooves are configured to facilitate the axial fixation provided by the resilient element **420**. For example, the grooves of the coupling portion **410** and/or the abutment **312** can comprise a substantially rectangular cross-section or a V-shaped cross-section (see, e.g., FIGS. **4**B and **4**C). Other shapes of the grooves are also compatible with certain implementations described herein.

[0057] In certain implementations, the substantially non-circular shape of the resilient element **420** has more stiffness than an O-ring of comparable size, and the size, shape, and materials of the resilient element **420** can be optimized for the particular usage. The substantially non-circular shape of the resilient element **420** can allow the coupling portion **410** to be moved into engagement with the abutment **312** at a non-zero angle (e.g., the longitudinal axis **412** of the coupling portion **410** at a non-zero angle relative to the longitudinal axis **340** of the abutment **312**), thereby elastically deforming the shape of the resilient element **420**, and then rotating the coupling portion **410** so that the longitudinal axis **412** is aligned with the longitudinal axis **340** to snap the coupling portion **410** onto the abutment **312**. In this way, the coupling portion **410** can engage the abutment **312** with less force applied than had the coupling portion **410** been moved into engagement with the abutment **312** solely along the longitudinal axes **412**, **340**.

[0058] FIG. **5** is a flow diagram of an example method **500** in accordance with certain implementations described herein. While the method **500** is described by referring to some of the structures of the example apparatus **400** of FIGS. **2**, **3**A-**3**D, and **4**A-**4**C, other apparatus and systems with other configurations of components can also be used to perform the method **500** in accordance with certain implementations described herein.

[0059] In an operational block **510**, the method **500** comprises attaching a device (e.g., apparatus **400**; coupling portion **410**) to an abutment (e.g., abutment **312**) affixed to a recipient's body by moving the device along a first direction towards the abutment (e.g., along a center axis of the coupling portion **410**) such that a ring-shaped elastically compressible member (e.g., resilient element **420**; garter spring; C-clip; O-ring) is compressed between an inner perimeter of the ring-shaped elastically compressible member and an outer perimeter of the ring-shaped elastically compressible member (e.g., the resilient element **420** is in a recess **414** of the device or the abutment and is compressed by respective surfaces of the device and the abutment such that the distance between the inner perimeter and the outer perimeter is reduced). For example, said attaching the device to the abutment is illustrated by the sequence of FIGS. **3**B, **3**C, and **3**D.

[0060] In an operational block **520**, the method **500** further comprises detaching the device from the abutment. For example, said detaching the device can comprise moving the device along a second direction away from the abutment, the second direction substantially parallel to the first direction (e.g., as illustrated by the sequence of FIGS. **3**D, **3**C, and **3**B).

[0061] In certain implementations, after attaching the device to the abutment, but before detaching the device from the abutment, the method **500** further comprises transmitting vibrations from the device to the recipient's body via the abutment. For example, the vibrations can be generated by the device in response to electrical signals indicative of sound detected by at least one microphone (e.g., of the device), received by the auditory system of the recipient via bone conduction, to provide a hearing percept to the recipient.

[0062] Although commonly used terms are used to describe the systems and methods of certain implementations for ease of understanding, these terms are used herein to have their broadest reasonable interpretations. Although various aspects of the disclosure are described with regard to illustrative examples and implementations, the disclosed examples and implementations should not be construed as limiting. Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain implementations include, while other implementations do not include, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more implementations or that one or more implementations necessarily include logic for deciding, with or

without user input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular implementation. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a nonexclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

[0063] It is to be appreciated that the implementations disclosed herein are not mutually exclusive and may be combined with one another in various arrangements. In addition, although the disclosed methods and apparatuses have largely been described in the context of various devices, various implementations described herein can be incorporated in a variety of other suitable devices, methods, and contexts. More generally, as can be appreciated, certain implementations described herein can be used in a variety of implantable medical device contexts that can benefit from certain attributes described herein.

[0064] Language of degree, as used herein, such as the terms "approximately," "about," "generally," and "substantially," represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms "approximately," "about," "generally," and "substantially" may refer to an amount that is within ±10% of, within ±5% of, within ±2% of, within ±1% of, or within ±0.1% of the stated amount. As another example, the terms "generally parallel" and "substantially parallel" refer to a value, amount, or characteristic that departs from exactly parallel by ±10 degrees, by ±5 degrees, by ±2 degrees, by ±1 degree, or by ±0.1 degree, and the terms "generally perpendicular" and "substantially perpendicular" refer to a value, amount, or characteristic that departs from exactly perpendicular by ±10 degrees, by ±5 degrees, by ±2 degrees, by ±1 degree, or by ±0.1 degree. The ranges disclosed herein also encompass any and all overlap, sub-ranges, and combinations thereof. Language such as "up to," "at least," "greater than," less than," "between," and the like includes the number recited. As used herein, the meaning of "a," "an," and "said" includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein, the meaning of "in" includes "into" and "on," unless the context clearly dictates otherwise.

[0065] While the methods and systems are discussed herein in terms of elements labeled by ordinal adjectives (e.g., first, second, etc.), the ordinal adjective are used merely as labels to distinguish one element from another (e.g., one signal from another or one circuit from one another), and the ordinal adjective is not used to denote an order of these elements or of their use.

[0066] The invention described and claimed herein is not to be limited in scope by the specific example implementations herein disclosed, since these implementations are intended as illustrations, and not limitations, of several aspects of the invention. Any equivalent implementations are intended to be within the scope of this invention. Indeed, various modifications of the invention in form and detail, in addition to those shown and described herein, will become apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the claims. The breadth and scope of the invention should not be limited by any of the example implementations disclosed herein but should be defined only in accordance with the claims and their equivalents.

1. An apparatus comprising:

a coupling portion configured to be releasably coupled to an abutment affixed to a recipient's body, the coupling portion comprising:

a substantially cylindrically symmetric body portion extending along a symmetry axis, the body portion comprising an outer body surface having a recess extending around the symmetry axis; and

a resilient member in the recess and extending around the symmetry axis, the resilient member extending outwardly past the outer body surface and configured to contact an inner abutment surface of the abutment, the resilient member configured to undergo compression by the inner abutment surface and an inner surface of the recess upon being releasably coupled to the abutment, the compression having a component substantially perpendicular to the symmetry axis.

2. The apparatus of claim **1**, wherein the resilient member comprises an O-ring, a C-clip, or a garter spring.

3. The apparatus of claim **1**, wherein the body portion, the recess, and the resilient member are substantially circularly symmetric about the symmetry axis.

4. The apparatus of claim **1**, wherein the coupling portion further comprises a first rigid surface and the abutment comprises a second rigid surface, the coupling portion configured to press the first rigid surface against the second rigid surface with a force generated by the compression of the resilient member.

5. The apparatus of claim **4**, wherein the apparatus further comprises an actuator configured to generate vibrations, at least a portion of the vibrations transmitted to the recipient's body via the first rigid surface and the second rigid surface.

6. The apparatus of claim **1**, wherein the coupling portion is configured to release from being coupled to the abutment upon tilting of the apparatus relative to the abutment by a predetermined angle.

7. The apparatus of claim **1**, wherein the compression of the resilient member reduces a distance between an inner perimeter of the resilient member and an outer perimeter of the resilient member.

8. The apparatus of claim **1**, wherein the apparatus comprises an external portion of a percutaneous bone conduction auditory prosthesis.

9. The apparatus of claim **1**, wherein the coupling portion comprises a male component and the abutment comprises a female component configured to mate with the male component of the coupling portion, or the coupling portion comprises a female component and the abutment comprises a male component configured to mate with the female component of the coupling portion.

10. The apparatus of claim **1**, wherein the resilient member has a substantially non-circular shape.

11. The apparatus of claim **10**, wherein the resilient member has a substantially elliptical or polygonal shape and/or a wave-like perimeter varies in the radial direction relative to the symmetry axis and/or the axial direction relative to the symmetry axis.

12. The apparatus of claim **10**, wherein the resilient member does not contact both the coupling portion and the abutment substantially continuously along the resilient member.

13. The apparatus of claim 10, wherein the resilient member is configured to fit within grooves of the coupling portion and the abutment.

14. The apparatus of claim 13, wherein the grooves are configured to facilitate axial fixation provided by the resilient member.

15. An apparatus comprising:

a rigid body portion having a center axis and configured to be releasably attached to an abutment affixed to a recipient's body by moving the rigid body portion along the center axis towards the recipient's body, the rigid body portion or the abutment comprising a channel completely encircling the center axis; and

an elastically compressible element in the channel and completely encircling the center axis, the elastically compressible element configured to, upon the rigid body portion being releasably attached to the abutment, apply forces having substantially radial force components to both the rigid body portion and the abutment.

16. The apparatus of claim 15, wherein the elastically compressible element comprises an O-ring, a C-clip, or a garter spring.

17. The apparatus of claim 15, wherein the rigid body portion and the abutment are configured to be snap coupled to one another.

18. The apparatus of claim 15, further comprising a transducer configured to generate vibrational energy, the rigid body portion and the abutment configured to provide a transmission path for the vibrational energy from the transducer to the recipient's body.

19. A method comprising:

attaching a device to an abutment affixed to a recipient's body by moving the device along a first direction towards the abutment such that a ring-shaped elastically compressible member is compressed between an inner perimeter of the ring-shaped elastically compressible member and an outer perimeter of the ring-shaped elastically compressible member; and

detaching the device from the abutment without damaging the device and/or the abutment.

20. The method of claim 19, wherein said detaching comprises moving the device along a second direction away from the abutment.

21. The method of claim 20, wherein the first direction and the second direction are substantially parallel to one another.

22. The method of claim 20, wherein the first direction and the second direction are at a non-zero angle relative to one another.

23. The method of claim 19, wherein the ring-shaped elastically compressible member comprises an O-ring, a C-clip, or a garter spring.

24. The method of claim 23, wherein the ring-shaped elastically compressible member is in a recess of the device or the abutment.

25. The method of claim 19, wherein said detaching comprises applying a torque to the device while the device is attached to the abutment such that an angle between a longitudinal axis of the device and a longitudinal axis of the abutment becomes greater than or equal to a predetermined value.

26. The method of claim 19, further comprising, after attaching the device to the abutment, but before detaching the device from the abutment, transmitting vibrations from the device to the recipient's body via the abutment, the vibrations generated by the device in response to electrical signals indicative of sound detected by at least one microphone of the device.

* * * * *