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Application Number	
Filing Date	2021-12-16
First Named Inventor	CARLSON, Erik
Art Unit	
Examiner Name	
Attorney Docket Number	ST0806US3/0532.000806US03

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	1	2640170	EP		2013-09-18	SANFORD EMERY A; et al.		
	2	2016/036309	WO		2016-03-10	LINDÉN OLLE; et al.		
	3	2016/126476	WO		2016-08-11	FLETCHER DOUGLAS D; et al.		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
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	Art Unit	
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	4	2019/037854	WO		2019-02-28	BALTENSPERGER CHRISTIAN; et al.		

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2021-12-16
	First Named Inventor	CARLSON, Erik
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ST0806US3/0532.000806US03

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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Signature	/Mark A. Hollingsworth/	Date (YYYY-MM-DD)	2021-12-16
Name/Print	Mark A. Hollingsworth	Registration Number	38491

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H04B 1/38 *(2015.01)*

(54) **Wireless headset comprising a housing and an earbud electrically coupled to the housing by a flexible circuit board**

Drahtloses Headset mit einem Gehäuse und einem Ohrhörer, der über eine flexible Leiterplatte elektrisch an das Gehäuse gekoppelt ist

Casque sans fil comprenant un boîtier et un écouteur bouton électriquement couplé au boîtier par une carte de circuit flexible

(84) Designated Contracting States:
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(56) References cited:
EP-A2- 0 918 357
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WO-A2-01/78354
US-A- 5 245 269
US-A1- 2002 131 585

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EP 2 640 170 B1

Description

Field of Invention

[0001] The present invention can relate to headsets. More particularly, the present invention can relate to headsets for communicating with an electronic device.

Background of the Invention

[0002] Headsets for providing hands- free communications are known in the art. Such headsets typically can be used in conjunction with a cellular telephone or a computer (e.g., Voice over IP). Some existing headsets include a microphone, a speaker (also referred to as a receiver), electronics for controlling the headset and communicating with another device (e.g., a cellular telephone), a battery and a connector for re-charging the battery.

[0003] There are many aspects involved in the design of headsets. For example, the size and weight of headsets can be key issues because of how they typically mount to a user's ear. A heavy or large headset can pull on a user's ear, creating an uncomfortable fit. The shape of headset earpieces (e.g., earbuds) may also be an important design consideration to take into account as it is desirable for earpieces to fit comfortably in, on, or over a wide range of different sizes and shapes of ears.

[0004] Additionally, the acoustic performance of headsets, such as receiver sound generation quality and microphone sound reception quality (e.g., ability to pick up a user's voice without undue background noise), can be important design considerations. Achieving desired receiver and microphone acoustic performance can become increasingly difficult as the size of a headset decreases.

[0005] Another example of an important design consideration can be the user interface of a headset. It may be desirable for a user interface to be intuitive for a first-time user, yet convenient for an experienced user.

[0006] Aesthetics may be yet another important design consideration for headsets.

[0007] Further still, ease of manufacturing headsets can be another design consideration. For example, it can be desirable to design a headset that can be mass produced in an affordable fashion.

[0008] In view of the foregoing, there is a need for an improved headset that addresses one or more of the above-identified considerations.

[0009] US2002/0131585 A1 discloses an in-the-ear headset. WO 01/43497 A1 discloses a flexible circuit board assembly for a hearing aid. EP 0918357 A2 discloses a battery connecter and electrical connection member. US 5,245,269 discloses a battery temperature sensing apparatus. WO 01/078354 A3 discloses a hands-free communication device. WO 01/86923 A1 discloses a headset.

Summary of the Invention

[0010] In accordance with one embodiment of the present invention, a wireless headset device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The earbud assembly can include an earbud flexible circuit board having mounted thereon a receiver and processing circuitry. The primary housing assembly can include a microphone and a primary housing flexible circuit board electrically coupled to the earbud circuit board and the microphone.

[0011] In accordance with another embodiment of the present invention, a wireless headset device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The earbud assembly can include an earbud flexible circuit board. The primary housing assembly can include a battery retaining region and a primary housing flexible circuit board. The circuit board components and circuitry can be selectively mounted on the earbud flexible circuit board and the primary housing flexible circuit board to maximize a size of the battery retaining region.

[0012] In accordance with yet another embodiment of the present invention, a wireless device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The primary housing assembly can have predetermined dimensions. The earbud assembly and the primary housing assembly can each have mounted therein a flexible circuit board comprising circuitry.

[0013] In accordance with yet another embodiment of the present invention, a headset device that includes an earbud assembly, a primary housing assembly, and at least one flexible circuit board is provided. The primary housing assembly can be fixed to the earbud assembly and can include a connector assembly. The at least one flexible circuit board can be electrically coupled to the connector assembly and can include Universal Serial Bus (USB) circuitry operative to process USB protocol communications and serial circuitry operative to process serial protocol communications.

Brief Description of the Drawings

[0014] The present invention will be apparent upon consideration of the following detailed description, taken in conjunction with accompanying drawings, in which:

[0015] FIG. 1 is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0016] FIG. 2 is a simplified block diagram of a headset connector system in accordance with an embodiment of the present invention;

[0017] FIG. 3 is a simplified cross-sectional illustration of a connector assembly in accordance with an embodiment of the present invention;

[0018] FIG. 4 is a simplified cross-sectional illustration

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of another connector assembly in accordance with an embodiment of the present invention;

[0019] FIG. 5 is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0020] FIG. 6A is a simplified cross-sectional illustration of a portion of a headset in accordance with an embodiment of the present invention;

[0021] FIG. 6B is a simplified cross-sectional illustration of a screw in accordance with an embodiment of the present invention;

[0022] FIG. 7 is a simplified block diagram of a display system in accordance with an embodiment of the present invention;

[0023] FIG. 8 is a simplified block diagram of a power distribution system in accordance with an embodiment of the present invention;

[0024] FIG. 9 is a simplified block diagram of another power distribution system in accordance with an embodiment of the present invention;

[0025] FIGS. 10A and 10B are illustrations of a headset in accordance with an embodiment of the present invention;

[0026] FIG. 11 is an exploded view of a headset in accordance with an embodiment of the present invention;

[0027] FIG. 12 is an exploded view of a headset in accordance with another embodiment of the present invention;

[0028] FIG. 13 is a simplified diagram showing how software in a Bluetooth device is organized in accordance with an embodiment of the present invention;

[0029] FIG. 14 is a simplified block diagram of the electrical system of a headset in accordance with an embodiment of the present invention;

[0030] FIG. 15 is a simplified block diagram of the core processor of a headset in accordance with an embodiment of the present invention;

[0031] FIG. 16 is a simplified schematic diagram of a power distribution system in accordance with an embodiment of the present invention;

[0032] FIGS. 17A-17C are illustrations of a traditional circuit board and distribution of electrical components in a headset;

[0033] FIG. 18 is a simplified block diagram of a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0034] FIGS. 19A and 19B are illustrations comparing the traditional circuit board of FIGS. 7A-7C to a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0035] FIGS. 20A-20C are illustrations of an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0036] FIG. 21A is an illustration of a headset earbud in accordance with an embodiment of the present invention;

[0037] FIG. 21B is a simplified exploded view of a headset earbud in accordance with an embodiment of the present invention;

[0038] FIGS. 22-25 and FIG. 26A are simplified illustrations of a headset earbud in various states of assembly in accordance with some embodiments of the present invention;

[0039] FIG. 26B is a simplified cross-sectional view of an audio receiver in accordance with an embodiment of the present invention;

[0040] FIG. 27A is a simplified cross-sectional view of a partially assembled headset earbud in accordance with an embodiment of the present invention;

[0041] FIG. 27B is a simplified cross-sectional view of a fully assembled headset earbud in accordance with an embodiment of the present invention;

[0042] FIG. 28 is an exploded view of an attachment system in accordance with an embodiment of the present invention;

[0043] FIG. 29 is a flowchart of an illustrative process for assembling a portion of a headset in accordance with an embodiment of the present invention.

[0044] FIGS. 30A and 30B are illustrations of a tool that can be used to assist in assembly of a portion of a headset in accordance with an embodiment of the present invention;

[0045] FIG. 30C is an illustration of the tool of FIGS. 30A and 30B being used in accordance with an embodiment of the present invention;

[0046] FIG. 31 is a cross-sectional view of a "finished" tube in accordance with an embodiment of the present invention;

[0047] FIG. 32 is a cross-sectional view of an initially manufactured tube in accordance with an embodiment of the present invention;

[0048] FIG. 33 is a perspective view of a cross section of the tube of FIG. 31 in accordance with an embodiment of the present invention;

[0049] FIG. 34 is an illustrative die and stamper for modifying the initially manufactured tube of FIG. 32 in accordance with an embodiment of the present invention;

[0050] FIG. 35 is a cross-sectional view of the tube of FIG. 34 once the stamper and die are removed from the tube in accordance with an embodiment of the present invention;

[0051] FIG. 36 is a perspective view of the tube of FIG. 35 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0052] FIG. 37 is a cross-sectional view of an illustrative tube formed using a single impact extrusion in accordance with an embodiment of the present invention;

[0053] FIG. 38 is a perspective view of the tube of FIG. 37 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0054] FIG. 39 is a cross-sectional view of an illustrative tube formed using a double impact extrusion in ac-

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cordance with an embodiment of the present invention;

[0055] FIG. 40 is a perspective view of the tube of FIG. 39 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0056] FIG. 41 is a cross-sectional view of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present invention;

[0057] FIG. 42 is a perspective view of a cross section of the tube of FIG. 41 in accordance with an embodiment of the present invention;

[0058] FIG. 43 is a perspective view of the tube of FIGS. 41 and 42 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0059] FIG. 44 is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube with using a die and stamper in accordance with an embodiment of the present invention;

[0060] FIG. 45 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention;

[0061] FIG. 46 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention;

[0062] FIG. 47 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention;

[0063] FIG. 48 is a cross-sectional view of a visual indicator system in accordance with an embodiment of the present invention;

[0064] FIG. 49 is an illustration of a visual indicator system of a headset in accordance with an embodiment of the present invention;

[0065] FIGS. 50A and 50B are illustrations of a headset in accordance with an embodiment of the present invention;

[0066] FIG. 51 is an illustration of a connector in accordance with an embodiment of the present invention;

[0067] FIG. 52 is an exploded view of a connector in accordance with an embodiment of the present invention;

[0068] FIG. 53 is an illustration of a microphone boot in accordance with an embodiment of the present invention;

[0069] FIG. 54 is a cross-sectional view of a connector in accordance with an embodiment of the present invention;

[0070] FIGS. 55A-55D are illustrations of a headset in accordance with an embodiment of the present invention;

[0071] FIG. 56 is a cross-sectional view of an electrical contact assembly coupled to a circuit board in accordance with an embodiment of the present invention;

[0072] FIGS. 57A and 57B are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0073] FIGS. 58A-58C are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0074] FIGS. 59A and 59B are illustrations of electrical contacts in accordance with an embodiment of the present invention;

[0075] FIGS. 60A and 60B are illustrations of a connector plate in accordance with an embodiment of the present invention;

[0076] FIGS. 61A and 61B are illustrations of magnetic components of a connector in accordance with an embodiment of the present invention;

[0077] FIGS. 62A and 62B are illustrations of a connector in accordance with an embodiment of the present invention;

[0078] FIGS. 63A and 63B are illustrations of a connector in accordance with an embodiment of the present invention;

[0079] FIG. 64 is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention;

[0080] FIG. 65 is a simplified graph of magnetic and spring forces involved in the coupling of a headset with a complementary connector in accordance with an embodiment of the present invention;

[0081] FIG. 66 is an illustration of a docking device that can receive a headset in accordance with an embodiment of the present invention;

[0082] FIG. 67A is an illustration of a connector in accordance with an embodiment of the present invention;

[0083] FIG. 67B is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention; and

[0084] FIG. 68 is a chart listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention.

Detailed Description of the Invention

[0085] The present invention relates to headsets and methods for manufacturing the same. Headsets are communication devices that are worn on a user's head in order to allow hands free data and/or voice communication with a host device such as a computer, phone handset, cellular phone, an automobile and/or the like. Headsets can include one or more speakers (in proximity to one or both ears) for audio output and/or one or more microphones for audio input.

[0086] Headsets can come in a variety of form factors or shapes. In some cases, headsets can be embodied as an earpiece that serves as the primary support mechanism for wearing the headset. For example the headset may be supported on the head by an earpiece worn over or in the ear. Alternatively, the headset may be supported by a frame or band that fits on or over the user's head. The headset may include a fixed or movable boom that

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places the microphone closer to the user's mouth (wraps around the face). Alternatively, the headset may be boomless such that the microphone is integrated with the earpiece thereby forming a more compact device (e.g., smaller, lighter, more aesthetically pleasing, etc.).

[0087] According to one aspect of the invention, the headset can be embodied as a small compact unit including a primary housing and an earbud member extending therefrom. The earbud member may be attached to or integrally formed with the primary housing. Various components can be placed at the surface of or within the confines of the earbud member and the primary housing. In fact, both of them can include one or more components depending on the needs of the device. The components contained within each of these can be widely varied. Examples of operational components can include speakers, microphones, antennas, connectors, buttons, displays, indicators, battery, and associated processors, controllers and circuitry. Generally, the earbud member includes at least a speaker while the primary housing includes at least a microphone (although this is not a requirement). Depending on their size, each of these members can include additional components of the headset. In one embodiment, the primary housing includes an antenna, user interface button, indicator or display (e.g., LEDs), battery, microphone, and/or a connector along with any accompanying circuitry while a speaker, a processor, and its accompanying circuitry can be located in the earbud. The button can be located on one end of the main housing. A user can interface with this button to perform various functions (e.g., terminating calls).

[0088] The shape and size and orientation of the earbud member and primary housing can be widely varied. In one embodiment, the earbud member is configured for insertion into the ear such that it supports the remaining portions of the headset (e.g., primary housing) proximate the user's head. In one embodiment, the primary housing can be configured as a longitudinal member (e.g., a tube). In one example, an earbud member, which contains a speaker, perpendicularly protrudes away from one end of a longitudinally extending primary housing, which includes a microphone at an opposite end of the longitudinally extending primary housing. Furthermore, the earbud member can expand outwardly and then inwardly from a neck portion that couples to the primary housing in order to form a bud that fits into an ear.

[0089] The primary housing can include a tube that forms a housing and receives internal components through an open end. The tube can be manufactured using one of several processes in order to reduce costs and increase speed and efficiency. In one embodiment, the tube can be manufactured to include features on the inner surface of the tube for supporting electronic components of the headset. Processes for creating such a tube can include applying a die and stamp to an extruded tube, single or double impact extrusion, or a progressive deep draw process.

[0090] The headset can include a hollow neck between the earbud and the primary housing in order to allow electrical wires to connect sets of discrete electronics disposed within the earbud and primary housing. In one embodiment, dual threaded inserts can be used to structurally reinforce the hollow neck without adding size to the device.

[0091] Small compact headsets have limited surface area for placing components. Therefore, one aspect of the invention relates to integrating multiple components into the same surface area of the headset in order to help form a small compact headset. Put another way, multiple components can be built into the same location on the headset in order to achieve the desired level of functionality without impacting a desired small size of the headset. The components may for example be selected from connectors, microphones, speakers, buttons, indicators, displays and/or the like. In one embodiment, an antenna and a button function at the same location of the headset. In another embodiment, a microphone and connector function at the same location of the headset. Other embodiments can also be realized. For example, a button can function at the same location of a speaker (e.g., at an earbud) or an indicator can function at the same location of a microphone.

[0092] Small compact headsets also have limited internal volume for placing internal components. Therefore one aspect of the invention relates to dividing/separating internal electronic assemblies into small multiple components that can be positioned at different locations (discretely) within the headset. By way of example, the electronics that would normally be embodied on a single large circuit board may be divided/separated out and placed on multiple smaller circuit boards, each of which can be positioned at different locations within the headset. The smaller circuit boards can be more easily placed within various small internal pockets found in a small compact device. Flexible wires and possibly wireless protocols can be used to operatively couple the electronics and/or discrete circuit boards together. In other words, a first portion of the electronics may be separated from a second portion of the electronics, and further the first portion may be positioned at a first location within the headset while the second portion may be positioned at a second location within the headset. Note that, two portions is not a limitation and the electronics can be divided into any number of smaller discrete portions.

[0093] Along a similar vein, another aspect of the invention relates to electronic assemblies that are partially flexible or bendable such that the assemblies can be folded into a small compact form in order to fit inside tightly spaced internal volumes. By way of example, the electronics that would normally be embodied on a single rigid circuit board may be placed on multiple rigid circuit boards that are interconnected by flexible or bendable circuit board portions that can be bent around various internal shapes and/or folded over itself while still functioning properly.

[0094] Another aspect of the invention relates to

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acoustical paths, ports and volumes that are built through a small compact headset in order to improve acoustical performance of the microphone and/or speaker (with limited impact on the form factor of the headset). In one embodiment, in order to control the flow of air through an earbud, acoustic ports can be integrated into one or more electronic components disposed therein and/or the earbud housing. In another embodiment, at least some of the ports that pass through the various housings are substantially hidden from view thereby enhancing the aesthetic appearance of the headset. For example, the ports may be positioned within a seam between two interfacing external surfaces of the headset. In one example, a first external surface is provided by the open end of a tube of the primary housing and the second external surface is provided by an end member disposed within the open end of the tube of the primary housing. The end member may for example include a connector assembly thereby integrating a connector with a microphone into the same surface area.

[0095] In accordance with one aspect of the invention, the connector assembly can include contacts for the transfer of power and data. The connector can be located on the end of the primary housing opposite a user interface button. The connector can have a symmetrical configuration so that it can be coupled with complementary connectors in more than one interface orientation (e.g., 90 degree symmetry, 180 degree symmetry, etc.). In one embodiment, switching circuitry can be included in order to accommodate this symmetry. Such circuitry can, for example, measure the polarity of data and/or power lines from the complementary connector to determine its interface orientation and route the data and/or power lines based on the determined orientation. In some embodiments, the connector assembly can be at least partially made of a ferromagnetic material, which can serve as an attraction plate for one or more magnets on a complementary connector in another device (e.g., a headset charger).

[0096] In accordance with another aspect of the invention, the headset can include an indicator that is hidden from view when inactive and that is in view when active. This can for example be accomplished with micrometer sized holes, called microperforations, that can be drilled into the wall of primary housing and/or earbud member. Through these holes, light sources on the inside of the primary housing and/or earbud member can create visual indicators for a user. A light diffuser can be used in combination with such microperforations so that the indicator can be illuminated with evenly distributed light.

[0097] Headsets may communicate with the host device via a wired and/or wireless connection. Wired connections may for example occur through a cable/connector arrangement. Wireless connections on the other hand can occur through the air (no physical connection is needed). The wired and wireless protocols may be widely varied. Wired protocols may for example be based on Universal Serial Bus (USB) interfaces, Firewire interfaces, conventional serial interfaces, parallel interfaces, and/or the like. Wireless protocols may, for example, be based on short range transmissions of voice and/or data. The wireless protocols may further be used to create personal area networks between the headset and a nearby host device such as a cellular phone. Some examples of wireless protocols that can be used include Bluetooth, Home RF, iEEE 802.11, IrDA, Wireless USB, and the like. The communication electronics may be embodied as a system on a chip (SOC).

[0098] Although other wireless protocols may be used, according to one aspect of the invention, the headset can include communication electronics based on the Bluetooth wireless protocol. The communication electronics may, for example, include or correspond to a Bluetooth System-on-a-Chip (SoC). The SoC can include circuitry for performing functions other than wireless communications. For example, in some embodiments, circuitry for communicating using wired Universal Serial Bus (USB) interfaces and conventional serial interfaces can be integrated into the SoC.

[0099] For increased functionality, according to one aspect of the invention, the headset can include power distribution circuitry. Such circuitry can operate the headset according to several different modes depending, for example, on the charge level of the battery or the availability of an external power source. In one mode, the power distribution circuitry can supply power to limited parts of the SoC while simultaneously charging the battery. The battery charging process can be further improved by using temperature detection circuitry (e.g., a thermistor) to monitor the battery temperature. This process can extend the battery life by charging it only when the monitored temperature is at, or below, a predetermined threshold. In another mode, the power distribution circuitry can selectively power various electronic components using the battery while other electronic components may be powered by an external power source.

[0100] Aspects and embodiments of the invention are discussed below with reference to FIGS. 1-68. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

[0101] FIG. 1 is a simplified block diagram of headset 10 in accordance with one embodiment of the present invention. Headset 10 can be configured to be a small compact unit in the form of a simple earpiece that can be placed in the ear. The headset can include a primary housing 11 and an earbud 12 that extends from the primary housing. Earbud 12 can fit into an ear thereby placing the primary housing next to a user's face. Each of these members can surround and protect various internal components and can also support thereon various external components associated with operating the headset. The components may be a plurality of electrical components that provide specific functions for the electronic device. For example, the components may generally be

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associated with generating, receiving, and/or transmitting data associated with operating the device.

[0102] Headset 10 includes processor 20 for controlling the headset's functions. In the illustrated embodiment, processor 20 can be provided in earbud 12. In other embodiments, processor 20 can be located anywhere in headset 10. Processor 20 can be electrically coupled to the other components of headset 10 through circuit boards and/or cables. Processor 20 may facilitate wireless communications with a host device. For example, processor 20 can generate signals for wireless transmission and process received wireless signals. In addition to wireless communications, processor 20 may coordinate the operation of the various components of headset 10. For example, processor 20 may control the charging of a battery or the operation of a display system.

[0103] Headset 10 also includes speaker system 13 for distributing audio information from earbud 12. Speaker system 13 can include an audio port at the end of the earbud and a receiver (e.g., a speaker) disposed at the end of the audio port. The audio port may be covered with a grill. Speaker system 13 may also include various ports internal and external to the earbud. For example, speaker system 13 may include acoustical paths inside the earbud and acoustical paths that pass through the surfaces of the earbud.

[0104] Headset 10 also includes one or more input mechanisms for providing inputs to the headset. The input mechanism may be placed at the primary housing and/or the earbud. The input mechanisms may be widely varied and may include for example slide switches, depressible buttons, dials, wheels, navigation pads, touch pads, and/or the like. For simplicity purposes, the headset may only include a single input mechanism. Furthermore, for aesthetical reasons, the input mechanism may be placed at a select location. In other embodiments, two or more input mechanisms may reside on the headset.

[0105] In one embodiment, headset 10 includes single button 14 located at one end of primary housing 11. Placing button 14 at the end preserves the side surfaces of primary housing 11. This can also be accomplished by configuring earbud 12 as a button (e.g., the earbud is depressible relative to the primary housing). Earbud 12 may also be configured to tilt, rotate, bend and/or slide in order to provide inputs while preserving the side surfaces of primary housing 11.

[0106] Headset 10 also includes a communication terminal for communicating with a host device. The communication terminal may be configured for wired or wireless connections. In the illustrated embodiment, the communication terminal is antenna 15 that supports wireless connections. Antenna 15 may be located internal to the primary housing or earbud. If the primary housing or earbud is not formed from a radio transparent material then a radio transparent window may need to be provided. In the illustrated embodiment, antenna 15 is located at one end of the headset. Placing antenna 15 and the accompanying radiotransparent window at the end preserves the side surfaces of primary housing 11. In one embodiment, button 14 and antenna 15 are integrated at the same end.

[0107] Headset 10 may also include one or more connectors 16 for transferring data and/or power to and from the headset. A data connection allows data to be transmitted to and received from a host device. A power connection, on the other hand, allows power to be delivered to the headset. The connectors may for example connect to a corresponding connector in a dock or cable in order to connect to a power source for charging and/or a data source for downloads or uploads. Although the location of the connector can be widely varied, in the illustrated embodiment, connector 16 is located at one of the ends in order to preserve the side surfaces of the primary housing.

[0108] In some embodiments, connector 16 and corresponding connectors may be shaped such that the two connectors can mate in two or more different interface orientations. To compensate for this possibility, headset 10 can include switching circuitry that is coupled to connector 16. Such switching circuitry can determine how connector 16 is coupled with a corresponding connector (e.g., how the connectors are physically orientated). Switching circuitry can determine this by measuring, for example, the polarity of data and/or power lines from the complementary connector. Switching circuitry can then route the data and/or power from the connector to other circuitry in headset 10 appropriately. In some embodiments, at least a portion of connector 16 can be magnetic or magnetically attractive. For example, connector 16 may include a ferromagnetic material that biases it to magnetic connectors. Such magnetic interactions can assist a user in coupling connector 16 with corresponding connectors and help prevent the connectors from uncoupling.

[0109] Headset 10 also includes microphone 17 for capturing speech provided by a user. The microphone is typically located internal to the primary housing. One or more acoustical ports may be configured into the primary housing in order to provide an acoustical path from outside the primary housing to the microphone. The location of the acoustical ports can be widely varied. In one embodiment, the acoustical ports are located at one end of the primary housing in order to preserve the sides of the primary housing. In one embodiment, the connector assembly and acoustical ports are integrated at the same end. Furthermore, the acoustical port may be configured to be substantially hidden from view by selective placement of the ports. For example, the ports may be placed at the seam between the connector assembly and the primary housing.

[0110] Headset 10 also includes display system 18 for providing visual feedback. The display system may be a complex display system comprising an LCD or other related display device capable of displaying graphical information and/or it may be an indicator assembly that only provides simple visual feedback as for example via

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an LED assembly. In one embodiment, the display system only comprises an indicator assembly that provides visual feedback along the side walls of the primary housing. In order to preserve the side walls, however, the indicator assembly may be hidden when inactive. This can be accomplished, for example, through microperforations through the primary housing. The microperforations allow light to pass through, but are so small that they are undetectable to a user.

[0111] Headset 10 also includes battery 19. Battery 19 may provide electrical power to components of headset 10. Charging circuitry may also be provided to charge battery 19 when an external power supply is connected to headset 10.

[0112] Headset 10 can also include support circuitry for the aforementioned components. For example, this may include circuit boards, various electrical components, processors and controllers. The support circuitry can be placed inside the primary housing and/or the earbud. In one embodiment, the support circuitry can be split or divided between the two locations in order to make a more compact device, i.e., the various electronics are distributed among volumes as needed. In order to further save space, the electronics may be stackable. In one embodiment, the electronics are placed on a circuit board with one or more flexible portions so that a stack is created by folding or bending the circuit board.

[0113] Although earbud 12 and primary housing 11 can be integrally formed, in the illustrated embodiment, the primary housing and earbud are separate housing members that are attached together. Any suitable means can be used to attach the two parts together including but not limited to screws, glues, epoxies, clips, brackets, and/or the like.

[0114] The position of the earbud relative to the primary housing may be widely varied. For example, the earbud may be placed at any external surface (e.g., top, side, front, or back) of the primary housing. In one embodiment, the earbud is located on a planar front side near one of the ends of the primary housing. In one embodiment, the earbud may be configured to move relative to the primary housing so that its position can be adjusted.

[0115] Each of the earbud 12 and primary housing 11 can be configured to surround its internal components at a peripheral region thereof so as to cover and protect the internal components. They can also be configured to support components externally if needed. Each of earbud 12 and primary housing 11 help define the shape and form of the headset. That is, their contours embody the outward physical appearance of the headset. Such contours may be rectilinear, curvilinear or both. In one embodiment, earbud 12 is formed as an outwardly extending protruding member while primary housing 11 is formed as a longitudinally extending member. For example, earbud 12 may be coupled to primary housing 11 through a neck, which can be a portion of the primary housing, earbud or a separate piece altogether. The axis of earbud 12 and primary housing 11 can be transverse, and more particularly perpendicular. The shapes of earbud 12 and primary housing 11 may be widely varied. In one embodiment, earbud 12 is formed as a reverse rounded circular conical member and primary housing 11 is configured with a pill shaped cross section. It is understood however that these are not limitations and that the form, shape, and orientation may vary according to the specific needs or design of the headset. By way of example, earbud 12 and primary housing 11 may have various cross-sectional shapes including for example, circular, square, rectangular, triangular, oval, and/or the like. In addition, their form may be such that they do not have a typical straight axis.

[0116] Earbud 12 and primary housing 11 may be formed by one or more members. In one embodiment, primary housing 11 may include an integrally formed member. By integral, it is meant that the member is a single complete unit. By being integrally formed, the member can be structurally stronger than conventional housings, which include two parts that are fastened together. Furthermore, unlike conventional housings that have a seam between the two parts, the member has a substantially seamless appearance. Moreover, the seamless housing can prevent contamination and can be more water resistant than conventional housings. The primary housing may, for example, be formed as a tube that defines a cavity therethrough between a first open end and second open end located opposite the first open end. In order to seal the ends of the tube, the primary housing can additionally include a pair of end caps. Each of the end caps can be configured to cover one of the open ends thereby forming a fully-enclosed housing system. The end caps may be formed from similar or different materials as the tube. Furthermore, the end caps may be attached to the tube using a variety of techniques, including but not limited to, fasteners, glues, clips, brackets, and/or the like. The end caps can also be movably attached, and be configured to carry operational components of the headset.

[0117] It is understood that the inner cross-sectional shape of primary housing 11 may be the same or different from the external cross-sectional shape of the primary housing. For example, it may be desirable to have a pill shaped external and a rectangularly shaped interior, etc. In addition, although not a requirement, the front and back surface of primary housing 11 may be substantially planar.

[0118] In one embodiment, primary housing 11 can be formed via an extrusion or related process. The extrusion process is capable of producing an integral tube without seams, crack, breaks, etc. As is generally well known, extrusion is a shaping process where a continuous work piece is produced by forcing molten or hot material through a shaped orifice, i.e., the extrusion process produces a length of a particular cross-sectional shape. The cross-sectional shape of the work piece is controlled at least in part on the shaped orifice. As the shaped work piece exits the orifice, it is cooled and thereafter cut to a

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desired length. The extrusion process is a continuous high volume process that produces intricate profiles and that accurately controls work piece dimensions (which can be a necessity for smaller parts). Furthermore, because extrusion has low tooling costs, it is relatively inexpensive when compared to other forming or manufacturing processes.

[0119] Primary housing 11 may be formed from a variety of extrudable materials or material combinations including but not limited to metals, metal alloys, plastics, ceramics and/or the like. By way of example, the metals may correspond to aluminum, titanium, steel, copper, etc., the plastic materials may correspond to polycarbonate, ABS, nylon, etc, and the ceramic materials may correspond to alumina, zirconia, etc. Zirconia may, for example, correspond to zirconia oxide.

[0120] FIG. 2 shows headset connector system 200 in accordance with an embodiment of the present invention. System 200 can include headset 210 and headset engaging connector 220. In some embodiments, headset 210 may correspond to headset 10 of FIG. 1. Headset 210 can include any number of headset connector contact regions (see e.g., regions 211, 212 and 213) disposed within face 214 of the headset. Face 214 can mate with headset engaging connector 220 such that a corresponding number of headset engaging contact regions disposed in the headset engaging connector (see e.g., regions 221, 222 and 223) electrically couple with the headset connector contact regions. Moreover, headset 210 can include switching circuitry 215 that is electrically coupled with each of the headset connector contact regions. Switching circuitry 215 can be operative to determine an interface orientation between the headset connector contact regions and headset engaging contact regions. For example, switching circuitry 215 can determine the interface orientation in which headset 210 is mated with headset engaging connector 220. Switching circuitry 215 can determine this by measuring the polarity of data and/or power lines from headset engaging connector 220. After having determined the interface orientation, switching circuitry 215 can route signals received on the headset connector contact regions based on the determined orientation. It is understood that switching circuitry can be provided in connector 220 to provide functionality similar to switching circuitry 215. For example, switching circuitry in connector 220 can determine the interface orientation of headset 210 and route electrical signals to contact regions based on the determined orientation.

[0121] In some embodiments, at least a portion of headset 210 and/or headset engaging connector 220 (e.g., a portion or all of housing 224) can be magnetically attractive. Moreover, headset engaging contact regions (see e.g., regions 221, 222, and 223) may be biased to protrude from housing 224 of connector 220. In such embodiments, headset 210 can be magnetically attracted to headset engaging connector 220 such that the magnetic forces can cause the headset engaging contact regions (see e.g., regions 221, 222, and 223) to press against the headset connector contact regions (see e.g., regions 211, 212, and 213).

[0122] FIG. 3 shows electronic device 300 in accordance with an embodiment of the present invention. In some embodiments, device 300 may be an electronic headset (see e.g., headset 10 of FIG. 1), but it is to be understood that device 300 is not limited to electronic headsets. Device 300 can include housing 310 and connector assembly 320. At least a portion of connector assembly 320 may be disposed in housing 310. Connector assembly 320 may include port 322, microphone 324 and channel 326 that fluidically couples the microphone to the port. Connector assembly 320 may also include one or more contacts (see e.g., contacts 321, 323, 325 and 327) for electrically coupling with another device. Port 322 may be provided in a location such that the contacts of connector assembly 320 are on the same exterior surface as the port or located nearby. In some embodiments, port 322 may be located between two contacts (see e.g., contacts 323 and 325).

[0123] FIG. 4 shows electronic device 400 in accordance with another embodiment of the present invention. Like device 300, device 400 may be an electronic headset in some embodiments (see e.g., headset 10 of FIG. 1) but it is to be understood that device 400 is not limited to electronic headsets. Device 400 can include housing 410 and joint connector and microphone assembly 420. Microphone 430, boot 440 and connector plate 450 may be provided in joint connector and microphone assembly 420. Microphone 430 may include one or more side surfaces and a top surface with microphone port 432. Microphone boot 440 may be mounted to the microphone such that the boot forms a seal with at least a portion of the top surface and the side surfaces. This seal can surround microphone port 432. Microphone boot 440 can further include a portion for sealing to connector plate 450 and an aperture for fluidically connecting microphone port 432 to connector port 452. Connector plate 450 may include one or more contacts (see e.g., contacts 451, 453, 455 and 457) for electrically coupling with another device. Connector port 452 may be provided in a location such that the port is in the same exterior surface as the contacts of connector assembly 420 or located near the contacts. In some embodiments, port 452 may be located between two contacts (see e.g., contacts 453 and 455).

[0124] FIG. 5 shows headset 500 in accordance with an embodiment of the invention. Headset 500 may correspond to an electronic headset (see e.g., headset 10 of FIG. 1) and may include primary housing 510 and earbud 520. Primary housing 510 may correspond to primary housing 11 and earbud 520 may correspond to earbud 12, for example. Earbud flexible circuit board 522 may be provided in earbud 520. Receiver 524 and processing circuitry 526 can be mounted on the earbud flexible circuit board 522. Earbud flexible circuit board 522 may be flexible such that it can fold upon itself or bend. Such flexibility may allow earbud flexible circuit board 522 to fit in smaller

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or less traditionally-shaped earbuds.

[0125] Primary housing 510 may be fixed to earbud 520. Primary housing 510 may include primary housing flexible circuit board 512 and microphone 514. Like earbud flexible circuit board 522, primary housing flexible circuit board 512 may be flexible such that it can fold upon itself or bend. Such flexibility may allow primary housing circuit board 512 to bend around other components in the primary housing (e.g., circuitry, antennas, or batteries) so as to conserve interior space inside the primary housing. For example, conserving interior space may result in more room to accommodate a larger battery. In another example, conserving interior space may result in a smaller primary housing. Earbud flexible circuit board 522 and microphone 514 can be electrically coupled to primary housing flexible circuit board 512. In some embodiments, such as the one shown in FIG. 5, earbud flexible circuit board 522 may extend into primary housing 510 such that it can couple with primary housing flexible circuit board 512. In other embodiments, primary housing flexible circuit board 512 may extend into earbud 520 such that it can couple with earbud flexible circuit board 522. It is to be understood that although primary housing flexible circuit board 512 and earbud flexible circuit board 522 are described as being flexible, one or both circuit boards may include both flexible and rigid portions. For example, each circuit board may include one or more rigid portions upon which electrical components (e.g., receiver 524, processing circuitry 526, or microphone 514) can be easily and stably mounted.

[0126] FIG. 6A shows headset device 600 in accordance with an embodiment of the present invention. Headset device 600 can include earbud housing 610, threaded neck 620, and primary housing 630. Headset device 600 can correspond to headset 10 of FIG. 1 such that, for example, earbud housing 610 corresponds to earbud 12 and primary housing 630 corresponds to primary housing 11. Earbud housing 610 can include earbud through-hole 612 and neck engaging surface 614. Threaded neck 620 can include first neck surface 622 that can mate with the earbud housing's neck engaging surface 614. First neck surface 622 and neck engaging surface 614 may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0127] Primary housing 630 can include primary housing through-hole 632 and neck engaging surface 634. Threaded neck 620 can further include second neck surface 624 that can mate with the primary housing's neck engaging surface. Second neck surface 624 and neck engaging surface 634 may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0128] FIG. 6B shows screw 690 for use with headset device 600 in accordance with the present invention. Screw 690 can be used as both an earbud screw and a primary housing screw. Screw 690 can include hollow channel 692 running through the center of the screw. Screw 690 may also include features 694 (e.g., notches) such that a tool can interface with the features and rotate the screw. As an earbud screw, screw 690 can be inserted into earbud through-hole 612 and tightened such that it fastens neck engaging surface 614 to first neck surface 622. As a primary housing screw,
screw 690 can be inserted into primary housing through-hole 632 and tightened such that it fastens neck engaging surface 634 to second neck surface 624.

[0129] FIG. 7 shows display system 700 in accordance with an embodiment of the present invention. Display system 700 can, for example, correspond to display system 18 of FIG. 1. System 700 can include housing 710, light source 720, diffuser 730 and control circuitry 740. Housing 710 can have signal indicator region 712 disposed therein. Signal indicator region 712 may be, for example, one or more apertures (e.g., microperforations) for transmitting light. Signal indicator region 712 may be configured to output a signal of a certain shape or form. Housing 710 can also include internal wall 714. Diffuser 730 can be located between light source 720 and internal wall 714. Control circuitry 740 may be electrically coupled with light source 720 to control when light source 720 emits light.

[0130] Diffuser 730 may be operable to diffuse light from light source 720 such that all of the light exiting the diffuser has an equal intensity or brightness. For example, diffuser 730 may be operable to evenly illuminate signal indicator region 712 with the light from light source 720. Diffuser 730 may be composed of a mixture of different particles that cause light diffusion. For example, diffuser 730 can include mainly clear particles with translucent particles distributed throughout. The translucent particles can cause light to be deflected from its original course so that the light is distributed throughout the diffuser. Accordingly, light exiting from any portion of the diffuser will have substantially even illumination.

[0131] FIG. 8 shows power distribution system 800 in accordance with an embodiment of the present invention. Power distribution system 800 can be employed in an electronic device (see e.g., headset 10 of FIG. 1) and can include switch 810, bus 820, first power regulating circuitry 822, core processing circuitry 824, battery 830, second power regulating circuitry 832, RF processing circuitry 834, and control circuitry 840. Core processing circuitry 824 may include circuitry for handling low-level, core functions of the electronic device, and RF processing circuitry 834 may include circuitry for handling RF communications for the electronic device. To power core processing circuitry 824 and RF processing circuitry 834, power distribution system 800 can include both bus 820 and battery 830 as potential power sources.

[0132] Bus 820 can be coupled to receive power from a source external to the system. For example, bus 820 may be coupled to a connector such that the bus can receive power through the connector. First power regulating circuitry 822 may be electrically coupled to bus 820

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and core processing circuitry 824. First power regulating circuitry 822 may be operable to, for example, convert power from bus 820 into a condition suitable for core processing circuitry 824 (e.g., by changing the voltage or regulating the current flow).

[0133] Battery 830 can be a device that stores chemical energy and makes it available in an electrical form. Battery 830 may be rechargeable. Second power regulating circuitry 832 may be electrically coupled to battery 830 and RF processing circuitry 834. Second power regulating circuitry 832 may be operable to, for example, convert power from bus 820 into a condition suitable for core processing circuitry 824 (e.g., by changing the voltage or regulating the current flow).

[0134] Switch 810 may be electrically coupled to both core processing circuitry 824 and RF processing circuitry 834. Switch 810 may be controlled by the presence of an external power source on bus 820. For example, switch 810 may be activated when the voltage of bus 820 goes below a predetermined threshold. When switch 810 is activated, first power regulating circuitry 822, core processing circuitry 824, RF processing circuitry 834, and second power regulating circuitry 832 may be electrically coupled such that both core processing circuitry and RF processing circuitry can share power.

[0135] Control circuitry 840 can be electrically coupled to bus 820, first power regulating circuitry 822, core processing circuitry 824, and second power regulating circuitry 832. Control circuitry 840 may be able to selectively active first power regulating circuitry 822 and second power regulating circuitry 832 based on bus 820, core processing circuitry 824, and/or any other signals in the electronic device.

[0136] FIG. 9 shows wireless headset 900 in accordance with an embodiment of the present invention. Headset 900 can be an electronic headset for communications (see e.g., headset 10 of FIG. 1). Headset 900 can include processor circuitry 910 that has a first power consumption portion 912 and a second power consumption portion 914. First power consumption portion 912 can, for example, include the core circuitry of an electronic device (e.g., boot-up circuitry), while second power consumption portion 914 can include the device's auxiliary circuitry (e.g., circuitry for RF communications). Headset 900 can further include power distribution circuitry 920. Power distribution circuitry 920 can selectively power first power consumption portion 912 independent of whether second power consumption portion 914 is powered. In some embodiments, power distribution circuitry 920 can selectively power any combination of first power consumption portion 912 and second power consumption portion 914 based on one or more monitored conditions of headset 900. For example, power distribution circuitry 920 can monitor if an external power source is present and/or the charge level of an internal battery in order to determine which power consumption portions to activate.

[0137] FIGS. 10A and 10B show perspective views of an illustrative headset in accordance with an embodiment of the present invention. Headset 1000 can correspond to headset 10 of FIG. 1. For example, primary housing 1010 can correspond to primary housing 11 and earbud 1020 can correspond to earbud 12.

[0138] Headset 1000 can include a housing that encloses the electronic and other elements of the headset. The housing can incorporate several pieces that are assembled using any suitable process (e.g., adhesive, screws, or press fit). In the example of FIGS. 10A and 10B, headset 1000 can include earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040. Earbud 1020 can include perforations (e.g., acoustic ports) 1021 and 1022 for allowing air to pass into and out of the earbud 1020. Front port 1021 can allow sound waves from a receiver located in earbud 1020 to reach a user's ear and/or the outside environment. Side ports 1022 can provide a path for acoustic pressure to vent to the outside environment. Earbud 1020 can be attached to primary housing 1010 by neck 1030.

[0139] Attached to one end of primary housing 1010 is antenna cap 1011. Antenna cap 1011 can have button 1012 disposed at least partially therethrough. A user can interface with button 1012 to control the headset. Primary housing 1010 can include display 1013 which can correspond to display system 700 of FIG. 7 or display system 18 of FIG. 1. In some embodiments, display 1013 may include microperforations such as those discussed in more detail below in connection with FIGS. 48 and 49. Located at the connector end of primary housing 1010, connector 1040 includes at least one port (not shown in FIG. 10A) for enabling a microphone inside housing 1010 to receive acoustic signals (e.g., a user's voice), and at least one contact 1042 for receiving power, data, or both from an external source. Connector 1040 may correspond to contact regions 211, 212, and 213 of FIG. 2, for example.

[0140] Earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be constructed from any suitable material including, for example, metal, plastic, silicone, rubber, foam, or combinations thereof. For example, earbud 1020 can be formed from a plastic element surrounded by a silicone seal and primary housing 1010 can be formed from aluminum. Earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be manufactured using any suitable process (e.g., molding, casting or extrusion). In some embodiments, earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be post processed to provide texture and other features on the inner or outer surfaces of the bodies. For example, a bead blast and anodization process can be used to apply a desired surface texture to primary housing 1010.

[0141] FIG. 11 is an exploded view of headset 1100 in accordance with an embodiment of the present invention. Headset 1100 can correspond to headset 10 of FIG. 1 or headset 1000 of FIGS. 10A and 10B, for example. In one embodiment of the present invention, earbud hous-

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ing 1120 can contain earbud circuit board 1122. Earbud circuit board 1122 can, for example, correspond to earbud circuit board 522 of FIG. 5. Earbud circuit board 1122 can be a flexible circuit board on which one or more of the following components are electrically and/or mechanically mounted: processor 1123 (which can be used to control the functions of headset 1100), receiver 1124, and other circuitry and components. The flexible nature of earbud circuit board 1122 can enable it to be folded onto itself, providing layers of circuitry that can be packed into earbud housing 1120, thereby occupying space within earbud housing 1120 that may otherwise be empty and unused. The flexible portions of earbud circuit board 1122 can replace the need for separate wires connecting different circuit boards, which might cause a substantial increase in size because, for example, each wire might involve a pair of connectors. Additionally, the flexible nature of circuit board 1122 can advantageously reduce the area or footprint required by circuit board 1122. That is, compared to another circuit board having similar circuitry and components disposed thereon but in an unfolded layout, circuit board 1122 can occupy less area. In addition, circuit board 1122 further can reduce the footprint or size requirements of other components of headset 1100, such as primary housing 1110 and antenna cap 1111, by incorporating within earbud housing 1120 electronics and other components that traditionally are located elsewhere within a headset. Earbud housing 1120 and the circuitry and components contained therein are discussed in more detail below in connection with FIGS. 18-27B, for example.

[0142] Earbud housing 1120 can be coupled to primary housing 1110 by neck 1130. Earbud housing 1120, primary housing 1110, and neck 1130 can correspond, respectively, to earbud housing 610, primary housing 630, and neck 620 of FIG. 6A. Neck 1130 can be constructed with a double threaded screw insert to receive screw member 1131 (associated with earbud housing 1120) and screw member 1132 (associated with primary housing 1110). Neck 1130 can connect earbud housing 1120 and primary housing 1110 in a manner that can reduce the likelihood of earbud housing 1120 and primary housing 1110 rotating independently of each other. That is, when headset 1100 is in use and the user adjusts its position by, for example, pulling primary housing 1110 down, the earbud housing 1120 can rotate in conjunction with primary housing 1110. However, in some embodiments, pulling primary housing 1110 down may cause the housing to rotate with respect to earbud housing 1120 so as to trigger a switch and signify a user input. A more detailed discussion of headset necks and their assembly can be found below in connection with FIGS. 28-30, for example.

[0143] In addition to earbud circuit board 1122, headset 1100 also can include primary housing circuit board 1115 on which additional electronic components 1113 can be electrically and/or mechanically mounted. Primary housing circuit board 1115 may, for example, correspond to primary housing circuit 512 of FIG. 5. Primary housing circuit board 1115 can be electrically coupled with the earbud circuit board by one or more wires, cables, flexible circuit boards, and the like. The arrangement of electronic components in both earbud circuit board 1122 and primary housing circuit board 1115 can advantageously reduce the size of headset 1100. The arrangement of the electronic components in headset 1100 will be discussed in more detail below in connection with FIGS. 18-20C, for example.

[0144] A user can control the functions of headset 1100 using button 1112, which can be electrically coupled with primary housing circuit board 1115. Button 1112 can extend from antenna cap 1111 such that it appears as a discrete user interface easily activated by a user. Button 1112 can be configured to move in any suitable manner including, for example, bending with respect to primary housing 1110, translating in and out of antenna cap 1111, rotating around an axis passing through connector plate 1141 and button 1112, or any combination thereof.

[0145] In one embodiment, button 1112 can include a switch such as a dome switch, which can be activated when a user depresses button 1112. Button 1112 can have a button guide structure. The button guide structure can have one or more guide channels to facilitate user actuation of the button with respect to the rest of headset 1100. In one embodiment of the present invention, the guide channel(s) can be provided in the form of a hole through the button guide structure. The switch actuation member can have a stem that is supported and guided by the guide channel. When pressed by a user, the switch actuation member moves along the guide channel towards the switch. Raised structures (e.g., ribs) can be used to ensure that the switch actuation member reciprocates smoothly within the guide channel.

[0146] Button 1112 and antenna cap 1111 can be constructed from a dielectric material such as plastic. Antenna 1118 can be formed by mounting an antenna resonating element within antenna cap 1111 (e.g., along an inner surface of antenna cap 1111) or on a portion of the button guide structure. Constructing button 1112 and antenna cap 1111 from a dielectric material can reduce or eliminate potential signal interference that can disrupt the proper operation of antenna 1118. In addition, a dielectric button 1112 can allow for smaller clearance between the antenna resonating element and conductive structures (e.g., primary housing circuit board 1115) in headset 1100.

[0147] Antenna 1118 can be electrically coupled with primary housing circuit board 1115 so that it can send and receive wireless (e.g., radio) signals. Antenna 1118 can include any suitable antenna resonating element for communicating between headset 1100 and an electronic device (e.g., a cellular telephone or a personal media device) . The antenna resonating element can be formed from a flex circuit containing a strip of conductor. The flex circuit can be attached to the button guide structure using, e.g., adhesive. For example, the flex circuit can contain

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registration holes that mate with corresponding registration bosses on the button guide structure. One or more of the bosses can be heat staked to the flex circuit.

[0148] Details about the operation and design of an antenna and button system similar to antenna 1118 and button 1112 can be found, e.g., in U.S. Patent Publication No. US 2008/166004 A1 entitled "Antenna and Button Assembly for Wireless Devices".

[0149] Appendages 1117 can be incorporated into antenna cap 1111 in order to mount the antenna cap to headset 1100. Appendages 1117 can, for example, fasten to primary housing 1110 or one or more brackets 1116 which will be discussed in more detail below.

[0150] Battery pack 1119 can be located within primary housing 1110. Battery pack 1119 can contain one or more suitable batteries including, for example, lithium ion, lithium ion polymer (Li-Poly), nickel metal hydride, or any other type of battery. Battery pack 1119 can be electrically coupled with circuit board 1115 for powering electronic components in headset 1100. Additionally, circuitry that is typically packaged within standard battery packs (e.g., charging or fuse protection circuitry) can be moved to primary housing circuit board 1115. Advantageously, the distribution of circuitry into earbud housing 1120 and the layout of circuit board 1115 can permit battery pack 1119 to occupy a substantial portion of the internal space of primary housing 1110. This can increase the energy storage capacity of headset 1100 (e.g., allow headset 1100 to operate for longer period of time in between charges) without increasing the size of primary housing 1110 and headset 1100.

[0151] Headset 1100 can include connector 1140 for enabling headset 1100 to electrically connect to other devices. An opening or port can be included in connector 1140 so that acoustic signals (e.g., speech from a user) can reach the microphone inside microphone boot 1144. Connector 1140 can, for example, correspond to assembly 320 of FIG 3 or assembly 420 of FIG. 4, for example. The microphone can be electrically coupled with circuit board 1115 in any suitable manner. Microphone boot 1144 can be placed inside the end of primary housing 1110 that is farthest from earbud housing 1120. This end may be referred to herein as the microphone or connector end of headset 1100, and is also the portion of headset 1100 that is closest to the user's mouth when in use. The arrangement of the microphone boot 1144 with respect to connector 1140 and accompanying parts is discussed in more detail below in connection with the description accompanying FIGS. 50A-54.

[0152] Connector 1140 can include connector plate 1141 in which contacts 1142 and accompanying casing 1143 can reside. As such, contacts 1142 can facilitate the electrical coupling of headset 1100 with another device. Accompanying casing 1143 can be made from a non-conductive material (e.g., a polymeric material). Casing 1143 can surround contacts 1142 to prevent the contacts from electrically coupling with connector plate 1141. Contacts 1142 and casing 1143 can be substantially flush with the surface of connector plate 1141 so that the combination of the contacts, casing and plate creates a substantially flat surface for mating with other connectors. Connector plate 1141 can be made of a ferromagnetic material so that it is biased to magnetic connectors, such as those discussed in connection with FIGS. 62A-67B, for example. The design of connector plate 1141, contacts 1142, casing 1143 and complementary magnetic connectors will be described in more detail below in connection with the discussion of FIGS. 55A-67B.

[0153] Headset 1100 can include one or more brackets 1116 to couple connector 1140 with appendages 1117 of antenna cap 1111. Brackets 1116 can prevent connector plate 1141 and antenna cap 1111 from moving axially away from each other or separating from primary housing 1110. Alternatively, connector plate 1141 and antenna cap 1111 can be coupled to one or more brackets that are secured to the inner surface of primary housing 1110.

[0154] As a matter of design choice, a seam can be included in between the peripheral surface of connector plate 1141 and the inner surface of primary housing 1110. That is, in addition to the predefined port for providing an acoustic pathway between the microphone and the outside environment, gaps can exist. These gaps can advantageously enable the microphone to receive acoustic signals in the event the predefined acoustic pathway is blocked (e.g., by a foreign object such as dirt). In other embodiments, an adhesive may be applied to provide a substantially airtight seal between connector plate 1141 and primary housing 1110. In yet another embodiment, a gasket may be used to provide a seal.

[0155] FIG. 12 shows a view of headset 1200 in accordance with another embodiment of the present invention. Headset 1200 can be similar to headset 1100, but with some substantial differences between the two. For example, headset 1200 can use a different attachment technique to couple connector 1240 to primary housing 1210. Connector 1240 can include tabs 1242 which can be used to couple with features (e.g., wall 1212) on an interior surface of primary housing 1210. Such a method might be advantageous to using the brackets 1116 in headset 1100. For example, the tabs 1242 can attach to the near end of primary housing 1210 which might provide connector 1240 with higher structural integrity than, for example, the method of using brackets to attach to a structure (e.g., antenna cap) on the other end of the primary housing. Headset 1200 can also include light diffuser 1244 which can be used in conjunction with a visual indicator system as discussed in connection with FIGS. 48 and 49. Additionally, headset 1200 can include antenna 1218 which can wrap around button guide 1217 in some embodiments.

[0156] The fundamental basics of the Bluetooth protocol are well known in the art, and discussed briefly below. For a more detailed discussion, please see Bluetooth Specification Version 2.0+EDR, Vol. 0, November 4,

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2004. Bluetooth wireless technology is based on an international, open standard for allowing intelligent devices to communicate with each other through wireless, low power, short-range communications. This technology allows any sort of electronic equipment, from computers and cell phones to keyboards and headphones, to make its own connections, without wires or any direct action from a user. Bluetooth is incorporated into numerous commercial products including laptop computers, PDAs, cell phones and printers, and is likely to be used in future products.

[0157] Bluetooth can be referred to as a frequency hopping spread spectrum (FHSS) radio system that operates in the 2.4 GHz unlicensed band. Bluetooth transmissions change frequencies based on a sequence which is known to both the transmitter and the receiver. According to one known standard, Bluetooth transmissions use 79 different frequencies ranging from 2.404 GHz to 2.480 GHz. Bluetooth's low power transmissions allow a typical range of about 10 meters or roughly 30-40 feet. This range can vary from about 1 meter to 100 meters depending on the amount of power used by the device for Bluetooth transmissions.

[0158] Bluetooth devices connect to each other to form networks known as piconets. A piconet includes two or more devices which are synchronized to a common clock signal and hopping sequence. Thus, for any device to connect to a given piconet, that device may need to have the same clock signal and hopping sequence. The synchronized clock and hopping sequence can be derived using the clock signal of one of the devices on the piconet. This device is often referred to as the "master" device while all other devices on the piconet are referred to as "slave" devices. Each piconet can include one master device and up to seven or more slave devices. Moreover, Bluetooth devices can belong to more than one piconet. The term "scatternet" is used to define Bluetooth networks which are made up of multiple, overlapping piconets. In the case where one Bluetooth device is on two or more piconets, all of the devices are on a single scatternet. Devices from one of the piconets can communicate with devices from another piconet by using the shared device to relay the signals.

[0159] When two Bluetooth devices initially connect, they first share some general information (e.g., device name, device type) with each other. In order to enhance the connection, the devices can establish a trusted relationship by using a secret passkey. This passkey is typically provided by a user or stored on memory in a device. According to a known Bluetooth standard, the process of establishing this trusted relationship is called pairing. Once two devices are paired, they typically share information and accept instructions from one another.

[0160] Bluetooth devices can operate with a maximum data throughput of approximately 2.1 Mbit/s (Megabits-per-second), but it is understood that such limitations change as technology advances, and that embodiments of the present invention may operate at other rates. This maximum throughput is shared among all devices on a piconet, meaning that if more than one slave device is communicating with the master, the sum of all communications is less than the maximum data throughput.

[0161] The Bluetooth standard includes a published software framework. The shared framework is called the Bluetooth Protocol Stack and includes different software applications to implement Bluetooth communications. FIG. 13 is a simplified schematic diagram of an exemplary Bluetooth Protocol Stack 1300 in accordance with an embodiment of the present invention. Low-level software is included in Lower Stack 1302. This section includes code to generate/receive radio signals, correct transmission errors and encrypt/decrypt transmissions, among other things. The Host Controller Interface (HCI) 1304 is a standardized interface between the low-level Bluetooth functions and applications. The HCI layer represents a division between the Lower Stack 1302 functions handled by a dedicated Bluetooth processor and the rest of the functions handled by an application-specific processor.

[0162] The Extended Synchronous Connection-Oriented (eSCO) 1306 layer is used to implement dedicated communication channels, commonly used for voice data, in between the Lower Stack 1302 and high-level applications. The Logical Link Control and Adaptation Protocol (L2CAP) 1308 layer combines and repackages the data transmitted and received by the multiple higher-level applications. The L2CAP 1308 layer combines all of these different communications into one data stream that can interface with Lower Stack 1302 The RFCOMM 1310 layer emulates the protocol used by serial connections. This allows software designers to easily integrate Bluetooth into existing applications which previously used a serial connection. The Service Discovery Protocol (SDP) 1312 layer is used by devices to provide information about what services (or functions) each device offers and how other devices can access those services through Bluetooth.

[0163] The Profiles 1314 layer allows a device to identify itself as a member of a generic group of devices with a predefined set of functions. For example, a device complying with the headset profile may support predefined methods relating to audio communications. The Application Layer 1316 contains programs that implement the useful tools created by all of the other layers. By writing different programs for Application Layer 1316, software developers can focus on new uses of the Bluetooth functionality without having to rewrite the code which controls the underlying communication tasks.

[0164] FIG. 14 shows a simplified block diagram of exemplary electronic system 1400 of a headset in accordance with an embodiment of the present invention. The system of 1400 can be implemented in, for example, headset 10 of FIG. 1 or headset 1000 of FIGS. 10A and 10B. System 1400 can include processor circuitry 1410, interface circuitry 1420, power distribution circuitry 1430, switching circuitry 1440 and 4 -pin symmetrical magnetic

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connector 1455.

[0165] Processor circuitry 1410 can include processor 1411 and auxiliary circuitry that operates in connection with processor 1411. Processor 1411 can coordinate all of the operations in system 1400, including, for example, Bluetooth transmissions, battery charging and processing (e.g., encoding and decoding) of acoustic signals. Processor 1411 can drive receiver 1412 to provide acoustic signals that may be heard by a user. Reset circuit 1413 can detect when system 1400 is connected to another device and subsequently instruct processor 1411 to reset. Power FET 1414 can be used with the power supply circuitry inside processor 1411 and will be discussed in more detail below in connection with the discussion of FIG. 15. Antenna 1415 can be used to send wireless signals to and receive wireless signals from another device (e.g., a phone or portable media device) . UART multiplexer 1416 can be electrically coupled with processor 1411 and can route data signals to different parts of processor 1411. This routing can reduce unwanted effects, such as inductance, in unused data lines

[0166] Interface circuitry 1420 can include a microphone isolation LDO 1421, a micro-electromechanical (MEMs) microphone 1422, LED driver 1424 and switch 1423. Microphone isolation LDO 1421 can be electrically coupled with MEMs microphone 1422. Microphone isolation techniques and MEMs microphones are well known. LED driver 1424 can be configured to drive a LED display unit based on one or more outputs of processor 1411. Details about the design and function of circuitry similar to LED driver 1424 can be found in WO 2008/085928 A1 entitled "Systems and Methods for Compact Multi-State Switch Networks". Switch 1423 can represent the electrical behavior of button 1012 of FIG. 10B. A user can interface with this switch to input commands to the headset. For example, a user can depress switch 1423 to initiate a telephone call, terminate a call, or both. In one embodiment, switch 1423 can be a single-pole, single-throw switch with a spring to bias it to an open position.

[0167] Power distribution circuitry 1430 can include overvoltage protection and fuse 1431, battery protection circuitry 1432 and thermistor 1433. Over-voltage protection and fuse 1431 can protect system 1400 in the event that an unsafe amount of voltage is applied to one or more inputs. The fuse in the protection circuitry can be an over-current protection device which disconnects the inputs of the headset if an over-current condition is detected. Battery protection circuitry 1432 can include circuitry to prevent the malfunction of a battery (e.g., a li-poly battery) which could result in a dangerous overheating situation. Battery protection circuitry 1432, in contrast to conventional headsets which has such circuitry integrated into the battery pack, can be separated from the battery pack and located elsewhere within a headset according to the invention. Thermistor 1433 can be located in the proximity of a battery (see e.g., battery pack 1119 of FIG. 11) and may change its resistance based on the battery's temperature. One or more inputs of processor 1411 can be electrically coupled with thermistor 1433 to monitor the temperature of the battery. Processor 1411 can be programmed to charge the battery differently depending on the detected battery temperature. For example, processor 1411 may charge the battery at a faster rate when the monitored battery temperature is low than when the temperature is high. By regulating the charging in this manner, the time required to completely charge a battery can be decreased without damaging the battery.

[0168] Symmetrical magnetic connector 1455 can allow system 1400 to connect to other devices and systems for communicating data or transmitting power. Connector 1455 represents the electrical behavior of connector 16 of FIG. 1, for example.

[0169] Switching circuitry 1440 can enable connector 1455 to connect and communicate with many different types of devices and in many interface orientations. Switching circuitry 1440 can, for example, correspond to switching circuitry 215 of FIG. 2. Switching circuitry 1440 can include power polarity switch circuit 1441 and data polarity switch circuit 1442. The two circuits can, for example, determine the type of communication interface being used and route the corresponding data and/or power lines to the correct pathways (e.g. internal electrical traces) for the detected interface. The two circuits can also determine the interface orientation of a connection with another device, for example, and route the corresponding data and/or power lines to the correct pathways (e.g., internal electrical traces) for the detected orientation. A detailed description of the design and function of exemplary circuits similar to switch circuits 1441 and 1442 can be found in U.S. Patent Publication No. US 2008/0167828 A1 entitled "Systems and Methods for Determining the Configuration of Electronic Connections".

[0170] FIG. 15 shows processor 1500 which can be used as the core processor or application processor of a headset in accordance with an embodiment of the present invention. Processor 1500 can, for example, correspond to processor 20 of FIG. 1. Processor 1500 can also be referred to as a System on a Chip (SoC) because it can be a single integrated circuit capable of a diverse range of functions. Processor 1500 can be a CSR BC04 Audio Processor with integrated Flash Memory that fully supports the Bluetooth V2.0+EDR specification. An oscillator 1510 and clock generation circuitry 1511 can be used in conjunction with a timing crystal to establish a timing signal (or clock) which processor 1500 can use to coordinate its activities. RF circuitry 1520 can be used to input and output RF signals for wireless communications. Baseband circuitry 1530 can coordinate communications so that they conform with the a communications protocol (e.g., a Bluetooth protocol) . Flash memory 1531 can store, for example, software and configuration information for processor 1500. Random access memory (RAM) 1532 can temporarily store data for Baseband circuitry 1530 and microprocessor 1533. RISC microprocessor 1533 can be programmed to perform various func-

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tions, such as monitoring a thermistor (see e.g., thermistor 1433 of FIG. 14) and coordinating battery charging as previously described, for example.

[0171] Full speed USB controller 1540 and UART circuitry 1541 can facilitate wired communication interfaces so that processor 1500 can share data with another device through a physical interface (e.g., connector contacts 1042 of FIG. 10A) . In one embodiment, processor 1500 can support both full speed USB and simplified RS-232 serial interfaces. A simplified RS-232 interface can include, for example, three lines: transmit data, receive data, and ground. In order to accommodate more than one interface over a limited number of data lines, USB controller 1540 and UART circuitry 1541 can be coupled to a switch (e.g., UART Multiplexer 1416 of FIG. 14) . This switch can route data lines to the circuitry, within processor 1500, that corresponds to the communication interface being used. A more detailed discussion of similar systems and methods for using more than one communications interface over a limited number of data lines can be found in U.S. Patent Publication No. US 2008/0167828 A1 entitled "Systems and Methods for Determining the Configuration of Electronic Connections". Processor 1500 can also support other interfaces in addition to those discussed above. For example, processor 1500 can include circuitry for supporting a proprietary communications interface.

[0172] Processor 1500 can include differential microphone input amplifier 1551 and differential speaker output amplifier 1552. Both the input amplifier 1551 and the output amplifier 1552 can be electrically coupled with Audio CODEC 1550 to process (e.g., encode and decode) audio signals. Power control and regulation circuitry 1560 can include low-dropout regulator (LDO) 1561, battery charger 1562 and switch mode power supply (SMPS) 1563. The power needed for the various subsystems of processor 1500 can be regulated by LDO 1561 or SMPS 1563 depending on both the charge level of the battery and any external power sources that might be connected. This will be described in more detail below in connection with the discussion of FIG. 16. Battery charger 1562 can output a controllable current between 25 and 100 milliamps to charge a battery (see e.g., battery pack 1119 of FIG. 11) . In accordance with an embodiment of the present invention, this controllable current can vary based on various factors (e.g., the detected temperature of the battery)

[0173] Programmable I/O 1570 can include LED driver 1571 and analog-to-digital converter (ADC) 1572. LED driver 1571 can use signals from other circuitry in processor 1500 to generate signals with sufficient current to illuminate one or more indicator LEDs. The design and operation of exemplary circuitry similar to LED driver 1571 can be found in WO 2008/085928 A1 entitled "Systems and Methods for Compact Multi-State Switch Networks". Analog-to-Digital Converter (ADC) 1572 can accept inputs from analog circuitry and convert them to digital signals to be used by other circuitry in processor 1500. For example, ADC 1572 can monitor the current running through a thermistor (see e.g., thermistor 1433 of FIG. 14) to determine the temperature of a battery. Circuitry in processor 1500 can use this temperature information to determine an appropriate charging current for battery charger 1562 to provide. Moreover, it is understood that ADC 1572 can process multiple analog signals concurrently. For example, in addition to the temperature information above, ADC 1572 can also process voltage information about the current charge level of a headset's battery.

[0174] While the processor described above and shown in FIG. 15 is a CSR BC04 Audio Processor, other processors with other configurations and functionality can be used in a headset.

[0175] FIG. 16 shows a simplified schematic of power distribution system 1600 for the subsystems of processor 1605 in accordance with an embodiment of the present invention. System 1600 can, for example, correspond to system 800 of FIG. 8 and headset 900 of FIG. 8. Moreover, processor 1605 can correspond to processor 1500 of FIG. 15. Processor 1605 can include both low-dropout regulator (LDO) 1620 and switch mode power supply (SMPS) 1625 as options for regulating power for processor 1605. SMPS 1625 can output power with a higher efficiency than LDO 1620, but can require the installation of several additional components, such as a relatively large capacitor and inductor, which can increase the cost (and size) of system 1600. In addition, SMPS 1625 may require an input voltage that meets, or exceeds, a predetermined voltage level to operate. Therefore, it may be a matter of design choice as to which power supply is used. For example, in low voltage applications, it may be advantageous to use LDO 1620. In other embodiments, such as the one shown in FIG. 16, LDO 1620 and SMPS 1625 can both be used to provide functionality over a wide range of input voltages and high power efficiency.

[0176] FIG. 16 shows processor 1605 which includes core circuitry 1610 and radio circuitry 1615 in accordance with an embodiment of the present invention. Radio circuitry 1615 can include, for example, circuitry related to RF communications. Additional functions (e.g., low-level system functions, firmware updates) can be executed by core circuitry 1610. Additionally, core circuitry 1610 can monitor and control other circuitry in system 1600 using, for example, input line 1614 and output lines 1611, 1612 and 1613.

[0177] Power distribution system 1600 can include circuitry for interfacing with two power sources. In FIG. 16, an internal battery is represented by BAT 1655, and an external power supply is represented as BUS 1650. From herein, the voltage of BAT 1655 will be referred to as VBAT. BUS 1650 can, for example, represent the power provided by a battery charger that is connected to system 1600. BUS 1650 can be electrically coupled with LDO 1620 such that the LDO draws power from an external source through BUS. Therefore, LDO 1620 operates when an external power supply is connected to system

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1600. Similarly, SMPS 1625 can be electrically coupled with BAT 1655 so that it draws power from the battery.

[0178] Other circuitry in power distribution system 1600 can include Power FET 1640, Analog-to-Digital Converter (ADC) 1630 and logic gates 1661, 1631 and 1632. Button 1660 can represent, for example, a signal from an on/off switch or other circuitry that can signal processor 1605.

[0179] An illustrative operation of system 1600, in which BAT 1655 is the only source of power, is now discussed. An absence of power on BUS 1650 prevents LDO 1620 from supplying power and causes FET 1640 to turn on, thereby effectively coupling nodes 1641 and 1642. System 1600 may be turned on when button 1660 is activated and outputs a high voltage. Activation of button 1660 can cause the button input of gate 1661 to go HIGH, which can cause the output of the gate 1661 to go HIGH. This HIGH signal can cause gate 1632 to assert a HIGH signal on its output. When gate 1632 outputs a high voltage, SMPS 1625 is activated and can begin providing power, if VBAT is at or above the predetermined voltage level (e.g., BAT 1655 has sufficient power to run SMPS 1625). Because power FET 1640 is on, the power provided by SMPS 1625 can be transmitted to radio circuitry 1615 and core circuitry 1610. As core circuitry 1610 begins to boot up, it can output a HIGH signal on line 1613 so that gate 1632 continues to output a HIGH signal after button 1660 is released. System 1600 can operate with full functionality at this point because both core circuitry 1610 and radio circuitry 1615 are receiving power. However, when VBAT drops below the predetermined voltage level (e.g., BAT 1655 is dead), SMPS may no longer be able to produce reliable power and system 1600 may begin to shut down.

[0180] An illustrative operation of system 1600 receiving power from an external power source on BUS 1650 is now discussed. The power on BUS 1650 can provide supply power to LDO 1620 and cause power FET 1640 to turn OFF or remain turned OFF, effectively decoupling nodes 1641 and 1642. Additionally, the power on BUS 1650 can cause gates 1661, 1631 and 1632 to output HIGH signals. When gate 1631 generates a HIGH signal, LDO 1620 can begin supplying power. Power from LDO 1620 may be provided to core circuitry 1610, but not to radio circuitry 1615, because power FET 1640 is not conducting. When core circuitry 1610 receives power, it can output a HIGH signal on line 1611 which causes the output of gate 1631 to maintain a HIGH signal so that LDO 1620 can continue operating.

[0181] SMPS 1625 may not be able to operate until VBAT has risen to or above the predetermined voltage level. Core circuitry 1610 can instruct battery charging circuitry (not shown) to begin using power from BUS 1650 to charge BAT 1655. Core circuitry 1610 can receive signals (e.g., digital signals) from ADC 1630 over line 1614. ADC 1630 can be electrically coupled with BAT 1655. ADC 1630 can convert a signal with a varying voltage (e.g., VBAT) into a digital signal that can be processed by core circuitry 1610. When VBAT has met or exceeded the predetermined voltage level, SMPS 1625 may now be able to operate and provide radio circuitry 1615 with power. Note that in some embodiments, SMPS 1625 may be powered ON substantially immediately when an external power service is connected to BUS 1650. Using ADC 1630, core circuitry 1610 can detect when SMPS turns on and coordinate the functions of processor 1605 accordingly. For example, when radio circuitry 1615 is powered, core circuitry 1610 can begin sending communications data to radio circuitry 1615. In this manner, processor 1605 can operate with full functionality before BAT 1655 is fully charged.

[0182] While BAT 1655 is charging, core circuitry 1610 can perform various other functions, regardless of whether VBAT has met or exceeded the predetermined voltage level. For example, core circuitry 1610 can run boot up processes, communicate over wired interfaces and run user interfaces. In this manner, core circuitry 1610 can, for example, handle auxiliary processes (e.g., downloading firmware updates via a wired interface and installing the updates) before processor 1605 has full functionality.

[0183] Several benefits may be realized by power distribution system 1600 in the manner discussed above. For example, the core circuitry 1610 can turn ON before the battery has reached a minimum charge threshold. This enables core circuitry 1610 to handle boot up processes in advance, thereby enabling headset to begin working immediately once the battery is charged to the minimum level. In effect, certain components may be powered independent of BAT 1655 when an external power supply is connected to BUS 1650.

[0184] Additionally, system 1600 limits the unnecessary use of BAT 1655. Traditionally, known headset circuitry is powered through a battery even if an external power supply is present. The power drained from the battery is then recharged using power from the external power supply. This charging and recharging can shorten a battery's lifespan. System 1600 allows core circuitry 1610 to draw power independent of BAT 1655 and directly from an external supply (if present), extending the life of BAT 1655.

[0185] To provide additional functionality, output line 1612 can be included in core circuitry 1610 so that the core circuitry can shut down system 1600. Line 1612 can be coupled with node 1633 such that line 1612 can drive node 1633 to a LOW signal. Therefore, if core circuitry outputs LOW signals to lines 1611, 1612 and 1613, the output of gates 1631 and 1632 go LOW, turning off both LDO 1620 and SMPS 1625, which causes core circuitry 1610 and radio circuitry 1615 to turn off.

[0186] While the previous discussion described a method and system for separately powering on core and RF radio circuitries, the same techniques can be applied to other electronic subsystems which, for example, might be unrelated to RF communications.

[0187] FIGS. 17A-17C show different views of known headset circuit boards, with particular emphasis on how

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circuitry and components are distributed therein. Electrical components 1796, including processor 1792, may be mounted on two sides of circuit board 1790. As can be appreciated by one of skill in the art, circuit board 1790 may occupy a relatively large, undistributed area. Such circuit boards can limit the amount that other components (e.g., batteries, buttons, antennas) are spatially integrated with the electronics. Thus, known headsets have to be relatively large to accommodate such boards and other components.

[0188] FIG. 18 is a simplified schematic system diagram of a headset showing a circuit board arrangement in accordance with an embodiment of the present invention. System 1800 can correspond to headset 500 of FIG. 5, for example. System 1800 can be divided into two independent and separately arranged circuit boards 1810 and 1820. That is, when boards 1810 and 1820 are installed in a headset according to an embodiment of the present invention, the boards may be electronically coupled to each other, but the boards themselves are discrete. Circuit board 1810 corresponds to earbud circuit board 522 of FIG. 5 and earbud circuit board 1122 of FIG. 11 and can include, for example, Bluetooth processor 1812, circuitry that requires placement close to the processor, balance RF filter circuitry 1814 and coaxial connector (see e.g., connector 2752 of FIG. 27B). Examples of circuitry required close proximity to processor 1812 can include a timing crystal, charging inductors, capacitors, field effect transistors and resistors.

[0189] Circuit board 1820 corresponds to primary housing circuit board 512 of FIG. 5 and primary housing circuit board 1115 of FIG. 11 and can, for example, include RF Antenna 1822, interface circuitry 1823, power distribution circuitry 1824, switching circuitry 1825, 4-pin symmetrical magnetic connector 1826, RF matching circuitry 1821 and coaxial connector (see e.g., connector 2752 of FIG. 27B).

[0190] Circuit boards 1810 and 1820 can be electrically coupled using, for example, co-ax cable 1830 and bus 1832. In the embodiment shown in FIG. 18, bus 1832 includes ten lines, but one of ordinary skill in the art will appreciate that the number of lines in the bus can vary.

[0191] Balance RF filter circuitry 1814 and RF matching circuitry 1821 can adjust RF signals to compensate for the specific effects of circuit board 1810, co-ax cable 1830, circuit board 1820 and antenna 1822. The functions of elements of additional circuitry in circuit board 1810 and 1820 have been described in more detail in the above discussion relating to FIG. 14.

[0192] FIGS. 19A and 19B compare respective top and bottom views of earbud circuit board 1920 according to an embodiment of the present invention to respective top and bottom views of the known circuit boards shown in FIGS. 17A-17C. In addition, FIGS. 19A and 19B show that selected components of known circuit board 1990 can be arranged on earbud circuit board 1920. For example, as shown, the encircled circuit and components such as components 1996 and processor 1992 can be placed on one or more sides of earbud circuit board 1920. The remaining electronic components such as components 1996 can be placed on primary housing circuit board (see e.g., circuit board 1115 of FIG. 11) which may be located inside the headset's primary housing.

[0193] Earbud circuit board 1920 can include a layer made from a flexible substrate that enables circuit board 1920 to bend onto itself, thereby effectively reducing the area needed to install circuit board 1920 into a headset according to the invention. The flexible layer of circuit board 1920 can include one or more layers of electrical traces for electrically coupling processor 1922 and electronic components 1926, for example. The flexible layer of circuit board 1920 can, for example, extend over the entire footprint of the circuit board, or be limited to predetermined portions of circuit board 1920.

[0194] Circuit board 1920 can include relatively rigid sections 1923, 1925 and 1927 which have increased structural strength and are easier to mount electrical components to. Rigid circuit board sections 1923, 1925, and 1927 can be fabricated by attaching rigid circuit board pieces to one or more outer surfaces of the flexible layer of circuit board 1920. Rigid pieces can be attached to a flexible layer using any suitable process, such as applying an adhesive, for example. Contacts can be included on complementary surfaces of the rigid pieces and the flex layer so that electrical traces can be routed across the different layers. One or more layers of electrical traces can be included in the rigid circuit board pieces so that the combination of rigid and flex layers can provide two or more layers of electrical traces. In the embodiment shown in FIGS. 19A and 19B, a flex circuit layer with two levels of traces can be located in between two rigid, single-trace layers such that the resulting rigid sections of circuit board 1920 include four layers of traces. In flexible sections of circuit board 1920, such as connector lead 1921, the absence of rigid pieces can result in two levels of traces.

[0195] Rigid sections 1925 and 1927 can have substantially circular footprints with different radii. Various electrical components, such as capacitors and resistors, for example, can be mounted on both sides of rigid section 1925. Rigid section 1927 can have a larger footprint than section 1925 in order to accommodate the mounting of processor 1922 on a first side and receiver 1924 on a second side of section 1925. Connector 1928 can be mounted to rigid section 1923 to enable earbud circuit board 1920 to electrically couple with a primary housing circuit board (see e.g., circuit board 1115 of FIG. 11).

[0196] FIGS. 20A and 20B show side and perspective views of earbud circuit board 2020 in a folded configuration in accordance with an embodiment of the present invention. Earbud circuit board 2020 may, for example, correspond to earbud circuit board 1920. The folded configuration may correspond to the configuration of circuit board 2020 when installed within a headset, or more particularly, the earbud of the headset, as shown in FIG. 20C. Top rigid section 2027 can be folded over middle

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rigid section 2025 so that both sections can fit in the earbud of a headset. Processor 2022, receiver 2024 and various other electronic components 2026 may be mounted to earbud circuit board 2020. Electronic components 2026 can include resistors, capacitors, transistors, amplifiers and other types of both passive and active electronic components, for example. It is to be understood that the term electronic components, as used herein, does not include interconnect devices (e.g., wires, traces, connectors, etc.). Earbud circuit board 2020 can further include rigid section 2023 and connector 2028 mounted thereon. Connector 2028 can be used to electrically couple earbud circuit board 2020 with a circuit board in a headset's primary housing (see e.g., circuit board 1115 or circuit board 2011).

[0197] Referring now to FIG. 20C, which shows earbud circuit board 2020 and primary housing circuit board 2011 installed in a possible configuration within headset 2000 in accordance with an embodiment of the present invention. Circuit board 2020 can be folded in a configuration similar to that of FIGS. 20A and 20B and inserted into earbud 2014. Primary housing circuit board 2011 can include a combination of rigid and flexible sections that are similar, in composition but not necessarily shape, to the rigid and flexible sections of circuit board 2020. Circuit board 2011 can be folded to provide a cavity 2012 for a battery (see e.g., battery pack 1119 of FIG. 11) . Circuit board 2011 can include connector 2018 which may connect to connector 2028 of earbud circuit board 2020. During installation, circuit board 2011 can be inserted through one of the open ends of primary housing 2010. Connector lead 2021 can be fed through headset neck 2013 so connector 2028 can mate with connector 2018 when circuit board 2011 has been inserted into primary housing 2010.

[0198] This distribution of electronics, where processor 2022 and other circuitry (e.g., receiver 2024 and other electronic components 2026) are located inside earbud 2014, advantageously allows for a generally smaller and more comfortable headset Although the discussion above is related to an embodiment in which a certain distribution of electronic components is used, other distributions can be used. For example, a battery can be placed inside the earbud and a processor can be placed in the primary housing.

[0199] FIG. 21A shows a perspective view of earbud housing 2100 and neck 2110 in accordance with an embodiment of the present invention. Bezel 2130 can cover the top of earbud housing 2100. One or more acoustic ports 2102 can be located in the wall of the earbud to allow pressure to vent out of earbud housing 2100.

[0200] FIG. 21B shows an exploded view of earbud housing 2100 of FIG. 21A in accordance with an embodiment of the present invention. Screens 2131 and 2132 can be located on top of bezel 2130. Screens 2131 and 2132 can, for example, provide dust protection and acoustic resistance. Top gasket 2134 can be attached to the underside of bezel 2130 to create a seal with receiver 2124, and bottom gasket 2123 can be attached to section 2127 (a rigid section) of circuit board 2120. Bracket 2135 can be used to mount circuit board 2120 inside earbud housing 2100. Mesh can cover acoustic ports 2102 and can, for example, impose acoustic resistance on air passing through those ports. Screw 2112 can be used to mount earbud housing 2100 to neck 2110. Gaskets 2134 and 2123 can be made of, for example, foam, rubber, or any other compressible material so that the gaskets can form acoustic (e.g., substantially air-tight) seals with surrounding parts.

[0201] FIG. 22 shows an interior view of empty earbud housing 2200 in accordance with an embodiment of the present invention. Mesh 2204 can be located on the inner wall of housing 2200 to control the flow of air through one or more acoustic ports 2202 and prevent foreign objects (e.g., dirt) from entering housing 2200. Mesh 2204 can, for example, be affixed to housing 2200 using an adhesive. Mesh 2204 can be made of nylon, plastic, or any other suitable material. Mesh 2204 can provide acoustic resistance to the passage of air between an acoustic volume inside housing 2200 and the outside environment when the earbud is assembled. Even though only one acoustic port is shown in FIG. 22, any number of acoustic ports can be used in accordance with the principles of the present invention.

[0202] FIG. 23 shows rigid section 2327 of an earbud circuit board mounted inside earbud housing 2300 in accordance with an embodiment of the present invention. Acoustic port 2328 can be provided in circuit board section 2327 to permit air flow through the circuit board. The size, shape and location of acoustic port 2328 can vary depending on, for example, the acoustic properties of the earbud and the desired sound output. If desired, more than one acoustic port may be provided. Although not shown in FIG. 23, a second rigid portion of the earbud circuit board, such as rigid section 2025 of FIGS. 20A and 20B, may too include one or more acoustic ports. Though such port(s) may not be necessary if sufficient air gaps exist between the inside wall of housing 2300 and the second rigid portion.

[0203] FIG. 24 shows bottom gasket 2440 mounted onto circuit board section 2427 in accordance with an embodiment of the present invention. Bottom gasket 2440 can include an combination of, for example, acoustic mesh 2430, adhesive, and foam 2441. Foam 2441 of gasket 2440 can be shaped to fit around receiver (see e.g., gasket 2740 and receiver 2724 of FIG. 27A) and acoustic port 2428. Mesh 2430 can be shaped to cover port 2428. In this manner, acoustic mesh 2430 can cover acoustic port 2428 even though foam 2441 does not. Mesh 2430 can be made of nylon, plastic, or any other suitable material that can provide acoustic resistance to the passage of air through port 2428 which couples the acoustic volume under circuit board section 2427 (see e.g., acoustic volume 2796 of FIGS. 27A and 27B) with the acoustic volume where the receiver is located (see e.g., acoustic volume 2794 of FIG. 27A).

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[0204] FIG. 25 shows the underside of bezel 2530 in accordance with an embodiment of the present invention. Bezel 2530 can include rim 2536 which extends from the bottom of bezel 2530. Rim 2536 can be of sufficient height to compress bottom gasket 2440 of FIG. 24 against circuit board section 2427 of FIG. 24 when bezel 2530 is mounted to the top of the earbud housing, thereby creating an acoustic seal between the rim and the circuit board. Gasket 2534 can be, for example, a layer of foam that is affixed to the underside of bezel 2530 using adhesive. Gasket 2534 can be shaped so that it can form a seal with the top of the earbud's receiver when bezel 2530 is mounted to the earbud. Bezel 2530 includes acoustic port 2533 for sound to exit an earbud. Screen 2531 can be located on the topside of bezel 2530 so that the screen completely covers acoustic port 2533. Screen 2531 can apply an acoustic resistance to air passing through acoustic port 2533.

[0205] FIG. 26A shows the underside of bezel 2630 with receiver 2620 installed in accordance with an embodiment of the present invention. Receiver 2620 can be placed inside rim 2636 so that the front output of receiver 2620 is encircled by the seal formed between the top of the earbud's receiver and the top gasket (see e.g., top gasket 2134 of FIG. 21B). Receiver 2620 can include spring contacts 2622 and 2624. Spring contacts 2622 and 2624 can, for example, be made from a metal or an alloy. Springs contact 2622 and 2624 can electrically couple with circuitry in a headset in order to input audio signals to receiver 2620.

[0206] FIG. 26B shows a cross-sectional view of receiver 2620 in accordance with an embodiment of the invention. Receiver 2620 can include spring contacts 2622 and 2624 which can connect receiver 2620 with a source of electrical signals (e.g., earbud circuit board 1115 of FIG. 11). Contacts 2622 and 2624 can include tips 2623 and 2625 to facilitate the physical contact with a contact on a circuit (e.g. a flex circuit board).

[0207] FIG. 27A shows a cross-sectional view of earbud housing 2700 with receiver 2724 and circuit board 2720 installed in accordance with an embodiment of the present invention. Bezel 2730 is mounted on top of earbud housing 2700. Bezel 2730 can be attached to housing 2700 using a notch and rib configuration 2738 or any other suitable method of attachment, such as adhesive, for example. In an alternative embodiment of the present invention, bezel 2730 can be integrally formed with earbud housing 2700. Neck 2710 can be coupled to the bottom of earbud housing 2700. Earbud circuit board 2720 can be located inside the earbud and extend through lumen 2716 of neck 2710.

[0208] Located on the top of bezel 2730, screens 2731 and 2732 can cover audio port 2733. Audio port 2733 can allow air to pass between the external environment 2798 and front volume 2792 of receiver 2724. Top gasket 2734 and bottom gasket 2740 can create acoustic seals around receiver 2724 so that receiver volume 2794 is created. Acoustic port 2728 can allow air to pass through top rigid section 2727 of circuit board 2720 so that a port between receiver volume 2794 and rear earbud volume 2796 is created. Acoustic port 2702 can be located in earbud housing 2700 so that air can pass between rear earbud volume 2796 and the external environment 2798. Mesh (see e.g., mesh 2204 of FIG. 22) can be applied to the inner wall of earbud housing 2700 to cover acoustic port 2702 such that some resistance is applied to air passing through the port.

[0209] In one embodiment of the present invention, receiver 2724 can form at least part of a wall defining front volume 2792 and at least part of a wall defining receiver volume 2794. Rim 2736 of bezel 2730 can extend from the bezel into the interior of the earbud and compress against bottom gasket 2740, thereby also forming at least part of a wall defining receiver volume 2794. In one embodiment of the present invention, top rigid section 2727 of circuit board 2720 can be disposed between receiver volume 2794 and rear earbud volume 2796, thereby forming at least part of a wall defining receiver volume 2794 and at least part of a wall defining rear earbud volume 2796. To ensure the desired acoustic seal between receiver volume 2794 and rear earbud volume 2796, top rigid section 2727 of circuit board 2720 can be rigidly coupled to earbud housing 2700, directly or indirectly. In contrast, in one embodiment of the present invention, middle rigid section 2725 of circuit board 2720, which can be disposed within rear earbud volume 2796, can be flexibly coupled to the earbud housing, directly or indirectly (e.g., via top rigid section 2727 and flexible section 2729 of circuit board 2720). As used herein, when a component forms part of a wall defining an acoustic volume, the component can do so directly or indirectly. For example, the component can directly form part of a wall defining an acoustic volume when part of the component is open to the acoustic volume. The component can indirectly form part of a wall defining an acoustic volume when the component is incorporated into another component open to the acoustic volume.

[0210] In order to prevent sound from exiting rear earbud volume 2796 through lumen 2716, a substance, such as silicon glue, can be used to fill the inside of neck 2710. It is advantageous to prevent sound from receiver 2724 leaking into the headset's primary housing (see e.g., primary housing 11 of FIG. 1) because the microphone is located therein. If sound from the receiver is picked up by the microphone, a potentially undesirable echo may be created.

[0211] FIG. 27B shows a cross-sectional view of earbud housing 2700 with coaxial cable 2750 and conductive stopper 2760 installed in accordance with an embodiment of the present invention. Coaxial cable 2750 can couple to rigid section 2725 of circuit board 2720 using connector 2752, for example. Coaxial cable 2750 can be used to couple a processor in earbud housing 2700 with an antenna provided in a headset's primary housing (see e.g., antenna 1218 in primary housing 1210). Coaxial cable 2750 can include, for example, an insulated wire

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surrounded by a conductive shield and an outer insulator. In some embodiments, the outer insulator may be removed from at least a portion of cable 2750. For example, insulator can be removed to create exposed portion 2754 of the cable such that the insulator can be electrically coupled with (e.g., grounded to) insert 2712. Insert 2712 can be grounded to neck 2710 through the insert's threads and the neck can be grounded to a headset's primary housing (see e.g., housing 11 of FIG. 1). By grounding the insulator of cable 2750, electromagnetic interference and other negative effects may be reduced thereby increasing the wireless performance of a headset.

[0212] Conductive stopper 2760 can be installed in the lumen 2716 of insert 2712. In some embodiments, conductive stopper 2760 can be made of silicone and filled with silver. Conductive stopper 2760 can include a slit for circuit board 2720 and coaxial cable 2750 to pass through lumen 2716. Providing conductive stopper 2760 in neck 2710 can have several benefits. For example, conductive stopper 2760 can help isolate any sounds in acoustic volume 2796 from a headset's primary housing. In some embodiments, conductive stopper 2760 can also press exposed portion 2754 of cable 2750 against the wall of insert 2712 such that the cable's insulator is always electrically coupled with (e.g., grounded to) the insert. In other embodiments, stopper 2760 can be made from a conductive material such that the stopper can electrically coupled exposed portion 2754 of the cable with insert 2712.

[0213] FIG. 28 shows a view of unassembled pieces of attachment system 2800 that can be used to attach earbud housing 2820 to primary housing 2810 in accordance with an embodiment of the present invention. The configuration described below can allow for a mechanically robust connection which prevents housing 2820 from rotating with respect to primary housing 2810. An additional benefit of this design is the open lumen that can be used to run wires (or flexible printed circuit boards) between the earbud and primary housing. Attachment system 2800 can, for example, correspond to device 600 of FIGS. 6A and 6B.

[0214] Attachment system 2800 can include insert 2840, earbud housing 2820, neck 2830, insert 2850 and primary housing 2810. In order to simplify manufacturing, inserts 2840 and 2850 can be substantially similar and can both include features 2841, (e.g., notches), threads 2842 and a through-hole. Features 2841 can be arranged in a pattern to promote proper interface with certain tools. A custom tool which can interface with inserts 2840 and 2850 is described in more detail in the discussion below corresponding to FIGS. 30A-30C.

[0215] Primary housing 2810 can include through-hole 2814. Insert 2850 can be located in primary housing 2810 so that the threaded part of insert 2850 protrudes through through-hole 2814. A through-hole can be provided through neck 2830, and the interior can be threaded so the neck can couple with inserts 2850 and 2840. Earbud housing 2820 can include an through-hole (see e.g., through-hole 612 of FIG. 6A) through which insert 2840 can pass to couple with neck 2830.

[0216] The top surface of neck 2830 can include one or more protrusions 2831 (e.g., tabs) which can interface with one or more slots (e.g., notches) in the bottom of housing 2820 to prevent the two parts from rotating independently of each other when coupled together. The slots in the bottom of housing 2820 are not shown in FIG. 28, but slots similar to slots 2816 can be provided on the neck engaging surface of earbud housing 2820 in accordance with an embodiment of the present invention. Earbud housing 2820 can have a curved exterior surface that can form a nearly seamless transition with the curved exterior surface of neck 2830.

[0217] The bottom surface of neck 2830 can include protrusions that interface with one or more slots 2816 in housing 2810 to prevent the two parts from rotating independently of each other when coupled together. The protrusions on the bottom surface of neck 2830 are not shown in FIG. 28, but protrusions similar to protrusions 2831 can be provided on the bottom surface of neck 2830 in accordance with an embodiment of the present invention. Primary housing 2810 can include recessed region 2818 so that the bottom surface of neck 2830 can be recessed below the primary exterior surface of the housing. Moreover, the exterior of neck 2830 can be shaped to provide a nearly seamless transition from earbud housing 2820 to primary housing 2810.

[0218] Neck 2830 and inserts 2840 and 2850 can be made from any suitable material (e.g., metals or polycarbonates). For example, neck 2830 can be made from aluminum and inserts 2840 and 2850 can be made from steel. The choice of materials for neck 2830 and inserts 2840 and 2850 can depend on factors such as structural strength, weight, price, ability to be machined, and cosmetic appearance.

[0219] FIG. 29 shows a flowchart of process 2900 for connecting a headset earbud with a primary housing (e.g., a tube) in accordance with an embodiment of the present invention. Note that the protrusions and slots of FIG. 28 are referred to, respectively, as tabs and notches in process 2900. At step 2901, a bottom insert (such as insert 2850 of FIG. 28) can be inserted into a primary housing. The bottom insert can be inserted from either side of the primary housing and manipulated so that the threaded end is protruding from a through-hole in the wall of the primary housing. At step 2902, thread-locking glue can be applied to the threads of the bottom insert. The glue can be applied so that it covers a complete circular path around the threads of the insert. Alternatively, the glue can be applied to just one section of the threads. The glue can be selected in order to prevent the insert from unscrewing itself due to external forces (e.g., vibration). In one embodiment, a sufficient quantity of glue may be applied to the threads of the insert to prevent moisture and other harmful elements from entering the inside of a headset through a seam which may exist be-

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tween the neck and the primary housing. At step 2903, a neck (such as neck 2830 of FIG. 28) can be screwed onto the insert to a predetermined level. At step 2904, the neck can be aligned to the primary housing so that one or more tabs (e.g., protrusions 2831) on the neck fit within one or more notches on the primary housing. At step 2905, a custom tool can be used to turn the bottom insert while the neck is rotationally fixed to the primary housing. At step 2906, the bottom insert can be tightened to a predetermined torque. This torque measurement can be estimated by hand or performed with a calibrated torque wrench. At step 2907, an earbud housing can be mounted to the neck so that one or more tabs on the neck fit within one or more notches on the earbud housing. At step 2908, thread-locking glue can be applied to the top insert threads. The glue used on the threads of the top insert can be the same as the glue used on the threads of the bottom insert and can be applied in a similar manner. At step 2909, the top insert can be screwed into the neck. At step 2910, the top insert can be tightened to a predetermined torque.

[0220] FIGS. 30A and 30B show custom tool 3000 that can be used to manipulate an insert (e.g., insert 2840 or insert 2850) with respect to a neck (e.g., neck 2830) in accordance with an embodiment of the present invention. Tool 3000 can include two members 3010 and 3020 which can be coupled together by fastener 3030. Fastener 3030 can allow members 3010 and 3020 to rotate (or pivot) independently around the faster.

[0221] Members 3010 and 3020 can include appendages 3011 and 3021 which can be used by a user to control tool 3000. Appendages 3011 and 3021 can be an ergonomic size and shape. For example, appendages 3021 can be curved to accommodate an average human hand. Appendages 3011 and 3021 can include plastic covers 3012 and 3022 with ridges 3013 and 3023 such that a user can easily grip the appendages with his/her hands. A spring 3040 can be coupled with appendages 3011 and 3021 such that the appendages are biased to separate from each other.

[0222] Members 3010 and 3020 may control the movement of manipulators 3014 and 3024, which can interface with a part, such as an insert. For example, when appendages 3011 and 3021 are squeezed together, manipulators 3014 and 3024 may be forced apart. Manipulators 3014 and 3024 can include narrow sections 3015 and 3025 and tips 3016 and 3026.

[0223] FIG. 30B shows a detailed view of the shape of tips 3016 and 3026 in accordance with an embodiment of the present invention. Tips 3016 and 3026 can include outward facing tabs 3017 and 3027 which can interface with features (see e.g., features 2841 of FIG. 28) of inserts in order to manipulate (e.g., screw into place) the inserts. Tabs 3017 and 3027 can form the outer surface of narrow sections 3015 and 3025.

[0224] FIG. 30C shows custom tool 3000 coupling neck 3090 with primary housing 3092 in accordance with step 2905 of FIG. 29 according to an embodiment of the present invention. FIG. 30C illustrates how the narrow section of the manipulators can be of sufficient length so that tabs 3017 and 3027 can interface with features on the insert (see e.g., features 2841 of FIG. 28). Note that to preserve the structural strength of the manipulators, the narrow section may not be constructed to be substantially longer than necessary.

[0225] Extruded tubes with internal features for securing elements are useful for electronic devices. For example, such tubes can be used as a primary housing (see e.g., housing 11 of FIG. 1) or an earbud housing (see e.g., earbud 12 of FIG. 1). The following discussion describes different processes for creating a tube having an internal wall, for example, for supporting circuitry or electronic components. It will be understood, however that the processes and devices described can be used to create any suitable feature on the inner surface of a tubular structure.

[0226] FIG. 31 is a cross-sectional view of a tube having an internal wall 3104 in accordance with an embodiment of the present invention. Tube 3100 has a wall thickness 3102, and includes internal wall 3104 that extends inward perpendicular from the elongated axis of the tube. Internal wall 3104 has a thickness 3106 and a height 3108 (as measured from the outer surface of the tube). The discussion accompanying FIGS. 32-33, 34-36, 37-28, 39-40, and 41-43 respectively relate to various methods for creating tube 3100 in accordance with some embodiments of the present invention.

[0227] Known extrusion processes are unable to extrude tubes with internal features such as an internal wall (e.g., internal wall 3104). For example, known extrusion processes involve forcing a molten material through an aperture in order to create an object with a cross-sectional shape that is similar to the shape of the aperture. This type of process is incapable of producing tubes with discreet internal features because such a tube will have a cross-sectional shape that varies along the length of the tube. To overcome this limitation, existing processes require manufacturing a tube having a wall thickness equal to the required height of the feature (e.g., height 3108), and subsequently removing excess material around the feature using a machining process so that the final wall thickness meets the desired specification (e.g., thickness 3102). FIG. 32 is a cross section of an illustrative tube manufactured with a wall thickness that is thicker than the desired end product wall thickness in accordance with an embodiment of the present invention. Tube 3200 may be formed from any material (e.g., metal, plastic, or composite) using any suitable process (e.g., extrusion, impact extrusion, or progressive deep draw). Wall thickness 3202 may be selected based on the features that will be carved into tube 3200.

[0228] FIG. 33 is a perspective view of a cross section of the illustrative tube of FIG. 32 once the tube has been machined to include an internal wall in accordance with an embodiment of the present invention. To form internal wall 3204 in tube 3200, the entire inner surface 3201 of

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tube 3200 is machined to remove excess material around the internal wall and to reduce tube thickness 3202 to a desired wall thickness. This machining step may be time consuming, expensive, and difficult to implement, as it requires an experienced machinist and expensive tools. Furthermore, machining may also leave marks on the part, which may be undesired (e.g., for aesthetic reasons). Also, some features may include geometry or aspects that cannot be manufactured by machining (e.g., sharp angles not directly accessible from either end of the tube) or features that cannot be manufactured within the required tolerances (e.g., due to the inherent size of the machining tools).

[0229] To overcome the limitations of an entirely machined tube, a number of approaches may be used. FIG. 34 is an illustrative die and stamper for modifying the internal aspect of a tube in accordance with an embodiment of the present invention. Tube 3400 is extruded with the desired final thickness 3402 required for the tube. Tube 3400 is extruded to a slightly longer length 3403 than required for the final product, as the longer portion may be part of a cold-worked process that is used to create the internal wall. A die 3410 may be inserted in a first end of tube 3400 and inserted such that die end 3412 is aligned with a desired location of internal wall 3404 (see FIG. 36). Die 3410 may fit flush against the inside wall of tube 3400 and may be operative to maintain wall thickness 3402 when stamper 3420 is used to cold-work the tubing not in contact with die 3410. Stamper 3420 is then inserted into the second end of tube 3400, and a stamping force is applied to cold work the portion of tube 3400 located between the second end and die 3410. Stamper 3420 causes the wall thickness 3422 of tube 3400 to increase in the cold worked portion of tube 3400 by forcing the excess tube length to be cold-worked into the internal wall. The shape of stamper 3420 and the distance between the second end of tube 3400 and die end 3412 may be set to obtain the desired thickness for internal wall 3404.

[0230] FIG. 35 is an cross-sectional view of the tube of FIG. 34 after stamper 3420 and die 3410 are removed from tube 3400 in accordance with an embodiment of the present invention. After stamping, tube 3400 includes two thicknesses, thickness 3402 which is the expected final thickness of the tube, and thickness 3422, which corresponds a maximum possible height of any internal wall that may be machined from the thicker portion.

[0231] To create internal wall 3404, portions of inner surface 3401 of tube 3400 may be machined. FIG. 36 is a perspective view of the tube of FIG. 35 when the tube is machined to create an internal wall in accordance with an embodiment of the present invention. The portions of inner surface 3401 having thickness 3422 may be machined to thickness 3402 such that internal wall 3404 remains in tube 3400. Surface 3430 of FIG. 36 can identify the surfaces that are machined to complete tube 3400. An advantage of this process over the process described in FIGS. 32 and 33 is that the amount of machining required for the tube can be greatly reduced, as are costs.

[0232] Another approach for forming features in a tube may include impact extrusion of one end of the tube. FIG. 37 is a cross section of an illustrative tube formed using impact extrusion in accordance with an embodiment of the present invention. Tube 3700 having wall thickness 3702 is formed using impact extrusion. Impact extrusion creates an indentation that extends to surface 3710, which corresponds to the surface of internal wall 3704 (FIG. 38) of tube 3700. The end of tube 3700 remains closed by material 3722.

[0233] To complete tube 3700 and construct internal wall 3704, material 3722 may be machined. FIG. 38 is a perspective view of the tube of FIG. 37 when tube 3700 is machined to create an internal wall in accordance with an embodiment of the present invention. Material 3722 may be machined to leave inner surface 3701 of tube 3700 with thickness 3702, and with internal wall 3704 extending from inner surface 3701. Surface 3730 may represent the surface that is machined to create wall 3704. Similar to the process of FIGS. 34-36, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0234] Another approach for forming features in a tube may include impact extrusion of both ends of a tube. FIG. 39 is a cross section of an illustrative tube 3900 formed using impact extrusion in accordance with an embodiment of the present invention. Tube 3900 having final wall thickness 3902 is formed using multiple impact extrusions. The impact extrusions create a first indentation 3910 that extends to surface 3912 with surrounding interior surface 3901 and a second indentation 3914 that extends to surface 3916 with surrounding interior surface 3921. The thickness of tube 3900 left by first indentation 3910 is thickness 3902, which may be the expected final thickness of the tube. The thickness of tube 3900 left by second indentation 3914 is thickness 3922. The difference between thickness 3902 and thickness 3922 may correspond to height 3908 of internal wall 3904.

[0235] In some embodiments, if internal wall 3904 is configured to be constrained between surfaces 3912 and 3916, the distance between surfaces 3912 and 3916 may correspond to the thickness 3906 of internal wall 3904. In embodiments where internal wall 3904 is constrained between surfaces 3912 and 3916, thickness 3922 may be the same as thickness 3902 (i.e., substantially the expected final thickness of tube 3900) because internal wall 3904 having height 3908 (as shown in FIG. 40) may be machined from the material left between surfaces 3912 and 3916. In such embodiments, height 3908 of internal wall 3904 may be determined by the machining process.

[0236] To complete tube 3900 and construct internal wall 3904, material between surface 3912 and 3916 may be machined. Material may also be machined from interior surface 3921. FIG. 40 is a perspective view of the

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tube of FIG. 39 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention. In some embodiments, material may be machined to leave interior surface 3921 with thickness 3902, and with internal wall 3904 extending from interior surfaces 3901 and/or 3921. Surface 3930 of FIG. 40 identifies the surface that may be machined to complete tube 3900. Similar to the processes of FIGS. 34-36 and 37-38, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0237] Yet another approach for forming features in a tube may include a progressive deep draw process. FIG. 41 is a cross section of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present invention. Tube 4100 is constructed to have two consecutive indentations 4110 and 4114 having distinct wall thicknesses. Indentation 4110 has wall thickness 4102, which may be the expected final thickness of tube 4100, and indentation 4114 has wall thickness 4122.

Tube 4100 may transition from indentation 4110 to indentation 4114 at plane 4112, which may correspond to the location of internal wall 4104 (FIG. 43) configured to be constructed in inner surface 4101 (FIG. 43) of tube 4100.

[0238] FIG. 42 is a perspective view of a cross section of the tube of FIG. 41 in accordance with an embodiment of the present invention. As shown in FIG. 42, tube 4100 is closed at the end of indentation 4114 by material 4124. To complete tube 4100 and construct internal wall 4104, material 4124 may be machined to open tube 4100, and indentation 4114 may be machined to reduce thickness 4122 to the thickness 4102 (e.g., the final expected thickness) while leaving internal wall 4104.

[0239] FIG. 43 is a perspective view of the tube of FIGS. 41 and 42 after the tube is machined to create an internal wall in accordance with an embodiment of the present invention. Surface 4130 of FIG. 43 identifies the surfaces that are machined to complete tube 4100. Similarly to the process of FIGS. 34-36, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0240] The following flow charts illustrate methods for forming a tube with a feature on the internal surface of the tube using embodiments of the invention described above. Internal features may include, for example, a wall, a protrusion, an aperture, a snap, a shelf, or any other suitable feature. FIG. 44 is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube using a die and stamper in accordance with an embodiment of the present invention. Process 4400 begins at step 4410. At step 4410, a tube is extruded and cut to a length that is slightly longer than the desired finished length. At step 4420, a die is inserted in one end of the tube, such that the end of the die placed in the tube extends to a desired location where the feature is intended to exist in the tube.

[0241] At step 4430, a stamper is inserted in the second end of the tube. At step 4440, a force is applied to the stamper to force excess material into the tube, thus cold working the tube to increase the thickness of the tube in the region adjacent the stamper. At step 4450, the tube is machined to form the feature. Process 4400 then ends at step 4450.

[0242] FIG. 45 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention. Process 4500 begins at step 4510. At step 4510, an indentation is formed in the material of the tube by impact extrusion such that the end of the indentation aligns with a desired location of the feature in the tube. At step 4520, the closed end of the material is machined to form the tube and the feature. Process 4500 then ends a step 4520.

[0243] FIG. 46 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention. Process 4600 begins at step 4610. At step 4610, a first indentation is formed in the material of the tube using a first impact extrusion. At step 4620, a second indentation opposing the first indentation is formed in the material using a second impact extrusion. The ends of the first and second indentations may be configured to align with the boundaries of the feature. At step 4630, the feature is machined in the material remaining between the first and second indentations. Process 4600 then ends at step 4630.

[0244] In an alternative embodiment of the present invention, steps 4610 and 4620 can be combined into one step, as indicated by the dotted line around steps 4610 and 4620 in FIG. 46. That is, the first and second indentations can be formed using a single impact. Advantageously, this can be more efficient than forming first and second indentations from two impacts.

[0245] FIG. 47 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention. Process 4700 begins at step 4710. At step 4710, first and second indentations are formed consecutively using a progressive deep draw process. The interface between the first and second indentations may be configured such that the feature is located at the interface. At step 4720, the material closing the tube (i.e., not removed by the progressive deep draw process) is removed. At step 4730, the feature is machined in the inner surface of the tube. Process 4700 then ends at step 4730.

[0246] It is understood that any of the processes described above in connection with providing a wall in the inner surfaces of a tube may be used to form any other suitable feature on the inner surface of a tube. In addition, it is understood that these processes may be used for non-extruded and non-tubular components. It is also un-

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derstood that any of the processes described above can be applied to a component formed from injection molded plastic or any other material.

[0247] In order to convey information, such as device status, visual indicator systems can be included in a headset. One type of indicator system can emit different colors of light to indicate what a device is doing. For example, a system in a headset can emit a green light if it is in a telephone conversation and a blinking red light if the battery power is low.

[0248] FIG. 48 shows a simplified cross-sectional view of a visual indicator system 4800 for a headset in accordance with an embodiment of the present invention. Visual indicator system 4800 can, for example, correspond to display system 18 of FIG. 1, system 700 of FIG. 7, or display 1013 of FIG. 10B. One or more light sources 4821 and 4822 can be integrated into system 4800. Light sources 4821 and 4822 can be, for example, LEDs that each emit a different color of light. Each color or combination of colors can be used to signify different information (e.g., the mode of a headset or a function the headset is performing) . Light sources 4821 and 4822 can be mounted onto circuit board 4820. Through circuit board 4820, the light sources can be electrically coupled with driver circuitry (see e.g., LED driver 1424 of FIG. 14) that is operable to activate each source individually or in combination. A detailed description of circuitry with this functionality can be found in WO 2008/085928 A1 entitled "Systems and Methods for Compact Multi-State Switch Networks.".

[0249] It is understood that, while the embodiment shown in FIG. 48 uses two separate light sources (e.g., light sources 4821 and 4822), any number of light sources can be provided without deviating from the scope of the present invention. In some embodiments, a single light source device can be provided that includes two LEDs such that the device can emit light from either of the LEDs or a combination of the two LEDs. For example, a light source device can be provided that includes a green LED and a red LED. Such a light source device may, for example, emit green light when activating only the green LED, red light when activating only the red LED, and amber light when activating both LEDs in combination.

[0250] Microperforations 4812 can be provided in housing 4810 so that light sources 4821 and 4822 are visible to a user. Outer apertures 4814 of microperforations can have a small diameter so that they are imperceptible to a user when light sources 4821 and 4822 are off. The diameter of inner apertures 4816 can be of a larger size so that they can guide more light through the microperforations . A detailed description of microperforations and their fabrication can be found in U.S. Patent Publication Nos. US 2008/0084404 A1 and US 2008/0024470 A1 which are both entitled "Invisible, Light-Transmissive Display System". For the purposes of illustration, only five microperforations are shown in FIG. 48, however a much larger number of microperforations can be used. It is further understood that none of the elements of FIG. 48, including microperforations 2402, are drawn to scale.

[0251] While U.S. Patent Publication Nos. US 2008/0084404 A1 and US 2008/0024470 A1, both entitled "Invisible, Light-Transmissive Display System, " describe microperforations for use with display systems, microperforations can also be used as acoustic ports in accordance with the present invention. For example, one or more microperforations can be provided such that acoustic pressure can pass through the microperforations and exit a volume. For example, acoustic ports 1021 and 1022 of FIGS. 10A and 10B may be composed of a plurality of microperforations in earbud 1020.

[0252] Light diffuser 4830 can be located between circuit board 4820 and an inner wall of housing 4810. Light diffuser 4830 can, for example, be made of a polycarbonate with sections of varying opacity. Outer core 4832 of diffuser 4830 can be made from a substantially opaque material such that light from light sources 4821 cannot pass through the core. Outer core 4832 can be substantially opaque in that it can transmit 0% to 20% of light. For example, if outer core 4832 is substantially opaque it can deflect light back into inner core 4834 such that the light doesn't exit the sides of the diffuser.

[0253] Inner core 4834 can be located within the inner wall of outer core 4832. The inner core 4834 of diffuser 4830 can be made from, for example, a combination of substantially transparent or translucent substrate 4835 and diffusing particles 4836 such that the particles are suspended in the substrate. In some embodiments, substrate 4385 can be substantially transparent in that it can transmit 80% to 100% of light. In other embodiments, substrate 4385 can be translucent such that it transmits any 0% to 100% of light. Both substrate 4835 and particles 4836 can be, for example, made from polycarbonate materials of different opacities. Particles 4836 can be made from an opaque or translucent material that alters the path of light through inner core 4834. Particles 4836 can have any form (e.g., a sphere, a cylinder, a cube, a prism, or an uneven form) . In some embodiments, each of particles 4836 can have a different form to simplify manufacturing. The combination of substrate 4835 and particles 4836 can thoroughly diffuse light from the light sources when it exits the top of inner core 4834. That is, the light from light sources 4821 and 4822 can be evenly spread across the top surface of inner core 4834 so that a user detects an even intensity of light exiting microperforations 4812.

[0254] It is understood that other diffusion means can be used without deviating from the scope of the present invention. For example, surface textures, coatings or labels can be applied to a light transmissive material such that any light passing through the material is substantially diffused.

[0255] Inner core 4834 can have a sufficient width 4890 so that it surrounds the footprint of light sources 4821 and 4822. In one embodiment, inner core width 4890 can

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be approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters), and the width 4892 of outer core 4832 can be approximately 2.8 millimeters (e.g., between 2.6 millimeters and 3.0 millimeters). In some embodiments, the width of the end of the diffuser proximal to circuit board 4820 can be different from the width of the end of the diffuser proximal to housing 4810. For example, diffuser 4830 can be in shape similar to a cone such that the width of the end of the diffuser proximal to housing 4810 is smaller than the width of the diffuser proximal to circuit board 4820. In other words, diffuser 4830 can, for example, be in the shape of a cone having a flattened top.

[0256] The bottom surface of outer core 4832 can extend below the bottom surface of inner core 4834 so that the outer core can be mounted to circuit board 4820 without the inner core damaging light sources 4821 and 4822. The outer core 4832 can be attached to circuit board 4820 using, for example, an adhesive or any other suitable material.

[0257] In FIG. 48, light source 4822 is activated and emitting light 4860. Because of the effect of light diffuser 4830, light 4862 can be evenly distributed as it exits the diffuser, thereby making it difficult for a person to discern whether the light is being generated by light source 4821 or light source 4822.

[0258] FIG. 49 shows the exterior of an embodiment of headset 4910 that includes visual indicator 4913 in accordance with an embodiment of the present invention. Headset 4910 may correspond to headset 10 of FIG. 1, for example. The embodiment shown in FIG. 49 uses LEDs 4921 and 4922 as light sources and includes a cylindrical light diffuser. Visual indicator 4913 can include microperforations 4912 which allow a user to see light being emitted from LEDs 4921 and 4922. A light diffuser can be included between the LEDs and microperforations 4912 so that the diffused light seen by a user is equally distributed over the microperforations. The diameter 4990 of the microperforated area can be substantially similar to or smaller than the diameter of the diffuser's inner core. Diameter 4990 can be, for example, approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters).

[0259] Alternatively, the size and shape of the microperforated area could be different from that of the light diffuser. For example, a microperforated area with a noncircular shape can be placed over a light diffuser so that a noncircular indicator is generated. Similarly, the shape of the light diffuser can be non-cylindrical. Moreover, the light diffuser can be larger than the microperforated area so that it can cover the footprint of any other light sources that might be included.

[0260] Numerous light sources of different colors can be used in conjunction with a light diffuser as described above in order to present a visual indicator to a user. Because of the effect of the material in the light diffuser, light from each different source may appear evenly distributed over an area. In this manner, the entire indicator can appear to change colors as different light sources are activated.

[0261] FIG. 50A includes a side view of headset 5000 in accordance with an embodiment of the present invention. Connector 5040 can include primary housing 5010, connector plate 5041, contacts 5043, casing 5044 and microphone port 5050. Connector plate 5041 can include recessed groove 5042 which runs around the perimeter of connector plate 5041. Groove 5042 can also be referred to as a recessed step in connector plate 5041. At the top of connector plate 5041, a microphone port 5050 can be located in groove 5042.

[0262] There are many benefits associated with placing microphone port 5050 along the edge of connector plate 5041. By including the microphone port near the connector plate, the microphone can be embedded in the connector which saves space inside the headset housing. The space that is saved can be used to incorporate other functionality or decrease the overall size of the headset. Moreover, locating the microphone port in the groove around the edge of the connector can hide it from view which increases the overall aesthetic appearance of the headset

[0263] FIG. 50B shows a detailed view of the microphone port area of a connector in accordance with an embodiment of the present invention. The dimensions of port 5050 can include, for example, a width 5090 of approximately 2.5 millimeters and a height 5092 of approximately 0.3 millimeters. These dimensions are merely illustrative and it is understood that other dimensions may be practiced.

[0264] FIG. 51 shows a view of connector 5140 with the primary housing removed in accordance with an embodiment of the present invention. Connector 5140 can, for example, correspond to connector 16 of FIG. 1, assembly 320 of FIG. 3, assembly 420 of FIG. 4, connector 1040 of FIG. 10A, or connector 1140 of FIG. 11. Connector 5140 can be mounted up primary housing circuit board 5115, for example. Connector 5140 can include connector plate 5141, contacts 5143 and accompanying casing 5144 to prevent the contacts from electrically coupling with the connector plate. Microphone port 5150 can be included in the top of connector plate 5141 to allow sound to reach microphone boot 5120. Microphone boot 5120 and a microphone contained therein can be located behind connector plate 5141. The microphone can be contained within microphone boot 5120 to, for example, protect the microphone from damage and control the flow of air into the microphone.

[0265] FIG. 52 shows an exploded view of connector 5140 of FIG. 51 which can include, for example, connector plate 5240, microphone boot 5220, microphone 5222, contacts 5243, casing 5244, bracket 5248 and screws 5249 in accordance with an embodiment of the present invention. Microphone 5222 can be a MEMs microphone and can be electrically coupled with circuit board 5215. Circuit board 5215 is similar to primary housing circuit board 1115 of FIG. 11. Microphone boot 5220 can mount

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over microphone 5222. Microphone boot 5220 can, for example, be made of silicon so that it can seal with surrounding parts when connector 5200 is assembled. Contacts 5243 can be included in casing 5244. Casing 5244 can be made of a non-conductive material (e.g., polymeric) so that contacts can not be electrically coupled with connector plate 5240. Casing 5244 can be mounted onto circuit board 5215 and include conductive elements (see e.g., shank 5707 and contact segment 5708 of FIG. 57B) which can electrically couple contacts 5243 with circuit board 5215. Bracket 5248 can couple with connector plate 5240 in order to hold connector 5200 together. Upward pressure from bracket 5248 can compress microphone boot in order to create an acoustic (e.g., substantially air-tight) seal for the passage of air into and out of microphone 5222. Circuit board 5215, casing 5244 and bracket 5248 can include one or more apertures for mounting to connector plate 5240. Screws 5249 can be inserted through these apertures and screwed into threaded cavities (see e.g., cavities 6046) on the back of connector plate 5240.

[0266] FIG. 53 shows a view of microphone boot 5320 which can include input aperture 5325 in accordance with an embodiment of the present invention. Microphone boot 5320 can, for example, correspond to microphone boot 5220 of FIG. 52. Air that flows into a headset by going around microphone boot 5320 can cause a noticeable loss in the quality of the audio signals picked up by a microphone in the boot. Therefore, microphone boot 5320 can include sealing surface 5326 to prevent air from leaking through any seams along the edge of the microphone boot. Sealing surface 5326 can be a horizontal surface of boot 5320 that extends to the perimeter of the boot's footprint. Sealing seams in this manner can direct the flow of air into aperture 5325 which can result in higher sound quality being received by the microphone.

[0267] Traditionally, the roof of a microphone boot creates a seal with the surfaces of surrounding parts. This can require a thicker roof which is structurally robust enough to support the pressure required to make an adequate seal. Because boot 5320 uses horizontal sealing surface 5326 (instead of roof 5327) to seal with surrounding parts, roof 5327 does not need to be very thick. This reduced thickness saves space in a housing and can result in a generally smaller or thinner headset.

[0268] FIG. 54 shows a perspective, cross-sectional view of connector plate 5440 which includes microphone boot 5420 and microphone 5422 in accordance with an embodiment of the present invention. Connector plate 5440, boot 5420 and microphone 5422 can, respectively, correspond to connector plate 5240, booth 5220 and microphone 5222 of FIG. 52, for example. The components shown in FIG. 54 can fit together so that air can pass through microphone port 5450, into boot aperture 5425 and reach microphone input 5421. Microphone port 5450 may, for example, be a cut-out in the recessed step of connector plate 5440. Because of other elements in the connector assembly (e.g., circuit board 5215 and bracket 5248), microphone 5422 and microphone boot 5420 can be pushed up against connector plate 5440 when installed in a headset. The pressure from this force can cause surface 5426 to form a seal with surface 5445 of connector plate 5440. This seal can prevent air from passing through seam 5490 in between connector plate 5440 and microphone boot 5420.

[0269] In some embodiments, porous plug 5428 may be provided in boot aperture 5425. Plug 5428 may be, for example, made from a porous foam (e.g., sintered polyethylene or super high-density polyethylene). Plug 5428 can help filter out high-frequency noises such as those generated by wind blowing into microphone port 5450. The acoustical performance of plug 5428 can be a factor of its porosity which can be controlled by manufacturing. For example, plug 5428 can be manufactured by melting particles of polyethylene together. The porosity of the resulting plug can be a function of how long the particles are melted, what temperature is used to melt the particles, and the particles size. In some embodiments, it may be advantageous to only use polyethylene particles of a certain size when forming plug 5428. For example, particles with a diameter between 177 microns and 250 microns may be melted to form plug 5428.

[0270] FIGS. 55A and 55B show views of the connector of headset 5500 in accordance with an embodiment of the present invention. Four contacts 5561, 5562, 5563 and 5564 can be integrated into the connector. The contacts can be of a substantially flat shape so that they are flush with the face of connector plate 5540. The contacts can, for example, be of an oval shape. The outer contacts 5561 and 5564 can be configured for coupling to either a power supply line or a ground line. The remaining inner contacts 5562 and 5563 can be configured for receiving and transmitting data.

[0271] Connector plate 5540 can be located within primary housing 5510 and can include recessed groove 5542. Height 5580 of primary housing 5510 can be approximately 5 millimeters or can be from a range between 4.7 and 5.3 millimeters. Height 5581 of the interior cavity of primary housing 5510 can be approximately 4 millimeters or can be from a range between 3.7 and 4.3 millimeters. Height 5582 of the raised face of connector plate 5540 can be approximately 3.3 millimeters or can be from a range between 3.0 and 3.6 millimeters. Heights 5580, 5581 and 5582 can be advantageous because they can provide a headset having a small form-factor yet large enough to adequately couple with a complementary connector. Heights 5581 and 5582 can also provide an adequate groove for sound from a user's voice to reach a microphone embedded in connector plate 5540 (see e.g., microphone 17 of FIG. 1). It is understood that these dimensions are merely illustrative. It is also understood that connector plate 5540 and the aperture in primary housing 5510 are angled with respect to the axis of primary housing 5510, and heights 5580, 5581 and 5582 reference the orthogonal heights of the corresponding elements.

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[0272] Connector plate 5540 can include four contacts 5561, 5562, 5563 and 5564 which can be separated by pitch 5583, which can be approximately 2 millimeters or from a range between 1.75 and 2.25 millimeters. Pitch can be defined as the distance from the centerline of a contact to the centerline of the nearest contact. Pitch 5583 can be advantageous because it can allow contacts on complementary connectors (see e.g., connector 6200 of FIG. 62A and 62B) to be sufficiently spaced apart such that magnetic components can be provided between the contacts.

[0273] Each contact can have a width 5584, which can be approximately 0.7 millimeters or from a range between 0.5 and 0.9 millimeters. The ring of exposed casing can have a width 5586 of approximately 0.2 millimeters or can be from a range between 0.12 and 0.3 millimeters. All of the rings of exposed casing can have the same width (e.g., width 5586). Width 5586 can be advantageous because it is large enough to prevent contacts 5561, 5562, 5563 and 5564 from shorting with connector plate 5540, but small enough to not impact the size of connector plate 5540. The contacts can be arranged on the face of connector plate 5540 so that they are symmetrical about the centerline of headset 5500. Dimension 5585, which represents the distance from the centerline of each contact to the centerline of the headset, can be approximately 1 millimeter. The dimensions of contacts 5561-5564 can be advantageous because the dimensions can provide a sufficient surface for coupling with a corresponding connector while maintaining a small form-factor headset. For example, if the contacts were much larger, the size of housing 5510 may need to increase.

[0274] FIG. 55C includes a side view of headset 5500 in accordance with an embodiment of the present invention. The angle between the face of connector plate 5540 and the axis of primary housing 5510 can be represented by angle 5587, which can be approximately 55 degrees or from a range between 10 and 80 degrees. Angle 5587 can be advantageous because it can provide a suitable angle for mating headset 5500 with a corresponding connector. Angle 5587 may also provide an appropriate angle for reflecting sound from a user's mouth to the microphone of headset 5500 (see e.g., microphone 17 of FIG. 1). Angle 5587 can also be provided to block outside sounds from the microphone of headset 5500.

[0275] As measured along the surface of connector plate 5540, the height 5588 of each contact can be approximately 1.5 millimeters. Height 5588 can be advantageous because it provides a substantial surface area for headset 5500 to couple with corresponding headsets but does not necessarily cause an increase in the size of housing 5510.

[0276] The connector plate 5540 can be recessed in primary housing 5510 by a depth 5589 of approximately 0.25 to 0.3 millimeters. This depth can be determined by measuring the distance between the face of connector plate 5540 and a plane defined by the end of primary housing 5510 (e.g., a plane including three points on the connector end of primary housing 5510). Depth 5589 can be advantageous because it can provide a sufficient depth to strengthen the mechanical link between headset 5500 and a corresponding connector, but not be of such a large depth that it becomes difficult to align the headset with such a connector.

[0277] FIG. 55D includes a top view of headset 5500 in accordance with an embodiment of the present invention. Width 5590 of primary housing 5510 can be approximately 12.3 millimeters or can be from a range between 10 and 14 millimeters. Width 5591 of the interior cavity of primary housing 5510 can be approximately 11.1 millimeters or can be from a range between 7 and 13 millimeters. Width 5592 of the raised face of connector plate 5540 can be approximately 10.3 millimeters or can be from a range between 5 and 11 millimeters. Widths 5590, 5591, and 5592 can be advantageous because they can provide a large enough area for headset 5500 to securely couple with a complementary connector, while not being so large so as to prevent headset 5500 from having a small form-factor. The dimensions given above apply to the embodiments shown in 55A, 55B, 55C and 55D and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0278] FIG. 56 illustrates an assembly of electrical contacts for connector 1040 in accordance with an embodiment of the present invention. Assembly 5601 can include plurality of electrical contacts 5602 disposed in non-conductive (e.g., polymeric) casing 5603. Casing 5603 can include protruding members such that each protruding member can extend through a cavity in a connector plate. In FIG. 52, for example, casing 5244 includes four protruding members and connector plate 5240 includes four cavities (or apertures). When casing 5244 is coupled with connector plate 5240, the casing's protruding members will fill those cavities. Accordingly, each protruding member can be referred to as a protruding cavity member as well. Electrical contacts 5602 can extend through at least a portion of depth 5690. In an assembled headset, each electrical contact 5602 can have a portion disposed in electrical contact with electrical contact 5604 of circuit board 5605, which can be flexible or rigid.

[0279] FIGS. 57A and 57B illustrate an assembly of electrical contacts in accordance with one embodiment of the present invention. Assembly 5701 can include plurality of electrical contacts 5702 disposed in non-conductive casing 5703. Each electrical contact 5702 can have first portion 5705 and second portion 5704, each of which are manufactured independently and assembled together thereafter.

[0280] First portion 5705 can have head 5706 and shank 5707. Head 5706 can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on head 5706 can have a conductive, durable finish that also is aesthetically appealing, for example,

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nickel, tin cobalt, or a blackened finish. Shank 5707 can be integrally formed with head 5706 or formed independently and then attached to head 5706 using adhesive material (e.g., glue, solder, weld, surface mount adhesion material, etc.). For example, during manufacturing, first portion 5705 can be formed from a cylindrical block of conductive material, turned to create shank 5707, and stamped or milled to shape head 5706, for example, into an oval shape.

[0281] Second portion 5704 can have engagement segment 5709 and contact segment 5708. Engagement segment 5709 can have a hole configured for accepting shank 5707 of first portion 5705 during assembly of electrical contact 5702 to casing 5703. Conductive adhesive material can be applied during manufacturing to mechanically and electrically couple first portion 5705 and second portion 5704 of electrical contact 5702. Contact segment 5708 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when in an assembled headset. The engagement surface of contact segment 5708 also can have a finish (e.g., gold-plating) that has good properties for adhering electrical contact 5702 to circuit board 5605, storage, and corrosion-resistance.

[0282] In one embodiment of the present invention, the center of the internal contact surface of second portion 5704 can be offset from the center of the external surface of first portion 5705 when considered in a plane substantially defined by the external contact surface of first portion 5705. This can be useful when design constraints require electrical contacts 5702 to electrically couple electronic components that are not co-linearly aligned, as in one embodiment of the present invention illustrated in FIG. 56. In one embodiment of the present invention, second portion 5704 can have a hook-shape to position the internal contact surface of second portion 5704 in an offset configuration with respect to shank 5707. In manufacturing, second portion 5704 can be stamped from sheet metal, machined from a solid block of conductive material, molded, or formed using a different method known in the art or otherwise. In one embodiment of the present invention, second portion 5704 can be stamped from sheet metal in high volume production situations to save valuable time and money.

[0283] FIGS. 58A-58C illustrate an assembly of electrical contacts in accordance with another embodiment of the present invention. Assembly 5801 can include plurality of electrical contacts 5802 disposed in non-conductive casing 5803. Similar to the embodiment illustrated in FIGS. 57A-57B, each electrical contact 5802 can have first portion 5805 and second portion 5804, each of which are manufactured independently and assembled together thereafter.

[0284] First portion 5805 can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on first portion 5805 can have a conductive, durable finish that also is aesthetically appealing.

[0285] Second portion 5804 can have engagement segment 5806, shank 5807, and contact segment 5808. Engagement segment 5806 can be electrically and mechanically coupled to first portion 5805 using, for example, surface mount technology, solder, weld, or another conductive adhesive. Shank 5807 can couple engagement segment 5806 to contact segment 5808. Contact segment 5808 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when headset assembly 5801 is installed in a headset (e.g., headset 10 of FIG. 1). The engagement surface of contact segment 5808 also can have a finish that has good properties for soldering, storage, and corrosion-resistance.

[0286] In one embodiment of the present invention, the center of the internal contact surface of contact segment 5808 can be offset from the center of the external surface of first portion 5805 when considered in a plane substantially defined by the external contact surface of first portion 5805. In one embodiment of the present invention, second portion 5804 also can have a hook-shape to position the internal contact surface of second portion 5804 in an offset configuration with respect to the external contact surface of first portion 5805.

[0287] FIG. 58C illustrates how assembly 5801 can be manufactured in accordance with one embodiment of the present invention. Initially, second portions 5804 of one or more electrical contacts 5802 can be stamped from single piece of sheet metal 5809 and folded into, e.g., a hook-shape as described above. This can create fingers 5810 in sheet metal 5809 that mechanically and electrically couple all electrical contacts 5802. First portions 5805, which also can be stamped in a separate operation, then can be adhered to engagement segments 5806 of each second portion 5804. This assembly then can be placed in an injection molding machine to injection-mold casing 5803 around the assembly. Once the injection molding procedure is complete, a blade can sever second portions 5804 of electrical contacts 5802 from the rest of sheet metal 5809, thereby mechanically and electrically decoupling each electrical contact 5802 from the other electrical contacts. Advantageously, because first portions 5805 and second portions 5804 can be formed from a stamping process, assembly 5801 can be used in high volume production situations by saving valuable time and money.

[0288] FIGS. 59A and 59B illustrate electrical contacts in accordance with further embodiments of the present invention. Electrical contacts 5901 and 5905 can be similar to that described above with respect to FIGS. 57A-58C, except that electrical contacts 5901 and 5905 can be formed as one unitary piece.

[0289] Electrical contact 5901 can have external contact portion 5902, shank 5903, and internal contact portion 5904. External contact portion 5902 can have an external surface for engagement with an external electrical contact of, for example, a connector on a charging

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dock or cable. Shank 5903 can couple external contact portion 5902 to internal contact portion 5904. Internal contact portion 5904 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when electrical contact 5901 is installed in a headset (e.g., headset 10 of FIG. 1). As in the above-described embodiments, the center of the internal contact surface of internal contact portion 5904 can be offset from the center of external contact portion 5902 when considered in a plane substantially defined by the external contact surface of external contact portion 5902. Electrical contact 5901 also can have a hook-shape to position the internal contact surface of internal contact portion 5904 in an offset configuration with respect to the center of external contact portion 5902. In one embodiment of the present invention, electrical contact 5901 can be machined from a single block of conductive material.

[0290] Similar to electrical contact 5901, electrical contact 5905 also can have external contact portion 5906, shank 5907, and internal contact portion 5908. Rather than being machined from a conductive material, however, electrical contact 5905 can be stamped from sheet metal and folded to form the hook-shape. Again, because the electrical contact can be manufactured using a stamping procedure, it can be used in high volume production situations.

[0291] FIGS. 60A and 60B show two views of connector plate 6040 of a headset connector in accordance with an embodiment of the present invention. Recessed step 6042 can run around the edge of connector plate 6040 in order to create a groove when the plate is installed in a primary housing (see e.g., primary housing 1110 of FIG. 11). Microphone port 6050 can be cut out of step 6042 in order to create an opening for sound to reach cavity 6051 where a microphone or microphone boot (see e.g., microphone boot 5220) can be located. In FIG. 60B, surface 6045 of connector plate 6040 can be used to compress the perimeter of a microphone boot so that an airtight seal is made.

[0292] Tabs 6047 and threaded cavities 6046 can be used to mount other elements onto connector plate 6040. For example, tabs 6047 can mate with a bracket that wraps around the entire connector assembly (see e.g., bracket 5248 of FIG. 52). This same bracket can include apertures for use in conjunction with threaded cavities 6046 so that inserts (e.g., screws) can fix the bracket against connector plate 6040. Bracket 5248 of FIG. 52 is an example of a bracket that is suitable for use with connector plate 6040.

[0293] In accordance with one aspect of the present invention, connector plate 6040 can be made of a material with magnetic properties. By incorporating magnetic properties into connector plate 6040, magnetic effects can be used to enhance the coupling between connector plate 6040 and a complementary connector (see e.g., FIG. 62B). Connector plate 6040 can include, for example, a ferromagnetic material such as a steel alloy. In another embodiment, connector plate 6040 can include a permanent rare-earth magnet that produces a magnetic field. Moreover, an embodiment of connector plate 6040 can include an electromagnet which produces a magnetic field as a result of the application of electric current. In the electromagnetic embodiment, the magnetic field can be controlled (e.g., through the application of an electric current) so that it is only present when necessary. In the embodiments where connector plate 6040 includes a permanent magnet or an electromagnet, a complementary connector (see e.g., FIG. 62B) can include a ferromagnetic material or a complementarily positioned permanent magnet or electromagnet.

[0294] FIG. 61A shows array 6180 of magnetic components which can be embedded in a connector in accordance with an embodiment of the present invention. Array 6180 can include components 6181, 6182, 6183, 6184 and 6185 which can be made of, for example, a permanent rare-earth magnetic material. An example of a suitable material for magnetic components 6181-6185 is magnetized Neodymium and, more specifically, N50 magnets. The magnetic components 6181-6185 can be shaped so that a substantially flat mating face 6186 is formed along one side. This mating face 6186 can, for example, be at an angle complementary to the angle of a headset's connector plate (see e.g., angle 5587 of FIG. 55D).

[0295] FIG. 61B shows a view of how connector plate 6140 can be used in combination with array 6180 of magnetic components in accordance with an embodiment of the present invention. If connector plate 6140 is made of a ferromagnetic material and array 6180 includes permanent magnets, the magnetic fields of array 6180 will generate magnetic forces biasing connector plate 6140 and array 6180 together. If array 6180 is embedded within a connector that mates with connector plate 6140, these magnetic forces can reinforce the connection.

[0296] In order to maximize the magnetic field generated by array 6180, it can be advantageous to arrange components 6181-6185 (e.g., magnets) so that the polarity of each component is in a particular orientation. For example, the components can be arranged so that the south pole of the outer two magnets are closest to the mating face, and the north pole of the inner three magnets are closest to the mating face. In this configuration, if one were to list the polarities encountered when passing horizontally over the mating face, the list would read south-north-north-north-south. This maximization of the magnetic field is one reason why it might be desirable to use an array of magnets as opposed to one large magnet.

[0297] While the embodiments described above include a ferromagnetic connector plate and an array of permanent magnets embedded in a complementary connector (see e.g., FIG. 62B), it is contemplated that any other magnetic configurations can be used. For example, an electromagnet element can be included in the connector plate and a ferromagnetic material can be located in a complementary connector. A detailed discussion

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about the use of electromagnetic and magnetic elements in connectors can be found in U.S. Patent Publication No. US 2007/0072442 A1 entitled "Electromagnetic Connector for Electronic Device" and U.S. Patent Publication No. US 2007/0072443 A1 and 11/235,875 entitled "Magnetic Connector for Electronic Device".

[0298] FIGS. 62A and 62B show connector 6200 that is complementary to and capable of mating with connector 1040 of FIG. 10A in accordance with an embodiment of the present invention. Connector 6200 can, for example, correspond to headset engaging connector 220 of FIG. 2. Connector 6200 can be integrated into, for example, a charger (see e.g., docking station 6400 of FIG. 64, device 6600 of FIG. 66, and docking station 6700 of FIG. 67B) which charges a battery in a headset or other apparatus that facilitates the charging of the headset (such as an apparatus discussed in U.S. Patent Publication No. US 2008/0167088 A1 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices".

[0299] The view of connector 6200 in FIG. 62A does not include connector housing 6210 so that magnetic array 6280 and contacts 6290, 6292, 6294 and 6296 can be seen. Array 6280 can be installed in connector 6200 such that it forms a magnetic array structure, and each magnet of the array can be separated by a gap of predetermined size. Array 6280 of magnetic components can be embedded in connector housing 6210 so that the surface of components 6282, 6283 and 6284 can be flush with mating face 6286. These exposed components can extended all of the way to the surface of a corresponding connector plate so that the strongest magnetic forces are generated. However, a connector can have no exposed magnetic elements For example, it can be desirable to recess magnetic components 6281 and 6285 in order to create a smaller connector.

[0300] Contacts 6290, 6292, 6294 and 6296 can be included in connector 6200. In order to integrate the contacts with the array 6280 of magnetic components, each contact can be placed in the gaps between magnetic components. In this manner, contact 6290 can be located in between magnetic components 6281 and 6282, contact 6292 can be located between components 6282 and 6283, etc. This integrated distribution of contacts can allow for a smaller connector. This is another example of a reason why it might be desirable to use multiple magnetic components that are spaced apart as opposed to a single, large magnetic component.

[0301] Each contact can include a spring mechanism, such as coil 6297 of contact 6296. Coil 6297 can bias contact tip 6296 to extend out of connector housing 6210. The coils 6291, 6293, 6295 and 6297 included in the contacts can be substantially planar or flat. A flat coil can allow for minimal spacing between magnetic components 6281-48815. This reduced spacing can result in a generally smaller connector. However, other types of coils and contacts can be used in accordance with the principles of the present invention. For example, a cylindrical spring biasing a cylindrical contact, commonly called a "pogo pin," can be used.

[0302] Contacts 6290, 6292, 6294 and 6296 can be position to electrically couple with, for example, the contacts located on the face of a connector plate of a headset. Connector housing 6210 can include an elevated face 6212 which can, for example, fit into a cavity in a complementary connector. For example, if connector 6200 were to mate with headset 1000 of FIGS. 10A and 10B, the elevated face 6212 can fit against recessed connector plate 1041 while the edge of primary housing 1010 can fit against the recessed perimeter 6214 of connector 6200. In this mating configuration, contacts 6290, 6292, 6294 and 6296 can be electrically coupled with contacts 1042 of headset 1000.

[0303] Connector 6200 can include contacts or wires (not shown) on the rear of housing 6210 so that the connector can be electrically coupled with other circuitry. For example, connector 6200 can be mounted onto a circuit board that includes power supply circuitry (such as circuitry discussed in U.S. Patent Publication No. US 2008/0167088 A1 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" that can be used to transmit power to a headset through one or more contacts.

[0304] FIGS. 63A and 63B show connector 6300 that is complementary to and capable of mating with connector 1040 of FIG. 10A in accordance with an embodiment of the present invention. Connector 6300 is substantially similar to connector 6200 in FIGS. 62A and 62B. For example, magnetic components 6382, 6383 and 6384 of FIG. 63A are similar, respectively, to magnetic component 6282, 6283, and 6284 of FIG. 62A.

[0305] Connector 6300 can include four contact tips 6390, 6392, 6394 and 6396 that can be biased to extend from housing 6310. Each contact tip can have a width 6303 of approximately 0.5 millimeters. Width 6303 may be advantageously sized to be large enough to easily connect with connectors on headsets (e.g., connector 16 of FIG. 1) while not being so large that contact tips 6390, 6392, 6394, and 6396 are stiff and cannot be depressed by a headset coupling with connector 6300.

[0306] The centerline of each contact tip can be separated from the centerline of an adjacent contact tip by pitch 6302. Pitch 6302 can be chosen so that the contacts of connector 6300 are capable of electrically coupling with the contacts of a headset connector (e.g., connector 1040 of FIG. 10A). Accordingly, pitch 6302 can be approximately 1.97 millimeters so that it corresponds to pitch 5583 shown in FIG. 55A. Moreover, pitch 6302 can be selected from a range between 1.75 and 2.25 millimeters. The size of pitch 6302 may also be advantageous for placing magnetic components (e.g., components 6382, 6383, and 6384) in between the contacts of connector 6300. The centerline of outer contact tips 6390 and 6396 can be separated by width 6301, which can be approximately 5.1 millimeters or from a range between 4.7 millimeters and 5.4 millimeters. Width 6301 can be

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selected such that contact tips 6390 and 6394 can couple with the outer contacts of a headset (see e.g., contacts 5561 and 5564 of FIG. 55A). In some embodiments, the outer contacts of a headset may be configured to receive power, and a connector, similar to connector 6300 but not including contact tips 6392 and 6394, can be provided to transmit only power to the headset. Such a connector may be easier to manufacture and cheaper than connector 6200.

[0307] Connector 6300 can have a raised face 6312 that is capable of coupling with a headset connector (e.g., connector 1040 of FIG. 10A). The housing 6310 of connector 6300 can have a total height 6304, which can be approximately 5.1 millimeters or from a range between 4.9 millimeters and 5.3 millimeters. The total height 6304 of a connector may be advantageously selected to corresponding with the total height of a headset's primary housing (see e.g., height 5580 of FIG. 55B) such that connector 6300 can receive a headset's primary housing. The raised face 6312 of housing 6310 can have a height 6305, which can be approximately 3.43 millimeters or from a range between 3.2 and 3.7 millimeters. Height 6305 can be selected such that it is less than the height of an internal cavity inside of a headset's primary housing (see e.g., height 5581) such that connector 6300 can easily couple with a headset. In summary, heights 6304 and 6305 can be selected in order to complement heights 5580 and 5581 of FIG. 55B. Thereby allowing headset 5500 to mate with connector 6300. It is understood that the mating face of connector 6300 is angled with respect to the rest of the connector. This angle can, for example, range from ten to thirty degrees. Heights 6304 and 6305 reference the orthogonal heights of the corresponding elements. This is similar to the radial dimensions that are shown in FIG. 55B.

[0308] In order to apply pressure to the contacts of a complementary connector, the contact tips 6390, 6392, 6394 and 6396 can be biased to extend from connector housing 6310. When no complementary connector is present, contact tips 6390, 6392, 6394 and 6396 can extend from the housing by distance 6306 of approximately 0.7 millimeters. Distance 6306 can be selected such that the contact tips can advantageously apply enough pressure to a headphone's contacts such that the tips can reliably couple with the headphone's contacts.

[0309] Connector 6300 can also include contacts or wires (not shown) that allow the connector to route electrical signals from contact tips 6390, 6392, 6394 and 6396 to other circuitry. The dimensions given above apply to the embodiments shown in 63A and 63B and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0310] FIG. 64 shows a view of headset 6498 coupled with connector 6499 in accordance with an embodiment of the present invention. Headset 6498 can be substantially similar to headset 1000 of FIGS. 10A and 10B and can include the features shown on connector 1040. Connector 6499 can be installed in, for example, docking station 6400 which can include a socket in which a headset can be inserted. Docking stations substantially similar to or the same as docking station 6400 are discussed in U.S. Patent Publication No. US 2008/0167088 A1 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices". The socket in docking station 6400 can be shaped to align headset 6498 properly with respect to connector 6499.Connector 6499 can include raised face 6412 and lower perimeter 6414 to further align headset 6498. Raised face 6412 can extend into the cavity created by a recessed headset connector while the headset's primary housing abuts perimeter 6414.

[0311] This alignment can result in the contacts of headset 6498 (see e.g., contacts 1042 of FIG. 10A) being approximately centered over the tip of contact 6490. Contact 6490 can be biased to extend beyond raised face 6412 by coil 6491. This bias can be represented by a force exerted in the direction of arrow 6401. Additionally, arrow 6402 can represent the magnetic force generated by the proximity of the connector plate of headset 6498 (see e.g., connector plate 1041 of FIG. 10A) to the array of magnetic components of connector 6499 (see e.g., array 6180 of FIGS. 61A and 61B). This magnetic force can cause contact 6490 to electrically couple with a contact on headset 6498. Connector 6499 can include additional contacts (see e.g., contacts 6290, 6292, 6294 and 6296) which can couple with the remaining contacts of headset 6498. Connector 6499 can be mounted on circuit board 6480 in docking station 6400 such that circuit board 6480 can route signals to and from headset 6498 when it is coupled with connector 6499.

[0312] FIG. 65 shows graph 6500 which depicts the approximate change of the two forces described above as the separation between the magnetic components and the connector plate varies in accordance with an embodiment of the present invention. In graph 6500, x-axis 6502 can represent the approximate force, and y-axis 6504 can represent the distance between the magnetic components and the connector plate. The separation where the x-axis intercepts the y-axis is zero, and this point can represent when the connector plate is in contact with the magnetic components. As the separation increases, approximate force 6508 from spring contacts pushing on a connector plate in a headset can decrease linearly because of the substantially linear nature of coil springs. While the spring force decreases linearly, the approximate magnetic force 6506 can decrease exponentially due to the behavior of magnetic materials.

[0313] It can be desirable to choose magnetic components (e.g., magnets, connector plates) and design spring components (e.g., contact coils) such that the magnetic force biasing a headset's connector plate to a complementary connector is greater than the force of the spring contacts pushing back on the connector plate at all possible distances of separation between the two parts. If there are situations where the spring force is

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greater than the magnetic force, it might be necessary to apply an external force in order to properly couple a headset with a complementary connector. Applying this external force might require intervention from a user, and therefore, it can be desirable to design a connection system so that the magnetic force is always greater that the spring force.

[0314] FIG. 66 shows charging device 6600 that can be used in conjunction with a headset in accordance with an embodiment of the present invention. In some embodiments, connector 6601 can be integrated into device 6600, thereby allowing device 6600 to be electrically coupled with a headset. Connector 6601 is similar to the connectors discussed in connection with FIGS. 61-65.

[0315] In some embodiments, auxiliary connector 6610 can be integrated into charging device 6600. As such, auxiliary connector 6610 can be used to couple an additional device, such as a cellular phone which can be used with a headset, to device 6600. In order to connect a headset or additional device to an external power supply (e.g., wall outlet or computer), device 6600 can include cable 6620. Circuitry 6630 can be integrated into device 6600 to facilitate charging of both a headset and an additional device. Circuitry 6630 can also provide a communications interface for data to be shared between a headset and an additional device. An example of a charging device similar to device 6600 is discussed in detail within U.S. Patent Publication No. US 2008/0167088 A1 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices".

[0316] FIGS. 67A and 67B show connector 6710 in accordance with an embodiment of the present invention. The face of connector 6710 can be shaped to include peak 6711. By incorporating peak 6711 into the connector face, connector 6710 is capable of mating with a headset in two different interface orientations (e.g., physical orientations) . When connector 6710 is installed in docking station 6700 (see FIG. 67B), peak 6711 creates cavities 6702 and 6704 which can each accept the long side 6721 of headset 6720. In the interface orientation shown in FIG. 67B, side 6721 of headset 6720 is in cavity 6704. However, if headset 6720 were inserted in another orientation, long side 6721 of the headset may be in cavity 6702. In either of these orientations, the contacts of connector 6710 can be electrically coupled with the contacts on headset 6720.

[0317] In some embodiments, switching circuitry can be included in headset 6720 to compensate for these different interface orientations. Such switching circuitry can determine the interface orientation of headset 6720 and connector 6710 and route signals received from the connector to pathways inside the headset (e.g., electrical traces) based on the determined orientation. In other embodiments, switching circuitry can be provided in docking station 6700 that can determine the interface orientation of connector 6710 and headset 6720 and route signals to the connector based on the determined orientation. A detailed discussion of similar switching circuitry can be found in U.S. Patent Publication No. US 2008/0167828 A1 entitled "Systems and Methods for Determining the Configuration of Electronic Connections".

[0318] Similar to the elevated face 6212 and recessed perimeter 6214 shown in FIG. 62B, raised face 6712 and recessed perimeter 6714 can be advantageous when coupling a headset (see e.g., headset 1000 of FIGS. 10A and 10B) to connector 6710. For example, raised face 6712 and recessed perimeter 6714 can provide structural features that strengthen the mechanical coupling of connector 6710 and a headset.

[0319] FIG. 68 shows chart 6800 listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. With regards to chart 6800, a communications system can include a headset (e.g,. headset 10 of FIG. 1) and a host device (e.g., a cellular telephone, a laptop computer, etc.) . Further defining the communications system referenced in chart 6800, the headset can be in communication with the host device and the host device can be communicating with other devices through a cellular network or other communications network (e.g., Voice over Internet Protocol).

[0320] Chart 6800 includes rows describing exemplary-modes and functions of the system and columns identifying inputs and outputs that correspond to each mode or function. Some of the functions listed in column 6810 typically occur when a system is in a certain mode, and therefore, these functions can be listed under their respective modes. For example, the answer call function 6812 and the reject call function 6813 are typically executed when a system is in incoming call mode 6811 and chart 6800 can reflect this by listing functions 6812 and 6813 directly under incoming call mode 6811.

[0321] For each row corresponding to a function, column 6820 can be used to identify an input that can cause that function to occur. For example, column 6820 may identify a manner in which a user can press a single button on a headset (see e.g., button 14 of FIG. 1) to initiate a corresponding function. It is understood that the initiated function may further depend on the mode in which a headset is in. For example, a long button press may initiate the reject call function 6813 if a system is in incoming call mode 6811, while the same type of button press may initiate function 6814 if the system is in another mode.

[0322] Outputs can be associated with each mode or function so that, for example, a user can be aware of a system's operation. Such outputs may be provided through a headset display system (see e.g., display system 18 of FIG. 1), a headset audio system (e.g., speaker system 13 of FIG. 1), and/or host device user interface (UI). A display screen and a speaker on a host device can, for example, be part of a host device UI used to provide outputs. Column 6830 lists outputs that can be provided by a headset display system to correspond with modes or functions listed in column 6810. For example,

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if a headset's display system includes an indicator that can output different colors using LEDs, column 6830 can include different colors and/or flashing patterns that the indicator can output based on the communication systems mode or function. Column 6840 lists outputs that can be provided by a headset audio system (e.g., a speaker) based on the communication system's mode or function. Column 6840 can, for example, include beeps, tones, or other noises that can be used to notify the operation of the communications system. Column 6850 lists outputs that can be provided by a Host Device UI. For example, column 6850, may include outputs that can be presented through a display screen on a host device.

[0323] In summary, chart 6800 identifies the inputs and outputs corresponding to various exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. For example, when a communications system is in incoming call mode 6811, the system's headset (e.g., headset 10 of FIG. 1) can display a slow blinking green light and output two beeps while the system's host device can display an incoming call screen (e.g., a graphic displaying information about the incoming call). Continuing the example, if a user presses a button on the headset (e.g., button 14 of FIG. 1) for a short amount of time, the system can answer the call while the headset displays a green light and outputs a short low tone followed by a short high tone. While the system is answering the call, the host device can display a call answer screen. It is understood that the modes and functions shown in FIG. 68 and discussed above are merely exemplary and that communication systems can operate using other modes and functions without deviating from the scope of the present invention.

[0324] Although particular embodiments of the present invention have been described above in detail, it will be understood that this description is merely for purposes of illustration. Alternative embodiments of those described herein are also within the scope of the present invention. For example, while one embodiment can include a Bluetooth headset, one or more features of the present invention also can be incorporated into headsets employing other wired and/or wireless communication protocols. Also, while some embodiments of the present invention can include headsets configured for communication with a cellular phone and/or personal media device (e.g., a portable media player similar to that sold under the trademark iPod® by Apple Inc. of Cupertino, California), one or more features of the present invention can also be incorporated into headsets configured for communication with any electronic device. Furthermore, while one embodiment illustratively described above can include a headset and methods for fabricating the same, one or more features of the present invention can also be incorporated into other electronic devices that require, e.g., circuit boards distributed within small acoustic volumes, symmetric connectors, extruded housings having one or more internal features, microperforations, co-located microphones and connectors, magnetic connectors, or any combination thereof.

[0325] Various configurations described herein may be combined without departing from the present invention. The above described embodiments of the present invention are presented for purposes of illustration and not of limitation. The present invention also can take many forms other than those explicitly described herein. Accordingly, it is emphasized that the invention is not limited to the explicitly disclosed methods, systems and apparatuses, but is intended to include variations to and modifications thereof which are within the scope of the following claims

Additional Statements Relevant to the Invention

[0326] There is provided a wireless headset device comprising: an earbud assembly comprising an earbud flexible circuit board having mounted thereon a receiver and processing circuitry; and a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a microphone and a primary housing flexible circuit board electrically coupled to the earbud circuit board and the microphone.

[0327] Preferably further comprising a neck assembly that fixes the earbud assembly to the primary housing assembly. Preferably the neck assembly comprising a through-hole through which a portion of the earbud flexible circuit board passes through to electrically connect to the primary housing circuit board .

[0328] Preferably wherein the earbud circuit board comprises traces for electrically coupling at least the receiver and the processing circuitry.

[0329] Preferably wherein the processing circuitry is operative to execute wireless communication processes.

[0330] Preferably wherein the processing circuitry is operative to process Bluetooth communication processes.

[0331] Preferably wherein the primary-housing assembly further comprises: an antenna electrically coupled to the primary housing circuit board.

[0332] Preferably wherein the primary housing assembly further comprises: a switch electrically coupled to the primary housing circuit board.

[0333] Preferably wherein the primary housing assembly further comprises: a connector assembly electrically coupled to the primary housing circuit board, the connector assembly operative to interface with a device other than the wireless headset device. Preferably wherein the connector assembly comprises: a multiple-pin symmetrical magnetic connector.

[0334] Preferably wherein the primary housing assembly further comprises: a battery electrically coupled to the primary housing circuit board.

[0335] Preferably further comprising: a thermistor in communication with and operative to provide the processing circuitry with a battery temperature signal.

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Preferably wherein the processing circuitry is operative to adjust a battery-charging rate based on the battery temperature signal.

[0336] Preferably wherein the primary housing circuit board comprises circuitry mounted thereon.

[0337] Preferably wherein the circuitry mounted on the primary housing circuit board comprises switching circuitry. Preferably wherein the circuitry mounted on the primary housing circuit board comprises adaptive battery charging circuitry.

[0338] There is provided a wireless headset device comprising: an earbud assembly comprising an earbud flexible circuit board; and a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a battery retaining region and a primary housing flexible circuit board, wherein circuit board components and circuitry are selectively mounted on the earbud flexible circuit board and the primary housing flexible circuit board to maximize a size of the battery retaining region.

[0339] Preferably wherein the earbud flexible circuit board is electrically coupled to the primary housing flexible circuit board.

[0340] There is provided a wireless headset device comprising: an earbud assembly; and a primary housing assembly having predetermined dimensions fixed to the earbud assembly, wherein the earbud assembly and the primary housing assembly each have mounted therein a flexible circuit board comprising circuitry.

[0341] Preferably wherein a distribution of circuitry among each flexible circuit board minimizes the predetermined dimensions.

[0342] Preferably wherein the wireless headset device is a Bluetooth wireless headset.

[0343] There is provided a headset device comprising: an earbud assembly; a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a connector assembly; and at least one flexible circuit board electrically coupled to the connector assembly, the at least one flexible circuit board comprising: Universal Serial Bus (USB) circuitry operative to process USB protocol communications; and serial circuitry operative to process serial protocol communications .

[0344] Preferably wherein the connector assembly is operative to interface with a device other than the headset device .

Claims

1. A wireless headset device (10) comprising:

   an earbud assembly (12) comprising an earbud flexible circuit board (522) and a processor (526) positioned within earbud assembly (12) and mounted on earbud flexible circuit board (522); and
   a primary housing assembly (510) coupled via a neck portion to the earbud assembly (12), the primary housing assembly (510) comprising:

      a battery (19);
      a microphone (17)positioned at an end of the primary housing assembly (510) opposite of the earbud assembly (12); and
      a primary housing flexible circuit board (512) electrically coupled to the earbud flexible circuit board (522), the battery (19), and the microphone (17), the primary housing flexible circuit board (512) being bent around the battery (19) to form a cavity (2012) to house the battery (19) so as to conserve space and extending within the primary housing assembly (510) to electrically connect with the microphone (17).

2. The device of claim 1, wherein the earbud flexible circuit board (522) is electrically coupled to the primary housing flexible circuit board (512).

Patentansprüche

1. Drahtlose Headset-Vorrichtung (10) umfassend:

   eine Ohrhörer-Anordnung (12), die eine Ohrhörer-flexible Leiterplatte (522) und einen Prozessor (526) umfasst, der innerhalb der Ohrhörer-Anordnung (12) positioniert ist und auf der Ohrhörer-flexiblen Leiterplatte (522) montiert ist; und
   eine Primär-Gehäuse-Anordnung (510), die über ein Halsteil mit der Ohrhörer-Anordnung (12) gekoppelt ist, wobei die Primär-Gehäuse-Anordnung (510) umfasst:

      eine Batterie (19);
      ein Mikrofon (17), der an einem Ende der Primär-Gehäuse-Anordnung (510) entgegengesetzt der Ohrhörer-Anordnung positioniert ist; und
      eine Primär-Gehäuse-flexible Leiterplatte (512), die elektrisch mit der Ohrhörer-flexiblen Leiterplatte (522), der Batterie (19) und dem Mikrofon (17) gekoppelt ist, wobei die Primär-Gehäuse-flexible Leiterplatte (512) um die Batterie (19) herum gebogen ist, um einen Hohlraum (2012) zu bilden, um die Batterie (19) aufzunehmen, um somit Platz zu sparen, und um sich innerhalb der Primär-Gehäuse-Anordnung (510) zu erstrecken, um sich elektrische mit dem Mikrofon (17) zu verbinden.

2. Vorrichtung nach Anspruch 1, wobei die Ohrhörer-flexible Leiterplatte (522) elektrisch mit der Primär-

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Gehäuse-flexiblen Leiterplatte (512) gekoppelt ist.

Revendications

1. Un dispositif de casque sans fil (10), comprenant :

   un bloc d'écouteur (12) comprenant une carte de circuit flexible d'écouteur (522) et un processeur (526) positionné au sein du bloc d'écouteur (12) et monté sur la carte de circuit flexible d'écouteur (522) ; et
   un bloc de boitier primaire (510) couplé via une partie de col au bloc d'écouteur (12), le bloc de boitier primaire (510) comprenant :

      une batterie (19) ;
      un microphone (17) positionné à une extrémité du bloc de boitier primaire (510) à l'opposé du bloc d'écouteur (12) ; et
      une carte de circuit flexible de boitier primaire (512) électriquement couplée à la carte de circuit flexible d'écouteur (522), à la batterie (19) et au microphone (17), la carte de circuit flexible de boitier primaire (512) étant courbée autour de la batterie (19) pour former une cavité (2012) pour loger la batterie (19) de manière à épargner l'espace et s'étendre au sein du bloc de boitier primaire (510) pour se connecter électriquement avec le microphone (17) .

2. Le dispositif de la revendication 1, dans lequel la carte de circuit flexible d'écouteur (522) est électriquement couplée à la carte de circuit flexible de boitier primaire (512).

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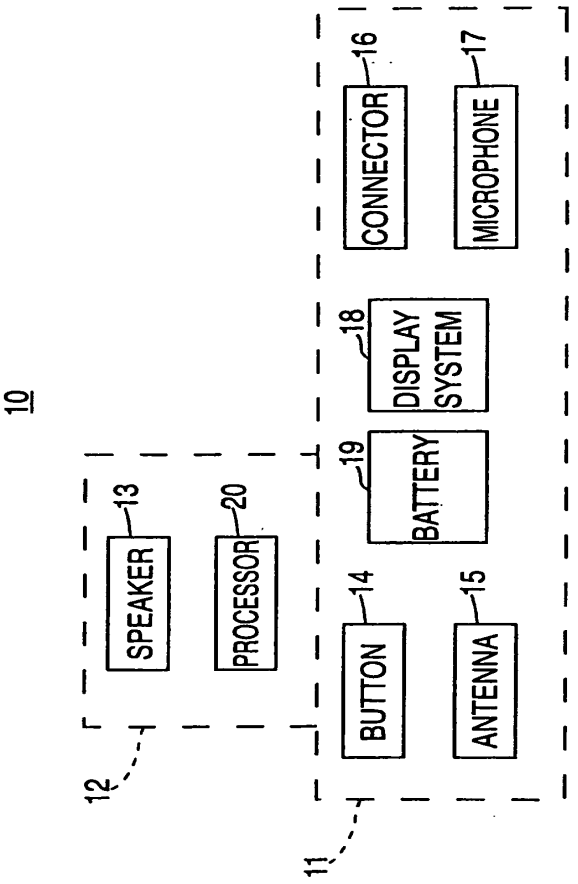


FIG. 1

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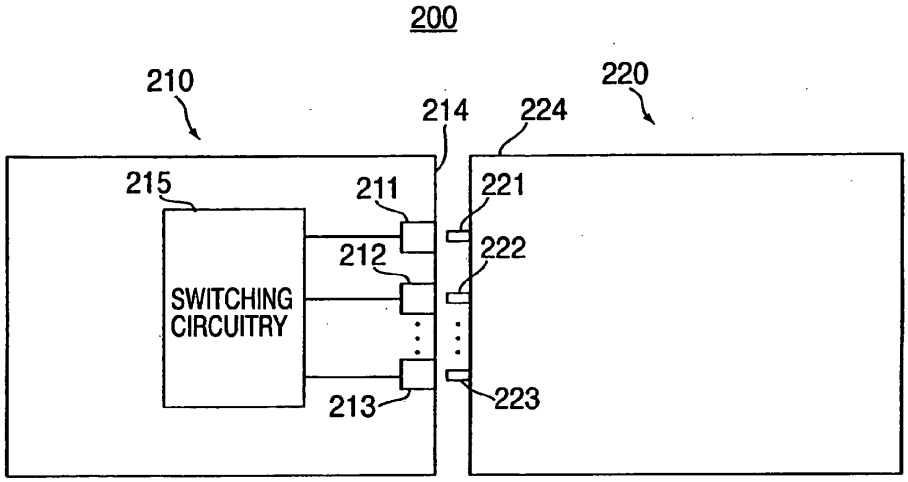

200
210
220
214
224
215
211
221
212
222
SWITCHING CIRCUITRY
213
223

FIG. 2

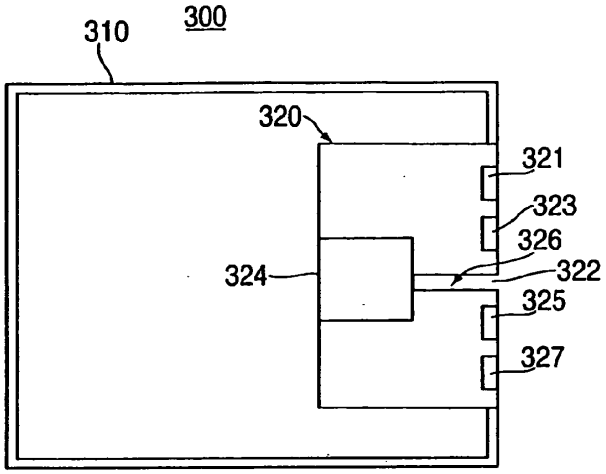


FIG. 3

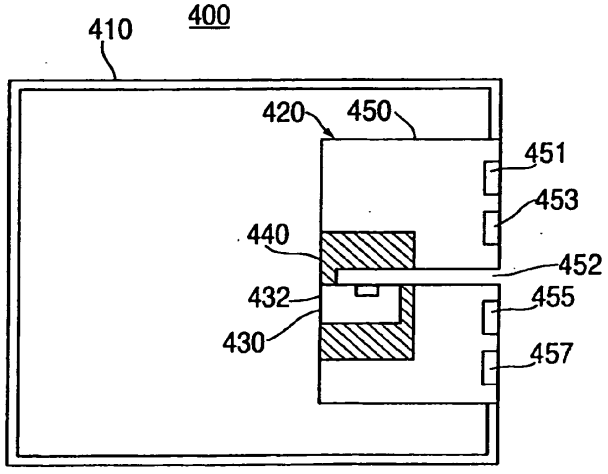


FIG. 4

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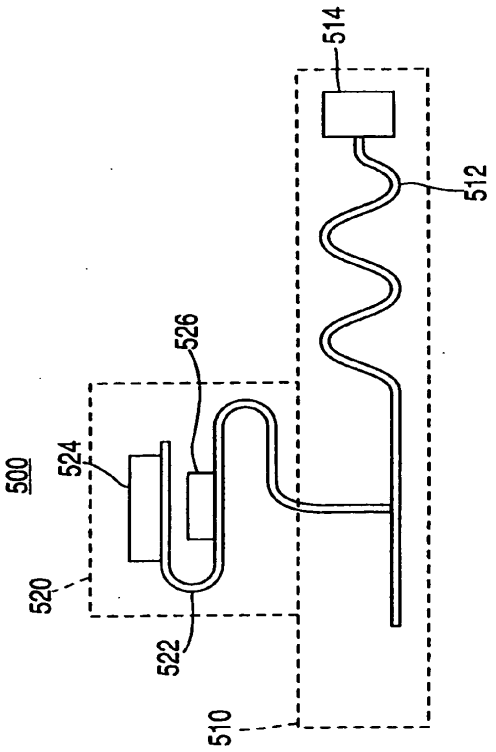


FIG. 5

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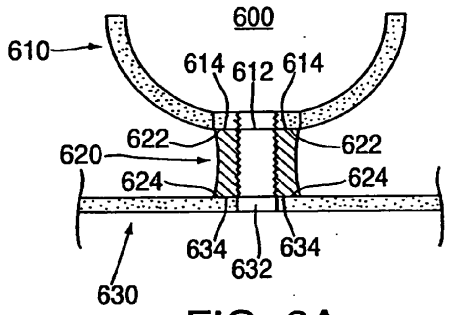

600
610
614
612
614
622
622
620
624
624
634
632
634
630

FIG. 6A

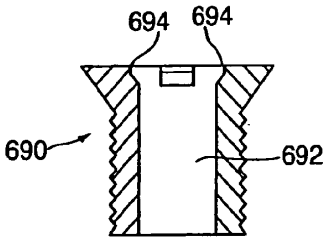

694
694
690
692

FIG. 6B

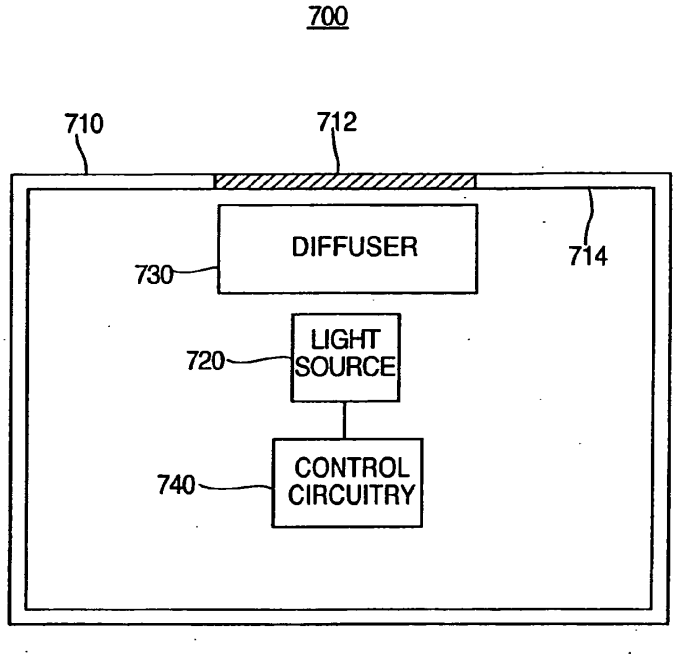


FIG. 7

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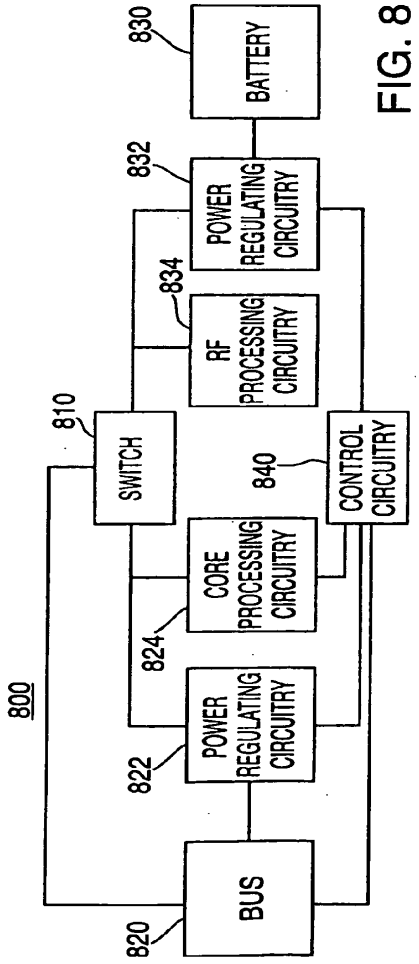


FIG. 8

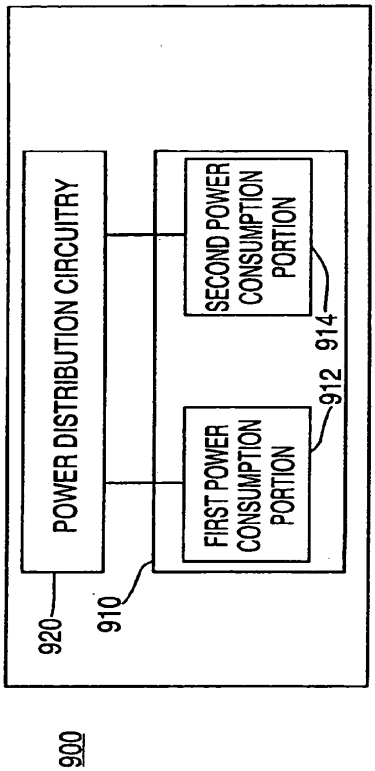


FIG. 9

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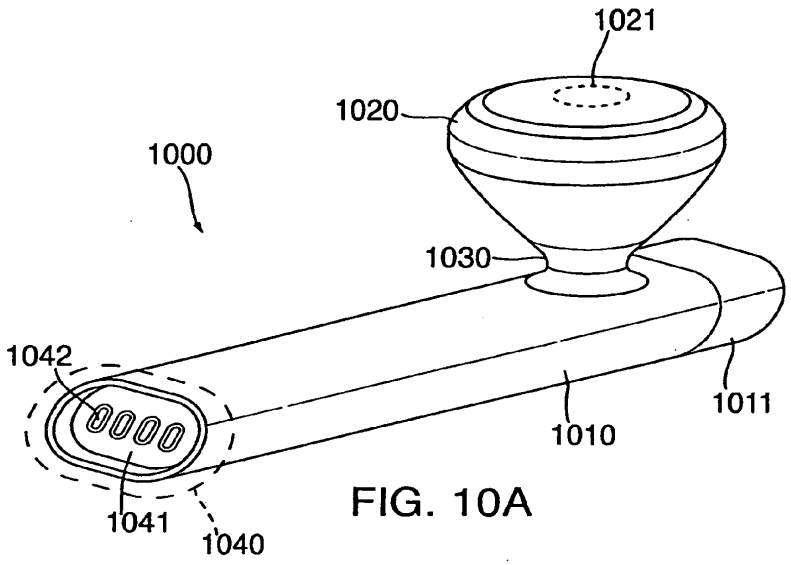


FIG. 10A

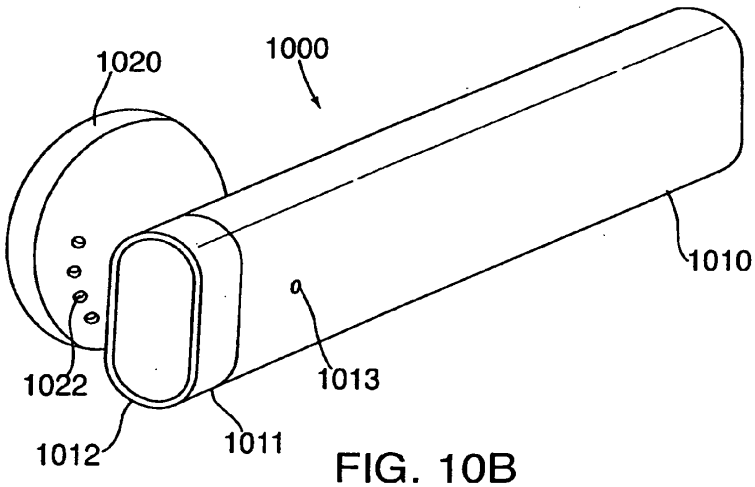


FIG. 10B

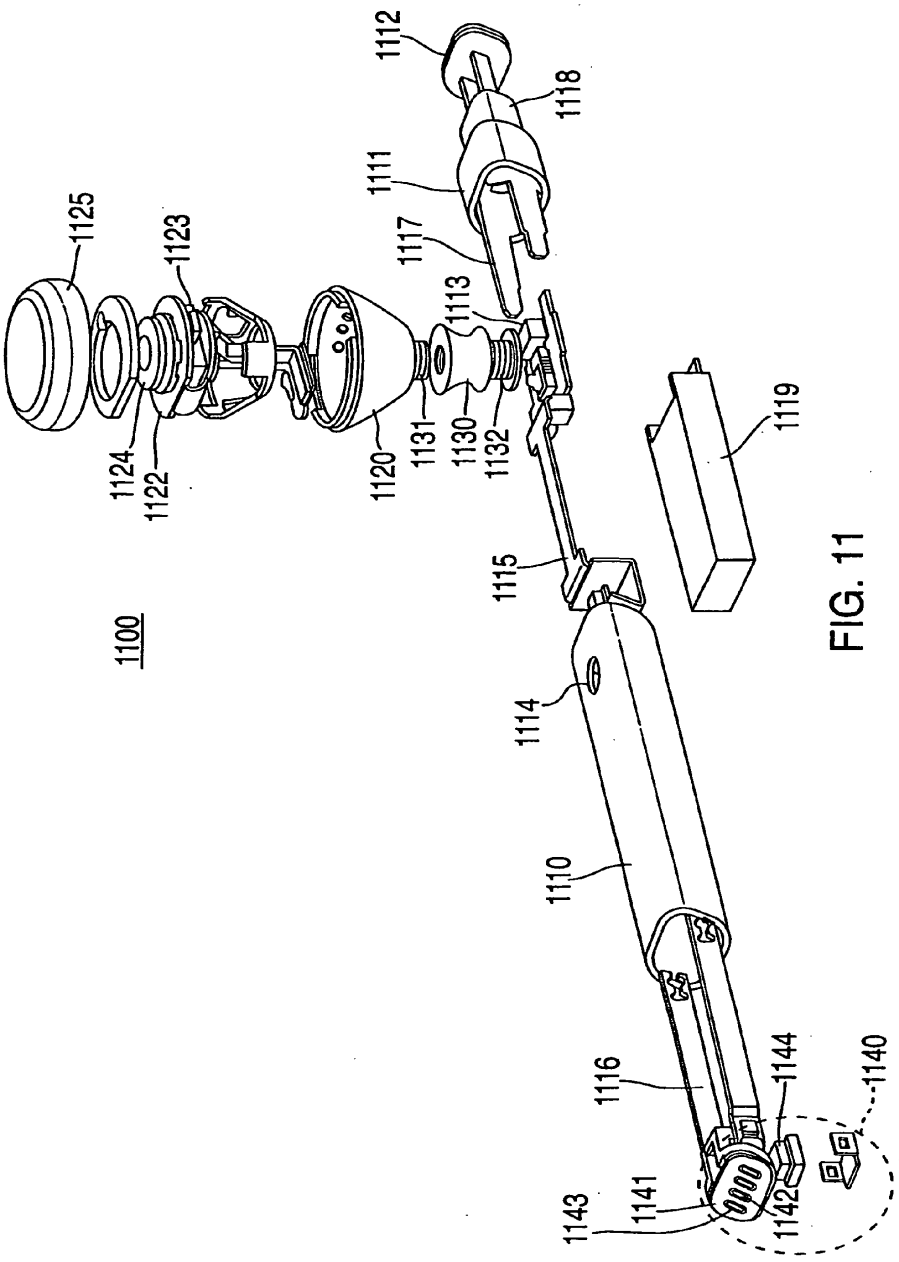

1112
1118
1111
1125
1123
1117
1113
1119
1124
1122
1120
1131
1130
1132
1115
1100
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1110
1116
1144
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1142

FIG. 11

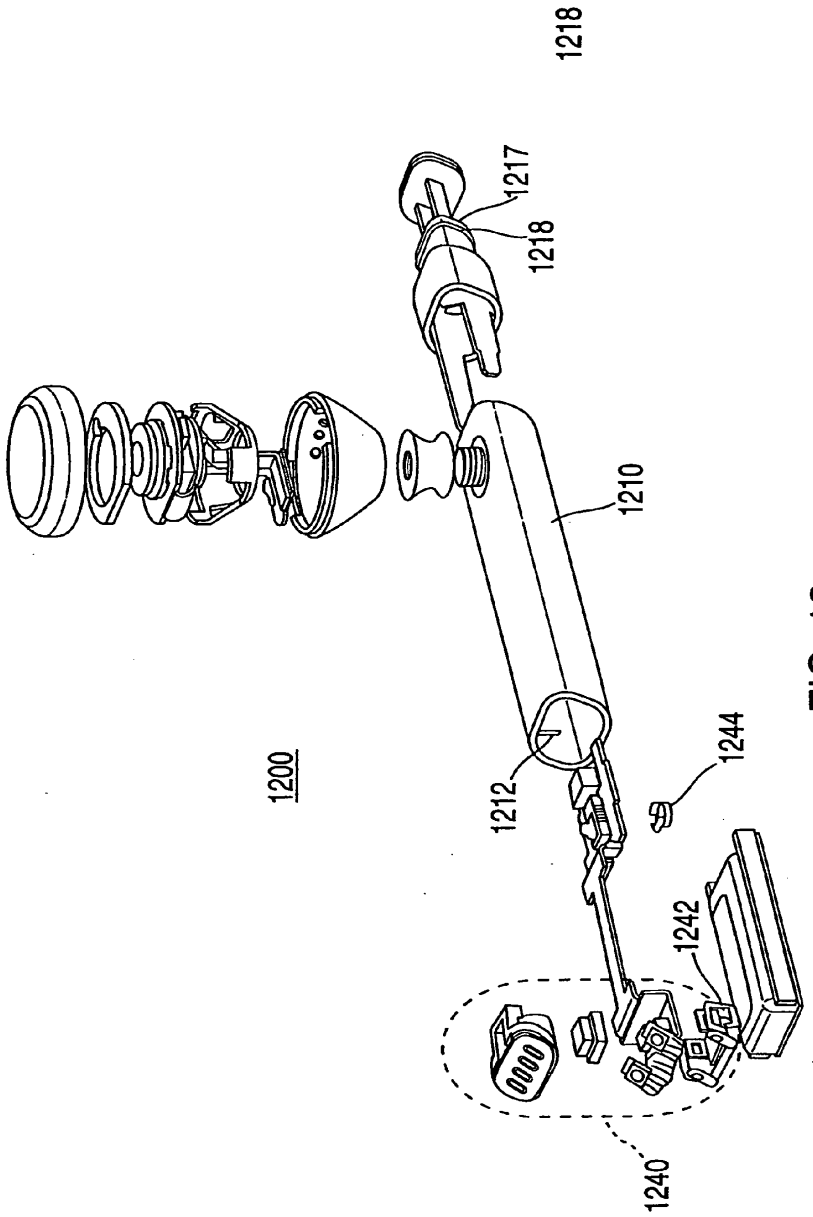


FIG. 12

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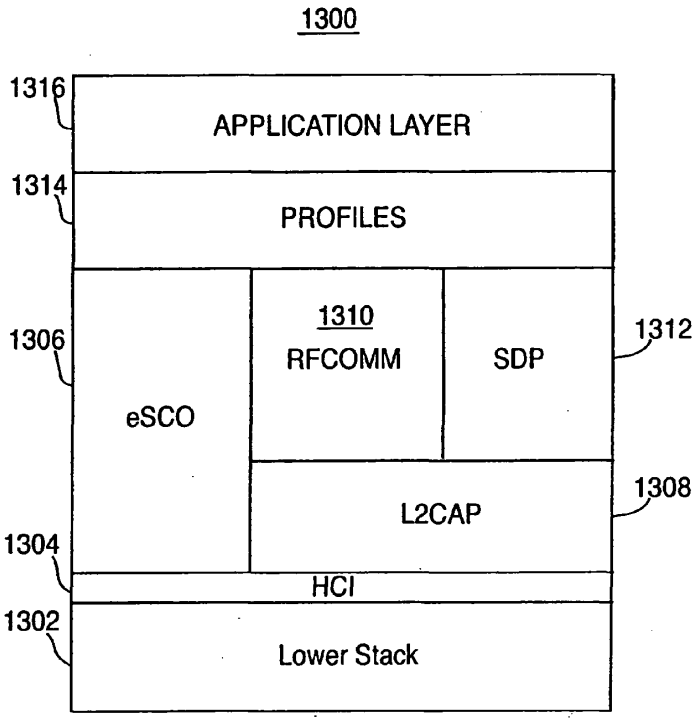


FIG. 13

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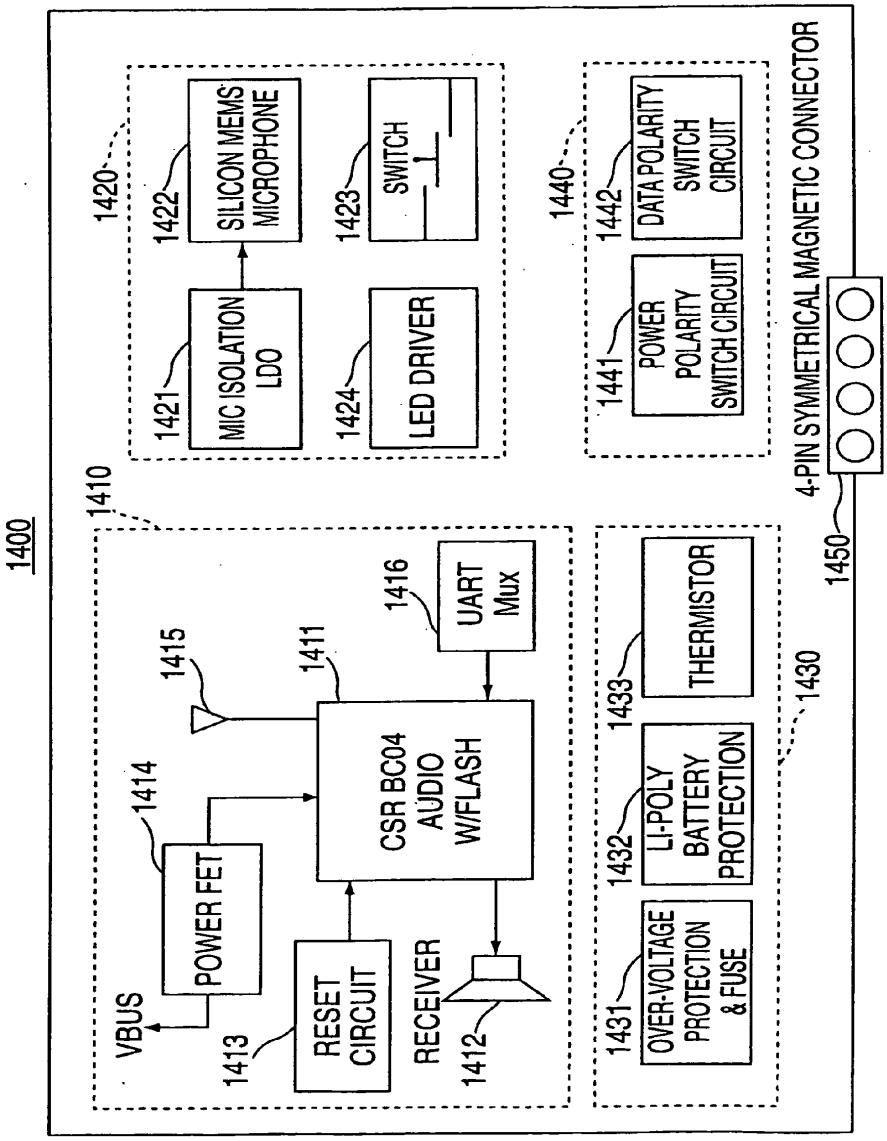


FIG. 14

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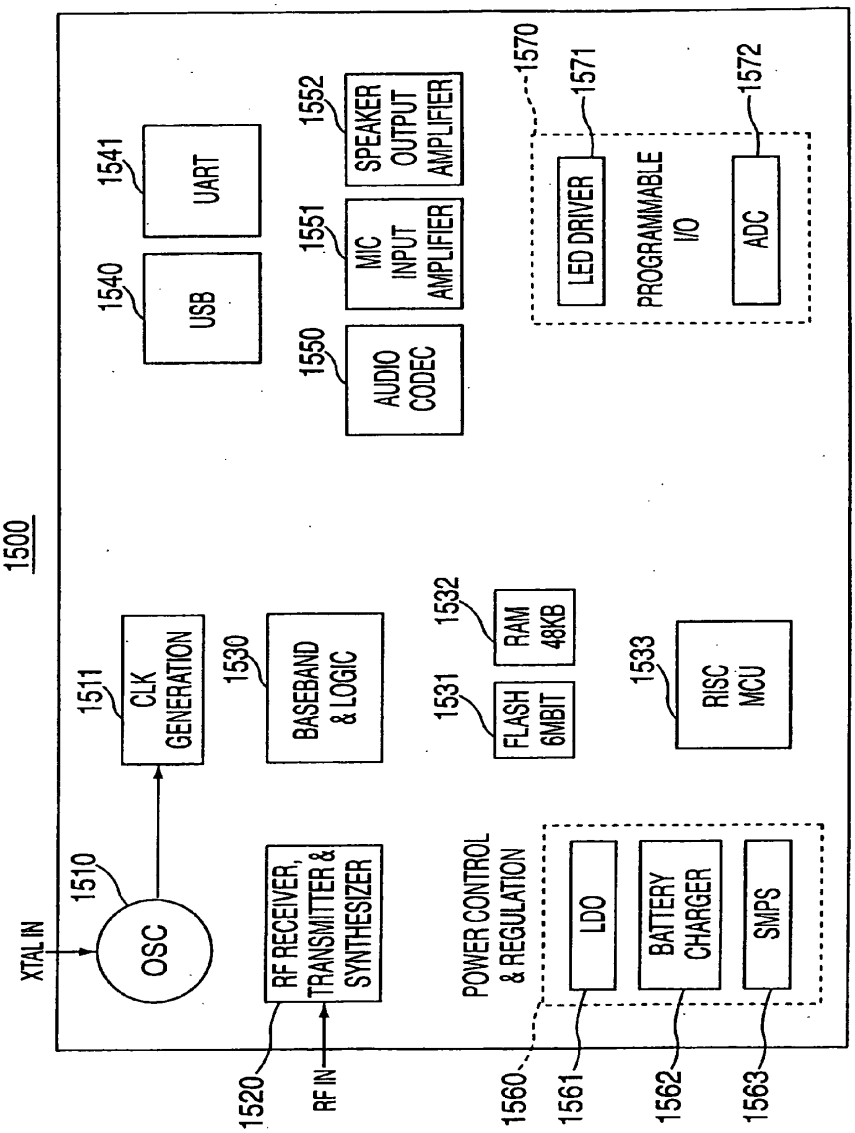


FIG. 15

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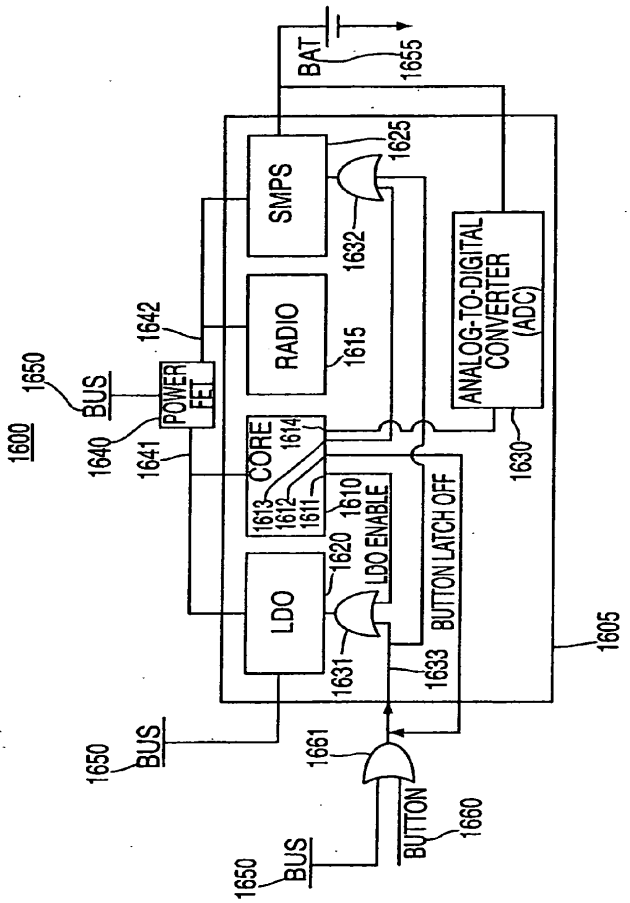

BAT
1655
SMPS
1625
1632
RADIO
1615
1642
1650
BUS
POWER FET
1640
1641
1600
CORE
1614
1613
1612
1611
1610
LDO ENABLE
1620
LDO
1631
1633
BUTTON LATCH OFF
ANALOG-TO-DIGITAL CONVERTER (ADC)
1630
1605
1650
BUS
1661
BUTTON
1660
1650
BUS

FIG. 16

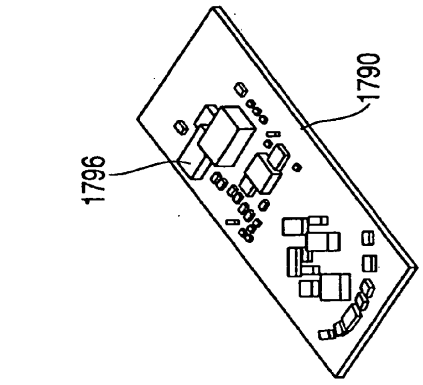


FIG. 17B
PRIOR ART

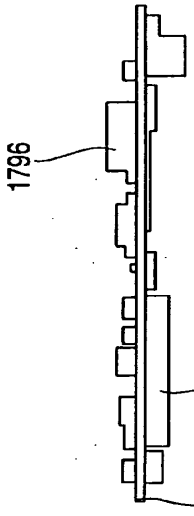


FIG. 17C
PRIOR ART

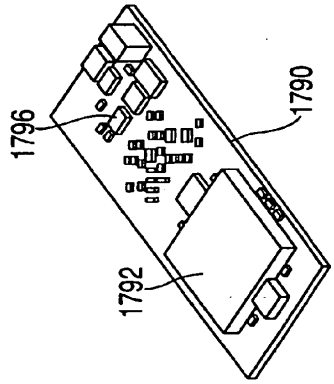


FIG. 17A
PRIOR ART

SONOVA EX1018
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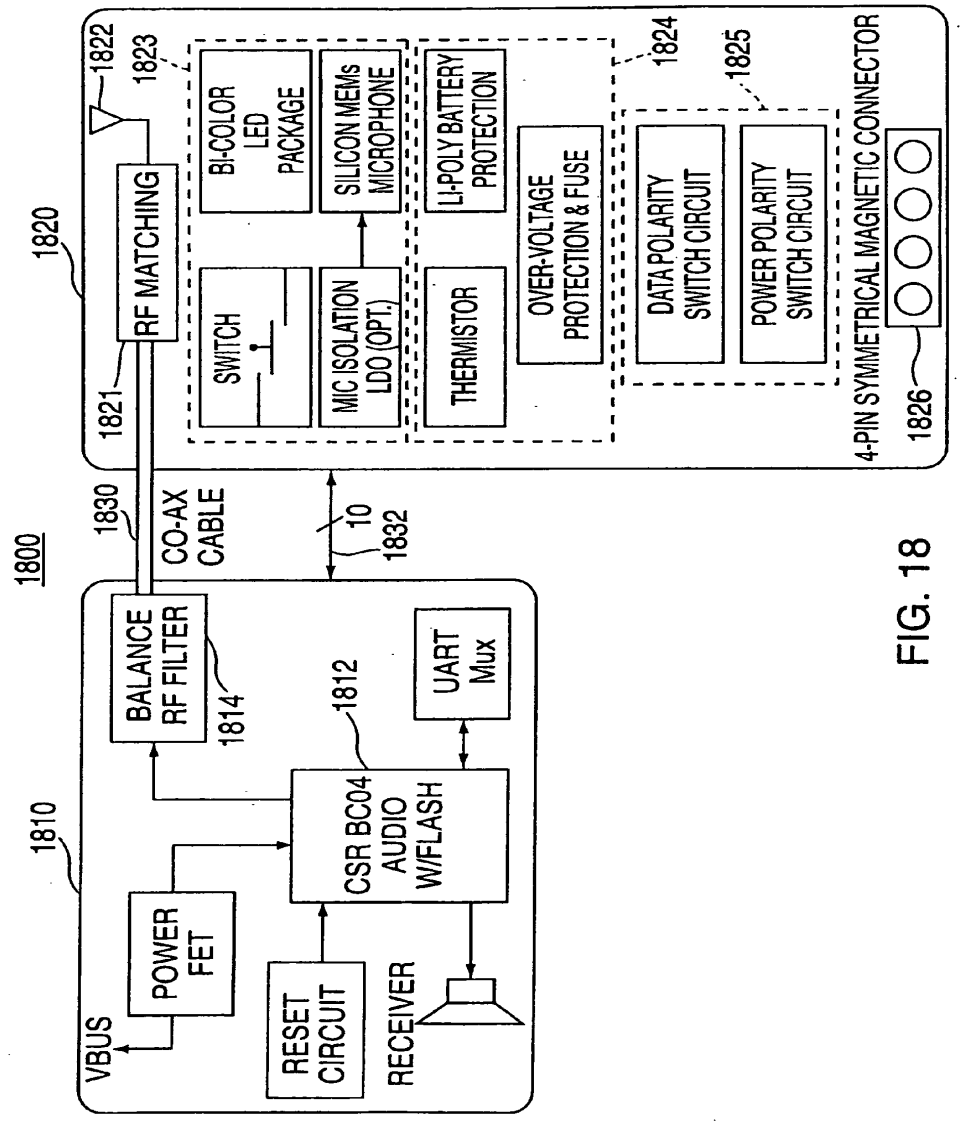


FIG. 18

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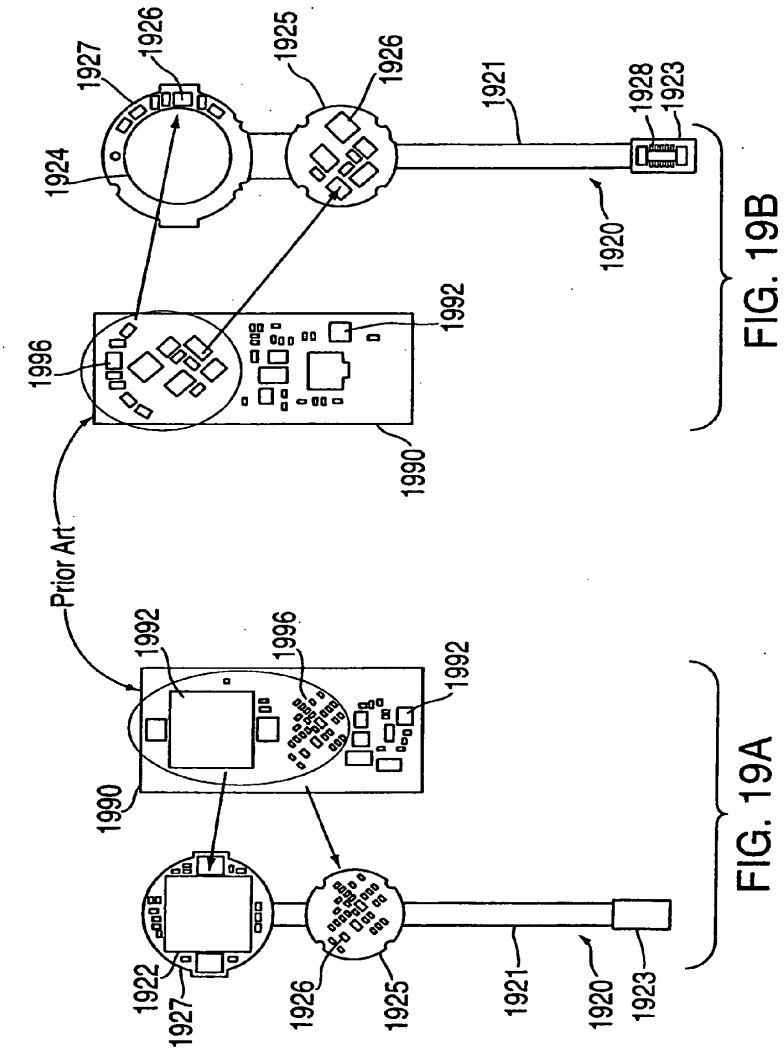


FIG. 19B

FIG. 19A

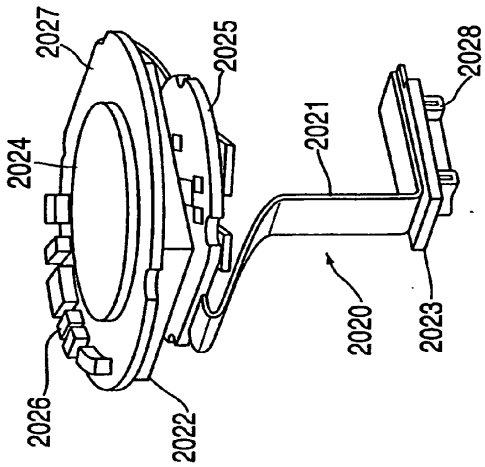


FIG. 20B

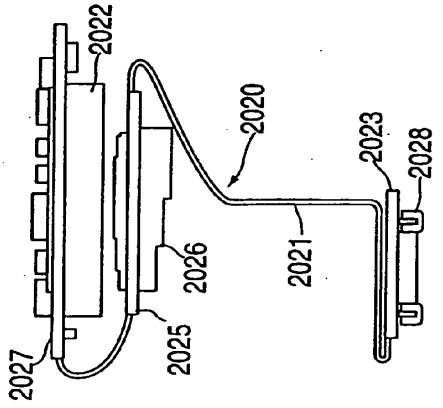


FIG. 20A

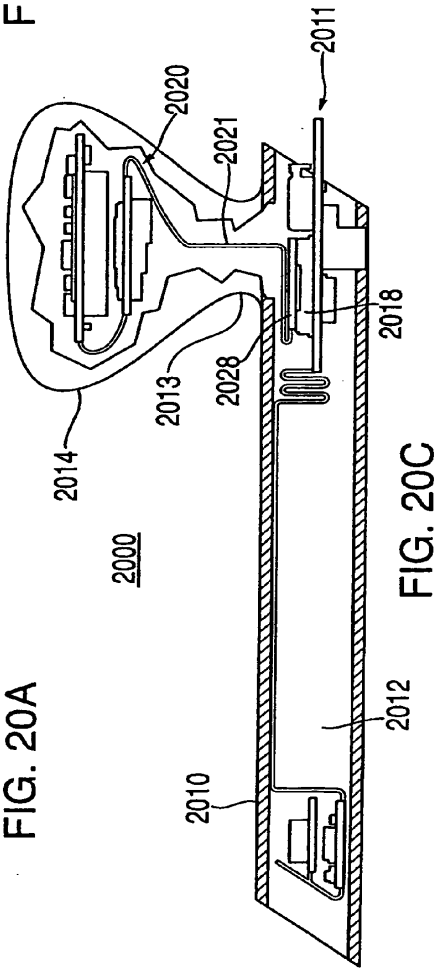


FIG. 20C

SONOVA EX1018
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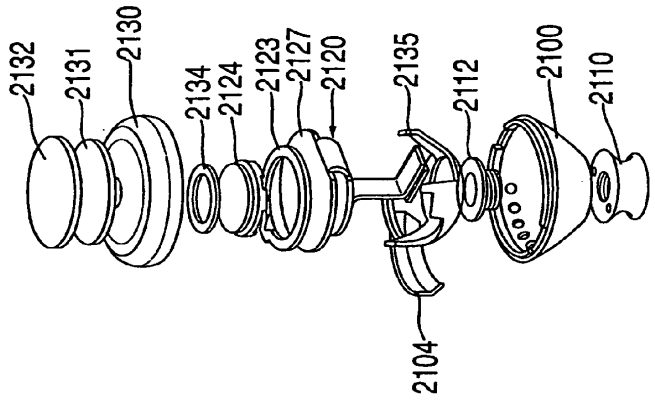


FIG. 21B

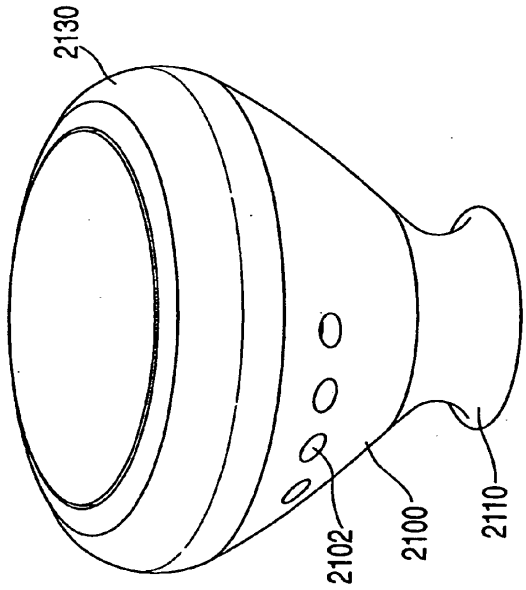


FIG. 21A

SONOVA EX1018
Page 60

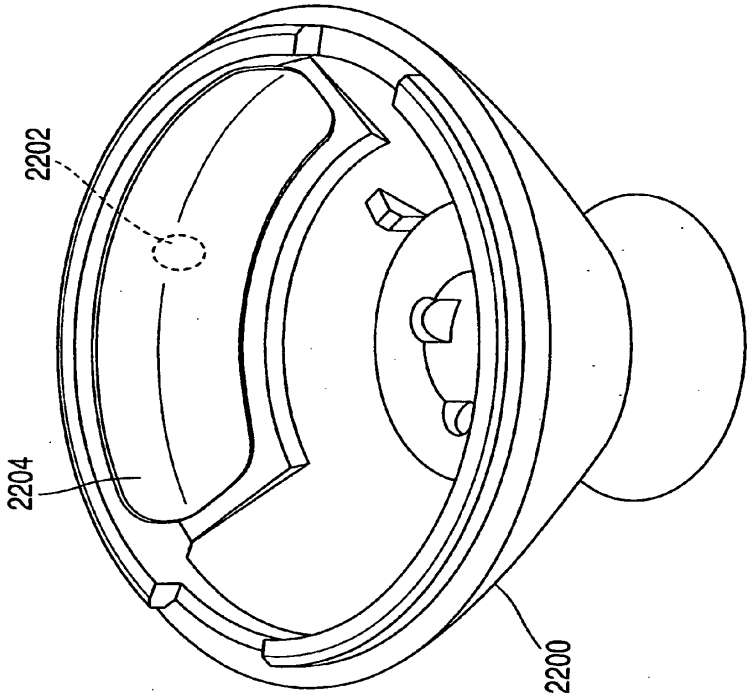


FIG. 22

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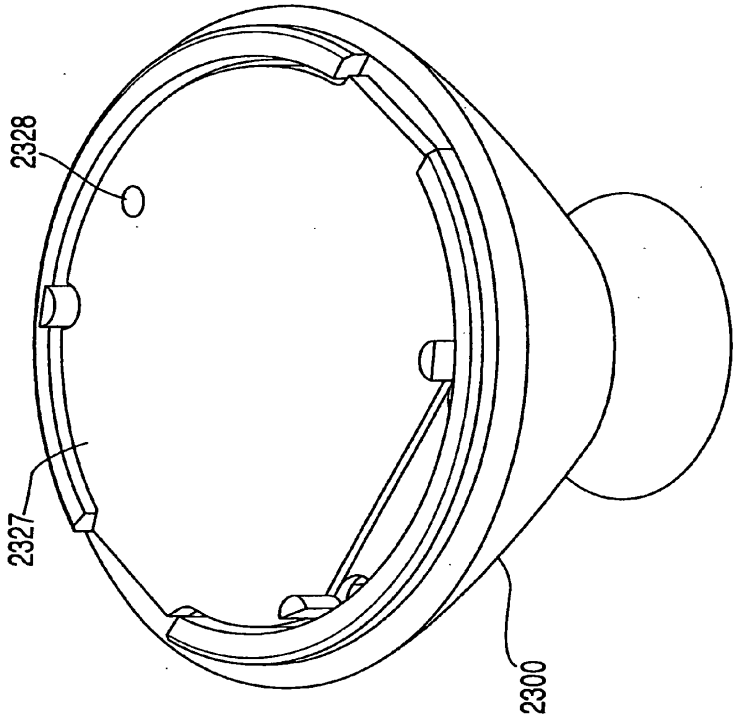


FIG. 23

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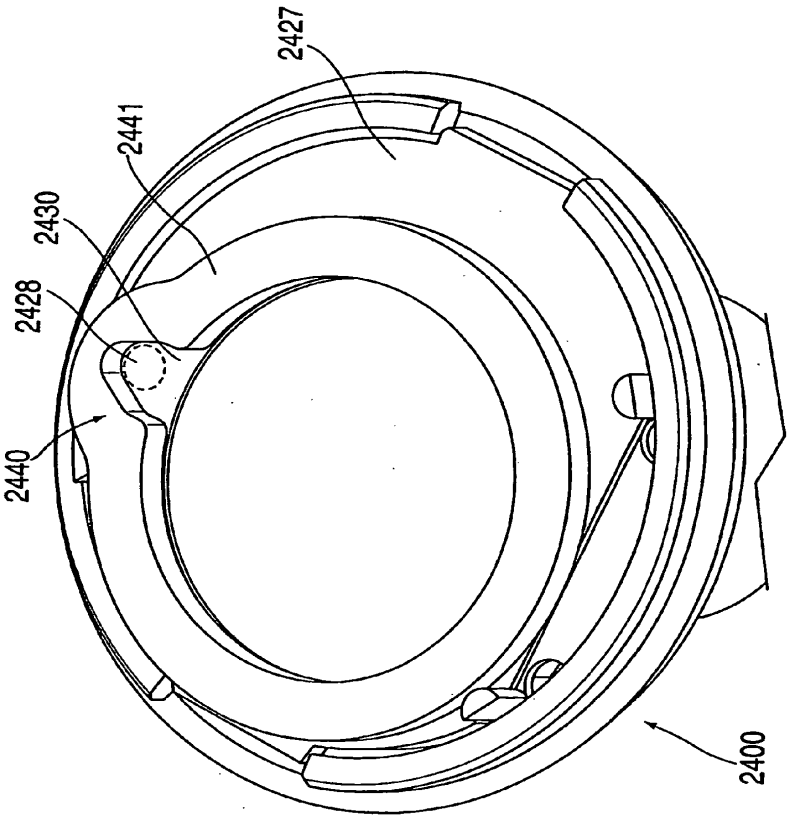


FIG. 24

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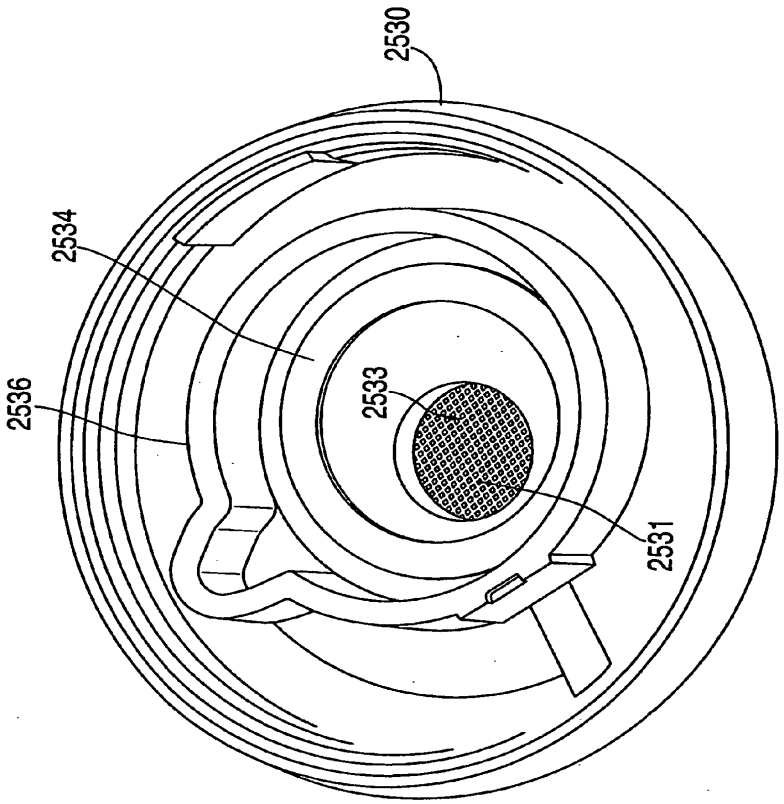


FIG. 25

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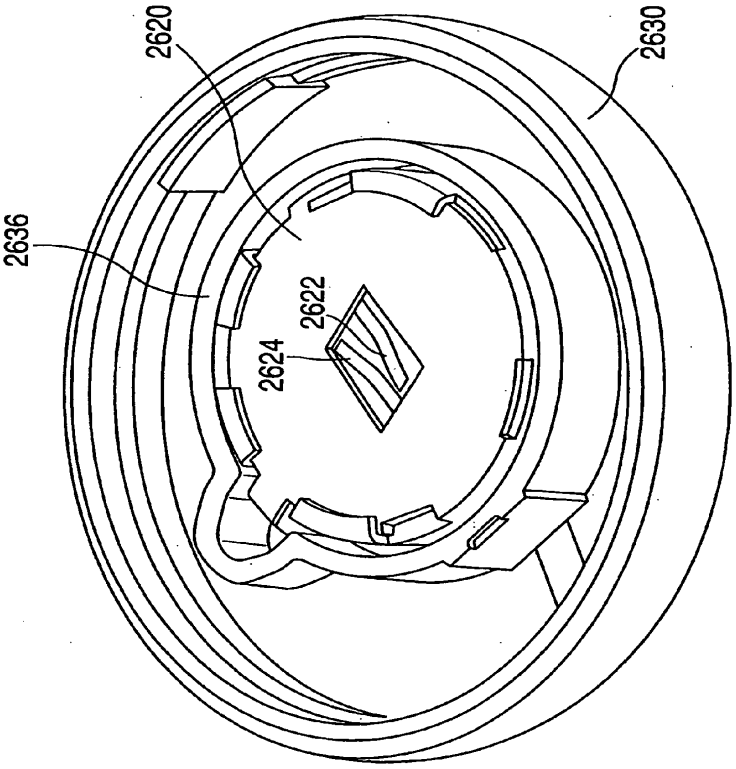


FIG. 26A

SONOVA EX1018
Page 65

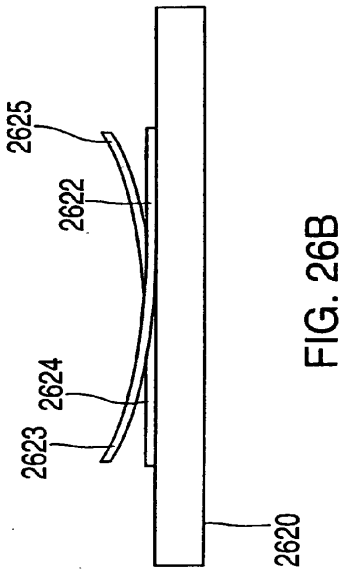


FIG. 26B

SONOVA EX1018
Page 66

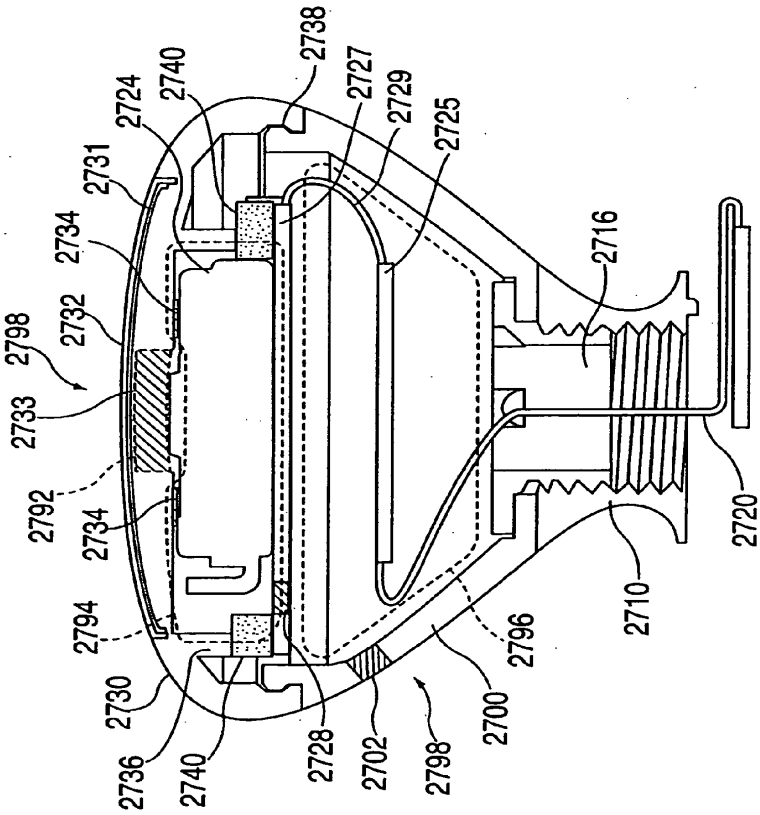


FIG. 27A

SONOVA EX1018
Page 67

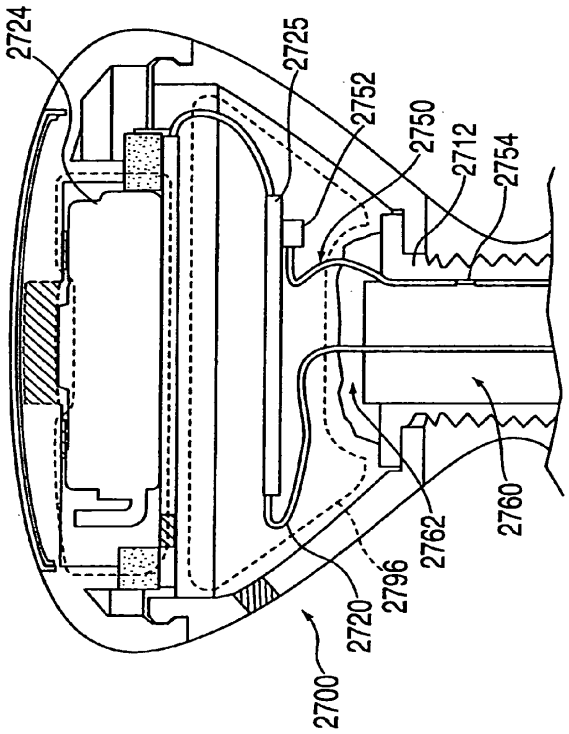


FIG. 27B

SONOVA EX1018
Page 68

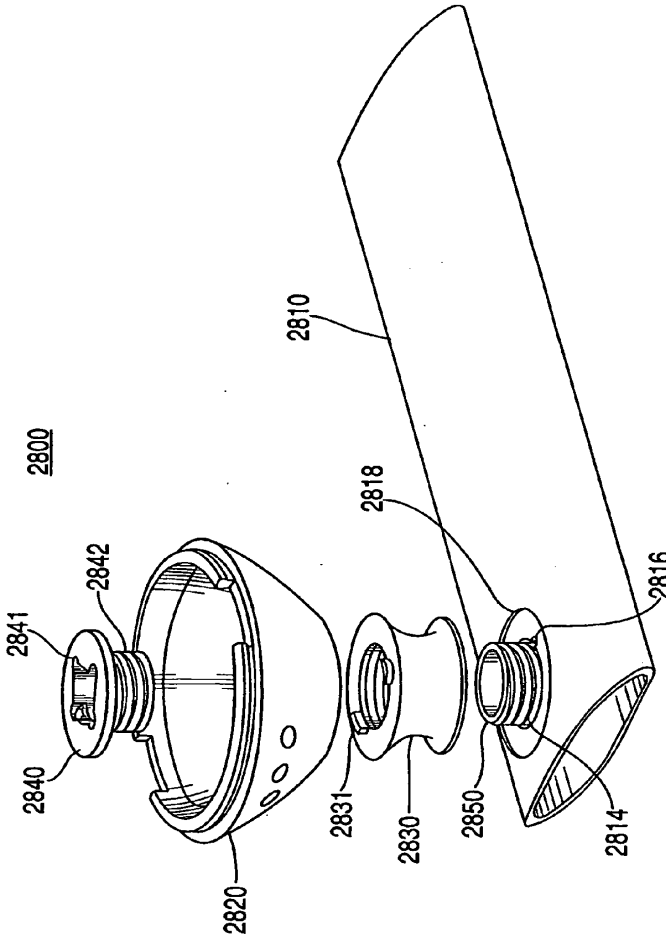


FIG. 28

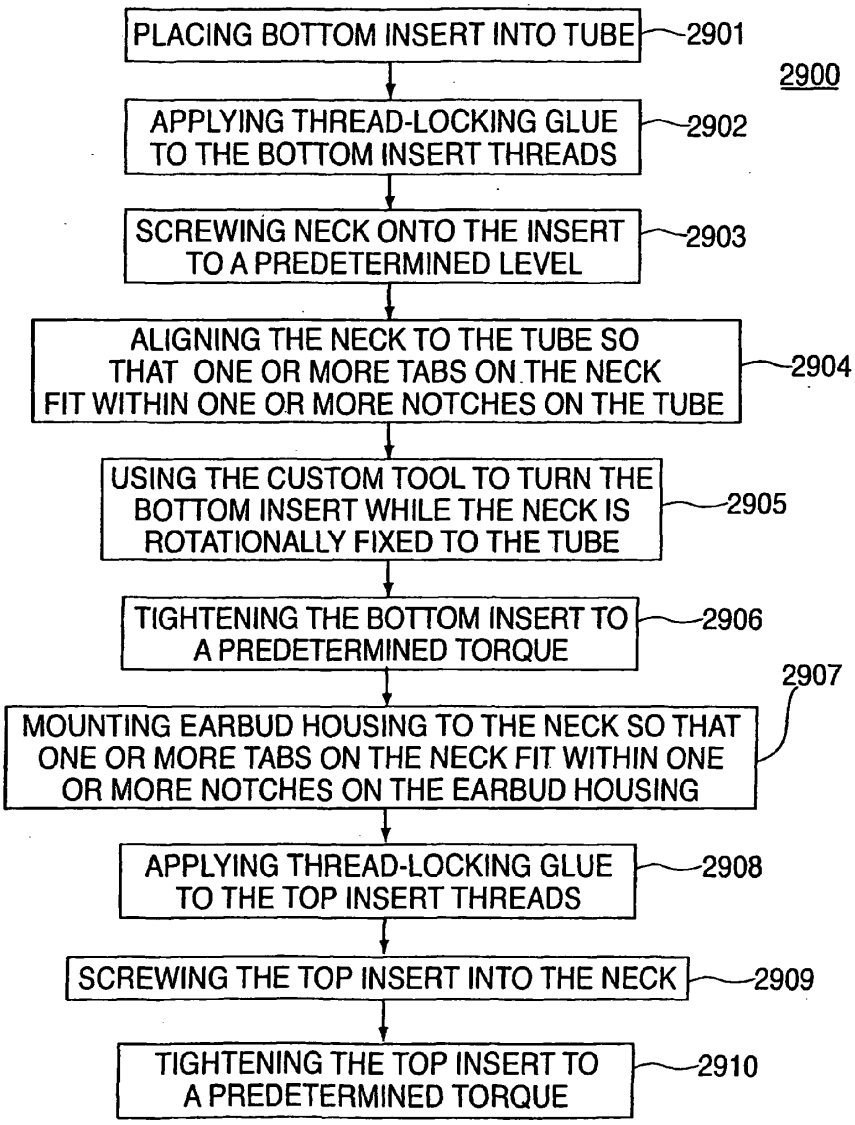


FIG. 29

SONOVA EX1018
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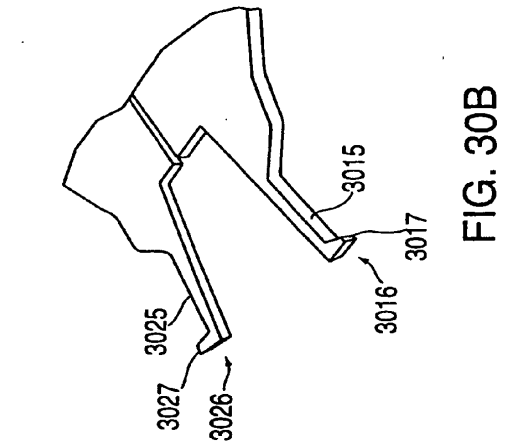


FIG. 30B

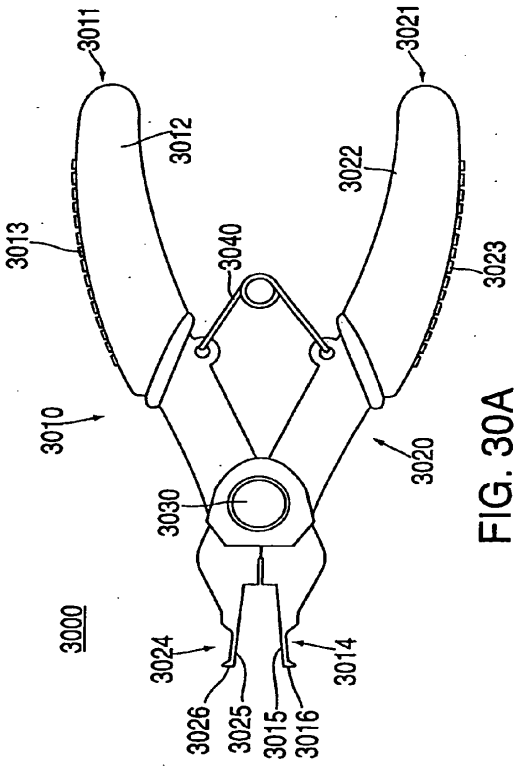


FIG. 30A

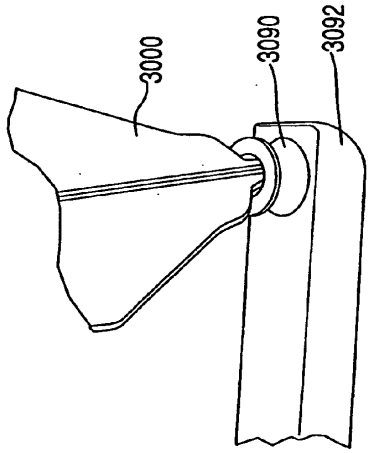


FIG. 30C

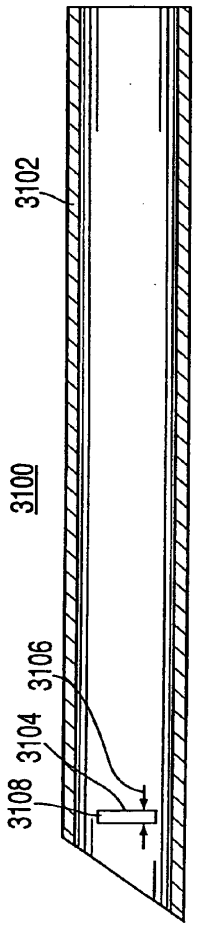


FIG. 31

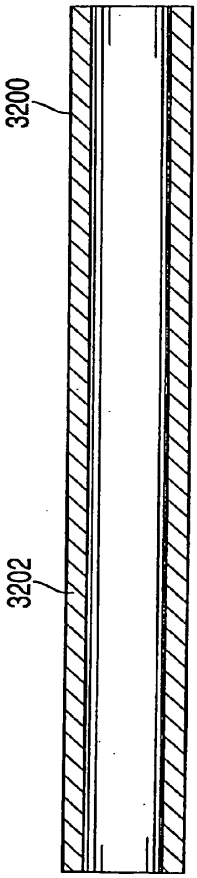


FIG. 32

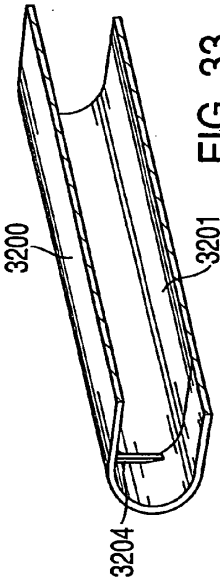


FIG. 33

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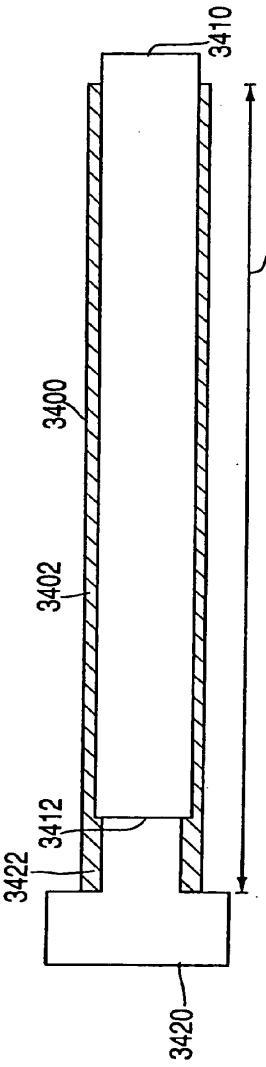


FIG. 34

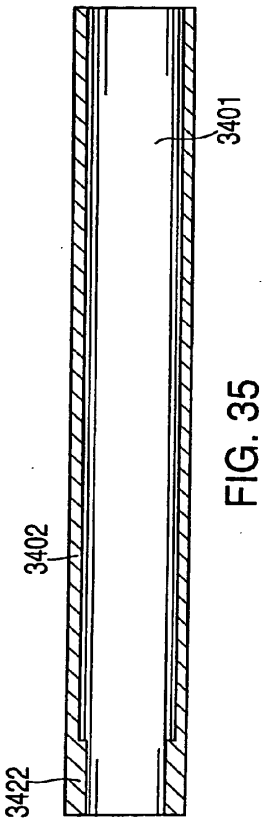


FIG. 35

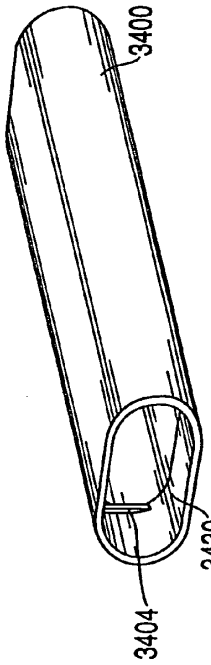


FIG. 36

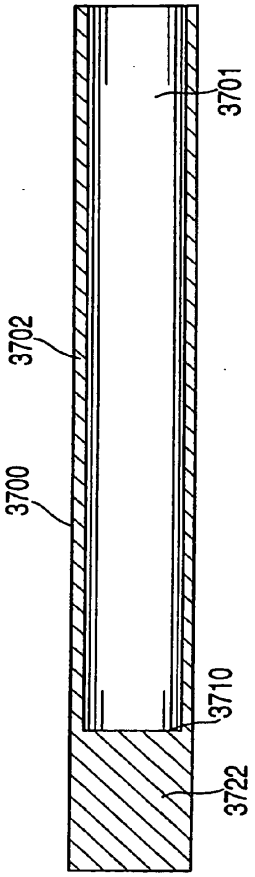


FIG. 37

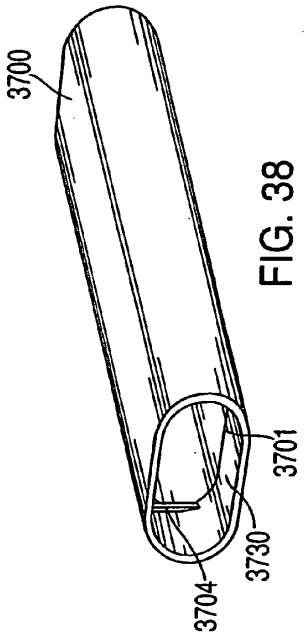


FIG. 38

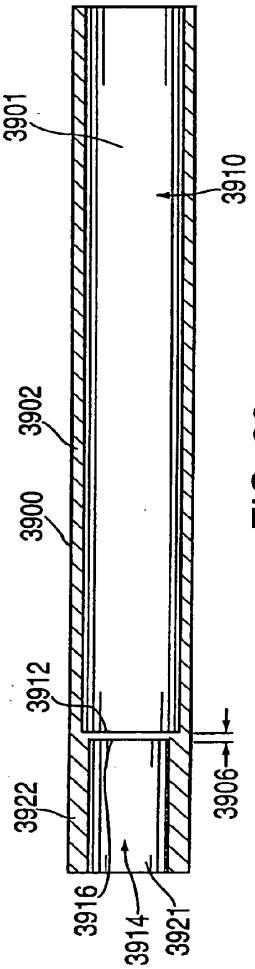


FIG. 39

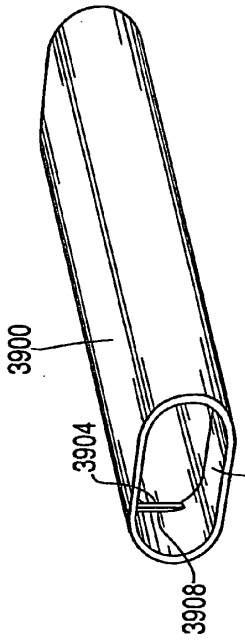


FIG. 40

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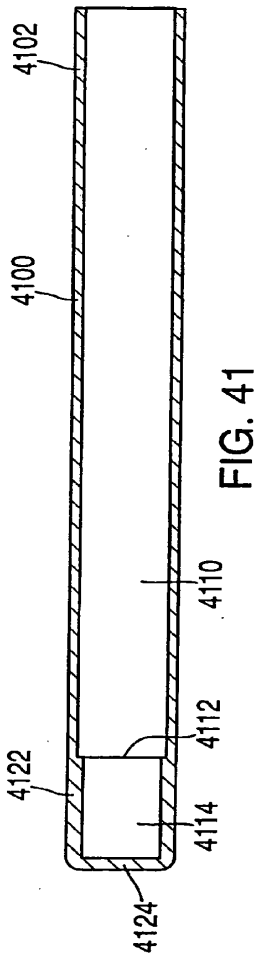


FIG. 41

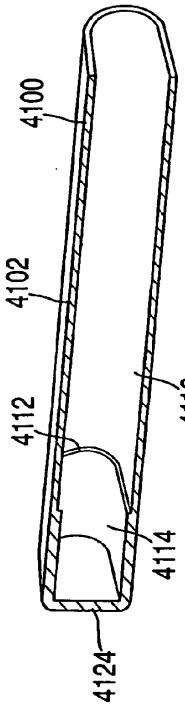


FIG. 42

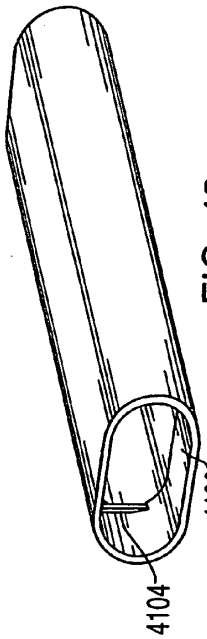


FIG. 43

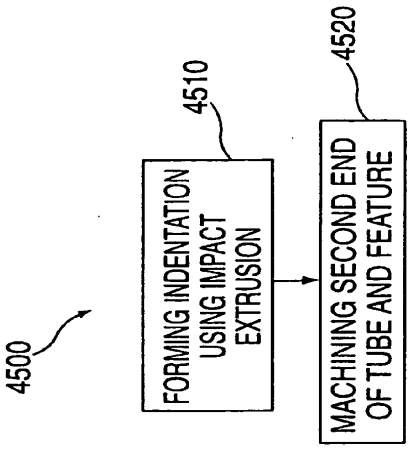


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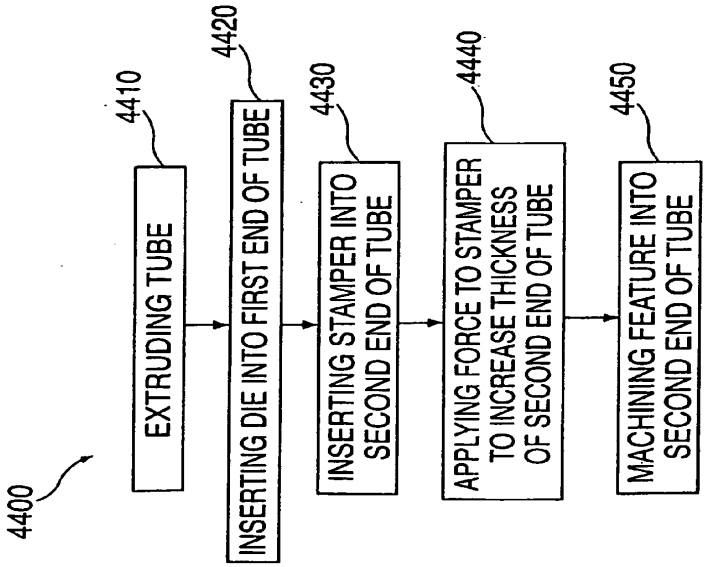


FIG. 44

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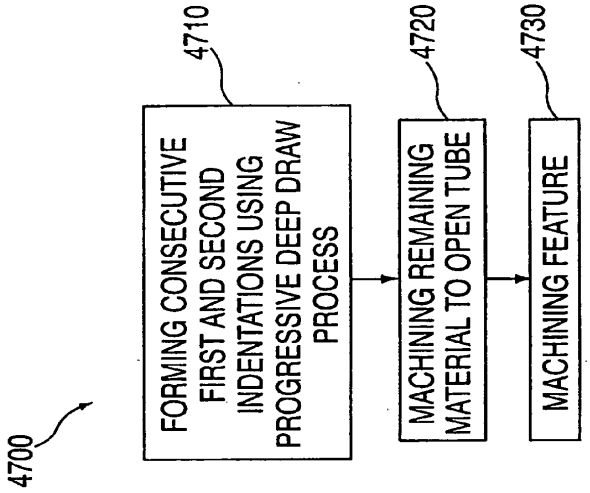


FIG. 47

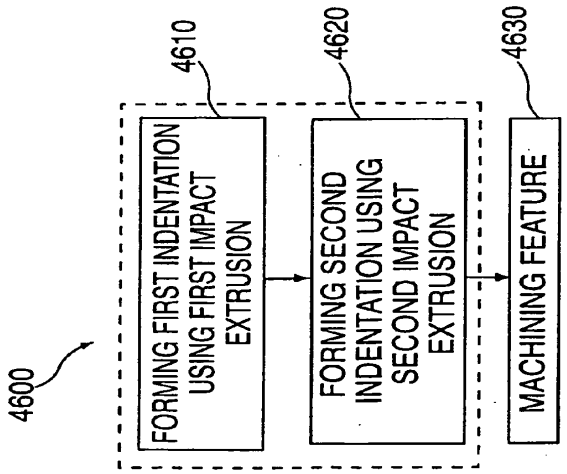


FIG. 46

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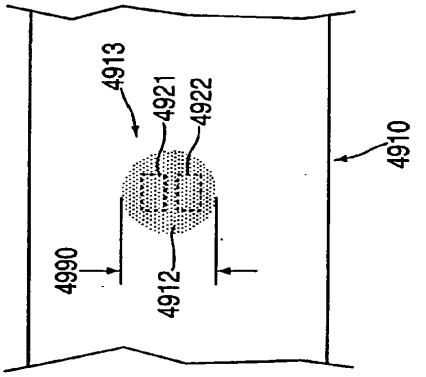

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FIG. 49

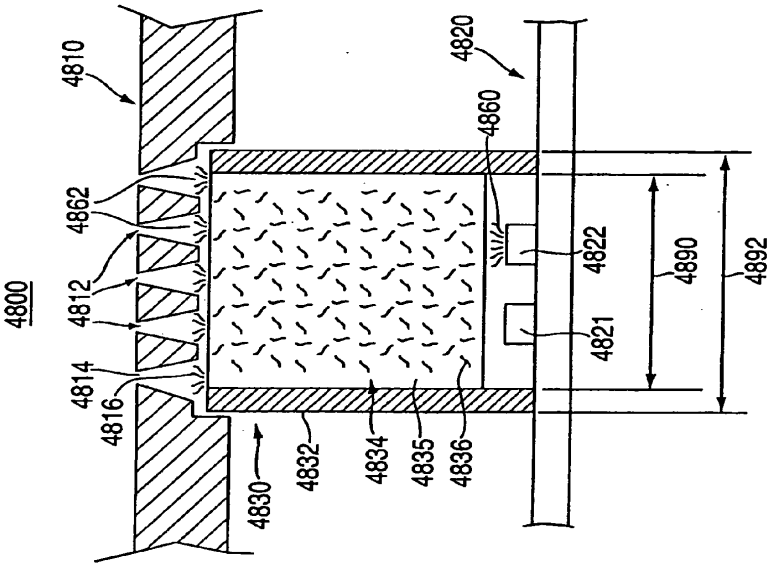

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FIG. 48

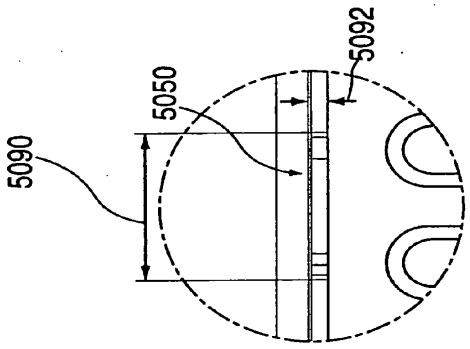


FIG. 50B

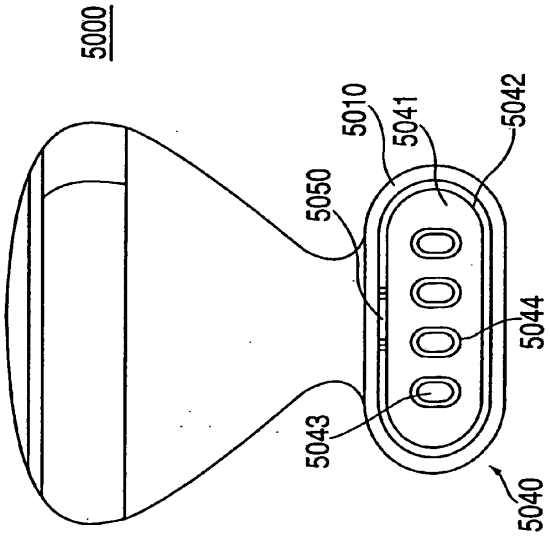


FIG. 50A

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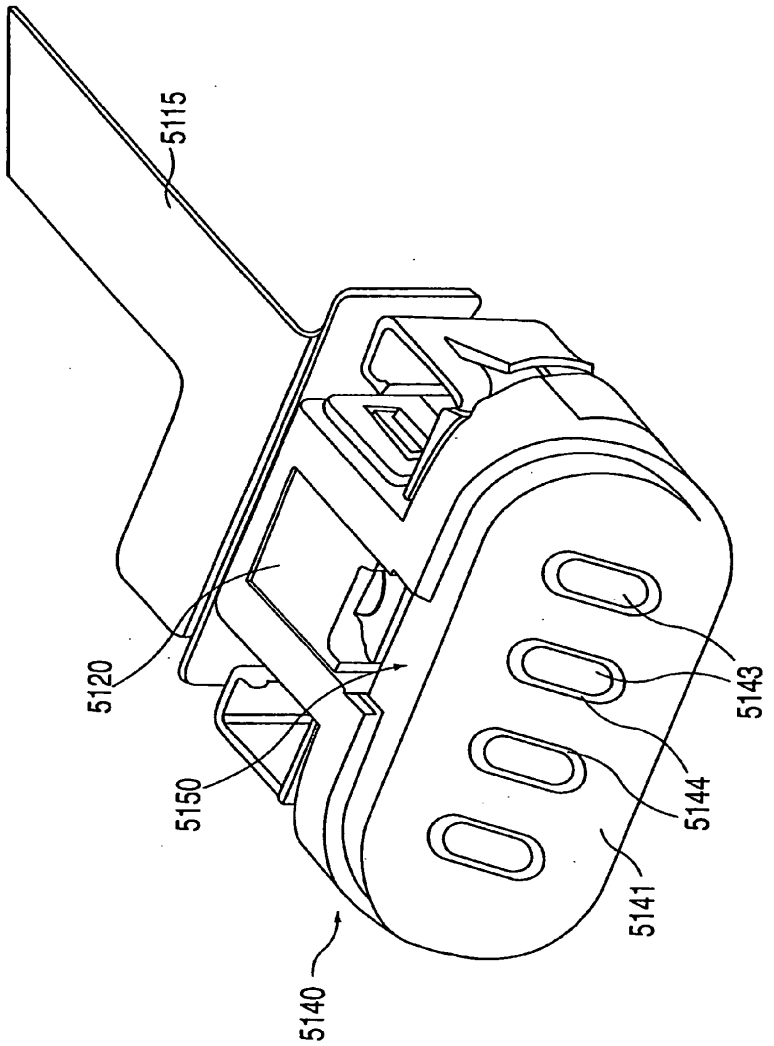


FIG. 51

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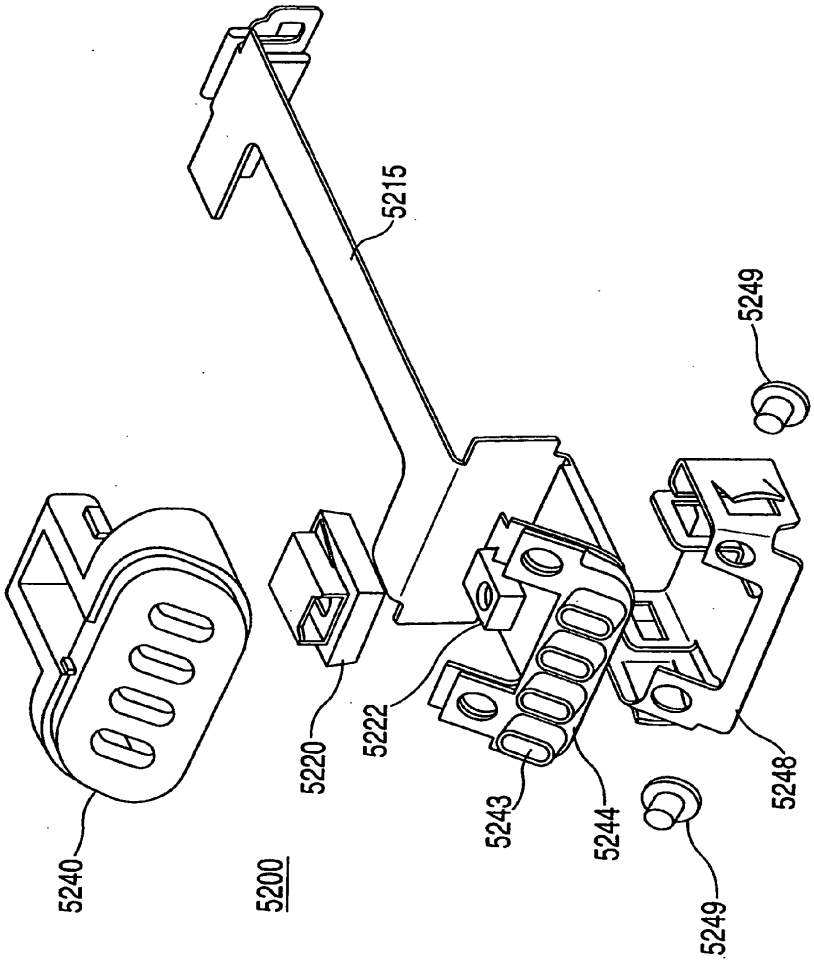


FIG. 52

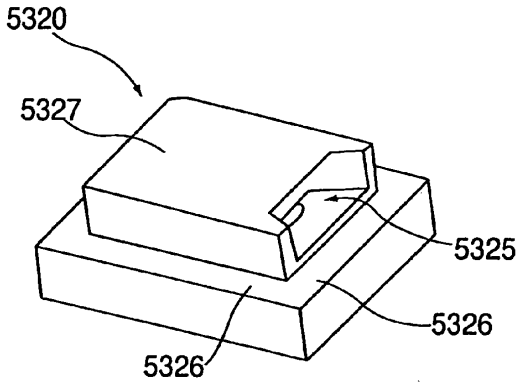

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FIG. 53

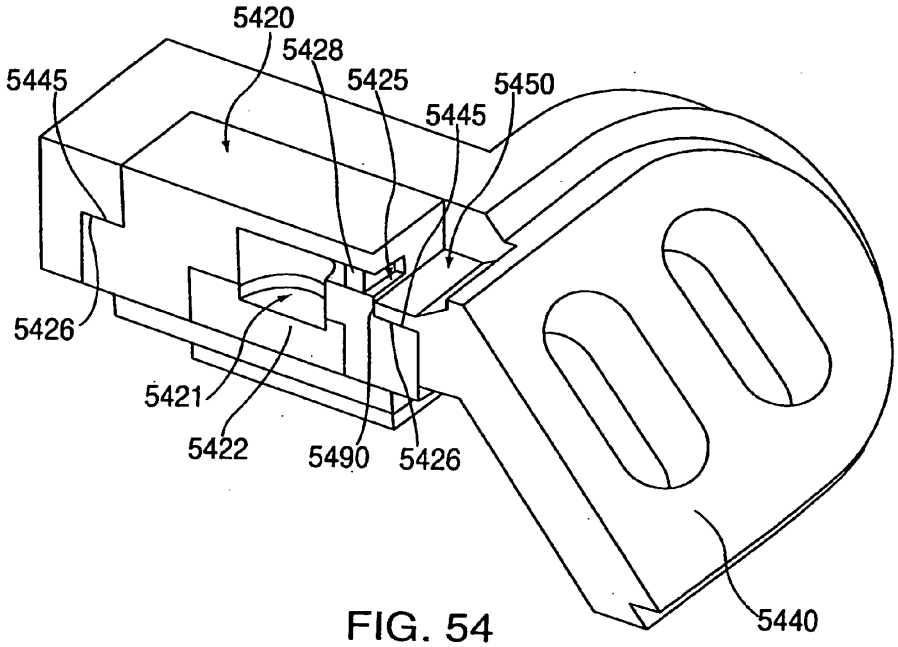

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FIG. 54

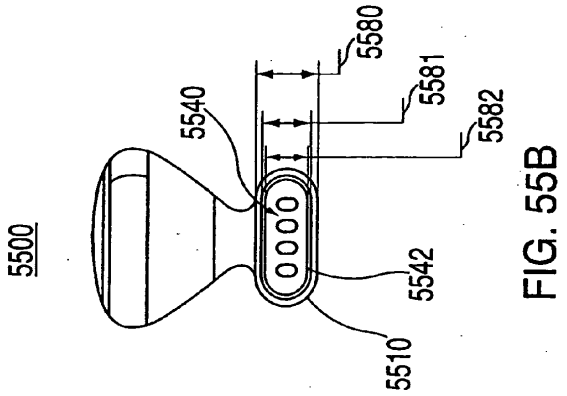


FIG. 55B

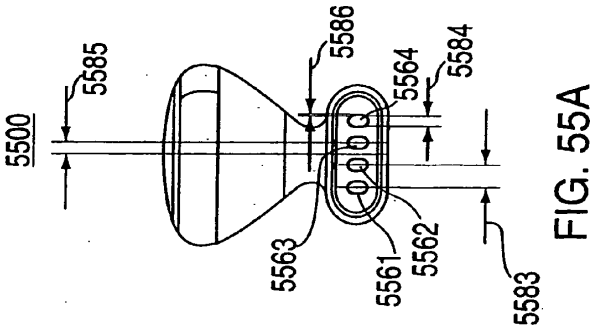


FIG. 55A

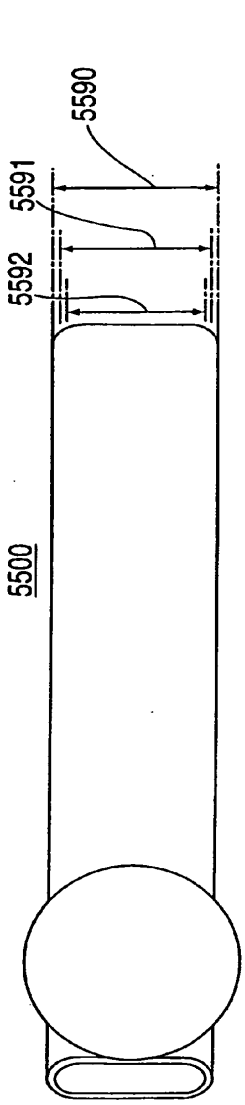


FIG. 55C

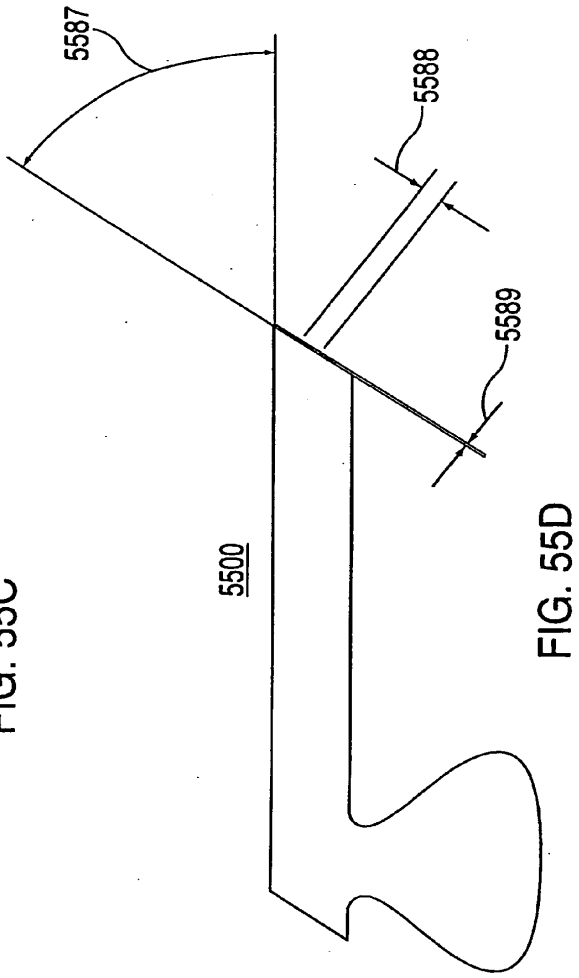


FIG. 55D

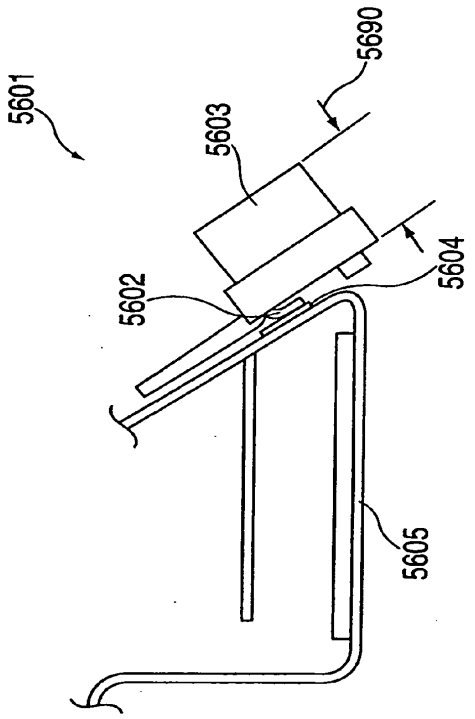


FIG. 56

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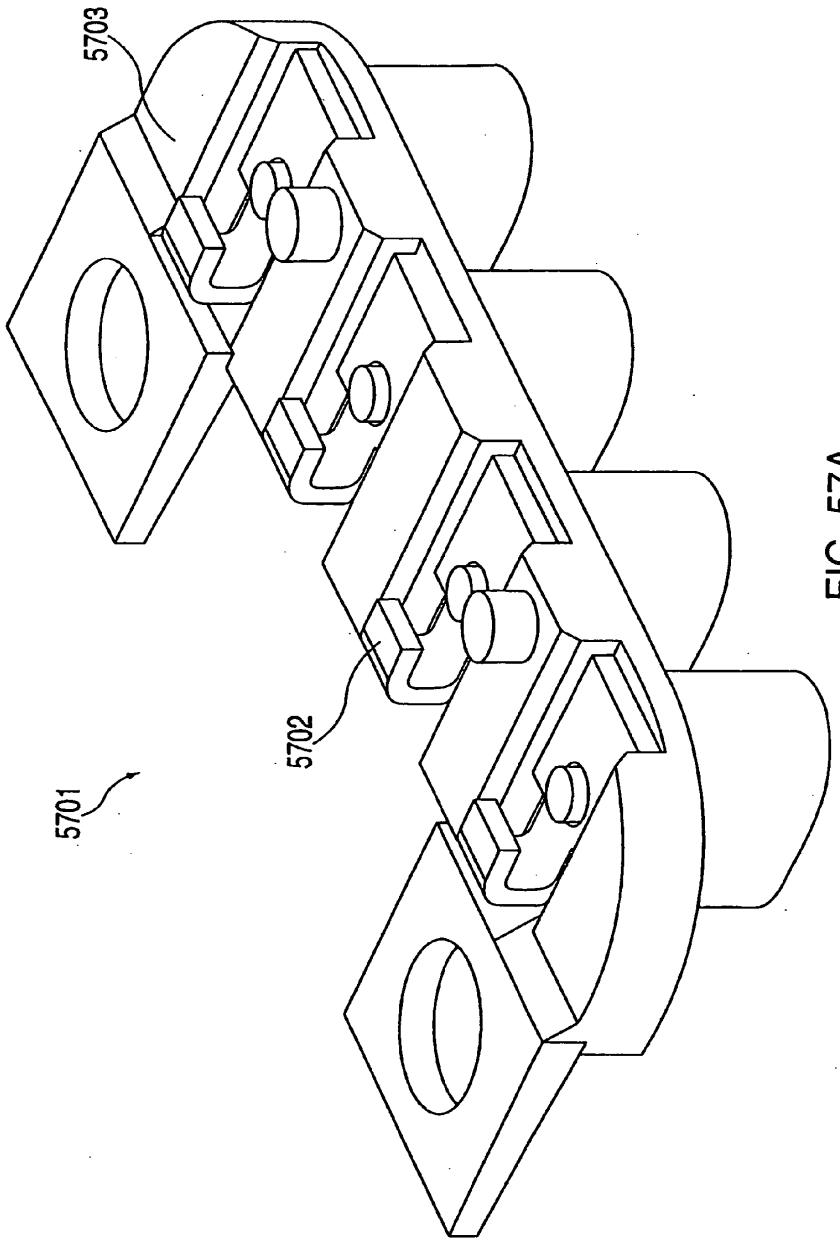


FIG. 57A

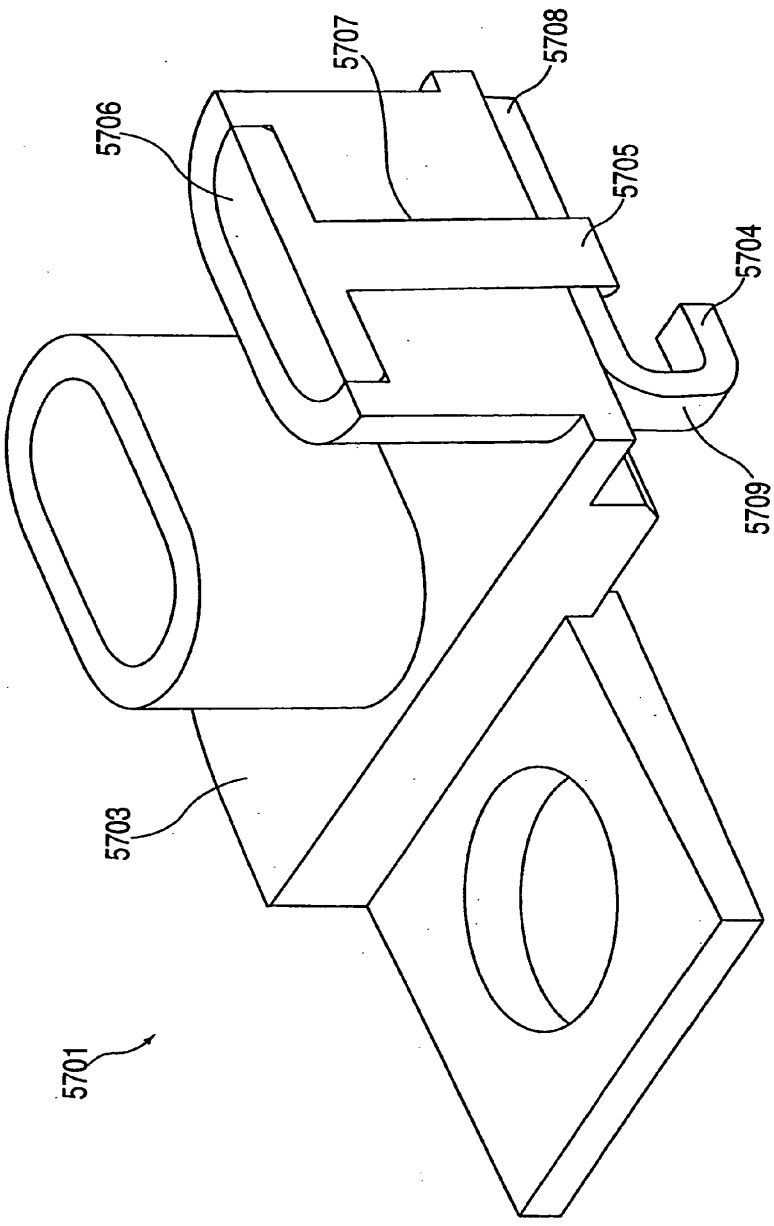


FIG. 57B

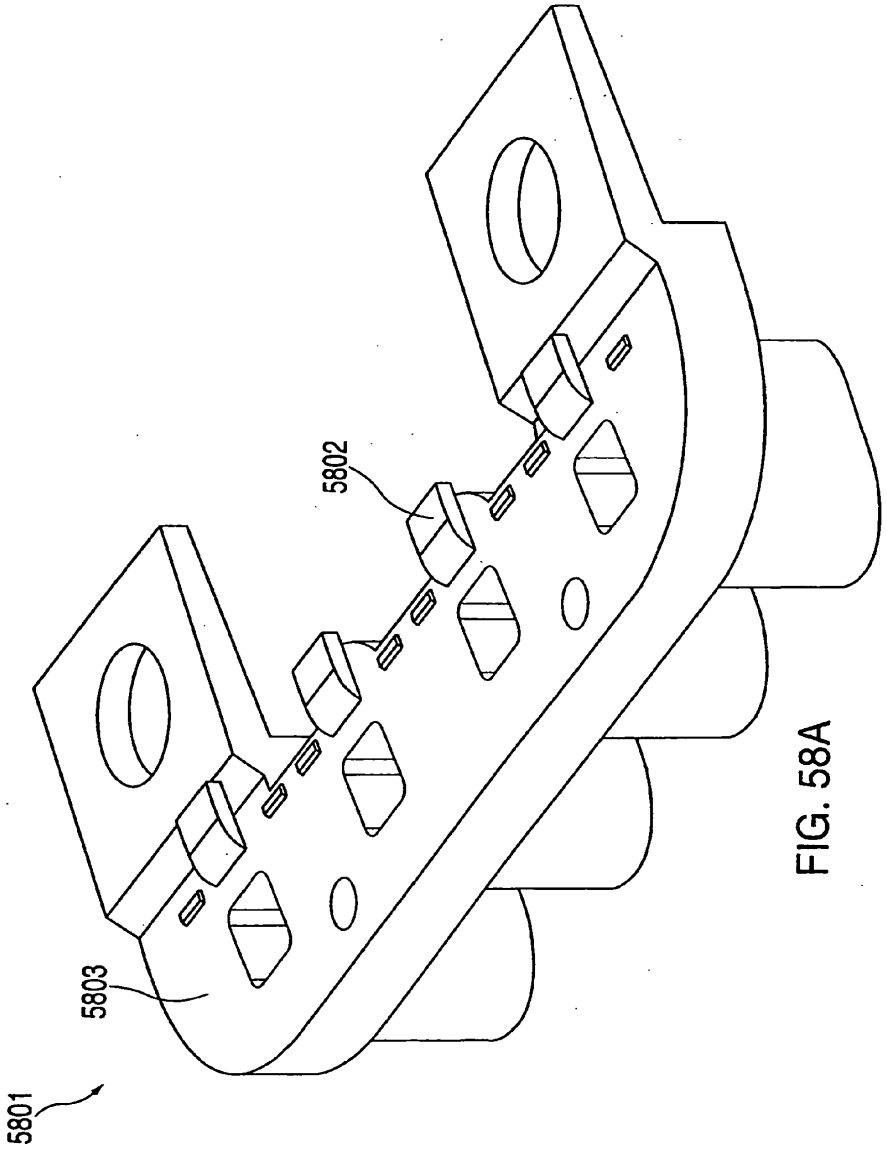


FIG. 58A

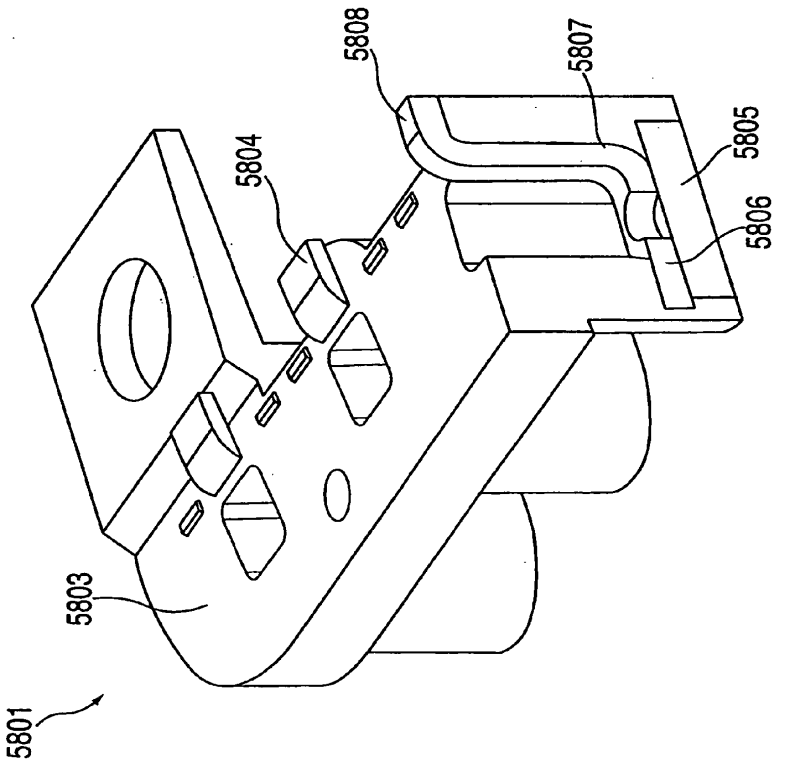


FIG. 58B

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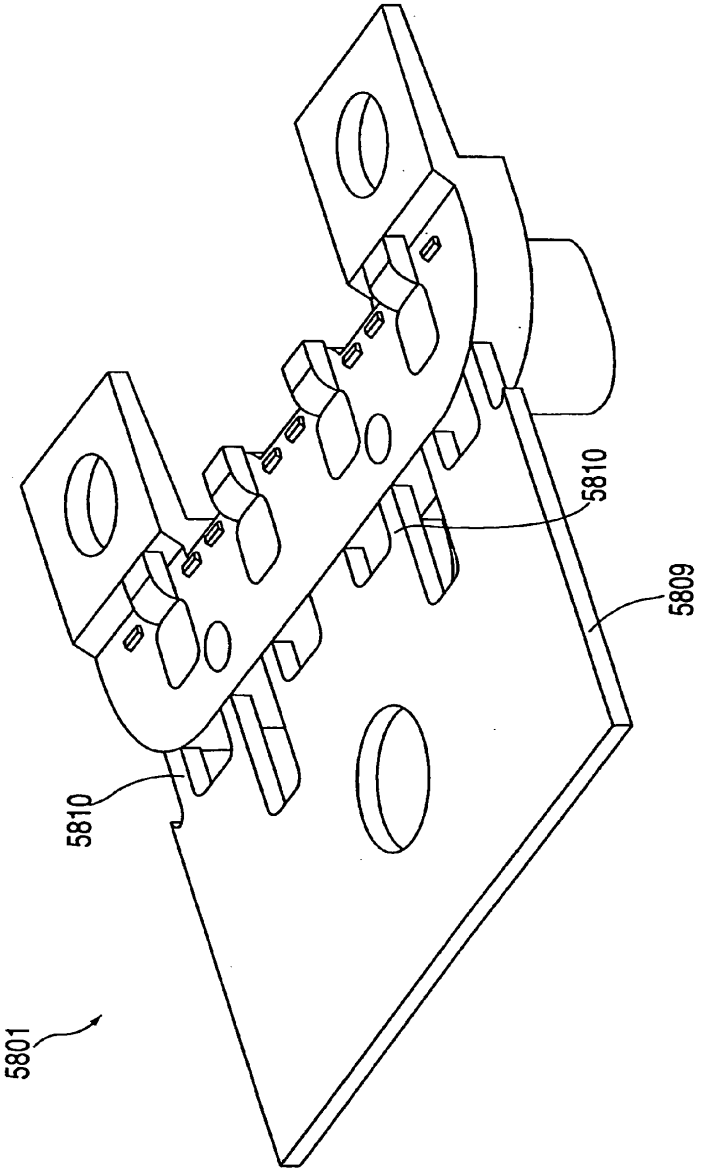


FIG. 58C

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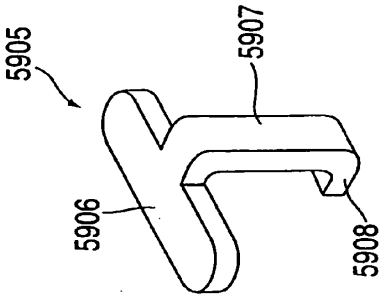


FIG. 59B

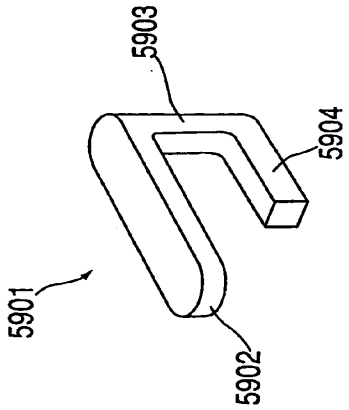


FIG. 59A

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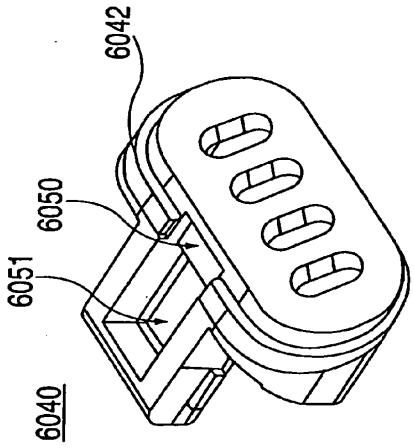


FIG. 60A

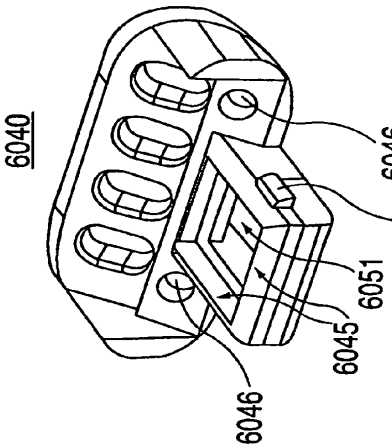


FIG. 60B

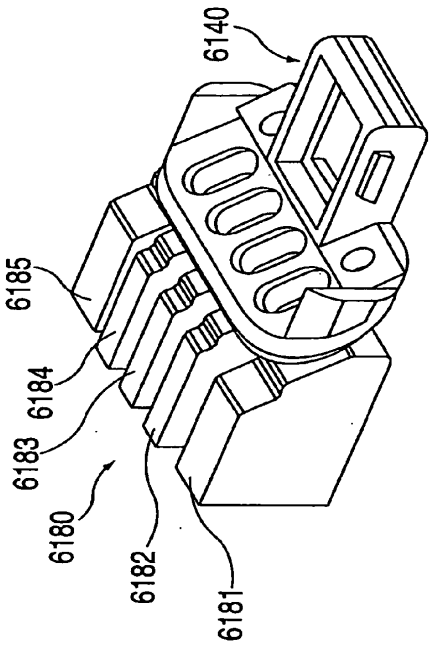


FIG. 61B

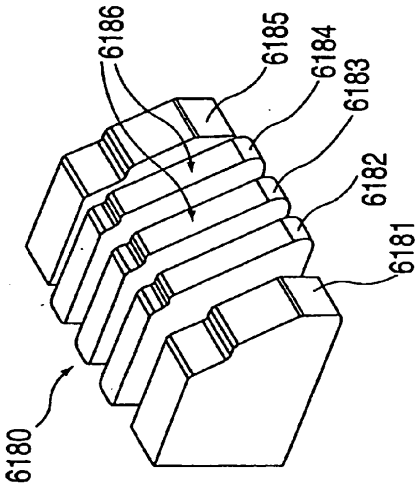


FIG. 61A

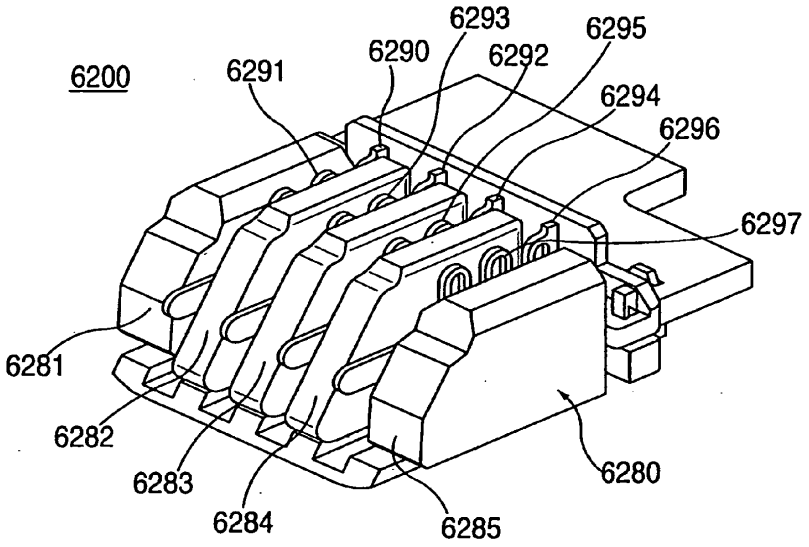


FIG. 62A

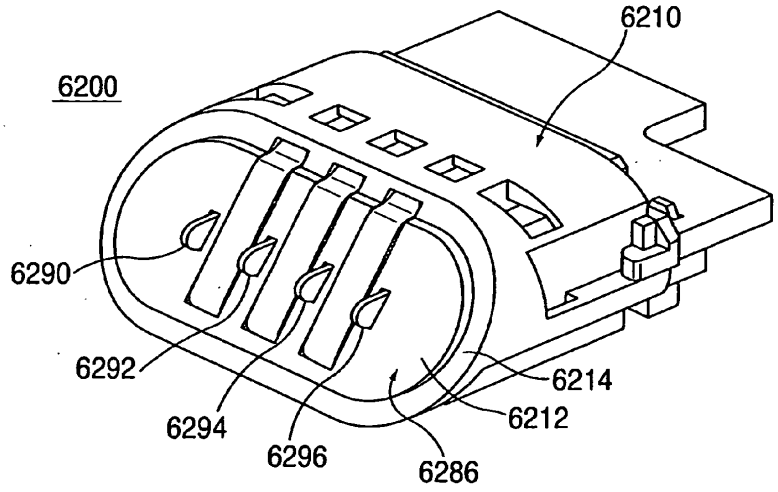


FIG. 62B

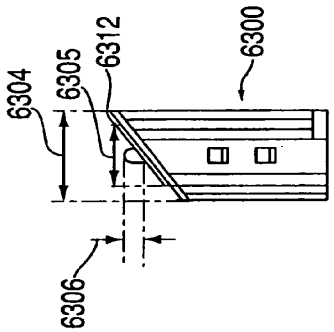


FIG. 63B

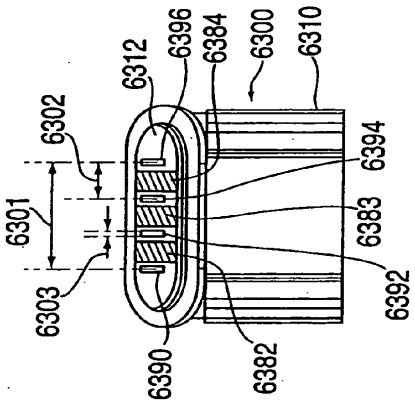


FIG. 63A

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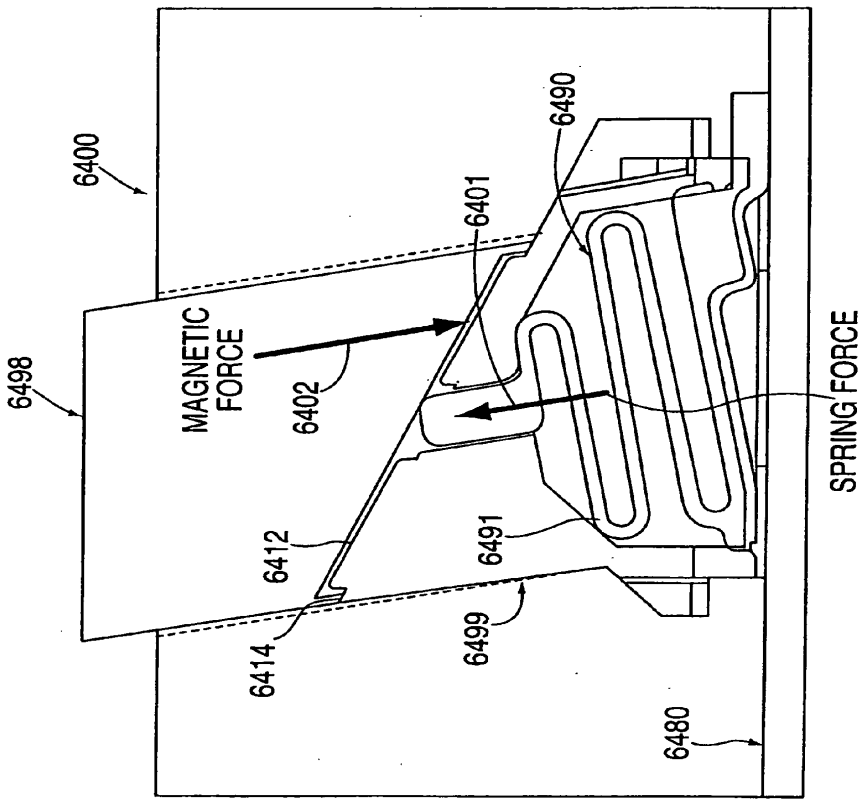

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MAGNETIC FORCE
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FIG. 64

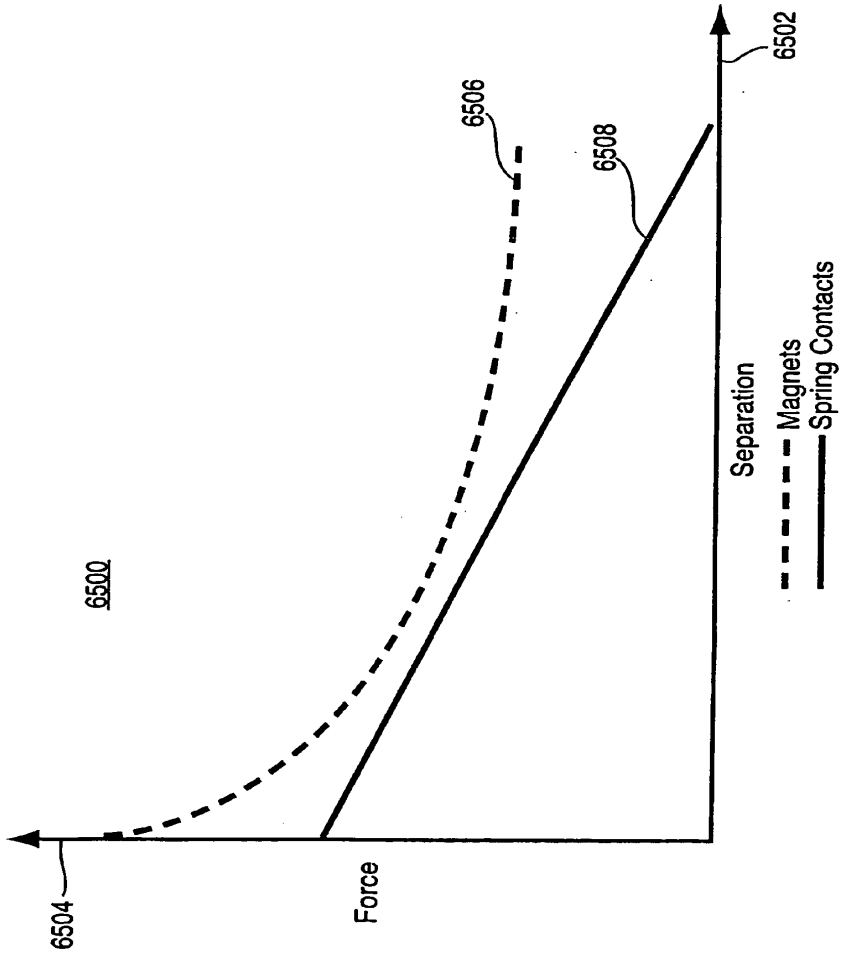


FIG. 65

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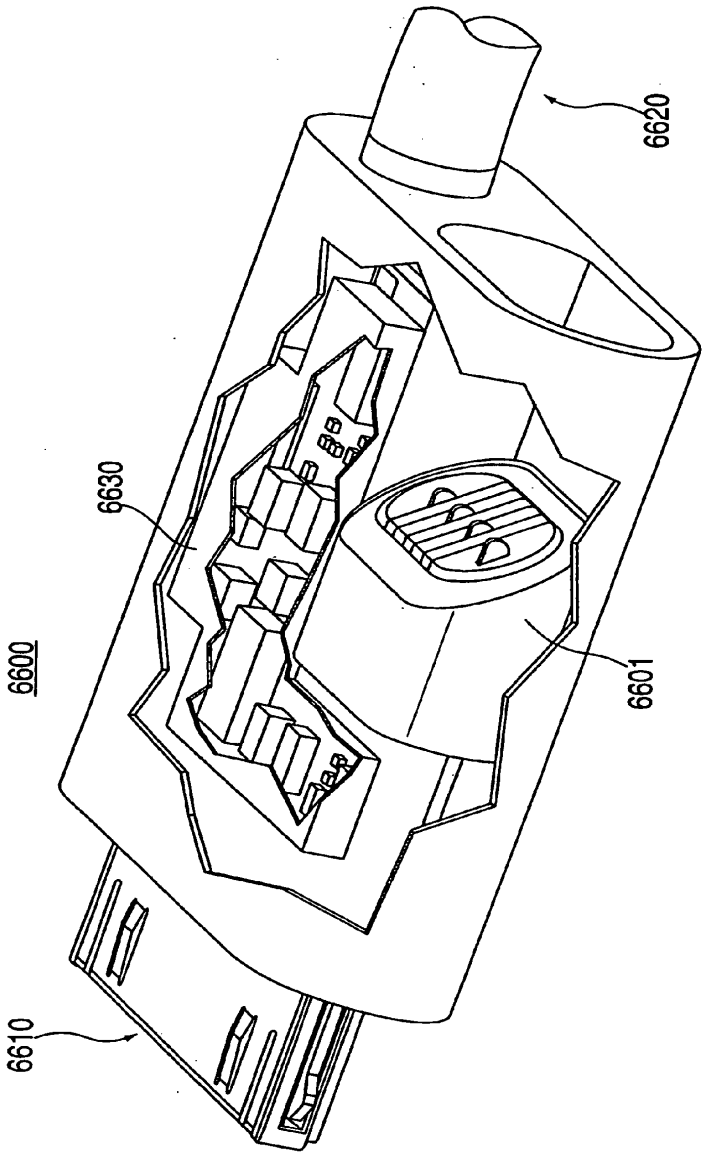


FIG. 66

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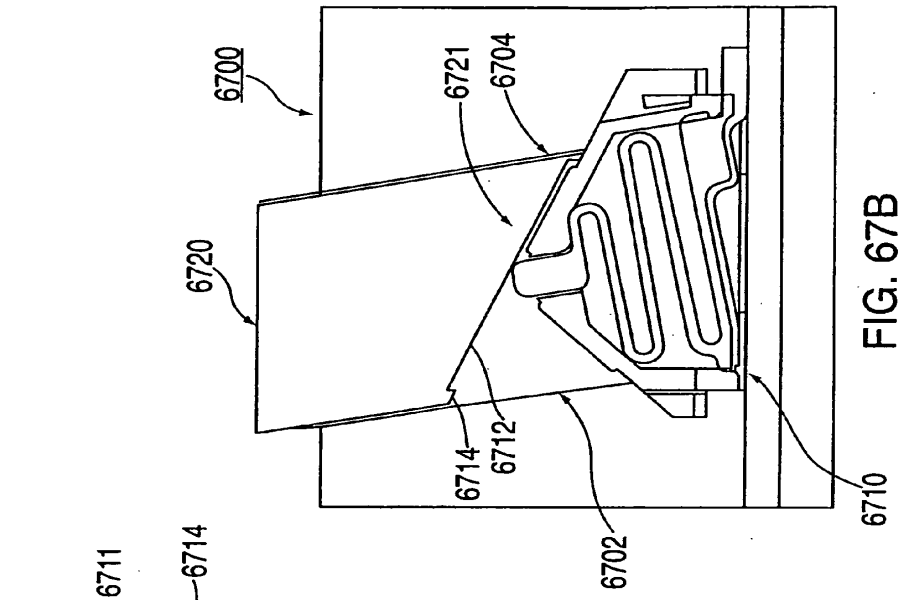


FIG. 67B

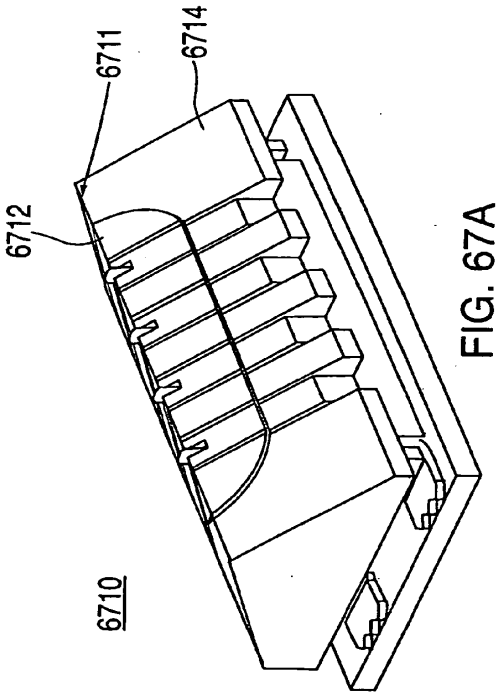
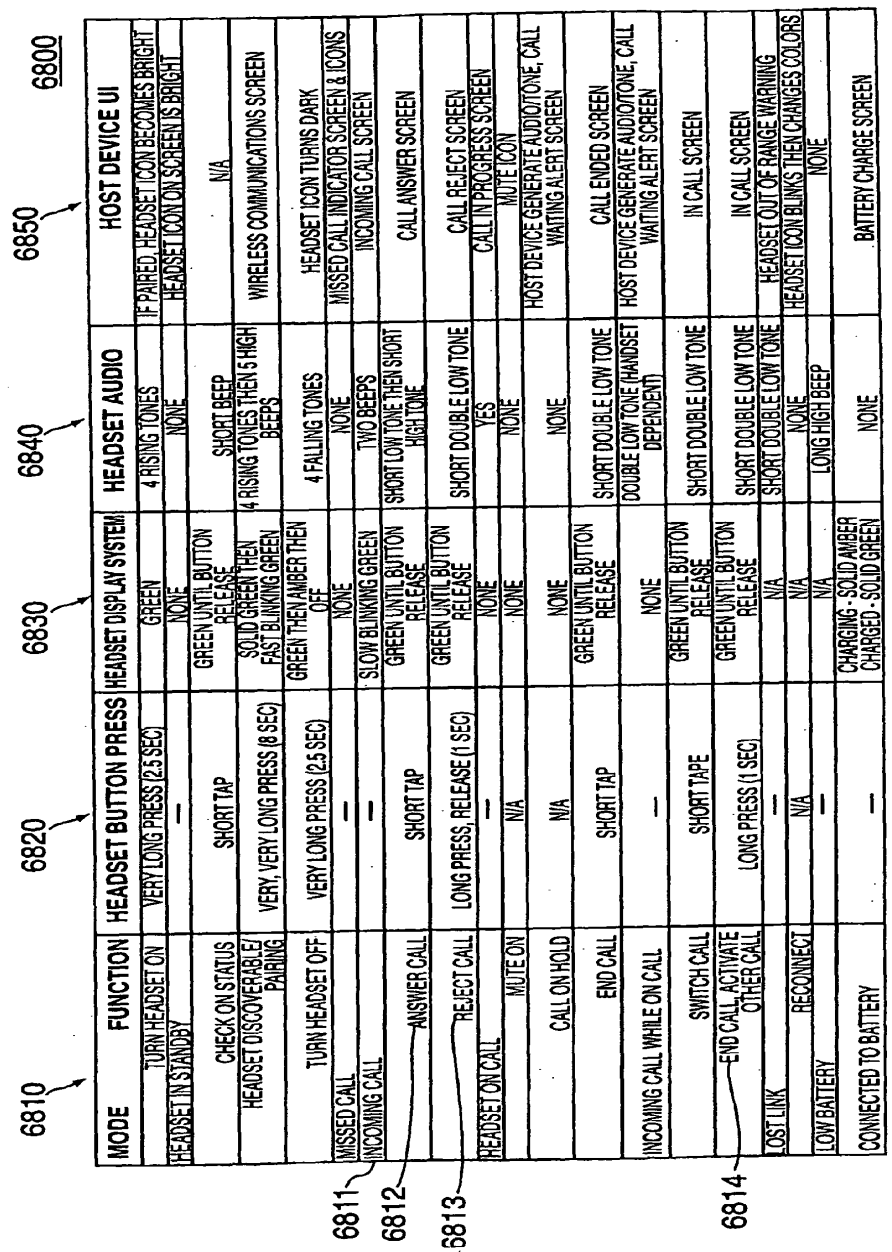


FIG. 67A



MODE	FUNCTION	HEADSET BUTTON PRESS	HEADSET DISPLAY SYSTEM	HEADSET AUDIO	HOST DEVICE UI
	TURN HEADSET ON	VERY LONG PRESS (2.5 SEC)	GREEN	4 RISING TONES	IF PAIRED, HEADSET ICON BECOMES BRIGHT
HEADSET IN STANDBY		—	NONE	NONE	HEADSET ICON ON SCREEN IS BRIGHT
	CHECK ON STATUS	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT BEEP	N/A
	HEADSET DISCOVERABLE/ PAIRING	VERY, VERY LONG PRESS (8 SEC)	SOLID GREEN THEN FAST BLINKING GREEN	4 RISING TONES THEN 5 HIGH BEEPS	WIRELESS COMMUNICATIONS SCREEN
	TURN HEADSET OFF	VERY LONG PRESS (2.5 SEC)	GREEN THEN AMBER THEN OFF	4 FALLING TONES	HEADSET ICON TURNS DARK
MISSED CALL		—	NONE	NONE	MISSED CALL INDICATOR SCREEN & ICONS
INCOMING CALL		—	SLOW BLINKING GREEN	TWO BEEPS	INCOMING CALL SCREEN
	ANSWER CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT LOW TONE THEN SHORT HIGH TONE	CALL ANSWER SCREEN
	REJECT CALL	LONG PRESS, RELEASE (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL REJECT SCREEN
HEADSET ON CALL		—	NONE	YES	CALL IN PROGRESS SCREEN
	MUTE ON	N/A	NONE	NONE	MUTE ICON
	CALL ON HOLD	N/A	NONE	NONE	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
	END CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL ENDED SCREEN
INCOMING CALL WHILE ON CALL		—	NONE	DOUBLE LOW TONE (HANDSET DEPENDENT)	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
	SWITCH CALL	SHORT TAPE	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
	END CALL, ACTIVATE OTHER CALL	LONG PRESS (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
LOST LINK		—	N/A	SHORT DOUBLE LOW TONE	HEADSET OUT OF RANGE WARNING
	RECONNECT	N/A	N/A	NONE	HEADSET ICON BLINKS THEN CHANGES COLORS
LOW BATTERY		—	N/A	LONG HIGH BEEP	NONE
CONNECTED TO BATTERY		—	CHARGING - SOLID AMBER CHARGED - SOLID GREEN	NONE	BATTERY CHARGE SCREEN

FIG. 68

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REFERENCES CITED IN THE DESCRIPTION

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H04N 21/218 (201 1.01)

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(54) Title: LONGITUDINAL ARRANGED WIRELESS EARBUDS AND THE CHARGING THEREOF

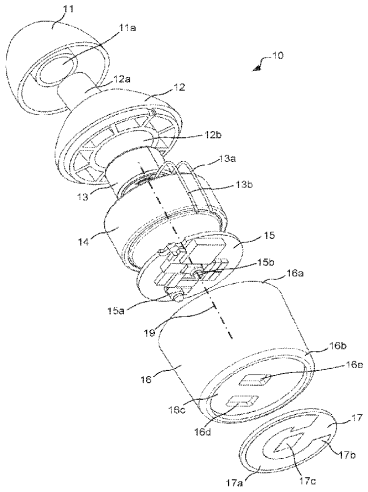


Fig 6

(57) Abstract: **A** wireless earbud (10) has an earbud housing (12, 16) having a longitudinal main axis (19) and an essentially circular cross section, a loudspeaker element (13), a rechargeable battery (14), at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114), and a charging interface member (17). The loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

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IMPROVEMENTS IN WIRELESS EARBUDS AND THE CHARGING THEREOF

Technical Field

The present invention generally relates to the field of wireless audio playback equipment, and more particularly to wireless earbuds and to storage and charging of such earbuds.

Background

Wireless earbuds, also known as wireless in-ear headphones or earphones, are expected to become increasingly popular. The advent and rapid growth of digital audio streaming services, such as Spotify, Pandora, Rhapsody, Google Play Music All Access, iTunes Radio, Music Unlimited, Rdio, Xbox Music and Beats Music, are likely drivers behind the expected growing popularity and desire for wireless earbuds.

Important characteristics of wireless earbuds are physical size, convenience and user-friendliness, duration between battery chargings, operational reliability and, of course, the perceived acoustic quality of the streamed audio.

Summary

It is an object of the invention to offer improvements in the technical field of wireless earbuds.

One aspect of the present invention is a wireless earbud, comprising an earbud housing having a longitudinal main axis and an essentially circular cross section, a loudspeaker element, a rechargeable battery, at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control, and a charging interface member, wherein the loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

Another aspect of the present invention is a storage and charging capsule for a pair of wireless earbuds, the storage and charging capsule comprising a base part, an elongate intermediate part, the intermediate part having a longitudinal major axis, and a cover part being retractable over the intermediate part, wherein the intermediate part has a first end attached to the base part, a second end, and an earbud chamber formed between the first and second ends, the earbud chamber being adapted to receive the pair of wireless earbuds arranged one after another along the longitudinal major axis of the

intermediate part, and wherein the capsule further has a power source for charging the pair of wireless earbuds when placed in the earbud chamber in the intermediate part.

Yet another aspect of the present invention is a wireless earbud having an idle mode and an operational mode, the wireless earbud comprising an earbud housing, a loudspeaker element, a rechargeable battery, and at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control, wherein the circuitry is configured for automatic power preservation by:

detecting connection of said battery to a charger and in response entering the idle mode, wherein existing connections to a second wireless earbud and to a wireless audio streaming host device will be disconnected; and

detecting disconnection of said battery from said charger and in response entering the operational mode by:

attempting a true wireless stereo, TWS, reconnection with the second wireless earbud;

if the attempt is successful, operating the wireless earbud as a TWS audio receiver and otherwise operating the wireless earbud as a mono wireless audio receiver;

if operated as a TWS audio receiver, determining whether the wireless earbud is a master device or a slave device with respect to the second wireless earbud;

if the wireless earbud is determined to be a master device, attempting to reconnect with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable; and

if reconnection with the wireless audio streaming host device fails, initiate a pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable.

Still another aspect of the present invention is a wireless audio streaming host device for use with a first wireless earbud and a second wireless earbud, the wireless audio streaming host device having a controller configured for:

receiving, by wireless communication, a message from the first earbud, the message indicating a current battery charge status for the first earbud;

receiving, by wireless communication, a message from the second earbud, the message indicating a current battery charge status for the second earbud;

determining which one of the first and second earbuds has a current master device role and a current slave device role, respectively;

assessing, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device; and, if a switch in roles is found appropriate:

causing, by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role; and

causing, by wireless communication, the other one among the first and second earbuds to assume a master device role.

Embodiments of the invention are defined by the appended dependent claims and are further explained in the detailed description section as well as on the drawings.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps, or components, but does not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof. All terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of the element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Brief Description of the Drawings

Objects, features and advantages of embodiments of the invention will appear from the following detailed description, reference being made to the accompanying drawings.

Fig 1 is a schematic isometric view of a storage and charging capsule for a pair of wireless earbuds, one of the earbuds being shown positioned in the capsule while the other earbud being shown outside of the capsule.

Fig 2 is a schematic isometric view of the storage and charging capsule, now showing both earbuds positioned in the capsule, a cover part of the capsule being retracted to expose the earbuds.

Fig 3 is a schematic isometric view of the storage and charging capsule, showing it in a situation where the cover part has been moved towards a closed position to encapsulate the earbuds.

Fig 4 is a schematic exploded view of the storage and charging capsule.

Fig 5 is a schematic isometric view of a wireless earbud.

Fig 6 is a first, schematic, exploded view of the wireless earbud.

Fig 7 is a second, schematic, exploded view of the wireless earbud.

Figs 8-10 are schematic top views of a main printed circuit board in the wireless earbud.

Fig 11 is a schematic block diagram of circuitry on the main printed circuit board.

Fig 12 is a schematic flowchart diagram illustrating a procedure for switching between idle and operational modes for the wireless earbud.

Detailed Description

Embodiments of the invention will now be described with reference to the accompanying drawings. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the particular embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

Figs 1-4 illustrate an embodiment of a storage and charging capsule 20 for a pair of wireless earbuds 10a, 10b. An embodiment of a wireless earbud 10, which may be one of the wireless earbuds 10a, 10b and is thus suitable for use with the storage and charging capsule 20, is illustrated in more detail in Figs 5-12.

As seen in Figs 1-4, the storage and charging capsule 20 comprises a base part 22, an elongate intermediate part 24 and a cover part 26 which is retractable over the intermediate part 24. A first end 25a of the intermediate part 24 is attached to the base part 22. An earbud chamber 31 is formed in the intermediate part 24 between its first and second ends 25a, 25b. The earbud chamber 31 is adapted to receive the pair of wireless earbuds 10a, 10b arranged one after another along a longitudinal major axis 60 of the intermediate part 24.

In Fig 1, a first earbud 10a of the earbud pair is shown outside of the capsule 20, while the second earbud 10b of the earbud pair is shown positioned in the capsule 20, and more specifically in the earbud chamber 31 formed in the intermediate part 24. Fig 2 shows both earbuds 10a, 10b positioned in the capsule 20, or more specifically in the earbud chamber 31.

The cover part 26 of the storage and charging capsule 20 is shaped essentially as a cylinder having an open end 27a for receiving the intermediate part 24, and a closed end 27b. The cover part 26 can be placed in a first, or open, position in which the cover part 26 is retracted by a user from the intermediate part 24 to allow insertion or removal of the earbuds 10a, 10b in or from the earbud chamber 31. In Figs 1 and 2, the cover part 26 of the capsule 20 is retracted to its first position and exposes the earbud 10b and the earbuds 10a, 10b, respectively.

The cover part 26 can moreover be placed in a second, or closed, position in which the cover part 26 encapsulates the intermediate part 24 with the open end 27a of the cover part 26 abutting against the proximal end 23b of the base part 22. Fig 3 shows the storage and charging capsule 20 in a situation where the cover part 26 has been moved by a user towards the second, or closed, position to encapsulate the earbuds 10a, 10b in the earbud chamber 31. The capsule 20 is not fully closed in Fig 3; the cover part 26 still has to be moved a distance 62 to abut against the base part 22.

When the capsule 20 is fully closed, the base part 22 and the cover part 26 will together essentially take the form of a cylinder. A ring 30 is affixed to the distal end 23a of the base part 22 to facilitate carrying of the storage and charging capsule 20 in for instance a necklace, a waist belt or a key ring. Thus, accidental loss or damage of the capsule 20 and the earbuds 10a, 10b contained therein may be prevented. The ring 30 may also act as a handle for the user when retracting the cover part 26 from the base part 22 to insert or remove the earbuds 10a, 10b.

To keep the cover part 26 safely engaged with the base part 22, the storage and charging capsule 20 further comprises a first magnet 58 mounted at the second end 25b of the intermediate part 24, and a second magnet (not shown) mounted at the closed end 27b of the cover part 26. The first and second magnets will thus urge the cover part 26 against the base part 22 in the second position of the cover part 26. Hence, accidental retraction of the cover part 26 and resulting potential loss or damage of the earbuds 10a, 10b in the capsule 20 may be prevented.

As is best seen in the exploded view of Fig 4, the storage and charging capsule 20 has a power source for charging the pair of wireless earbuds 10a, 10b when placed in the earbud chamber 31 in the intermediate part 24. In the disclosed embodiment, the power source comprises a rechargeable battery 40 which is accommodated in the base part 22 and which can be charged by a cable connection interface 46, 47, such as a micro Universal Serial Bus (USB) interface.

The storage and charging capsule 20 further comprises a power transmission arrangement for feeding electric power from the rechargeable battery 40 to the earbuds 10a, 10b when placed in the earbud chamber 31 in the intermediate part 24. As seen in Fig 4, the power transmission arrangement comprises a first charging connector disc 42 at the first end 25a of the intermediate part 24. The first charging connector disc 42 comprises a plurality of charging connector elements 44a, 44b, 44c which are symmetrically distributed over a surface of the charging connector disc 42 to allow electric contact with a charging interface of the nearest earbud (earbud 10a in Figs 1-4), irrespective of the radial orientation of the earbud in the earbud chamber 31.

In the disclosed embodiment, there are three charging connector elements 44a, 44b, 44c in the form of pogo pins soldered onto the surface of the charging connector disc 42, being a circuit board substrate. The resilient tips of the pogo pins 44a, 44b, 44c extend through respective openings 54a, 54b, 54c at the first end 25a of the intermediate part 24. The earbuds 10a, 10b are to be placed "nose to nose" in the earbud chamber 31 in the intermediate part 24, with their respective foam tips 11 at the front ends thereof (Fig 6) abutting each other.

The resiliency of the foam tips 11 will urge the rear end of the earbud 10a towards the resilient tips of the pogo pins 44a, 44b, 44c. As a result, they will reach electric contact with a conductive partem 17a provided at the rear end of the earbud 10a (see Fig 6). One of the pogo pins 44a, 44b, 44c, such as the center pogo pin 44b, will provide a first power supply potential, such as ground or 0 V. The other two of the pogo pins 44a, 44b, 44c, such as the leftmost and rightmost pogo pins 44a and 44c, will provide a second power supply potential, such as + V_{cc}. The opposite order is of course also possible. Particulars of the charging procedure for the earbud will be described in more detail in a later section of this document.

To allow charging also of the other earbud 10b, the power transmission arrangement in the storage and charging capsule 20 further comprises a second charging connector disc 48 at the second end 25b of the intermediate part 24. Like the first disc 42, the second charging connector disc 48 comprises a plurality of charging connector elements symmetrically distributed over a surface of the second charging connector disc 48 to allow electric contact with a charging interface of the other earbud 10b, irrespective of its radial orientation in the earbud chamber 31.

In the disclosed embodiment, the second charging connector disc 48 has three charging connector elements in the form of pogo pins soldered onto the surface of the charging connector disc 48, being a circuit board substrate. The resilient tips of these

pogo pins extend through respective openings at the second end 25b of the intermediate part 24. In Fig 4, only one of the pogo pins are seen at 50c, and only two of the openings are seen at 56a, 56b. The charging functions of the pogo pins of the second charging connector disc 48 are analogous to what has been described above for the pogo pins 44a, 44b, 44c of the first charging connector disc 42.

The charging connector elements 44a, 44b, 44c of the first charging connector disc 42 are connected to the rechargeable battery 40. The charging connector elements 50c of the second charging connector disc 48 are connected to the charging connector elements 44a, 44b, 44c of the first charging connector disc 42, or directly to the rechargeable battery, by an interconnector 52 extending between the first and second ends 25a, 25b of the intermediate part 24.

An embodiment of a wireless earbud 10, which may be one of the wireless earbuds 10a, 10b as referred to above in conjunction with the storage and charging capsule 20, will now be described in more detail with reference to Figs 5-12.

Figs 5 to 7 show the wireless earbud 10 in schematic isometric and exploded views. Even though shown in isolation, the earbud 10 will typically be used together with a second earbud to form a pair of earbuds, like the earbud pair 10a, 10b as previously referred to. One of the earbuds may then be used for playing left-channel stereo audio into one ear of the user, whereas the other earbud will be used for playing right-channel stereo audio into the other ear.

For the illustrated embodiment, the principal components of the wireless earbud 10 are as follows.

The wireless earbud 10 comprises an earbud housing 12, 16 having a longitudinal main axis 19 and an essentially circular cross section. The wireless earbud 10 further comprises a loudspeaker element 13, a rechargeable battery 14 and at least one main printed circuit board 15 having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control. The main printed circuit board 15 and its circuitry will be described in more detail later with reference to the remaining drawings.

Moreover, the wireless earbud 10 comprises a charging interface member 17. As seen in Figs 6 and 7, the loudspeaker element 13, the rechargeable battery 14, the main printed circuit board 15 and the charging interface member 17 are arranged in a successive order along the longitudinal main axis of the earbud housing 12, 16. More specifically, in this embodiment, the loudspeaker element 13, the rechargeable battery 14, the main printed circuit board 15 and the charging interface member 17 all have a

generally circular cross section and are coaxially disposed around the longitudinal main axis 19 of the earbud housing 12, 16.

The earbud housing comprises a tapered front housing portion 12 and a rear housing portion 16. The tapered front housing portion 12 comprises a loudspeaker chamber 12b for accommodating the loudspeaker element 13. Further, the tapered front housing portion 12 comprises a sound guiding channel forming element 12a for receiving an earbud foam tip 11 by threading a flexible hollow engagement portion 11a thereof onto the sound guiding channel forming element 12a. Preferably, the frictional engagement between the sound guiding channel forming element 12a and the foam tip 11 is designed to be firm but yet possible to interrupt. This will make sure that the foam tip 11 stays in place during normal use but may be removed for replacement by another foam tip for reasons of wear and tear or user preference.

The loudspeaker element 13 is operatively connected to the audio codec circuitry on the main printed circuit board 15 via two connecting wires 13a, 13b. In the disclosed embodiment, the loudspeaker element 13 is a magnetic balanced armature (BA) receiver, such as an SR-3 1843-000 mini siren which is provided by Knowles Electronics, Itasca, Illinois, USA. Using a balanced armature receiver for the loudspeaker element 13 is advantageous, since it offers high audio performance at a small physical size. As a result, it has been made possible to design the earbud 10 to have a compact overall size.

In the illustrated embodiment, the rear housing portion 16 is essentially cylindrical or frusto-conical. The rear housing portion 16 comprises a first end 16a proximate to the front housing portion 12, and a second distal end 16b. Together with the front housing portion 12, the rear housing portion 16 accommodates the main printed circuit board 15 inside the rear housing portion 16 nearest its second distal end 16b, then the rechargeable battery 14 and the loudspeaker element 13 in successive order towards the front housing portion 12 along the longitudinal main axis 19 of the earbud housing. Thus, a very compact physical size is obtained.

In the illustrated embodiment, the rear housing portion 16 has a wall 16c at the second distal end 16b. The main printed circuit board 15 is mounted at an internal surface of the wall 16c. Moreover, the charging interface member 17 is mounted at an external surface of the wall 16c in a shallow protective recess formed by the wall 16c and the surrounding parts of the second distal end 16b of the rear housing portion 16.

As seen in Fig 6, the wall 16c comprises first and second openings 16d, 16e for providing access from the outside of the wall to the main printed circuit board 15 inside

the wall 16c, i.e. inside the earbud housing. In the disclosed embodiment, the openings 16d, 16e in the wall 16c at the second distal end 16b of the rear housing portion 16 have dual purposes - to allow charging of the rechargeable battery 14, and to allow programming or writing of data to the circuitry of the main printed circuit board 15 during product manufacture or upgrade.

Hence, the main printed circuit board 15 has mounted thereon first and second charging connectors 15a, 15b which are aligned with the first and second openings 16d, 16e in the wall 16c to provide electric contact with the charging interface member 17 at the external surface of the wall 16c through contact areas 17d, 17e (Fig 7). In the disclosed embodiment, the charging connectors 15a, 15b are elongated resilient members, such as pogo pins, which protrude partly through the first and second openings 16d, 16e in the wall 16c. In other embodiments, elongated resilient connecting members may protrude from the charging interface member 17 through the first and second openings 16d, 16e in the wall 16c to the main printed circuit board 15.

In the disclosed embodiment, the charging interface member 17 comprises a circuit board substrate which is mounted to the external surface of the wall 16c of the rear housing portion 16. A conductive pattern 17a is printed on the external surface of the circuit board substrate, i.e. the surface which faces away from the wall 16c. The conductive partem is designed for electric contact with a power transmission arrangement in a storage and charging capsule for the wireless earbud, typically the storage and charging capsule 20 previously described with reference to Figs 1 to 4.

The conductive partem 17a on the charging interface member 17 (i.e. circuit board substrate) comprises a first sub-pattern 17b adapted to reach electrical contact with a first charging connector element of the power transmission arrangement in the storage and charging capsule, i.e. the pogo pin 44a or 44c when the earbud 10a in Figs 1 to 4 implements the earbud 10. The conductive partem 17a also comprises a second sub-pattern 17c electrically isolated from the first sub-pattern 17b and being adapted to reach electrical contact with a second charging connector element of the power transmission arrangement in the storage and charging capsule (e.g. the pogo pin 50c when the earbud 10b in Figs 1 to 4 implements the earbud 10).

Advantageously, the conductive partem 17a may be designed as a graphical symbol representing the individual earbud 10, a product type of the earbud 10, or a producer or supplier of the earbud 10. Such a graphical symbol may convey technical or commercial information pertaining to the individual earbud 10, its product type, or its producer or supplier. When used together with the storage and charging capsule 20

shown in Figs 1 to 4, the symmetrical distribution of the charging connector elements (e.g. 44a, 44b, 44c) over the surface of the charging connector disc (e.g. 42) will guarantee electrical contact with the conductive pattern 17a on the earbud 10, irrespective of the radial orientation of the earbud 10 in the earbud chamber 31 of the storage and charging capsule 20. As a result, great flexibility in the layout of the graphical symbol formed by the conductive partem 17a is achieved together with a reliable charging procedure.

As already indicated, in the disclosed embodiment, the first and second openings 16d, 16e in the wall 16c of the rear housing portion 16 of the earbud 10 are aligned with a programming or data writing interface on the main printed circuit board 15. When assembling the earbud 10 during manufacture, at a late stage in the assembly process, all parts of the earbud 10 may have been assembled except for the charging interface member 17. Hence, at this stage, the openings 16d, 16e in the wall 16c are available for insertion of probes or electrodes of a programming or data writing device. The probes or electrodes may access the programming or data writing interface on the main printed circuit board 15 to fill memories and registers thereof with software or firmware instructions, and/or data. Such a procedure is commonly referred to as "flashing" (of flash memories). In one embodiment, the earbuds 10a and 10b are paired with each other by writing the Bluetooth address of the first wireless earbud 10a into a memory or register of the second wireless earbud 10b, and vice versa.

Once the programming or data writing has been completed, the assembly procedure may be finalized by a step of affixing the charging interface member 17 on the wall 16c of rear housing portion 16 of the earbud 10 by means of for instance an adhesive. A medium-strong adhesive may be chosen, in some embodiments, to provide a balance between safe mounting of the charging interface member 17 on the one hand, and the ability of a non-destructive removal thereof at a later time in the event of a need for a product repair or software/firmware/data upgrade.

One inventive aspect can be seen in a kit of parts comprising a storage and charging capsule 20 and two wireless earbuds 10/lOa, 10b as referred to above.

Reference is now made to Figs 8 to 11 which illustrate the main circuit board 15 and its circuitry in more detail. Starting with Fig 11, the main circuit board 15 comprises circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114. Other circuitry may also be included on the main circuit board 15 in different embodiments.

Earbud operation control 114 may include general control of the wireless radio communication 110 e.g. for establishing, maintaining and communicating over a wireless link 111 to a wireless audio streaming host device 100. The wireless audio streaming host device 100 may for instance be a mobile terminal (e.g. smartphone), personal digital assistant, palmtop computer, tablet computer (a.k.a. surfpad), laptop computer, stationary computer, smart TV or video game console, without limitation. The wireless audio streaming host device 100 may, for instance, be capable of connecting to a mobile telecommunication network in compliance with a mobile telecommunication standard, such as (without limitation) GSM, UMTS, LTE, LTE Advanced, D-AMPS, CDMA2000, FOMA or TD-SCDMA, and/or to a data communication network, such as the Internet.

Earbud operation control 114 may also include power management 116 for receiving power from the rechargeable battery 14 and for charging the rechargeable battery 14 by means of, for instance, the storage and charging capsule 20.

The main printed circuit board 15 has a front surface 15_f, a rear surface 15_r and a circumferential edge surface 15_e. In the disclosed embodiment, components are provided on all three surfaces, as is seen in Fig 8, Fig 9 and Fig 10, respectively. This is beneficial since it allows a size-efficient implementation, as will be clear from the following disclosure. It is moreover beneficial since it allows an efficient implementation of an antenna function for the wireless radio communication 110.

In the disclosed embodiment, the main printed circuit board 15 has an essentially circular sectional shape, which again is beneficial for the reasons given above. In other embodiments, the main printed circuit board 15 may have another shape. In still other embodiments, the main printed circuit board 15 may be divided into two or more printed circuit boards. The term "main printed circuit board" as used herein shall therefore include a single printed circuit board but also a plurality of printed circuit board jointly carrying the components disclosed in this document.

Fig 8 illustrates the schematic layout of the front surface 15_f of the main printed circuit board 15. Fig 9 illustrates the schematic layout of the read surface 15_r of the main printed circuit board 15. Component Dl, Fig 8, is a BlueCore CSR8670 WLCSP System on a Chip (SoC) integrated circuit device for Bluetooth 4.0. The device is available from Cambridge Silicon Radio Ltd, Churchill House, Cambridge Business Park, Cowley Road, Cambridge, CB4 0WZ, UK. Component D1 features Bluetooth 4.0 software, a radio with an integrated balun, an 80 MHz RISC MCU (application processor) and an 80 MIPS DSP (digital signal processor), internal flash memory, a

stereo audio codec, noise reduction, audio interfaces, serial interfaces, integrated switch-mode regulators, linear regulators and battery charger, LED controllers, etc.

In the disclosed embodiment, component D1 implements the circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114 as seen in Fig 11. In other embodiments, these functions may be implemented by different components, including but not limited to central processing units (CPUs), digital signal processor (DSPs), application-specific integrated circuits (ASICs) or field-programmable gate arrays (FPGAs).

In other embodiments, in addition or as an alternative to Bluetooth 4.0, the wireless earbud 10 may be compliant with other Bluetooth versions, or with AirPlay, PlayFi, Miracast, WiDi, DLNA or Wi-Fi Direct, for instance, or any combinations thereof.

The various elements labeled TPn (n being integer numbers) are input and output terminals for the component Dl, and serial interfaces. The various capacitors Cn, Rn and Ln (n being integer numbers) are provided for decoupling and noise filtering purposes. Component XT1 is a 26 MHz Bluetooth® crystal oscillator. Component SAW90 is an antenna filter. Components Q80 and D80 form a battery safety control circuit. SP1 and SP2 are soldering pads for the charging connectors 15a, 15b (Fig 6). Recesses M1 and M2 are for receiving power from the rechargeable battery 14.

Reference is now made to Fig 10 which illustrates an efficient implementation of an antenna function for the wireless radio communication 110. The antenna comprises an elongate radiator partem 70 disposed at the circumference of the main printed circuit board. More specifically, in the disclosed embodiment the elongate radiator pattern 70 of the antenna is disposed on the actual circumferential edge surface 15_e of the circular main printed circuit board 15 along a portion of its circumference, as is seen in Fig 10. The elongate radiator pattern 70 is formed by means of gold plating in the disclosed embodiment; other conductive materials are of course possible as an alternative.

The antenna is an inverted F antenna, and the elongate radiator pattern 70 provided on the portion of the circular circumferential edge surface 15_e of the main printed circuit board 15 is tuned for resonance at a quarter-wave length suitable for the circuitry for wireless radio communication 110. The feeding point is indicated at 71 in Fig 10.

The antenna design is efficient for several reasons. First, since a circular geometrical shape represents the largest possible ratio between circumference and area,

a sufficient length of the elongate radiator pattern 70 on the circular circumferential edge surface 15_e is available even when the area of the front and rear surfaces 15f, 15_r is limited. Thus, the main printed circuit board 15 can be made compact and still accommodate a sufficiently long antenna 70 for the circuitry for wireless radio communication 110. Hence, antenna performance can be optimized in the smallest possible space.

Also, since the circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114 is disposed on the front and rear surfaces 15f, 15_r of the main printed circuit board 15 with a component concentration towards the center of the front and rear surfaces, a maximum distance 72 is enabled to the component ground plane, as indicated by 74. Again, antenna performance is optimized.

Further, by integrating the antenna 70 on the main printed circuit board 15 (as opposed to having a separate antenna), the risk is reduced for potential losses due to interconnection. Once more, antenna performance is optimized.

Fig 12 schematically illustrates a procedure for switching between idle and operational modes for a wireless earbud. The wireless earbud, for instance any of the earbuds 10, 10a, 10b referred to above, has an idle mode and an operational mode. The wireless earbud comprises an earbud housing (for instance housing 12, 16), a loudspeaker element (for instance loudspeaker element 13), a rechargeable battery (for instance rechargeable battery 14), and at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control (for instance the main printed circuit board 15 with its circuitry 110-116 as previously described). The circuitry is configured for automatic power preservation by performing the following steps.

First, connection of the battery to a charger is detected (not seen in Fig 12). This may for instance involve insertion of the earbud into the storage and charging capsule 20 as described above. The detection may be based on a comparison of voltage levels. If the charger supplies charging at a higher voltage, such as 5 V, than the nominal voltage of the rechargeable battery in the earbud, such as 3.3 V, then the higher voltage will indicate connection to a charger.

In response to detecting connection to a charger, the earbud (e.g. earbud 10a) will enter idle mode, wherein existing connections to a second wireless earbud (e.g. earbud 10b) and to a wireless audio streaming host device (e.g. device 100) will be disconnected.

Then, at a later point of time when the wireless earbud is removed from the charger, disconnection of the battery from the charger will be detected, see 122 in Fig 12. In response, the wireless earbud will enter operational mode by the following steps:

Firmware in the circuitry on the main printed circuit board will boot, see 124 in Fig 12. In step 126, a true wireless stereo, TWS, reconnection with the second wireless earbud will be attempted.

If the attempt is successful, the wireless earbud will be operated as a TWS audio receiver, see 166, in association with the second wireless earbud. Otherwise, the wireless earbud will be operated as a mono wireless audio receiver, see 144, if the failure persists after repeated additional attempts, as seen at 132 and 164.

When the wireless earbud is operated as a TWS audio receiver, as verified at 140 and 142, it is determined at 146 and 148 whether the wireless earbud is a master device ("inquiry bud") or a slave device with respect to the second wireless earbud.

If the wireless earbud is determined to be a master device, attempts are made at 150 and 154 to reconnect with the wireless audio streaming host device (e.g. device 100), and other known wireless audio streaming host devices if applicable.

If reconnection with the wireless audio streaming host device (e.g. device 100) has been successful, see 156 and 158, then the execution ends at 162 with a successful automatic reconnection both with the second earbud and with the wireless audio streaming host device completely without any use of manual intervention by the earbud user (other than removing the earbud from the charger). Hence, a power-efficient and automatic procedure for switching between idle and operational modes for a wireless earbud, without requiring any manual actuators like buttons, etc, is provided.

Should reconnection with the wireless audio streaming host device (e.g. device 100) on the other hand fail, a more time and power consuming pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices, if applicable, will be initiated, see 158 and 160 in Fig 12.

When a pair of earbuds, such as earbuds 10a and 10b, is used for true wireless stereo streaming from a wireless audio streaming host device, such as device 100 in Fig 11, one of the earbuds will have a role as master device with respect to the other one of the earbuds, which will correspondingly be a slave device. This is for instance the case with Bluetooth-based wireless audio streaming. Another inventive power preservation scheme has therefore been provided which compensates for the fact that the master device will consume more power than the slave device. Therefore, after some time, the

master device will run out of power and need to be recharged, even though the slave device still may have a decent remaining battery charge status.

According to this inventive aspect, a wireless audio streaming host device is provided for use with a first wireless earbud and a second wireless earbud, for instance earbuds 10a and 10b according to the previous description. The wireless audio streaming host device may for instance be any of the example devices 100 shown in Fig 11 and will have a controller in the form of a CPU, DSP, ASIC, FPGA, etc. The controller will be configured to receive a message from the first earbud by wireless communication, such as Bluetooth. The message will indicate a current battery charge status for the first earbud. Correspondingly, the controller will be configured to receive a message from the second earbud by wireless communication. This message will indicate a current battery charge status for the second earbud.

The controller will determine which one of the first and second earbuds has a current master device role and a current slave device role, respectively.

The controller will then assess, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device. The assessment may for instance be based on absolute or relative threshold values. For instance, if the master earbud device has below x % of remaining battery charge, or if the difference in remaining battery charge between the two earbuds exceeds a certain value, a switch of roles may be concluded as appropriate.

If a switch in roles is found appropriate, the controller will cause, again by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role. The controller will also cause, by wireless communication, the other one among the first and second earbuds to assume a master device role. The causing may be done by control messages sent by the controller of the wireless audio streaming host device to both earbuds directly, or by a control message sent to the master earbud device that will then in turn send a control message to the slave earbud device, etc. Other ways of causing the switch in roles are also possible, as is believed to be understood *per se* by those skilled in the art.

The invention has been described above in detail with reference to embodiments thereof. However, as is readily understood by those skilled in the art, other embodiments are equally possible within the scope of the present invention, as defined by the appended claims.

CLAIMS

1. A wireless earbud (10), comprising:

an earbud housing (12, 16) having a longitudinal main axis (19) and an essentially circular cross section;

a loudspeaker element (13);

a rechargeable battery (14);

at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114); and

a charging interface member (17),

wherein the loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

2. The wireless earbud (10) as defined in claim 1, wherein the loudspeaker element (13), the rechargeable battery (14), the main printed circuit board (15) and the charging interface member (17) all have a generally circular cross section and are coaxially disposed around the longitudinal main axis (19) of the earbud housing (12, 16).

3. The wireless earbud (10) as defined in claim 1 or 2, wherein the earbud housing (12, 16) comprises a tapered front housing portion (12) and a rear housing portion (16), the tapered front housing portion comprising:

a loudspeaker chamber (12b) for accommodating the loudspeaker element (13); and

a sound guiding channel forming element (12a) for receiving an earbud foam tip (11).

4. The wireless earbud (10) as defined in claim 3, wherein the loudspeaker element (13) is a magnetic balanced armature (BA) receiver.

5. The wireless earbud (10) as defined in claim 1 or 2, wherein the earbud housing (12, 16) comprises a front housing portion (12) and an essentially cylindrical or frusto-conical rear housing portion (16), the rear housing portion comprising a first end

(16a) proximate to the front housing portion and a second distal end (16b), the rear housing portion together with the front housing portion accommodating the main printed circuit board (15) inside the rear housing portion nearest its second distal end, then the rechargeable battery (14) and the loudspeaker element (13) in successive order towards the front housing portion along the longitudinal main axis (19) of the earbud housing.

6. The wireless earbud (10) as defined in claim 5, the rear housing portion (16) having a wall (16c) at the second distal end (16b), wherein the main printed circuit board (15) is mounted at an internal surface of said wall, and wherein the charging interface member (17) is mounted at an extemal surface of said wall.

7. The wireless earbud (10) as defined in claim 6, the wall (16c) at the second distal end (16b) of the rear housing portion (16) comprising first and second openings (16d, 16e) for providing access from the outside of said wall to the main printed circuit board (15) inside said wall.

8. The wireless earbud (10) as defined in claim 7, the main printed circuit board (15) having mounted thereon first and second charging connectors (15a, 15b) being aligned with the first and second openings (16d, 16e) in said wall (16c) for providing electric contact with the charging interface member (17) at the external surface of said wall.

9. The wireless earbud (10) as defined in claim 7 or 8, the first and second openings (16d, 16e) in said wall (16c) being aligned with a programming or data writing interface on the main printed circuit board (15).

10. The wireless earbud (10) as defined in any of claims 7-9, wherein the charging interface member (17) comprises a circuit board substrate mounted to the extemal surface of said wall (16c), and a conductive pattern (17a) printed on an external surface of the circuit board substrate facing away from said wall, the conductive pattern being designed for electric contact with a power transmission arrangement in a storage and charging capsule (20) for the wireless earbud.

11. The wireless earbud (10) as defined in claim 10, wherein the conductive partem (17a) of the charging interface member (17) comprises a first sub-pattern (17b) adapted to reach electrical contact with a first charging connector element (44a/44c) of the power transmission arrangement in the storage and charging capsule (20), and a second sub-pattern (17c) electrically isolated from the first sub-pattern and being adapted to reach electrical contact with a second charging connector element (50c) of the power transmission arrangement in the storage and charging capsule.

12. The wireless earbud (10) as defined in claim 10 or 11, wherein the conductive pattern () is designed as a graphical symbol representing the individual earbud (10), a product type of said earbud, or a producer or supplier of said earbud.

13. The wireless earbud (10) as defined in any preceding claim, the main printed circuit board (15) having a front surface (15f), a rear surface (15_r) and a circumferential edge surface (15_e), wherein the main printed circuit board further comprises an antenna for the circuitry for wireless radio communication (110), the antenna comprising an elongate radiator partem (70) disposed at the circumference of the main printed circuit board.

14. The wireless earbud (10) as defined in claim 13, wherein the elongate radiator pattern (70) of the antenna is disposed on the circumferential edge surface (15_e) of the main printed circuit board (15).

15. The wireless earbud (10) as defined in claim 14, the main printed circuit board (15) having an essentially circular sectional shape and thus an essentially circular circumference, wherein the elongate radiator pattern (70) of the antenna is provided on the circular circumferential edge surface (15_e) of the main printed circuit board along a portion of its circumference.

16. The wireless earbud (10) as defined in claim 15, wherein the antenna is an inverted F antenna, and wherein the elongate radiator pattern (70) provided on the portion of the circular circumferential edge surface (15_e) of the main printed circuit board (15) is tuned for resonance at a quarter-wave length suitable for the circuitry for wireless radio communication (110).

17. The wireless earbud (10) as defined in claim 16, wherein the circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114) is disposed on one or both of the front and rear surfaces (15f, 15_r) of the main printed circuit (15) and with a component concentration towards the center of the front and rear surfaces.

18. A storage and charging capsule (20) for a pair of wireless earbuds (10a, 10b), the storage and charging capsule comprising:

a base part (22);

an elongate intermediate part (24), the intermediate part having a longitudinal major axis (60); and

a cover part (26) being retractable over the intermediate part,

wherein the intermediate part has a first end (25a) attached to the base part, a second end (25b), and an earbud chamber (31) formed between the first and second ends, the earbud chamber being adapted to receive the pair of wireless earbuds arranged one after another along the longitudinal major axis of the intermediate part, and

wherein the capsule further has a power source (40) for charging the pair of wireless earbuds when placed in the earbud chamber in the intermediate part.

19. The storage and charging capsule (20) as defined in claim 18, wherein the power source comprises a rechargeable battery (40) and wherein the capsule (20) further comprises a power transmission arrangement for feeding electric power from the rechargeable battery to both earbuds (10a, 10b) when placed in the earbud chamber (31) in the intermediate part (24).

20. The storage and charging capsule (20) as defined in claim 19, the rechargeable battery (40) being accommodated in the base part (22), wherein the power transmission arrangement comprises a first charging connector disc (42) at the first end (25a) of the intermediate part (24), the first charging connector disc comprising a plurality of charging connector elements (44a-44c) symmetrically distributed over a surface of the charging connector disc to allow electric contact with a charging interface of one (10a) of the earbuds (10a, 10b) irrespective of its radial orientation in the earbud chamber (31).

21. The storage and charging capsule (20) as defined in claim 20, wherein the plurality of charging connector elements (44a-44c) are adapted to reach electric contact with a conductive pattern (17a) provided at a rear end of the earbud (10a).

22. The storage and charging capsule (20) as defined in claim 20 or 21, wherein the power transmission arrangement further comprises a second charging connector disc (48) at the second end (25b) of the intermediate part (24), the second charging connector disc comprising a plurality of charging connector elements symmetrically distributed over a surface of the second charging connector disc to allow electric contact with a charging interface of the other earbud (10b) irrespective of its radial orientation in the earbud chamber, wherein the charging connector elements (44a-c) of the first charging connector disc (42) are connected to the rechargeable battery (40), and wherein the charging connector elements of the second charging connector disc (48) are connected to the charging connector elements of the first charging connector disc or to the rechargeable battery by an interconnector (52) extending between the first and second ends (25a, 25b) of the intermediate part (24).

23. The storage and charging capsule (20) as defined in any of claims 18-22, the cover part (26) being shaped essentially as a cylinder having an open end (27a) for receiving the intermediate part (24), and a closed end (27b), the cover part being placeable in a first position in which the cover part is retracted from the intermediate part to allow insertion or removal of the earbuds (10a, 10b) in/from the earbud chamber (31), and in a second position in which the cover part encapsulates the intermediate part with the open end of the cover part abutting against the base part (22).

24. The storage and charging capsule (20) as defined in claim 23, further comprising a first magnet (58) mounted at the second end (25b) of the intermediate part (24) and a second magnet mounted at the closed end (27b) of the cover part (26), the first and second magnets urging the cover part against the base part (22) in the second position of the cover part.

25. A wireless earbud (10/10a) having an idle mode and an operational mode, the wireless earbud comprising:

an earbud housing (12, 16);

a loudspeaker element (13);

a rechargeable battery (14); and

at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114);

wherein the circuitry is configured for automatic power preservation by:

detecting connection of said battery to a charger and in response entering the idle mode, wherein existing connections to a second wireless earbud (10b) and to a wireless audio streaming host device (100) will be disconnected; and

detecting (122) disconnection of said battery from said charger and in response entering the operational mode by:

attempting (126) a true wireless stereo, TWS, reconnection with the second wireless earbud;

if the attempt is successful, operating (166) the wireless earbud as a TWS audio receiver and otherwise operating (144) the wireless earbud as a mono wireless audio receiver;

if operated as a TWS audio receiver, determining (146, 148) whether the wireless earbud is a master device or a slave device with respect to the second wireless earbud;

if the wireless earbud is determined to be a master device, attempting (150, 154) to reconnect with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable; and

if reconnection with the wireless audio streaming host device fails, initiating (158, 160) a pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable.

26. The wireless earbud as defined in claim 25, wherein the circuitry for wireless radio communication (110) is compliant with one or more of Bluetooth, AirPlay, PlayFi, Miracast, WiDi, DLNA or Wi-Fi Direct.

27. A wireless audio streaming host device (100) for use with a first wireless earbud (10a) and a second wireless earbud (10b), the wireless audio streaming host device having a controller configured for:

receiving, by wireless communication, a message from the first earbud, the message indicating a current battery charge status for the first earbud;

receiving, by wireless communication, a message from the second earbud, the message indicating a current battery charge status for the second earbud;

determining which one of the first and second earbuds has a current master device role and a current slave device role, respectively;

assessing, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device; and, if a switch in roles is found appropriate:

causing, by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role; and

causing, by wireless communication, the other one among the first and second earbuds to assume a master device role.

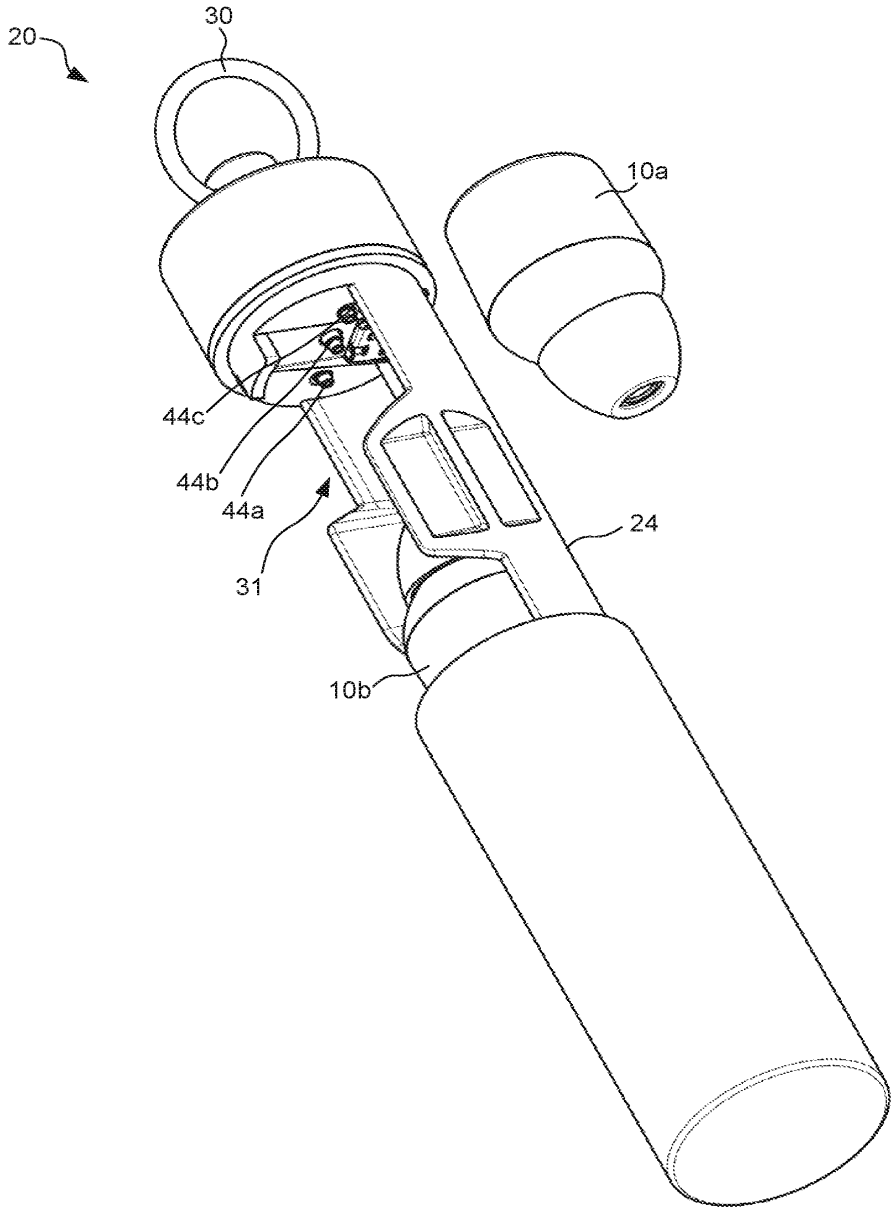


Fig 1

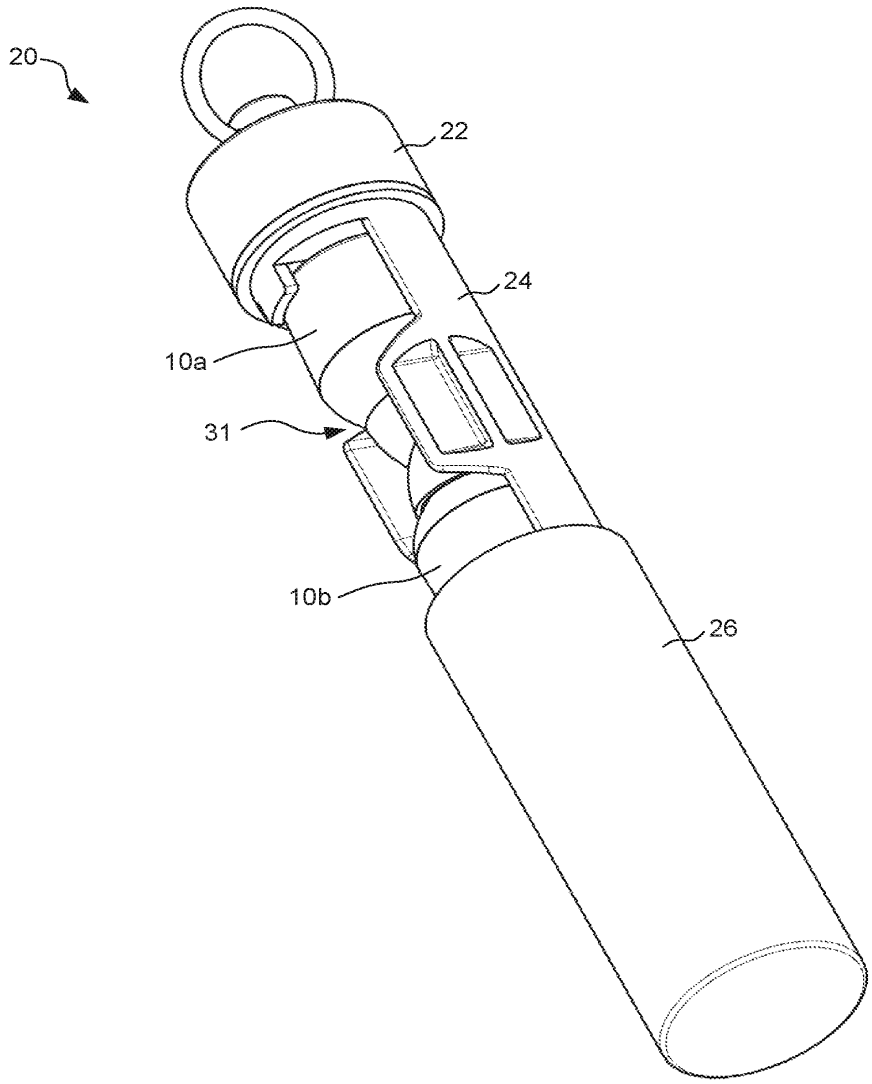


Fig 2

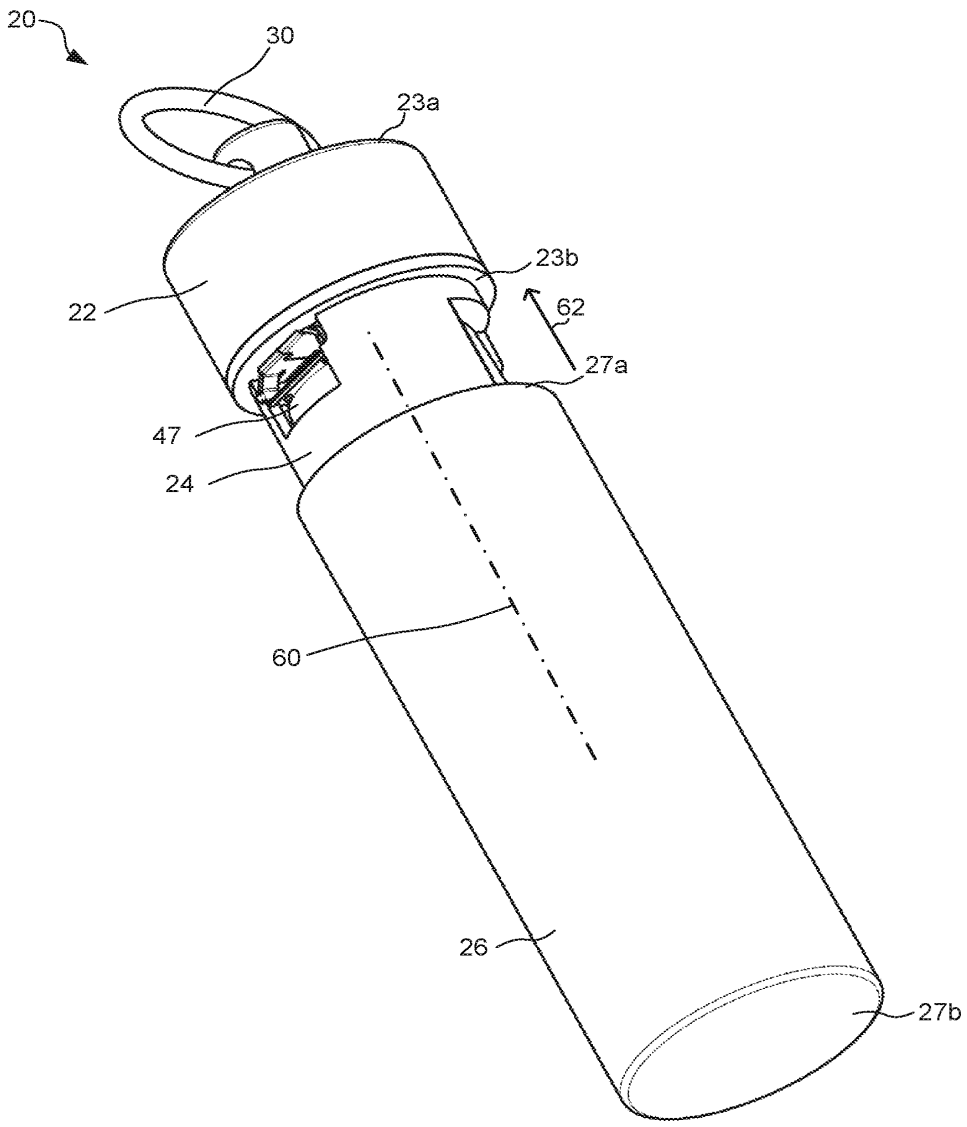


Fig 3

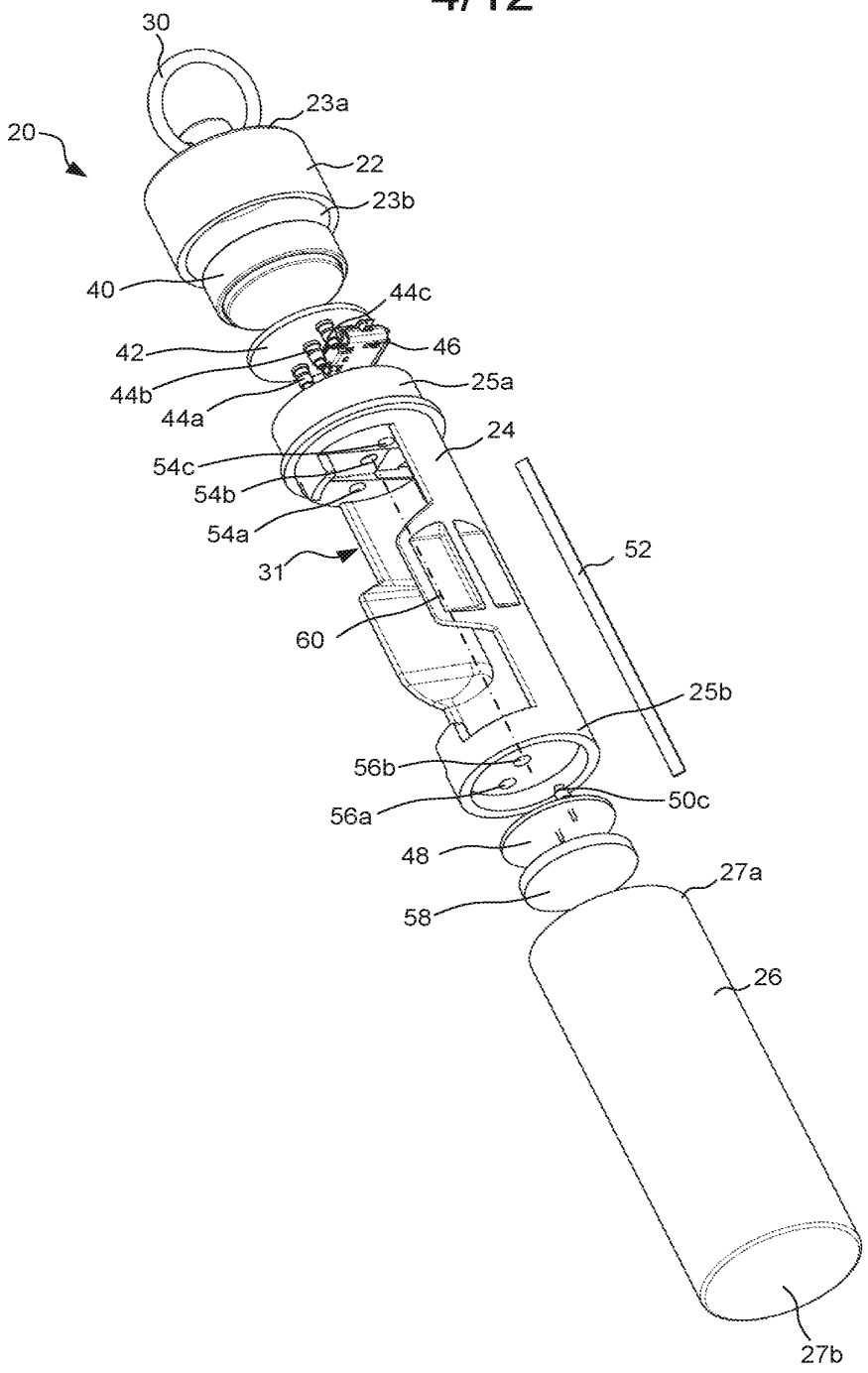

30
23a
20
22
23b
40
44c
42
46
44b
25a
44a
24
54c
54b
54a
52
31
60
25b
56b
50c
56a
48
27a
58
26
27b

Fig 4

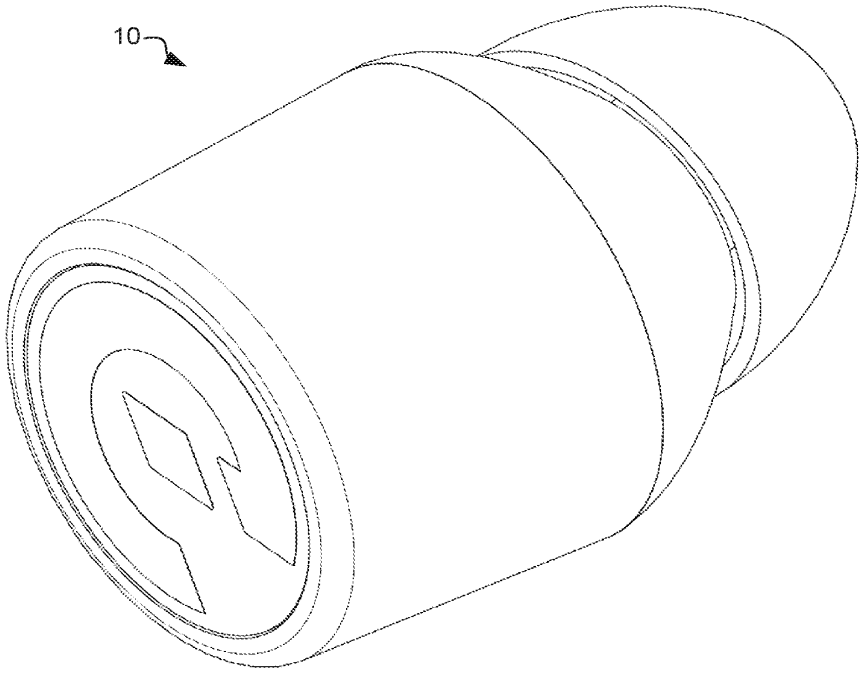


Fig 5

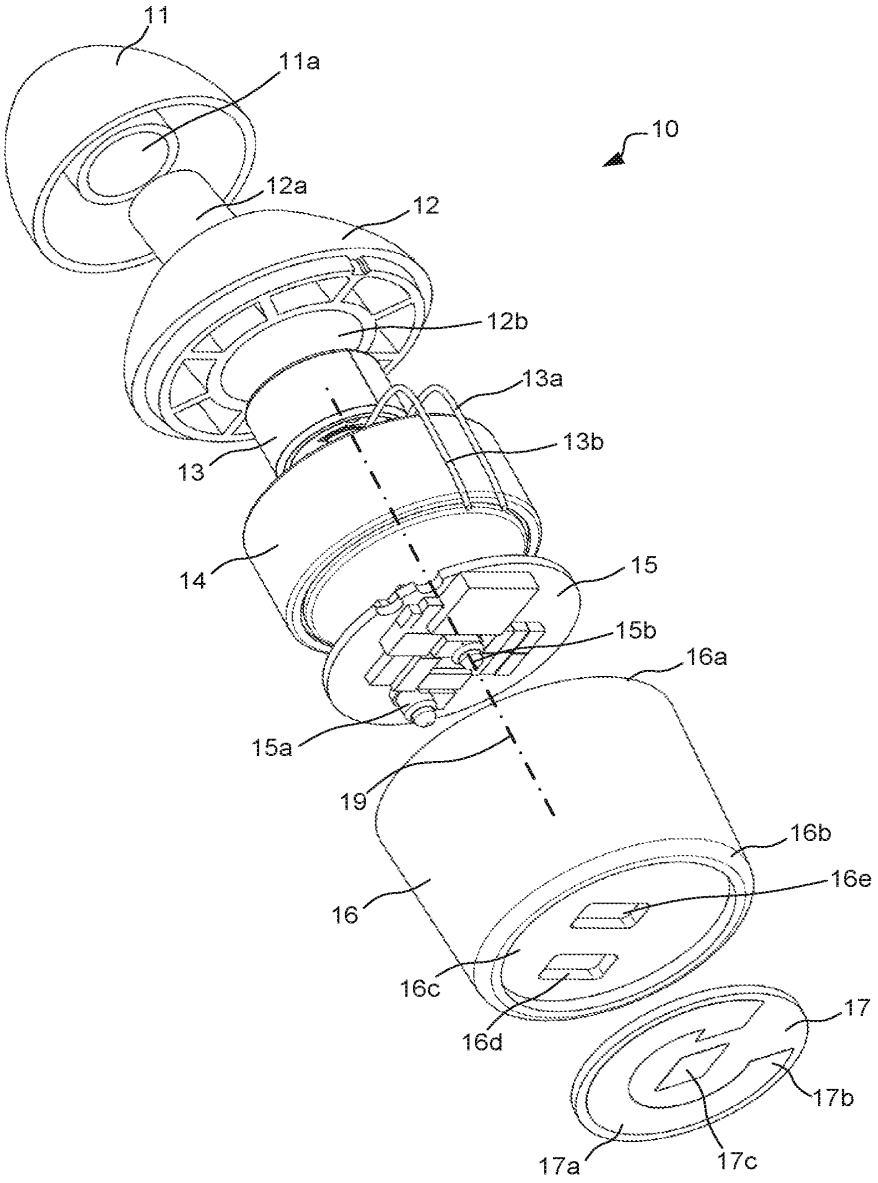

11
11a
10
12a
12
12b
13a
13b
13
14
15
15b
16a
15a
19
16b
16e
16
16c
16d
17
17b
17a
17c

Fig 6

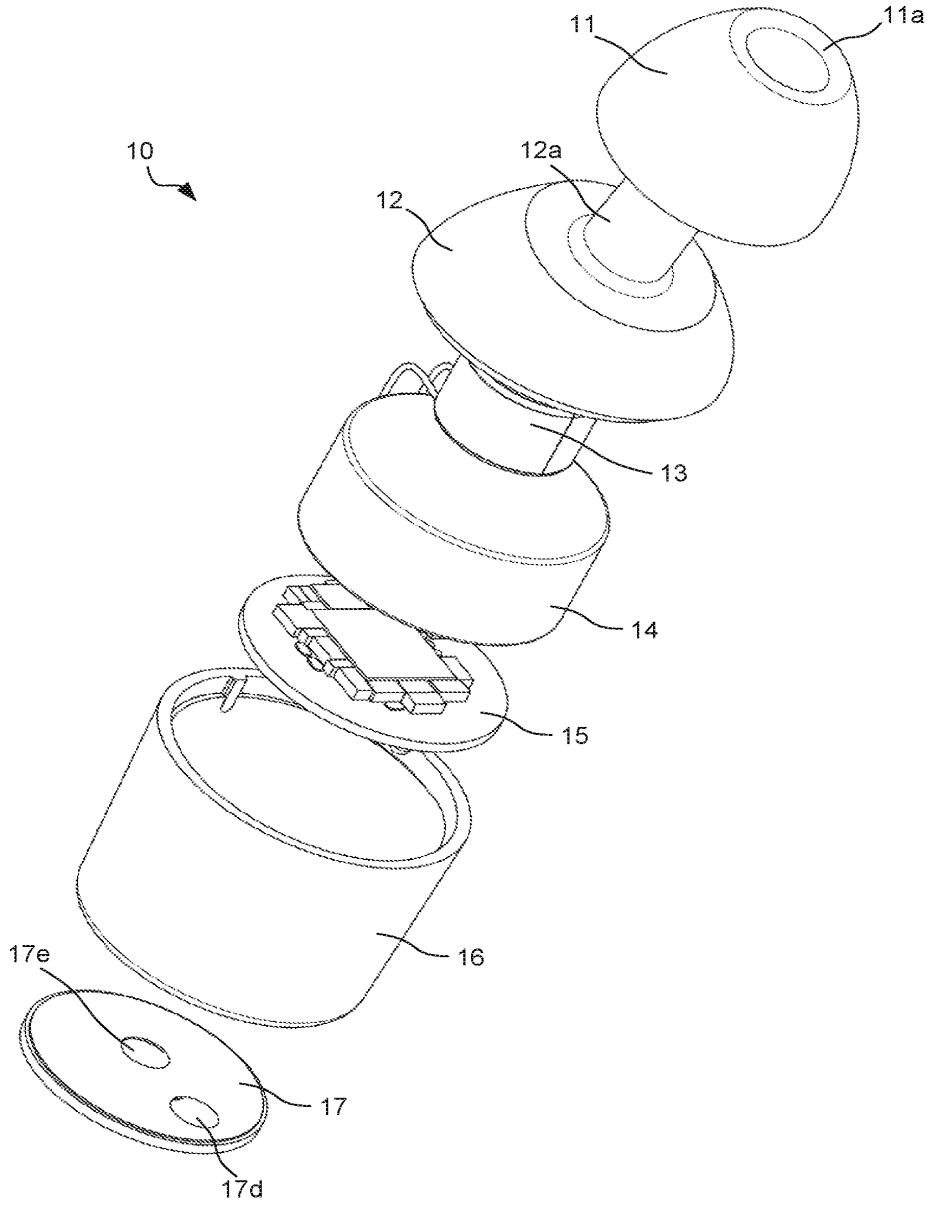


Fig 7

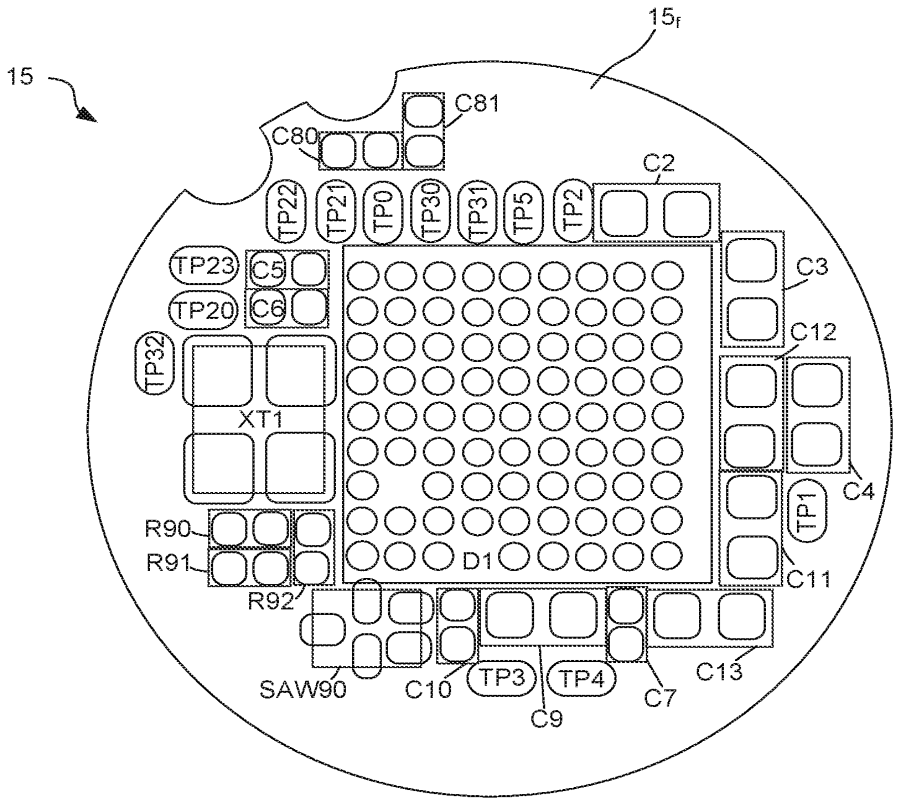

15
15f
C81
C80
C2
TP22
TP21
TP0
TP30
TP31
TP5
TP2
TP23
C5
C3
TP20
C6
C12
TP32
XT1
C4
TP1
R90
R91
D1
C11
R92
SAW90
C10
TP3
TP4
C7
C13
C9

Fig 8

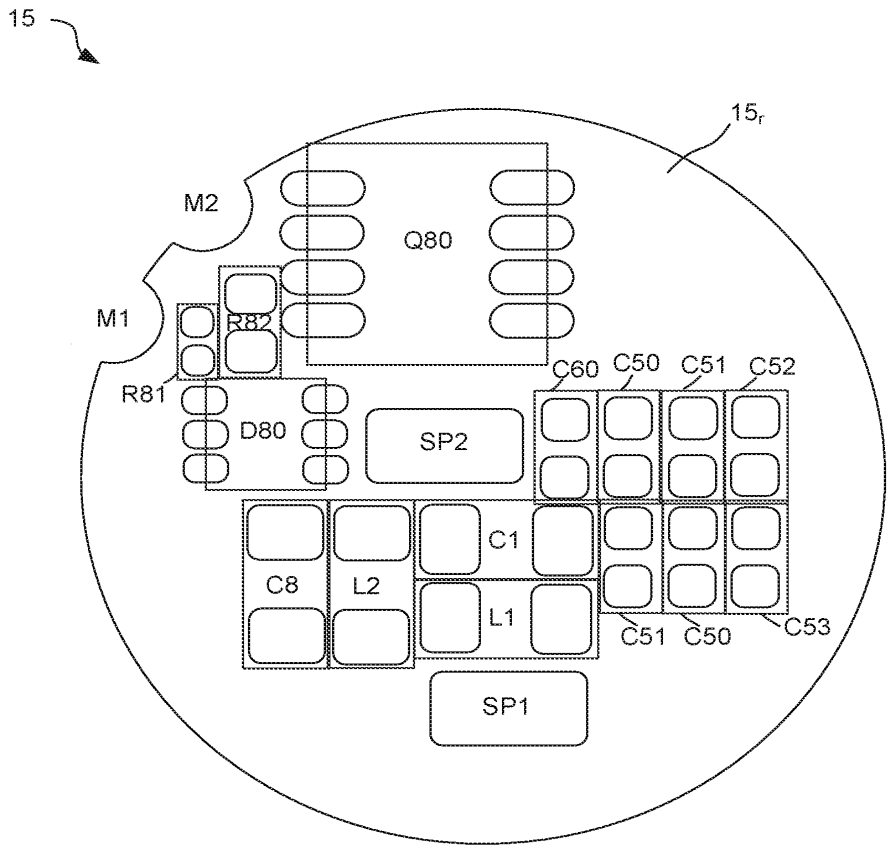

15
15r
M2
M1
Q80
R82
R81
D80
SP2
C60
C50
C51
C52
C1
C8
L2
L1
C51
C50
C53
SP1

Fig 9

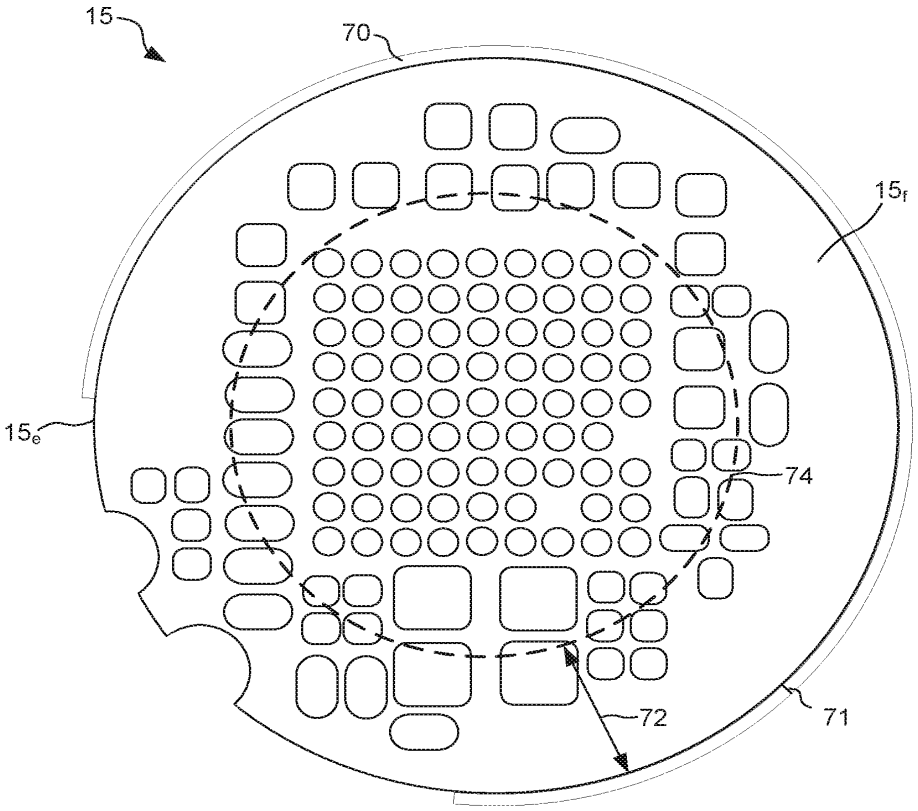


Fig 10

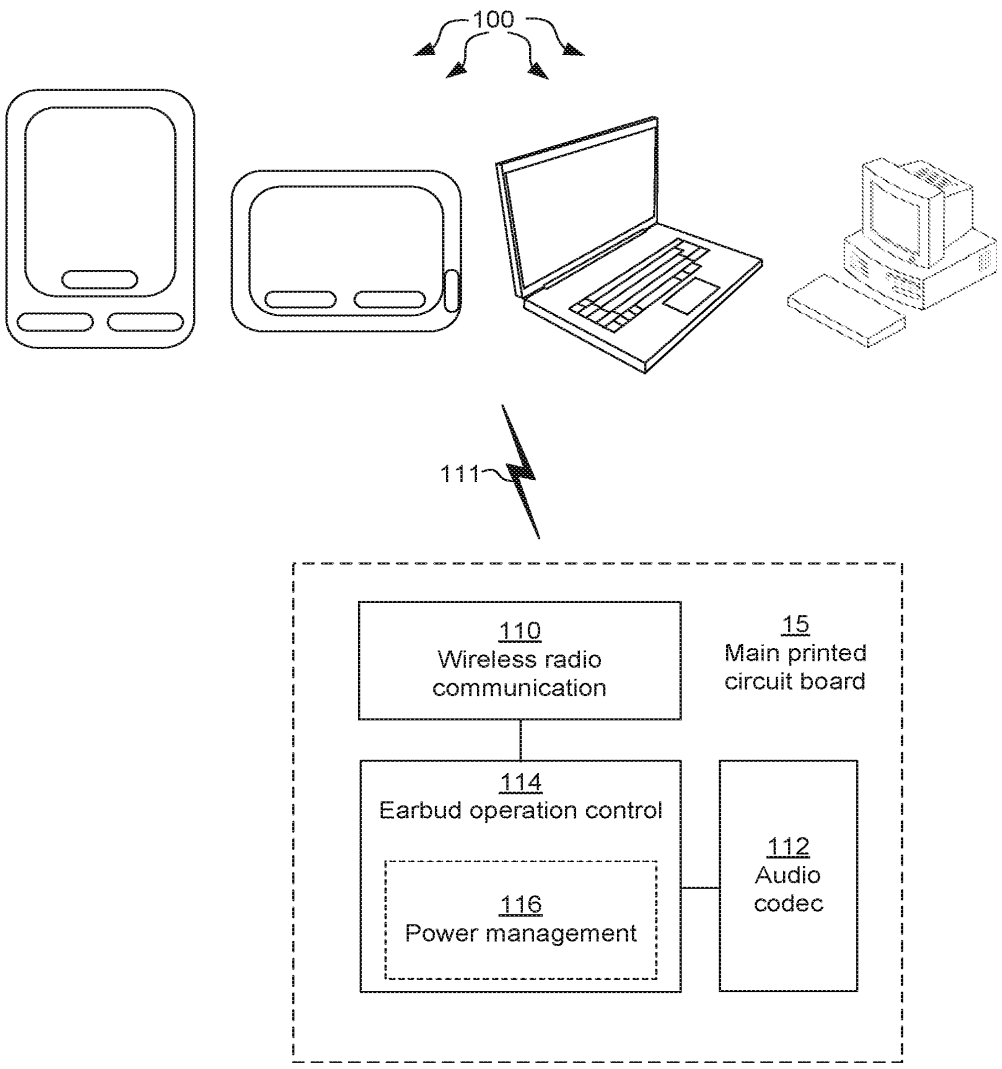

100
111
110
Wireless radio communication
15
Main printed circuit board
114
Earbud operation control
116
Power management
112
Audio codec

Fig 11

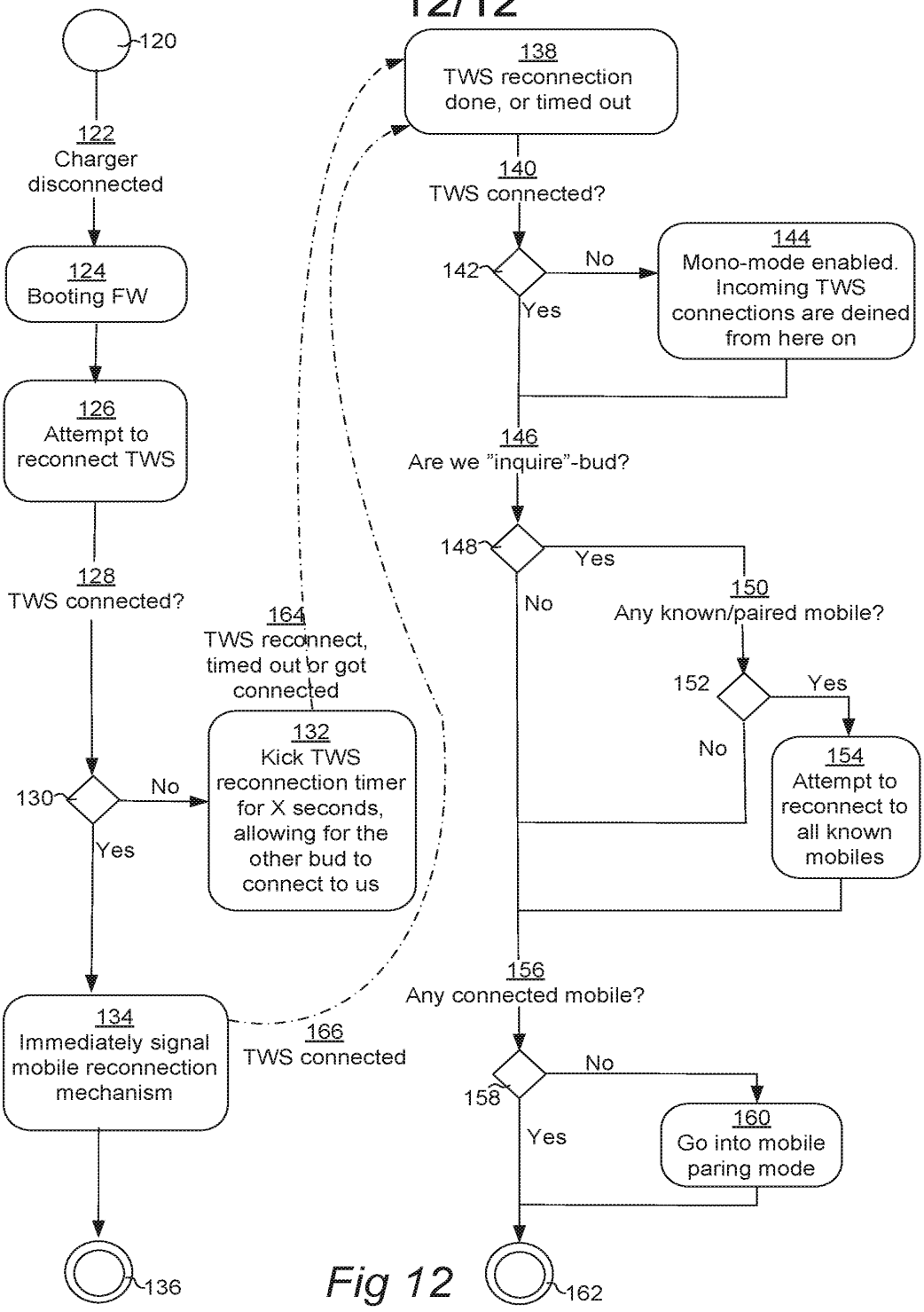

120
122
Charger disconnected
124
Booting FW
126
Attempt to reconnect TWS
128
TWS connected?
130
No
Yes
132
Kick TWS reconnection timer for X seconds, allowing for the other bud to connect to us
134
Immediately signal mobile reconnection mechanism
136
164
TWS reconnect, timed out or got connected
166
TWS connected
138
TWS reconnection done, or timed out
140
TWS connected?
142
No
Yes
144
Mono-mode enabled. Incoming TWS connections are deined from here on
146
Are we "inquire"-bud?
148
Yes
No
150
Any known/paired mobile?
152
Yes
No
154
Attempt to reconnect to all known mobiles
156
Any connected mobile?
158
No
Yes
160
Go into mobile paring mode
162

Fig 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 5/050941

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: H02J, H04N, H04R

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 201 00290637 A 1 (LERNER NOA), 18 November 2010 (2010-1 1-18)	1-4, 13-15
A	--	5-12, 16-1 7, 25-26
Y	US 200801 8 1442 A 1 (GOLDSTEIN STEVEN W ET AL), 3 1 July 2008 (2008-07-31)	1-4, 13-15
A	--	5-12, 16-1 7, 25-26

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y " document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01-02-2016	02-02-2016
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Henrik Andersson Telephone No. +46 8 782 28 oo

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 5/050941

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 201 401 661 22 A 1 (GOLDSTEIN STEVEN W ET AL), 19 June 2014 (2014-06-1 9)	1-4, 13-15
A	--	5-12, 16-1 7, 25-26
A	EP 2640170 A 1 (APPLE INC), 18 September 2013 (2013-09-18)	1-17, 25-26
	--	
A	WO 2010132359 A2 (ASIUS TECHNOLOGIES LLC ET AL), 18 November 201 0 (201 0-1 1-18)	1-17, 25-26
	--	
P, X	US 201 50245127 A 1 (SHAFFER JONATHAN EVERETT), 27 August 201 5 (2015-08-27)	1-17, 25-26
	--	
E	US 201 50350762 A 1 (BIRGER JOHAN ET AL), 3 December 2015 (2015-12-03)	1-17, 25-26
	--	

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 5/050941

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

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

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

2. ☐ Claims Nos.:
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:

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. Ill 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: Claims 1-17, 25-26 directed to a wireless earbud and its construction.

2: Claims 18-24 directed to a storage and charging capsule and its construction.

3: Claim 27 directed to a wireless audio streaming host device for streaming wireless audio and communication.

.../...

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 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.: 1-1 7,25-26

A wireless earbud and its construction.

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.

Continuation of: Box No. III

A partial search has been carried out, which relates to the invention 1 mentioned above.

The present application has been considered to contain 3 inventions which are not linked such that they form a single general inventive concept, as required by Rule 13 PCT for the following reasons:

Claims 1-1 7, 25-26 relates to the problem of providing a wireless earbud with improved construction. This problem appears to be solved by an apparatus where a wireless earbud has a housing having a longitudinal main axis and an essentially circular cross section, where a speaker element, a rechargeable battery, a printed circuit board and a charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

Claims 18-24 relates to the problem of providing a storage and charging capsule for earbuds with improved construction. This problem is solved by an apparatus where a capsule has a base part, an elongate intermediate part that has a longitudinal major axis and a cover part being retractable over the intermediate part and wherein the intermediate part has a first end attached to the base part and a second end and an earbud chamber formed between the first and second ends and wherein the capsule also has a power source for charging earbuds placed in the chamber.

Claim 27 relates to the problem of streaming wireless audio from a host device to earbuds. This problem is solved by an apparatus where a wireless audio streaming host device for use with earbuds has a controller for receiving a message from a earbud indicating a current battery charge status and receiving a message from another earbud indicating a current battery charge status for that second earbud and determining which one of them that has a current master device role and slave role and assessing whether a switch in roles is appropriate and causing that switch.

As both the problems and solutions are technically different, no single general concept can be formulated based on the technical features of the inventions. Consequently, the requirements of Rule 13.1 PCT are not met.

Continuation of: second sheet

International Patent Classification (IPC)

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[Continued on nextpage]

(54) Title: HEARING PROTECTOR WITH COMPARTMENT FOR RECHARGEABLE BATTERY PACK

(57) Abstract: A hearing protection device is provided. The hearing protection device can include a speaker to relay sounds, such as conversations, to the user of the hearing protection. The hearing protection device can be powered by a rechargeable battery pack or separately by standard batteries.

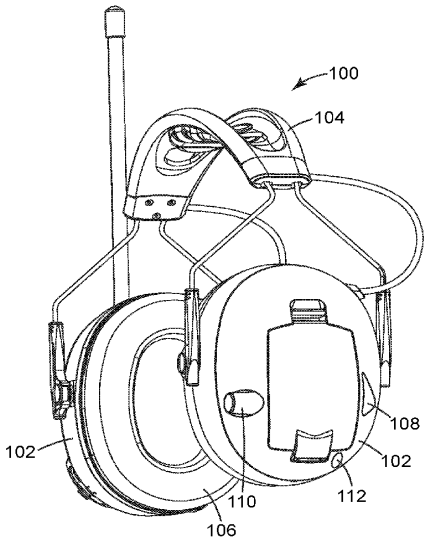


Fig. 1

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TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17 :

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

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.1 ?(in))*

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— *with international search report (Art. 21(3))*

HEARING PROTECTOR WITH COMPARTMENT FOR RECHARGEABLE BATTERY PACK

Background

People frequently wear hearing protection when they are in loud or noisy environments. Hearing protection can reduce the amount of noise the user's ears are exposed to. In some cases the user might want to hear some noises, such as a conversations or commands from people around them, music, other entertainment or other communication (e.g. AM/FM radio transmissions, Bluetooth transmissions, or communication from other transceivers) delivered through an input sound source. If the user is wearing hearing protection, hearing these desirable noises can be difficult or impossible. Therefore, there is a need to allow the user of hearing protection to still be able to hear some external noises, while still reducing the loud or undesirable noises.

Hearing protectors often require power to operate the apparatus. Batteries are often used to power these products. Users of hearing protection products can appreciate the convenience of using different battery types in the same apparatus. However, the different form factors of rechargeable batteries compared to standard cylindrical batteries often makes it difficult for a single apparatus to be powered by either type of battery without modifications that change the appearance and/or size of the apparatus. For safety reasons, it is also desired that products which can use rechargeable batteries have a means of preventing charging from occurring if a non-rechargeable battery or wrong type of rechargeable battery is used in the apparatus.

Summary

Sound external to a hearing protection headset can be input by one or more microphones on the headset. The ambient external sound or background noises can be monitored, analyzed and filtered so that a user of the headset can better hear human voices.

In one example, an apparatus for hearing protection includes a sound input source, such as a microphone, disposed on the apparatus. The sound input source is configured to pick up an input sound wave from the environment and to convert the input sound wave to an incoming signal. The apparatus also includes a processor that is configured to receive the incoming signal and create an output signal. The apparatus can further include a speaker disposed on the apparatus. The speaker is configured to produce the output from the processor.

In one example, an apparatus for hearing protection includes a microphone disposed on the apparatus and configured to pick up an input sound wave from the environment and convert the input sound wave to an incoming signal. The apparatus also includes a processor, configured to receive the incoming signal and create an output signal. The apparatus also includes a speaker disposed on the apparatus, the speaker configured to produce the output from the processor. The apparatus also includes a battery compartment that comprises three contacts: a first positive contact configured to make electrical

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contact with a positive terminal of a battery or battery pack, a second negative contact configured to make electrical contact with a negative terminal of a battery or battery pack, and a third contact configured to facilitate charging of a rechargeable battery pack. The hearing protection device apparatus can be configured to prevent recharging unless there is a contact of a rechargeable battery pack making contact with the third contact. In an embodiment, the hearing protection apparatus can be powered by two standard cylindrical batteries alone, or the hearing protection device can be powered by a rechargeable battery pack alone.

One embodiment of the present disclosure is an apparatus for hearing protection comprising: two ear cups, each ear cup defining a cavity configured to fit a user's ear; a processor, configured to receive an incoming signal and create an output signal; a speaker disposed within at least one of the two ear cups, the speaker configured to produce the output from the processor; wherein one of the two ear cups comprises a battery compartment configured to house one or more batteries or battery packs, wherein the battery compartment further comprises:

a first positive contact configured to make electrical contact with a positive terminal of one of the one or more batteries or battery packs,

a second negative contact configured to make electrical contact with a negative terminal of one of the one or more batteries or battery packs, and

a third contact configured to facilitate charging of a rechargeable battery pack selected from one of the one or more batteries or battery packs; and

wherein the battery compartment defines an open battery-receiving space configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes, wherein the apparatus further comprises a charging port, wherein the charging port is configured to receive a cable for recharging the rechargeable battery pack. In an embodiment, the apparatus is configured to prevent charging to the one or more batteries or battery packs unless there is a contact of a rechargeable battery pack contacting the third contact.

Brief Description of the Drawings

The present disclosure may be more completely understood in connection with the following drawings, in which:

FIG. 1 is a perspective view of the headset, according to an embodiment.

FIG. **2** is a perspective view of the headset, according to an embodiment.

FIG. **3** is a schematic of certain headset components, according to an embodiment.

FIG. 4 is a perspective view of a headset embodiment with a rechargeable battery pack, according to an embodiment.

FIG. 5 is a perspective view of the headset with two standard batteries, according to an embodiment.

FIG. 6 is a perspective view of the empty battery compartment of the headset, according to an embodiment.

FIG. 7 is a schematic diagram of certain elements of a rechargeable battery pack and hearing protector, according to an embodiment.

FIG. 8 is a perspective cut-away view of a rechargeable battery pack of FIG. 7, according to an embodiment.

FIG. 9a is a perspective view of a rechargeable battery pack, according to an embodiment.

FIG. 9b is a perspective view of a rechargeable battery pack, according to an embodiment.

While the present disclosure is susceptible to various modifications and alternative forms, specifics thereof have been shown by way of example and drawings, and will be described in detail. It should be understood, however, that the present disclosure is not limited to the particular embodiments described. On the contrary, the intention is to cover modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure.

Detailed Description

The embodiments of the present disclosure described herein are not intended to be exhaustive or to limit the present disclosure to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art can appreciate and understand the principles and practices of the present disclosure.

All publications and patents mentioned herein are hereby incorporated by reference. The publications and patents disclosed herein are provided solely for their disclosure. Nothing herein is to be construed as an admission that the inventors are not entitled to antedate any publication and/or patent, including any publication and/or patent cited herein.

FIG. 1 is a perspective view of a headset 100. In an embodiment, the headset 100 can include an ear cup 102 and a headband 104. The headset 100 can include two ear cups 102. The headband 104 can couple a first ear cup 102 with a second ear cup 102. The headband 104 can be arced, such as to extend over the top of a user's head while the headset 100 is in use. The headband 104 can be flexible, such as to allow the user to spread the first ear cup 102 from the second ear cup 102 when the user is putting on the headset 100. The headband 104 can include padding, such as to at least partially conform to the user's head and increase the user's comfort.

The ear cups 102 can be configured to fit at least partially around a user's ear, and be disposed on the side of a user's head while in use. The ear cup 102 can define a cavity. The cavity can be configured for a user's ear, a human ear, to fit within the cavity, while the user is wearing the headset 100. The ear cup 102 can include a seal ring 106. The seal ring 106 can be ring shaped, such as to extend around the user's ear. The seal ring 106 can be flexible and able to conform to the user's head. The seal ring 106

can provide a seal between the ear cup 102 and the user's head, such as to reduce the amount of noise or sound waves that reach the user's ear, thereby at least partially protecting the user's ear from external noises. The seal ring 106 can include leather, cloth, rubber, plastic, or a polymer, such as polyurethane.

The headset 100 can include a sound input source 108. In one embodiment, one or both of the ear cups 102 can include a sound input source 108. In an embodiment, the sound input source 108 can comprise a microphone. In an embodiment, there is one microphone 108 on each of two ear cups 102. In an embodiment, there can be more than one microphone 108 on one or both of the ear cups 102. In one embodiment, one or more microphones 108 are located at other locations on the headset 100. The microphone 108 can be disposed on the outside surface of the ear cup 102 opposite the cavity. The microphone 108 can pick up sound and noise from the surrounding environment. The microphone 108 can be inset, such that the microphone 108 does not extend past the outer surface of the ear cup 102. In an embodiment with two ear cups 102, each ear cup 102 can include a microphone 108. In another embodiment with two ear cups 102, only one ear cup 102 includes a microphone 108. In another embodiment with two ear cups 102, one microphone 108 is positioned on a headband portion. The noises and sounds picked up by the microphone 108 can be relayed to the user through a speaker in the cavity of the ear cup 102.

One of the ear cups 102 can include a knob 110. The user can rotate the knob 110 to control the electronics of the headset 100, such as to turn the electronics "ON" or "OFF", or to increase or decrease the volume from the speakers in the ear cups 102.

The ear cups 102 can include an input connection 112. The input connection 112 can allow a user to connect an external audio device into the headset 100, such as an AM/FM radio, a two-way radio, an MP3 player, a cellphone, or the like. The user can hear the external audio device through the one or more speakers disposed in the ear cups 102. In an embodiment, the input connection 112 can accommodate a 3.5 mm audio input. In an embodiment, an external audio device can be connected to the headset 100 through a wireless connection, such as Bluetooth connection. In an embodiment, the headset includes a Bluetooth receiver. In an embodiment, the external audio device can be built in or integral with the headset 100.

A perspective view of the headset 100 is shown in FIG. 2, from a different perspective angle than what is shown in FIG. 1. The ear cups 102 can include a battery compartment 214. The battery compartment 214 can house one or more batteries or battery packs.

As used herein, the term battery means a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. As used herein, the term battery pack means a set of any number of preferably identical batteries, including a single battery. A battery pack may also include other components, such as a temperature sensor or charging circuitry. A battery pack also includes a housing for containing the battery or batteries and other components.

The batteries can be used to power the electronic components of the headset 100. In an embodiment, two AA batteries can be disposed within the battery compartment 214. In an embodiment, the AA batteries can include an alkaline AA battery, a carbon AA battery, a lithium AA battery, a nickel-metal hydride AA battery, or a nickel-cadmium AA battery. In an embodiment, a rechargeable battery pack can be disposed within the battery compartment. In an embodiment, the rechargeable battery pack can use a lithium ion battery. A charging port 215 can be disposed on one or more of the ear cups. In an embodiment, the charging port can be configured to receive a cable for recharging the rechargeable battery pack. In an embodiment, the charging port is disposed on the headset in a location that permits the rechargeable battery pack to be charged while the rechargeable battery pack is inside the battery compartment. In an embodiment, the charging port is disposed on an exterior surface of the ear cup, not within the battery compartment. A battery door 216 can at least partially enclose the battery compartment 214. The battery door 216 can be configured to be removed from the headset 100 when access to the batteries are desired, such as to replace the batteries. In an embodiment, the compartment door can fully enclose the batteries or battery pack within the battery compartment without protruding above the adjacent outer surfaces of ear cup 102. In embodiments, the battery compartment door protrudes no more than 5 millimeters above adjacent outer surfaces of the ear cup when the battery compartment houses the one or more batteries or battery pack and the battery compartment door is closed. The battery compartment door can comprise a hinge. In an embodiment, the battery door 216 is a separate element from the batteries or battery packs. In an embodiment, the battery door is a separate element from the remainder of the headset 100.

Each ear cup 102 can include a speaker 218, shown in FIG. 3. The speaker 218 can produce an output, such as a sound wave. Incoming sound and noise from sound input 108 can be input into a processor 220 and be processed, such as to eliminate at least some of the noise, to produce an output through the speaker 218. As used herein, the term sound refers to desirable audio information while the term noise refers to undesirable audio information. The speaker 218 can provide sound to the user, such as desirable audio. Desirable audio can include conversations, commands, warnings or other communications, such as communications between two people. The input from each microphone can be processed to eliminate at least some of the noise, such as undesirable noises. Undesirable noises can include mechanical noises, noises from ventilation systems, distant conversations, impulse noises, grinding, squeaking, engine noises, gun shots, explosions and the other similar noises.

The headset 100 can include digital electronic components, analog electronic components or a mix of both types.

The speaker 218 can relay sounds from the surrounding environment picked up by the sound input 108. The speaker 218 can relay sounds from an external audio device connected from the input connection 112. The output from the speaker 218 can be limited to a maximum output level, such as to protect the user's ears. In different embodiments, the maximum output level from the speaker 218 due to

sound from the microphone can be at least 80 dB(A), not more than 90 dB(A), at least 70 dB(A), not more than 100 dB(A), and combinations of these constraints. In an embodiment, the output from the speaker 218 is limited to 82 dB(A) when the ambient sound level is less than 106 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 85 dB(A) when the ambient sound level is less than 106 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 82 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 85 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 can be limited to 82 dB(A) when an external audio device is connected to the input connection 112. The sounds picked up by the microphone 108 can be processed before they are produced as output from the speaker 218. The processing can increase the quality or clarity of what the user hears, such as by reducing background noise, suppressing impulse noises or keeping an input level constant. In one embodiment where each of two ear cups 102 has a microphone 108, the incoming sound and noise is processed by a single processor. In another embodiment where each of the two ear cups 102 has a microphone 108, the incoming sound and noise is processed by separate processors.

The individual features described herein can be present in various embodiments. Also combinations of the individual features described herein can be present in various embodiments. In an embodiment, a hearing protection apparatus can include a battery compartment that comprises three contacts: a first positive contact configured to make electrical contact with a positive terminal of a battery or battery pack, a second negative contact configured to make electrical contact with a negative terminal of a battery or battery pack, and a third contact configured to facilitate charging of a rechargeable battery pack. The hearing protection device apparatus can be configured to prevent recharging unless there is a contact of a rechargeable battery pack making contact with the third contact. In an embodiment, the hearing protection apparatus can be powered by two standard cylindrical batteries alone, or the hearing protection device can be powered by a rechargeable battery pack alone.

The hearing protection apparatus comprises a battery compartment that is configured to house one or more batteries or battery packs. The user has the option to power the apparatus with either a rechargeable battery pack alone or two standard cylindrical batteries alone as the power source; the battery compartment is configured to secure either power source within the compartment. The ability to use standard cylindrical batteries provides users with a power option that is readily available in commercial outlets and inexpensive to purchase. The ability to use a rechargeable battery pack carries many benefits also, including longer use times and lower operational costs than standard batteries can provide. The ability for the rechargeable battery pack to be recharged by charging circuitry built into the hearing protection apparatus lowers a user's costs by not requiring an external charger unit. In some embodiments, the rechargeable battery pack can be substituted for the standard cylindrical batteries within

the same battery compartment, where the same battery compartment door is able to close over the rechargeable battery pack as over the standard cylindrical batteries.

FIG. 4 and FIG. 5 show embodiments of the apparatus where different types of batteries or battery packs are used to provide power to the apparatus. In FIG. 4, a rechargeable battery pack 222 is disposed in the battery compartment 214. The rechargeable battery pack has contact 225 for its positive terminal that makes contact with positive contact 224 of the battery compartment, and the rechargeable battery pack has a contact 227 for its negative terminal that makes contact with negative contact 226 of the battery compartment. In addition, the rechargeable battery pack also includes a third contact 229 which contacts a third contact 228 of the battery compartment that is configured to facilitate recharging of the rechargeable battery pack. There are many different options for how the third contact can facilitate recharging of the battery pack, as will be described herein. In an embodiment, the third contact 228 in the battery compartment is electrically connected to charging port 215. FIG. 4 also shows compartment door 216 which can fully enclose rechargeable battery pack 222 within the battery compartment.

FIG. 5 shows the battery compartment 214 with two AA batteries 230 used to power the apparatus instead of the rechargeable battery pack. One battery has a contact 225 on one end for a positive terminal that makes contact with positive contact 224 of the battery compartment, and one battery has a contact 227 on one end for a negative terminal that makes contact with negative contact 226 of the battery compartment. Additional positive terminal 226P and negative terminals 224N are disposed on the battery compartment to make contact with the opposite end of each battery. When two AA batteries are used instead of the rechargeable battery pack, there is no contact on either of the AA batteries that makes contact with third contact 228 of the battery compartment. The batteries 230 cannot be recharged in the apparatus because they do not make contact with third contact 228.

FIG. 6 shows a perspective of the battery compartment 214 without any batteries or battery packs inside it. First contact 224, a positive contact configured to make electrical contact with a positive terminal, second contact 226, a negative contact configured to make electrical contact with a negative terminal, and third contact 228 can be seen in the figure. In an embodiment, third contact 228 is configured to make electrical contact with a positive charging contact of a rechargeable battery pack. In an embodiment, third contact 228 is configured to make electrical contact with a negative charging contact of a rechargeable battery pack. In such embodiments, the third contact is electrically connected to a charging port within the housing of the headset or an ear cup of the apparatus. The electrical connection of the third contact with the charging port may be via some circuitry. In an embodiment, the third contact is electrically connected to a charging port, wherein the charging port is located somewhere on the headset, and charging of the rechargeable battery pack occurs through a circuit that includes the third contact 228 and either the first positive contact 224 or the second negative contact 226. In an embodiment, charging to the one or more battery packs occurs through either a circuit that includes the

third contact and the first positive contact and excludes the second negative contact or a circuit that includes the third contact and the second negative contact and excludes the first positive contact.

The third contact 228 can also be connected to other systems or devices for monitoring or protecting the rechargeable battery in the battery pack. In an embodiment, these systems or devices can be in the rechargeable battery pack. In other embodiments, these systems or devices are within the housing of the headset or an ear cup of the apparatus. In an embodiment, portions of these systems or devices are in the rechargeable battery pack and portions of these systems or devices are within the housing of the headset or an ear cup of the device.

In an embodiment, the third contact is configured to make electrical contact with a temperature monitoring device. In such embodiments, the apparatus could prevent current from flowing or issue a warning to the user if the temperature of the battery pack approaches an unsafe level. In one embodiment, the battery pack includes a temperature sensor while the headset includes a temperature monitoring circuit that receives input from the temperature sensor via the third contact.

In embodiments, the third contact 228 can be configured to make contact with an identification device or circuit within the headset and rechargeable battery pack. In such embodiments, the identification circuit is configured to identify if an improper battery type is placed into the compartment and prevent current flow in the apparatus, issue a warning to the user or both. The identification circuit could prevent or allow current flow based on an electrical connection to the third contact of the rechargeable battery pack. Alternatively, or in addition, the identification device could prevent or allow current flow based on a mechanical connection to the third contact of the rechargeable battery pack. In alternative embodiments, such as where a mechanical connection to the third contact provides the indication that the correct rechargeable battery is in the compartment, the identification device could be located entirely within the headset.

The charging port 215 can also be electrically connected to the first positive contact 224 and the second negative contact 226 with the third contact 228 being electrically connected to a device or system that controls the charging circuit, such as an identification device, a monitoring device, or other control device. In such embodiments, charging can only occur if a rechargeable battery pack also has a separate contact that is electrically connected to the third contact 228. In an embodiment, the charging circuit is electrically connected to the first positive contact and the second negative contact, and the third contact is electrically connected to an identification device within the rechargeable battery pack. In an embodiment, the charging port is electrically connected to the first positive contact and the second negative contact, and the charging of the rechargeable battery pack occurs through a circuit that includes the first positive contact and the second negative contact. In an embodiment, the charging circuit is electrically connected to the first positive contact and the second negative contact, the third contact is electrically connected to an identification or a protection device within the rechargeable battery pack, and the charging of the rechargeable battery pack occurs through a circuit that includes the first positive contact and the second

negative contact. In an embodiment, the identification system is located within the rechargeable battery pack. In other embodiments, the identification system or device is located within the housing of the headset or an ear cup of the apparatus. In an embodiment, portions of the identification system are located in the rechargeable battery pack and portions of the identification systems are located within the housing of the headset or an ear cup of the device.

The battery compartment 2 l4 defines an open battery-receiving space wherein the space includes a first region 232 having at least a portion of the first region adjacent to the first positive contact 224, a second region 234 having at least a portion of the second region adjacent to the second negative contact 226, and a third region 236, the third region at least partially overlapping both the first region and the second region; wherein the first, second, and third regions together are configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes. In an embodiment, the third region is wider than double the diameter of the standard cylindrical battery shape. The battery compartment can accommodate the form factors of different batteries or battery packs. First region 232 and second region 234 are cylindrical regions that are defined by portions of the battery compartment that include curved surfaces that can help secure at least a portion of the one or more batteries or rechargeable battery pack against the battery compartment. The curved surfaces may comprise portions of cylindrical shapes that conform to an outside surface of a standard cylindrical battery. In an embodiment, the battery compartment surfaces may define one or more curved surfaces, adjacent to the positive and negative contacts of the battery compartment, that are configured to secure the batteries or battery packs against the compartment. The battery compartment can comprise a bottom surface having at least a first curved surface and a second curved surface, wherein the first curved surface is adjacent to the first positive contact of the battery compartment and the second curved surface is adjacent to the second negative contact of the battery compartment. In embodiments, a bottom surface of the battery compartment may comprise one or more curved surfaces that bound at least a portion of the first and second regions.

In an embodiment, the curved surfaces 239 on the bottom surface of the battery compartment may extend below an adjacent flat section 240 disposed on the bottom surface of the battery compartment. The width of the flat section 240 can vary depending on the desired spacing between the cylindrical batteries. One curved surface is also adjacent to positive contact 224 and the other curved section is also adjacent to negative contact 226. The curved surfaces can extend from 0.5 to 3-mm below the flat section, or 1 to 2 mm below the flat section. In other embodiments, a top surface of the battery compartment may comprise one or more curved surfaces that bound at least a portion of the first and second regions. In an embodiment, the curved surfaces on the top surface of the battery compartment may extend above an adjacent flat section disposed on the top surface of the battery compartment. One curved surface is also adjacent to a positive contact and the other curved surface is also adjacent to a negative contact. The curved surface can extend from 0.5 to 3-mm above the flat section, or 1 to 2 mm above the flat section. In an embodiment, the thickness of the rechargeable battery pack is less than the

diameter of a standard cylindrical battery shape. Though curved surfaces are present in some embodiments, other embodiments do not include any curved surfaces in the battery compartment.

The rechargeable battery pack can comprise a protection monitoring circuit (PMC) which protects the rechargeable battery from different conditions that may occur during use, including overcharging, over discharging, overcurrent, and load short circuiting. In an embodiment, the protection monitoring circuit in the rechargeable battery pack makes electrical contact with the third contact 228 in the battery compartment. In an embodiment, the protection monitoring circuit is configured to make electrical contact with the third contact 229 of the rechargeable battery pack. The PMC can include aspects of the identification circuit and temperature monitoring circuit described herein.

FIG. 7 shows elements of a schematic design for the rechargeable battery pack and headset using a protection monitoring circuit. The rechargeable battery pack 222 comprises a lithium ion cell245 that has a positive terminal 225 connected to contact 224 and a negative terminal 227 connected to contact 226 The rechargeable battery pack also includes third contact 229. When the rechargeable battery is positioned in the battery compartment 214, then the first contact 225, second contact 227 and third contact 229 of the rechargeable battery pack 222 are in contact with the first contact 224, second contact 226 and third contact 226 of the battery compartment 214. The battery compartment 214 is located in one of the ear cups 102, which is electrically connected to the other ear cup 102 by a headband cable. In an embodiment, the rechargeable battery pack 222 includes a charger circuit 254 and a protection monitoring circuit 250. In the embodiment of FIG. 7, the third contact 228 of the battery compartment is electrically connected to the charging port 215 in the opposite ear cup 102 by the headset cable. Additional elements including fuses 251, 252, and 253 and diodes 255 can be included to work in conjunction with the PMC 250 and the charger circuit 254 to provide protection and recharging functions to the rechargeable battery and the headset.

A perspective cut-away view of an embodiment of the rechargeable battery pack is shown in FIG. 8. In FIG. 8, the rechargeable battery pack 222 can include a lithium ion cell 260 and a printed circuit board 270 containing circuitry that is configured to control the charging and protection functions of the battery pack. The circuitry on the printed circuit board 270 can also be configured to control temperature monitoring and identification functions as well. The battery pack includes a top surface 280 and a bottom surface 290. In FIG. 8, the lithium ion battery is positioned towards the top portion of the battery pack. In other embodiments, the lithium ion battery can be positioned towards the bottom portion of the battery pack, from the perspective of FIG. 8. In FIG. 8, the rechargeable battery pack has contact 225 for its positive terminal that makes contact with a positive contact of the battery compartment, and the rechargeable battery pack has a contact 227 for its negative terminal that makes contact with a negative contact of the battery compartment. In addition, the rechargeable battery pack also includes a third contact 229 which contacts a third contact of the battery compartment that is configured to facilitate recharging of the rechargeable battery pack. The third contact may be disposed on the same surface of

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the rechargeable battery pack as the contacts for the positive and negative terminals are disposed on, or the third contact may be disposed on a surface that extends from the surface that the contacts for the positive and negative terminals are disposed on. In embodiments, the third contact could be recessed from the contacts for the positive and negative terminals.

Additional features for the shape of the rechargeable battery pack are shown in FIG. 9a and FIG 9b. The shape features of the rechargeable battery pack can be used to secure the rechargeable battery pack inside the battery compartment.

A perspective view of the rechargeable battery pack is shown in FIG. 9a. The rechargeable battery back includes top surface 280, bottom surface 290, curved portions 291 and 292, and sides 300. The top surface 280 is wider than the bottom surface 290, and sides 300 extend past curved portions 291 and 292 in order to accommodate the rechargeable battery positioned towards the top portion of the pack in this embodiment. When installed in the battery compartment, curved portions 291 and 292 are secured against the battery compartment in the first and second regions of the battery compartment so that the rechargeable battery pack stays in place during recharging and use. At least a portion of the bottom surface 290 is also secured against the battery compartment. Portions of the top surface 280 and sides 300 are secured against the battery compartment in the third region. FIG. 9b also shows extensions 310 and 320. In an embodiment, the extension 310 and 320 are configured to secure one or more portions of the rechargeable battery pack against the battery compartment. Extensions can be included on any side or surface of the rechargeable battery pack to help secure the rechargeable battery pack against the battery compartment. Such extensions can be useful when the length, width, and height dimensions of a rechargeable battery in the battery pack are different from the length, width, and height dimensions of standard cylindrical batteries. In an embodiment, extensions protrude from the sides 300 of the battery pack to secure one or more portions of the rechargeable battery pack against the battery compartment. In other embodiments, the extensions can protrude from one or more of the top, bottom, or side surfaces of the rechargeable battery pack.

In an embodiment, at least a portion of the third contact 229 may be disposed on at least a portion of extension 310. The extensions 310 can extend 0.5 to 3 mm from the surfaces or sides of the rechargeable battery pack, more preferably from 1-2 mm.

The apparatus can use different batteries or battery packs as power sources. When standard cylindrical battery shapes are used, the apparatus can operate on AA-sized or AAA-sized batteries. The standard cylindrical batteries can be rechargeable or non-rechargeable batteries. However, in an embodiment, the apparatus will not recharge standard cylindrical rechargeable batteries. A typical AA battery measures 49.2 to 50.5 mm in length, including the button terminal, and 13.5 to 14.5 mm in diameter. The positive terminal button contact can be about 1 mm high and about 5.5 mm in diameter. The flat negative terminal contact can be about 7 mm in diameter. Examples of cylindrical batteries that can be used include alkaline AA batteries, carbon AA batteries, non-rechargeable lithium AA batteries,

rechargeable nickel-metal hydride AA batteries, and rechargeable nickel-cadmium AA batteries. The voltage of the AA batteries that can be used in the apparatus can be between 1 and 2 V, preferably between 1.1 and 1.6 V. When a rechargeable battery pack is used to power the apparatus, the rechargeable battery pack can comprise a rechargeable lithium- ion battery, a lithium-polymer battery, or other rechargeable battery. The voltage provided by the rechargeable battery can be between 2.5 to 5 V, preferably 3 to 4 V.

The rechargeable battery pack can have several different shapes, depending on the desired dimensions of the space defined in the battery compartment. The rechargeable battery pack can have an overall width no more than 38 mm, no more than 42 mm, or no more than 50 mm. The rechargeable battery pack can have an overall width no less than 25 mm, no less than 28 mm, or no less than 35 mm. The rechargeable battery pack can have an overall length no more than 55 mm, no more than 52 mm, or no more than 46 mm. The rechargeable battery pack can have an overall length no less than 35 mm, no less than 40 mm, or no less than 45 mm. The rechargeable battery pack can have an overall thickness no more than 20 mm, no more than 16 mm, or no more than 14 mm. The rechargeable battery pack can have an overall thickness no less than 8 mm, no less than 10 mm, or no less than 15 mm.

It should be noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a composition containing "a compound" includes a mixture of two or more compounds. It should also be noted that the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

It should also be noted that, as used in this specification and the appended claims, the phrase "configured" describes a system, apparatus, or other structure that is constructed or configured to perform a particular task or adopt a particular configuration to. The phrase "configured" can be used interchangeably with other similar phrases such as arranged and configured, constructed and arranged, constructed, manufactured and arranged, and the like.

All publications and patent applications in this specification are indicative of the level of ordinary skill in the art to which this present disclosure pertains. All publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated by reference.

The present disclosure has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the present disclosure.

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Claims:

We claim

1. An apparatus for hearing protection, comprising:

two ear cups, each ear cup defining a cavity configured to fit a user's ear;

a processor, configured to receive an incoming signal and create an output signal;

a speaker disposed within at least one of the two ear cups, the speaker configured to produce the output from the processor;

wherein one of the two ear cups comprises a battery compartment configured to house one or more batteries or battery packs, wherein the battery compartment further comprises:

a first positive contact configured to make electrical contact with a positive terminal of one of the one or more batteries or battery packs,

a second negative contact configured to make electrical contact with a negative terminal of one of the one or more batteries or battery packs, and

a third contact configured to facilitate charging of a rechargeable battery pack selected from one of the one or more batteries or battery packs; and

wherein the battery compartment defines an open battery-receiving space configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes,

wherein the apparatus further comprises a charging port, wherein the charging port is configured to receive a cable for recharging the rechargeable battery pack.

2. The apparatus of claim 1 wherein the apparatus is configured to prevent charging to the one or more batteries or battery packs unless there is a contact of a rechargeable battery pack contacting the third contact.

3. The apparatus of claim 2 wherein charging to the one or more batteries or battery packs occurs through either a circuit that includes the third contact and the first positive contact and excludes the second negative contact or a circuit that includes the third contact and the second negative contact and excludes the first positive contact.

4. The apparatus of claim 2 wherein charging to the one or more batteries or battery packs occurs through a circuit that includes the first positive contact and the second negative contact.

5. The apparatus of claim 1 wherein the wherein the battery-receiving space comprises:

a first region having at least a portion of the region adjacent to the first positive contact,

a second region having at least a portion of the region adjacent to the second negative contact, and

a third region, the third region at least partially overlapping both the first region and the second region; and

wherein the first, second, and third regions together are configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes.

6. The apparatus of claim 5, wherein third region has a width wider than double the diameter of the standard cylindrical battery shape.

7. The apparatus of claim 1 wherein the battery compartment further comprises a bottom surface having at least a first curved surface and a second curved surface, wherein the first curved surface is adjacent to the first positive contact of the battery compartment and the second curved surface is adjacent to the second negative contact of the battery compartment.

8. The apparatus of claim 1 wherein the standard cylindrical battery shape is a standard AA battery shape or a standard AAA battery shape.

9. The apparatus of claim 5 wherein the first and second regions of the battery compartment are located closer to the user's head than the third region.

10. The apparatus of claim 5 wherein the third region of the battery compartment is located closer to the user's head than the first and second regions.

11. The apparatus of claim 1 wherein the third contact is configured to make electrical contact with a positive charging contact of a rechargeable battery pack selected from one of the one or more batteries or battery packs.

12. The apparatus of claim 11 wherein the third contact is electrically connected to the charging port.

13. The apparatus of claim 11 further comprising a fuse and a charging device wherein the third contact is electrically connected to the fuse and charging device.

14. The apparatus of claim 1 further comprising a temperature monitoring device wherein the third contact is electrically connected to the temperature monitoring device.

15. The apparatus of claim 1 further comprising an identification device wherein the third contact is configured to make contact with an identification device.

16. The apparatus of claim 1 further comprising the rechargeable battery pack, wherein the rechargeable battery pack comprises a lithium ion cell .

17. The apparatus of claim 1 further comprising a standard cylindrical battery, wherein the standard cylindrical battery comprises an alkaline AA battery, a carbon AA battery, a lithium AA battery, a nickel-metal hydride AA battery, or a nickel-cadmium AA battery.

18. The apparatus of claim 1 wherein the battery compartment is at least partially enclosed by a battery compartment door.

19. The apparatus of claim 18 wherein the battery compartment door protrudes no more than 5 millimeters above adjacent outer surfaces of the ear cup when the battery compartment houses the one or more batteries or battery pack and the battery compartment door is closed.

20. The apparatus of claim 1 further comprising a microphone disposed on the apparatus, the microphone configured to pick up an input sound wave from the environment and convert the input sound wave to an incoming signal.

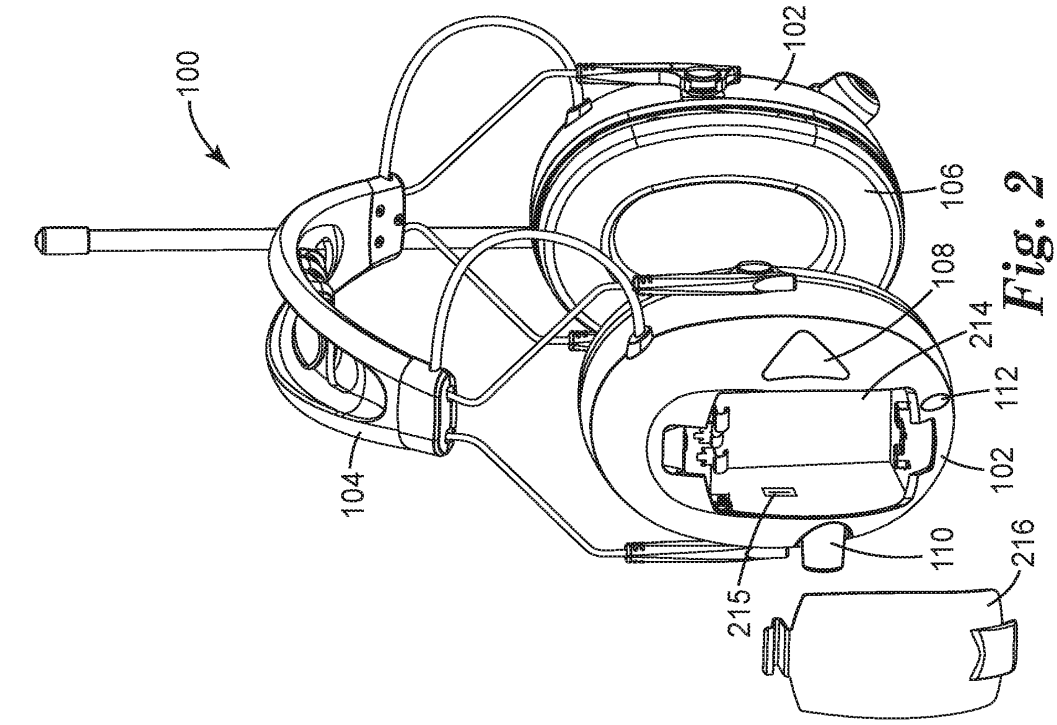

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Fig. 2

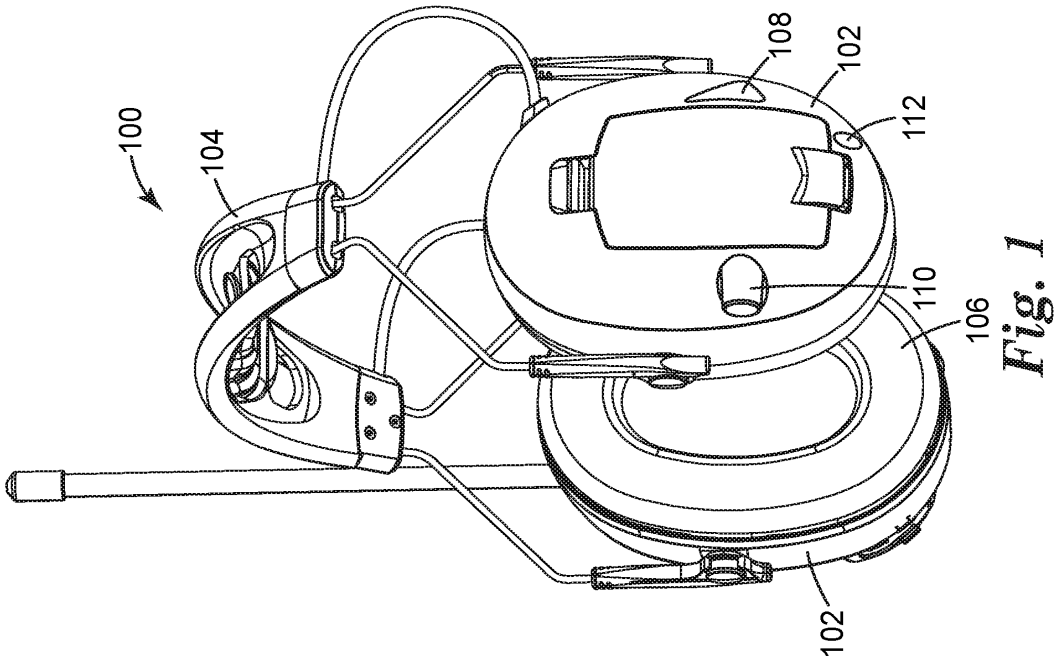

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Fig. 1

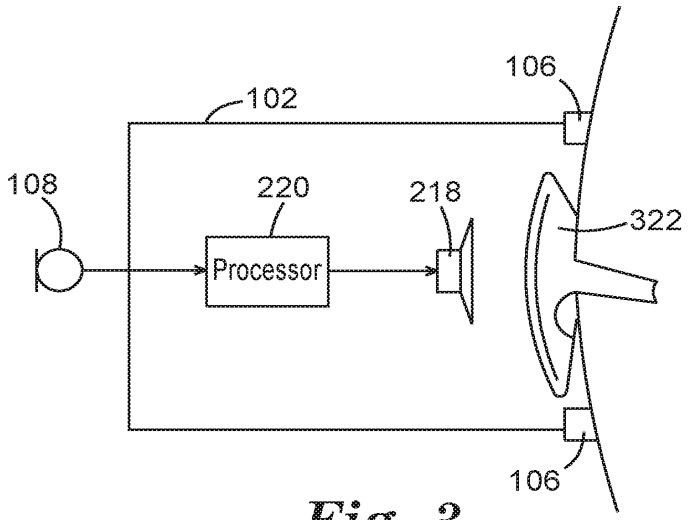

106
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Processor
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Fig. 3

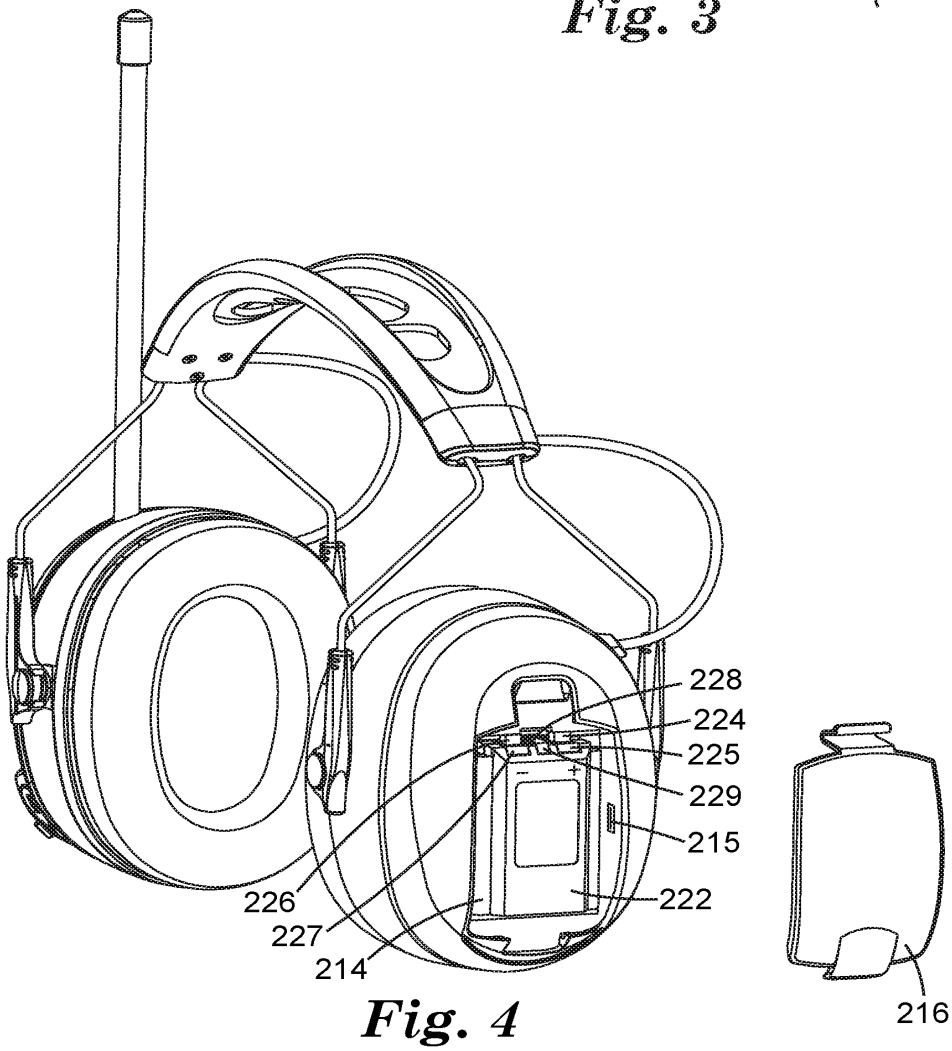

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Fig. 4

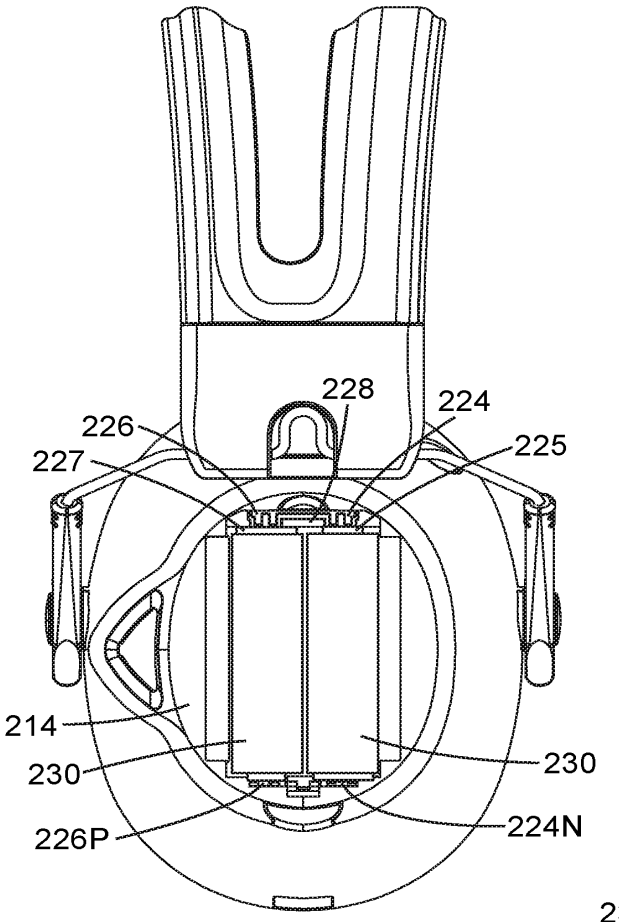

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Fig. 5

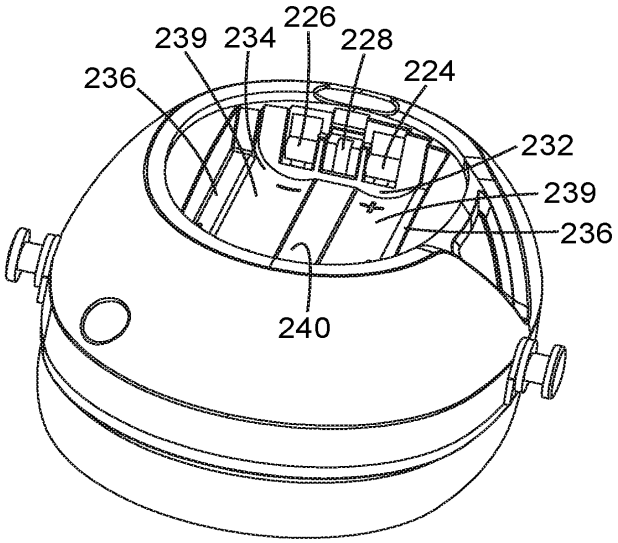

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Fig. 6

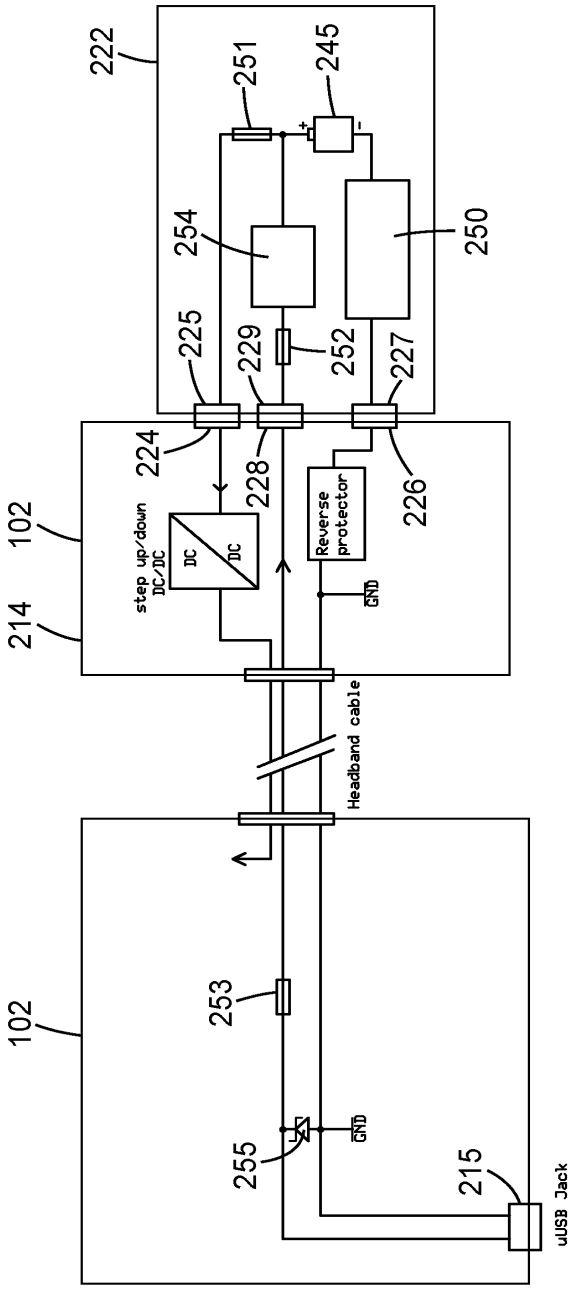

222
251
245
254
250
225
229
252
227
224
228
226
102
step up/down DC-DC
DC
DC
Reverse protector
GND
214
Headband cable
102
253
255
GND
215
uUSB Jack

Fig. 7

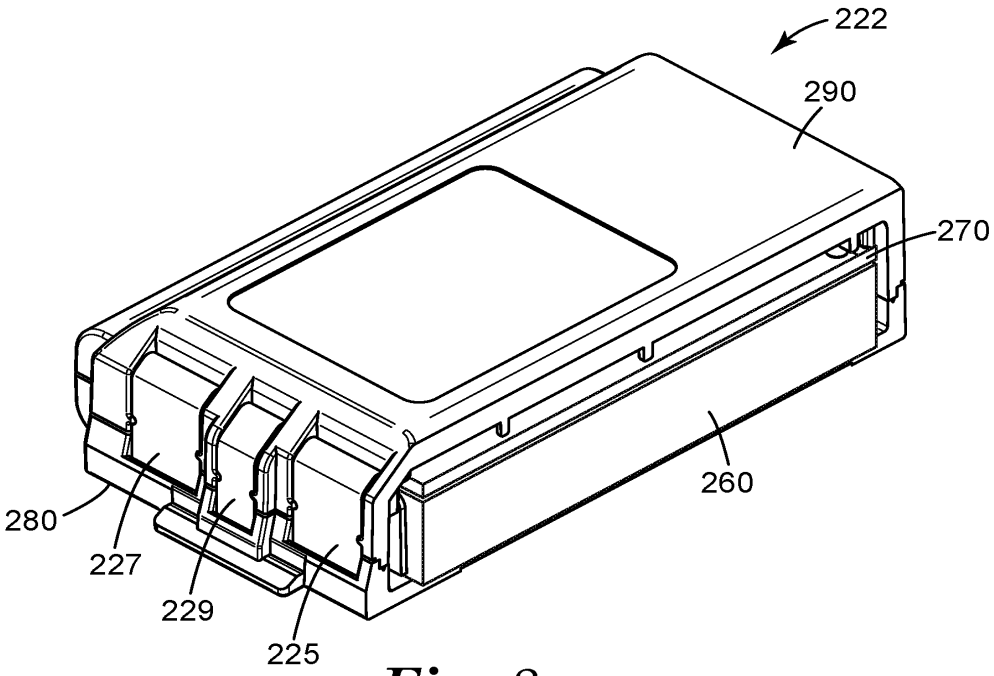


Fig. 8

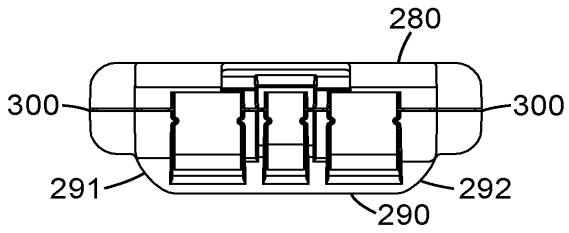


Fig. 9a

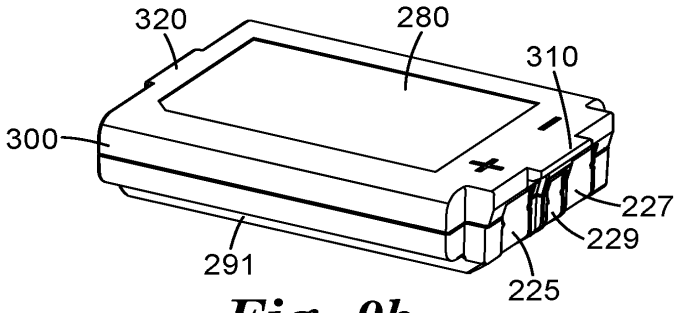


Fig. 9b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/1 5037

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G10K 11/16; A61 F 11/14 (2016.01)
CPC - G10K 11/1788; H04R 1/1091 ; A61 F 11/06
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)
IPC(8): H04R 1/10, 3/00, 5/033, 25/00; G10K 11/16, 11/178, 11/36; A61F 11/06, 11/12, 11/14; A42B 3/16 (2016.01); CPC: H04R 1/1008, 1/033, 1/1091, 5/033, 5/0335, 2201/107; G10K 11/002, 11/16, 11/1788; A61F 11/06, 11/12, 11/14, 201 1/145; A42B 3/163

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); EBSCO Discovery Service IP.com; Google Scholar; KEYWORDS: headphone*, headset*, ear*, hearing*, protecti*, batteries*, battery*, housing*, enclosure*, compartment*, *charge*, earcup, terminal*, contact*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0180874 A1 (GAUGER, D et al.) July 31, 2008; abstract; figures 1-7; paragraphs [0001-0003, 0018, 0019, 0028]	1
A	US 7,457,649 B1 (WILSON, J) November 25, 2008; abstract; figures 1-7; column 2, lines 35-44; column 4, lines 28-35 and 45-64; column 5, lines 39-60	1
A	US 2014/0219465 A1 (ZEIKOS, INC.) August 07, 2014; abstract; figure 2; paragraphs [0021, 0032]	1
A	US 2014/021 1976 A1 (BEATS ELECTRONICS, LLC.) July 31, 2014; entire document	1-20
A	US 201 1/0142249 A1 (SHINOZAKI, R) June 16, 201 1; entire document	1-20
A	US 2010/0310093 A1 (SEMEKEN, K) December 09, 2010; entire document	1-20
A	US 2009/027971 1 A1 (HERINGSLACK, H) November 12, 2009; entire document	1-20
A	US 2008/0069391 A1 (STEYN, A et al.) March 20, 2008; entire document	1-20

☐ 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
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2016 (15.03.2016)	**03 APR 2016**

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** HEARING DEVICE CHARGER WITH INSERTION/EJECTION CONTROL

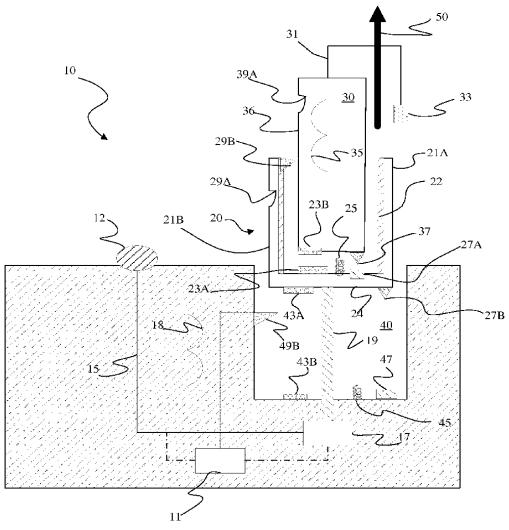


Figure 1

(57) **Abstract:** A charger for a hearing device that provides a user with control of insertion and/or ejection of the hearing device into or out of the charger. A user may use a user control to move the hearing device in the charger from a position where the hearing device can be charged by the charger and a removal position where the user may easily, manually remove the hearing device from the charger.

WO 2019/037854 A1

HEARING DEVICE CHARGER WITH INSERTION/EJECTION CONTROL

BACKGROUND

Embodiments of the present disclosure provide a hearing device charger comprising a mechanism for inserting and/or ejecting a hearing device into/from the hearing device charger.

Hearing devices are often fitted with rechargeable batteries and may be recharged either using wireless charging or direct charging of the rechargeable batteries using charging terminals, while the batteries are still in the hearing device. For effective charging of the hearing device, either wirelessly of by providing a charging current to the hearing device, the hearing device may be held in a charging position in the hearing device charger.

United States Patent No. 8,253,377 (the '377 patent') describes a hearing aid battery charger for a hearing aid equipped with rechargeable batteries. In the '377 patent, the hearing aid is held in a charging position in the hearing aid battery charger while a charging current is provided to the hearing aid batteries. The '377 patent discloses charging the rechargeable batteries while the batteries are still disposed in the hearing aid.

SUMMARY

In embodiments of the present disclosure, a hearing device charger is provided with insertion/ejection control. In some embodiments, the hearing device comprises a rechargeable battery that is configured to be recharged by a charging current provided by the charger via electrical contacts. In some embodiments, the charger and the hearing device comprise induction coils or the like to provide for wireless charging of the hearing device.

In embodiments of the present disclosure, the charging device comprises a user control configured to receive an input from a user to either insert the hearing device into the charger or to eject the hearing device from the charger and a mechanism that can insert and/or eject the hearing device from the charger in response to the user input.

In some embodiments, the hearing device is held in the charger to provide for electrical communication of a charging current supplied by the charger to the hearing device. In some embodiments, the charger is configured so that when the hearing device is inserted in the charger, an induction coil in the hearing device is aligned with an induction coil in the charger to provide for wireless charging.

In some embodiments of the present disclosure, the hearing device is ejected from the charger to provide that a user can grasp the hearing device. In some embodiments, the hearing device is completely ejected from a hearing dock of the charger. In some embodiments, after ejection from the charger, a longitudinal length of the hearing device extends beyond a top of the hearing dock such that a user can grasp the hearing device with their fingers to remove it from the charger.

These and further objects, features and advantages of the present invention will become apparent from the following description when taken in connection with the accompanying drawings which, for purposes of illustration only, show several embodiments in accordance with the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

In the figures, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

Figure 1 illustrates a charger for charging a re-chargeable ear worn communication device comprising a cradle configured for inserting and/or ejecting the ear worn communication device from the charger, in accordance with some embodiments of the present disclosure.

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Figure 2 illustrates a hearing device charger comprising a cradle configured to insert a re-chargeable ear worn communication device into the charger and/or eject the re-chargeable ear worn communication device from the charger using a mechanical mechanism, in accordance with some embodiments of the present disclosure.

Figure 3 illustrates a system for inserting a re-chargeable ear worn communication device into and/or ejecting a re-chargeable ear worn communication device from a charger, in accordance with an embodiment of the present disclosure.

Figure 4 illustrates a mechanically controlled system for inserting/ejecting a re-chargeable ear worn communication device from a charging dock, in accordance with some embodiments of the present disclosure.

Figure 5 is a flow-type illustration of a method for inserting and/or ejecting a re-chargeable ear worn communication device into/out of a charger, in accordance with some embodiments of the present disclosure.

DESCRIPTION

The ensuing description provides some embodiment(s) of the invention, and is not intended to limit the scope, applicability or configuration of the invention or inventions. Various changes may be made in the function and arrangement of elements without departing from the scope of the invention as set forth herein. Some embodiments maybe practiced without all the specific details. For example, circuits may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

Some embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A

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process is terminated when its operations are completed, but could have additional steps not included in the figure and may start or end at any step or block. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

Moreover, as disclosed herein, the term "storage medium" may represent one or more devices for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash memory devices and/or other machine readable mediums for storing information. The term "computer-readable medium" includes, but is not limited to portable or fixed storage devices, optical storage devices, wireless channels and various other mediums capable of storing, containing or carrying instruction(s) and/or data.

Furthermore, embodiments may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium such as storage medium. A processor(s) may perform the necessary tasks. A code segment may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class or any combination of instructions, data structures or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters or memory contents. Information, arguments, parameters, data, *etc.* may be passed, forwarded or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The phrases "in some implementations," "according to some implementations," "in the implementations shown," "in other implementations," and generally mean the particular feature, structure, or characteristic following the phrase is included in at least one implementation of the disclosed technology, and may be included in more than one

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implementation. In addition, such phrases do not necessarily refer to the same embodiments or different implementations.

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings and figures. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the subject matter herein. However, it will be apparent to one of ordinary skill in the art that the subject matter may be practiced without these specific details. In other instances, well known methods, procedures, components, and systems have not been described in detail so as not to unnecessarily obscure features of the embodiments. In the following description, it should be understood that features of one embodiment may be used in combination with features from another embodiment where the features of the different embodiment are not incompatible.

Hearing devices include hearing instruments - such as behind-the-ear hearing aids, in-the-ear hearing aids *etc.* - earphones, in-ear headphones, noise protection systems worn on/in the ear that include a speaker, and/or the like.

Many hearing devices are configured to be rechargeable to avoid the inefficient and problematic issue of replacing batteries. Moreover, charging systems are often designed to charge the rechargeable batteries *in-situ, e.g.,* while installed in the hearing device. For example, the '377 patent describes systems and methods for charging a hearing aid in a charger without removing the hearing aid's rechargeable batteries.

Hearing devices, especially hearing devices equipped with rechargeable batteries, are being designed to smaller scales to make the instruments less bulky and to provide that the instruments can be comfortably and unobtrusively positioned in and/or proximal to the ear. Hearing device designs often comprise miniaturized systems that are almost invisible on the wearer.

Wireless/Bluetooth technology means that the earpiece of the hearing device may be miniaturized and wireless/Bluetooth signals may be transmitted to the miniature earpiece for

delivery to the ear. Further, hearing devices are being made of materials, such as metal, polymers and/or the like, that increase the durability and/or wear resistance of the instrument and/or make the hearing device cosmetically appealing.

The smaller size of hearing devices and/or the properties of the new fabrication materials often make the hearing devices difficult to handle. This is especially true when it comes to a user inserting or removing the hearing device from a charger, where the hearing device needs to be positioned inside a charging dock in a charging position for effective charging. The insertion/removing problem is further compounded because, in general, chargers include a mechanism to hold hearing devices in the charging position in the charger. For example: for wireless chargers, for effective charging, an induction coil in the hearing device needs to be aligned with an induction coil in the wireless charger; and for wired charging, charging terminals on the hearing device need to be contacted with/held in contact with charging terminals in the charger/charging dock.

Mechanisms for holding hearing devices in a charging position may be mechanical and require the user to apply a force to insert and/or remove the hearing device from the holding mechanism. Moreover, a significant problem with insertion/removal of hearing devices from chargers by a user of the hearing device is the use by the user of cables/conduits or the like extending from the hearing device. Such use of the cables/conduits, especially when repeated, can cause serious damage to the hearing devices. Often the cables/conduits extending from the hearing device are some of the most fragile components of the hearing device.

For example, many in-ear communication devices include a wire(s) connecting outer-ear and in-ear parts of the hearing device and many hearing devices, such as for example behind-the-ear hearing instruments, include a sound delivery system that communicates sound detected by a microphone situated external to the ear into the inner-ear, both of which, the wire - especially at the connection point with the earphone - and/or the sound delivery system may be easily damaged by being used by a user to insert/eject the hearing device into/from the charger.

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Embodiments of the present disclosure provide a charger for a hearing device comprising a user control and an insertion and/or an ejection mechanism for inserting the hearing device into and/or ejecting the hearing device out of the charger. More particularly, but not by way of limitation, some embodiments of the present disclosure provide for insertion of the hearing device into the charger and into a charging position and/or ejection of the hearing device from the charging position out of the charging device/to a removal position in the charging device, without the user applying a force or applying only a minimal force to the hearing device.

Figure 1 illustrates a hearing device charger comprising a cradle configured to insert a hearing device into the charger and/or eject the hearing device from the charger, in accordance with some embodiments of the present disclosure.

In Fig. 1, a charger 10 comprises a cradle 20. The cradle 20 is configured to receive a hearing device 30. The hearing device 30 comprises batteries (not shown) or the like that provide for powering operation of the hearing device when worn by a user. The batteries are drained as a result of operation of the hearing device 30 and may be recharged by the charger 10.

The hearing device 30 may comprise a communication component 31, for example an electronic cable, an electronic cable attached to a speaker for in-ear operation, a sound tube and/or the like, that extends from the hearing device 30. The communication component 31 may in some aspects be configured in use to deliver sound from the hearing device 30 to a user's ear. In other aspects, the hearing device 30 may be configured to be worn in the ear and the communication component 31 may provide communication outside of the ear, such as via an antenna, communication device, wireless communication receiver, microphone and/or the like.

In some embodiments, the hearing device 30 may comprise an in-ear component 33, such as an ear-tip, speaker and/or the like, which in some embodiments may provide sound output in the inner-ear. Where the hearing device 30 is configured to be worn behind a user's ear (a behind-the-ear "BTE" hearing device), the communication component 31 and/or the in-ear component 33, which in combination may comprise a sound delivery system 31, 33, may comprise a sound

tube, ear hook, electric cable, ear-tip, speaker and/or the like that is configured to deliver sound from the hearing device into the user's ear.

In certain embodiments, the cradle 20 is configured to insert the hearing device 30 to a charging position in the charger 10. For example, for wireless charging, the cradle 20 may move the hearing device 30 to a position in the charger 10 where a wireless induction coil 35 in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the cradle 20 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, the cradle 20 can be configured to eject the hearing device 30 from the charging position to an ejected position in the charger 10; where the hearing device 30 is accessible to the user for removal from the cradle 20 with little or no force and/or for grasping by the user by a body/housing of the hearing device 30.

For charging of the rechargeable batteries using a charging current, the cradle 20 may comprise a first terminal 27A that is configured to contact a charging terminal 37 of the hearing device 30. The cradle 20 may be configured to accommodate the hearing device 30, such that when the hearing device 30 is inserted into the cradle 20, the charging terminal 37 contacts the first terminal 27A providing for electrical communication between the charging terminal 37 and the first terminal 27A.

While the following description describes inserting/holding the hearing device 30 in the charger 10 to provide for use of a charging current, it is to be understood that the insertion/holding techniques/systems can also apply to insertion/holding the hearing device 30 in the charger 30 in a charging position for wireless charging.

In some embodiments of the present disclosure, the cradle 20 is shaped to provide that the hearing device can only be inserted into the cradle 20 in a single orientation, and this single orientation is configured to provide that the charging terminal 37 contacts the first terminal 27A when the hearing device 30 is inserted into the cradle 20.

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In some embodiments, the cradle 20 is configured to provide that in excess of 50% of a longitudinal length of the hearing device 30 extends beyond walls 21A, 21B of the cradle 20 when the hearing device 30 is inserted into the cradle 20. The longitudinal length of the hearing device 30 comprises a length of the hearing device 30 aligned with a longitudinal axis 50 of the charging dock 40. Preferably, in some embodiments greater than 60%, 70% or 80% of the longitudinal length of the hearing device 30 extends beyond the walls 21A, 21B of the cradle 20 when the hearing device 30 is inside the cradle 20 with the charging terminal 37 in contact with/held in contact with the first terminal 27A. Having this amount of the hearing device 30 extends beyond the walls 21A, 21B of the cradle 20 provide for ease of handling of the hearing device 30 by a user of the hearing device 30. It has been found that where a large surface area of the housing 36 of the hearing device 30 is accessible to a user, the user will grip the hearing device 30 by the housing 36 of the hearing device 30 to insert/remove the hearing device 30 from the cradle 20, rather than using the communication component 31.

The cradle 20 may be shaped to provide that there is space between an outer-surface 36 of the hearing device 30 and an inner-surface 22 of the cradle 20. In such embodiments, gravity may provide for holding the charging terminal 37 and the first terminal 27A in contact. In some embodiments, magnets 23A and 23B may be used to hold the hearing device 30 in the cradle so that the charging terminal 37 and the first terminal 27A are held in contact. In some embodiments, one of the magnets 23A and 23B may not be a magnet but comprise a metallic compound to provide for the magnetic coupling. In this way, using only one magnet, the magnetic coupling force is reduced lessening the force needed to remove the hearing device 30 from the cradle 20. In some embodiments, the inner-surface 22 and or the outer-surface 36 may comprise an elastic and/or grippy/adhesive material that may hold the hearing device 30 in the cradle 20 after insertion by a user.

In some embodiments, a latch system may be used to hold the hearing device 30 in the cradle 20 such that the charging terminal 37 and the first terminal 27A are held in contact. The latch system may comprise a notch 39A or the like in the hearing device 30 and a nose 29B extending from the inner-surface 22 of the cradle. In some embodiments, the notch 39A may

be a notch in the inner-surface 22 of the cradle and the nose 29B may extend from the outer-surface 36 of the hearing device 30. When the hearing device 30 is inserted into the cradle 20, such that the notch 39A and the nose 29B align, the notch 39A and the nose 29B interact to hold the hearing device 30 in the cradle 20 so that charging terminal 37 and the first terminal 27A are in contact.

In some embodiments, the charger 10 comprises a user input 12. The user input 12 may comprise an electrical switch or the like such that a user input may be electronically conveyed via electrical communicator 15 to an electrical actuator 17. The electrical actuator 17 may comprise a motor, a pump and/or the like and may interact with the cradle 20 via an interaction element 19. As such, in some embodiments of the present disclosure, the electrical actuator 17 receives communication of a user input to the user input 12 and generates motion of the cradle 20 into or out of the charger 10 via the interaction element 19. The interaction element 19 may in some embodiments comprise a screw-type mechanism a geared mechanism, a combination of coupled substrates, a hydraulic system and/or the like that is configured to translate an output from the electrical actuator 17 into motion of the cradle 20 into or out of the charger 10. In some embodiments of the present disclosure, the user input 12, the electrical communicator 15, the electrical actuator 17 and the interaction element 19 provide insertion/ejection of the hearing device 30 into/from the charger 10.

In some embodiments, the user input 12 may comprise an electrical switch or the like that can control the electrical actuator 17 to either insert the cradle 20 into the charger 10 or to eject the cradle 20 from the charger 10. In some embodiments, the user input 12 may comprise two separate inputs, one to control insertion of the cradle 20 and one to control ejection of the cradle 20. In some embodiments, the user input 12 may include a light or the like to identify the user input 12 to a user and/or to identify a status of the cradle 20, *e.g.,* whether the cradle is inserted, ejected and/or whether the hearing device 30 is being charged/is fully charged.

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In some embodiments, a controller 11 or the like may control the operation of the electrical actuator 17. The controller 11 may comprise processing circuitry that controls the operation of the electrical actuator 17 based upon a user's input.

The controller 11 may, in some embodiments, control the latch system such that when a user input is received by the controller 11 to insert the hearing device 30 in the charger 10, the controller 11 may control the latch system such that the latch, nose 29B or the like, is activated to position and/or hold the hearing device 30 in the cradle 20. Similarly, when a user input is received by the controller 11 to eject the hearing device 30 from the charger 10, the controller 11 may control the latch system such that the latch, nose 29B or the like, is retracted.

In some embodiments, an elastic element 25, such as a spring or the like, may be used to assist or provide for ejection of the hearing device 30 from the cradle 20. For example, if a user applied a force to the hearing device 30 to remove the hearing device 30 from the cradle 20, a force generated in response to compression of the elastic element 25 will assist the user's force. In some embodiments using a latch system, where the latch system is deactivated or its holding force is overcome, the elastic element 25 may at least partially eject the hearing device 30 from the cradle 20.

In some embodiments, the electrical actuator 17 is configured to move the cradle 20 into and out of a charging dock 40 in the charger 10 that is configured to accommodate the cradle 20. Like the cradle 20, the charging dock 40 may comprise: a magnet 43B for interacting with a magnet 43A on the cradle 20; a nose 49B or the like for coupling with a notch 29A or the like on the cradle to provide a latch system; an elastic element 45 to assist in removing the cradle 20 from the charging dock 40; an electrical terminal 47 for contacting with an electrical terminal 27B on the cradle 20, which is in conductive communication with the first terminal 27A; and a magnet 43B for interacting with a magnet 43A on the cradle 20 and holding the electrical terminal 47 in contact with electrical terminal 27B.

In some embodiments, the walls 21A, 21B may be moveably attached to a base of the cradle 24. For example, the walls 21A, 21B may be attached by a hinge to the base 24, may be

attached so that the walls 21A, 21B may translate over the base 24 and/or the like. In such embodiments, when the cradle 20 is moved into or out of the charging dock 40, the walls 21A, 21B may be configured to move with respect to the base 24. For example, in some embodiments, the walls 21A, 21B may be configured to move inwards with respect to the base 24 and in so doing 'grip' the hearing device 30 as the hearing device 30 is inserted into the charging dock 40. This gripping of the hearing device 30 may be achieved by a transducer moving the walls 21A, 21B, by a spring loaded mechanism where interior walls of the charging dock 40 'push' the walls 21A, 21B inwards, by contact between the walls 21A, 21B of the cradle 20 and the charging dock 40, and/or the like. Conversely, when the cradle 20 is ejected from the charging dock 40, the walls 21A, 21B may move outward relative to the base 24 releasing the hearing device 30. In such embodiments, there may be no retaining force being applied to the hearing device 30 when the cradle 20 is in an ejected position for a user to overcome when removing the hearing device 30 from the cradle 20. Moreover, access to the hearing device 30 may be improved.

Figure 2 illustrates a hearing device charger comprising a cradle configured to insert an hearing device instrument into the charger and/or eject the hearing device from the charger with a mechanical input, in accordance with some embodiments of the present disclosure.

As described with respect to Fig. 1, the cradle 20 may be used to insert/eject the hearing device 30 from the charger 10. In some embodiments, the user input 12 may comprise a switch, a button, a lever or a lid moveably coupled to the charger. The lid (not shown) may comprise a hinged lid or the like that covers the charging dock 40. In some embodiments, the user input 12 is configured to translate a user input force - *e.g.,* a force that moves the switch, the button, the lever or the lid - to a mechanical insertion/ejection system.

For example, in some embodiments, the user input 12 may be coupled with a first lever 210A that is in turn coupled to a second lever 210B. The first lever 201A may be coupled with a pivot point 205A, which may comprise an axle, a gear and/or the like, such that movement of the first lever 210A causes the second lever to pivot around the pivot point 205A. The

coupling of the first and second levers 210A & B is configured to provide for translating a direction of the force applied by the user to the user input 12. The second lever 210B is coupled in turn with an insertion/ejection mechanism 220. The second lever 210B may be coupled with the insertion/ejection mechanism 220 and may pivot around a pivot point 205B, which may comprise an axle, a gear and/or the like. The coupling of the second levers 210B and the insertion/ejection mechanism 220 is configured to provide for translating a direction of the force acting on the second lever 210B, such that the insertion/ejection mechanism 220 moves in a longitudinal direction in the charging dock 40.

In some embodiments, the insertion/ejection mechanism 220 is coupled with the cradle 20 and moves the cradle 20 longitudinally, in and out of the charging dock 40. The insertion/ejection mechanism 220 may comprise a lever/rod or the like or a plurality of separate components and/or levers/rods. In different embodiments, different numbers of levers and pivots may be used to provide for translation of a force applied to the user input 12 into movement of the cradle 20 into/out of the charging dock 40. For example, the user input 12 may comprise a switch or the like where the user input 12 may move along the surface of the charger 10 and a series of mechanical connections may translate this sliding motion into movement of the cradle 20 into/out of the charging dock 40. It is to be understood that the hearing device 30 is a small, light device, and the the charging dock 40 is also a small volume, such that only small input forces are needed at the user input 12 to cause the cradle 20 to move into/out of the charging dock 40.

In some embodiments, the insertion/ejection mechanism described in Fig. 2 may be used in reverse, *e.g.,* the user may pull on the user input 12, rather than push the user input 12, to move the user input 12 in an opposite direction relative to an initial input to provide for insertion of the hearing device 30 in contrast to ejection of the hearing device 30. In other embodiments, two user inputs may be used, one to provide for insertion of the hearing device 30 and one to provide for ejection 30 of the hearing device 30.

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In certain embodiments, the cradle 20 can be configured to insert the hearing device 30 to a charging position in the charger 10. For example, for wireless charging, the cradle 20 may move the hearing device 30 to a position in the charger 10 where a wireless induction coil 35 in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the cradle 20 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, the cradle 20 can be configured to eject the hearing device 30 from the charging position to an ejected position in the charger 10, where the hearing device 30 is accessible to the user for removal from the cradle 20 with little or no force and/or for grasping by a body/housing of the hearing device 30.

Figure 3 illustrates a system for inserting a hearing device into and/or ejecting an hearing device from a charger, in accordance with an embodiment of the present disclosure.

In Fig. 3, a charger 10 comprises a charging dock 140. The charging dock 140 is configured to receive a hearing device 30. The hearing device 30 may comprise a communication component 31, for example an electronic cable, a sound tube or the like, that extends from the hearing device 30. The communication component 31 being configured in use to deliver sound from the hearing device 30 to a user's ear. In some embodiments, the hearing device 30 may comprise an in-ear component 33, such as an ear-tip, speaker and/or the like. Where the hearing device 30 is configured to be worn behind a user's ear (a BTE hearing device), the communication component 31 and/or the in-ear component 33, which in combination may comprise a sound delivery system 31, 33, may comprise a sound tube, ear hook, electric cable, ear-tip, speaker and/or the like that is configured to deliver sound from the hearing device into the user's ear.

In certain embodiments, the charging dock 140 is configured so that when the hearing device 30 is inserted into the charging dock it is positioned/held in a charging position in the charger 10. For example, for wireless charging, the hearing device 30 may be inserted by the insertion mechanism described herein to a position in the charger 10 where a wireless induction coil 35

in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the charging dock 140 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, insertion/ejection mechanism described herein is configured to eject the hearing device 30 from the charging position to an ejected/removing position in the charger 10, where the hearing device 30 is accessible to the user for removal from the charger 10 with little or no force and/or for grasping by a body/housing of the hearing device 30. In some embodiments, the hearing device 30 may be completely ejected from the charger 10, such that after ejection, the hearing device is completely outside of the charging dock 140 after ejection so that the complete hearing device 30 is accessible to the user.

While the following description describes inserting/holding the hearing device 30 in the charger 10 to provide for application of a charging current, it is to be understood that the insertion/holding techniques/systems can also apply to insertion/holding the hearing device 30 in the charger 30 in a charging position for wireless charging.

In some embodiments, the charging dock 140 comprises a docking terminal 147 that is configured to contact a charging terminal 37 of the hearing device 30. In some embodiments, the charging dock 140 is configured to accommodate the hearing device 30 such that when the hearing device 30 is inserted into the charging dock 140 the charging terminal 37 contacts the docking terminal 147 providing for electrical communication between the charging terminal 37 and the docking terminal 147.

In some embodiments of the present disclosure, the charging dock 140 is shaped to provide that the hearing device can only be inserted into the charging dock 140 in a single orientation, and this single orientation is configured to provide that the charging terminal 37 contacts the first docking terminal 147 when the hearing device 30 is inserted into the charging dock 140.

The charging dock 140 may be shaped to provide that there is space between an outer-surface 36 of the hearing device 30 and an inner-surface 22 of charging dock walls 111A and 11IB. In such embodiments, gravity may provide the force for holding the charging terminal 37 in

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contact with the docking terminal 147. In some embodiments, magnets 143B and 23B (one of the magnets 143B and 23B may comprise a metallic compound instead of a magnet to provide for metallic coupling) may be used to hold the hearing device 30 in the charging dock 140 so that the charging terminal 37 and the docking terminal 147 are held in contact. In some embodiments, an inner-surface of the charging dock walls 111A and 11IB and or the outer-surface 36 may comprise an elastic and/or grippy material that may hold the hearing device 30 in the charging dock 140 after insertion by a user.

In some embodiments, a latch system (nose 149B and notch 39A) may be used to hold the hearing device 30 in the charging dock 140 such that the docking terminal 147 and the first terminal 27A are held in contact. In some embodiments, the location of the nose 149B on the charging dock 140 and the notch 39A on the hearing device 30 may be reversed. In some embodiments of the present disclosure, the nose 149B may be retractable into a cavity (not shown) and may be spring loaded so that as the hearing device 30 is inserted in the charging dock 140, the nose 149B slides along an outer-surface of the hearing device 30 until it is inserted by a spring-type mechanism into the notch 39A. When the hearing device 30 is inserted into the charging dock 140, such that the notch 39A and the nose 29B align, the notch 39A and the nose 29B interact to hold the hearing device 30 in the charging dock 140, such that charging terminal 37 and the first terminal 147 are in contact.

In some embodiments, the charger 10 comprises a user input 112. The user input 112 may comprise an electrical switch or the like such that a user input may be electronically conveyed via electrical communicator 115 to an electrical actuator 117. The electrical actuator 117 may comprise a motor or the like and may interact with the hearing device 30 via an interaction element 119. As such, in some embodiments of the present disclosure, the electrical actuator 117 may receive communication of a user input to the user input 112 and generate motion of the hearing device into or out of the charging dock 140 via the interaction element 119.

In some embodiments, an end of the interaction element (not shown) may comprise a magnet, a grippy material, a latch and/or the like to provide for coupling of the interaction element 119

with the hearing device 30. In some embodiments, however, the hearing device 30 may be inserted into the charging dock 140 by the user pushing on the hearing device 30.

The interaction element 119 may in some embodiments comprise a screw-type mechanism, a geared mechanism, a combination of coupled substrates and/or the like that are configured to translate mechanical motion of the electrical actuator 117 into motion of the hearing device 30 into or out of the charging dock 140. In some embodiments of the present disclosure, the user input 112, the electrical communicator 115, the electrical actuator 117 and the interaction element 119 can provide insertion/ejection of the hearing device 30 into/from the charging dock 140.

The user input 112 may comprise an electrical switch or the like that can communicate with the electrical actuator 117 to either insert the hearing device 30 into the charger 10 or to eject the hearing device 30 from the charging dock 140. In some embodiments, the user input 112 may comprise two separate inputs one to control insertion of the hearing device 30 and one to control ejection of the hearing device 30. In some embodiments, the user input 112 may include a light or the like to identify the user input 112 to a user and/or to identify a status of the hearing device 30, *e.g.,* whether the hearing device 30 is inserted, ejected, in contact with the charging terminals and/or whether the hearing device 30 is being charged or is fully charged.

In some embodiments, a controller 111 or the like that may control the operation of the electrical actuator 117. The controller 111 may comprise processing circuitry that controls the operation of the electrical actuator 117 based upon a user's input and/or a charging state of the hearing device 30, for example the controller 111 may control ejection of the hearing device 30 from the charger 10 when the hearing device 30 is fully charged.

The controller 111 may, in some embodiments, control the latch system such that when a user input is received by the controller 111 to insert the hearing device 30 in the charger 10, the controller 111 may control the latch system such that the nose 149B or the like, is activated to position and/or hold the hearing device 30 in the charging dock 140. Similarly, when a user

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input is received by the controller 111 to eject the hearing device 30 from the charging dock 140, the controller 111 may control the latch system such that the latch, nose 149B or the like, is retracted.

In some embodiments, an elastic element (not shown) such as a spring or the like, may be used to assist or provide for ejection of the hearing device 30 from the charging dock 140. For example, the controller 111 may control the nose 149B to retract from the notch 39A so that the elastic element may eject the hearing device 30 from the charging dock 140.

In some embodiments of the present disclosure, the charger 10 may comprise a protection device for the communication component 31 and/or the in-ear component 33. In some embodiments, the protection device may comprise a recess 143 into which the communication component 31 and/or the in-ear component 33 may be stored when the hearing device is in the charging dock 140 and/or a guard (not shown) that may prevent/make it difficult for the user of the hearing device 30 to access the communication component 31 and/or the in-ear component 33 when the hearing device 30 is in the charging dock 140.

In some embodiments, the charging dock 140 is configured to provide that after ejection in excess of 50% of the length of the hearing device 30 extends beyond walls 111A, 11IB of the charging dock 140. Preferably, in some embodiments greater than 60%, 70% or 80% of the length of the hearing device 30 extends beyond the walls 111A, 11IB of the charging dock 140 when the hearing device 30 is ejected from the charging dock 140 to provide for handling of the hearing device 30 by a user of the hearing device 30. It has been found that where a large surface area of the side of the hearing device 30 is accessible to a user, the user will grip the hearing device 30 by the sides of the hearing device 30 to insert/remove the hearing device 30 from the charging dock 140, rather than using the communication component 31.

Figure 4 illustrates a mechanically controlled system for inserting/ejecting an hearing device from a charging dock, in accordance with some embodiments of the present disclosure.

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As described with respect to Fig. 3, some embodiments of the present disclosure provide a system for inserting/ejecting the hearing device 30 from the charging dock 140 using the user input 112. In some of these embodiments, the user input 112 may comprise a switch or a button configured to translate a user input force - *e.g.,* a force that moves the switch or button - to a mechanical arrangement of levers.

For example, the user input 112 may be coupled with a first lever 210A that is in turn coupled to a second lever 210B. The first lever 201A may be coupled with a pivot point 205A, which may comprise an axle, a gear and/or the like, such that movement of the first lever 210A causes the second lever to pivot around the pivot point 205A. The coupling of the first and second levers 210A & B is configured to provide for translating a direction of the force applied by the user to the user input 112.

In some embodiments of the present disclosure, the second lever 210B is coupled with an insertion/ejection mechanism 220. The second lever 210B may be coupled with the insertion/ejection mechanism 220 and may pivot around a pivot point 205B, which may comprise an axle, a gear and/or the like. The coupling of the second levers 210B and the insertion/ejection mechanism 220 is configured to provide for translating a direction of the force acting on the second lever 210B such that the insertion/ejection mechanism 220 moves in a longitudinal direction in the charging dock 140.

The insertion/ejection mechanism 220 may comprise a lever/rod or the like or a plurality of separate components. In different embodiments, different numbers of levers and pivots may be used to provide for translation of a force applied to the user input 112 into movement of the hearing device 30 into/out of the charging dock 140. For example, the user input 112 may comprise a switch or the like where the user input 112 may move along the surface of the charger 10 and a series of mechanical connections may translate this sliding motion into movement of the insertion/ejection mechanism 220 into/out of the charging dock 140. It is to be understood that the hearing device 30 is a small, light device and as such the charging dock

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140 comprises a small volume such that only small input forces are needed at the user input 112 to cause the hearing device 30 to move into/out of the charging dock 140.

In some embodiments, the insertion/ejection mechanism described in Fig. 4 may be used in reverse, *e.g.,* the user may pull on the user input 112 rather than push the user input 112, move the user input 112 in an opposite direction relative to an initial input to provide for insertion of the hearing device 30 in contrast to ejection of the hearing device 30. In other embodiments, two user inputs may be used, one to provide for insertion of the hearing device 30 and one to provide for ejection of the hearing device 30.

In some embodiments, however, the hearing device 30 may be inserted into the charging dock 140 by the user pushing on the hearing device 30. Similarly, rather than using the user input 112 to eject the hearing device 30, a user may push the hearing device 30 downwards so that the latch system is released and a compliant element 145 may, as a result, provide for ejection of the hearing device 30 from the charging dock 140.

Figure 5 is a flow-type illustration of a method for inserting and/or ejecting a hearing device into/out of a charger, in accordance with some embodiments of the present disclosure.

In step 305, a user places a hearing device in a charger. The user may place the hearing device in a cradle or in a charging dock of the charger. In some embodiments, the user may simply place the hearing device into the cradle/charging dock where the internal dimensions of the cradle charging dock are greater than that of the hearing device so that little or no force is required for the placement. In other embodiments, the user may need to apply a force to the hearing device so that the hearing device is held in the cradle/charging dock by friction with walls of the cradle/charging dock, a latch system and/or the like. Requiring application of force to the hearing device for placing in the charger has in general not been found to be detrimental to the hearing device.

In some embodiments, where the charger is a wireless charger, the charging dock may comprise sloping sides leading to a charging cavity shaped to receive the hearing device in a

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certain alignment, where the certain alignment aligns a receiving induction coil in the hearing device with a charging induction coil in the charger. In such embodiments, a user may simply 'drop' the hearing device in a top of the charging dock and let gravity 'insert' the hearing device in the charging cavity.

In step 310, the user inputs an insertion command into the charger. In some embodiments, this may comprise pushing a button, a switch or the like. In other embodiments, the user may push the hearing devise itself.

In step 315, the hearing device is inserted into a charging position in the charger. In mechanical systems, according to embodiments of the present disclosure, a force applied by a user to an input in step 310 is translated by the mechanical system into movement of the cradle or an insertion mechanism into a charging dock in the charger. In this way, the hearing device is inserted into a charging position in the charging dock. In some embodiments, a holding system may hold the hearing device in the charging dock. The holding mechanism may comprise walls of a docking cradle that may retract and clamp the hearing device such that it is held in the cradle and the cradle is moved to a charging position in the charger.

In some embodiments, a user's input in step 310 is electronically communicated to an actuator and the actuator may provide for insertion of the hearing device into the charger. The electronic communication with the actuator may be made via processing circuitry that controls the actuator. The actuator may comprise an electrical motor, a mechanical actuator configured to convert an electronic signal to mechanical motion, a controlled compliant coupling, a hydraulic actuator and/or the like.

In some embodiments, the charger may not require steps 310 or 315 as the user may insert the hearing device directly in the charger into a charging position. Or as described above, where the charger comprises a wireless charger, gravity may insert the hearing device in the charger. In yet other embodiments, the charger may comprise a box like structure and the lid may serve as a user input, such that closing the lid of the charging box either causes an electrical

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communication to insert the hearing device in the charger or provides an input force that drives a mechanical system to insert the hearing device into the charger.

In step 320, the charger chargers the hearing device, where charging may be via electrical connections or wireless charging. Indicators may be provided that provide optical signals regarding the charging status of the hearing device, *e.g.,* charging, charged, and/or the like and/or the status of the hearing device in the charger, *e.g.,* inserted, in charging position, ejected and/or the like.

In step 325, a user inputs an ejection command. The ejection command may be made by pushing a button, operating a switching mechanism, pushing on the hearing device in the charger and/or the like. In some embodiments where the charger comprises a box like structure with a lid, the user input for ejecting the hearing device may comprise opening the lid of the box.

In step 330 the hearing device is ejected from the charger. In embodiments where the user ejection command is communicated electronically an electro-to-mechanical actuator may be used to eject the hearing device from the charger. In embodiments, where the user ejection command is communicated via mechanical means, the force of the user input may be translated via a mechanical system to a force the hearing device causing it to eject from the charger. For example, kinetic motion of a button, switch, a lid of the charger and/or the like may be translated via a mechanical system to a force on the hearing device in direction such that the hearing device is ejected from the charger. In some embodiments, where the hearing device is inserted in a charging cradle, the force may be applied to the charging cradle to eject the cradle and the hearing device from the charger.

In embodiments, where the charger includes a holding device to hold the hearing device in the charger, the user command may also be communicated to the holding mechanism to release the hearing device. In some embodiments, ejection of the hearing device from the charger comprises moving the hearing device and/or a charging cradle in a charging dock such that at least 60%, 70% or preferably 80% of a length of the hearing device is accessible to a user

above the walls of the charging dock. In some embodiments, the whole hearing device may be ejected from the charging dock such that it lays on top of the ejection mechanism and can easily be picked up by a user.

In some embodiments, the ejection mechanism is configured to provide that at least 0.5 centimetres. 0.75 centimetres or in excess of 1.0 centimetres in length of the hearing device housing extends outside of the hearing device holder/ charging dock when the hearing device is ejected from the charger.

While the principles of the disclosure have been described above in connection with specific apparatuses and methods, it is to be clearly understood that this description is made only by way of example and not as limitation on the scope of the invention.

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CLAIMS:

1. A hearing device charger configured to charge a rechargeable hearing device, which comprises a hearing device housing, a sound delivery system and a rechargeable battery, the hearing device charger comprising:

a power supply for supplying a charging current to the rechargeable hearing device;

a charging dock configured to accommodate at least a portion of the hearing device;

characterised in that the hearing device charger comprises:

a user control configured to receive an input from a user to either insert the hearing device into a charging position in the charging dock or eject the hearing device to a removing position in the charging dock; and

an insertion/ejection mechanism configured to move the hearing device between the charging position and the removing position.

2. The hearing device charger according to claim 1, wherein the user control comprises one of a switch, a button, a lever or a lid that is moveably coupled with the hearing device charger.

3. The hearing device charger according to any of the preceding claims, wherein the insertion/ejection mechanism comprises a mechanical insertion/ejection mechanism comprising a plurality of levers in mechanical communication with the user control and configured to mechanically translate an input force applied by the user to the user control to an insertion/ejection force applied to the hearing device.

4. The hearing device charger according to claim 3, wherein the mechanical insertion/ejection mechanism comprises one or more gears.

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5. The hearing device charger according to claims 1 or 2, wherein the injection/insertion mechanism comprises an electrical actuator in electrical communication with the user control and configured to move the hearing device between the charging position and the removing position.

6. The hearing device charger according to claim 9, wherein the electrical actuator comprises one of an electrical motor and a hydraulic pump.

7. The hearing device charger according to claims 1 or 2, wherein the injection/insertion mechanism comprises a hydraulic actuator in fluid communication with the user control and configured to move the hearing device between the charging position and the removing position.

8. The hearing device charger according to any of the previous claims, wherein the insertion/injection mechanism further comprises a cradle configured to hold the hearing device.

9. The hearing device charger according to claim 8, wherein the cradle comprises moveable side walls that move inward to squeeze against the hearing device housing during insertion and/or move outwards to release the hearing device during ejection.

10. The hearing device charger according to any of the preceding claims, wherein:

the rechargeable battery comprises battery terminals for charging the rechargeable battery;

the charging dock comprises charging terminals electrically connected with the power supply and configured to provide an electrical connection with the battery terminals; and

the charging dock comprises a holding mechanism for holding the hearing device in the charging position, such that in the charging position the battery terminals contact the charging terminals.

11. The hearing device charger of claim 10, wherein the holding mechanism comprises at least one of a latch system, an elastic element and a magnet.

12. The hearing device charger according to claims 10 or 11, wherein the holding mechanism further comprises a release mechanism for releasing the holding mechanisms when the hearing device is moved from the charging position to the removing position.

13. The hearing device charger according to any of the preceding claims, wherein in the removing position at least 0.5 centimetres. 0.75 centimetres or in excess of 1.0 centimetres in length of the hearing device housing extends outside of the hearing device holder.

14. The hearing device charger according to any of the preceding claims, wherein in the removing position less than 30% or preferably less than 20% of a longitudinal length of the hearing device body is disposed within the hearing device holder.

15. The hearing device charger according to any of the preceding claims, further comprising a guard section configured to receive at least a portion of the sound delivery mechanism.

16. The hearing device charger according to any of the preceding claims, further comprising:

an indicator light configured to indicate a status of the hearing device.

17. The hearing device charger according to any one of claims 1 through 10 or 13 through 16, wherein:

the hearing device charger comprises a charging induction coil;

the hearing device comprises a hearing device induction coil; and

in the charging position, the charging induction coil and the hearing device induction coil are aligned for wireless charging of the hearing device.

18. A method for inserting/injecting a hearing device into/out of a charging dock of a hearing device charger, comprising:

using a user control to receive a user input;

communicating the user input to an actuator; and

using the actuator to move the hearing device between a charging position and a removing position in the charging dock, wherein the charging position comprises a position configured for charging the hearing device and the removing position comprises a position configured for removal of the hearing device by the user.

19. The method of claim 18, wherein in the removing position greater than 70% or preferably greater than 80% of a longitudinal length of the hearing device extends outside of the charging dock.

20. The method of one of claims 18 or 19, wherein in the removing position the hearing device is completely ejected from the charging dock.

21. The method of any one of claims 18 through 20, wherein:

the user control comprises one of a switch, a button, an input lever and a lid of the hearing device charger that is moveably coupled with the hearing device charger;

communicating the user input to the actuator and using the actuator to move the hearing device between the charging position and the removing position in the charging dock comprises mechanically communicating a force applied by the user to the user control to the

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hearing device to move the hearing device between the charging position and the removing position.

22. The method according to any one of claims 20 through 22, wherein:

communicating the user input to the actuator comprises electronically communicating the user input to the actuator; and

using the actuator to move the hearing device between the charging position and the removing position in the charging dock comprises controlling the actuator to move the hearing device between the charging position and the removing position.

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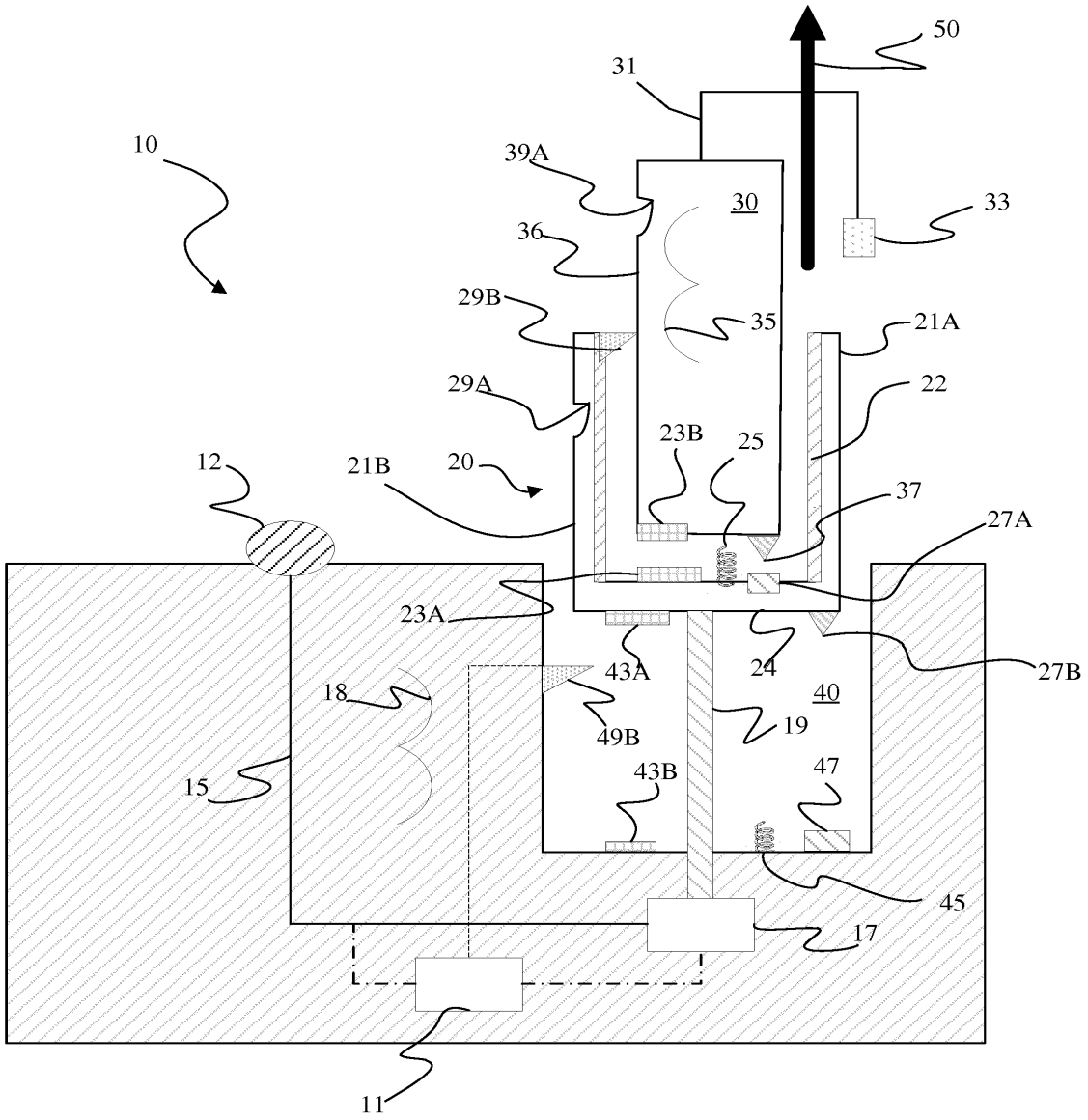

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31
10
39A
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29B
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21A
29A
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23B
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12
21B
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27A
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43A
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27B
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49B
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15
43B
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17
11

Figure 1

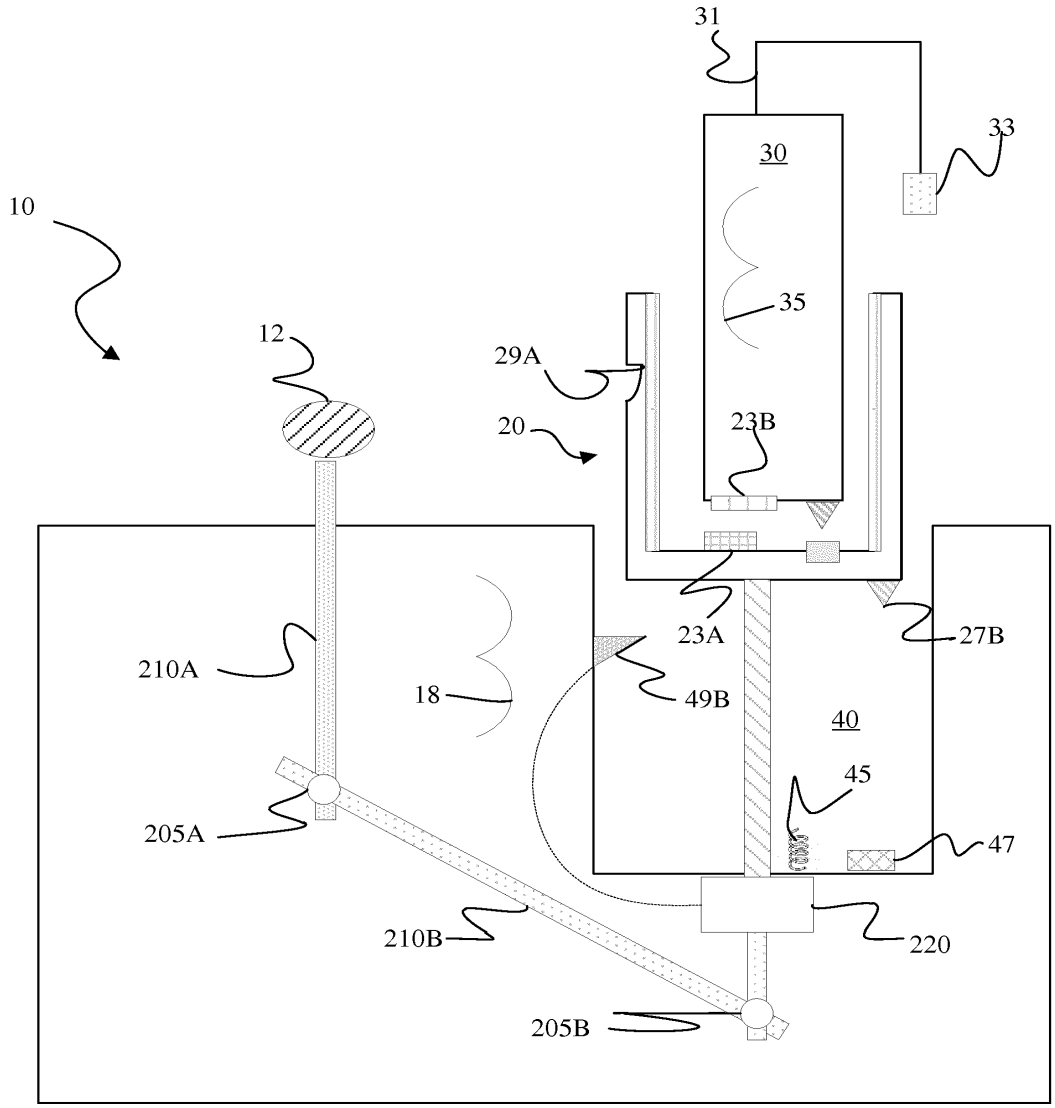

31
33
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10
35
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29A
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23A
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210A
18
49B
40
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205A
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210B
220
205B

Figure 2

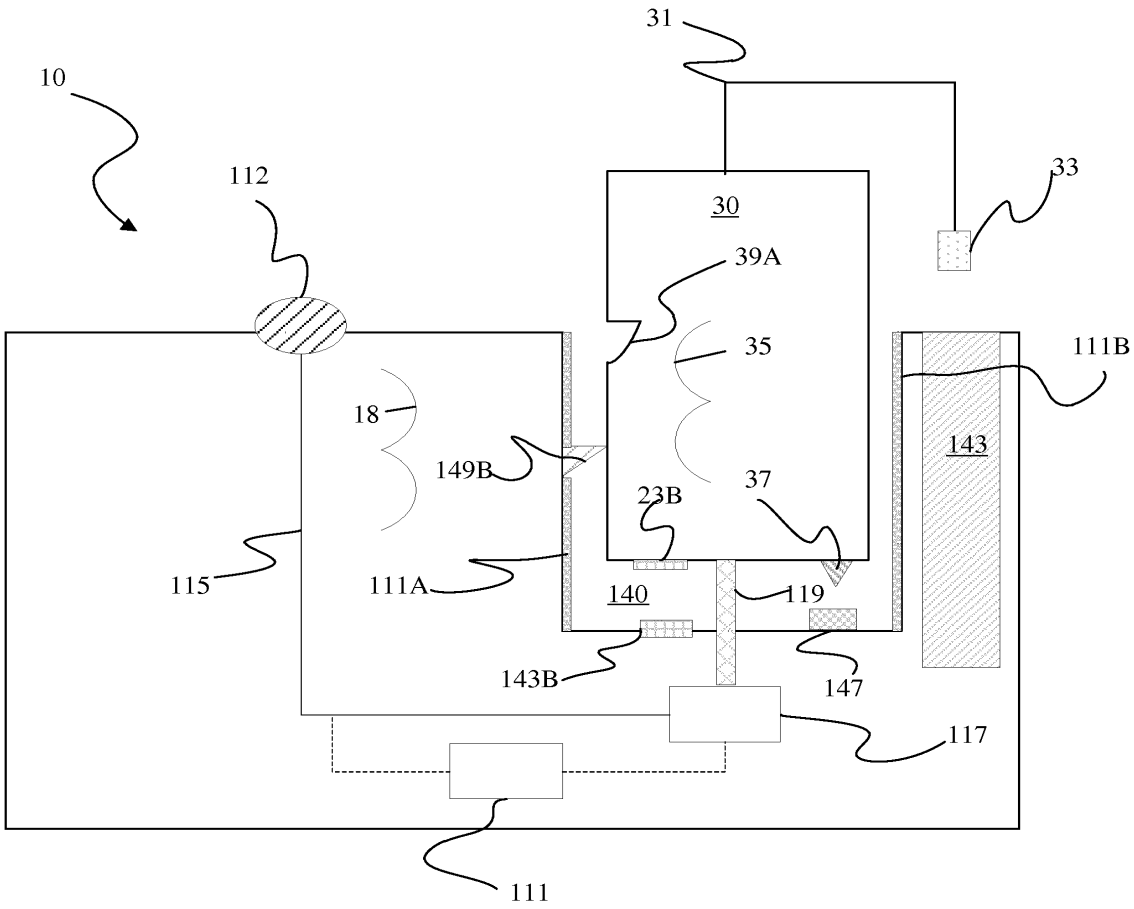

31
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112
33
30
39A
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111B
18
143
149B
37
23B
115
111A
140
119
143B
147
117
111

Figure 3

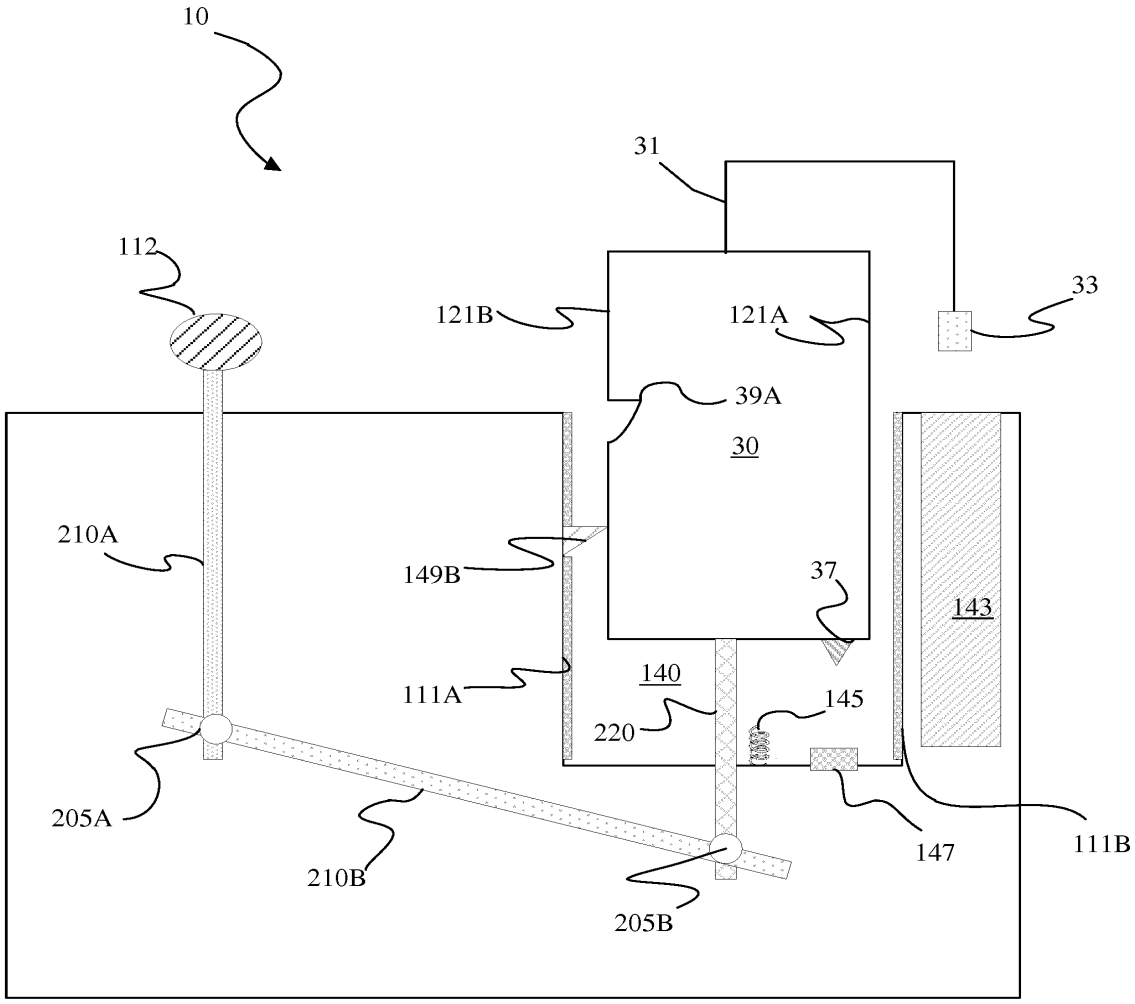

10
31
112
121B
121A
33
39A
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210A
149B
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143
111A
140
145
220
205A
147
111B
210B
205B

Figure 4

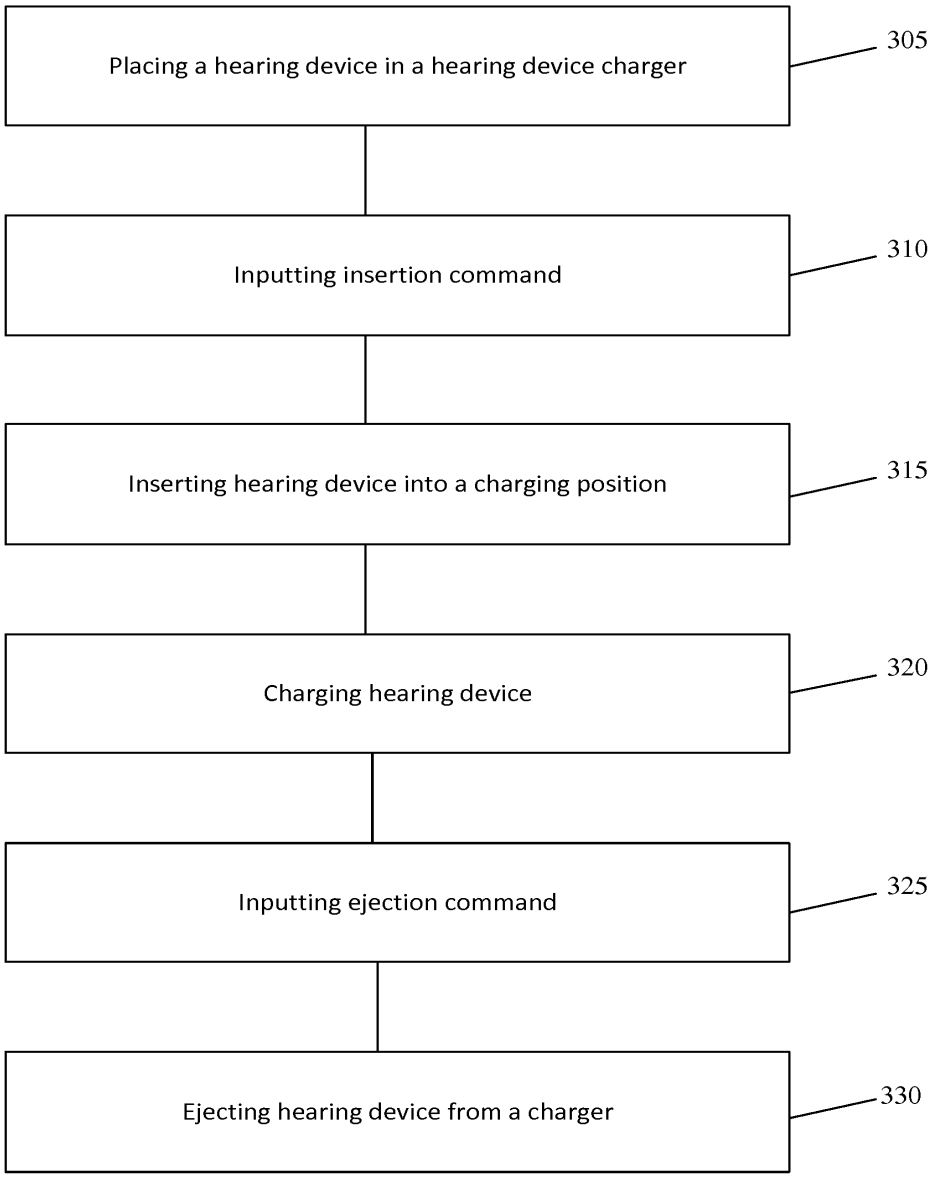

Placing a hearing device in a hearing device charger
305
Inputting insertion command
310
Inserting hearing device into a charging position
315
Charging hearing device
320
Inputting ejection command
325
Ejecting hearing device from a charger
330

Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/071325

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/10 H04R25/00
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)
H04R

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	US 2009/200984 A1 (MEINCKE HANS [DK] ET AL) 13 August 2009 (2009-08-13)	1-4, 8-16, 18-21
Y	page 2, paragraph 21 - page 4, paragraph	17
A	71; figures 5, 7, 8-11, 15, 17	5-7 ,22

A	US 2008/007217 A1 (RILEY LOUIS F [US]) 10 January 2008 (2008-01-10) page 1, paragraph 16 - page 1, paragraph 18; figures 1-3	1-22

Y	US 2002/113572 A1 (ZINK UWE [US] ET AL) 22 August 2002 (2002-08-22) page 2, paragraph 18 - page 3, paragraph 39; figures 1-4	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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2018	01/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Duffner, Orla

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/071325

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Form PCT/ISA/210 (patent family annex) (April 2005)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
ST0806WO1-0532-000		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2020/041956	14 July 2020 (14-07-2020)	19 July 2019 (19-07-2019)
Applicant		
STARKEY LABORATORIES, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 3
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

Form PCT/ISA/210 (first sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/041956

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/10 H04R25/00
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)
H04R

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, COMPENDEX, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 2016/126476 A1 (3M INNOVATIVE PROPERTIES CO [US]) 11 August 2016 (2016-08-11) page 7, line 23 - page 7, line 34 page 10, line 31 - page 11, line 4 figures 6,8,9b ----- -/--	1

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2020	02/11/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Meiser, Jürgen

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2019/037854 A1 (SONOVA AG [CH]) 28 February 2019 (2019-02-28) page 5, paragraph 3 page 7, last paragraph - page 8, paragraph 1 figure 1	7-14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2020/041956

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		US 2019132665 A1	02-05-2019
		US 2020084533 A1	12-03-2020
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WO 2019037854 A1	28-02-2019	US 2020260176 A1	13-08-2020
		WO 2019037854 A1	28-02-2019

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2020/041956	14.07.2020	19.07.2019

International Patent Classification (IPC) or both national classification and IPC
INV. H04R1/10 H04R25/00

Applicant
STARKEY LABORATORIES, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Meiser, Jürgen Telephone No. +49 89 2399-0

Form PCT/ISA/237 (Cover Sheet) (January 2015)

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-15
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-15
Industrial applicability (IA)	Yes:	Claims	1-15
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1 WO 2016/036309 A1 (EPICKAL AB [SE]) 10 March 2016 (2016-03-10)

D2 WO 2016/126476 A1 (3M INNOVATIVE PROPERTIES CO [US]) 11 August 2016 (2016-08-11)

D3 EP 2 640 170 A1 (APPLE INC [US]) 18 September 2013 (2013-09-18)

D4 WO 2019/037854 A1 (SONOVA AG [CH]) 28 February 2019 (2019-02-28)

2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of **claim 1** does not involve an inventive step in the sense of Article 33(3) PCT.

2.1 **D1** is regarded as being the prior art closest to the subject-matter of **claim 1**, and discloses a system, comprising:
- at least one hearing device (cf. device 10a in fig.1) configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact (fig.5-7; 15a/15b cathode and anode; 14 rechargeable power source; 17 charging interface member); and
- a charging module (fig.4) comprising:
a second charging interface (charging mounting discs 42 and 48) configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact (cf. p.5,l.29 - p.7,l.11);
an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device (cf. p.5,l.29 - p.7,l. 11).

2.2 The subject-matter of **claim 1** therefrom, differs in that the claimed system comprises an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts and is therefore new.

2.3 The problem to be solved by the present invention may therefore be regarded as how to ensure that the electrical contacts of the hearing device do not simultaneously touch the respective contacts of the charging module.

2.4 The solution proposed in **claim 1** of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the following reasons: The feature to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts is regarded as a matter of normal design procedure and is already known to the skilled person, which common knowledge is illustrated e.g. by D2; using contacts having varying length, fig. 9b, 8 and 6 and p.7,l.23-34, and p.10,l. 31-p.11,l.4, which refer to a third contact in the middle extending above the contact surface. Its inclusion would therefore be an obvious design possibility for the skilled person in order to solve the problem posed.

3 **Dependent claims 2-15** do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step.

claims 2-4: the implementation of the second cathode based on a pogo pin and/or a spring is well known to the skilled person, see e.g. D1, p.6,l.10-25; D3, para[299]-[300];

claims 5-6: use of magnets and/or mechanical retention mechanism is also know to the skilled person, see e.g. D1, fig.1-2 and p.5,l.1-14; p.5,l.22-28; D3, para[293]-[295], connector plate 61640 in fig.61B is connected with array 6180 by magnetic force, wherein the connector plate is a part of the charging circuit of hearing device 1100 in fig.11; para[297]-[299] and fig.62A-62B;

claims 7-8: the use of electric charging contacts in order to transmit information signals is known to the skilled person, see e.g. D3, para[94]-[96] and [167], transmitting power and/or communicating data; D4, fig. 1, charging terminal 37 and the first terminal 27A are in contact for charging and/or exchanging of signals;

claim 9: cf. e.g. D4, fig.1, hearing device 36 with contact terminals 37; D3, contact terminals in fig.62A-62B; D1, fig. 4, contact pins 44a-44c and 50c;

claims 10-13: the arrangement of the first and second anode and cathode contact terminals is merely one of several straightforward possibilities which the skilled person would select, depending on the circumstances, without exercising inventive skill; the exact arrangement is due to requirements like spatial conditions and/or manufacturing conditions; see e.g. D1, arrangement of contact terminals in fig. 4; D4, fig.1, hearing device 36 with contact terminals 37; D3, contact terminals in fig.62A-62B;

claim 14: hearing devices in different shapes are well known, cf. D4, p.5,third paragraph; p.7,last paragraph-p.8,first paragraph; D1, earbuds which are worn in the ear canal, p.1,l.9-13; D3, para[85], [87] and [100], fig.1,10A;

claim 15: the charge rate based on a state of charge comes within the scope of the customary practice followed by the skilled person and dependent on technical requirements.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE
First Named Inventor/Applicant Name:	Erik Carlson
Filer:	Mark A. Hollingsworth/Tracey Dotter
Attorney Docket Number:	ST0806US1/0532.000806US03

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	320	320
UTILITY SEARCH FEE	1111	1	700	700
UTILITY EXAMINATION FEE	1311	1	800	800
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	3	100	300
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	1051	1	160	160

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2280**

Electronic Acknowledgement Receipt	
EFS ID:	44541908
Application Number:	17553716
International Application Number:	
Confirmation Number:	1905
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE
First Named Inventor/Applicant Name:	Erik Carlson
Customer Number:	142537
Filer:	Mark A. Hollingsworth
Filer Authorized By:	
Attorney Docket Number:	ST0806US1/0532.000806US03
Receipt Date:	16-DEC-2021
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Time Stamp:	21:39:43
Application Type:	Utility under 35 USC 111(a)

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Payment Type	DA
Payment was successfully received in RAM	$2280
RAM confirmation Number	E2021BFL40024693
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	2021-12-16-Transmittal.pdf	316190 806ea34032639af62661e37506333a979f938275	no	1
Warnings:					
Information:					
2	Application Data Sheet	2021-12-16-ADS.pdf	1256362 fc2728af6ee38020103b9a665564a1a29d719255	no	9
Warnings:					
Information:					
3	Power of Attorney	2021-12-16-POA.pdf	362643 e98e64f8e0f09e446255d9131b40c037c79859a2	no	4
Warnings:					
Information:					
4		2021-12-16-Application.pdf	213768 07f1880866e5e74232aa0daf4c2de23f902de933	yes	49

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	42
Claims	43	48
Abstract	49	49

Warnings:					
Information:					
5	Drawings-only black and white line drawings	2021-12-16-Drawings.pdf	509138 0f64b35f47b2143f7d458564cb032e347a2afe4a	no	15

Warnings:					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	2021-12-16-SB08.pdf	1053419 fc5bf81016a32a83128d093d646264398ae9591a	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
7	Foreign Reference	EP2640170B1.pdf	1494397 2aee207ed09ac9d48e91ba089994df41f1c2503f	no	97
Warnings:					
Information:					
8	Foreign Reference	WO2016036309A1.pdf	613476 f9c549ef8bcc56f895b091ed27d023650ddc8757	no	42
Warnings:					
Information:					
9	Foreign Reference	WO2016126476A1.pdf	377354 81abcab53d266f003386788a343f93b5d100d087	no	23
Warnings:					
Information:					
10	Foreign Reference	WO2019037854A1.pdf	479829 dc8a92854180a85e8b95f75db651100e2934a115	no	36
Warnings:					
Information:					
11	Other Reference-Patent/App/Search documents	ISR.pdf	355428 bcda2e2a7dc67b3cc3aedf21e4a34e9d6c001348	no	10
Warnings:					
Information:					

12	Fee Worksheet (SB06)	fee-info.pdf	48208 2c0d441b3c24df80c71b4035579d489453e2f588	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7080212		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

RELATED APPLICATIONS

This application is a continuation of PCT Application No. PCT/US2020/041956, filed July 14, 2020, which claims priority to U.S. Provisional Application No. 62/876,454, filed July 19, 2019, and U.S. Provisional Application No. 62/943,375, filed December 4, 2019, the content of which are hereby incorporated by reference in their entireties.

TECHNICAL FIELD

This application relates generally to ear-worn electronic devices, including hearing devices, hearing aids, personal amplification devices, and other hearables.

BACKGROUND

Hearing devices provide sound for the wearer. Some examples of hearing devices are headsets, hearing aids, speakers, cochlear implants, bone conduction devices, and personal listening devices. For example, hearing aids provide amplification to compensate for hearing loss by transmitting amplified sounds to a wearer's ear canals. Hearing devices may be capable of performing wireless communication with other devices, such as receiving streaming audio from a streaming device via a wireless link. Wireless communication may also be performed for programming the hearing device and transmitting information from the hearing device. For performing such wireless communication, hearing devices such as hearing aids can include a wireless transceiver and an antenna. In order to provide power to electronic circuitry of a hearing device, a rechargeable battery is often housed within the hearing device, which requires routine charging to ensure proper operation of the hearing device.

SUMMARY

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface

comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Embodiments are directed to a system, comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole. A biasing arrangement is configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device. A retention arrangement is disposed on one or both of the hearing device and the charging module. The retention arrangement is configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode

elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. The first anode contact comprises a plurality of first electrode elements configured to communicate power and one or more disparate information signals. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprises a second cathode contact and a second anode contact. The second anode contact comprises a plurality of second electrode elements configured to communicate power and the one or more disparate information signals. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device. The first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source and a first charging interface comprising a plurality of first electrode elements. The plurality of first electrode elements comprises first cathode and anode contacts configured to communicate power and a first data contact configured to communicate one or more disparate information signals. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprises a plurality of second electrode elements. The plurality of second electrode elements comprises second cathode and anode contacts

configured to communicate power and a second data contact configured to communicate one or more disparate information signals. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

The above summary is not intended to describe each disclosed embodiment or every implementation of the present disclosure. The figures and the detailed description below more particularly exemplify illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Throughout the specification reference is made to the appended drawings wherein:

Figures 1A and 1B illustrate an ear-worn electronic device arrangement incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figures 2A and 2B illustrate a custom hearing aid system which incorporates charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 3 illustrates an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 4 illustrates an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 5 illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 6 illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 7 illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 8A illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 8B illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 8C illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 8D illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figure 8E illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

Figures 8F-8I illustrate a charging interface of an ear-worn electronic device in accordance with any of the embodiments disclosed herein;

Figure 8J illustrates a charging interface of a hearing device comprising a central data contact surrounded by a triangular arrangement of curvilinear-shaped peripheral contacts coupled to a multi-phase rectifier in accordance with any of the embodiments disclosed herein;

Figure 8K illustrates a charging interface of a charging module comprising a central data pin surrounded by a pair of arcuate contacts in accordance with any of the embodiments disclosed herein;

Figure 9 is a cross-sectional view of a portion of a hearing device comprising charging circuitry in accordance with any of the embodiments disclosed herein;

Figure 10 is a cross-sectional view of a portion of a charging module comprising charging circuitry in accordance with any of the embodiments disclosed herein;

Figures 11 and 12 illustrate a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 13 is a schematic showing electrical components of a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 14A is a schematic showing electrical components of a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

Figure 14B illustrates a charging interface of a hearing device comprising a central cathode pin surrounded by split-ring pin connectors in accordance with any of the embodiments disclosed herein;

Figure 14C illustrates a charging interface of a hearing device comprising a central data pin surrounded by split-ring pin connectors coupled to a multi-phase rectifier in accordance with any of the embodiments disclosed herein;

Figure 14D illustrates a charging interface of a charging module comprising a central data pin surrounded by split-ring pin connectors in accordance with any of the embodiments disclosed herein;

Figure 15 illustrates a method of implementing accelerated charging of one or more hearing devices using a charging module in accordance with any of the embodiments disclosed herein; and

Figure 16 is a graph that characterizes accelerated charging of a lithium-ion battery of a hearing device in accordance with any of the embodiments disclosed herein.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

DETAILED DESCRIPTION

It is understood that the embodiments described herein may be used with any ear-worn or ear-level electronic device without departing from the scope of this disclosure. The devices depicted in the figures are intended to demonstrate the subject matter, but not in a limited, exhaustive, or exclusive sense. Ear-worn electronic devices (also referred to herein as "hearing devices"), such as hearables (e.g., wearable earphones, ear monitors, and earbuds), hearing aids, hearing instruments, and hearing assistance devices, typically include an enclosure, such as a housing or shell, within which internal components are disposed. Typical components of a hearing device can include a processor (e.g., a digital signal processor or DSP), memory circuitry, power management circuitry, one or more communication devices (e.g., a radio, a near-field magnetic induction (NFMI) device), one or

more antennas, one or more microphones, and a receiver/speaker, for example. Hearing devices can incorporate a long-range communication device, such as a Bluetooth® transceiver or other type of radio frequency (RF) transceiver. A communication device (e.g., a radio or NFMI device) of a hearing device can be configured to facilitate communication between a left ear device and a right ear device of the hearing device.

Hearing devices of the present disclosure can incorporate an antenna coupled to a high-frequency transceiver, such as a 2.4 GHz radio. The RF transceiver can conform to an IEEE 802.11 (e.g., WiFi®) or Bluetooth® (e.g., BLE, Bluetooth® 4. 2 or 5.0) specification, for example. It is understood that hearing devices of the present disclosure can employ other transceivers or radios, such as a 900 MHz radio. Hearing devices of the present disclosure can be configured to receive streaming audio (e.g., digital audio data or files) from an electronic or digital source. Representative electronic/digital sources (e.g., accessory devices) include an assistive listening system, a TV streamer, a radio, a smartphone, a laptop, a cell phone/entertainment device (CPED) or other electronic device that serves as a source of digital audio data or other types of data files. Hearing devices of the present disclosure can be configured to effect bi-directional communication (e.g., wireless communication) of data with an external source, such as a remote server via the Internet or other communication infrastructure. Hearing devices that include a left ear device and a right ear device can be configured to effect bi-directional communication (e.g., wireless communication) therebetween, so as to implement ear-to-ear communication between the left and right ear devices.

The term hearing device of the present disclosure refers to a wide variety of ear-level electronic devices that can aid a person with impaired hearing. The term hearing device also refers to a wide variety of devices that can produce processed sound for persons with normal hearing. Hearing devices of the present disclosure include hearables (e.g., wearable earphones, headphones, earbuds, virtual reality headsets), hearing aids (e.g., hearing instruments), cochlear implants, and bone-conduction devices, for example. Hearing devices include, but are not limited to, behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC), receiver-in-canal (RIC), receiver-in-the-ear (RITE) or completely-in-the-canal (CIC) type hearing devices or some combination of the above. Throughout this

disclosure, reference is made to a "hearing device," which is understood to refer to a system comprising a single left ear device, a single right ear device, or a combination of a left ear device and a right ear device.

Figures 1A and 1B illustrate various components of a representative hearing device arrangement in accordance with various embodiments. Figures 1A and 1B illustrate first and second hearing devices 100A and 100B configured to be supported at, by, in or on left and right ears of a wearer. In some embodiments, a single hearing device 100A or 100B can be supported at, by, in or on the left or right ear of a wearer. As illustrated, the first and second hearing devices 100A and 100B include the same functional components. It is understood that the first and second hearing devices 100A and 100B can include different functional components. The first and second hearing devices 100A and 100B can be representative of any of the hearing devices disclosed herein.

The first and second hearing devices 100A and 100B include an enclosure 101a, 101b configured for placement, for example, over or on the ear, entirely or partially within the external ear canal (e.g., between the pinna and ear drum) or behind the ear. Disposed within the enclosure 101a, 101b is a processor 102a, 102b which incorporates or is coupled to memory 103a, 103b. The processor 102a, 102b can include or be implemented as a multi-core processor, a digital signal processor (DSP), an audio processor or a combination of these processors. For example, the processor 102a, 102b may be implemented in a variety of different ways, such as with a mixture of discrete analog and digital components that include a processor configured to execute programmed instructions contained in a processor-readable storage medium (e.g., solid-state memory, e.g., Flash).

The processor 102a, 102b is coupled to a wireless transceiver 104a, 104b (also referred to herein as a radio), such as a BLE transceiver or other IEEE 802.11 compliant transceiver. The wireless transceiver 104a, 104b is operably coupled to an antenna 106a, 106b configured for transmitting and receiving radio signals. Impedance matching circuitry 105a, 105b can be operably coupled to the wireless transceiver 104a, 104b and the antenna 106a, 106b. The antenna 106a, 106b is disposed in, on, or extends from the enclosure 101a, 101b. The wireless transceiver 104a, 104b and the antenna 106a, 106b can be configured to operate in the 2.4 GHz ISM frequency band or other applicable communication band

(referred to as the "Bluetooth® band" herein). The wireless transceiver 104a, 104b and antenna 106a, 106b can be configured to enable ear-to-ear communication between the two hearing devices 100A and 100B, as well as communications with an external device (e.g., a smartphone or a digital music player).

A battery 110a, 110b or other power source (rechargeable or conventional) is provided within the enclosure 101a, 101b and is configured to provide power to the various components of the hearing devices 100A and 100B. The battery 110a, 110b is coupled to power management circuitry 111a, 111b, such as a power management integrated circuit (PMIC). The power management circuitry 111a, 111b is coupled to a charging interface 113a, 113b, which is configured to physically and electrically couple to a corresponding charging interface of a charging module. A speaker or receiver 108a, 108b is coupled to an amplifier (not shown) and the processor 102a, 102b. The speaker or receiver 108a, 108b is configured to generate sound which is communicated to the wearer's ear.

In some embodiments, the hearing devices 100A and 100B include a microphone 112a, 112b mounted on or inside the enclosure 101a, 101b. The microphone 112a, 112b may be a single microphone or multiple microphones, such as a microphone array. The microphone 112a, 112b can be coupled to a preamplifier (not shown), the output of which is coupled to the processor 102a, 102b. The microphone 112a, 112b receives sound waves from the environment and converts the sound into an input signal. The input signal is amplified by the preamplifier and sampled and digitized by an analog-to-digital converter of the processor 102a, 102b, resulting in a digitized input signal. In some embodiments (e.g., hearing aids), the processor 102a, 102b (e.g., DSP circuitry) is configured to process the digitized input signal into an output signal in a manner that compensates for the wearer's hearing loss. When receiving an audio signal from an external source, the wireless transceiver 104a, 104b may produce a second input signal for the DSP circuitry of the processor 102a, 102b that may be combined with the input signal produced by the microphone 112a, 112b or used in place thereof. In other embodiments, (e.g., hearables), the processor 102a, 102b can be configured to process the digitized input signal into an output signal in a manner that is tailored or optimized for the wearer (e.g., based on wearer

preferences). The output signal is then passed to an audio output stage that drives the speaker or receiver 108a, 108b, which converts the output signal into an audio output.

Some embodiments are directed to a custom hearing aid, such as an ITC, CIC, or IIC hearing aid, for example. For example, some embodiments are directed to a custom hearing aid which includes a wireless transceiver and an antenna arrangement configured to operate in the 2.4 GHz ISM frequency band (referred to as the "Bluetooth® band" herein). Figures 2A and 2B illustrate a custom hearing aid system which includes two hearing devices, e.g., left 201a and right 201b side hearing devices, configured to wirelessly communicate with each other and external devices and systems. Figure 2A conceptually illustrates functional blocks of the hearing devices 201a, 201b. The position of the functional blocks in Figure 2A does not necessarily indicate actual locations of components that implement these functional blocks within the hearing devices 201a, 201b. Figure 2B is a block diagram of components that may be disposed at least partially within the enclosure 205a, 205b of the hearing device 201a, 201b.

Each hearing device 201a, 201b includes a physical enclosure 205a, 205b that encloses an internal volume. The enclosure 205a, 205b is configured for at least partial insertion within the wearer's ear canal. The enclosure 205a, 205b includes an external side 202a, 202b that faces away from the wearer and an internal side 203a, 203b that is inserted in the ear canal. The enclosure 205a, 205b comprises a shell 206a, 206b and a faceplate 207a, 207b. The faceplate 207a, 207b may include a battery door 208a, 208b or drawer disposed near the external side 202a, 202b of the enclosure 205a, 205b and configured to allow the battery 240a, 240b to be inserted and removed from the enclosure 205a, 205b. An antenna 220a, 220b can be mounted to the faceplate 207a, 207b or elsewhere in the enclosure 205a, 205b. The antenna arrangement 220a, 220b can include a matching circuit that compensates for a smaller size antenna which allows the antenna arrangement 220a, 220b to fit within a customized device, such as a device that fits partially or fully within the ear canal of the wearer. The matching circuit can be designed so that the power transfer from the transceiver of the electronics 230a, 230b to the antenna arrangement 220a, 220b, provides a specified antenna efficiency, e.g., an optimal antenna efficiency for the customized environment.

The battery 240a, 240b powers electronic circuitry 230a, 230b which is also disposed within the shell 206a, 206b. As illustrated in Figures 2A and 2B, the hearing device 201a, 201b may include one or more microphones 251a, 251b configured to pick up acoustic signals and to transduce the acoustic signals into microphone electrical signals. The electrical signals generated by the microphones 251a, 251b may be conditioned by an analog front end 231 (see Figure 2B) by filtering, amplifying and/or converting the microphone electrical signals from analog to digital signals so that the digital signals can be further processed and/or analyzed by the processor 260. The processor 260 may perform signal processing and/or control various tasks of the hearing device 201a, 201b. In some implementations, the processor 260 comprises a DSP that may include additional computational processing units operating in a multi-core architecture.

The processor 260 is configured to control wireless communication between the hearing devices 201a, 201b and/or an external accessory device (e.g., a smartphone, a digital music player) via the antenna 220a, 220b. The wireless communication may include, for example, audio streaming data and/or control signals. The electronic circuitry 230a, 230b of the hearing device 201a, 201b includes a transceiver 232. The transceiver 232 has a receiver portion that receives communication signals from the antenna arrangement 220a, 220b, demodulates the communication signals, and transfers the signals to the processor 260 for further processing. The transceiver 232 also includes a transmitter portion that modulates output signals from the processor 260 for transmission via the antenna arrangement 220a, 220b. Electrical signals from the microphone 251a, 251b and/or wireless communication received via the antenna 220a, 220b may be processed by the processor 260 and converted to acoustic signals played to the wearer's ear 299 via a speaker 252a, 252b.

The battery 240a, 240b is of a rechargeable type, such as a lithium-ion battery for example. Power management circuitry 241a, 241b (e.g., a PMIC) is operatively coupled to the battery 240a, 240b and to a charging interface 243a, 243b. The charging interface 243a, 243b is configured to physically and electrically couple to a corresponding charging interface of a charging module.

The use of rechargeable batteries in hearing devices (e.g., hearing aids) has been well-received in the marketplace. Self-contained batteries require electrical contacts for

recharging. One complication of contact charging is the difficulty of placing a relatively small hearing device in a charger. Traditional approaches for charging hearing devices often require the wearer to fiddle with the hearing device to achieve the proper connection for charging. There is a need to provide a connection arrangement that allows the wearer to properly attach the hearing device to the charging fixture of the charger with relative ease.

Contact charging requires two electrical connections, namely, an anode (positive) connection and a cathode (negative) connection. When placing a hearing device into a charging fixture, it can be advantageous to connect the cathodes prior to connecting the anodes. For example, connecting the cathodes of the hearing devices and the charging fixture prior to connecting the anodes can serve to provide a consistent inrush current waveform when coupling the hearing devices and charger fixture together. Provision of a consistent inrush current waveform from the charger to the hearing devices informs the charging circuitry of the charger that the hearing devices are properly attached to the proper charging fixture and that a charging procedure can be initiated. If the hearing devices are properly connected to the charging fixture, full charging power can be supplied by the charging fixture to the hearing devices. If one or both of the hearing devices are not properly connected to the charging fixture, charging through the improper connection can be disabled. This can protect against the presence of foreign objects (e.g., keys, coins, other hearing devices) that can be intentionally or unintentionally introduced into the charging fixture. In some implementations, connecting the cathodes of the hearing devices and charger fixture prior to connecting the anodes can serve to establish a ground, which can reduce or minimize spurious electrical spikes in the circuitry.

A system comprising a charging module and at least one hearing device in accordance with any of the embodiments disclosed herein provides a number of technical advantages over conventional charging arrangements. As discussed above, a charging system according to any of the embodiments disclosed herein facilitates connection between charger and hearing device cathodes prior to connection between anodes, which provides for a consistent inrush current waveform when coupling the hearing devices and charger fixture together. A charging system according to any of the embodiments disclosed herein provides enhanced detection of incorrect placement of hearing devices and/or presence of foreign

conductive objects at the charging interface, which results in disabling of charging through the improper connection. A charging system according to any of the embodiments disclosed herein significantly reduces or minimizes spurious electrical spikes in the circuitry, by ensuring that the cathodes of the hearing devices and charger fixture are connected prior to connecting the anodes.

Embodiments of the disclosure are defined in the claims. However, below there is provided a non-exhaustive listing of non-limiting examples. Any one or more of the features of these examples may be combined with any one or more features of another example, embodiment, or aspect described herein.

Example Ex1. A system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact; an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Example Ex2. The system according to Ex1, wherein the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

Example Ex3. The system according to Ex2, wherein the second cathode contact comprises an elongated electrode; and the biasing arrangement comprises a spring.

Example Ex4. The system according to Ex2 or Ex3, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

Example Ex5. The system according to one or more of Ex1 to Ex4 comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

Example Ex6. The system according to Ex5, wherein the retention arrangement comprises one or more magnets or a mechanical retention arrangement.

Example Ex7. The system according to one or more of Ex1 to Ex6, wherein the first anode contact is configured to communicate power and one or more disparate information signals, the second anode contact is configured to communicate power and the one or more disparate information signals, and the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

Example Ex8. The system according to Ex7, wherein the one or more disparate information signals comprise one or more of data signals generated by one or both of the charging module and the hearing device, audio signals generated by one or both of the charging module and the hearing device, and signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

Example Ex9. The system according to one or more of Ex1 to Ex8, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

Example Ex10. The system according to one or more of Ex1 to Ex9, wherein the first anode contact comprises a plurality of electrode elements, and the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

Example Ex11. The system according to Ex10, wherein the second anode contact comprises a plurality of electrode elements, and the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

Example Ex12. The system according to Ex10 or Ex11, wherein one of both of the plurality of electrodes of the first anode contact are substantially equidistant from the first

cathode contact, and the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

Example Ex13. The system according to Ex 10 or Ex 11, wherein one of both of the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact, and the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

Example Ex14. The system according to one or more of Ex1 to Ex13, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

Example Ex15. The system according to one or more of Ex1 to Ex14, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0C when a state of charge (SoC) of the rechargeable power sources is within a predetermined SoC range.

Figure 3 illustrates a system in accordance with any of the embodiments disclosed herein. Figure 3 shows a cross-sectional view of a portion of an ear-worn electronic hearing device 302 and a portion of a charging module 322. The components of the hearing device 302 shown in Figure 3 are disposed in or on a housing configured to be worn at, in or on an ear of a wearer. The hearing device 302 includes a rechargeable power source 304 (e.g., a lithium-ion battery) coupled to power management circuitry 306 (e.g., a PMIC). The power management circuitry 306 is coupled to a first charging interface 310 comprising a first cathode contact 312 and a first anode contact 314 spaced apart from the first cathode contact 312. In the embodiment shown in Figure 3, the power management circuitry 306 is coupled to the first cathode contact 312 via a first connection 307 and to the first anode contact 314 via a second connection 309. The first anode contact 314 can comprise a single contact or a multiplicity of contacts coupled to the second connection 309.

The charging module 322 includes a second charging interface 330 configured to detachably couple (e.g., mechanically and electrically) with the first charging interface 310 of the hearing device 302. The second charging interface 330 includes a second anode

contact 334 having a contact surface 335 and a displaceable second cathode contact 332. The charging module 322 includes charging circuitry 326 coupled to the second charging interface 330 and a power source 324. The power source 324 can be configured to receive power from a standard wall outlet and/or can include a rechargeable or a conventional battery. In some embodiments, the power source 324 can be configured to receive wireless power from an external power source (e.g., inductive, radiofrequency, optical). For example, the power source 324 can be configured to implement inductive charging in accordance with the Qi open interface standard developed by the Wireless Power Consortium. In the embodiment shown in Figure 3, the charging circuitry 326 is coupled to the second cathode contact 332 via a connection 337 and to the second anode contact 334 via a second connection 339. The second anode contact 334 can comprise a single contact or a multiplicity of contacts coupled to the second connection 339.

The second cathode contact 332 is configured for displacement between a first position 331a above the contact surface 335 of the second anode contact 334 and a second position 331b at or below the contact surface 335 of the second anode contact 334. In some configurations, the second cathode contact 332 can be configured for displacement between the first position 331a above the contact surface 335 and a second position 331b above the contact surface 335 but below the first position 331a.

When the hearing device 302 and the charging module 322 are in a non-contacting relationship, such as shown in Figure 3, the second cathode contact 332 is positioned at the first position 331a above the contact surface 335 of the second anode contact 334. When the hearing device 302 and the charging module 322 are in a contacting relationship, the second cathode contact 332 is movable from the first position 331a to the second position 331b and establishes electrical contact with the first cathode contact 312 prior to electrical contact being established between the second anode contact 334 and the first anode contact 314.

More particularly, when the hearing device 302 and the charging module 322 are brought into contact with one another, the second cathode contact 332 positioned at the first position 331a establishes electrical contact with the first cathode contact 312 of the hearing device 302 prior to electrical contact being established between the first and second anode contacts 314, 334. After first establishing electrical contact between the first and second

cathode contacts 312, 332, the second cathode contact 332 is displaced into the body of the charging module 322 as the hearing device 302 is forcibly advanced onto the charging module 322. After displacing the second cathode into the body of the charging module 322 partially or entirely, electrical contact is then established between the first and second anode contacts 314, 334.

The charging module 322 includes an arrangement (shown in other figures) configured to displace at least a portion of the second cathode contact 332 above the contact surface 335 to facilitate electrical contact between the first and second cathode contacts 312, 332 prior to electrical contact between the first and second anode contacts 314, 334. The charging module 322 can also include a retention arrangement (shown in other figures) configured to maintain engagement between the first and second charging interfaces 310, 330 during charging of the rechargeable power source 304 of the hearing device 302. In some embodiments, the retention arrangement can comprise one or more magnets disposed at or near one or both of the first and second charging interfaces 310, 330. In other embodiments, the retention arrangement can comprise a mechanical retention arrangement configured to mechanically maintain engagement between the first and second charging interfaces 310, 330.

Figure 4 illustrates a system in accordance with any of the embodiments disclosed herein. Figure 4 shows a cross-sectional view of a portion of an ear-worn electronic hearing device 402 and a portion of a charging module 422. The components of the hearing device 402 shown in Figure 4 are disposed in or on a housing configured to be worn at, in or on an ear of a wearer. The hearing device 402 includes a rechargeable power source 404 (e.g., a lithium-ion battery) coupled to power management circuitry 406 (e.g., a PMIC). The power management circuitry 406 is coupled to a first charging interface 410. In the embodiment shown in Figure 4, the first charging interface 410 comprises a first cathode contact 412 and a multiplicity of anode contacts, 414, 416. In the illustrative example shown in Figure 4, the first charging interface 410 includes two anode contacts 414, 416, it being understood that the first charging interface 410 can include more than two spaced-apart anode contacts (e.g., 3, 4, 5 or 6 anode contacts).

In the embodiment shown in Figure 4, the power management circuitry 406 is coupled to the first cathode contact 412 via a first connection 407 and to the first and second anode contacts 414, 416 via separate connections. As shown, the power management circuitry 406 is coupled to the first anode contact 414 via a connection 409 and to the second anode contact 416 via a connection 411. It is understood that each physically separate anode contact of the first charging interface 410 can be coupled to the power management circuitry 406 via a separate electrical conductor. It is also understood that, in some configurations, the first charging interface 410 can include anode contacts coupled to the power management circuitry 406 via separate connections in combination with two or more anode contacts coupled to the power management circuitry 406 via a common connection.

The charging module 422 includes a second charging interface 430 configured to detachably couple (e.g., mechanically and electrically) with the first charging interface 410 of the hearing device 402. The charging module 422 includes charging circuitry 426 coupled to the second charging interface 430 and a power source 424. The power source 424 can be configured to receive power from a standard wall outlet and/or can include a rechargeable or a conventional battery. In some embodiments, the power source 424 can be configured to receive wireless power from an external power source (e.g., inductive, radiofrequency, optical). For example, the power source 424 can be configured to implement inductive charging in accordance with the Qi open interface standard developed by the Wireless Power Consortium. The second charging interface 430 includes a second cathode contact 432 and a multiplicity of anode contacts 434, 436. In the embodiment shown in Figure 4, the second cathode contact 432 is fixed in terms of its position on the charging module 422. In this regard, the second cathode contact 432 shown in Figure 4 it is not a displaceable cathode contact. However, it is understood that, in a variant embodiment of Figure 4, the second cathode contact 432 can be implemented as a displaceable cathode contact in the manner illustrated and described with reference to Figure 3.

In the illustrative example shown in Figure 4, the second charging interface 430 includes two anode contacts 434, 436, it being understood that the second charging interface 430 can include more than two spaced-apart anode contacts (e.g., 3, 4, 5 or 6 anode contacts). The number of anode contacts of the second charging interface 430 may or may not be equal

to the number of anode contacts of the first charging interface 410. In the embodiment shown in Figure 4, the charging circuitry 426 is coupled to the second cathode contact 432 via a connection 437 and to the first and second anode contacts 434, 436 via separate connections. More particularly, the first anode contact 434 is coupled to the charging circuitry 426 via connection 439, and the second anode contact 436 is coupled to the charging circuitry 426 via connection 441.

The charging module 422 can include a retention arrangement (shown in other figures) configured to maintain engagement between the first and second charging interfaces 410, 430 during charging of the rechargeable power source 404 of the hearing device 402. In some embodiments, the retention arrangement can comprise one or more magnets disposed at or near one or both of the first and second charging interfaces 410, 430. In other embodiments, the retention arrangement can comprise a mechanical retention arrangement configured to mechanically maintain engagement between the first and second charging interfaces 410, 430.

Provision of electrically separate anode contacts at the first and second charging interfaces 410, 430 provides for the communication of power and one or more disparate information signals between the charging module 422 and the hearing device 402. For example, charging of the rechargeable power supply 404 can be accomplished via first and second cathode contacts 412, 432 and anode contacts 414, 434. Data signals generated by one or both of the charging module 422 and the hearing device 402 can be communicated via anode contacts 416, 436. Although referred to as anode contacts generally, it is understood that the contacts of the first and second charging interfaces 410, 430 that are used for communicating information signals can be any form of electrical contact. Various types of disparate information signals can be communicated between respective pairs of anode contacts of the first and second charging interfaces 410, 430. The disparate forms of information signals can include state of charge and charging status data, control or command signals, audio signals, video signals, and signals from one or more accessory devices (e.g., smartphone, tablet, wearable sensor) configured to communicatively couple to one or both of the hearing device 402 and charging module 422.

Figure 5 illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 500 shown in Figure 5 includes a cathode contact 502, which is typically coupled to a negative contact charging connection 506. The charging interface 500 also includes an anode contact 504, which is typically coupled to a positive contact charging connection 508. In the embodiment shown in Figure 5, the cathode contact 502 is surrounded by the anode contact 504, which has a continuous annular configuration.

In some embodiments, the hearing device and the charging module can have a charging interface that generally corresponds to the charging interface 500 shown in Figure 5. When implemented on a hearing device, for example, a region of the cathode contact 502 (e.g., central region) can be recessed relative to a contact surface of the anode contact 504 (see, e.g., Figures 9 and 12). When implemented on a charging module, and according to some embodiments, the cathode contact 502 can be displaceable (see, e.g., Figures 3, 10, and 11) and proud relative to a contact surface of the anode contact 504. In other embodiments, the cathode contact 502 is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact 504. Although shown as having a generally circular shape, the cathode and anode contacts 502, 504 can have any curvilinear or polygonal shape.

Figure 6 illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 600 shown in Figure 6 includes a cathode contact 602, which is typically coupled to a negative contact charging connection 606. The charging interface 600 also includes an anode contact 604, which is typically coupled to a positive contact charging connection 608. In the embodiment shown in Figure 6, the anode contact 604 comprises a multiplicity of electrode elements 604a, 604b, 604c, each of which is coupled to connection 608. The anode contact 604 has a concentric tri-trace anode configuration. As shown, the cathode contact 602 is surrounded by the concentric tri-trace anode 604 comprising arcuate electrode elements 604a, 604b, 604c. The arcuate electrode elements 604a, 604b, 604c are situated at substantially the same radius (e.g., ~4-5 mm) relative to the cathode contact 602 (e.g., ~2-3 mm diameter). Although three arcuate electrode elements are shown in Figure 6, the concentric anode 604 can comprise two, four, five or more electrode elements, for example.

In some embodiments, the hearing device and the charging module can have a charging interface that generally corresponds to the charging interface 600 shown in Figure 6. When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact 602 (e.g., central region) can be recessed relative to a contact surface of the anode contact 604 (see, e.g., Figures 9 and 12). When implemented on a charging module, for example, the cathode contact 602 can be displaceable (see, e.g., Figures 10 and 11) and proud relative to a contact surface of the anode contact 604. Although shown as having a generally circular or arcuate shape, the cathode and anode contacts 602, 604 can have any curvilinear or polygonal shape.

It is understood that the charging interface of the hearing device and that of the charging module can be substantially the same or different in configuration. For example, and in accordance with some embodiments, the charging module can have a charging interface corresponding to the charging interface 500 shown in Figure 5 (cathode contact surrounded by an annular anode contact). In such embodiments, the hearing device can have a charging interface corresponding to the charging interface 600 shown in Figure 6 (cathode contact surrounded by tri-trace anode contact).

Figure 7 illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 700 shown in Figure 7 includes a cathode contact 702 surrounded by a multiplicity of anode elements 704a, 704b, 704c. In the embodiment shown in Figure 7, the cathode contact 702 and anode elements 704a, 704b, 704c have a polygonal shape. For example, the cathode contact 702 has a generally square shape, and each of the anode elements 704a, 704b, 704c has a generally rectangular shape. It is understood that a charging interface can include cathode and anode contact elements having the same or different curvilinear or polygonal shape.

Figure 8A illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 800 shown in Figure 8A includes a cathode contact 802, which is typically coupled to a negative contact charging connection 806. The charging interface 800 also includes an anode contact 804, which comprising a contact element typically coupled to a positive contact charging connection 808. In the embodiment shown in Figure 8A, the anode contact 804 has a concentric tri-trace anode configuration comprising

a multiplicity of electrode elements 804a, 804b, 804c. As shown, the cathode contact 802 is surrounded by the concentric tri-trace anode 804 comprising individual arcuate electrode elements 804a, 804b, 804c. The arcuate electrode elements 804a, 804b, 804c are situated at substantially the same radius relative to the cathode contact 802. Although three arcuate electrode elements are shown in Figure 8A, the concentric anode 804 can comprise two, four, five or more electrode elements, for example.

According to various embodiments, a hearing device and a charging module incorporate the charging interface 800 shown in Figure 8A. Each of the electrode elements of the anode contact 804 is coupled to a separate electrical connection. More particularly, electrode element 804a is coupled to connection 810, electrode element 804b is coupled to connection 808, and electrode element 804c is coupled to connection 812. Electrode element 804b represents an anode contact of the charging interface 800. The electrode element 804b and the cathode contact 802 are configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device and the charging module via electrode elements 804a, 804c and connections 810, 812. For example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device.

When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact 802 (e.g., central region) can be recessed relative to a contact surface of the anode contact 804 (see, e.g., Figures 9 and 12). Alternatively, the cathode contact 802 and the anode contact 804 can be substantially coplanar. When implemented on a charging module, and in accordance with some embodiments, the cathode contact 802 is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact 804. In accordance with other embodiments, the cathode contact 802 can be displaceable (see, e.g., Figures 10 and 11) and proud relative to a contact surface of the anode contact 804. Although shown as having a generally circular or arcuate shape, the cathode and anode contacts 802, 804 can have any curvilinear or polygonal shape.

Figure 8B illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 820 shown in Figure 8B includes an arrangement of electrodes 824 comprising at least one cathode contact 824a and at least one anode contact 824b. The electrode arrangement 824 can include additional electrodes, such as electrode 824c, which can be a cathode contact or an anode contact. It is understood that the electrodes of the arrangement 824 can be configured as cathode or anode contacts, as long as the arrangement of electrodes 824 includes at least one cathode contact and at least one anode contact. A data contact 822 is shown surrounded by electrodes of the electrode arrangement 824. In the representative embodiment shown in Figure 8B, the electrode arrangement 824 has a concentric tri-trace electrode configuration comprising contacts 824a, 824b, 824c, which surround data contact 822. In some embodiments, the electrode arrangement 824 includes two arcuate electrodes, such as cathode contact 824a and anode contact 824b, which can be spaced apart from one another in the manner shown in Figure 14D, for example. The arcuate electrode elements 824a, 824b, 824c are situated at substantially the same radius relative to the data contact 822. Although three arcuate electrode elements are shown in Figure 8B, the electrode arrangement 824 can comprise two, four, five or more electrode elements, for example.

According to various embodiments, a hearing device and a charging module incorporate the charging interface 820 shown in Figure 8B. Cathode contact 824a is typically coupled to a negative contact charging connection 830, and anode contact 824b is typically coupled to a positive contact charging connection 828. Electrical contact 824c can be coupled to either a negative or a positive charging connection 832. The electrode arrangement 824 is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. One or more information signals can be communicated between the hearing device and the charging module via data contact 822 via signal connection 826. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device.

Figure 8C illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 840a shown in Figure 8C includes a cathode contact

842, which is typically coupled to a negative contact charging connection 846. The charging interface 840a also includes an anode contact 844, which is typically coupled to a positive contact charging connection 848. In the embodiment shown in Figure 8C, the anode contact 844 comprises a multiplicity of electrode elements 844a, 844b, 844c, each of which is coupled to connection 848. The anode contact 844 has a triangular configuration, and is arranged to surround the cathode contact 842. The triangular anode contact 844 includes three electrode elements 844a, 844b, 844c each having a generally curvilinear shape. In some embodiments, the electrode elements 844a, 844b, 844c have a closed curved shape comprising only curved lines (e.g., no line segments). For example, the electrode elements 844a, 844b, 844c can have a non-polygonal shape (e.g., a geometric shape that does not conform to the definition of a polygon). Representative examples of electrode elements 844a, 844b, 844c having a generally curvilinear shape include those having a generally round (e.g., circular) shape, an elliptical shape, and an oval shape. It is understood that the electrode elements 844a, 844b, 844c can also have an arbitrary closed curvilinear shape (e.g., a meandering shape) and/or a closed curvilinear shape comprising predominately curved lines (e.g., a minor percentage (≤ 10-20%) of line segments).

The electrode elements 844a, 844b, 844c can be situated at substantially the same distance (e.g., ~2-6 mm, ~4-5 mm, ~3-5 mm) relative to the cathode contact 842. The cathode contact 842 can have a diameter of about 1.5 mm to about 3 mm, and the electrode elements 844a, 844b, 844c can have the same or smaller diameter (e.g., about 1 mm to about 2.5 mm). Although three electrode elements 844a, 844b, 844c are shown in Figure 8C, the anode contact 844 can comprise one, two, four, five or more electrode elements, for example, arranged in a substantially triangular shape. Also, although the electrode elements 842, 844a, 844b, 844c are shown having the same general shape in Figure 8C (and other figures), it is understood that the electrode elements 842, 844a, 844b, 844c can have different shapes. For example, the electrode elements 842, 844a, 844b, 844c can have different curvilinear shapes or any combination of generally curvilinear shapes and generally rectilinear shapes.

When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact 842 (e.g., central region) can be recessed relative to a contact surface of the anode contact 844 (see, e.g., Figures 9 and 12). Alternatively, the cathode

contact 842 and the anode contact 844 can be substantially coplanar. When implemented on a charging module, and in accordance with some embodiments, the cathode contact 842 is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact 844. In accordance with other embodiments, the cathode contact 842 can be displaceable (see, e.g., Figures 10 and 11) and proud relative to a contact surface of the anode contact 844.

Figure 8D illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 840b shown in Figure 8D includes a cathode contact 842, which is typically coupled to a negative contact charging connection 846. The charging interface 840b also includes an anode contact 844, which is typically coupled to a positive contact charging connection 848. In the embodiment shown in Figure 8D, the anode contact 844 has a triangular anode configuration comprising a multiplicity of electrode elements 844a, 844b, 844c. As shown, the cathode contact 842 is surrounded by the triangular anode 844 comprising individual electrode elements 844a, 844b, 844c. The electrode elements 844a, 844b, 844c are situated at substantially the same distance relative to the cathode contact 842. Although three electrode elements 844a, 844b, 844c are shown in Figure 8D, the anode contact 844 can comprise one, two, four, five or more electrode elements, for example, arranged in a generally triangular shape. The electrode elements 842, 844a, 844b, 844c can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to Figure 8C.

According to various embodiments, a hearing device and a charging module can incorporate the charging interface 840b shown in Figure 8D. Each of the electrode elements of the anode contact 844 is coupled to a separate electrical connection. More particularly, electrode element 844a is coupled to connection 850, electrode element 844b is coupled to connection 848, and electrode element 844c is coupled to connection 852. Electrode element 844b represents an anode contact of the charging interface 840b. The electrode element 844b and the cathode contact 842 are configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device and the charging module via electrode elements 844a, 844c and connections 850, 852. For

example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device.

Figure 8E illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface 840c shown in Figure 8E includes an arrangement of electrodes 844 comprising at least one cathode contact 844a and at least one anode contact 844b. The electrode arrangement 844 can include additional electrodes, such as electrode 844c, which can be a cathode contact or an anode contact. It is understood that any of the electrodes of the arrangement 844 can be configured as cathode or anode contacts, as long as the arrangement of electrodes 844 includes at least one cathode contact and at least one anode contact. A data contact 842 is shown surrounded by electrodes of the electrode arrangement 844. The electrode elements 842, 844a, 844b, 844c can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to Figure 8C.

In the representative embodiment shown in Figure 8E, the electrode arrangement 844 has a generally triangular configuration comprising contacts 844a, 844b, 844c, which surround data contact 842. In some embodiments, the electrode arrangement 844 can include two electrodes, such as cathode contact 844a and anode contact 844b, which are shaped to generally form a triangular pattern and can be spaced apart (e.g., equidistantly) from the data contact 842. The electrode elements 844a, 844b, 844c can be situated at substantially the same distance relative to the data contact 842. Although three curvilinear shaped electrode elements 844a, 844b, 844c are shown surrounding the central data contact 842 in Figure 8E, the electrode arrangement 844 can comprise one, two, four, five or more curvilinear shaped electrode elements that having a generally triangular pattern and surround the data contact 842.

According to various embodiments, a hearing device and a charging module can incorporate the charging interface 840c shown in Figure 8E. Cathode contact 844a is typically coupled to a negative contact charging connection 850, and anode contact 844b is typically coupled to a positive contact charging connection 848. Electrical contact 844c can be coupled to either a negative or a positive charging connection 852. The electrode

arrangement 844 is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. One or more information signals can be communicated between the hearing device and the charging module via data contact 842 and signal connection 846. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device.

When implemented on a hearing device, and in accordance with either of the embodiments shown in Figures 8D and 8E, a region of the central contact 842 (e.g., central region) can be recessed relative to a contact surface of the peripheral contacts 844a, 844b, 844c (see, e.g., Figures 9 and 12). Alternatively, the central contact 842 and the peripheral contacts 844a, 844b, 844c can be substantially coplanar. In accordance with either of the embodiments shown in Figures 8D and 8E (and other embodiments shown in other figures), when implemented on a hearing device, a region of the central contact 842 (e.g., central region) can be elevated relative to a contact surface of the peripheral contacts 844a, 844b, 844c.

Figures 8F-8I illustrate a custom hearing device (e.g., a custom hearing aid) in accordance with any of the embodiments disclosed herein. The hearing device 860 shown in Figures 8F-8I is configured to be worn at least partially within the ear canal of a wearer's ear. The hearing device 860 is representative of any type of ITE hearing aid, such as an ITC, IIC or CIC hearing aid, for example. The hearing device 860 includes a faceplate 862 and a shell 864 connected to the shell 864. The shell 864 houses the electronic and electrical components of the hearing device 860, such as those previously described. The shell 864 is typically shaped to conform to a particular wearer's ear canal using a mold taken from the wearer's ear. In some configurations, the shell 864 can be constructed from semi-soft material (e.g., polymeric material) which can conform to the shape of the wearer's ear canal when the shell 864 is inserted therein. The faceplate 862 includes a charging interface 840d and other components/structures of the hearing device 860, such as one or two microphones 866.

The charging interface 840d disposed on the faceplate 862 comprises a central contact 842 surrounded by three peripheral contacts 844a, 844b, 844c arranged in a substantially

triangular pattern. The peripheral contacts 844a, 844b, 844c can be situated at substantially the same distance (e.g., ~2-5 mm, ~4-5 mm, ~3-4 mm) relative to the central contact 842. The central contact 842 can have a diameter of about 2 mm to about 3 mm, and the peripheral contacts 844a, 844b, 844c can have the same or smaller diameter (e.g., about 1 mm to about 2.5 mm, ~1.5-2 mm).

The charging interface 840d can be representative of any of the charging interfaces discussed herein. For example, charging interface 840d can be configured and wired in the manner of charging interface 840a shown in Figure 8C. In this representative configuration, the charging interface 840d includes a central cathode contact 842, coupled to a negative charging connection, and three anode contacts 844a, 844b, 844c, each coupled to a positive charging connection. The anode contacts 844a, 844b, 844c are arranged in a substantially triangular pattern and surround the cathode contact 842. The contacts 842, 844a, 844b, 844c can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to Figure 8C.

According to another example embodiment, the charging interface 840d can be configured and wired in the manner of charging interface 840b shown in Figure 8D. In this representative configuration, central contact 842 is configured as a cathode contact and peripheral contact 844b is an anode contact of the charging interface 840d. Central cathode contact 842 and peripheral anode contact 844b are configured to communicate power produced by a charging module when charging the rechargeable power source of the hearing device 860. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device 860 and the charging module via peripheral contacts 844a, 844c. For example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device 860.

According to another example embodiment, the charging interface 840d can be configured and wired in the manner of charging interface 840c shown in Figure 8E. In this representative configuration, the charging interface 840d includes at least one cathode contact 844a and at least one anode contact 844b. Electrode 844c can be configured as a cathode contact or an anode contact (or a separate signal communicating contact). A central

data contact 842 can be surrounded by contacts 844a, 844b, 844c arranged in a substantially triangular pattern. The contacts 842, 844a, 844b, 844c can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to Figure 8C.

In accordance with any of the embodiments shown in Figures 8F-8I, a region of the charging interface 840d which includes the central contact 842 (e.g., central region) can be recessed relative to a contact surface of the peripheral contacts 844a, 844b, 844c (see, e.g., Figures 9 and 12). Alternatively, the central contact 842 and the peripheral contacts 844a, 844b, 844c can be substantially coplanar. In accordance with alternative embodiments, the central region of the charging interface 840d which includes the central contact 842 can be elevated relative to a contact surface of the peripheral contacts 844a, 844b, 844c. In accordance with any of the embodiments disclosed herein, the peripheral contacts 844a, 844b, 844c can be surrounded by a peripheral wall having a height greater than that of an exposed surface of peripheral contacts 844a, 844b, 844c.

Figure 8J illustrates a charging interface of a hearing device in accordance with any of the embodiments disclosed herein. The charging interface 870 shown in Figure 8J includes an arrangement of peripheral electrodes 874 comprising at least one cathode contact 874a and at least one anode contact 874b. The peripheral electrode arrangement 874 can include additional electrodes, such as electrode 874c, which can be an anode contact or a cathode contact. A data contact 872 is shown surrounded by electrodes of the electrode arrangement 874. In the representative embodiment shown in Figure 8J, each of the peripheral electrodes 874a, 874b, 874c and the data contact 872 has a generally curvilinear shape (e.g., rounded, circular, elliptical, oval).

The charging interface 870 is coupled to poly-phase rectification circuitry disposed in the housing of the hearing device, which is illustrated as a 3-phase rectifier 890 in Figure 8J. Contacts 874a, 874b, and 874c are coupled to the 3-phase rectifier 890 via charging connections 880, 878, and 882, respectively. The electrode arrangement 874 is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. In the embodiment shown in Figure 8J, power is contained within the concentric electrode arrangement 874. Using this electrode configuration, if at least one contact of the electrode arrangement 874 is connected to ground

(GND) and at least one other contact of the electrode arrangement 874 is connected to power (PWR), then the 3-phase rectifier 890 will supply the correct polarity with the correct voltage.

The charging interface 870 of the hearing device is configured to establish electrical connection with a charging interface 891 of a charging module, an example of which is shown in Figure 8K. The charging interface 870 of the hearing device includes at least two contacts 874a, 874b which serve as cathode and anode contacts. The two contacts 896, 898 of the charging module's charging interface 891 are configured and arranged so that each contact 896, 898 electrically connects with only one of the three contacts 874a, 874b, 874c of the hearing device's charging interface 870. This arrangement ensures that anode and cathode contacts of the hearing device electrically connect with respective anode and cathode contacts of the charging module. In Figure 8K, the contacts 896, 898 of the charging module's charging interface 891 are shown as having an arcuate shape. The contacts 896, 898 may alternatively have a curvilinear shape, a rectilinear shape, or other shape.

One or more information signals can be communicated between the hearing device and the charging module via data contact 872 and signal connection 876. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device. One or more disparate signals can be communicated over data contact 872 using a sequential or multiplexing data transmission technique (e.g., time-division multiplexing, frequency-division multiplexing, code-division multiplexing).

Figure 9 is a cross-sectional view of a portion of a hearing device in accordance with any of the embodiments disclosed herein. The portion of the hearing device 900 shown in Figure 9 includes a charging interface 902 incorporated on the shell or housing 904 of the hearing device 900. The charging interface 902 is situated at or near an exterior surface of the housing 904. For example, the charging interface 902 can be situated on a faceplate of an in-the-ear type hearing device (e.g., ITE, ITC, IIC, CIC device). In the case of an on-the-ear type hearing device (e.g., BTE, RIC, RITE device), for example, the charging interface 902 can be situated at or near a bottom or top end surface of the housing 902. The charging

interface 902 is configured to physically and electrically coupled to a corresponding charging interface of a charging module (see, e.g., Figures 3, 4, 10, and 11).

The charging interface 902 includes a cathode contact 906 partially or entirely surrounded by an anode contact 908. The anode contact 908 can be a single electrical contact or comprise a multiplicity of electrical contacts (see, e.g., Figures 3-8). For example, the anode contact 908 can comprise a single annular electrical contact or two or more arcuate electrical contacts (e.g., a concentric tri-trace anode configuration). The cathode contact 906 is shown extending slightly beyond the exterior surface of the housing 904 relative to the anode contact 908, which is shown as substantially coplanar with the exterior surface of the housing 904. In some implementations, the cathode contact 906 can be substantially coplanar with exterior surface of the housing 904. The cathode contact 906 can include a recessed region 907, which is typically situated within a central region of the cathode contact 906. The recessed region 907 serves to guide a corresponding cathode contact of a charging module into proper contact with the cathode contact 906.

In the embodiment shown in Figure 9, the hearing device 900 includes a retention arrangement 910. The retention arrangement 910 is configured to maintain engagement between the charging interface 902 and a corresponding charging interface of a charging module during charging of a rechargeable power source of the hearing device 900. The retention arrangement 910 includes a magnet 911 or magnetizable structure which can interact with a corresponding magnet or magnetizable structure of the charging module. In some embodiments, the anode contact 908 partially or entirely comprises magnetic material, in which case the separate magnet 911 or magnetizable structure need not be included in the retention arrangement 910.

Figure 10 is a cross-sectional view of a portion of a charging module in accordance with any of the embodiments disclosed herein. The portion of the charging module 1000 shown in Figure 10 includes a charging interface 1002 disposed on a charging surface 1004 of the charging module 1000. The charging interface 1002 is configured to physically and electrically coupled to a corresponding charging interface of a hearing device (see, e.g., Figures 3, 4, 9, and 12). The charging interface 1002 includes a cathode contact 1006 partially or entirely surrounded by an anode contact 1008. The anode contact 1008 can be a

single electrical contact or comprise a multiplicity of electrical contacts (see, e.g., Figures 3-8). For example, the anode contact 1008 can comprise a single annular electrical contact or two or more arcuate electrical contacts (e.g., a concentric tri-trace anode configuration).

The charging interface 1002 includes a through-hole 1012 within which the cathode contact 1006 is disposed. The cathode contact 1006 is displaceable within the through-hole 1012. A biasing arrangement 1014 is configured to bias at least a portion 1006a of the cathode contact 1006 above a contact surface 1009 of the anode contact 1008. As such, the cathode contact 1006 is proud relative to the anode contact 1008 prior to engagement with a corresponding charging interface of a hearing device. The biasing arrangement 1014 is configured to bias at least the portion 1006a of the cathode contact 1006 above the contact surface 1009 to facilitate electrical contact between the cathode contact 1006 and a corresponding cathode contact of a hearing device prior to electrical contact between the anode contact 1008 and corresponding anode contact of the hearing device.

According to some embodiments, the cathode contact 1006 comprises an elongated electrode, and the biasing arrangement 1014 comprises a spring 1016. In some embodiments, the cathode contact 1006 and biasing arrangement 1014 define a spring-loaded pogo pin assembly. The pogo pin assembly 1014 includes a center post pogo pin 1006 which is seated into the housing of the charging module 1000 via pogo housing 1018. The pogo housing 1018 contains a pogo spring 1016 and a pogo endstop 1019.

The charging module 1000 also includes a retention arrangement 1020 configured to maintain engagement between the charging interface 1002 and a corresponding charging interface of a hearing device during charging of a rechargeable power source of the hearing device. The retention arrangement 1020 includes a magnet 1022 or magnetizable structure which can interact with a corresponding magnet or magnetizable structure of the hearing device. In some embodiments, the anode contact 1008 partially or entirely comprises magnetic material, in which case the separate magnet 1022 or magnetizable structure need not be included in the retention arrangement 1020. In some embodiments, the anode contact 1008 can be implemented as a ring magnet plated with electrically conductive material. The ring magnet provides attraction to a different magnet or magnetizable structure in the hearing device in order to align the electrical contacts. The plating provides corrosion resistance.

Figures 11 and 12 illustrate a system in accordance with any of the embodiments disclosed herein. The system includes a hearing aid 1202 (Figure 12) configured to be worn at least partially within the ear canal of a wearer's ear. The hearing aid 1202 is representative of any type of ITE hearing aid, such as an ITC, IIC or CIC hearing aid, for example. The hearing aid 1202 includes a charging interface 1204 comprising a cathode contact 1206 surrounded by an anode contact 1208. Although shown as a concentric tri-trace anode in Figure 12, the anode contact 1208 can be configured as a single electrode element or a multiplicity of electrode elements. The charging interface 1204 is disposed on a faceplate 1203 of the hearing aid 1202.

Figure 11 shows a charging module 1122 which can be installed in, or be integral to, a charging fixture. The charging module 1122 includes a charging interface 1124 which includes a displaceable central cathode contact 1126 surrounded by a concentric anode contact 1128. The displaceable central cathode contact 1126 can be implemented as a spring-loaded elongated electrode, such as that shown in Figure 10 (e.g., a spring-loaded pogo pin assembly). It is understood that a charging fixture will typically include two of the charging modules 1122 configured to charge two of the hearing aids 1202.

Figure 13 is a schematic showing electrical components of a system in accordance with any of the embodiments disclosed herein. The schematic of system 1300 includes electrical components of a hearing device 1302 and electrical components of a charging module 1320. The hearing device 1302 includes a rechargeable power source 1304, such as a lithium-ion battery. The rechargeable power source 1304 is coupled to power management circuitry 1306, such as a PMIC. The power management circuitry 1306 is coupled to an anode contact R3 and a cathode contact R6. The anode contact R3 and cathode contact R6 of the hearing device 1302 can have a configuration and functionality described previously.

The charging module 1320 includes a power source V, which is represented as a battery in Figure 13. The power source V can include a rechargeable battery, a conventional battery, and/or an AC/DC converter configured to receive power from a standard wall outlet. In some embodiments, the power source V can be configured to receive wireless power from an external power source (e.g., Qi, inductive, radiofrequency, optical). The charging module impedance is represented by R1, which is shown coupled to an anode contact R2 via anode

switch S1. Resistor R4 represents a pulldown resistor for current sensing. Resistor R4 is coupled to a cathode contact R5 via cathode switch S2. The anode contact R2 and cathode contact R5 of the charging module 1320 can have a configuration and functionality described previously. In some embodiments, the charging module 1320 is not configured to control anode switch S1 and cathode switch S2 independently, so mechanically ensuring a ground (GND) contact first provides for a more accurate and consistent inrush current profile as previously discussed.

Figure 14A is a schematic showing electrical components of a system in accordance with any of the embodiments disclosed herein. The schematic of system 1400 includes electrical components of a hearing device 1402 and electrical components of a charging module 1420. The hearing device 1402 includes a rechargeable power source 1404, such as a lithium-ion battery. The rechargeable power source 1404 is coupled to power management circuitry 1406, such as a PMIC. The power management circuitry 1406 is coupled to a rectifier 1408. The rectifier 1408 is coupled to a contact arrangement 1410 comprising a cathode contact, at least one anode contact, and one or more electrical contacts configured to communicate information signals between the hearing device 1402 and the charging module 1420. The rectifier 1408 can be implemented as an N-phase rectifier, where N is equal to the number of electrical contacts of the contact arrangement 1410.

Any of contacts R3, R6, and R7 of the hearing device 1402 can be configured as an anode contact or a cathode contact. Any of contacts R3, R6, and R7 can be configured as an electrical contact configured to communicate information signals. In some embodiments, contacts R3, R6, and R7 can be configured as split-ring pin connectors, with the center pin connector being used for data signal transmission and the other two connectors being used as cathode and anode contacts for charging. Other electrical contact configurations are contemplated. For example, and with reference to the embodiment shown in Figure 14B, the hearing device 1402 can include a charging interface 1403 comprising a central cathode pin R7 surrounded by split-ring pin connectors R3 and R6. One of connectors R3 and R6 is configured as an anode contact for charging, and the other of connectors R3 and R6 is configured as an electrical contact configured for data signal transmission. The contact

arrangement 1410 of the hearing device 1402 can have a configuration and functionality described previously.

The charging module 1420 includes a power source V, which is represented as a battery in Figure 14. The power source V can include a rechargeable battery, a conventional battery, and/or an AC/DC converter configured to receive power from a standard wall outlet. In some embodiments, the power source V can be configured to receive wireless power from an external power source (e.g., Qi, inductive, radiofrequency, optical). The charging module impedance is represented by R1, which is shown coupled to an anode contact R2 via anode switch S1. Resistor R4 represents a pulldown resistor for current sensing. Resistor R4 is coupled to a cathode contact R5 via cathode switch S2. The anode contact R2 and cathode contact R5 of the charging module 1420 can have a configuration and functionality described previously. In some embodiments, the charging module 1420 is not configured to control anode switch S1 and cathode switch S2 independently, so mechanically ensuring a ground (GND) contact first provides for a more accurate inrush current profile as previously discussed.

In addition to providing anode and cathode contacts for charging, the hearing device 1402 and charging module 1420 include one or more additional electrical contacts for communicating information signals between the hearing device 1402 and charging module 1420. For example, data can be communicated via one or more contacts, which can be split into multiple contacts each providing a separate connection for disparate signal transmission. The type of signal transmitted over each contact can be detected automatically by the charging module 1420, which can reconfigure the charger connections in real time. For example, the charging module 1420 can include circuitry for detecting whether a particular contact is being used to transmit power and/or data, such as by detecting the pull-up strength of the contacts. In some embodiments, the charging module 1420 can include circuitry configured to detect the connections by cycling through known protocol possibilities and using the one that works through a handshaking procedure.

Figure 14C illustrates a charging interface of a hearing device in accordance with any of the embodiments disclosed herein. The charging interface 1430 shown in Figure 14C includes an arrangement of electrodes 1434 comprising at least one cathode contact 1434a

and at least one anode contact 1434b. The electrode arrangement 1434 can include additional electrodes, such as electrode 1434c, which can be an anode contact or a cathode contact. A data contact 1432 is shown surrounded by electrodes of the electrode arrangement 1434. In the representative embodiment shown in Figure 14C, the electrode arrangement 1434 has a concentric tri-trace electrode configuration comprising contacts 1434a, 1434b, 1434c, which surround data contact 1432. In some embodiments, the electrode arrangement 1434 includes two arcuate electrodes, such as cathode contact 1434a and anode contact 1434b, which can be spaced apart from one another (e.g., see Figure 14D). The arcuate electrode elements 1434a, 1434b, 1434c are situated at substantially the same radius relative to the data contact 1432. Although three arcuate electrode elements are shown in Figure 14C, the electrode arrangement 1434 can comprise two, four, five or more electrode elements, for example.

The charging interface 1430 is coupled to poly-phase rectification circuitry, which is illustrated as a 3-phase rectifier 1450 in Figure 14C. Contacts 1434a, 1434b, and 1434c are coupled to the 3-phase rectifier 1450 via charging connections 1440, 1438, and 1442, respectively. The electrode arrangement 1434 is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. In the embodiments shown in Figure 14C, power is contained within the concentric electrode arrangement 1434. Using this electrode configuration, if at least one contact of the electrode arrangement 1434 is connected to ground (GND) and at least one other contact of the electrode arrangement 1434 is connected to power (PWR), then the 3-phase rectifier 1450 will supply the correct polarity with the correct voltage.

The charging interface 1430 is configured to establish electrical connection with a charging interface of a charging module, an example of which is shown in Figure 14D. The charging interface 1450 includes at least two contacts 1454, 1456 which serve as anode and cathode contacts. The two contacts 1454, 1456 of the charging module's charging interface 1450 are configured and arranged so that each contact 1454, 1456 electrically connects with only one of the three contacts 1434a, 1434b, 1434c of the hearing device's charging interface 1430. This arrangement ensures that anode and cathode contacts of the hearing device 1430 electrically connect with respective anode and cathode contacts of the charging module.

One or more information signals can be communicated between the hearing device and the charging module via data contact 1432 and signal connection 1436. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device. One or more disparate signals can be communicated over data contact 1432 using a sequential or multiplexing data transmission technique (e.g., time-division multiplexing, frequency-division multiplexing, code-division multiplexing).

Figure 15 illustrates a method of implementing accelerated charging of one or more hearing devices using a charging module in accordance with any of the embodiments disclosed herein. In the illustrative method shown in Figure 15, two ear-worn electronic devices are subject to accelerated charging via two charging modules provided on the charging fixture. The method shown in Figure 15 involves establishing connection 1502 between first and second ear-worn electronic devices and first and second charging modules of the charging fixture. The method involves determining 1504 the state of charge (SoC) of the rechargeable power sources of the ear-worn electronic devices. A check 1506 is made to determine if the SoC of the rechargeable power sources is within a predetermined SoC range (e.g., 5-35%). If the SoC of the rechargeable power sources fall within the predetermined SoC range, the method involves charging 1508 the rechargeable power sources at an accelerated charge rate above 1.0C (e.g., 1.5C – 3.0C). Accelerated charging continues while the SoC of the rechargeable power sources remain within the predetermined SoC range. Accelerated charging is discontinued when the SoC of the rechargeable power sources is beyond the predetermined SoC range. In some embodiments, accelerated charging is discontinued in response to expiration of a predetermined time limit (e.g., 15 minutes), reaching a predetermined voltage limit (e.g., 4.1V), or reaching a predetermined energy limit (e.g., 7.5 mAh).

At the termination of accelerated charging, the ear-worn electronic devices may be removed from the charging modules of the charging fixture for immediate use. In some embodiments, five minutes of accelerated charging allows the ear worn electronic devices to be used for between 2 and 6 hours of normal operation. Rather than using the ear worn electronic devices after termination of accelerated charging, the method can involve charging

1510 the rechargeable power sources at a normal charge rate at or below 1.0 C. A check 1512 is made to determine if rechargeable power sources are fully charged. If not, charging at the normal charge rate continues. When the rechargeable power sources are fully charged, the charging procedure is terminated 1514. Accelerated charging can be implemented in accordance with the teachings disclosed in commonly-owned U.S. Patent Application Serial No. 16/012,399 (Higgins et al.), filed on June 19, 2018 and entitled PORTABLE CHARGING UNIT WITH ACCELERATED CHARGING FOR HEARING ASSISTANCE DEVICES, which is incorporated herein by reference.

Figure 16 is a graph that characterizes accelerated charging of a lithium-ion battery of an ear-worn electronic device in accordance with any of the embodiments disclosed herein. The graph of Figure 16 characterizes battery voltage 1602 and charge current 1604 as a function of time during different phases of a charging procedure. As is indicated below the time axis, the different phases of the charging procedure include a pre-charge phase (A), an accelerated constant current charge phase (B), a constant voltage charge phase (D), and a charge complete phase (E). During the pre-charge phase (A), the charge current 1604 is low (e.g., 0.1C) and the battery voltage 1602 slowly increases. It is noted that a well-designed system should stay out of this regime. The pre-charge phase (A) continues until the battery voltage 1602 reaches 3.0 V, at which time the accelerated constant current charge phase (B) is initiated.

During the accelerated charging phase (B), the charge current 1604 rapidly increases to a charge rate above 1.0C, such as 1.5C. During the accelerated charging phase (B), high current is supplied to the battery which results in a rapid increase in battery voltage 1602. For example, a charge current of 5 mA can be supplied to the battery during the latter part of the pre-charge phase (A) (e.g., at 0.3C). The charge current can be increased to between 17 and 24 mA during the accelerated charging phase (B). The accelerated charging phase (B) continues until a predetermined time limit (e.g., 5-15 min) has been reached. In some embodiments, the accelerated charging phase (B) continues until a predetermined battery voltage 1602 (e.g., 4.1 V) or predetermined energy level (e.g., 7.5 mAh) has been reached.

At the conclusion of the accelerated charging phase (B), the charge current 1604 rapidly decreases to a normal charge current level (e.g., 5 mA at a charge rate of 0.3C) at the

initiation of the constant current charge phase (C). During the constant current charge phase (C), a normal charge current (e.g., 5mA) is supplied to the battery resulting in a continued increase in the battery voltage 1602. When the battery voltage 1602 reaches a predetermined level (e.g., 4.2 V), the charging procedure transitions from the constant current charge phase (C) to the constant voltage charge phase (D). During the constant voltage charge phase (D), the charge current 1604 decreases until a cutoff 1606 is reached, at which time the charging procedure is terminated. It is noted that at the charging complete phase (E), the battery voltage 1602 slightly drops over time (e.g., from 4.1 V to 3.9 V). In the embodiment shown in the Figure 16, the charge current 1604 supplied during the accelerated charging phase (B) changes in a step-wise fashion. It is understood that, in some embodiments, the charge current 1604 can decrease gradually as the accelerated charging phase (B) transitions to the constant current charge phase (C).

Although reference is made herein to the accompanying set of drawings that form part of this disclosure, one of at least ordinary skill in the art will appreciate that various adaptations and modifications of the embodiments described herein are within, or do not depart from, the scope of this disclosure. For example, aspects of the embodiments described herein may be combined in a variety of ways with each other. Therefore, it is to be understood that, within the scope of the appended claims, the claimed invention may be practiced other than as explicitly described herein.

All references and publications cited herein are expressly incorporated herein by reference in their entirety into this disclosure, except to the extent they may directly contradict this disclosure. Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims may be understood as being modified either by the term “exactly” or “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein or, for example, within typical ranges of experimental error.

The recitation of numerical ranges by endpoints includes all numbers subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5) and any range within

that range. Herein, the terms "up to" or "no greater than" a number (e.g., up to 50) includes the number (e.g., 50), and the term "no less than" a number (e.g., no less than 5) includes the number (e.g., 5).

The terms "coupled" or "connected" refer to elements being attached to each other either directly (in direct contact with each other) or indirectly (having one or more elements between and attaching the two elements). Either term may be modified by "operatively" and "operably," which may be used interchangeably, to describe that the coupling or connection is configured to allow the components to interact to carry out at least some functionality (for example, a radio chip may be operably coupled to an antenna element to provide a radio frequency electromagnetic signal for wireless communication).

Terms related to orientation, such as "top," "bottom," "side," and "end," are used to describe relative positions of components and are not meant to limit the orientation of the embodiments contemplated. For example, an embodiment described as having a "top" and "bottom" also encompasses embodiments thereof rotated in various directions unless the content clearly dictates otherwise.

Reference to "one embodiment," "an embodiment," "certain embodiments," or "some embodiments," etc., means that a particular feature, configuration, composition, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. Thus, the appearances of such phrases in various places throughout are not necessarily referring to the same embodiment of the disclosure. Furthermore, the particular features, configurations, compositions, or characteristics may be combined in any suitable manner in one or more embodiments.

The words "preferred" and "preferably" refer to embodiments of the disclosure that may afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful and is not intended to exclude other embodiments from the scope of the disclosure.

As used in this specification and the appended claims, the singular forms "a," "an," and "the" encompass embodiments having plural referents, unless the content clearly dictates

otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

As used herein, "have," "having," "include," "including," "comprise," "comprising" or the like are used in their open-ended sense, and generally mean "including, but not limited to." It will be understood that "consisting essentially of," "consisting of," and the like are subsumed in "comprising," and the like. The term "and/or" means one or all of the listed elements or a combination of at least two of the listed elements.

The phrases "at least one of," "comprises at least one of," and "one or more of" followed by a list refers to any one of the items in the list and any combination of two or more items in the list.

CLAIMS

What is claimed is:

1. A system, comprising:

at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact;

an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

2. The system of claim 1, wherein

the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and

the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

3. The system of claim 2, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

4. The system of claim 2, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

5. The system of claim 1, comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

6. The system of claim 5, wherein the retention arrangement comprises:

one or more magnets; or

a mechanical retention arrangement.

7. The system of claim 1 according, wherein:

the first anode contact is configured to communicate power and one or more disparate information signals;

the second anode contact is configured to communicate power and the one or more disparate information signals; and

the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

8. The system of claim 7, wherein the one or more disparate information signals comprise one or more of:

data signals generated by one or both of the charging module and the hearing device;

audio signals generated by one or both of the charging module and the hearing device; and

signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

9. The system of claim 1, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

10. The system of claim 1, wherein:

the first anode contact comprises a plurality of electrode elements; and

the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

11. The system of claim 10, wherein:

the second anode contact comprises a plurality of electrode elements; and

the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

12. The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact; and

the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

13. The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact; and

the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

14. The system of claim 1 according to any of the preceding claims, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

15. The system of claim 1, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0C

when a state of charge (SoC) of the rechargeable power sources is within a predetermined SoC range.

16. A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact, the first anode contact comprising a plurality of electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole;

a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device; and

a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

17. The system of claim 16, wherein the first cathode contact is surrounded by the electrode elements of the first anode contact.

18. The system of claim 16, wherein the electrode elements of the first anode contact are arranged in a substantially triangular pattern.

19. The system of claim 16, wherein:

the first cathode contact is surrounded by the first electrode elements of the first anode contact; and

the second cathode contact is surrounded by the second electrode elements of the second anode contact.

20. The system of claim 16, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

21. The system of claim 16, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

22. The system of claim 16, wherein the retention arrangement comprises a mechanical retention mechanism configured to:

restrain the second cathode contact at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces; and

release the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism.

23. A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising:

a rechargeable power source; and

a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact, the first anode contact comprising a plurality of first electrode elements configured to communicate power and one or more disparate information signals, the first anode contact comprising a plurality of electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprising a second cathode contact and a second anode contact, the second anode contact comprising a plurality of second electrode elements configured to communicate power and the one or more disparate information signals; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device;

wherein the first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

ABSTRACT

A system includes a hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Figure 1A

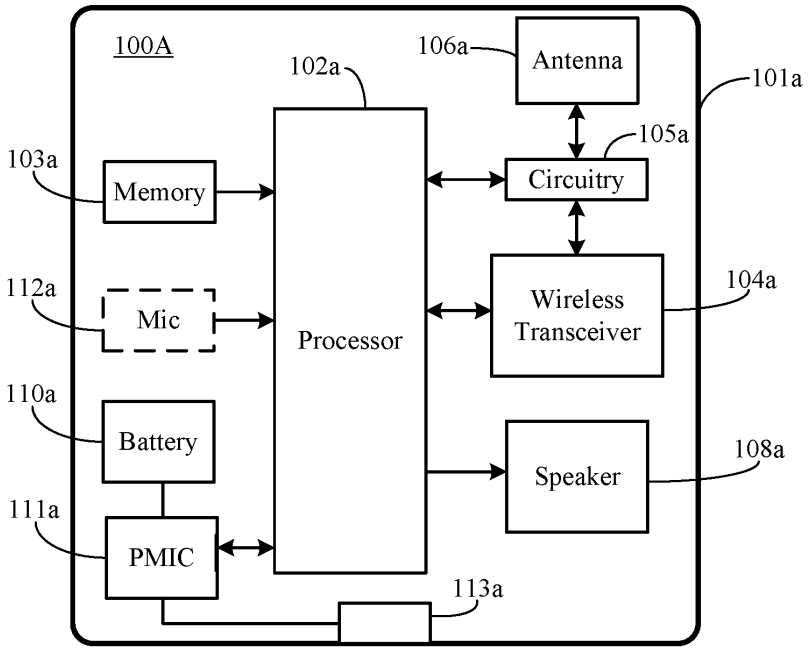
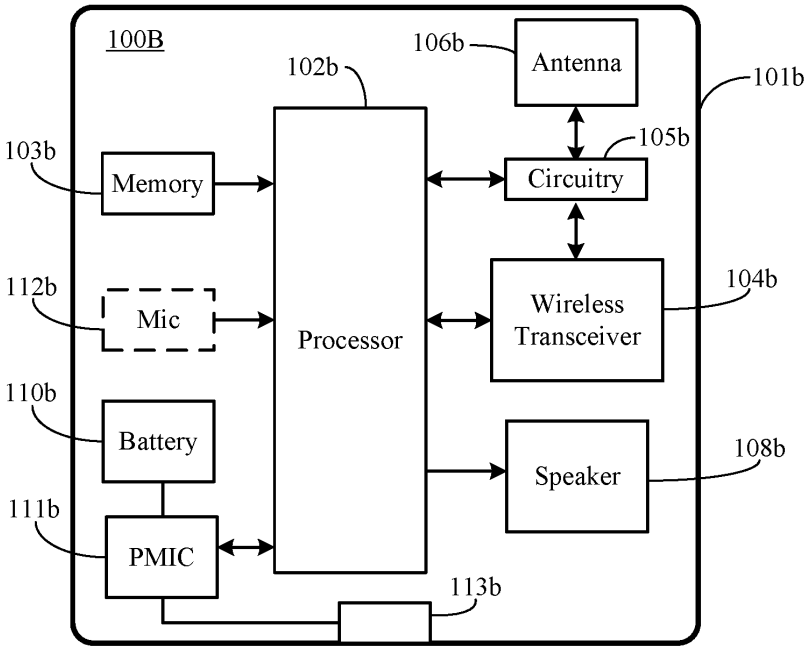


Figure 1B



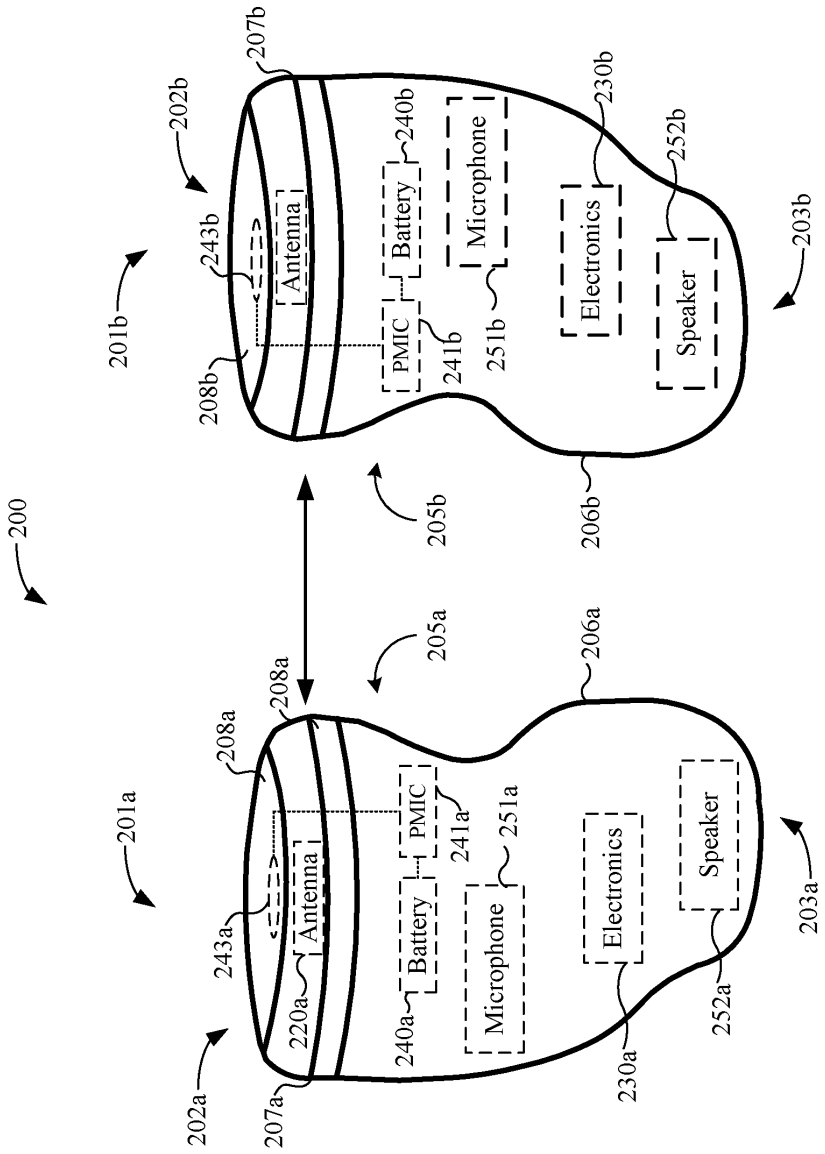

200
201a
201b
202a
202b
203a
203b
205a
205b
206a
206b
207a
207b
208a
208a
208b
220a
230a
230b
240a
240b
241a
241b
243a
243b
251a
251b
252a
252b
Antenna
Battery
PMIC
Microphone
Electronics
Speaker

Figure 2A

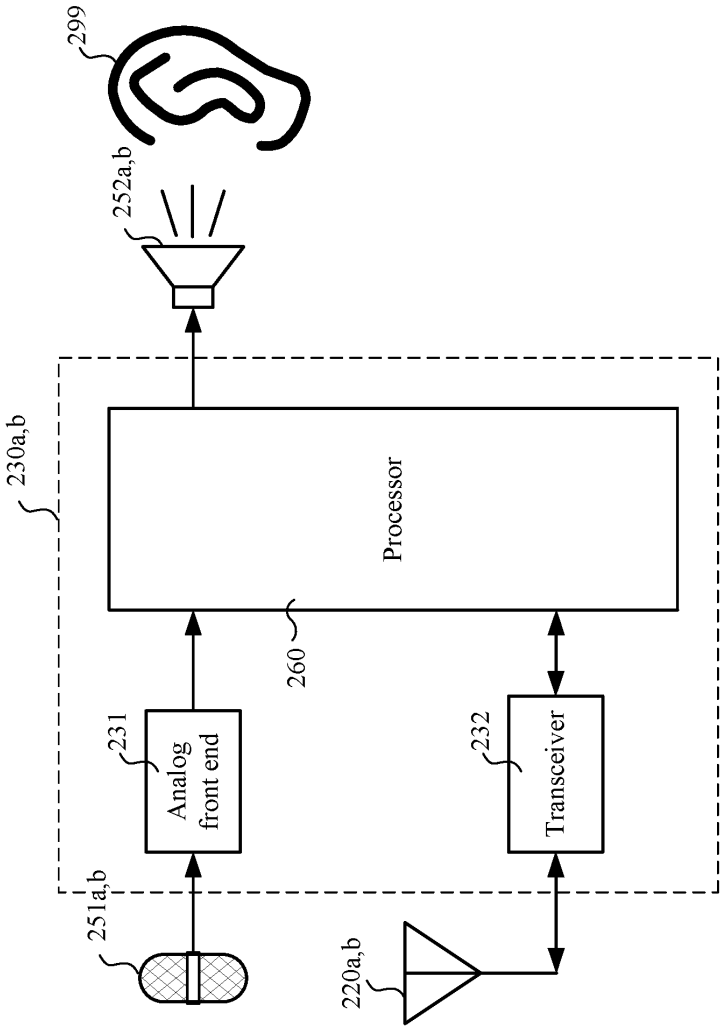

299
252a,b
230a,b
Processor
260
231
Analog front end
232
Transceiver
251a,b
220a,b

Figure 2B

Figure 3

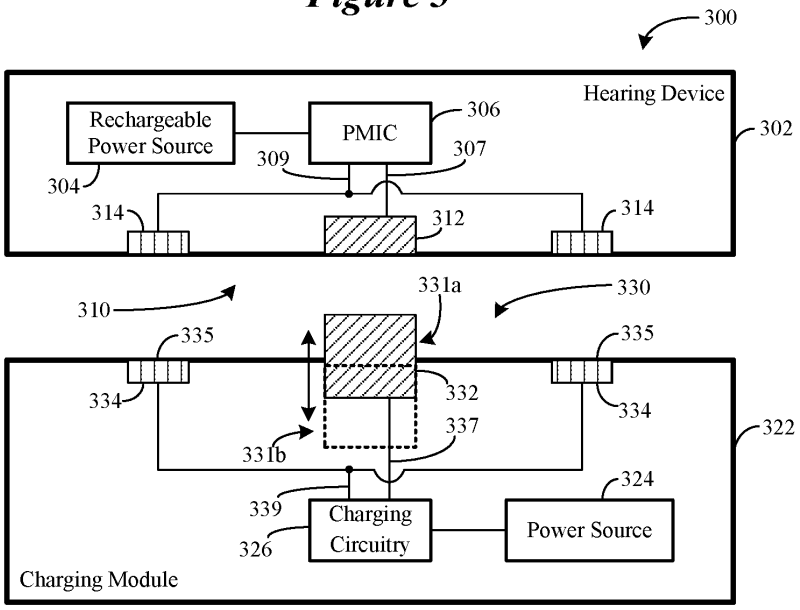


Figure 4

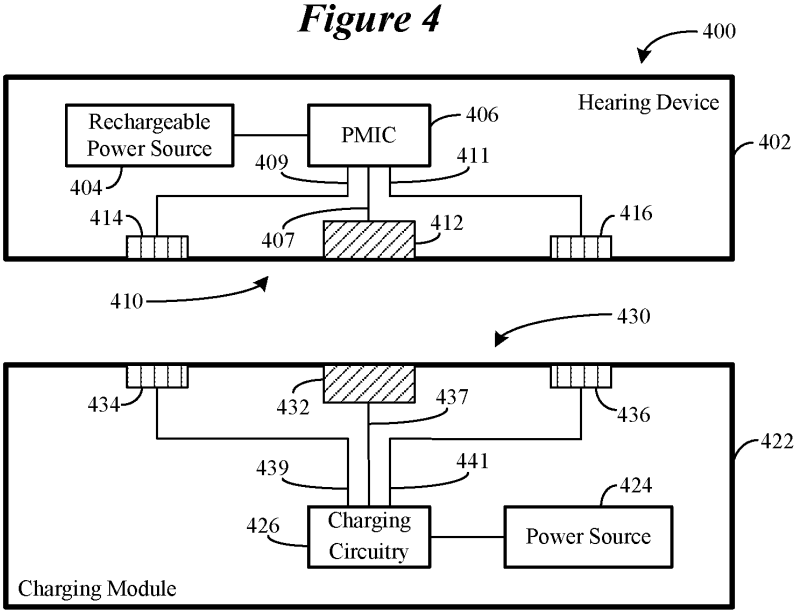


Figure 5

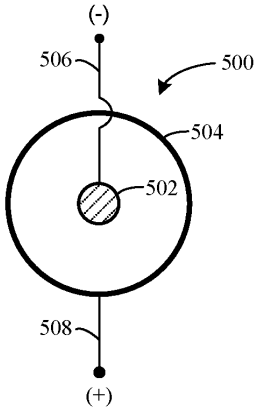


Figure 6

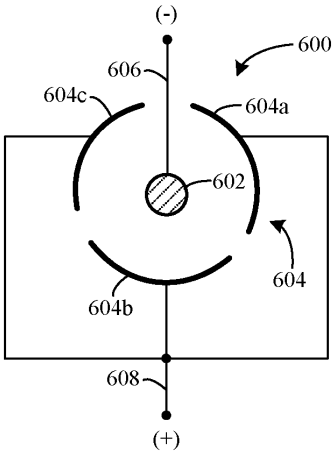


Figure 7

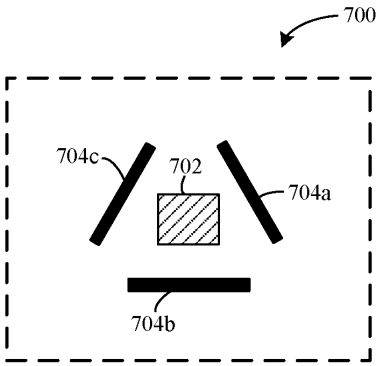


Figure 8A

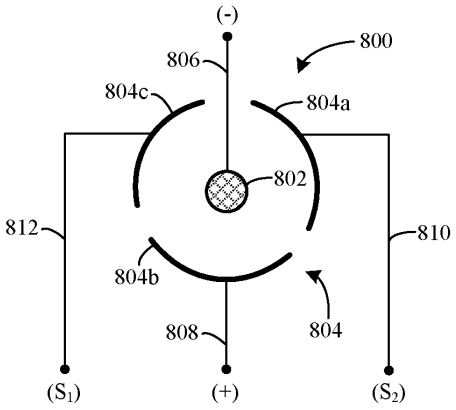


Figure 8B

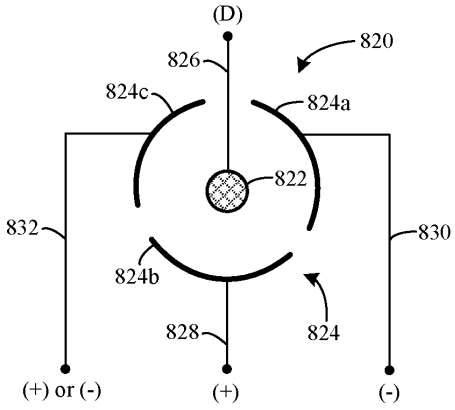


Figure 8C

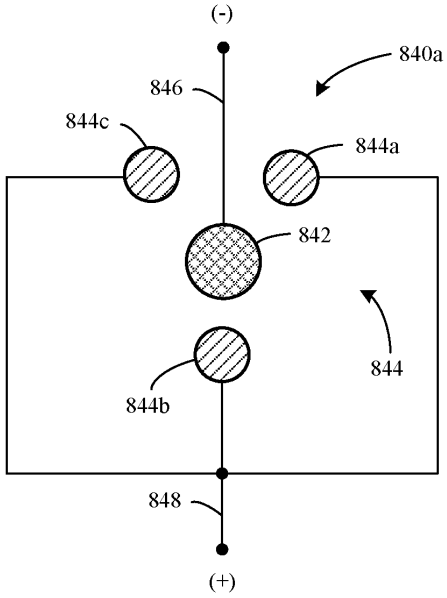


Figure 8D

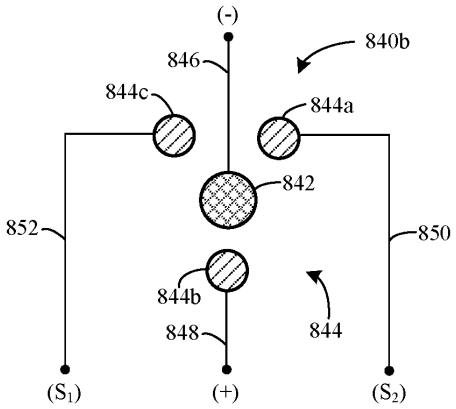
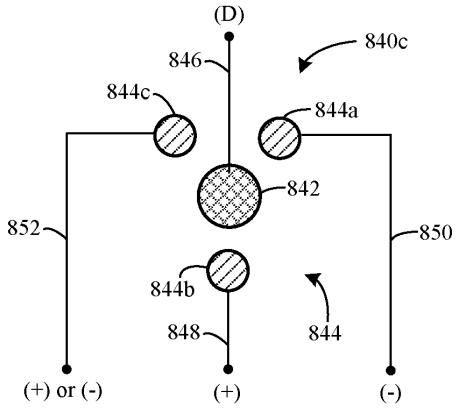


Figure 8E



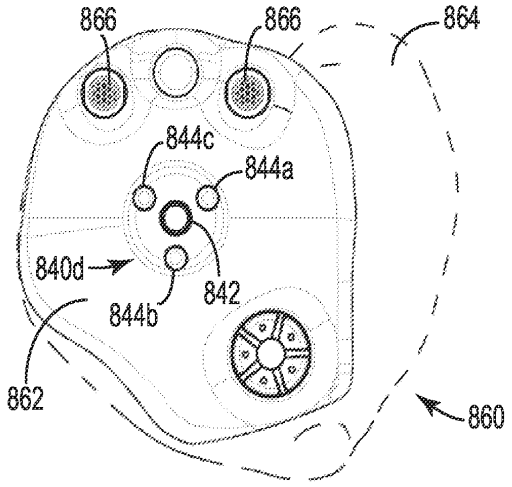


Figure 8F

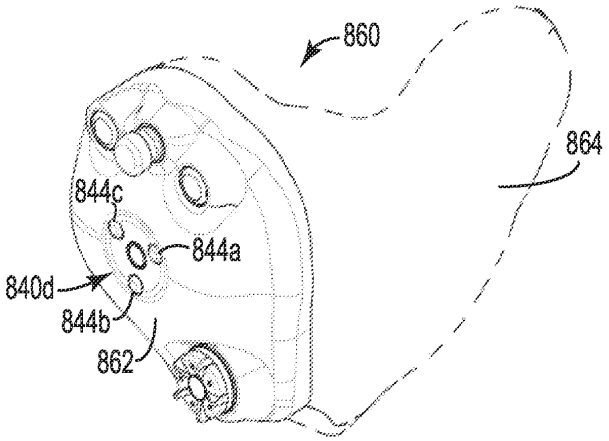


Figure 8G

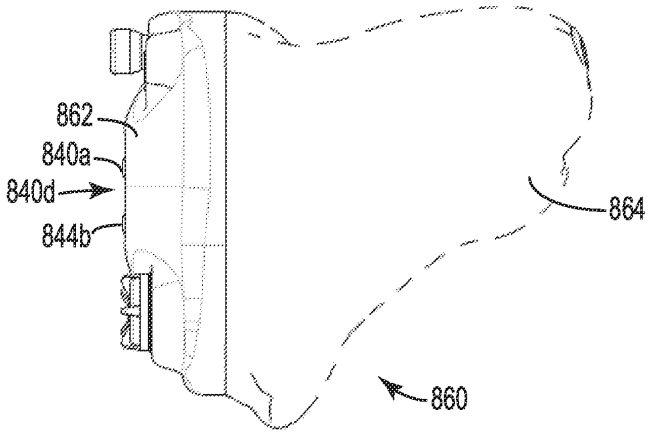


Figure 8H

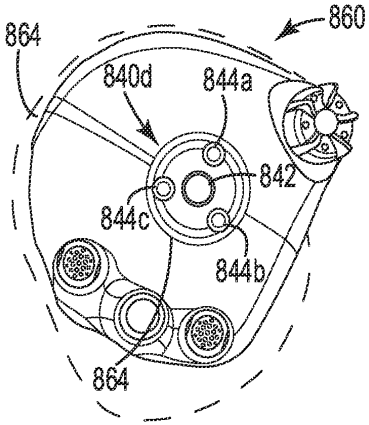


Figure 8I

SONOVA EX1018
Page 275

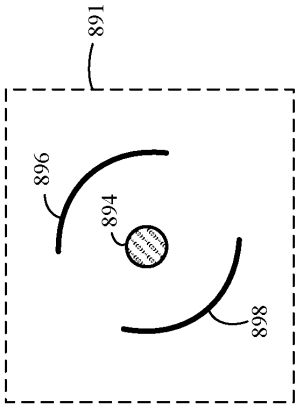


Figure 8K

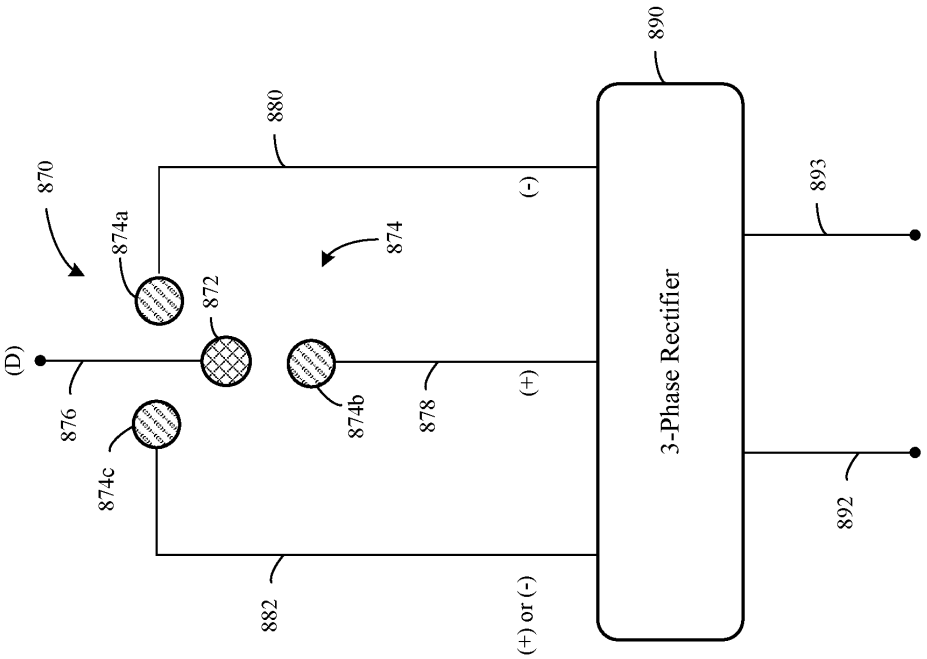


Figure 8J

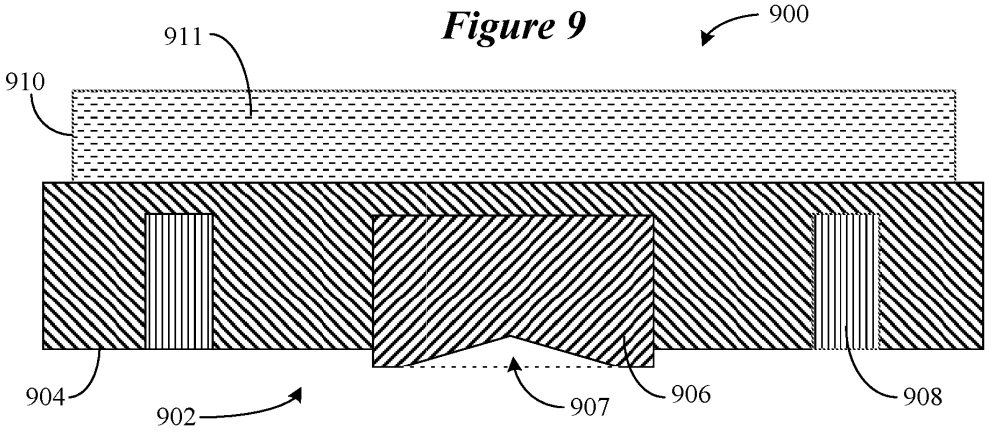


Figure 9

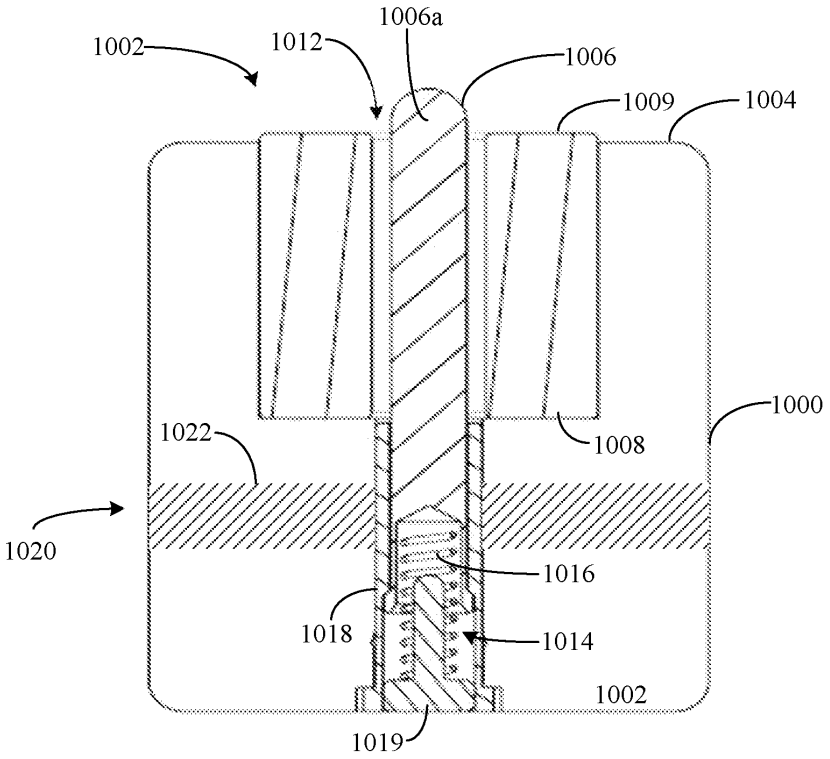


Figure 10

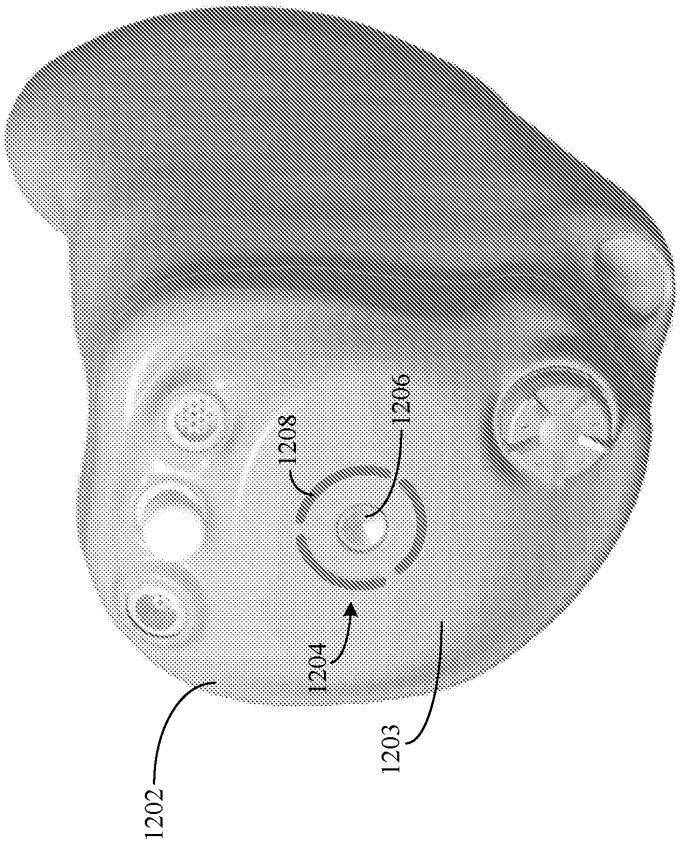


Figure 12

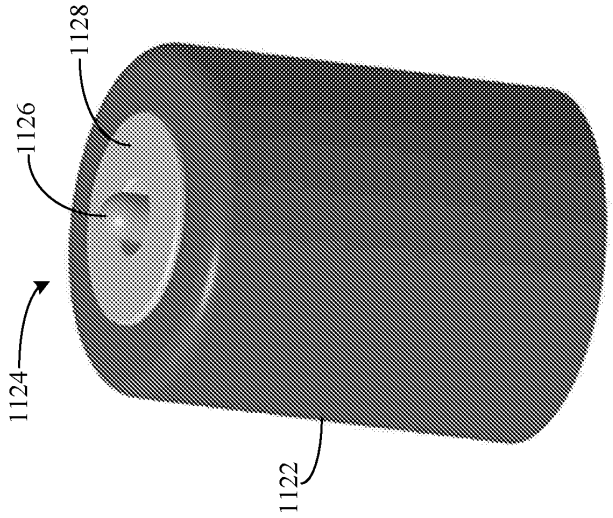


Figure 11

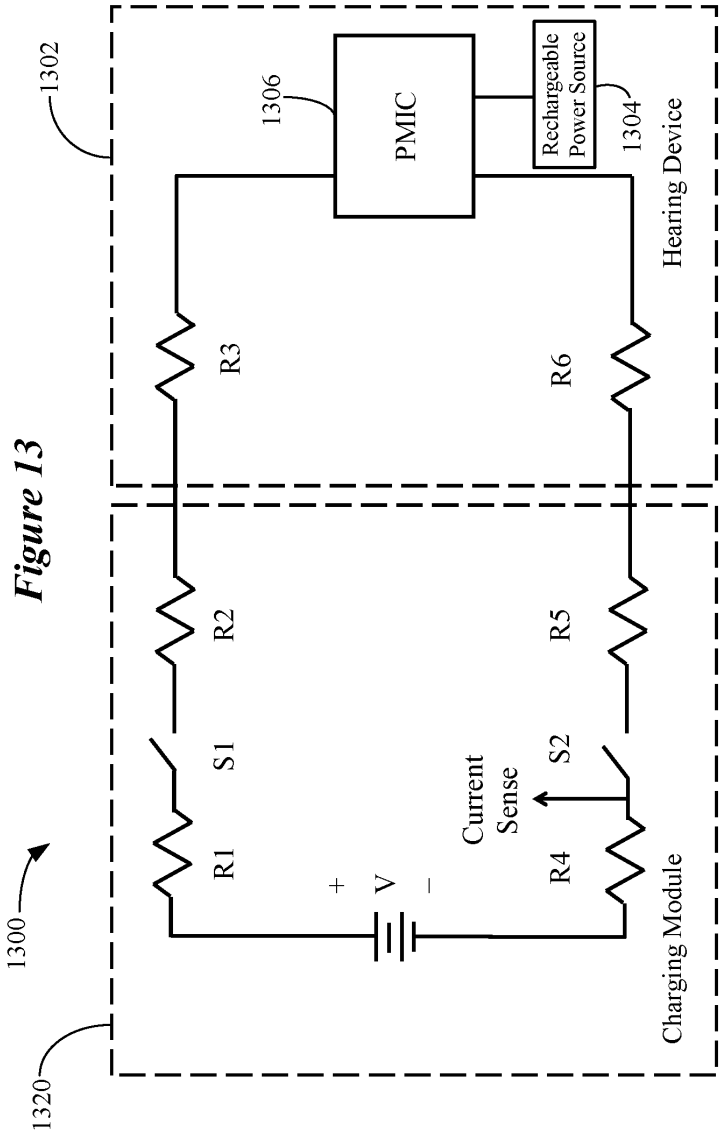

1302
1306
PMIC
Rechargeable Power Source
1304
Hearing Device
R3
R6
R2
R5
S1
S2
R1
R4
Current Sense
+
V
–
1300
1320
Charging Module

Figure 13

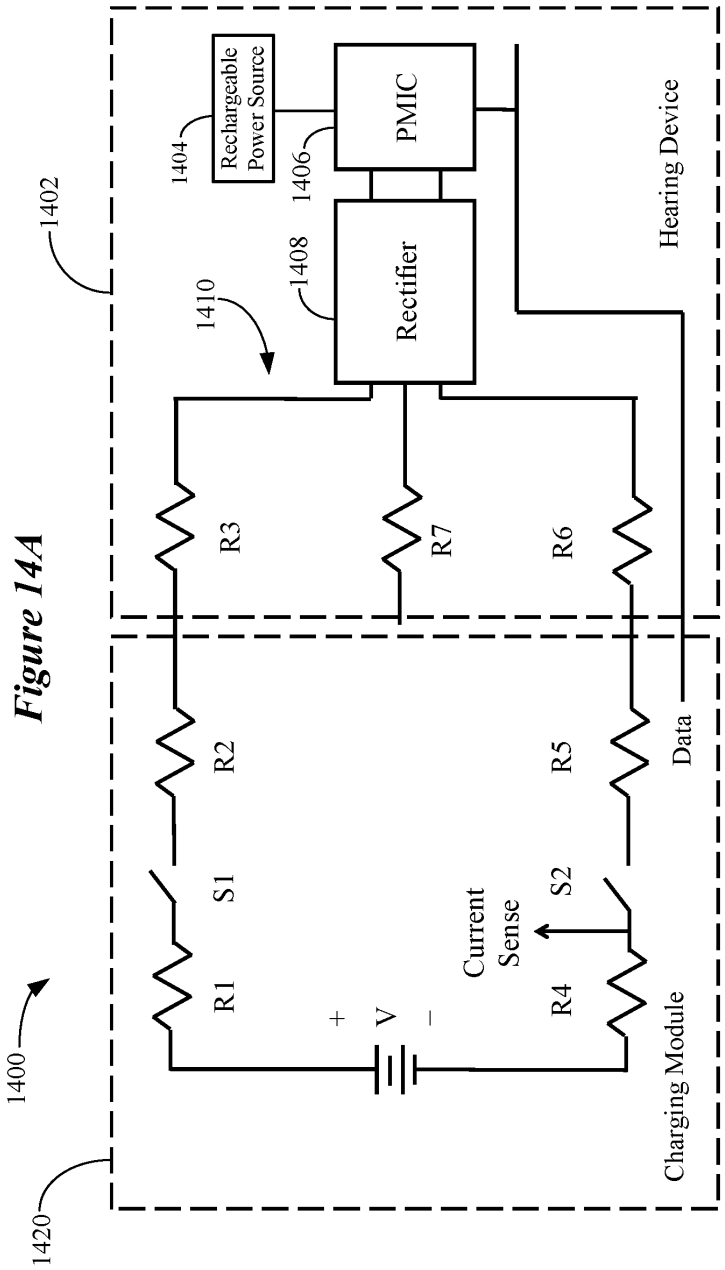


Figure 14A

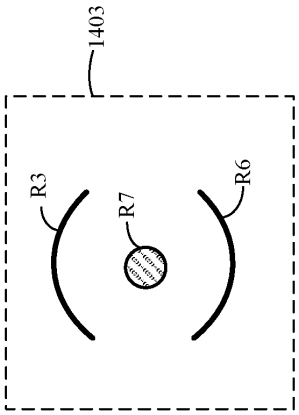


Figure 14B

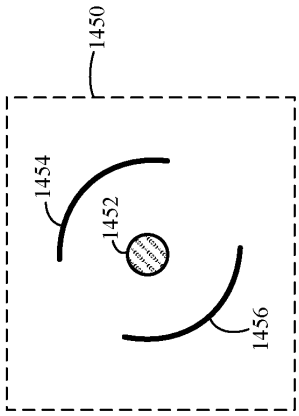


Figure 14D

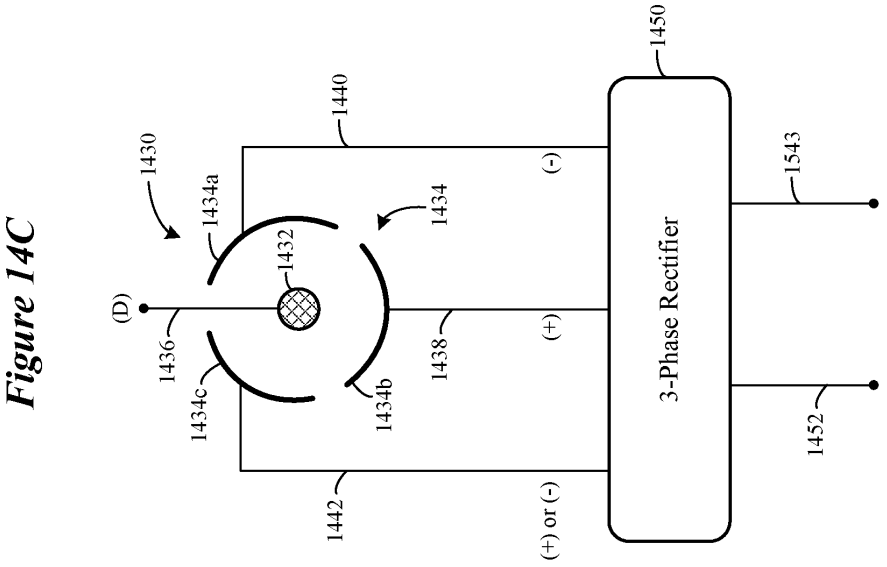


Figure 14C

Figure 15

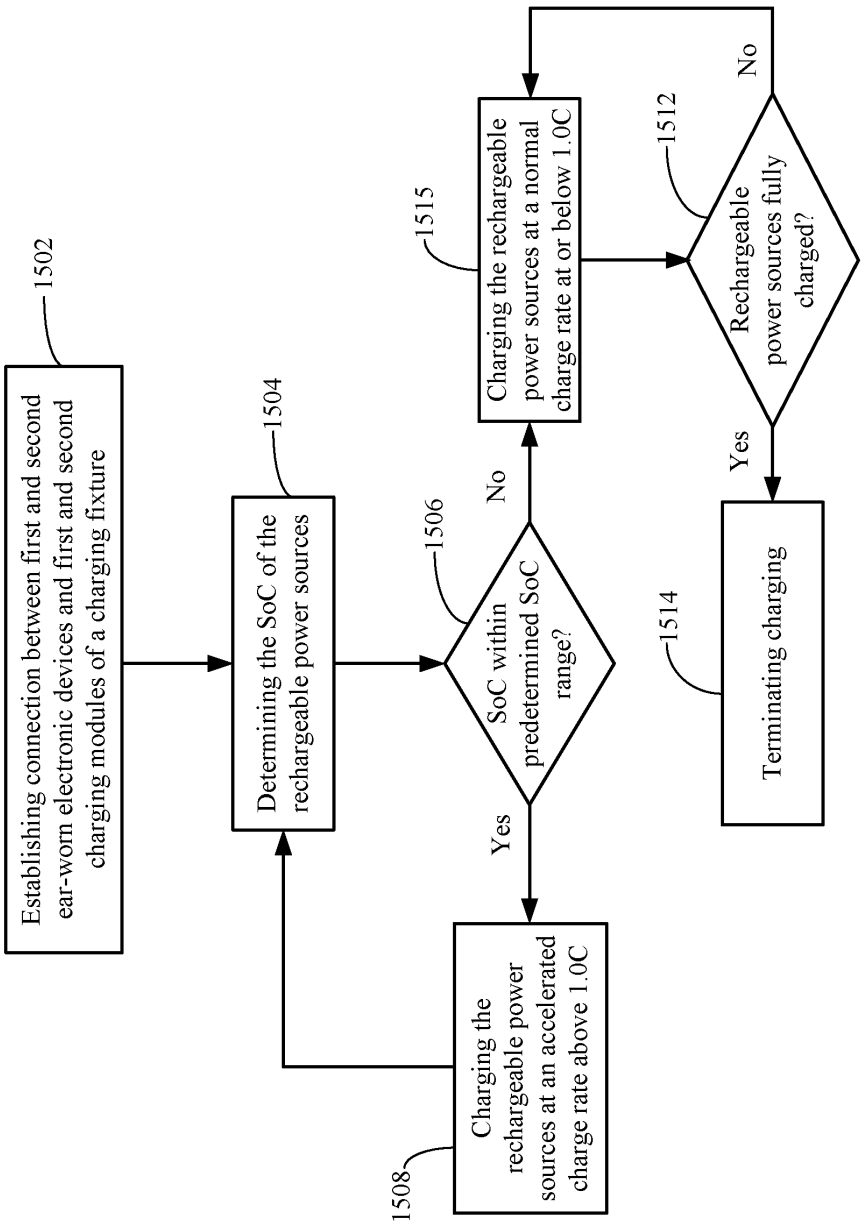
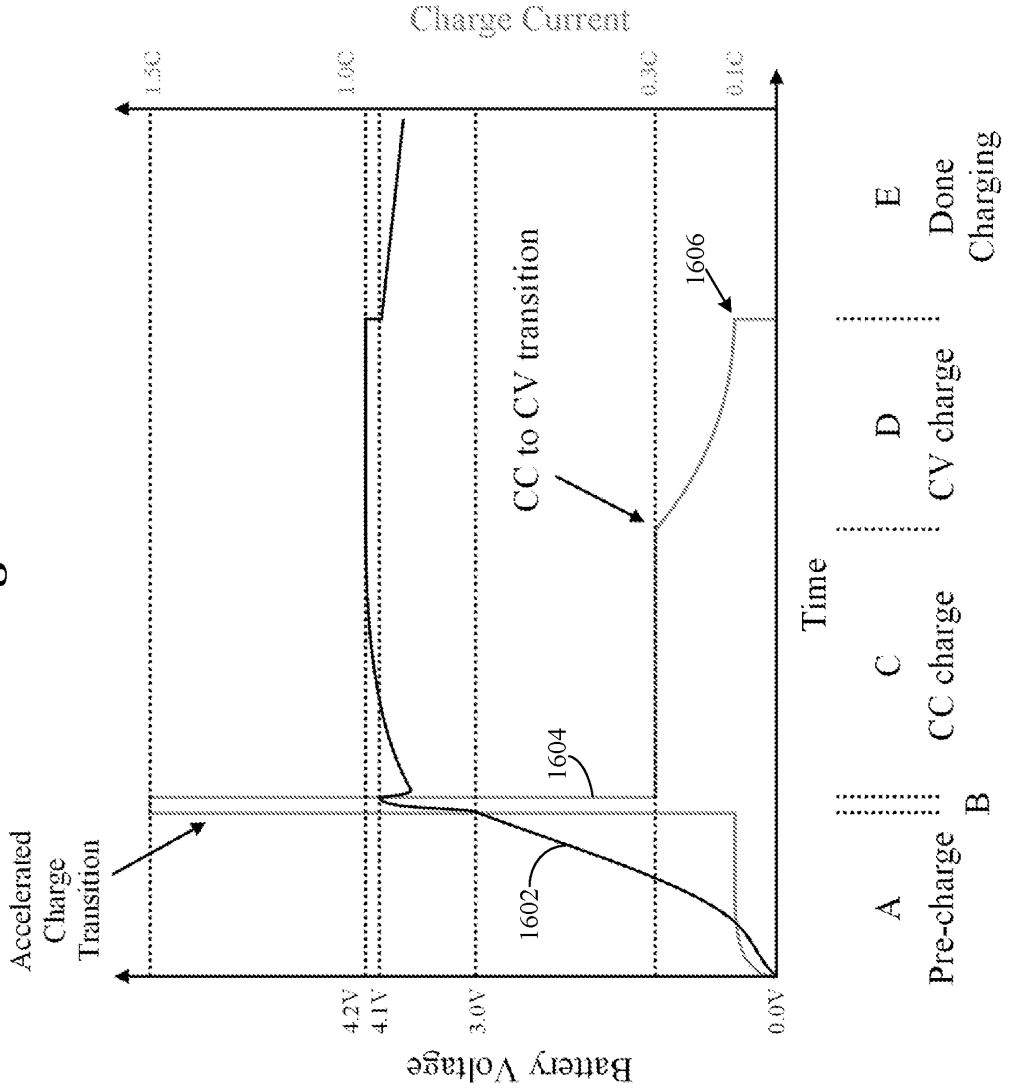

1502
Establishing connection between first and second ear-worn electronic devices and first and second charging modules of a charging fixture
1504
Determining the SoC of the rechargeable power sources
1506
SoC within predetermined SoC range?
Yes
No
1508
Charging the rechargeable power sources at an accelerated charge rate above 1.0C
1515
Charging the rechargeable power sources at a normal charge rate at or below 1.0C
1512
Rechargeable power sources fully charged?
Yes
No
1514
Terminating charging

Figure 16


Charge Current
1.5C
1.0C
0.3C
0.1C
Battery Voltage
4.2V
4.1V
3.0V
0.0V
Accelerated Charge Transition
CC to CV transition
1602
1604
1606
Time
A
Pre-charge
B
Accelerated CC charge
C
CC charge
D
CV charge
E
Done Charging

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	Unassigned
Filing Date	December 16, 2021
First Named Inventor	Erik Carlson
Title	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE
Art Unit	Unassigned
Examiner Name	Unassigned
Attorney Docket Number	ST0806US1/0532.000806US03

SIGNATURE of Applicant or Patent Practitioner

Signature	/Mark A. Hollingsworth/	Date (Optional)	December 16, 2021
Name	Mark A. Hollingsworth	Registration Number	38,491
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Starkey Laboratories, Inc.

Application No./Patent No.: Unassigned Filed/Issue Date: December 16, 2021

Titled: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Starkey Laboratories, Inc., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 051918, Frame 0191, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**.

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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Mark A. Hollingsworth/	December 16, 2021
Signature	Date
Mark A. Hollingsworth	38,491
Printed or Typed Name	Title or Registration Number

PTO/AIA/83 (07-12)
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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒ Practitioners associated with Customer Number: 142537

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☒ The address associated with Customer Number: 142537

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: Starkey Laboratories, Inc.
6600 Washington Ave. S.
Eden Prairie, MN 55344

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	10/4/16
Name	Thomas Ting	Telephone	952-947-4699
Title	General Counsel, Starkey Laboratories, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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TRANSMITTAL FORM	Application Number	Unassigned
	Confirmation Number	Unassigned
	Attorney Docket Number	ST0806US1/0532.000806US03
Please consider this a REQUEST FOR EXTENSION OF TIME and charge any fees required under 37 CFR §1.136 to Deposit Account No. 13-4895.	Customer Number	142537

☐ Applicant asserts small entity status
☐ Applicant asserts micro entity status

ENCLOSURES (check all that apply)

- ☑ Application:
  - Description: 42 page(s)
  - Claims: 6 page(s)
  - Abstract: 1 page(s)
  - Drawings: 15 page(s)
- ☑ Application Data Sheet
- ☐ Provisional Cover Sheet
- ☐ Inventor's Oath/Declaration
- ☐ Sequence Listing in ASCII format
- ☐ Sequence Communication
- ☐ Response to Pre-Exam Notice
- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement
- ☑ List of Documents (SB08 or equivalent)
  - ☑ copies of documents attached: 5
- ☐ Amendment/Response
  - ☐ Restriction ☐ After Final
- ☑ Power of Attorney
- ☑ Statement Under 37 CFR §3.73
- ☐ Terminal Disclaimer
- ☐ Appeal Communication
- ☐ After Allowance Communication
- ☐ Issue Fee Transmittal
- ☐ Petition: _____
- ☐ Other: _____

FEES (check all that apply)

☐ **PLEASE DEFER FEES**

☑ **PLEASE CHARGE THE FEES INDICATED BELOW**

Deposit Account Number: 13-4895
Deposit Account Name: MRG IP Law, P.A.

☑ Credit any overpayment of fee(s)
☑ Payment made via EFS-Web
☑ Charge all fees required under 37 CFR §§1.16 and 1.17
☐ Charge all fees required EXCEPT for excess claims fees and/or multiple dependent claim fees under 37 CFR §1.16 (h), (i), or (j)

1. Basic Filing, Search, and Examination Fees

Application Type	Filing Fee	Search Fee	Examination Fee	Total Fees:
☐ Provisional	☐ $____			$ 0
☑ Utility	☑ $ 320	☑ $ 700	☑ $ 800	$ 1820
☐ Design	☐ $____	☐ $____	☐ $____	$ 0

2. Excess Claims Fees

Total Claims pending: 23 − 20 (20 or highest paid) = 3 x $ 100 = $ 300
Indep. Claims pending: ____ − ____ (3 or highest paid) = ____ x $____ = $ ____
☐ Multiply dependent claim $____

3. Application Size Fees (round up to whole numbers)

Total Sheets: ____ x 75% (if filing by EFS) = ____ - 100 = ____ / 50 = ____ x $____ (fee) = $ ____

4. Extension Fees

☐ 1st month $____ ☐ 2nd month $____ ☐ 3rd month $____ ☐ 4th month $____ ☐ 5th month $____

5. Additional Fees

☐ IDS fee $____ ☐ RCE fee $____ ☐ Issue fee $____
☐ Appeal fee $____ ☐ Terminal Disclaimer fee $____ ☑ Other: late oath $ 160

6. TOTAL AMOUNT OF PAYMENT: $ 2280

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Mueting Raasch Group		
Signature	/Mark A. Hollingsworth/		
Printed Name	Mark A. Hollingsworth		
Date	December 16, 2021	Registration No.	38491

Certificate of EFS-Web Transmission

In accordance with 37 CFR 1.8, I hereby certify that this correspondence is being EFS-Web transmitted to the USPTO and each submitted paper is identified herein.

Signature	/Mark A. Hollingsworth/		
Printed Name	Mark A. Hollingsworth	Date	December 16, 2021

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Erik		Carlson	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	Stillwater	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	6700 Washington Avenue South		
Address 2			
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Thomas		Burns	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	Minneapolis	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	6700 Washington Avenue South		
Address 2			
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kyle		Olson	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

City	St. Louis Park	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	6700 Washington Avenue South		
Address 2			
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

Inventor 4 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kent		Giswold	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Minnetonka	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	6700 Washington Avenue South		
Address 2			
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	142537		
Email Address	ptodocketing@mrgs.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		
Attorney Docket Number	ST0806US1/532.000806US03	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	15	Suggested Figure for Publication (if any)	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	142537		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCT/US2020/041956	2020-07-14

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/US2020/041956	Claims benefit of provisional	62876454	2019-07-19
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/US2020/041956	Claims benefit of provisional	62943375	2019-12-04
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.			Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Starkey Laboratories, Inc.		
Mailing Address Information For Applicant:			
Address 1	6700 Washington Avenue South		
Address 2			
City	Eden Prairie	**State/Province**	MN
Country	US	Postal Code	55344
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Mark A. Hollingsworth/			Date (YYYY-MM-DD)	2021-12-16
First Name	Mark	Last Name	Hollingsworth	Registration Number	38491

Additional Signature may be generated within this form by selecting the Add button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ST0806US1/532.000806US03
	Application Number	
Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Figure 1A

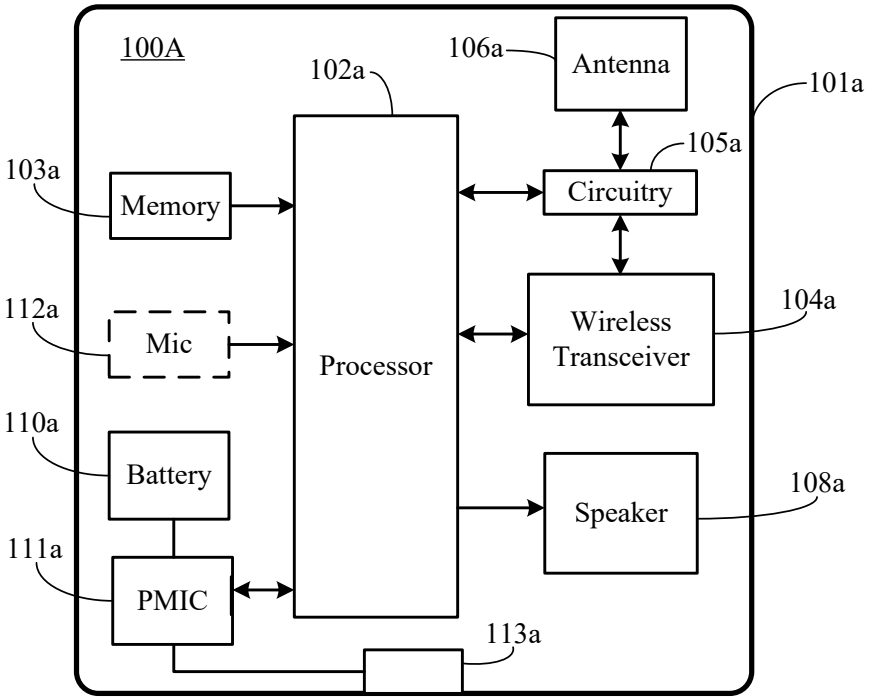
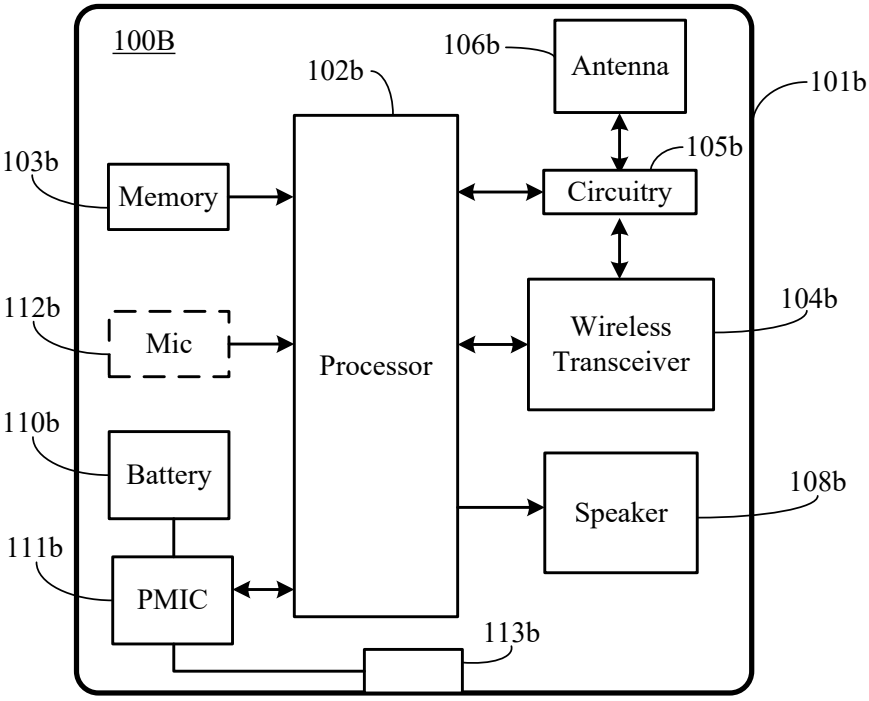


Figure 1B



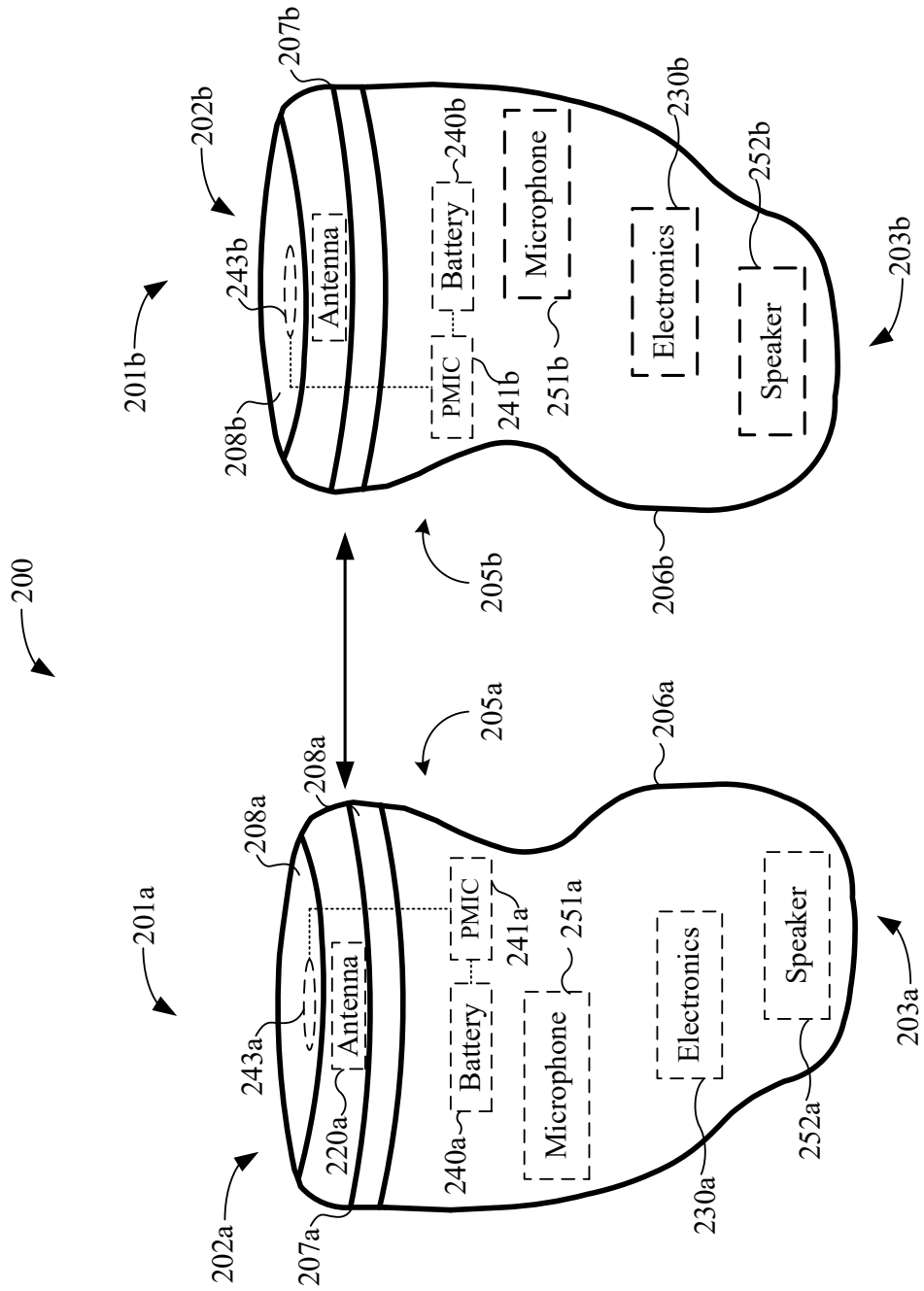

200
201a
201b
202a
202b
203a
203b
205a
205b
206a
206b
207a
207b
208a
208b
220a
230a
230b
240a
240b
241a
241b
243a
243b
251a
251b
252a
252b
Antenna
Battery
PMIC
Microphone
Electronics
Speaker

Figure 2A

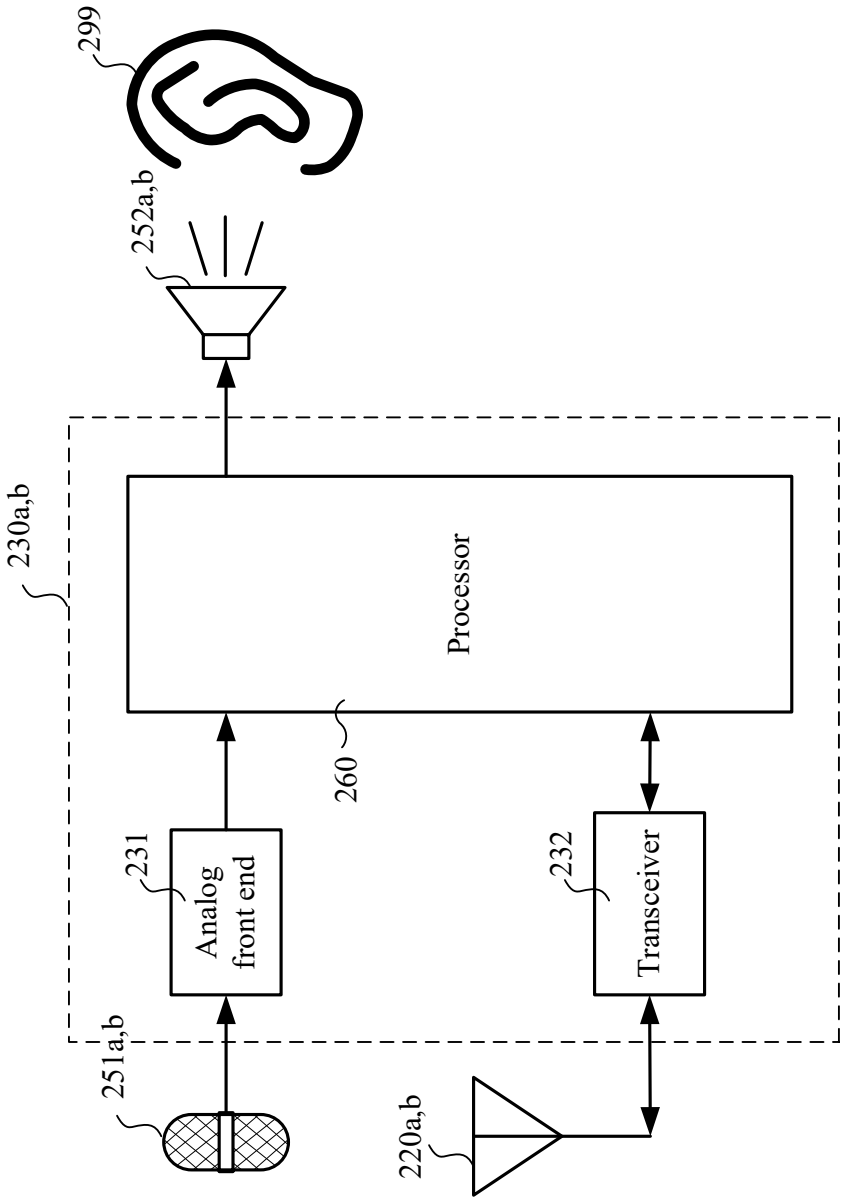

299
252a,b
230a,b
Processor
260
231
Analog
front end
232
Transceiver
251a,b
220a,b

Figure 2B

Figure 3

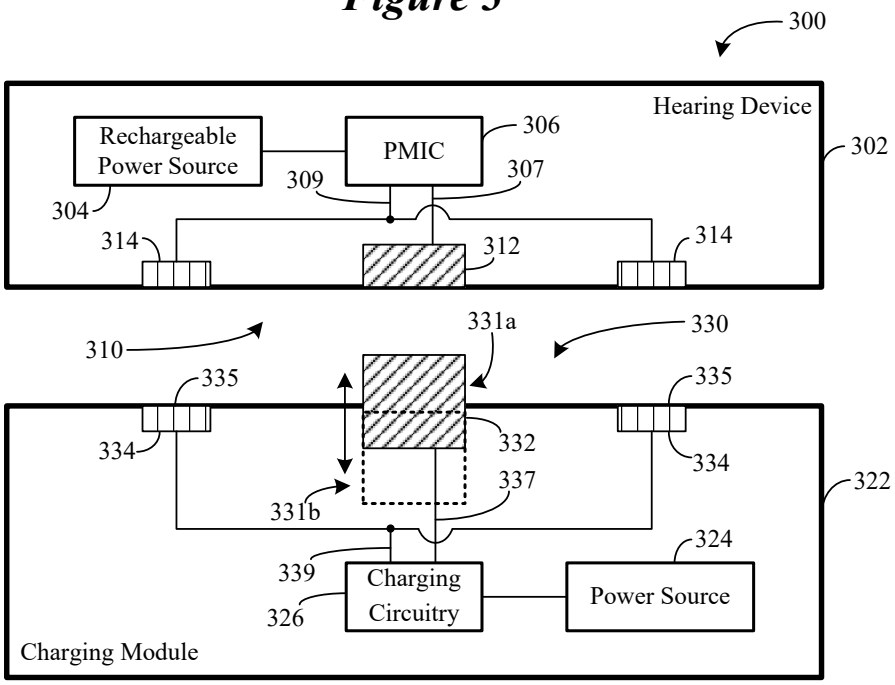


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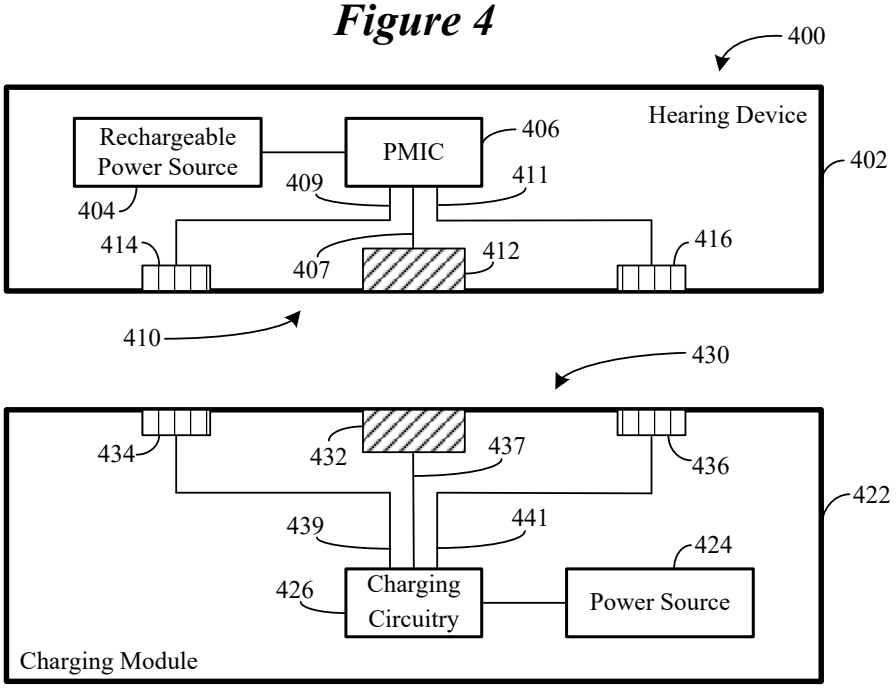


Figure 5

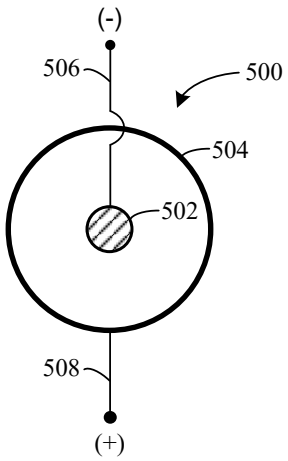


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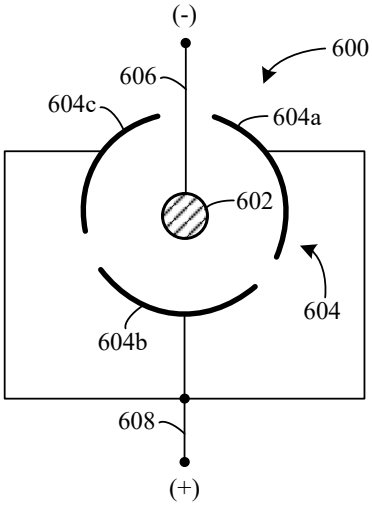


Figure 7

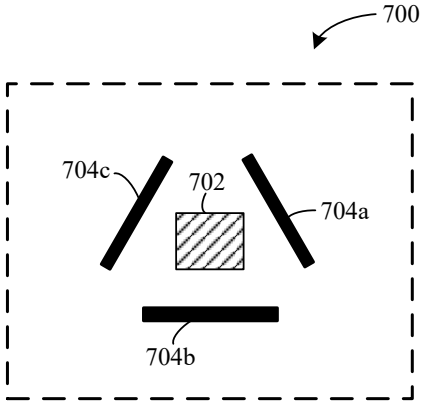


Figure 8A

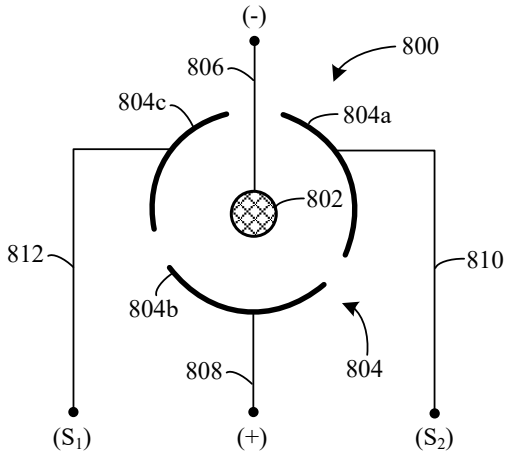


Figure 8B

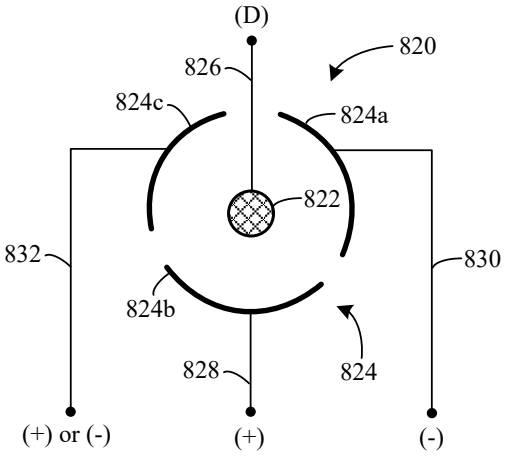


Figure 8C

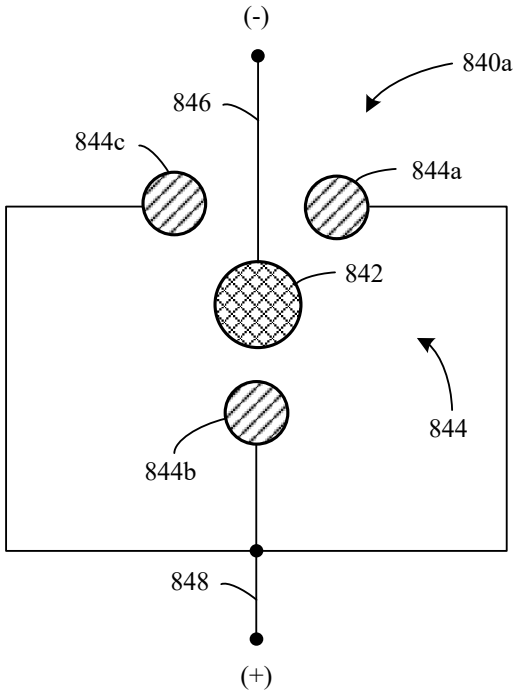


Figure 8D

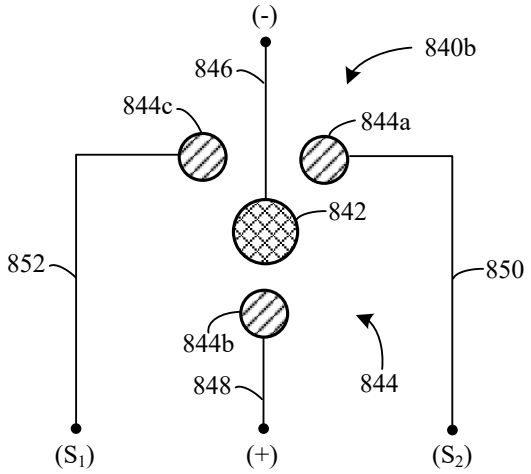
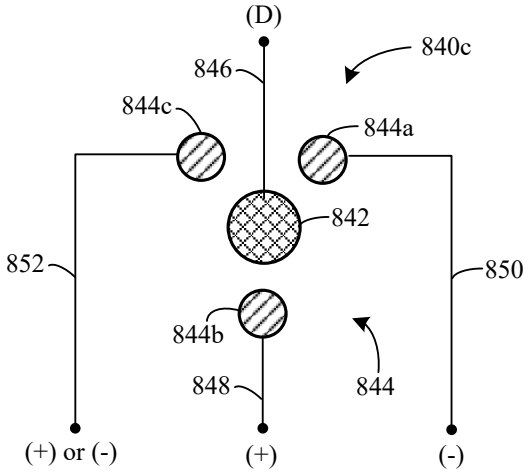


Figure 8E



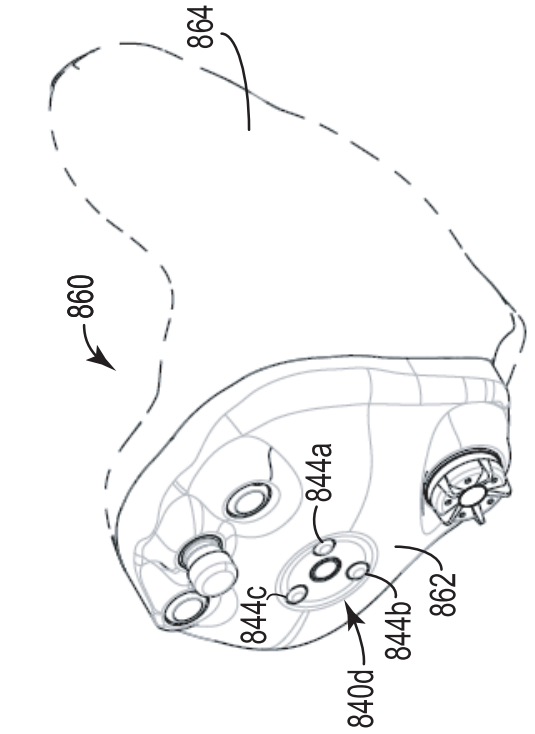


Figure 8G

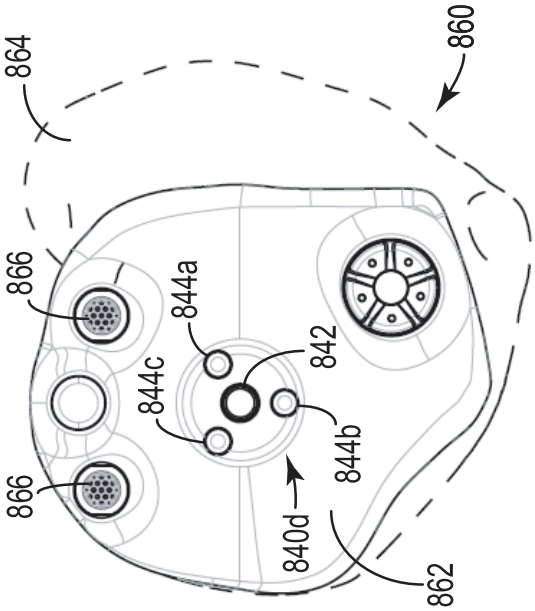


Figure 8F

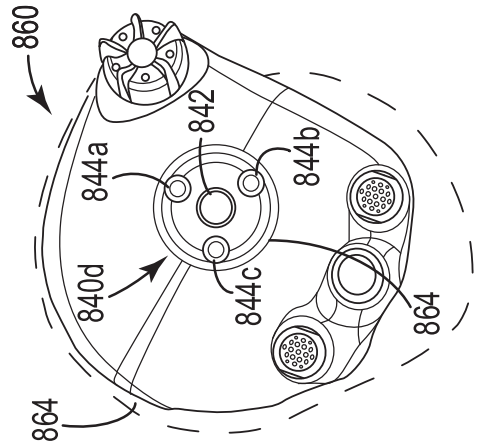


Figure 8I

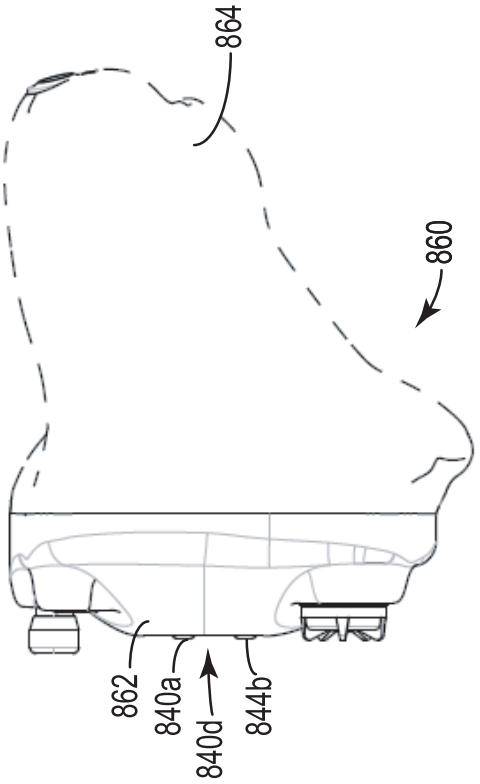


Figure 8H

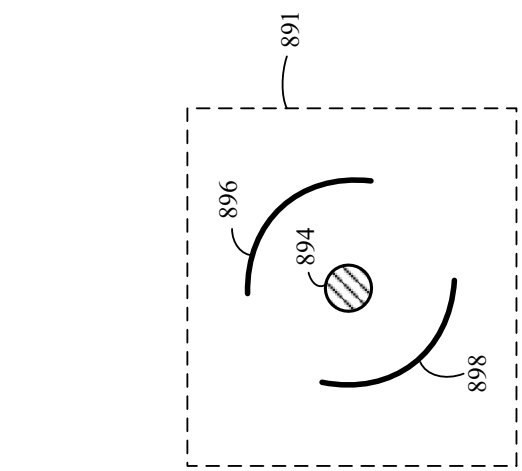


Figure 8K

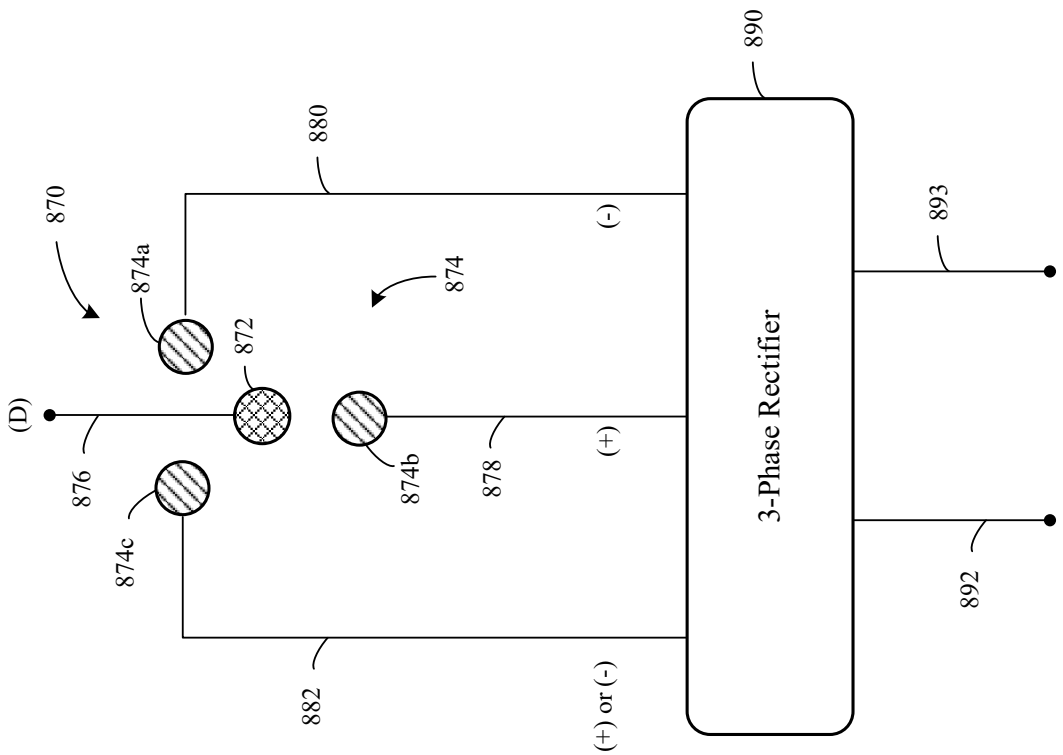
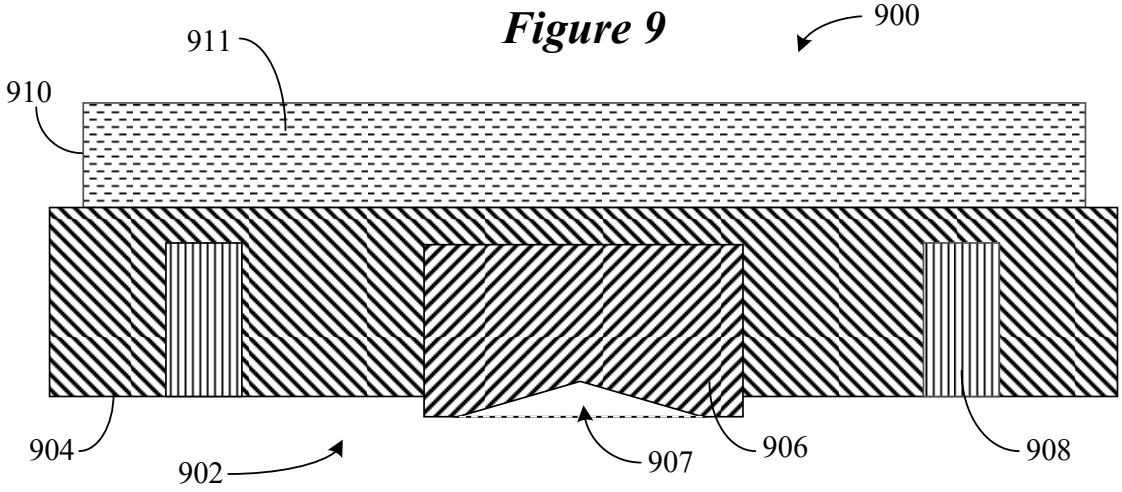


Figure 8J

Figure 9



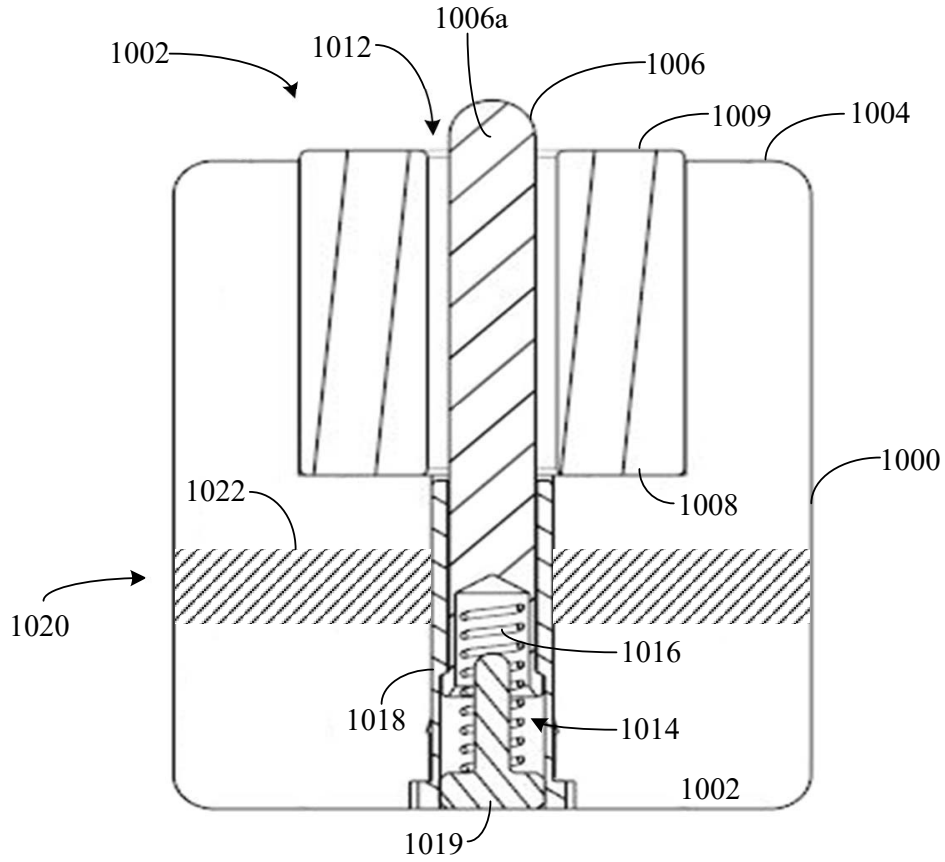


Figure 10

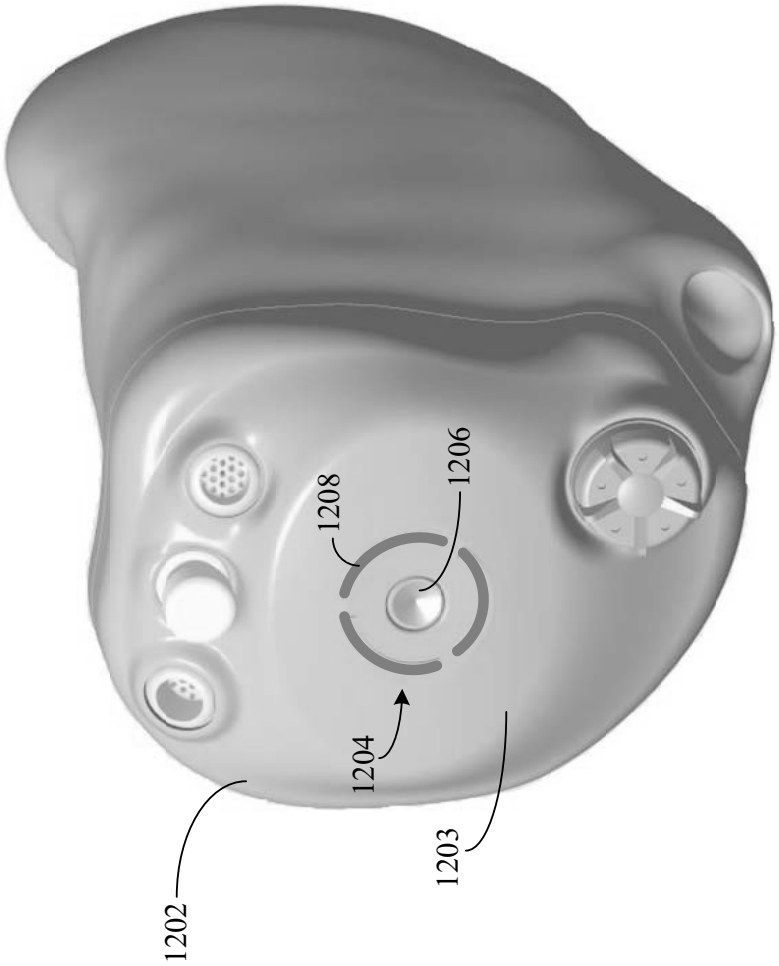


Figure 12

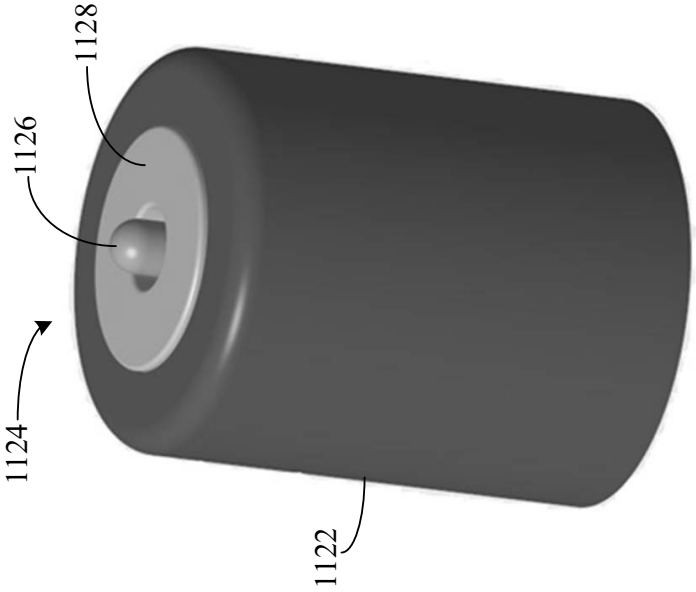


Figure 11

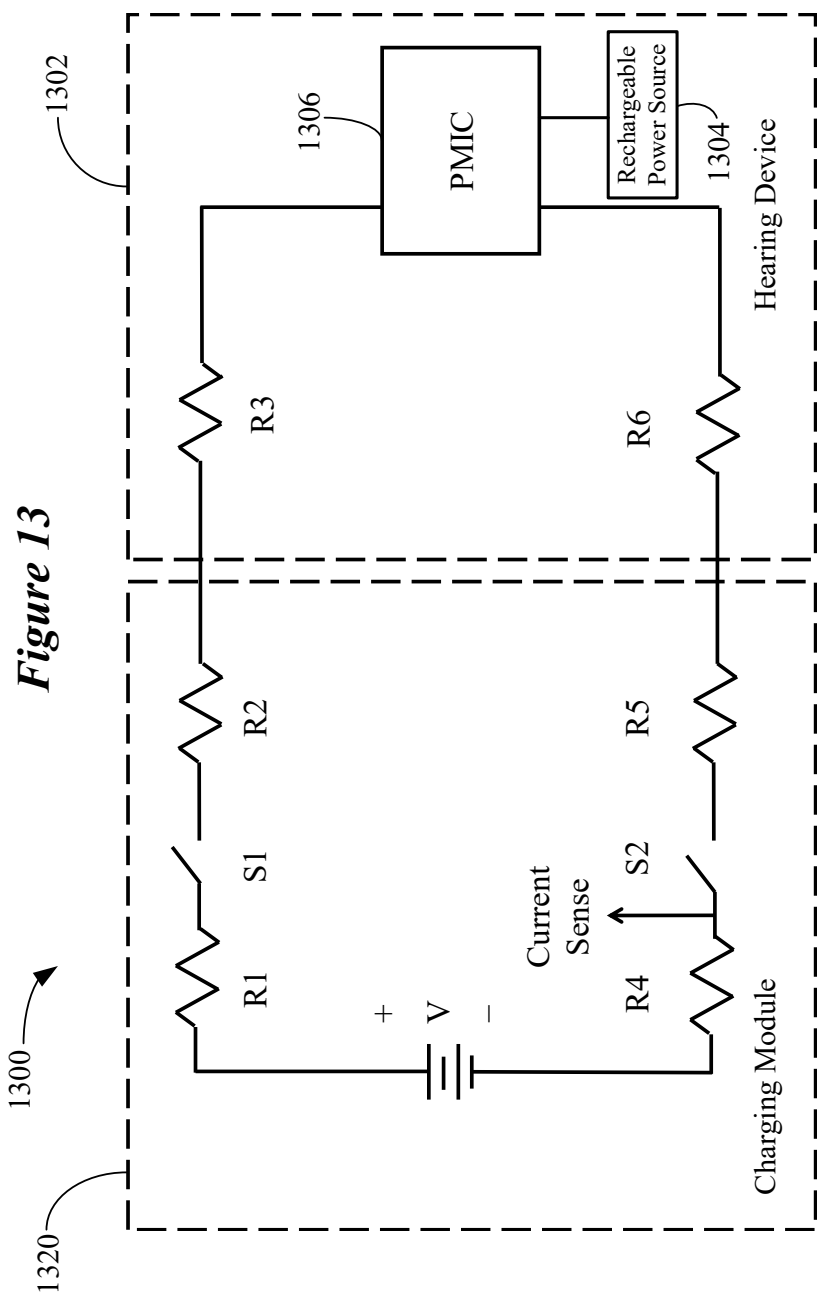

1302
1306
PMIC
Rechargeable Power Source
1304
Hearing Device
R3
R6
R2
R5
S1
S2
Current Sense
R1
+
V
–
R4
1300
1320
Charging Module

Figure 13

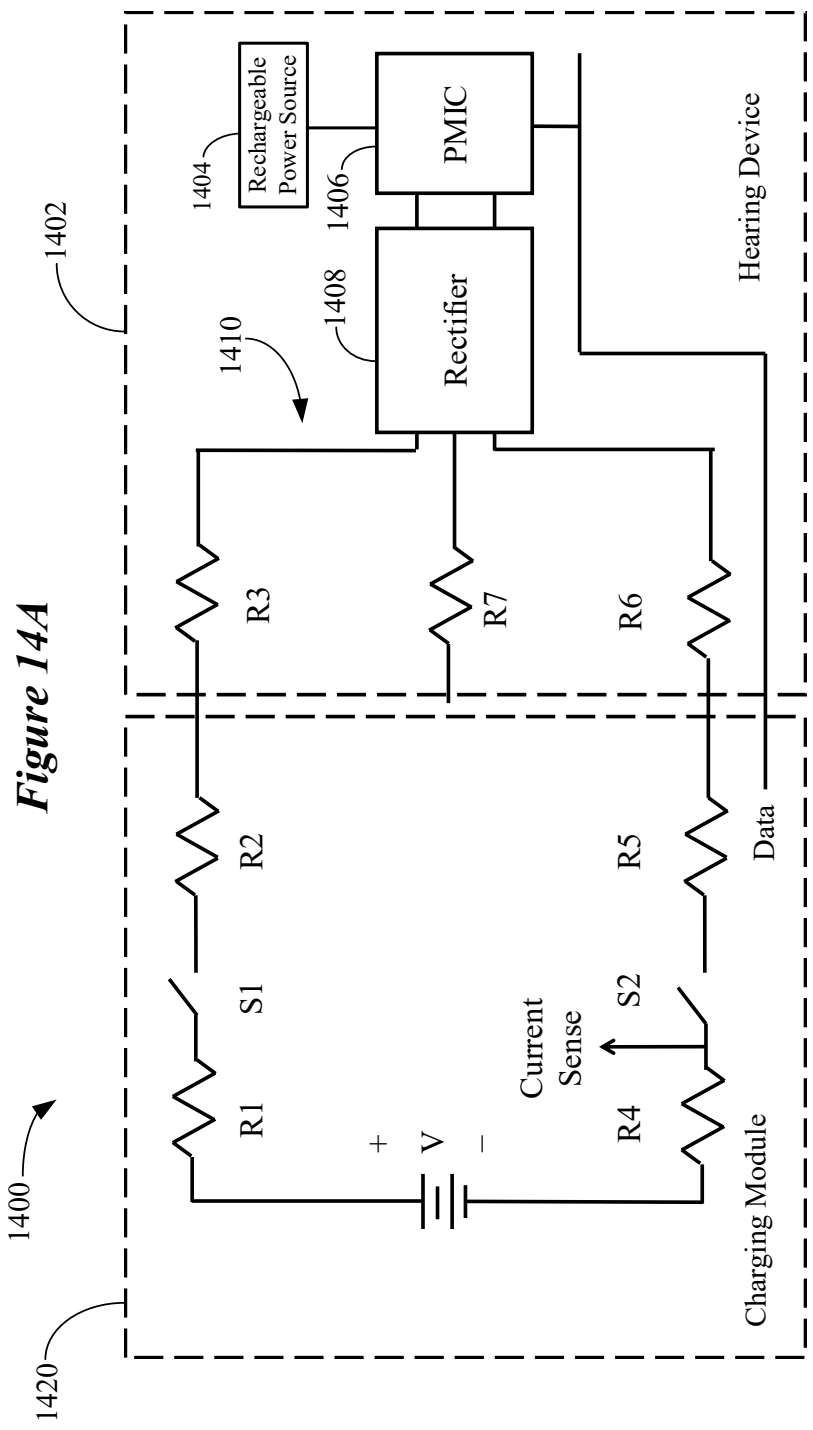


Figure 14A

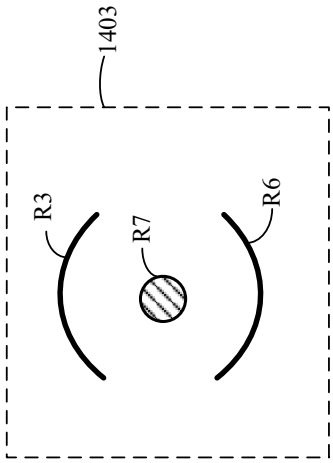


Figure 14B

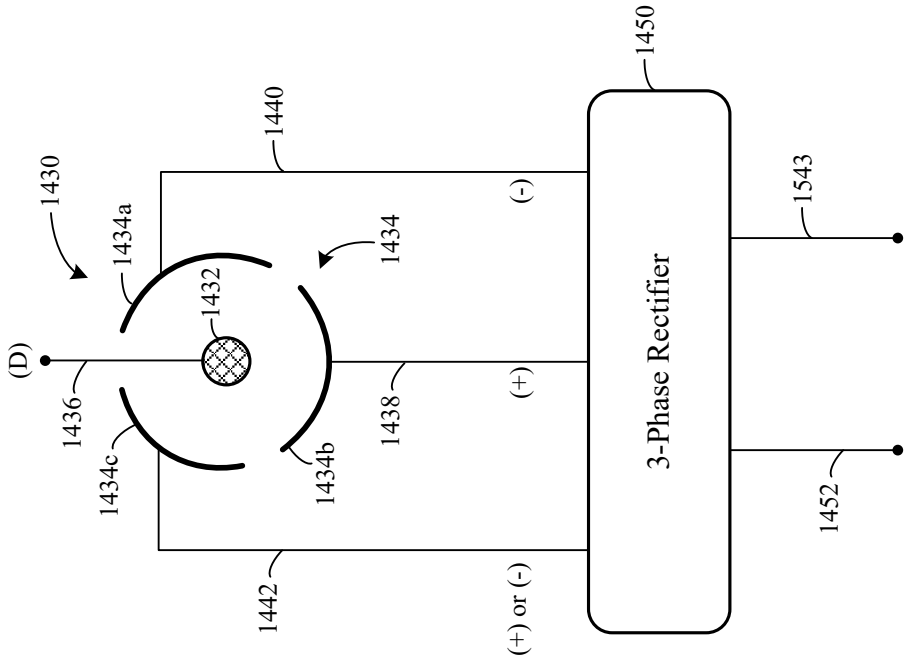


Figure 14C

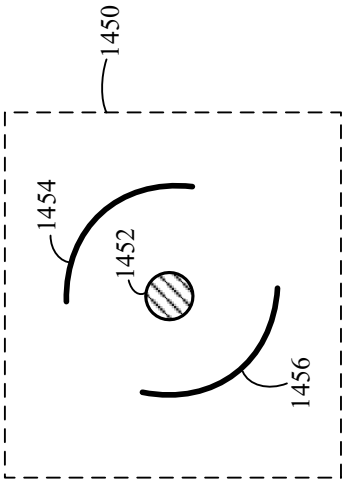


Figure 14D

Figure 15

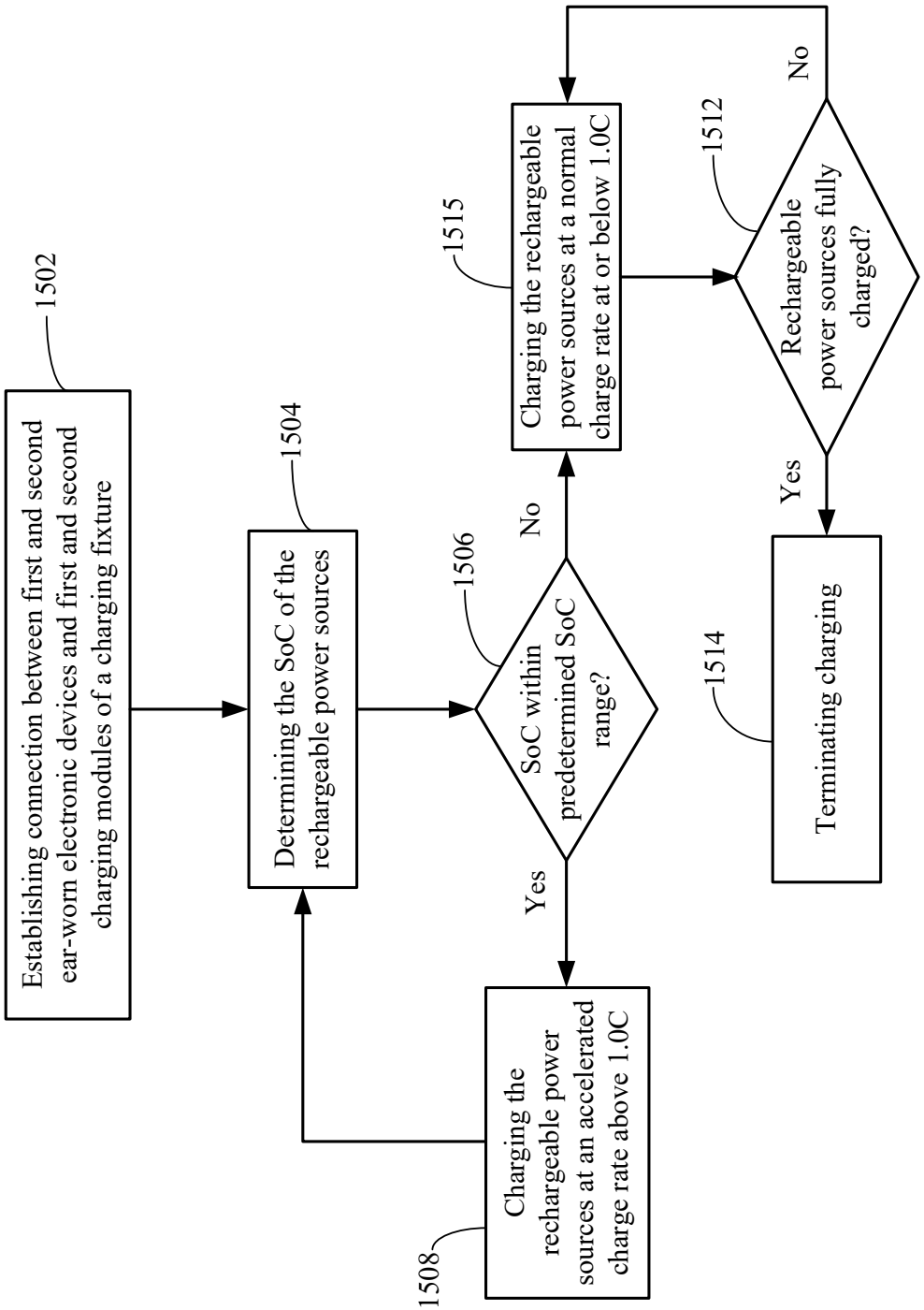
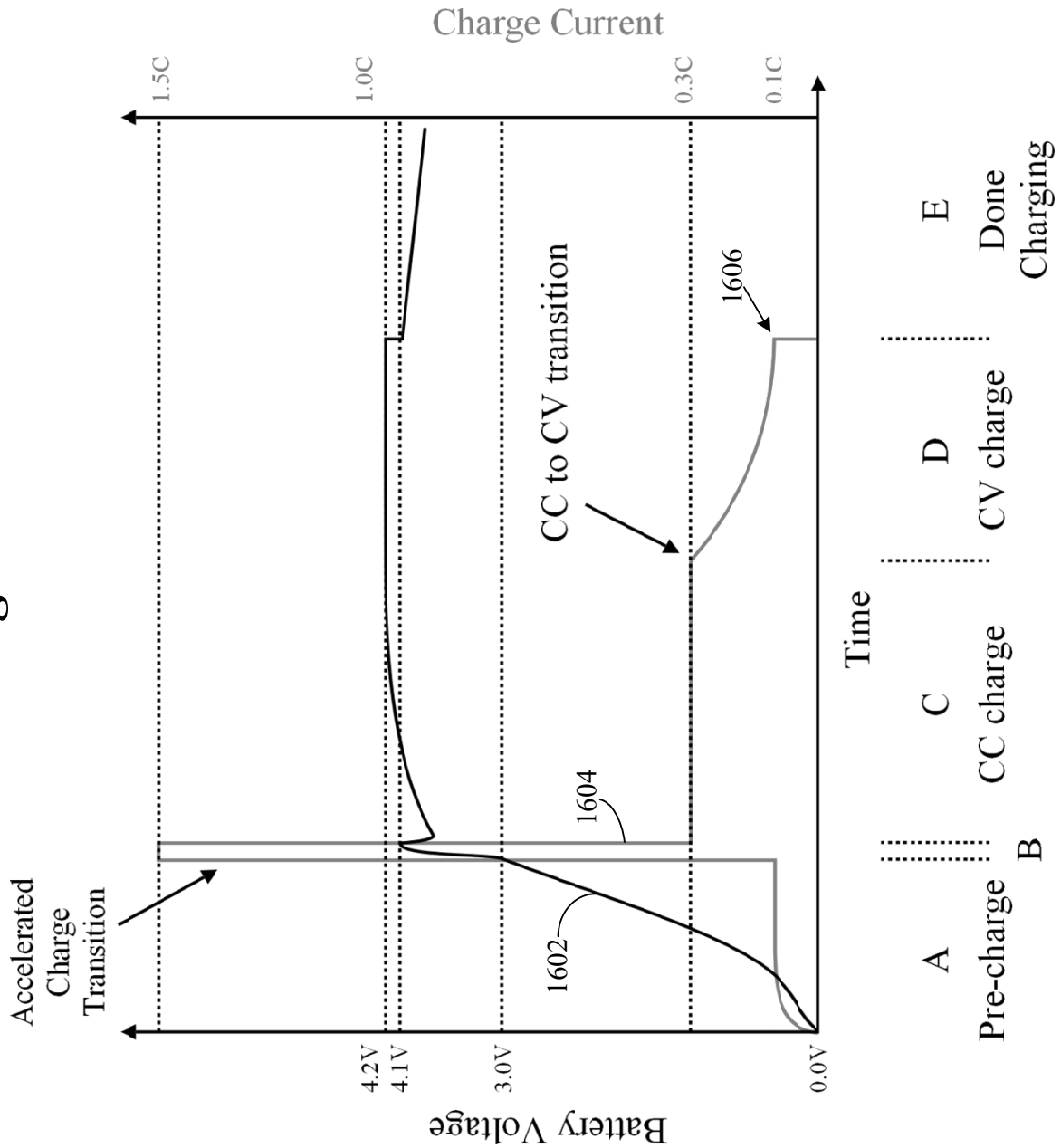

1502
Establishing connection between first and second ear-worn electronic devices and first and second charging modules of a charging fixture
1504
Determining the SoC of the rechargeable power sources
1506
SoC within predetermined SoC range?
Yes
No
1508
Charging the rechargeable power sources at an accelerated charge rate above 1.0C
1515
Charging the rechargeable power sources at a normal charge rate at or below 1.0C
1512
Rechargeable power sources fully charged?
Yes
No
1514
Terminating charging

Figure 16


Charge Current
1.5C
1.0C
0.3C
0.1C
Accelerated Charge Transition
CC to CV transition
1606
1604
1602
4.2V
4.1V
3.0V
0.0V
Battery Voltage
Time
A
Pre-charge
B
Accelerated CC charge
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D
CV charge
E
Done Charging

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03

CONFIRMATION NO. 1905

142537
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

INFORMAL NOTICE

OC000000130783275

Date Mailed: 01/03/2022

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Erik Carlson
  Thomas Burns
  Kyle Olson
  Kent Giswold

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/zmoguss/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/553,716

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	320
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	700
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	800
TOTAL CLAIMS (37 CFR 1.16(i))	23 minus 20 =	* 3			OR	x 100 =	300
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 480 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2120

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/553,716	12/16/2021		2280	ST0806US1/532.000806US03	23	3

CONFIRMATION NO. 1905

FILING RECEIPT

142537
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

OC000000130783274

Date Mailed: 01/03/2022

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Erik Carlson, Stillwater, MN;
Thomas Burns, Minneapolis, MN;
Kyle Olson, St. Louis Park, MN;
Kent Giswold, Minnetonka, MN;

Applicant(s)

Starkey Laboratories, Inc., Eden Prairie, MN;

Power of Attorney: The patent practitioners associated with Customer Number 142537

Domestic Priority data as claimed by applicant

This application is a CON of PCT/US2020/041956 07/14/2020
which claims benefit of 62/876,454 07/19/2019
and claims benefit of 62/943,375 12/04/2019

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 12/29/2021
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/553,716**
Projected Publication Date: 04/07/2022
Non-Publication Request: No
Early Publication Request: No
Title

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03

CONFIRMATION NO. 1905

142537
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

PUBLICATION NOTICE

OC000000133018538

Title:SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Publication No.US-2022-0109924-A1
Publication Date:04/07/2022

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

142537 7590 07/27/2023

MRG/HD - Starkey
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111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

EXAMINER
MONIKANG, GEORGE C

ART UNIT	PAPER NUMBER
2651	

NOTIFICATION DATE	DELIVERY MODE
07/27/2023	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eofficeaction@appcoll.com
patents@starkey.com
ptodocketing@mrgs.com

Office Action Summary	**Application No.** 17/553,716	**Applicant(s)** Carlson et al.	
	Examiner GEORGE C MONIKANG	**Art Unit** 2651	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 12/16/2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-23 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-23 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention.

Claims 1, 5-6, 9-14 are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Linden et al, WO 2016036309 A1. (The Linden et al reference is cited in IDS filed 12/16/2021)

Re Claim 1, Linden et al discloses a system (*fig. 1: device 10a*), comprising: at least one hearing device configured to be worn at (*fig. 1: device 10a*), in or on an ear of a wearer (*fig. 1: device 10a*), the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact (*figs. 5-7: 15a/15b cathode and anode; rechargeable power source 14; charging interface member 17; pg. 9, lines 6-14: 15a/15b are pogo pins charging connectors wherein the is a positive and negative connection (cathode and anode)*); and a charging module (*fig. 4*) comprising: a second charging interface (*pg. 5, line 29 through pg. 7, line 11: charging discs 42 & 48*) configured to detachably couple with the first charging

interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts are displaceable*); an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts are displaceable*); and charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device (*pg. 5, line 29 through pg. 7, line 11*).

Re Claim 5, Linden et al discloses the system of claim 1, comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device (*pg. 5, lines 22-28: magnet acts as retention*).

Re Claim 6, Linden et al discloses the system of claim 5, wherein the retention arrangement comprises: one or more magnets; or a mechanical retention arrangement (*pg. 5, lines 22-28: magnet acts as retention; wherein magnet is selected as the Markush claim language*).

Re Claim 9, Linden et al discloses the system of claim 1, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts are at least one or more of the above shapes*).

Re Claim 10, Linden et al discloses the system of claim 1, wherein: the first anode contact comprises a plurality of electrode elements; and the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts*).

Re Claim 11, Linden et al discloses the system of claim 10, wherein: the second anode contact comprises a plurality of electrode elements; and the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts*).

Re Claim 12, Linden et al discloses the system of claim 10, wherein one of both of: the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact; and the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact (*pg. 5, line 29 through pg. 7, line 11: pogo pins contacts, wherein the pogo pins are equidistant to each other*).

Re Claim 13, Linden et al discloses the system of claim 10, wherein one of both of: the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact (*fig. 4: pogo pin 50c is illustrated to be in a rectangular format vis-a-vis the other pogo pins 44*); and the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact (*fig. 4: pogo pin 50c is illustrated to be in a rectangular format vis-a-vis the other pogo pins 44*).

Re Claim 14, Linden et al discloses the system of claim 1 according to any of the preceding claims, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a

housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal (*pg. 1, lines 9-13: in-ear earphones are ear canal insert earphones; wherein an in-the-ear is selected from the Markush claim language*).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

The factual inquiries for establishing a background for determining obviousness under 35 U.S.C. 103 are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 2-4 & 16-22 are rejected under 35 U.S.C. 103 as being unpatentable over Linden et al, WO 2016036309 A1 as applied to claim 1 above, in view of Shi et al, US Patent 10798500 B1.

Re Claim 2, Linden et al discloses the system of claim 1, wherein the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and the displacement arrangement comprises a

biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface. However, Shi et al teaches the concept of pogo pin charge contacts for a hearing aid device where the pogo pins are mounted with a through hole to accommodate pogo pin displacement (*Shi et al, fig. 3: positive and negative pogo pins 43a/43b with mounting holes 412; col. 3, line 59 through col. 4, line 15*). It would have been obvious to modify the Linden et al device with mounting holes for their pogo pins as taught in Shi et al for the purpose of being able to seamlessly mount the pogo pins while accommodating for the displacement.

Re Claim 3, the combined teachings of Linden et al and Shi et al disclose the system of claim 2, wherein: the second cathode contact comprises an elongated electrode; and the biasing arrangement comprises a spring (*Linden et al, pg. 6, lines 10-25: pogo pins are elongated contacts that inherently include springs*).

Re Claim 4, the combined teachings of Linden et al and Shi et al disclose the system of claim 2, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly (*Linden et al, pg. 6, lines 10-25: pogo pins are elongated contacts that inherently include springs*).

Claim 16 has been analyzed and rejected according to claims 1-2, 5, 9.

Claim 17 has been analyzed and rejected according to claims 1-2, 5, 9-11.

Claim 18 has been analyzed and rejected according to claims 1-2, 5, 9, 13.

Claim 19 has been analyzed and rejected according to claims 1-2, 5, 9-11.

Claim 20 has been analyzed and rejected according to claims 1-3, 5, 9.

Claim 21 has been analyzed and rejected according to claims 1-2, 4-5, 9.

Re Claim 22, the combined teachings of Linden et al and Shi et al disclose the system of claim 16, wherein the retention arrangement comprises a mechanical retention mechanism configured to: restrain the second cathode contact at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces (*Linden et al, pg. 5, lines 22-28: magnet acts as retention, where the magnet can be disassociated and re-attached per user's control*); and release the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism (*Linden et al, pg. 5, lines 22-28: magnet acts as retention, where the magnet can be disassociated and re-attached per user's control*).

Claims 7-8 & 23 are rejected under 35 U.S.C. 103 as being unpatentable over Linden et al, WO 2016036309 A1 as applied to claim 1 above, in view of Sanford et al, EP 2640170 B1. (The Sanford et al reference is cited in IDS filed 12/16/2021)

Re Claim 7, Linden et al discloses the system of claim 1 according, but fails to explicitly disclose wherein: the first anode contact is configured to communicate power and one or more disparate information signals; the second anode contact is configured to communicate power and the one or more disparate information signals; and the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device. However, Sanford et al discloses a hearing device that includes connectors that enable transfer of power and data (*Sanford et al, para 0094-0096*). It would have been obvious to modify the Linden et al hearing device such that its positive/negative pogo pin

contacts could also transfer data as taught in Sanford et al along with power for the purpose of obtaining a device that can transfer power as well as data via its connectors.

Re Claim 8, the combined teachings of Linden et al and Sanford et al disclose the system of claim 7, wherein the one or more disparate information signals comprise one or more of: data signals generated by one or both of the charging module and the hearing device; audio signals generated by one or both of the charging module and the hearing device; and signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device (*Sanford et al, para 0094-0096: data signals are selected from the Markush claim language*).

Claim 23 has been analyzed and rejected according to claims 1, 7, 9.

Claim 15 is rejected under 35 U.S.C. 103 as being unpatentable over Linden et al, WO 2016036309 A1 as applied to claim 1 above, in view of Collins et al, US Patent Pub. 20180370522 A1.

Re Claim 15, Linden et al discloses the system of claim 1, but fails to disclose wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power sources is within a predetermined SoC range. However, Collins et al teaches the concept of a rechargeable battery where the state of charge (SoC) rate can be accelerated to up until a maximum SoC rate (*Collins et al, para 0005: maximum charge rate will naturally be predetermined*). It would have been obvious to modify Linden et al such that the charge rate of its rechargeable battery can

be increased/accelerated until a maximum charge rate as taught in Collins et al for the purpose of being able to vary the SoC rate as necessary. Though the Collins reference does not state the level of charge rate to be above 1.0 C, it would have been designer's preference to set 1.0 C as the minimum charge rate to be above since there is a set maximum SoC rate for the purpose of insuring sufficient SoC acceleration.

Contact

Any inquiry concerning this communication or earlier communications from the examiner should be directed to GEORGE C MONIKANG whose telephone number is (571)270-1190. The examiner can normally be reached Mon. - Fri., 9AM-5PM, ALT. Fridays off.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carolyn R. Edwards can be reached on 571-270-7136. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GEORGE C MONIKANG/
Primary Examiner, Art Unit 2651 7/21/2023

Notice of References Cited	Application/Control No. 17/553,716	Applicant(s)/Patent Under Reexamination Carlson et al.	
	Examiner GEORGE C MONIKANG	Art Unit 2651	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-10798500-B1	10-2020	Shi; Yiquan	H04R25/02	1/1
*	B	US-20180370522-A1	12-2018	COLLINS; Patrick Gordon	B60W10/08	1/1
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2651

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/21/2023								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
	13	✓								
	14	✓								
	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								
	21	✓								
	22	✓								
	23	✓								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2651

CPC - Searched*		
Symbol	Date	Examiner
H04R1/1025; H01M10/46; H04R25/602; H04R2225/31	07/21/2023	GM

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
381	312, 322, 323	07/21/2023	GM

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
No double patenting issues. Inventor search completed in EAST.	07/21/2023	GM

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2651	7/21/2023

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1	"17553716"	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 03:50 PM
L2	1	(hearing SAME aid SAME charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L3	576	(charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L4	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L5	0	(charg$8 SAME pogo SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L6	0	(charg$8 SAME pogo SAME positive SAME negative) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L7	6	(charg$8 SAME pogo SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:14 PM
L8	69	(charg$8 SAME pogo SAME positive SAME negative)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:19 PM
L9	1	(charg$8 SAME pogo SAME positive SAME negative SAME hearing)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:20 PM
L10	0	(charg$8 SAME pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:20 PM
L11	75	(pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
L12	0	(pogo SAME pin$1 SAME triang$6) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
L13	623	(state WITH charge WITH rate WITH recharg$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:28 PM
L14	0	(state WITH charge WITH rate WITH recharg$6) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:29 PM
L15	2	(state WITH charge WITH rate WITH	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:30 PM

		recharg$6 WITH accelerate)					
L16	11	(state SAME charge SAME rate SAME recharg$6 SAME accelerate)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:33 PM
L17	133	carlson-erik$.in.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L18	0	carlson-erik$.in. AND (battery).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L19	3	carlson-erik$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L20	5	burns-thomas$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:43 PM
L21	14	olson-kyle$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:44 PM
L22	1	giswold-kent$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:47 PM
L23	0	(state WITH charge WITH rate WITH recharg$6) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L24	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L25	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/323	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:03 PM
L26	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L27	4	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h01m10/46	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L28	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r25/602	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L29	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L30	20	(charg$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L31	21	(charg$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:08 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/553,716
Filing Date	2021-12-16
First Named Inventor	CARLSON, Erik
Art Unit	
Examiner Name	
Attorney Docket Number	ST0806US3/0532.000806US03

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
/G.C.M/	1	2640170	EP		2013-09-18	SANFORD EMERY A; et al.		
/G.C.M/	2	2016/036309	WO		2016-03-10	LINDÉN OLLE; et al.		
/G.C.M/	3	2016/126476	WO		2016-08-11	FLETCHER DOUGLAS D; et al.		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17/553,716
	Filing Date	2021-12-16
	First Named Inventor	CARLSON, Erik
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ST0806US3/0532.000806US03

/G.C.M/	4	2019/037854	WO		2019-02-28	BALTENSPERGER CHRISTIAN; et al.		

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
/G.C.M/	1	International Search Report and Written Opinion from PCT Application No. PCT/US2020/041956 dated November 2, 2020, 10 pages.	

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EXAMINER SIGNATURE

Examiner Signature	/GEORGE C MONIKANG/	Date Considered	07/21/2023

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17/553,716
	Filing Date	2021-12-16
	First Named Inventor	CARLSON, Erik
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ST0806US3/0532.000806US03

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Mark A. Hollingsworth/	Date (YYYY-MM-DD)	2021-12-16
Name/Print	Mark A. Hollingsworth	Registration Number	38491

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	08/02/2023 11:29:23 AM ET	ST0806US1/532.000806US03

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	62546801	AUTHORIZED BY	Jay Pralle
CUSTOMER #	142537	FILING DATE	12/16/2021
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Erik Carlson

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 134895	E202382B30346620	Margaret Rausch

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
134895	37 CFR 1.16 (National application filing, search, and examination fees); 37 CFR 1.17 (Patent application and reexamination processing fees); 37 CFR 1.19 (Document supply fees); 37 CFR 1.20 (Post Issuance fees); 37 CFR 1.21 (Miscellaneous fees and charges)

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1806	SUBMISSION OF AN INFORMATION DISCLOSURE STATEMENT	260.00	1	260.00
			TOTAL AMOUNT:	$260.00

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National Stage of an International Application under 35 U.S.C. 371

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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 640 170 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.09.2013 Bulletin 2013/38

(21) Application number: **13171970.0**

(22) Date of filing: **03.01.2008**

(51) Int Cl.:
H05K 1/02 *(2006.01)* ***H04W 52/02*** *(2009.01)*
H04R 1/10 *(2006.01)* ***H04M 1/60*** *(2006.01)*
H04M 1/05 *(2006.01)* ***H04M 1/02*** *(2006.01)*
H04B 1/38 (2006.01)

(84) Designated Contracting States:
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(30) Priority: **06.01.2007 US 879177 P**
06.01.2007 US 879195 P
28.06.2007 US 824443

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
11188316.1 / 2 426 825
08712959.9 / 2 119 197

(71) Applicant: **Apple Inc.**
Cupertino, CA 95014 (US)

(72) Inventors:
- **Sanford, Emery A**
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- **Hankey, Evans M**
San Francisco, CA California 94110 (US)

(74) Representative: **Rooney, John-Paul**
Withers & Rogers LLP
4 More London Riverside
London SE1 2AU (GB)

Remarks:
This application was filed on 14-06-2013 as a divisional application to the application mentioned under INID code 62.

(54) Wireless Headset Comprising a Housing and an Earbud Electrically Coupled to the Housing by a Flexible Circuit Board

(57) A wireless headset device (10) comprising: an earbud assembly (12) comprising an earbud flexible circuit board (522); and a primary housing assembly (510) coupled via a neck portion to the earbud assembly (12), the primary housing assembly (510) comprising: a battery (19); a microphone (17); and a primary housing flexible circuit board (512) electrically coupled to the earbud flexible circuit board (522), the battery (19), and the microphone (17), the primary housing flexible circuit board (512) being bent around the battery (19) so as to conserve space.

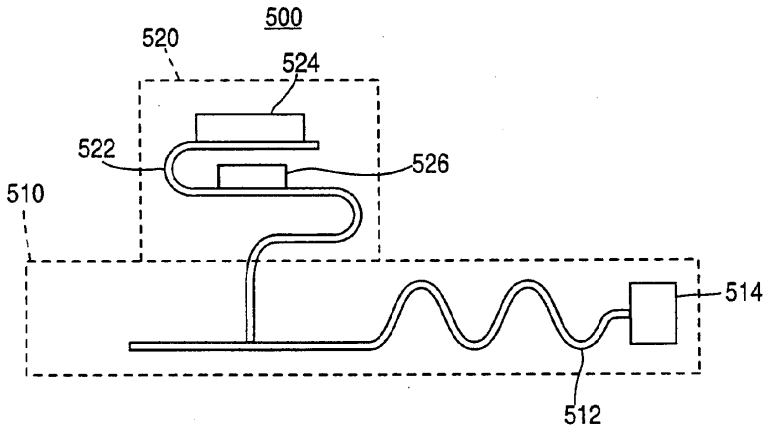


FIG. 5

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Description

Field of Invention

[0001] The present invention can relate to headsets. More particularly, the present invention can relate to headsets for communicating with an electronic device.

Background of the Invention

[0002] Headsets for providing hands- free communications are known in the art. Such headsets typically can be used in conjunction with a cellular telephone or a computer (e.g., Voice over IP). Some existing headsets include a microphone, a speaker (also referred to as a receiver), electronics for controlling the headset and communicating with another device (e.g., a cellular telephone), a battery and a connector for re-charging the battery.

[0003] There are many aspects involved in the design of headsets. For example, the size and weight of headsets can be key issues because of how they typically mount to a user's ear. A heavy or large headset can pull on a user's ear, creating an uncomfortable fit. The shape of headset earpieces (e.g., earbuds) may also be an important design consideration to take into account as it is desirable for earpieces to fit comfortably in, on, or over a wide range of different sizes and shapes of ears.

[0004] Additionally, the acoustic performance of headsets, such as receiver sound generation quality and microphone sound reception quality (e.g., ability to pick up a user's voice without undue background noise) , can be important design considerations. Achieving desired receiver and microphone acoustic performance can become increasingly difficult as the size of a headset decreases.

[0005] Another example of an important design consideration can be the user interface of a headset. It may be desirable for a user interface to be intuitive for a first-time user, yet convenient for an experienced user.

[0006] Aesthetics may be yet another important design consideration for headsets.

[0007] Further still, ease of manufacturing headsets can be another design consideration. For example, it can be desirable to design a headset that can be mass produced in an affordable fashion.

[0008] In view of the foregoing, there is a need for an improved headset that addresses one or more of the above-identified considerations.

Summary of the Invention

[0009] In accordance with one embodiment of the present invention, a wireless headset device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The earbud assembly can include an earbud flexible circuit board having mounted thereon a receiver and processing circuitry. The primary housing assembly can include a microphone and a primary housing flexible circuit board electrically coupled to the earbud circuit board and the microphone.

[0010] In accordance with another embodiment of the present invention, a wireless headset device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The earbud assembly can include an earbud flexible circuit board. The primary housing assembly can include a battery retaining region and a primary housing flexible circuit board. The circuit board components and circuitry can be selectively mounted on the earbud flexible circuit board and the primary housing flexible circuit board to maximize a size of the battery retaining region.

[0011] In accordance with yet another embodiment of the present invention, a wireless device that includes an earbud assembly and a primary housing assembly, fixed to the earbud assembly, is provided. The primary housing assembly can have predetermined dimensions. The earbud assembly and the primary housing assembly can each have mounted therein a flexible circuit board comprising circuitry.

[0012] In accordance with yet another embodiment of the present invention, a headset device that includes an earbud assembly, a primary housing assembly, and at least one flexible circuit board is provided. The primary housing assembly can be fixed to the earbud assembly and can include a connector assembly. The at least one flexible circuit board can be electrically coupled to the connector assembly and can include Universal Serial Bus (USB) circuitry operative to process USB protocol communications and serial circuitry operative to process serial protocol communications.

Brief Description of the Drawings

[0013] The present invention will be apparent upon consideration of the following detailed description, taken in conjunction with accompanying drawings, in which:

[0014] FIG. 1 is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0015] FIG. 2 is a simplified block diagram of a headset connector system in accordance with an embodiment of the present invention;

[0016] FIG. 3 is a simplified cross-sectional illustration of a connector assembly in accordance with an embodiment of the present invention;

[0017] FIG. 4 is a simplified cross-sectional illustration of another connector assembly in accordance with an embodiment of the present invention;

[0018] FIG. 5 is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0019] FIG. 6A is a simplified cross-sectional illustration of a portion of a headset in accordance with an embodiment of the present invention;

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[0020] FIG. 6B is a simplified cross-sectional illustration of a screw in accordance with an embodiment of the present invention;

[0021] FIG. 7 is a simplified block diagram of a display system in accordance with an embodiment of the present invention;

[0022] FIG. 8 is a simplified block diagram of a power distribution system in accordance with an embodiment of the present invention;

[0023] FIG. 9 is a simplified block diagram of another power distribution system in accordance with an embodiment of the present invention;

[0024] FIGS. 10A and 10B are illustrations of a headset in accordance with an embodiment of the present invention;

[0025] FIG. 11 is an exploded view of a headset in accordance with an embodiment of the present invention;

[0026] FIG. 12 is an exploded view of a headset in accordance with another embodiment of the present invention;

[0027] FIG. 13 is a simplified diagram showing how software in a Bluetooth device is organized in accordance with an embodiment of the present invention;

[0028] FIG. 14 is a simplified block diagram of the electrical system of a headset in accordance with an embodiment of the present invention;

[0029] FIG. 15 is a simplified block diagram of the core processor of a headset in accordance with an embodiment of the present invention;

[0030] FIG. 16 is a simplified schematic diagram of a power distribution system in accordance with an embodiment of the present invention;

[0031] FIGS. 17A-17C are illustrations of a traditional circuit board and distribution of electrical components in a headset;

[0032] FIG. 18 is a simplified block diagram of a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0033] FIGS. 19A and 19B are illustrations comparing the traditional circuit board of FIGS. 7A-7C to a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0034] FIGS. 20A-20C are illustrations of an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0035] FIG. 21A is an illustration of a headset earbud in accordance with an embodiment of the present invention;

[0036] FIG. 21B is a simplified exploded view of a headset earbud in accordance with an embodiment of the present invention;

[0037] FIGS. 22-25 and FIG. 26A are simplified illustrations of a headset earbud in various states of assembly in accordance with some embodiments of the present invention;

[0038] FIG. 26B is a simplified cross-sectional view of an audio receiver in accordance with an embodiment of the present invention;

[0039] FIG. 27A is a simplified cross-sectional view of a partially assembled headset earbud in accordance with an embodiment of the present invention;

[0040] FIG. 27B is a simplified cross-sectional view of a fully assembled headset earbud in accordance with an embodiment of the present invention;

[0041] FIG. 28 is an exploded view of an attachment system in accordance with an embodiment of the present invention;

[0042] FIG. 29 is a flowchart of an illustrative process for assembling a portion of a headset in accordance with an embodiment of the present invention.

[0043] FIGS. 30A and 30B are illustrations of a tool that can be used to assist in assembly of a portion of a headset in accordance with an embodiment of the present invention;

[0044] FIG. 30C is an illustration of the tool of FIGS. 30A and 30B being used in accordance with an embodiment of the present invention;

[0045] FIG. 31 is a cross-sectional view of a "finished" tube in accordance with an embodiment of the present invention;

[0046] FIG. 32 is a cross-sectional view of an initially manufactured tube in accordance with an embodiment of the present invention;

[0047] FIG. 33 is a perspective view of a cross section of the tube of FIG. 31 in accordance with an embodiment of the present invention;

[0048] FIG. 34 is an illustrative die and stamper for modifying the initially manufactured tube of FIG. 32 in accordance with an embodiment of the present invention;

[0049] FIG. 35 is a cross-sectional view of the tube of FIG. 34 once the stamper and die are removed from the tube in accordance with an embodiment of the present invention;

[0050] FIG. 36 is a perspective view of the tube of FIG. 35 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0051] FIG. 37 is a cross-sectional view of an illustrative tube formed using a single impact extrusion in accordance with an embodiment of the present invention;

[0052] FIG. 38 is a perspective view of the tube of FIG. 37 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0053] FIG. 39 is a cross-sectional view of an illustrative tube formed using a double impact extrusion in accordance with an embodiment of the present invention;

[0054] FIG. 40 is a perspective view of the tube of FIG. 39 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0055] FIG. 41 is a cross-sectional view of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present inven-

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tion;

[0056] FIG. 42 is a perspective view of a cross section of the tube of FIG. 41 in accordance with an embodiment of the present invention;

[0057] FIG. 43 is a perspective view of the tube of FIGS. 41 and 42 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0058] FIG. 44 is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube with using a die and stamper in accordance with an embodiment of the present invention;

[0059] FIG. 45 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention;

[0060] FIG. 46 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention;

[0061] FIG. 47 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention;

[0062] FIG. 48 is a cross-sectional view of a visual indicator system in accordance with an embodiment of the present invention;

[0063] FIG. 49 is an illustration of a visual indicator system of a headset in accordance with an embodiment of the present invention;

[0064] FIGS. 50A and 50B are illustrations of a headset in accordance with an embodiment of the present invention;

[0065] FIG. 51 is an illustration of a connector in accordance with an embodiment of the present invention;

[0066] FIG. 52 is an exploded view of a connector in accordance with an embodiment of the present invention;

[0067] FIG. 53 is an illustration of a microphone boot in accordance with an embodiment of the present invention;

[0068] FIG. 54 is a cross-sectional view of a connector in accordance with an embodiment of the present invention;

[0069] FIGS. 55A-55D are illustrations of a headset in accordance with an embodiment of the present invention;

[0070] FIG. 56 is a cross-sectional view of an electrical contact assembly coupled to a circuit board in accordance with an embodiment of the present invention;

[0071] FIGS. 57A and 57B are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0072] FIGS. 58A-58C are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0073] FIGS. 59A and 59B are illustrations of electrical contacts in accordance with an embodiment of the present invention;

[0074] FIGS. 60A and 60B are illustrations of a connector plate in accordance with an embodiment of the present invention;

[0075] FIGS. 61A and 61B are illustrations of magnetic components of a connector in accordance with an embodiment of the present invention;

[0076] FIGS. 62A and 62B are illustrations of a connector in accordance with an embodiment of the present invention;

[0077] FIGS. 63A and 63B are illustrations of a connector in accordance with an embodiment of the present invention;

[0078] FIG. 64 is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention;

[0079] FIG. 65 is a simplified graph of magnetic and spring forces involved in the coupling of a headset with a complementary connector in accordance with an embodiment of the present invention;

[0080] FIG. 66 is an illustration of a docking device that can receive a headset in accordance with an embodiment of the present invention;

[0081] FIG. 67A is an illustration of a connector in accordance with an embodiment of the present invention;

[0082] FIG. 67B is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention; and

[0083] FIG. 68 is a chart listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention.

Detailed Description of the Invention

[0084] The present invention relates to headsets and methods for manufacturing the same. Headsets are communication devices that are worn on a user's head in order to allow hands free data and/or voice communication with a host device such as a computer, phone handset, cellular phone, an automobile and/or the like. Headsets can include one or more speakers (in proximity to one or both ears) for audio output and/or one or more microphones for audio input.

[0085] Headsets can come in a variety of form factors or shapes. In some cases, headsets can be embodied as an earpiece that serves as the primary support mechanism for wearing the headset. For example the headset may be supported on the head by an earpiece worn over or in the ear. Alternatively, the headset may be supported by a frame or band that fits on or over the user's head. The headset may include a fixed or movable boom that places the microphone closer to the user's mouth (wraps around the face). Alternatively, the headset may be boomless such that the microphone is integrated with the earpiece thereby forming a more compact device (e.g., smaller, lighter, more aesthetically pleasing, etc.).

[0086] According to one aspect of the invention, the headset can be embodied as a small compact unit including a primary housing and an earbud member ex-

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tending therefrom. The earbud member may be attached to or integrally formed with the primary housing. Various components can be placed at the surface of or within the confines of the earbud member and the primary housing. In fact, both of them can include one or more components depending on the needs of the device. The components contained within each of these can be widely varied. Examples of operational components can include speakers, microphones, antennas, connectors, buttons, displays, indicators, battery, and associated processors, controllers and circuitry. Generally, the earbud member includes at least a speaker while the primary housing includes at least a microphone (although this is not a requirement). Depending on their size, each of these members can include additional components of the headset. In one embodiment, the primary housing includes an antenna, user interface button, indicator or display (e.g., LEDs), battery, microphone, and/or a connector along with any accompanying circuitry while a speaker, a processor, and its accompanying circuitry can be located in the earbud. The button can be located on one end of the main housing. A user can interface with this button to perform various functions (e.g., terminating calls).

[0087] The shape and size and orientation of the earbud member and primary housing can be widely varied. In one embodiment, the earbud member is configured for insertion into the ear such that it supports the remaining portions of the headset (e.g., primary housing) proximate the user's head. In one embodiment, the primary housing can be configured as a longitudinal member (e.g., a tube). In one example, an earbud member, which contains a speaker, perpendicularly protrudes away from one end of a longitudinally extending primary housing, which includes a microphone at an opposite end of the longitudinally extending primary housing. Furthermore, the earbud member can expand outwardly and then inwardly from a neck portion that couples to the primary housing in order to form a bud that fits into an ear.

[0088] The primary housing can include a tube that forms a housing and receives internal components through an open end. The tube can be manufactured using one of several processes in order to reduce costs and increase speed and efficiency. In one embodiment, the tube can be manufactured to include features on the inner surface of the tube for supporting electronic components of the headset. Processes for creating such a tube can include applying a die and stamp to an extruded tube, single or double impact extrusion, or a progressive deep draw process.

[0089] The headset can include a hollow neck between the earbud and the primary housing in order to allow electrical wires to connect sets of discrete electronics disposed within the earbud and primary housing. In one embodiment, dual threaded inserts can be used to structurally reinforce the hollow neck without adding size to the device.

[0090] Small compact headsets have limited surface area for placing components. Therefore, one aspect of the invention relates to integrating multiple components into the same surface area of the headset in order to help form a small compact headset. Put another way, multiple components can be built into the same location on the headset in order to achieve the desired level of functionality without impacting a desired small size of the headset. The components may for example be selected from connectors, microphones, speakers, buttons, indicators, displays and/or the like. In one embodiment, an antenna and a button function at the same location of the headset. In another embodiment, a microphone and connector function at the same location of the headset. Other embodiments can also be realized. For example, a button can function at the same location of a speaker (e.g., at an earbud) or an indicator can function at the same location of a microphone.

[0091] Small compact headsets also have limited internal volume for placing internal components. Therefore one aspect of the invention relates to dividing/separating internal electronic assemblies into small multiple components that can be positioned at different locations (discretely) within the headset. By way of example, the electronics that would normally be embodied on a single large circuit board may be divided/separated out and placed on multiple smaller circuit boards, each of which can be positioned at different locations within the headset. The smaller circuit boards can be more easily placed within various small internal pockets found in a small compact device. Flexible wires and possibly wireless protocols can be used to operatively couple the electronics and/or discrete circuit boards together. In other words, a first portion of the electronics may be separated from a second portion of the electronics, and further the first portion may be positioned at a first location within the headset while the second portion may be positioned at a second location within the headset. Note that, two portions is not a limitation and the electronics can be divided into any number of smaller discrete portions.

[0092] Along a similar vein, another aspect of the invention relates to electronic assemblies that are partially flexible or bendable such that the assemblies can be folded into a small compact form in order to fit inside tightly spaced internal volumes. By way of example, the electronics that would normally be embodied on a single rigid circuit board may be placed on multiple rigid circuit boards that are interconnected by flexible or bendable circuit board portions that can be bent around various internal shapes and/or folded over itself while still functioning properly.

[0093] Another aspect of the invention relates to acoustical paths, ports and volumes that are built through a small compact headset in order to improve acoustical performance of the microphone and/or speaker (with limited impact on the form factor of the headset). In one embodiment, in order to control the flow of air through an earbud, acoustic ports can be integrated into one or more electronic components disposed therein and/or the earbud housing. In another embodiment, at least some of

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the ports that pass through the various housings are substantially hidden from view thereby enhancing the aesthetic appearance of the headset. For example, the ports may be positioned within a seam between two interfacing external surfaces of the headset. In one example, a first external surface is provided by the open end of a tube of the primary housing and the second external surface is provided by an end member disposed within the open end of the tube of the primary housing. The end member may for example include a connector assembly thereby integrating a connector with a microphone into the same surface area.

[0094] In accordance with one aspect of the invention, the connector assembly can include contacts for the transfer of power and data. The connector can be located on the end of the primary housing opposite a user interface button. The connector can have a symmetrical configuration so that it can be coupled with complementary connectors in more than one interface orientation (e.g., 90 degree symmetry, 180 degree symmetry, etc.). In one embodiment, switching circuitry can be included in order to accommodate this symmetry. Such circuitry can, for example, measure the polarity of data and/or power lines from the complementary connector to determine its interface orientation and route the data and/or power lines based on the determined orientation. In some embodiments, the connector assembly can be at least partially made of a ferromagnetic material, which can serve as an attraction plate for one or more magnets on a complementary connector in another device (e.g., a headset charger).

[0095] In accordance with another aspect of the invention, the headset can include an indicator that is hidden from view when inactive and that is in view when active. This can for example be accomplished with micrometer sized holes, called microperforations, that can be drilled into the wall of primary housing and/or earbud member. Through these holes, light sources on the inside of the primary housing and/or earbud member can create visual indicators for a user. A light diffuser can be used in combination with such microperforations so that the indicator can be illuminated with evenly distributed light.

[0096] Headsets may communicate with the host device via a wired and/or wireless connection. Wired connections may for example occur through a cable/connector arrangement. Wireless connections on the other hand can occur through the air (no physical connection is needed). The wired and wireless protocols may be widely varied. Wired protocols may for example be based on Universal Serial Bus (USB) interfaces, Firewire interfaces, conventional serial interfaces, parallel interfaces, and/or the like. Wireless protocols may, for example, be based on short range transmissions of voice and/or data. The wireless protocols may further be used to create personal area networks between the headset and a nearby host device such as a cellular phone. Some examples of wireless protocols that can be used include Bluetooth, Home RF, iEEE 802.11, IrDA, Wireless USB, and the like. The communication electronics may be embodied as a system on a chip (SOC).

[0097] Although other wireless protocols may be used, according to one aspect of the invention, the headset can include communication electronics based on the Bluetooth wireless protocol. The communication electronics may, for example, include or correspond to a Bluetooth System-on-a-Chip (SoC). The SoC can include circuitry for performing functions other than wireless communications. For example, in some embodiments, circuitry for communicating using wired Universal Serial Bus (USB) interfaces and conventional serial interfaces can be integrated into the SoC.

[0098] For increased functionality, according to one aspect of the invention, the headset can include power distribution circuitry. Such circuitry can operate the headset according to several different modes depending, for example, on the charge level of the battery or the availability of an external power source. In one mode, the power distribution circuitry can supply power to limited parts of the SoC while simultaneously charging the battery. The battery charging process can be further improved by using temperature detection circuitry (e.g., a thermistor) to monitor the battery temperature. This process can extend the battery life by charging it only when the monitored temperature is at, or below, a predetermined threshold. In another mode, the power distribution circuitry can selectively power various electronic components using the battery while other electronic components may be powered by an external power source.

[0099] Aspects and embodiments of the invention are discussed below with reference to FIGS. 1-68. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

[0100] FIG. 1 is a simplified block diagram of headset 10 in accordance with one embodiment of the present invention. Headset 10 can be configured to be a small compact unit in the form of a simple earpiece that can be placed in the ear. The headset can include a primary housing 11 and an earbud 12 that extends from the primary housing. Earbud 12 can fit into an ear thereby placing the primary housing next to a user's face. Each of these members can surround and protect various internal components and can also support thereon various external components associated with operating the headset. The components may be a plurality of electrical components that provide specific functions for the electronic device. For example, the components may generally be associated with generating, receiving, and/or transmitting data associated with operating the device.

[0101] Headset 10 includes processor 20 for controlling the headset's functions. In the illustrated embodiment, processor 20 can be provided in earbud 12. In other embodiments, processor 20 can be located anywhere in headset 10. Processor 20 can be electrically coupled to the other components of headset 10 through circuit

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boards and/or cables. Processor 20 may facilitate wireless communications with a host device. For example, processor 20 can generate signals for wireless transmission and process received wireless signals. In addition to wireless communications, processor 20 may coordinate the operation of the various components of headset 10. For example, processor 20 may control the charging of a battery or the operation of a display system.

[0102] Headset 10 also includes speaker system 13 for distributing audio information from earbud 12. Speaker system 13 can include an audio port at the end of the earbud and a receiver (e.g., a speaker) disposed at the end of the audio port. The audio port may be covered with a grill. Speaker system 13 may also include various ports internal and external to the earbud. For example, speaker system 13 may include acoustical paths inside the earbud and acoustical paths that pass through the surfaces of the earbud.

[0103] Headset 10 also includes one or more input mechanisms for providing inputs to the headset. The input mechanism may be placed at the primary housing and/or the earbud. The input mechanisms may be widely varied and may include for example slide switches, depressible buttons, dials, wheels, navigation pads, touch pads, and/or the like. For simplicity purposes, the headset may only include a single input mechanism. Furthermore, for aesthetical reasons, the input mechanism may be placed at a select location. In other embodiments, two or more input mechanisms may reside on the headset.

[0104] In one embodiment, headset 10 includes single button 14 located at one end of primary housing 11. Placing button 14 at the end preserves the side surfaces of primary housing 11. This can also be accomplished by configuring earbud 12 as a button (e.g., the earbud is depressible relative to the primary housing). Earbud 12 may also be configured to tilt, rotate, bend and/or slide in order to provide inputs while preserving the side surfaces of primary housing 11.

[0105] Headset 10 also includes a communication terminal for communicating with a host device. The communication terminal may be configured for wired or wireless connections. In the illustrated embodiment, the communication terminal is antenna 15 that supports wireless connections. Antenna 15 may be located internal to the primary housing or earbud. If the primary housing or earbud is not formed from a radio transparent material then a radio transparent window may need to be provided. In the illustrated embodiment, antenna 15 is located at one end of the headset. Placing antenna 15 and the accompanying radiotransparent window at the end preserves the side surfaces of primary housing 11. In one embodiment, button 14 and antenna 15 are integrated at the same end.

[0106] Headset 10 may also include one or more connectors 16 for transferring data and/or power to and from the headset. A data connection allows data to be transmitted to and received from a host device. A power connection, on the other hand, allows power to be delivered to the headset. The connectors may for example connect to a corresponding connector in a dock or cable in order to connect to a power source for charging and/or a data source for downloads or uploads. Although the location of the connector can be widely varied, in the illustrated embodiment, connector 16 is located at one of the ends in order to preserve the side surfaces of the primary housing.

[0107] In some embodiments, connector 16 and corresponding connectors may be shaped such that the two connectors can mate in two or more different interface orientations. To compensate for this possibility, headset 10 can include switching circuitry that is coupled to connector 16. Such switching circuitry can determine how connector 16 is coupled with a corresponding connector (e.g., how the connectors are physically orientated). Switching circuitry can determine this by measuring, for example, the polarity of data and/or power lines from the complementary connector. Switching circuitry can then route the data and/or power from the connector to other circuitry in headset 10 appropriately. In some embodiments, at least a portion of connector 16 can be magnetic or magnetically attractive. For example, connector 16 may include a ferromagnetic material that biases it to magnetic connectors. Such magnetic interactions can assist a user in coupling connector 16 with corresponding connectors and help prevent the connectors from uncoupling.

[0108] Headset 10 also includes microphone 17 for capturing speech provided by a user. The microphone is typically located internal to the primary housing. One or more acoustical ports may be configured into the primary housing in order to provide an acoustical path from outside the primary housing to the microphone. The location of the acoustical ports can be widely varied. In one embodiment, the acoustical ports are located at one end of the primary housing in order to preserve the sides of the primary housing. In one embodiment, the connector assembly and acoustical ports are integrated at the same end. Furthermore, the acoustical port may be configured to be substantially hidden from view by selective placement of the ports. For example, the ports may be placed at the seam between the connector assembly and the primary housing.

[0109] Headset 10 also includes display system 18 for providing visual feedback. The display system may be a complex display system comprising an LCD or other related display device capable of displaying graphical information and/or it may be an indicator assembly that only provides simple visual feedback as for example via an LED assembly. In one embodiment, the display system only comprises an indicator assembly that provides visual feedback along the side walls of the primary housing. In order to preserve the side walls, however, the indicator assembly may be hidden when inactive. This can be accomplished, for example, through microperforations through the primary housing. The microperforations allow light to pass through, but are so small that they are

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undetectable to a user.

[0110] Headset 10 also includes battery 19. Battery 19 may provide electrical power to components of headset 10. Charging circuitry may also be provided to charge battery 19 when an external power supply is connected to headset 10.

[0111] Headset 10 can also include support circuitry for the aforementioned components. For example, this may include circuit boards, various electrical components, processors and controllers. The support circuitry can be placed inside the primary housing and/or the earbud. In one embodiment, the support circuitry can be split or divided between the two locations in order to make a more compact device, i.e., the various electronics are distributed among volumes as needed. In order to further save space, the electronics may be stackable. In one embodiment, the electronics are placed on a circuit board with one or more flexible portions so that a stack is created by folding or bending the circuit board.

[0112] Although earbud 12 and primary housing 11 can be integrally formed, in the illustrated embodiment, the primary housing and earbud are separate housing members that are attached together. Any suitable means can be used to attach the two parts together including but not limited to screws, glues, epoxies, clips, brackets, and/or the like.

[0113] The position of the earbud relative to the primary housing may be widely varied. For example, the earbud may be placed at any external surface (e.g., top, side, front, or back) of the primary housing. In one embodiment, the earbud is located on a planar front side near one of the ends of the primary housing. In one embodiment, the earbud may be configured to move relative to the primary housing so that its position can be adjusted.

[0114] Each of the earbud 12 and primary housing 11 can be configured to surround its internal components at a peripheral region thereof so as to cover and protect the internal components. They can also be configured to support components externally if needed. Each of earbud 12 and primary housing 11 help define the shape and form of the headset. That is, their contours embody the outward physical appearance of the headset. Such contours may be rectilinear, curvilinear or both. In one embodiment, earbud 12 is formed as an outwardly extending protruding member while primary housing 11 is formed as a longitudinally extending member. For example, earbud 12 may be coupled to primary housing 11 through a neck, which can be a portion of the primary housing, earbud or a separate piece altogether. The axis of earbud 12 and primary housing 11 can be transverse, and more particularly perpendicular. The shapes of earbud 12 and primary housing 11 may be widely varied. In one embodiment, earbud 12 is formed as a reverse rounded circular conical member and primary housing 11 is configured with a pill shaped cross section. It is understood however that these are not limitations and that the form, shape, and orientation may vary according to the specific needs or design of the headset. By way of example, earbud 12 and primary housing 11 may have various cross-sectional shapes including for example, circular, square, rectangular, triangular, oval, and/or the like. In addition, their form may be such that they do not have a typical straight axis.

[0115] Earbud 12 and primary housing 11 may be formed by one or more members. In one embodiment, primary housing 11 may include an integrally formed member. By integral, it is meant that the member is a single complete unit. By being integrally formed, the member can be structurally stronger than conventional housings, which include two parts that are fastened together. Furthermore, unlike conventional housings that have a seam between the two parts, the member has a substantially seamless appearance. Moreover, the seamless housing can prevent contamination and can be more water resistant than conventional housings. The primary housing may, for example, be formed as a tube that defines a cavity therethrough between a first open end and second open end located opposite the first open end. In order to seal the ends of the tube, the primary housing can additionally include a pair of end caps. Each of the end caps can be configured to cover one of the open ends thereby forming a fully-enclosed housing system. The end caps may be formed from similar or different materials as the tube. Furthermore, the end caps may be attached to the tube using a variety of techniques, including but not limited to, fasteners, glues, clips, brackets, and/or the like. The end caps can also be movably attached, and be configured to carry operational components of the headset.

[0116] It is understood that the inner cross-sectional shape of primary housing 11 may be the same or different from the external cross-sectional shape of the primary housing. For example, it may be desirable to have a pill shaped external and a rectangularly shaped interior, etc. In addition, although not a requirement, the front and back surface of primary housing 11 may be substantially planar.

[0117] In one embodiment, primary housing 11 can be formed via an extrusion or related process. The extrusion process is capable of producing an integral tube without seams, crack, breaks, etc. As is generally well known, extrusion is a shaping process where a continuous work piece is produced by forcing molten or hot material through a shaped orifice, i.e., the extrusion process produces a length of a particular cross-sectional shape. The cross-sectional shape of the work piece is controlled at least in part on the shaped orifice. As the shaped work piece exits the orifice, it is cooled and thereafter cut to a desired length. The extrusion process is a continuous high volume process that produces intricate profiles and that accurately controls work piece dimensions (which can be a necessity for smaller parts). Furthermore, because extrusion has low tooling costs, it is relatively inexpensive when compared to other forming or manufacturing processes.

[0118] Primary housing 11 may be formed from a va-

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riety of extrudable materials or material combinations including but not limited to metals, metal alloys, plastics, ceramics and/or the like. By way of example, the metals may correspond to aluminum, titanium, steel, copper, etc., the plastic materials may correspond to polycarbonate, ABS, nylon, etc, and the ceramic materials may correspond to alumina, zirconia, etc. Zirconia may, for example, correspond to zirconia oxide.

[0119] FIG. 2 shows headset connector system 200 in accordance with an embodiment of the present invention. System 200 can include headset 210 and headset engaging connector 220. In some embodiments, headset 210 may correspond to headset 10 of FIG. 1. Headset 210 can include any number of headset connector contact regions (see e.g., regions 211, 212 and 213) disposed within face 214 of the headset. Face 214 can mate with headset engaging connector 220 such that a corresponding number of headset engaging contact regions disposed in the headset engaging connector (see e.g., regions 221, 222 and 223) electrically couple with the headset connector contact regions. Moreover, headset 210 can include switching circuitry 215 that is electrically coupled with each of the headset connector contact regions. Switching circuitry 215 can be operative to determine an interface orientation between the headset connector contact regions and headset engaging contact regions. For example, switching circuitry 215 can determine the interface orientation in which headset 210 is mated with headset engaging connector 220. Switching circuitry 215 can determine this by measuring the polarity of data and/or power lines from headset engaging connector 220. After having determined the interface orientation, switching circuitry 215 can route signals received on the headset connector contact regions based on the determined orientation. It is understood that switching circuitry can be provided in connector 220 to provide functionality similar to switching circuitry 215. For example, switching circuitry in connector 220 can determine the interface orientation of headset 210 and route electrical signals to contact regions based on the determined orientation.

[0120] In some embodiments, at least a portion of headset 210 and/or headset engaging connector 220 (e.g., a portion or all of housing 224) can be magnetically attractive. Moreover, headset engaging contact regions (see e.g., regions 221, 222, and 223) may be biased to protrude from housing 224 of connector 220. In such embodiments, headset 210 can be magnetically attracted to headset engaging connector 220 such that the magnetic forces can cause the headset engaging contact regions (see e.g., regions 221, 222, and 223) to press against the headset connector contact regions (see e.g., regions 211, 212, and 213).

[0121] FIG. 3 shows electronic device 300 in accordance with an embodiment of the present invention. In some embodiments, device 300 may be an electronic headset (see e.g., headset 10 of FIG. 1), but it is to be understood that device 300 is not limited to electronic headsets. Device 300 can include housing 310 and connector assembly 320. At least a portion of connector assembly 320 may be disposed in housing 310. Connector assembly 320 may include port 322, microphone 324 and channel 326 that fluidically couples the microphone to the port. Connector assembly 320 may also include one or more contacts (see e.g., contacts 321, 323, 325 and 327) for electrically coupling with another device. Port 322 may be provided in a location such that the contacts of connector assembly 320 are on the same exterior surface as the port or located nearby. In some embodiments, port 322 may be located between two contacts (see e.g., contacts 323 and 325).

[0122] FIG. 4 shows electronic device 400 in accordance with another embodiment of the present invention. Like device 300, device 400 may be an electronic headset in some embodiments (see e.g., headset 10 of FIG. 1) but it is to be understood that device 400 is not limited to electronic headsets. Device 400 can include housing 410 and joint connector and microphone assembly 420. Microphone 430, boot 440 and connector plate 450 may be provided in joint connector and microphone assembly 420. Microphone 430 may include one or more side surfaces and a top surface with microphone port 432. Microphone boot 440 may be mounted to the microphone such that the boot forms a seal with at least a portion of the top surface and the side surfaces. This seal can surround microphone port 432. Microphone boot 440 can further include a portion for sealing to connector plate 450 and an aperture for fluidically connecting microphone port 432 to connector port 452. Connector plate 450 may include one or more contacts (see e.g., contacts 451, 453, 455 and 457) for electrically coupling with another device. Connector port 452 may be provided in a location such that the port is in the same exterior surface as the contacts of connector assembly 420 or located near the contacts. In some embodiments, port 452 may be located between two contacts (see e.g., contacts 453 and 455).

[0123] FIG. 5 shows headset 500 in accordance with an embodiment of the invention. Headset 500 may correspond to an electronic headset (see e.g., headset 10 of FIG. 1) and may include primary housing 510 and earbud 520. Primary housing 510 may correspond to primary housing 11 and earbud 520 may correspond to earbud 12, for example. Earbud flexible circuit board 522 may be provided in earbud 520. Receiver 524 and processing circuitry 526 can be mounted on the earbud flexible circuit board 522. Earbud flexible circuit board 522 may be flexible such that it can fold upon itself or bend. Such flexibility may allow earbud flexible circuit board 522 to fit in smaller or less traditionally-shaped earbuds.

[0124] Primary housing 510 may be fixed to earbud 520. Primary housing 510 may include primary housing flexible circuit board 512 and microphone 514. Like earbud flexible circuit board 522, primary housing flexible circuit board 512 may be flexible such that it can fold upon itself or bend. Such flexibility may allow primary housing circuit board 512 to bend around other compo-

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nents in the primary housing (e.g., circuitry, antennas, or batteries) so as to conserve interior space inside the primary housing. For example, conserving interior space may result in more room to accommodate a larger battery. In another example, conserving interior space may result in a smaller primary housing. Earbud flexible circuit board 522 and microphone 514 can be electrically coupled to primary housing flexible circuit board 512. In some embodiments, such as the one shown in FIG. 5, earbud flexible circuit board 522 may extend into primary housing 510 such that it can couple with primary housing flexible circuit board 512. In other embodiments, primary housing flexible circuit board 512 may extend into earbud 520 such that it can couple with earbud flexible circuit board 522. It is to be understood that although primary housing flexible circuit board 512 and earbud flexible circuit board 522 are described as being flexible, one or both circuit boards may include both flexible and rigid portions. For example, each circuit board may include one or more rigid portions upon which electrical components (e.g., receiver 524, processing circuitry 526, or microphone 514) can be easily and stably mounted.

[0125] FIG. 6A shows headset device 600 in accordance with an embodiment of the present invention. Headset device 600 can include earbud housing 610, threaded neck 620, and primary housing 630. Headset device 600 can correspond to headset 10 of FIG. 1 such that, for example, earbud housing 610 corresponds to earbud 12 and primary housing 630 corresponds to primary housing 11. Earbud housing 610 can include earbud through-hole 612 and neck engaging surface 614. Threaded neck 620 can include first neck surface 622 that can mate with the earbud housing's neck engaging surface 614. First neck surface 622 and neck engaging surface 614 may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0126] Primary housing 630 can include primary housing through-hole 632 and neck engaging surface 634. Threaded neck 620 can further include second neck surface 624 that can mate with the primary housing's neck engaging surface. Second neck surface 624 and neck engaging surface 634 may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0127] FIG. 6B shows screw 690 for use with headset device 600 in accordance with the present invention. Screw 690 can be used as both an earbud screw and a primary housing screw. Screw 690 can include hollow channel 692 running through the center of the screw. Screw 690 may also include features 694 (e.g., notches) such that a tool can interface with the features and rotate the screw. As an earbud screw, screw 690 can be inserted into earbud through-hole 612 and tightened such that it fastens neck engaging surface 614 to first neck surface 622. As a primary housing screw,
screw 690 can be inserted into primary housing through-hole 632 and tightened such that it fastens neck engaging surface 634 to second neck surface 624.

[0128] FIG. 7 shows display system 700 in accordance with an embodiment of the present invention. Display system 700 can, for example, correspond to display system 18 of FIG. 1. System 700 can include housing 710, light source 720, diffuser 730 and control circuitry 740. Housing 710 can have signal indicator region 712 disposed therein. Signal indicator region 712 may be, for example, one or more apertures (e.g., microperforations) for transmitting light. Signal indicator region 712 may be configured to output a signal of a certain shape or form. Housing 710 can also include internal wall 714. Diffuser 730 can be located between light source 720 and internal wall 714. Control circuitry 740 may be electrically coupled with light source 720 to control when light source 720 emits light.

[0129] Diffuser 730 may be operable to diffuse light from light source 720 such that all of the light exiting the diffuser has an equal intensity or brightness. For example, diffuser 730 may be operable to evenly illuminate signal indicator region 712 with the light from light source 720. Diffuser 730 may be composed of a mixture of different particles that cause light diffusion. For example, diffuser 730 can include mainly clear particles with translucent particles distributed throughout. The translucent particles can cause light to be deflected from its original course so that the light is distributed throughout the diffuser. Accordingly, light exiting from any portion of the diffuser will have substantially even illumination.

[0130] FIG. 8 shows power distribution system 800 in accordance with an embodiment of the present invention. Power distribution system 800 can be employed in an electronic device (see e.g., headset 10 of FIG. 1) and can include switch 810, bus 820, first power regulating circuitry 822, core processing circuitry 824, battery 830, second power regulating circuitry 832, RF processing circuitry 834, and control circuitry 840. Core processing circuitry 824 may include circuitry for handling low-level, core functions of the electronic device, and RF processing circuitry 834 may include circuitry for handling RF communications for the electronic device. To power core processing circuitry 824 and RF processing circuitry 834, power distribution system 800 can include both bus 820 and battery 830 as potential power sources.

[0131] Bus 820 can be coupled to receive power from a source external to the system. For example, bus 820 may be coupled to a connector such that the bus can receive power through the connector. First power regulating circuitry 822 may be electrically coupled to bus 820 and core processing circuitry 824. First power regulating circuitry 822 may be operable to, for example, convert power from bus 820 into a condition suitable for core processing circuitry 824 (e.g., by changing the voltage or regulating the current flow).

[0132] Battery 830 can be a device that stores chemical energy and makes it available in an electrical form. Battery 830 may be rechargeable. Second power regu-

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lating circuitry 832 may be electrically coupled to battery 830 and RF processing circuitry 834. Second power regulating circuitry 832 may be operable to, for example, convert power from bus 820 into a condition suitable for core processing circuitry 824 (e.g., by changing the voltage or regulating the current flow).

[0133] Switch 810 may be electrically coupled to both core processing circuitry 824 and RF processing circuitry 834. Switch 810 may be controlled by the presence of an external power source on bus 820. For example, switch 810 may be activated when the voltage of bus 820 goes below a predetermined threshold. When switch 810 is activated, first power regulating circuitry 822, core processing circuitry 824, RF processing circuitry 834, and second power regulating circuitry 832 may be electrically coupled such that both core processing circuitry and RF processing circuitry can share power.

[0134] Control circuitry 840 can be electrically coupled to bus 820, first power regulating circuitry 822, core processing circuitry 824, and second power regulating circuitry 832. Control circuitry 840 may be able to selectively active first power regulating circuitry 822 and second power regulating circuitry 832 based on bus 820, core processing circuitry 824, and/or any other signals in the electronic device.

[0135] FIG. 9 shows wireless headset 900 in accordance with an embodiment of the present invention. Headset 900 can be an electronic headset for communications (see e.g., headset 10 of FIG. 1). Headset 900 can include processor circuitry 910 that has a first power consumption portion 912 and a second power consumption portion 914. First power consumption portion 912 can, for example, include the core circuitry of an electronic device (e.g., boot-up circuitry), while second power consumption portion 914 can include the device's auxiliary circuitry (e.g., circuitry for RF communications). Headset 900 can further include power distribution circuitry 920. Power distribution circuitry 920 can selectively power first power consumption portion 912 independent of whether second power consumption portion 914 is powered. In some embodiments, power distribution circuitry 920 can selectively power any combination of first power consumption portion 912 and second power consumption portion 914 based on one or more monitored conditions of headset 900. For example, power distribution circuitry 920 can monitor if an external power source is present and/or the charge level of an internal battery in order to determine which power consumption portions to activate.

[0136] FIGS. 10A and 10B show perspective views of an illustrative headset in accordance with an embodiment of the present invention. Headset 1000 can correspond to headset 10 of FIG. 1. For example, primary housing 1010 can correspond to primary housing 11 and earbud 1020 can correspond to earbud 12.

[0137] Headset 1000 can include a housing that encloses the electronic and other elements of the headset. The housing can incorporate several pieces that are assembled using any suitable process (e.g., adhesive, screws, or press fit). In the example of FIGS. 10A and 10B, headset 1000 can include earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040. Earbud 1020 can include perforations (e.g., acoustic ports) 1021 and 1022 for allowing air to pass into and out of the earbud 1020. Front port 1021 can allow sound waves from a receiver located in earbud 1020 to reach a user's ear and/or the outside environment. Side ports 1022 can provide a path for acoustic pressure to vent to the outside environment. Earbud 1020 can be attached to primary housing 1010 by neck 1030.

[0138] Attached to one end of primary housing 1010 is antenna cap 1011. Antenna cap 1011 can have button 1012 disposed at least partially therethrough. A user can interface with button 1012 to control the headset. Primary housing 1010 can include display 1013 which can correspond to display system 700 of FIG. 7 or display system 18 of FIG. 1. In some embodiments, display 1013 may include microperforations such as those discussed in more detail below in connection with FIGS. 48 and 49. Located at the connector end of primary housing 1010, connector 1040 includes at least one port (not shown in FIG. 10A) for enabling a microphone inside housing 1010 to receive acoustic signals (e.g., a user's voice), and at least one contact 1042 for receiving power, data, or both from an external source. Connector 1040 may correspond to contact regions 211, 212, and 213 of FIG. 2, for example.

[0139] Earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be constructed from any suitable material including, for example, metal, plastic, silicone, rubber, foam, or combinations thereof. For example, earbud 1020 can be formed from a plastic element surrounded by a silicone seal and primary housing 1010 can be formed from aluminum. Earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be manufactured using any suitable process (e.g., molding, casting or extrusion). In some embodiments, earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040 can be post processed to provide texture and other features on the inner or outer surfaces of the bodies. For example, a bead blast and anodization process can be used to apply a desired surface texture to primary housing 1010.

[0140] FIG. 11 is an exploded view of headset 1100 in accordance with an embodiment of the present invention. Headset 1100 can correspond to headset 10 of FIG. 1 or headset 1000 of FIGS. 10A and 10B, for example. In one embodiment of the present invention, earbud housing 1120 can contain earbud circuit board 1122. Earbud circuit board 1122 can, for example, correspond to earbud circuit board 522 of FIG. 5. Earbud circuit board 1122 can be a flexible circuit board on which one or more of the following components are electrically and/or mechanically mounted: processor 1123 (which can be used to control the functions of headset 1100), receiver 1124, and other circuitry and components. The flexible nature

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of earbud circuit board 1122 can enable it to be folded onto itself, providing layers of circuitry that can be packed into earbud housing 1120, thereby occupying space within earbud housing 1120 that may otherwise be empty and unused. The flexible portions of earbud circuit board 1122 can replace the need for separate wires connecting different circuit boards, which might cause a substantial increase in size because, for example, each wire might involve a pair of connectors. Additionally, the flexible nature of circuit board 1122 can advantageously reduce the area or footprint required by circuit board 1122. That is, compared to another circuit board having similar circuitry and components disposed thereon but in an unfolded layout, circuit board 1122 can occupy less area. In addition, circuit board 1122 further can reduce the footprint or size requirements of other components of headset 1100, such as primary housing 1110 and antenna cap 1111, by incorporating within earbud housing 1120 electronics and other components that traditionally are located elsewhere within a headset. Earbud housing 1120 and the circuitry and components contained therein are discussed in more detail below in connection with FIGS. 18-27B, for example.

[0141] Earbud housing 1120 can be coupled to primary housing 1110 by neck 1130. Earbud housing 1120, primary housing 1110, and neck 1130 can correspond, respectively, to earbud housing 610, primary housing 630, and neck 620 of FIG. 6A. Neck 1130 can be constructed with a double threaded screw insert to receive screw member 1131 (associated with earbud housing 1120) and screw member 1132 (associated with primary housing 1110). Neck 1130 can connect earbud housing 1120 and primary housing 1110 in a manner that can reduce the likelihood of earbud housing 1120 and primary housing 1110 rotating independently of each other. That is, when headset 1100 is in use and the user adjusts its position by, for example, pulling primary housing 1110 down, the earbud housing 1120 can rotate in conjunction with primary housing 1110. However, in some embodiments, pulling primary housing 1110 down may cause the housing to rotate with respect to earbud housing 1120 so as to trigger a switch and signify a user input. A more detailed discussion of headset necks and their assembly can be found below in connection with FIGS. 28-30, for example.

[0142] In addition to earbud circuit board 1122, headset 1100 also can include primary housing circuit board 1115 on which additional electronic components 1113 can be electrically and/or mechanically mounted. Primary housing circuit board 1115 may, for example, correspond to primary housing circuit 512 of FIG. 5. Primary housing circuit board 1115 can be electrically coupled with the earbud circuit board by one or more wires, cables, flexible circuit boards, and the like. The arrangement of electronic components in both earbud circuit board 1122 and primary housing circuit board 1115 can advantageously reduce the size of headset 1100. The arrangement of the electronic components in headset 1100 will be discussed in more detail below in connection with FIGS. 18-20C, for example.

[0143] A user can control the functions of headset 1100 using button 1112, which can be electrically coupled with primary housing circuit board 1115. Button 1112 can extend from antenna cap 1111 such that it appears as a discrete user interface easily activated by a user. Button 1112 can be configured to move in any suitable manner including, for example, bending with respect to primary housing 1110, translating in and out of antenna cap 1111, rotating around an axis passing through connector plate 1141 and button 1112, or any combination thereof.

[0144] In one embodiment, button 1112 can include a switch such as a dome switch, which can be activated when a user depresses button 1112. Button 1112 can have a button guide structure. The button guide structure can have one or more guide channels to facilitate user actuation of the button with respect to the rest of headset 1100. In one embodiment of the present invention, the guide channel(s) can be provided in the form of a hole through the button guide structure. The switch actuation member can have a stem that is supported and guided by the guide channel. When pressed by a user, the switch actuation member moves along the guide channel towards the switch. Raised structures (e.g., ribs) can be used to ensure that the switch actuation member reciprocates smoothly within the guide channel.

[0145] Button 1112 and antenna cap 1111 can be constructed from a dielectric material such as plastic. Antenna 1118 can be formed by mounting an antenna resonating element within antenna cap 1111 (e.g., along an inner surface of antenna cap 1111) or on a portion of the button guide structure. Constructing button 1112 and antenna cap 1111 from a dielectric material can reduce or eliminate potential signal interference that can disrupt the proper operation of antenna 1118. In addition, a dielectric button 1112 can allow for smaller clearance between the antenna resonating element and conductive structures (e.g., primary housing circuit board 1115) in headset 1100.

[0146] Antenna 1118 can be electrically coupled with primary housing circuit board 1115 so that it can send and receive wireless (e.g., radio) signals. Antenna 1118 can include any suitable antenna resonating element for communicating between headset 1100 and an electronic device (e.g., a cellular telephone or a personal media device). The antenna resonating element can be formed from a flex circuit containing a strip of conductor. The flex circuit can be attached to the button guide structure using, e.g., adhesive. For example, the flex circuit can contain registration holes that mate with corresponding registration bosses on the button guide structure. One or more of the bosses can be heat staked to the flex circuit.

[0147] Details about the operation and design of an antenna and button system similar to antenna 1118 and button 1112 can be found, e.g., in U.S. Patent Application No. 11/651,094 entitled "Antenna and Button Assembly for Wireless Devices," which is incorporated herein.

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[0148] Appendages 1117 can be incorporated into antenna cap 1111 in order to mount the antenna cap to headset 1100. Appendages 1117 can, for example, fasten to primary housing 1110 or one or more brackets 1116 which will be discussed in more detail below.

[0149] Battery pack 1119 can be located within primary housing 1110. Battery pack 1119 can contain one or more suitable batteries including, for example, lithium ion, lithium ion polymer (Li-Poly), nickel metal hydride, or any other type of battery. Battery pack 1119 can be electrically coupled with circuit board 1115 for powering electronic components in headset 1100. Additionally, circuitry that is typically packaged within standard battery packs (e.g., charging or fuse protection circuitry) can be moved to primary housing circuit board 1115. Advantageously, the distribution of circuitry into earbud housing 1120 and the layout of circuit board 1115 can permit battery pack 1119 to occupy a substantial portion of the internal space of primary housing 1110. This can increase the energy storage capacity of headset 1100 (e.g., allow headset 1100 to operate for longer period of time in between charges) without increasing the size of primary housing 1110 and headset 1100.

[0150] Headset 1100 can include connector 1140 for enabling headset 1100 to electrically connect to other devices. An opening or port can be included in connector 1140 so that acoustic signals (e.g., speech from a user) can reach the microphone inside microphone boot 1144. Connector 1140 can, for example, correspond to assembly 320 of FIG 3 or assembly 420 of FIG. 4, for example. The microphone can be electrically coupled with circuit board 1115 in any suitable manner. Microphone boot 1144 can be placed inside the end of primary housing 1110 that is farthest from earbud housing 1120. This end may be referred to herein as the microphone or connector end of headset 1100, and is also the portion of headset 1100 that is closest to the user's mouth when in use. The arrangement of the microphone boot 1144 with respect to connector 1140 and accompanying parts is discussed in more detail below in connection with the description accompanying FIGS. 50A-54.

[0151] Connector 1140 can include connector plate 1141 in which contacts 1142 and accompanying casing 1143 can reside. As such, contacts 1142 can facilitate the electrical coupling of headset 1100 with another device. Accompanying casing 1143 can be made from a non-conductive material (e.g., a polymeric material). Casing 1143 can surround contacts 1142 to prevent the contacts from electrically coupling with connector plate 1141. Contacts 1142 and casing 1143 can be substantially flush with the surface of connector plate 1141 so that the combination of the contacts, casing and plate creates a substantially flat surface for mating with other connectors. Connector plate 1141 can be made of a ferromagnetic material so that it is biased to magnetic connectors, such as those discussed in connection with FIGS. 62A-67B, for example. The design of connector plate 1141, contacts 1142, casing 1143 and complementary magnetic connectors will be described in more detail below in connection with the discussion of FIGS. 55A-67B.

[0152] Headset 1100 can include one or more brackets 1116 to couple connector 1140 with appendages 1117 of antenna cap 1111. Brackets 1116 can prevent connector plate 1141 and antenna cap 1111 from moving axially away from each other or separating from primary housing 1110. Alternatively, connector plate 1141 and antenna cap 1111 can be coupled to one or more brackets that are secured to the inner surface of primary housing 1110.

[0153] As a matter of design choice, a seam can be included in between the peripheral surface of connector plate 1141 and the inner surface of primary housing 1110. That is, in addition to the predefined port for providing an acoustic pathway between the microphone and the outside environment, gaps can exist. These gaps can advantageously enable the microphone to receive acoustic signals in the event the predefined acoustic pathway is blocked (e.g., by a foreign object such as dirt). In other embodiments, an adhesive may be applied to provide a substantially airtight seal between connector plate 1141 and primary housing 1110. In yet another embodiment, a gasket may be used to provide a seal.

[0154] FIG. 12 shows a view of headset 1200 in accordance with another embodiment of the present invention. Headset 1200 can be similar to headset 1100, but with some substantial differences between the two. For example, headset 1200 can use a different attachment technique to couple connector 1240 to primary housing 1210. Connector 1240 can include tabs 1242 which can be used to couple with features (e.g., wall 1212) on an interior surface of primary housing 1210. Such a method might be advantageous to using the brackets 1116 in headset 1100. For example, the tabs 1242 can attach to the near end of primary housing 1210 which might provide connector 1240 with higher structural integrity than, for example, the method of using brackets to attach to a structure (e.g., antenna cap) on the other end of the primary housing. Headset 1200 can also include light diffuser 1244 which can be used in conjunction with a visual indicator system as discussed in connection with FIGS. 48 and 49. Additionally, headset 1200 can include antenna 1218 which can wrap around button guide 1217 in some embodiments.

[0155] The fundamental basics of the Bluetooth protocol are well known in the art, and discussed briefly below. For a more detailed discussion, please see Bluetooth Specification Version 2.0+EDR, Vol. 0, November 4, 2004, which is hereby incorporated by reference in its entirety. Bluetooth wireless technology is based on an international, open standard for allowing intelligent devices to communicate with each other through wireless, low power, short-range communications. This technology allows any sort of electronic equipment, from computers and cell phones to keyboards and headphones, to make its own connections, without wires or any direct

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action from a user. Bluetooth is incorporated into numerous commercial products including laptop computers, PDAs, cell phones and printers, and is likely to be used in future products.

[0156] Bluetooth can be referred to as a frequency hopping spread spectrum (FHSS) radio system that operates in the 2.4 GHz unlicensed band. Bluetooth transmissions change frequencies based on a sequence which is known to both the transmitter and the receiver. According to one known standard, Bluetooth transmissions use 79 different frequencies ranging from 2.404 GHz to 2.480 GHz. Bluetooth's low power transmissions allow a typical range of about 10 meters or roughly 30-40 feet. This range can vary from about 1 meter to 100 meters depending on the amount of power used by the device for Bluetooth transmissions.

[0157] Bluetooth devices connect to each other to form networks known as piconets. A piconet includes two or more devices which are synchronized to a common clock signal and hopping sequence. Thus, for any device to connect to a given piconet, that device may need to have the same clock signal and hopping sequence. The synchronized clock and hopping sequence can be derived using the clock signal of one of the devices on the piconet. This device is often referred to as the "master" device while all other devices on the piconet are referred to as "slave" devices. Each piconet can include one master device and up to seven or more slave devices. Moreover, Bluetooth devices can belong to more than one piconet. The term "scatternet" is used to define Bluetooth networks which are made up of multiple, overlapping piconets. In the case where one Bluetooth device is on two or more piconets, all of the devices are on a single scatternet. Devices from one of the piconets can communicate with devices from another piconet by using the shared device to relay the signals.

[0158] When two Bluetooth devices initially connect, they first share some general information (e.g., device name, device type) with each other. In order to enhance the connection, the devices can establish a trusted relationship by using a secret passkey. This passkey is typically provided by a user or stored on memory in a device. According to a known Bluetooth standard, the process of establishing this trusted relationship is called pairing. Once two devices are paired, they typically share information and accept instructions from one another.

[0159] Bluetooth devices can operate with a maximum data throughput of approximately 2.1 Mbit/s (Megabits-per- second) , but it is understood that such limitations change as technology advances, and that embodiments of the present invention may operate at other rates. This maximum throughput is shared among all devices on a piconet, meaning that if more than one slave device is communicating with the master, the sum of all communications is less than the maximum data throughput.

[0160] The Bluetooth standard includes a published software framework. The shared framework is called the Bluetooth Protocol Stack and includes different software applications to implement Bluetooth communications. FIG. 13 is a simplified schematic diagram of an exemplary Bluetooth Protocol Stack 1300 in accordance with an embodiment of the present invention. Low-level software is included in Lower Stack 1302. This section includes code to generate/receive radio signals, correct transmission errors and encrypt/decrypt transmissions, among other things. The Host Controller Interface (HCI) 1304 is a standardized interface between the low-level Bluetooth functions and applications. The HCI layer represents a division between the Lower Stack 1302 functions handled by a dedicated Bluetooth processor and the rest of the functions handled by an application-specific processor.

[0161] The Extended Synchronous Connection-Oriented (eSCO) 1306 layer is used to implement dedicated communication channels, commonly used for voice data, in between the Lower Stack 1302 and high-level applications. The Logical Link Control and Adaptation Protocol (L2CAP) 1308 layer combines and repackages the data transmitted and received by the multiple higher-level applications. The L2CAP 1308 layer combines all of these different communications into one data stream that can interface with Lower Stack 1302 The RFCOMM 1310 layer emulates the protocol used by serial connections. This allows software designers to easily integrate Bluetooth into existing applications which previously used a serial connection. The Service Discovery Protocol (SDP) 1312 layer is used by devices to provide information about what services (or functions) each device offers and how other devices can access those services through Bluetooth.

[0162] The Profiles 1314 layer allows a device to identify itself as a member of a generic group of devices with a predefined set of functions. For example, a device complying with the headset profile may support predefined methods relating to audio communications. The Application Layer 1316 contains programs that implement the useful tools created by all of the other layers. By writing different programs for Application Layer 1316, software developers can focus on new uses of the Bluetooth functionality without having to rewrite the code which controls the underlying communication tasks.

[0163] FIG. 14 shows a simplified block diagram of exemplary electronic system 1400 of a headset in accordance with an embodiment of the present invention. The system of 1400 can be implemented in, for example, headset 10 of FIG. 1 or headset 1000 of FIGS. 10A and 10B. System 1400 can include processor circuitry 1410, interface circuitry 1420, power distribution circuitry 1430, switching circuitry 1440 and 4-pin symmetrical magnetic connector 1455.

[0164] Processor circuitry 1410 can include processor 1411 and auxiliary circuitry that operates in connection with processor 1411. Processor 1411 can coordinate all of the operations in system 1400, including, for example, Bluetooth transmissions, battery charging and processing (e.g., encoding and decoding) of acoustic signals.

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Processor 1411 can drive receiver 1412 to provide acoustic signals that may be heard by a user. Reset circuit 1413 can detect when system 1400 is connected to another device and subsequently instruct processor 1411 to reset. Power FET 1414 can be used with the power supply circuitry inside processor 1411 and will be discussed in more detail below in connection with the discussion of FIG. 15. Antenna 1415 can be used to send wireless signals to and receive wireless signals from another device (e.g., a phone or portable media device). UART multiplexer 1416 can be electrically coupled with processor 1411 and can route data signals to different parts of processor 1411. This routing can reduce unwanted effects, such as inductance, in unused data lines.

[0165] Interface circuitry 1420 can include a microphone isolation LDO 1421, a micro-electromechanical (MEMs) microphone 1422, LED driver 1424 and switch 1423. Microphone isolation LDO 1421 can be electrically coupled with MEMs microphone 1422. Microphone isolation techniques and MEMs microphones are well known, and a person of ordinary skill in the art will appreciate that these elements can be replaced by other equivalent microphone configurations without deviating from the spirit of the present invention.

LED driver 1424 can be configured to drive a LED display unit based on one or more outputs of processor 1411. Details about the design and function of circuitry similar to LED driver 1424 can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein. Switch 1423 can represent the electrical behavior of button 1012 of FIG. 10B. A user can interface with this switch to input commands to the headset. For example, a user can depress switch 1423 to initiate a telephone call, terminate a call, or both. In one embodiment,

switch 1423 can be a single-pole, single-throw switch with a spring to bias it to an open position.

[0166] Power distribution circuitry 1430 can include over-voltage protection and fuse 1431, battery protection circuitry 1432 and thermistor 1433. Over-voltage protection and fuse 1431 can protect system 1400 in the event that an unsafe amount of voltage is applied to one or more inputs. The fuse in the protection circuitry can be an over-current protection device which disconnects the inputs of the headset if an over-current condition is detected. Battery protection circuitry 1432 can include circuitry to prevent the malfunction of a battery (e.g., a li-poly battery) which could result in a dangerous overheating situation. Battery protection circuitry 1432, in contrast to conventional headsets which has such circuitry integrated into the battery pack, can be separated from the battery pack and located elsewhere within a headset according to the invention. Thermistor 1433 can be located in the proximity of a battery (see e.g., battery pack 1119 of FIG. 11) and may change its resistance based on the battery's temperature. One or more inputs of processor 1411 can be electrically coupled with thermistor 1433 to monitor the temperature of the battery. Processor 1411 can be programmed to charge the battery differently depending on the detected battery temperature. For example, processor 1411 may charge the battery at a faster rate when the monitored battery temperature is low than when the temperature is high. By regulating the charging in this manner, the time required to completely charge a battery can be decreased without damaging the battery.

[0167] Symmetrical magnetic connector 1455 can allow system 1400 to connect to other devices and systems for communicating data or transmitting power. Connector 1455 represents the electrical behavior of connector 16 of FIG. 1, for example.

[0168] Switching circuitry 1440 can enable connector 1455 to connect and communicate with many different types of devices and in many interface orientations. Switching circuitry 1440 can, for example, correspond to switching circuitry 215 of FIG. 2. Switching circuitry 1440 can include power polarity switch circuit 1441 and data polarity switch circuit 1442. The two circuits can, for example, determine the type of communication interface being used and route the corresponding data and/or power lines to the correct pathways (e.g. internal electrical traces) for the detected interface. The two circuits can also determine the interface orientation of a connection with another device, for example, and route the corresponding data and/or power lines to the correct pathways (e.g., internal electrical traces) for the detected orientation. A detailed description of the design and function of exemplary circuits similar to switch circuits 1441 and 1442 can be found in U.S. Patent Application No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein.

[0169] FIG. 15 shows processor 1500 which can be used as the core processor or application processor of a headset in accordance with an embodiment of the present invention. Processor 1500 can, for example, correspond to processor 20 of FIG. 1. Processor 1500 can also be referred to as a System on a Chip (SoC) because it can be a single integrated circuit capable of a diverse range of functions. Processor 1500 can be a CSR BC04 Audio Processor with integrated Flash Memory that fully supports the Bluetooth v2.0+EDR specification. An oscillator 1510 and clock generation circuitry 1511 can be used in conjunction with a timing crystal to establish a timing signal (or clock) which processor 1500 can use to coordinate its activities.

RF circuitry 1520 can be used to input and output RF signals for wireless communications. Baseband circuitry 1530 can coordinate communications so that they conform with the a communications protocol (e.g., a Bluetooth protocol). Flash memory 1531 can store, for example, software and configuration information for processor 1500. Random access memory (RAM) 1532 can temporarily store data for Baseband circuitry 1530 and microprocessor 1533. RISC microprocessor 1533 can be programmed to perform various functions, such as monitor-

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ing a thermistor (see e.g., thermistor 1433 of FIG. 14) and coordinating battery charging as previously described, for example.

[0170] Full speed USB controller 1540 and UART circuitry 1541 can facilitate wired communication interfaces so that processor 1500 can share data with another device through a physical interface (e.g., connector contacts 1042 of FIG. 10A). In one embodiment, processor 1500 can support both full speed USB and simplified RS-232 serial interfaces. A simplified RS-232 interface can include, for example, three lines: transmit data, receive data, and ground. In order to accommodate more than one interface over a limited number of data lines, USB controller 1540 and UART circuitry 1541 can be coupled to a switch (e.g., UART Multiplexer 1416 of FIG. 14). This switch can route data lines to the circuitry, within processor 1500, that corresponds to the communication interface being used. A more detailed discussion of similar systems and methods for using more than one communications interface over a limited number of data lines can be found in U.S. Patent Application No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein. Processor 1500 can also support other interfaces in addition to those discussed above without deviating from the spirit of the present invention. For example, processor 1500 can include circuitry for supporting a proprietary communications interface.

[0171] Processor 1500 can include differential microphone input amplifier 1551 and differential speaker output amplifier 1552. Both the input amplifier 1551 and the output amplifier 1552 can be electrically coupled with Audio CODEC 1550 to process (e.g., encode and decode) audio signals. Power control and regulation circuitry 1560 can include low-dropout regulator (LDO) 1561, battery charger 1562 and switch mode power supply (SMPS) 1563. The power needed for the various subsystems of processor 1500 can be regulated by LDO 1561 or SMPS 1563 depending on both the charge level of the battery and any external power sources that might be connected. This will be described in more detail below in connection with the discussion of FIG. 16. Battery charger 1562 can output a controllable current between 25 and 100 milliamps to charge a battery (see e.g., battery pack 1119 of FIG. 11). In accordance with an embodiment of the present invention, this controllable current can vary based on various factors (e.g., the detected temperature of the battery).

[0172] Programmable I/O 1570 can include LED driver 1571 and analog-to-digital converter (ADC) 1572. LED driver 1571 can use signals from other circuitry in processor 1500 to generate signals with sufficient current to illuminate one or more indicator LEDs. The design and operation of exemplary circuitry similar to LED driver 1571 can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein. Analog-to-Digital Converter (ADC) 1572 can accept inputs from analog circuitry and convert them to digital signals to be used by other circuitry in processor 1500. For example, ADC 1572 can monitor the current running through a thermistor (see e.g., thermistor 1433 of FIG. 14) to determine the temperature of a battery. Circuitry in processor 1500 can use this temperature information to determine an appropriate charging current for battery charger 1562 to provide. Moreover, it is understood that ADC 1572 can process multiple analog signals concurrently. For example, in addition to the temperature information above, ADC 1572 can also process voltage information about the current charge level of a headset's battery.

[0173] While the processor described above and shown in FIG. 15 is a CSR BC04 Audio Processor, other processors with other configurations and functionality can be used in a headset without deviating from the spirit of the present invention.

[0174] FIG. 16 shows a simplified schematic of power distribution system 1600 for the subsystems of processor 1605 in accordance with an embodiment of the present invention. System 1600 can, for example, correspond to system 800 of FIG. 8 and headset 900 of FIG. 8. Moreover, processor 1605 can correspond to processor 1500 of FIG. 15. Processor 1605 can include both low-dropout regulator (LDO) 1620 and switch mode power supply (SMPS) 1625 as options for regulating power for processor 1605. SMPS 1625 can output power with a higher efficiency than LDO 1620, but can require the installation of several additional components, such as a relatively large capacitor and inductor, which can increase the cost (and size) of system 1600. In addition, SMPS 1625 may require an input voltage that meets, or exceeds, a predetermined voltage level to operate. Therefore, it may be a matter of design choice as to which power supply is used. For example, in low voltage applications, it may be advantageous to use LDO 1620. In other embodiments, such as the one shown in FIG. 16, LDO 1620 and SMPS 1625 can both be used to provide functionality over a wide range of input voltages and high power efficiency.

[0175] FIG. 16 shows processor 1605 which includes core circuitry 1610 and radio circuitry 1615 in accordance with an embodiment of the present invention. Radio circuitry 1615 can include, for example, circuitry related to RF communications. Additional functions (e.g., low-level system functions, firmware updates) can be executed by core circuitry 1610. Additionally, core circuitry 1610 can monitor and control other circuitry in system 1600 using, for example, input line 1614 and output lines 1611, 1612 and 1613.

[0176] Power distribution system 1600 can include circuitry for interfacing with two power sources. In FIG. 16, an internal battery is represented by BAT 1655, and an external power supply is represented as BUS 1650. From herein, the voltage of BAT 1655 will be referred to as VBAT. BUS 1650 can, for example, represent the power provided by a battery charger that is connected to system 1600. BUS 1650 can be electrically coupled with LDO

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1620 such that the LDO draws power from an external source through BUS. Therefore, LDO 1620 operates when an external power supply is connected to system 1600. Similarly, SMPS 1625 can be electrically coupled with BAT 1655 so that it draws power from the battery.

[0177] Other circuitry in power distribution system 1600 can include Power FET 1640, Analog-to-Digital Converter (ADC) 1630 and logic gates 1661, 1631 and 1632. Button 1660 can represent, for example, a signal from an on/off switch or other circuitry that can signal processor 1605.

[0178] An illustrative operation of system 1600, in which BAT 1655 is the only source of power, is now discussed. An absence of power on BUS 1650 prevents LDO 1620 from supplying power and causes FET 1640 to turn on, thereby effectively coupling nodes 1641 and 1642. System 1600 may be turned on when button 1660 is activated and outputs a high voltage. Activation of button 1660 can cause the button input of gate 1661 to go HIGH, which can cause the output of the gate 1661 to go HIGH. This HIGH signal can cause gate 1632 to assert a HIGH signal on its output. When gate 1632 outputs a high voltage, SMPS 1625 is activated and can begin providing power, if VBAT is at or above the predetermined voltage level (e.g., BAT 1655 has sufficient power to run SMPS 1625). Because power FET 1640 is on, the power provided by SMPS 1625 can be transmitted to radio circuitry 1615 and core circuitry 1610. As core circuitry 1610 begins to boot up, it can output a HIGH signal on line 1613 so that gate 1632 continues to output a HIGH signal after button 1660 is released. System 1600 can operate with full functionality at this point because both core circuitry 1610 and radio circuitry 1615 are receiving power. However, when VBAT drops below the predetermined voltage level (e.g., BAT 1655 is dead), SMPS may no longer be able to produce reliable power and system 1600 may begin to shut down.

[0179] An illustrative operation of system 1600 receiving power from an external power source on BUS 1650 is now discussed. The power on BUS 1650 can provide supply power to LDO 1620 and cause power FET 1640 to turn OFF or remain turned OFF, effectively decoupling nodes 1641 and 1642. Additionally, the power on BUS 1650 can cause gates 1661, 1631 and 1632 to output HIGH signals. When gate 1631 generates a HIGH signal, LDO 1620 can begin supplying power. Power from LDO 1620 may be provided to core circuitry 1610, but not to radio circuitry 1615, because power FET 1640 is not conducting. When core circuitry 1610 receives power, it can output a HIGH signal on line 1611 which causes the output of gate 1631 to maintain a HIGH signal so that LDO 1620 can continue operating.

[0180] SMPS 1625 may not be able to operate until VBAT has risen to or above the predetermined voltage level. Core circuitry 1610 can instruct battery charging circuitry (not shown) to begin using power from BUS 1650 to charge BAT 1655. Core circuitry 1610 can receive signals (e.g., digital signals) from ADC 1630 over line 1614. ADC 1630 can be electrically coupled with BAT 1655. ADC 1630 can convert a signal with a varying voltage (e.g., VBAT) into a digital signal that can be processed by core circuitry 1610. When VBAT has met or exceeded the predetermined voltage level, SMPS 1625 may now be able to operate and provide radio circuitry 1615 with power. Note that in some embodiments, SMPS 1625 may be powered ON substantially immediately when an external power service is connected to BUS 1650. Using ADC 1630, core circuitry 1610 can detect when SMPS turns on and coordinate the functions of processor 1605 accordingly. For example, when radio circuitry 1615 is powered, core circuitry 1610 can begin sending communications data to radio circuitry 1615. In this manner, processor 1605 can operate with full functionality before BAT 1655 is fully charged.

[0181] While BAT 1655 is charging, core circuitry 1610 can perform various other functions, regardless of whether VBAT has met or exceeded the predetermined voltage level. For example, core circuitry 1610 can run boot up processes, communicate over wired interfaces and run user interfaces. In this manner, core circuitry 1610 can, for example, handle auxiliary processes (e.g., downloading firmware updates via a wired interface and installing the updates) before processor 1605 has full functionality.

[0182] Several benefits may be realized by power distribution system 1600 in the manner discussed above. For example, the core circuitry 1610 can turn ON before the battery has reached a minimum charge threshold. This enables core circuitry 1610 to handle boot up processes in advance, thereby enabling headset to begin working immediately once the battery is charged to the minimum level. In effect, certain components may be powered independent of BAT 1655 when an external power supply is connected to BUS 1650.

[0183] Additionally, system 1600 limits the unnecessary use of BAT 1655. Traditionally, known headset circuitry is powered through a battery even if an external power supply is present. The power drained from the battery is then recharged using power from the external power supply. This charging and recharging can shorten a battery's lifespan. System 1600 allows core circuitry 1610 to draw power independent of BAT 1655 and directly from an external supply (if present) , extending the life of BAT 1655.

[0184] To provide additional functionality, output line 1612 can be included in core circuitry 1610 so that the core circuitry can shut down system 1600. Line 1612 can be coupled with node 1633 such that line 1612 can drive node 1633 to a LOW signal. Therefore, if core circuitry outputs LOW signals to lines 1611, 1612 and 1613, the output of gates 1631 and 1632 go LOW, turning off both LDO 1620 and SMPS 1625, which causes core circuitry 1610 and radio circuitry 1615 to turn off.

[0185] While the previous discussion described a method and system for separately powering on core and RF radio circuitries, the same techniques can be applied to other electronic subsystems which, for example, might

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be unrelated to RF communications.

[0186] FIGS. 17A-17C show different views of known headset circuit boards, with particular emphasis on how circuitry and components are distributed therein. Electrical components 1796, including processor 1792, may be mounted on two sides of circuit board 1790. As can be appreciated by one of skill in the art, circuit board 1790 may occupy a relatively large, undistributed area. Such circuit boards can limit the amount that other components (e.g., batteries, buttons, antennas) are spatially integrated with the electronics. Thus, known headsets have to be relatively large to accommodate such boards and other components.

[0187] FIG. 18 is a simplified schematic system diagram of a headset showing a circuit board arrangement in accordance with an embodiment of the present invention. System 1800 can correspond to headset 500 of FIG. 5, for example. System 1800 can be divided into two independent and separately arranged circuit boards 1810 and 1820. That is, when boards 1810 and 1820 are installed in a headset according to an embodiment of the present invention, the boards may be electronically coupled to each other, but the boards themselves are discrete. Circuit board 1810 corresponds to earbud circuit board 522 of FIG. 5 and earbud circuit board 1122 of FIG. 11 and can include, for example, Bluetooth processor 1812, circuitry that requires placement close to the processor, balance RF filter circuitry 1814 and coaxial connector (see e.g., connector 2752 of FIG. 27B). Examples of circuitry required close proximity to processor 1812 can include a timing crystal, charging inductors, capacitors, field effect transistors and resistors.

[0188] Circuit board 1820 corresponds to primary housing circuit board 512 of FIG. 5 and primary housing circuit board 1115 of FIG. 11 and can, for example, include RF Antenna 1822, interface circuitry 1823, power distribution circuitry 1824, switching circuitry 1825, 4-pin symmetrical magnetic connector 1826, RF matching circuitry 1821 and coaxial connector (see e.g., connector 2752 of FIG. 27B).

[0189] Circuit boards 1810 and 1820 can be electrically coupled using, for example, co-ax cable 1830 and bus 1832. In the embodiment shown in FIG. 18, bus 1832 includes ten lines, but one of ordinary skill in the art will appreciate that the number of lines in the bus can vary.

[0190] Balance RF filter circuitry 1814 and RF matching circuitry 1821 can adjust RF signals to compensate for the specific effects of circuit board 1810, co-ax cable 1830, circuit board 1820 and antenna 1822. The functions of elements of additional circuitry in circuit board 1810 and 1820 have been described in more detail in the above discussion relating to FIG. 14.

[0191] FIGS. 19A and 19B compare respective top and bottom views of earbud circuit board 1920 according to an embodiment of the present invention to respective top and bottom views of the known circuit boards shown in FIGS. 17A-17C. In addition, FIGS. 19A and 19B show that selected components of known circuit board 1990 can be arranged on earbud circuit board 1920. For example, as shown, the encircled circuit and components such as components 1996 and processor 1992 can be placed on one or more sides of earbud circuit board 1920. The remaining electronic components such as components 1996 can be placed on primary housing circuit board (see e.g., circuit board 1115 of FIG. 11) which may be located inside the headset's primary housing.

[0192] Earbud circuit board 1920 can include a layer made from a flexible substrate that enables circuit board 1920 to bend onto itself, thereby effectively reducing the area needed to install circuit board 1920 into a headset according to the invention. The flexible layer of circuit board 1920 can include one or more layers of electrical traces for electrically coupling processor 1922 and electronic components 1926, for example. The flexible layer of circuit board 1920 can, for example, extend over the entire footprint of the circuit board, or be limited to predetermined portions of circuit board 1920.

[0193] Circuit board 1920 can include relatively rigid sections 1923, 1925 and 1927 which have increased structural strength and are easier to mount electrical components to. Rigid circuit board sections 1923, 1925, and 1927 can be fabricated by attaching rigid circuit board pieces to one or more outer surfaces of the flexible layer of circuit board 1920. Rigid pieces can be attached to a flexible layer using any suitable process, such as applying an adhesive, for example. Contacts can be included on complementary surfaces of the rigid pieces and the flex layer so that electrical traces can be routed across the different layers. One or more layers of electrical traces can be included in the rigid circuit board pieces so that the combination of rigid and flex layers can provide two or more layers of electrical traces. In the embodiment shown in FIGS. 19A and 19B, a flex circuit layer with two levels of traces can be located in between two rigid, single-trace layers such that the resulting rigid sections of circuit board 1920 include four layers of traces. In flexible sections of circuit board 1920, such as connector lead 1921, the absence of rigid pieces can result in two levels of traces.

[0194] Rigid sections 1925 and 1927 can have substantially circular footprints with different radii. Various electrical components, such as capacitors and resistors, for example, can be mounted on both sides of rigid section 1925. Rigid section 1927 can have a larger footprint than section 1925 in order to accommodate the mounting of processor 1922 on a first side and receiver 1924 on a second side of section 1925. Connector 1928 can be mounted to rigid section 1923 to enable earbud circuit board 1920 to electrically couple with a primary housing circuit board (see e.g., circuit board 1115 of FIG. 11).

[0195] FIGS. 20A and 20B show side and perspective views of earbud circuit board 2020 in a folded configuration in accordance with an embodiment of the present invention. Earbud circuit board 2020 may, for example, correspond to earbud circuit board 1920. The folded configuration may correspond to the configuration of circuit

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board 2020 when installed within a headset, or more particularly, the earbud of the headset, as shown in FIG. 20C. Top rigid section 2027 can be folded over middle rigid section 2025 so that both sections can fit in the earbud of a headset. Processor 2022, receiver 2024 and various other electronic components 2026 may be mounted to earbud circuit board 2020. Electronic components 2026 can include resistors, capacitors, transistors, amplifiers and other types of both passive and active electronic components, for example. It is to be understood that the term electronic components, as used herein, does not include interconnect devices (e.g., wires, traces, connectors, etc.). Earbud circuit board 2020 can further include rigid section 2023 and connector 2028 mounted thereon. Connector 2028 can be used to electrically couple earbud circuit board 2020 with a circuit board in a headset's primary housing (see e.g., circuit board 1115 or circuit board 2011).

[0196] Referring now to FIG. 20C, which shows earbud circuit board 2020 and primary housing circuit board 2011 installed in a possible configuration within headset 2000 in accordance with an embodiment of the present invention. Circuit board 2020 can be folded in a configuration similar to that of FIGS. 20A and 20B and inserted into earbud 2014. Primary housing circuit board 2011 can include a combination of rigid and flexible sections that are similar, in composition but not necessarily shape, to the rigid and flexible sections of circuit board 2020. Circuit board 2011 can be folded to provide a cavity 2012 for a battery (see e.g., battery pack 1119 of FIG. 11). Circuit board 2011 can include connector 2018 which may connect to connector 2028 of earbud circuit board 2020. During installation, circuit board 2011 can be inserted through one of the open ends of primary housing 2010. Connector lead 2021 can be fed through headset neck 2013 so connector 2028 can mate with connector 2018 when circuit board 2011 has been inserted into primary housing 2010.

[0197] This distribution of electronics, where processor 2022 and other circuitry (e.g., receiver 2024 and other electronic components 2026) are located inside earbud 2014, advantageously allows for a generally smaller and more comfortable headset. Although the discussion above is related to an embodiment in which a certain distribution of electronic components is used, other distributions can be used without deviating from the spirit of the present invention. For example, a battery can be placed inside the earbud and a processor can be placed in the primary housing.

[0198] FIG. 21A shows a perspective view of earbud housing 2100 and neck 2110 in accordance with an embodiment of the present invention. Bezel 2130 can cover the top of earbud housing 2100. One or more acoustic ports 2102 can be located in the wall of the earbud to allow pressure to vent out of earbud housing 2100.

[0199] FIG. 21B shows an exploded view of earbud housing 2100 of FIG. 21A in accordance with an embodiment of the present invention. Screens 2131 and 2132 can be located on top of bezel 2130. Screens 2131 and 2132 can, for example, provide dust protection and acoustic resistance. Top gasket 2134 can be attached to the underside of bezel 2130 to create a seal with receiver 2124, and bottom gasket 2123 can be attached to section 2127 (a rigid section) of circuit board 2120. Bracket 2135 can be used to mount circuit board 2120 inside earbud housing 2100. Mesh can cover acoustic ports 2102 and can, for example, impose acoustic resistance on air passing through those ports. Screw 2112 can be used to mount earbud housing 2100 to neck 2110. Gaskets 2134 and 2123 can be made of, for example, foam, rubber, or any other compressible material so that the gaskets can form acoustic (e.g., substantially air-tight) seals with surrounding parts.

[0200] FIG. 22 shows an interior view of empty earbud housing 2200 in accordance with an embodiment of the present invention. Mesh 2204 can be located on the inner wall of housing 2200 to control the flow of air through one or more acoustic ports 2202 and prevent foreign objects (e.g., dirt) from entering housing 2200. Mesh 2204 can, for example, be affixed to housing 2200 using an adhesive. Mesh 2204 can be made of nylon, plastic, or any other suitable material. Mesh 2204 can provide acoustic resistance to the passage of air between an acoustic volume inside housing 2200 and the outside environment when the earbud is assembled. Even though only one acoustic port is shown in FIG. 22, any number of acoustic ports can be used in accordance with the principles of the present invention.

[0201] FIG. 23 shows rigid section 2327 of an earbud circuit board mounted inside earbud housing 2300 in accordance with an embodiment of the present invention. Acoustic port 2328 can be provided in circuit board section 2327 to permit air flow through the circuit board. The size, shape and location of acoustic port 2328 can vary depending on, for example, the acoustic properties of the earbud and the desired sound output. If desired, more than one acoustic port may be provided. Although not shown in FIG. 23, a second rigid portion of the earbud circuit board, such as rigid section 2025 of FIGS. 20A and 20B, may too include one or more acoustic ports. Though such port(s) may not be necessary if sufficient air gaps exist between the inside wall of housing 2300 and the second rigid portion.

[0202] FIG. 24 shows bottom gasket 2440 mounted onto circuit board section 2427 in accordance with an embodiment of the present invention. Bottom gasket 2440 can include an combination of, for example, acoustic mesh 2430, adhesive, and foam 2441. Foam 2441 of gasket 2440 can be shaped to fit around receiver (see e.g., gasket 2740 and receiver 2724 of FIG. 27A) and acoustic port 2428. Mesh 2430 can be shaped to cover port 2428. In this manner, acoustic mesh 2430 can cover acoustic port 2428 even though foam 2441 does not. Mesh 2430 can be made of nylon, plastic, or any other suitable material that can provide acoustic resistance to the passage of air through port 2428 which couples the

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acoustic volume under circuit board section 2427 (see e.g., acoustic volume 2796 of FIGS. 27A and 27B) with the acoustic volume where the receiver is located (see e.g., acoustic volume 2794 of FIG. 27A).

[0203] FIG. 25 shows the underside of bezel 2530 in accordance with an embodiment of the present invention. Bezel 2530 can include rim 2536 which extends from the bottom of bezel 2530. Rim 2536 can be of sufficient height to compress bottom gasket 2440 of FIG. 24 against circuit board section 2427 of FIG. 24 when bezel 2530 is mounted to the top of the earbud housing, thereby creating an acoustic seal between the rim and the circuit board. Gasket 2534 can be, for example, a layer of foam that is affixed to the underside of bezel 2530 using adhesive. Gasket 2534 can be shaped so that it can form a seal with the top of the earbud's receiver when bezel 2530 is mounted to the earbud. Bezel 2530 includes acoustic port 2533 for sound to exit an earbud. Screen 2531 can be located on the topside of bezel 2530 so that the screen completely covers acoustic port 2533. Screen 2531 can apply an acoustic resistance to air passing through acoustic port 2533.

[0204] FIG. 26A shows the underside of bezel 2630 with receiver 2620 installed in accordance with an embodiment of the present invention. Receiver 2620 can be placed inside rim 2636 so that the front output of receiver 2620 is encircled by the seal formed between the top of the earbud's receiver and the top gasket (see e.g., top gasket 2134 of FIG. 21B). Receiver 2620 can include spring contacts 2622 and 2624. Spring contacts 2622 and 2624 can, for example, be made from a metal or an alloy. Springs contact 2622 and 2624 can electrically couple with circuitry in a headset in order to input audio signals to receiver 2620.

[0205] FIG. 26B shows a cross-sectional view of receiver 2620 in accordance with an embodiment of the invention. Receiver 2620 can include spring contacts 2622 and 2624 which can connect receiver 2620 with a source of electrical signals (e.g., earbud circuit board 1115 of FIG. 11). Contacts 2622 and 2624 can include tips 2623 and 2625 to facilitate the physical contact with a contact on a circuit (e.g. a flex circuit board).

[0206] FIG. 27A shows a cross-sectional view of earbud housing 2700 with receiver 2724 and circuit board 2720 installed in accordance with an embodiment of the present invention. Bezel 2730 is mounted on top of earbud housing 2700. Bezel 2730 can be attached to housing 2700 using a notch and rib configuration 2738 or any other suitable method of attachment, such as adhesive, for example. In an alternative embodiment of the present invention, bezel 2730 can be integrally formed with earbud housing 2700. Neck 2710 can be coupled to the bottom of earbud housing 2700. Earbud circuit board 2720 can be located inside the earbud and extend through lumen 2716 of neck 2710.

[0207] Located on the top of bezel 2730, screens 2731 and 2732 can cover audio port 2733. Audio port 2733 can allow air to pass between the external environment 2798 and front volume 2792 of receiver 2724. Top gasket 2734 and bottom gasket 2740 can create acoustic seals around receiver 2724 so that receiver volume 2794 is created. Acoustic port 2728 can allow air to pass through top rigid section 2727 of circuit board 2720 so that a port between receiver volume 2794 and rear earbud volume 2796 is created. Acoustic port 2702 can be located in earbud housing 2700 so that air can pass between rear earbud volume 2796 and the external environment 2798. Mesh (see e.g., mesh 2204 of FIG. 22) can be applied to the inner wall of earbud housing 2700 to cover acoustic port 2702 such that some resistance is applied to air passing through the port.

[0208] In one embodiment of the present invention, receiver 2724 can form at least part of a wall defining front volume 2792 and at least part of a wall defining receiver volume 2794. Rim 2736 of bezel 2730 can extend from the bezel into the interior of the earbud and compress against bottom gasket 2740, thereby also forming at least part of a wall defining receiver volume 2794. In one embodiment of the present invention, top rigid section 2727 of circuit board 2720 can be disposed between receiver volume 2794 and rear earbud volume 2796, thereby forming at least part of a wall defining receiver volume 2794 and at least part of a wall defining rear earbud volume 2796. To ensure the desired acoustic seal between receiver volume 2794 and rear earbud volume 2796, top rigid section 2727 of circuit board 2720 can be rigidly coupled to earbud housing 2700, directly or indirectly. In contrast, in one embodiment of the present invention, middle rigid section 2725 of circuit board 2720, which can be disposed within rear earbud volume 2796, can be flexibly coupled to the earbud housing, directly or indirectly (e.g., via top rigid section 2727 and flexible section 2729 of circuit board 2720). As used herein, when a component forms part of a wall defining an acoustic volume, the component can do so directly or indirectly. For example, the component can directly form part of a wall defining an acoustic volume when part of the component is open to the acoustic volume. The component can indirectly form part of a wall defining an acoustic volume when the component is incorporated into another component open to the acoustic volume.

[0209] In order to prevent sound from exiting rear earbud volume 2796 through lumen 2716, a substance, such as silicon glue, can be used to fill the inside of neck 2710. It is advantageous to prevent sound from receiver 2724 leaking into the headset's primary housing (see e.g., primary housing 11 of FIG. 1) because the microphone is located therein. If sound from the receiver is picked up by the microphone, a potentially undesirable echo may be created.

[0210] FIG. 27B shows a cross-sectional view of earbud housing 2700 with coaxial cable 2750 and conductive stopper 2760 installed in accordance with an embodiment of the present invention. Coaxial cable 2750 can couple to rigid section 2725 of circuit board 2720 using connector 2752, for example. Coaxial cable 2750 can be

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used to couple a processor in earbud housing 2700 with an antenna provided in a headset's primary housing (see e.g., antenna 1218 in primary housing 1210). Coaxial cable 2750 can include, for example, an insulated wire surrounded by a conductive shield and an outer insulator. In some embodiments, the outer insulator may be removed from at least a portion of cable 2750. For example, insulator can be removed to create exposed portion 2754 of the cable such that the insulator can be electrically coupled with (e.g., grounded to) insert 2712. Insert 2712 can be grounded to neck 2710 through the insert's threads and the neck can be grounded to a headset's primary housing (see e.g., housing 11 of FIG. 1). By grounding the insulator of cable 2750, electromagnetic interference and other negative effects may be reduced thereby increasing the wireless performance of a headset.

[0211] Conductive stopper 2760 can be installed in the lumen 2716 of insert 2712. In some embodiments, conductive stopper 2760 can be made of silicone and filled with silver. Conductive stopper 2760 can include a slit for circuit board 2720 and coaxial cable 2750 to pass through lumen 2716. Providing conductive stopper 2760 in neck 2710 can have several benefits. For example, conductive stopper 2760 can help isolate any sounds in acoustic volume 2796 from a headset's primary housing. In some embodiments, conductive stopper 2760 can also press exposed portion 2754 of cable 2750 against the wall of insert 2712 such that the cable's insulator is always electrically coupled with (e.g., grounded to) the insert. In other embodiments, stopper 2760 can be made from a conductive material such that the stopper can electrically coupled exposed portion 2754 of the cable with insert 2712.

[0212] FIG. 28 shows a view of unassembled pieces of attachment system 2800 that can be used to attach earbud housing 2820 to primary housing 2810 in accordance with an embodiment of the present invention. The configuration described below can allow for a mechanically robust connection which prevents housing 2820 from rotating with respect to primary housing 2810. An additional benefit of this design is the open lumen that can be used to run wires (or flexible printed circuit boards) between the earbud and primary housing. Attachment system 2800 can, for example, correspond to device 600 of FIGS. 6A and 6B.

[0213] Attachment system 2800 can include insert 2840, earbud housing 2820, neck 2830, insert 2850 and primary housing 2810. In order to simplify manufacturing, inserts 2840 and 2850 can be substantially similar and can both include features 2841, (e.g., notches), threads 2842 and a through-hole. Features 2841 can be arranged in a pattern to promote proper interface with certain tools. A custom tool which can interface with inserts 2840 and 2850 is described in more detail in the discussion below corresponding to FIGS. 30A-30C.

[0214] Primary housing 2810 can include through-hole 2814. Insert 2850 can be located in primary housing 2810 so that the threaded part of insert 2850 protrudes through through-hole 2814. A through-hole can be provided through neck 2830, and the interior can be threaded so the neck can couple with inserts 2850 and 2840. Earbud housing 2820 can include an through-hole (see e.g., through-hole 612 of FIG. 6A) through which insert 2840 can pass to couple with neck 2830.

[0215] The top surface of neck 2830 can include one or more protrusions 2831 (e.g., tabs) which can interface with one or more slots (e.g., notches) in the bottom of housing 2820 to prevent the two parts from rotating independently of each other when coupled together. The slots in the bottom of housing 2820 are not shown in FIG. 28, but slots similar to slots 2816 can be provided on the neck engaging surface of earbud housing 2820 in accordance with an embodiment of the present invention. Earbud housing 2820 can have a curved exterior surface that can form a nearly seamless transition with the curved exterior surface of neck 2830.

[0216] The bottom surface of neck 2830 can include protrusions that interface with one or more slots 2816 in housing 2810 to prevent the two parts from rotating independently of each other when coupled together. The protrusions on the bottom surface of neck 2830 are not shown in FIG. 28, but protrusions similar to protrusions 2831 can be provided on the bottom surface of neck 2830 in accordance with an embodiment of the present invention. Primary housing 2810 can include recessed region 2818 so that the bottom surface of neck 2830 can be recessed below the primary exterior surface of the housing. Moreover, the exterior of neck 2830 can be shaped to provide a nearly seamless transition from earbud housing 2820 to primary housing 2810.

[0217] Neck 2830 and inserts 2840 and 2850 can be made from any suitable material (e.g., metals or polycarbonates). For example, neck 2830 can be made from aluminum and inserts 2840 and 2850 can be made from steel. The choice of materials for neck 2830 and inserts 2840 and 2850 can depend on factors such as structural strength, weight, price, ability to be machined, and cosmetic appearance.

[0218] FIG. 29 shows a flowchart of process 2900 for connecting a headset earbud with a primary housing (e.g., a tube) in accordance with an embodiment of the present invention. Note that the protrusions and slots of FIG. 28 are referred to, respectively, as tabs and notches in process 2900. At step 2901, a bottom insert (such as insert 2850 of FIG. 28) can be inserted into a primary housing. The bottom insert can be inserted from either side of the primary housing and manipulated so that the threaded end is protruding from a through-hole in the wall of the primary housing. At step 2902, thread-locking glue can be applied to the threads of the bottom insert. The glue can be applied so that it covers a complete circular path around the threads of the insert. Alternatively, the glue can be applied to just one section of the threads. The glue can be selected in order to prevent the insert from unscrewing itself due to external forces (e.g., vibra-

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tion). In one embodiment, a sufficient quantity of glue may be applied to the threads of the insert to prevent moisture and other harmful elements from entering the inside of a headset through a seam which may exist between the neck and the primary housing. At step 2903, a neck (such as neck 2830 of FIG. 28) can be screwed onto the insert to a predetermined level. At step 2904, the neck can be aligned to the primary housing so that one or more tabs (e.g., protrusions 2831) on the neck fit within one or more notches on the primary housing. At step 2905, a custom tool can be used to turn the bottom insert while the neck is rotationally fixed to the primary housing. At step 2906, the bottom insert can be tightened to a predetermined torque. This torque measurement can be estimated by hand or performed with a calibrated torque wrench. At step 2907, an earbud housing can be mounted to the neck so that one or more tabs on the neck fit within one or more notches on the earbud housing. At step 2908, thread-locking glue can be applied to the top insert threads. The glue used on the threads of the top insert can be the same as the glue used on the threads of the bottom insert and can be applied in a similar manner. At step 2909, the top insert can be screwed into the neck. At step 2910, the top insert can be tightened to a predetermined torque.

[0219] FIGS. 30A and 30B show custom tool 3000 that can be used to manipulate an insert (e.g., insert 2840 or insert 2850) with respect to a neck (e.g., neck 2830) in accordance with an embodiment of the present invention. Tool 3000 can include two members 3010 and 3020 which can be coupled together by fastener 3030. Fastener 3030 can allow members 3010 and 3020 to rotate (or pivot) independently around the faster.

[0220] Members 3010 and 3020 can include appendages 3011 and 3021 which can be used by a user to control tool 3000. Appendages 3011 and 3021 can be an ergonomic size and shape. For example, appendages 3021 can be curved to accommodate an average human hand. Appendages 3011 and 3021 can include plastic covers 3012 and 3022 with ridges 3013 and 3023 such that a user can easily grip the appendages with his/her hands. A spring 3040 can be coupled with appendages 3011 and 3021 such that the appendages are biased to separate from each other.

[0221] Members 3010 and 3020 may control the movement of manipulators 3014 and 3024, which can interface with a part, such as an insert. For example, when appendages 3011 and 3021 are squeezed together, manipulators 3014 and 3024 may be forced apart. Manipulators 3014 and 3024 can include narrow sections 3015 and 3025 and tips 3016 and 3026.

[0222] FIG. 30B shows a detailed view of the shape of tips 3016 and 3026 in accordance with an embodiment of the present invention. Tips 3016 and 3026 can include outward facing tabs 3017 and 3027 which can interface with features (see e.g., features 2841 of FIG. 28) of inserts in order to manipulate (e.g., screw into place) the inserts. Tabs 3017 and 3027 can form the outer surface of narrow sections 3015 and 3025.

[0223] FIG. 30C shows custom tool 3000 coupling neck 3090 with primary housing 3092 in accordance with step 2905 of FIG. 29 according to an embodiment of the present invention. FIG. 30C illustrates how the narrow section of the manipulators can be of sufficient length so that tabs 3017 and 3027 can interface with features on the insert (see e.g., features 2841 of FIG. 28). Note that to preserve the structural strength of the manipulators, the narrow section may not be constructed to be substantially longer than necessary.

[0224] Extruded tubes with internal features for securing elements are useful for electronic devices. For example, such tubes can be used as a primary housing (see e.g., housing 11 of FIG. 1) or an earbud housing (see e.g., earbud 12 of FIG. 1). The following discussion describes different processes for creating a tube having an internal wall, for example, for supporting circuitry or electronic components. It will be understood, however that the processes and devices described can be used to create any suitable feature on the inner surface of a tubular structure.

[0225] FIG. 31 is a cross-sectional view of a tube having an internal wall 3104 in accordance with an embodiment of the present invention. Tube 3100 has a wall thickness 3102, and includes internal wall 3104 that extends inward perpendicular from the elongated axis of the tube. Internal wall 3104 has a thickness 3106 and a height 3108 (as measured from the outer surface of the tube). The discussion accompanying FIGS. 32-33, 34-36, 37-28, 39-40, and 41-43 respectively relate to various methods for creating tube 3100 in accordance with some embodiments of the present invention.

[0226] Known extrusion processes are unable to extrude tubes with internal features such as an internal wall (e.g., internal wall 3104). For example, known extrusion processes involve forcing a molten material through an aperture in order to create an object with a cross-sectional shape that is similar to the shape of the aperture. This type of process is incapable of producing tubes with discreet internal features because such a tube will have a cross-sectional shape that varies along the length of the tube. To overcome this limitation, existing processes require manufacturing a tube having a wall thickness equal to the required height of the feature (e.g., height 3108), and subsequently removing excess material around the feature using a machining process so that the final wall thickness meets the desired specification (e.g., thickness 3102). FIG. 32 is a cross section of an illustrative tube manufactured with a wall thickness that is thicker than the desired end product wall thickness in accordance with an embodiment of the present invention. Tube 3200 may be formed from any material (e.g., metal, plastic, or composite) using any suitable process (e.g., extrusion, impact extrusion, or progressive deep draw). Wall thickness 3202 may be selected based on the features that will be carved into tube 3200.

[0227] FIG. 33 is a perspective view of a cross section

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of the illustrative tube of FIG. 32 once the tube has been machined to include an internal wall in accordance with an embodiment of the present invention. To form internal wall 3204 in tube 3200, the entire inner surface 3201 of tube 3200 is machined to remove excess material around the internal wall and to reduce tube thickness 3202 to a desired wall thickness. This machining step may be time consuming, expensive, and difficult to implement, as it requires an experienced machinist and expensive tools. Furthermore, machining may also leave marks on the part, which may be undesired (e.g., for aesthetic reasons). Also, some features may include geometry or aspects that cannot be manufactured by machining (e.g., sharp angles not directly accessible from either end of the tube) or features that cannot be manufactured within the required tolerances (e.g., due to the inherent size of the machining tools).

[0228] To overcome the limitations of an entirely machined tube, a number of approaches may be used. FIG. 34 is an illustrative die and stamper for modifying the internal aspect of a tube in accordance with an embodiment of the present invention. Tube 3400 is extruded with the desired final thickness 3402 required for the tube. Tube 3400 is extruded to a slightly longer length 3403 than required for the final product, as the longer portion may be part of a cold-worked process that is used to create the internal wall. A die 3410 may be inserted in a first end of tube 3400 and inserted such that die end 3412 is aligned with a desired location of internal wall 3404 (see FIG. 36). Die 3410 may fit flush against the inside wall of tube 3400 and may be operative to maintain wall thickness 3402 when stamper 3420 is used to cold-work the tubing not in contact with die 3410. Stamper 3420 is then inserted into the second end of tube 3400, and a stamping force is applied to cold work the portion of tube 3400 located between the second end and die 3410. Stamper 3420 causes the wall thickness 3422 of tube 3400 to increase in the cold worked portion of tube 3400 by forcing the excess tube length to be cold-worked into the internal wall. The shape of stamper 3420 and the distance between the second end of tube 3400 and die end 3412 may be set to obtain the desired thickness for internal wall 3404.

[0229] FIG. 35 is an cross-sectional view of the tube of FIG. 34 after stamper 3420 and die 3410 are removed from tube 3400 in accordance with an embodiment of the present invention. After stamping, tube 3400 includes two thicknesses, thickness 3402 which is the expected final thickness of the tube, and thickness 3422, which corresponds a maximum possible height of any internal wall that may be machined from the thicker portion.

[0230] To create internal wall 3404, portions of inner surface 3401 of tube 3400 may be machined. FIG. 36 is a perspective view of the tube of FIG. 35 when the tube is machined to create an internal wall in accordance with an embodiment of the present invention. The portions of inner surface 3401 having thickness 3422 may be machined to thickness 3402 such that internal wall 3404 remains in tube 3400. Surface 3430 of FIG. 36 can identify the surfaces that are machined to complete tube 3400. An advantage of this process over the process described in FIGS. 32 and 33 is that the amount of machining required for the tube can be greatly reduced, as are costs.

[0231] Another approach for forming features in a tube may include impact extrusion of one end of the tube. FIG. 37 is a cross section of an illustrative tube formed using impact extrusion in accordance with an embodiment of the present invention. Tube 3700 having wall thickness 3702 is formed using impact extrusion. Impact extrusion creates an indentation that extends to surface 3710, which corresponds to the surface of internal wall 3704 (FIG. 38) of tube 3700. The end of tube 3700 remains closed by material 3722.

[0232] To complete tube 3700 and construct internal wall 3704, material 3722 may be machined. FIG. 38 is a perspective view of the tube of FIG. 37 when tube 3700 is machined to create an internal wall in accordance with an embodiment of the present invention. Material 3722 may be machined to leave inner surface 3701 of tube 3700 with thickness 3702, and with internal wall 3704 extending from inner surface 3701. Surface 3730 may represent the surface that is machined to create wall 3704. Similar to the process of FIGS. 34-36, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0233] Another approach for forming features in a tube may include impact extrusion of both ends of a tube. FIG. 39 is a cross section of an illustrative tube 3900 formed using impact extrusion in accordance with an embodiment of the present invention. Tube 3900 having final wall thickness 3902 is formed using multiple impact extrusions. The impact extrusions create a first indentation 3910 that extends to surface 3912 with surrounding interior surface 3901 and a second indentation 3914 that extends to surface 3916 with surrounding interior surface 3921. The thickness of tube 3900 left by first indentation 3910 is thickness 3902, which may be the expected final thickness of the tube. The thickness of tube 3900 left by second indentation 3914 is thickness 3922. The difference between thickness 3902 and thickness 3922 may correspond to height 3908 of internal wall 3904.

[0234] In some embodiments, if internal wall 3904 is configured to be constrained between surfaces 3912 and 3916, the distance between surfaces 3912 and 3916 may correspond to the thickness 3906 of internal wall 3904. In embodiments where internal wall 3904 is constrained between surfaces 3912 and 3916, thickness 3922 may be the same as thickness 3902 (i.e., substantially the expected final thickness of tube 3900) because internal wall 3904 having height 3908 (as shown in FIG. 40) may be machined from the material left between surfaces 3912 and 3916. In such embodiments, height 3908 of internal wall 3904 may be determined by the machining process.

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[0235] To complete tube 3900 and construct internal wall 3904, material between surface 3912 and 3916 may be machined. Material may also be machined from interior surface 3921. FIG. 40 is a perspective view of the tube of FIG. 39 once the tube is machined to create an internal wall in accordance with an embodiment of the present invention. In some embodiments, material may be machined to leave interior surface 3921 with thickness 3902, and with internal wall 3904 extending from interior surfaces 3901 and/or 3921. Surface 3930 of FIG. 40 identifies the surface that may be machined to complete tube 3900. Similar to the processes of FIGS. 34-36 and 37-38, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0236] Yet another approach for forming features in a tube may include a progressive deep draw process. FIG. 41 is a cross section of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present invention. Tube 4100 is constructed to have two consecutive indentations 4110 and 4114 having distinct wall thicknesses. Indentation 4110 has wall thickness 4102, which may be the expected final thickness of tube 4100, and indentation 4114 has wall thickness 4122.

Tube 4100 may transition from indentation 4110 to indentation 4114 at plane 4112, which may correspond to the location of internal wall 4104 (FIG. 43) configured to be constructed in inner surface 4101 (FIG. 43) of tube 4100.

[0237] FIG. 42 is a perspective view of a cross section of the tube of FIG. 41 in accordance with an embodiment of the present invention. As shown in FIG. 42, tube 4100 is closed at the end of indentation 4114 by material 4124. To complete tube 4100 and construct internal wall 4104, material 4124 may be machined to open tube 4100, and indentation 4114 may be machined to reduce thickness 4122 to the thickness 4102 (e.g., the final expected thickness) while leaving internal wall 4104.

[0238] FIG. 43 is a perspective view of the tube of FIGS. 41 and 42 after the tube is machined to create an internal wall in accordance with an embodiment of the present invention. Surface 4130 of FIG. 43 identifies the surfaces that are machined to complete tube 4100. Similarly to the process of FIGS. 34-36, this process is advantageous over the process described in FIGS. 32-33 because the amount of machining required for the tube can be greatly reduced.

[0239] The following flow charts illustrate methods for forming a tube with a feature on the internal surface of the tube using embodiments of the invention described above. Internal features may include, for example, a wall, a protrusion, an aperture, a snap, a shelf, or any other suitable feature. FIG. 44 is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube using a die and stamper in accordance with an embodiment of the present invention. Process 4400 begins at step 4410. At step 4410, a tube is extruded and cut to a length that is slightly longer than the desired finished length. At step 4420, a die is inserted in one end of the tube, such that the end of the die placed in the tube extends to a desired location where the feature is intended to exist in the tube.

[0240] At step 4430, a stamper is inserted in the second end of the tube. At step 4440, a force is applied to the stamper to force excess material into the tube, thus cold working the tube to increase the thickness of the tube in the region adjacent the stamper. At step 4450, the tube is machined to form the feature. Process 4400 then ends at step 4450.

[0241] FIG. 45 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention. Process 4500 begins at step 4510. At step 4510, an indentation is formed in the material of the tube by impact extrusion such that the end of the indentation aligns with a desired location of the feature in the tube. At step 4520, the closed end of the material is machined to form the tube and the feature. Process 4500 then ends a step 4520.

[0242] FIG. 46 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention. Process 4600 begins at step 4610. At step 4610, a first indentation is formed in the material of the tube using a first impact extrusion. At step 4620, a second indentation opposing the first indentation is formed in the material using a second impact extrusion. The ends of the first and second indentations may be configured to align with the boundaries of the feature. At step 4630, the feature is machined in the material remaining between the first and second indentations. Process 4600 then ends at step 4630.

[0243] In an alternative embodiment of the present invention, steps 4610 and 4620 can be combined into one step, as indicated by the dotted line around steps 4610 and 4620 in FIG. 46. That is, the first and second indentations can be formed using a single impact. Advantageously, this can be more efficient than forming first and second indentations from two impacts.

[0244] FIG. 47 is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention. Process 4700 begins at step 4710. At step 4710, first and second indentations are formed consecutively using a progressive deep draw process. The interface between the first and second indentations may be configured such that the feature is located at the interface. At step 4720, the material closing the tube (i.e., not removed by the progressive deep draw process) is removed. At step 4730, the feature is machined in the inner surface of the tube. Process 4700 then ends at step 4730.

[0245] It is understood that any of the processes described above in connection with providing a wall in the

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inner surfaces of a tube may be used to form any other suitable feature on the inner surface of a tube. In addition, it is understood that these processes may be used for non-extruded and non-tubular components. It is also understood that any of the processes described above can be applied to a component formed from injection molded plastic or any other material.

[0246] In order to convey information, such as device status, visual indicator systems can be included in a headset. One type of indicator system can emit different colors of light to indicate what a device is doing. For example, a system in a headset can emit a green light if it is in a telephone conversation and a blinking red light if the battery power is low.

[0247] FIG. 48 shows a simplified cross-sectional view of a visual indicator system 4800 for a headset in accordance with an embodiment of the present invention. Visual indicator system 4800 can, for example, correspond to display system 18 of FIG. 1, system 700 of FIG. 7, or display 1013 of FIG. 10B. One or more light sources 4821 and 4822 can be integrated into system 4800. Light sources 4821 and 4822 can be, for example, LEDs that each emit a different color of light. Each color or combination of colors can be used to signify different information (e.g., the mode of a headset or a function the headset is performing). Light sources 4821 and 4822 can be mounted onto circuit board 4820. Through circuit board 4820, the light sources can be electrically coupled with driver circuitry (see e.g., LED driver 1424 of FIG. 14) that is operable to activate each source individually or in combination. A detailed description of circuitry with this functionality can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein.

[0248] It is understood that, while the embodiment shown in FIG. 48 uses two separate light sources (e.g., light sources 4821 and 4822), any number of light sources can be provided without deviating from the spirit and scope of the present invention. In some embodiments, a single light source device can be provided that includes two LEDs such that the device can emit light from either of the LEDs or a combination of the two LEDs. For example, a light source device can be provided that includes a green LED and a red LED. Such a light source device may, for example, emit green light when activating only the green LED, red light when activating only the red LED, and amber light when activating both LEDs in combination.

[0249] Microperforations 4812 can be provided in housing 4810 so that light sources 4821 and 4822 are visible to a user. Outer apertures 4814 of microperforations can have a small diameter so that they are imperceptible to a user when light sources 4821 and 4822 are off. The diameter of inner apertures 4816 can be of a larger size so that they can guide more light through the microperforations. A detailed description of microperforations and their fabrication can be found in U.S. Patent Application Nos. 11/456,833 and 11/551,988 which are both entitled "Invisible, Light-Transmissive Display System," and which are both incorporated herein. For the purposes of illustration, only five microperforations are shown in FIG. 48, however a much larger number of microperforations can be used without deviating from the spirit of the present invention. It is further understood that none of the elements of FIG. 48, including microperforations 2402, are drawn to scale.

[0250] While the incorporated U.S. Patent Application Nos. 11/456,833 and 11/551,988, both entitled "Invisible, Light-Transmissive Display System," describe microperforations for use with display systems, microperforations can also be used as acoustic ports in accordance with the present invention. For example, one or more microperforations can be provided such that acoustic pressure can pass through the microperforations and exit a volume. For example, acoustic ports 1021 and 1022 of FIGS. 10A and 10B may be composed of a plurality of microperforations in earbud 1020.

[0251] Light diffuser 4830 can be located between circuit board 4820 and an inner wall of housing 4810. Light diffuser 4830 can, for example, be made of a polycarbonate with sections of varying opacity. Outer core 4832 of diffuser 4830 can be made from a substantially opaque material such that light from light sources 4821 cannot pass through the core. Outer core 4832 can be substantially opaque in that it can transmit 0% to 20% of light. For example, if outer core 4832 is substantially opaque it can deflect light back into inner core 4834 such that the light doesn't exit the sides of the diffuser.

[0252] Inner core 4834 can be located within the inner wall of outer core 4832. The inner core 4834 of diffuser 4830 can be made from, for example, a combination of substantially transparent or translucent substrate 4835 and diffusing particles 4836 such that the particles are suspended in the substrate. In some embodiments, substrate 4385 can be substantially transparent in that it can transmit 80% to 100% of light. In other embodiments, substrate 4385 can be translucent such that it transmits any 0% to 100% of light. Both substrate 4835 and particles 4836 can be, for example, made from polycarbonate materials of different opacities. Particles 4836 can be made from an opaque or translucent material that alters the path of light through inner core 4834. Particles 4836 can have any form (e.g., a sphere, a cylinder, a cube, a prism, or an uneven form). In some embodiments, each of particles 4836 can have a different form to simplify manufacturing. The combination of substrate 4835 and particles 4836 can thoroughly diffuse light from the light sources when it exits the top of inner core 4834. That is, the light from light sources 4821 and 4822 can be evenly spread across the top surface of inner core 4834 so that a user detects an even intensity of light exiting microperforations 4812.

[0253] It is understood that other diffusion means can be used without deviating from the spirit and scope of the present invention. For example, surface textures,

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coatings or labels can be applied to a light transmissive material such that any light passing through the material is substantially diffused.

[0254] Inner core 4834 can have a sufficient width 4890 so that it surrounds the footprint of light sources 4821 and 4822. In one embodiment, inner core width 4890 can be approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters), and the width 4892 of outer core 4832 can be approximately 2.8 millimeters (e.g., between 2.6 millimeters and 3.0 millimeters). In some embodiments, the width of the end of the diffuser proximal to circuit board 4820 can be different from the width of the end of the diffuser proximal to housing 4810. For example, diffuser 4830 can be in shape similar to a cone such that the width of the end of the diffuser proximal to housing 4810 is smaller than the width of the diffuser proximal to circuit board 4820. In other words, diffuser 4830 can, for example, be in the shape of a cone having a flattened top.

[0255] The bottom surface of outer core 4832 can extend below the bottom surface of inner core 4834 so that the outer core can be mounted to circuit board 4820 without the inner core damaging light sources 4821 and 4822. The outer core 4832 can be attached to circuit board 4820 using, for example, an adhesive or any other suitable material.

[0256] In FIG. 48, light source 4822 is activated and emitting light 4860. Because of the effect of light diffuser 4830, light 4862 can be evenly distributed as it exits the diffuser, thereby making it difficult for a person to discern whether the light is being generated by light source 4821 or light source 4822.

[0257] FIG. 49 shows the exterior of an embodiment of headset 4910 that includes visual indicator 4913 in accordance with an embodiment of the present invention. Headset 4910 may correspond to headset 10 of FIG. 1, for example. The embodiment shown in FIG. 49 uses LEDs 4921 and 4922 as light sources and includes a cylindrical light diffuser. Visual indicator 4913 can include microperforations 4912 which allow a user to see light being emitted from LEDs 4921 and 4922. A light diffuser can be included between the LEDs and microperforations 4912 so that the diffused light seen by a user is equally distributed over the microperforations. The diameter 4990 of the microperforated area can be substantially similar to or smaller than the diameter of the diffuser's inner core. Diameter 4990 can be, for example, approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters).

[0258] Alternatively, the size and shape of the microperforated area could be different from that of the light diffuser. For example, a microperforated area with a noncircular shape can be placed over a light diffuser so that a noncircular indicator is generated. Similarly, the shape of the light diffuser can be non- cylindrical. Moreover, the light diffuser can be larger than the microperforated area so that it can cover the footprint of any other light sources that might be included.

[0259] Numerous light sources of different colors can be used in conjunction with a light diffuser as described above in order to present a visual indicator to a user. Because of the effect of the material in the light diffuser, light from each different source may appear evenly distributed over an area. In this manner, the entire indicator can appear to change colors as different light sources are activated.

[0260] FIG. 50A includes a side view of headset 5000 in accordance with an embodiment of the present invention. Connector 5040 can include primary housing 5010, connector plate 5041, contacts 5043, casing 5044 and microphone port 5050. Connector plate 5041 can include recessed groove 5042 which runs around the perimeter of connector plate 5041. Groove 5042 can also be referred to as a recessed step in connector plate 5041. At the top of connector plate 5041, a microphone port 5050 can be located in groove 5042.

[0261] There are many benefits associated with placing microphone port 5050 along the edge of connector plate 5041. By including the microphone port near the connector plate, the microphone can be embedded in the connector which saves space inside the headset housing. The space that is saved can be used to incorporate other functionality or decrease the overall size of the headset. Moreover, locating the microphone port in the groove around the edge of the connector can hide it from view which increases the overall aesthetic appearance of the headset

[0262] FIG. 50B shows a detailed view of the microphone port area of a connector in accordance with an embodiment of the present invention. The dimensions of port 5050 can include, for example, a width 5090 of approximately 2.5 millimeters and a height 5092 of approximately 0.3 millimeters. These dimensions are merely illustrative and it is understood that other dimensions may be practiced.

[0263] FIG. 51 shows a view of connector 5140 with the primary housing removed in accordance with an embodiment of the present invention. Connector 5140 can, for example, correspond to connector 16 of FIG. 1, assembly 320 of FIG. 3, assembly 420 of FIG. 4, connector 1040 of FIG. 10A, or connector 1140 of FIG. 11. Connector 5140 can be mounted up primary housing circuit board 5115, for example. Connector 5140 can include connector plate 5141, contacts 5143 and accompanying casing 5144 to prevent the contacts from electrically coupling with the connector plate. Microphone port 5150 can be included in the top of connector plate 5141 to allow sound to reach microphone boot 5120. Microphone boot 5120 and a microphone contained therein can be located behind connector plate 5141. The microphone can be contained within microphone boot 5120 to, for example, protect the microphone from damage and control the flow of air into the microphone.

[0264] FIG. 52 shows an exploded view of connector 5140 of FIG. 51 which can include, for example, connector plate 5240, microphone boot 5220, microphone 5222,

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contacts 5243, casing 5244, bracket 5248 and screws 5249 in accordance with an embodiment of the present invention. Microphone 5222 can be a MEMs microphone and can be electrically coupled with circuit board 5215. Circuit board 5215 is similar to primary housing circuit board 1115 of FIG. 11. Microphone boot 5220 can mount over microphone 5222. Microphone boot 5220 can, for example, be made of silicon so that it can seal with surrounding parts when connector 5200 is assembled. Contacts 5243 can be included in casing 5244. Casing 5244 can be made of a non-conductive material (e.g., polymeric) so that contacts can not be electrically coupled with connector plate 5240. Casing 5244 can be mounted onto circuit board 5215 and include conductive elements (see e.g., shank 5707 and contact segment 5708 of FIG. 57B) which can electrically couple contacts 5243 with circuit board 5215. Bracket 5248 can couple with connector plate 5240 in order to hold connector 5200 together. Upward pressure from bracket 5248 can compress microphone boot in order to create an acoustic (e.g., substantially air-tight) seal for the passage of air into and out of microphone 5222. Circuit board 5215, casing 5244 and bracket 5248 can include one or more apertures for mounting to connector plate 5240. Screws 5249 can be inserted through these apertures and screwed into threaded cavities (see e.g., cavities 6046) on the back of connector plate 5240.

[0265] FIG. 53 shows a view of microphone boot 5320 which can include input aperture 5325 in accordance with an embodiment of the present invention. Microphone boot 5320 can, for example, correspond to microphone boot 5220 of FIG. 52. Air that flows into a headset by going around microphone boot 5320 can cause a noticeable loss in the quality of the audio signals picked up by a microphone in the boot. Therefore, microphone boot 5320 can include sealing surface 5326 to prevent air from leaking through any seams along the edge of the microphone boot. Sealing surface 5326 can be a horizontal surface of boot 5320 that extends to the perimeter of the boot's footprint. Sealing seams in this manner can direct the flow of air into aperture 5325 which can result in higher sound quality being received by the microphone.

[0266] Traditionally, the roof of a microphone boot creates a seal with the surfaces of surrounding parts. This can require a thicker roof which is structurally robust enough to support the pressure required to make an adequate seal. Because boot 5320 uses horizontal sealing surface 5326 (instead of roof 5327) to seal with surrounding parts, roof 5327 does not need to be very thick. This reduced thickness saves space in a housing and can result in a generally smaller or thinner headset.

[0267] FIG. 54 shows a perspective, cross-sectional view of connector plate 5440 which includes microphone boot 5420 and microphone 5422 in accordance with an embodiment of the present invention. Connector plate 5440, boot 5420 and microphone 5422 can, respectively, correspond to connector plate 5240, booth 5220 and microphone 5222 of FIG. 52, for example. The components shown in FIG. 54 can fit together so that air can pass through microphone port 5450, into boot aperture 5425 and reach microphone input 5421. Microphone port 5450 may, for example, be a cut-out in the recessed step of connector plate 5440. Because of other elements in the connector assembly (e.g., circuit board 5215 and bracket 5248), microphone 5422 and microphone boot 5420 can be pushed up against connector plate 5440 when installed in a headset. The pressure from this force can cause surface 5426 to form a seal with surface 5445 of connector plate 5440. This seal can prevent air from passing through seam 5490 in between connector plate 5440 and microphone boot 5420.

[0268] In some embodiments, porous plug 5428 may be provided in boot aperture 5425. Plug 5428 may be, for example, made from a porous foam (e.g., sintered polyethylene or super high-density polyethylene). Plug 5428 can help filter out high-frequency noises such as those generated by wind blowing into microphone port 5450. The acoustical performance of plug 5428 can be a factor of its porosity which can be controlled by manufacturing. For example, plug 5428 can be manufactured by melting particles of polyethylene together. The porosity of the resulting plug can be a function of how long the particles are melted, what temperature is used to melt the particles, and the particles size. In some embodiments, it may be advantageous to only use polyethylene particles of a certain size when forming plug 5428. For example, particles with a diameter between 177 microns and 250 microns may be melted to form plug 5428.

[0269] FIGS. 55A and 55B show views of the connector of headset 5500 in accordance with an embodiment of the present invention. Four contacts 5561, 5562, 5563 and 5564 can be integrated into the connector. The contacts can be of a substantially flat shape so that they are flush with the face of connector plate 5540. The contacts can, for example, be of an oval shape. The outer contacts 5561 and 5564 can be configured for coupling to either a power supply line or a ground line. The remaining inner contacts 5562 and 5563 can be configured for receiving and transmitting data.

[0270] Connector plate 5540 can be located within primary housing 5510 and can include recessed groove 5542. Height 5580 of primary housing 5510 can be approximately 5 millimeters or can be from a range between 4.7 and 5.3 millimeters. Height 5581 of the interior cavity of primary housing 5510 can be approximately 4 millimeters or can be from a range between 3.7 and 4.3 millimeters. Height 5582 of the raised face of connector plate 5540 can be approximately 3.3 millimeters or can be from a range between 3.0 and 3.6 millimeters. Heights 5580, 5581 and 5582 can be advantageous because they can provide a headset having a small form-factor yet large enough to adequately couple with a complementary connector. Heights 5581 and 5582 can also provide an adequate groove for sound from a user's voice to reach a microphone embedded in connector plate 5540 (see e.g., microphone 17 of FIG. 1). It is understood that these di-

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mensions are merely illustrative. It is also understood that connector plate 5540 and the aperture in primary housing 5510 are angled with respect to the axis of primary housing 5510, and heights 5580, 5581 and 5582 reference the orthogonal heights of the corresponding elements.

[0271] Connector plate 5540 can include four contacts 5561, 5562, 5563 and 5564 which can be separated by pitch 5583, which can be approximately 2 millimeters or from a range between 1.75 and 2.25 millimeters. Pitch can be defined as the distance from the centerline of a contact to the centerline of the nearest contact. Pitch 5583 can be advantageous because it can allow contacts on complementary connectors (see e.g., connector 6200 of FIG. 62A and 62B) to be sufficiently spaced apart such that magnetic components can be provided between the contacts.

[0272] Each contact can have a width 5584, which can be approximately 0.7 millimeters or from a range between 0.5 and 0.9 millimeters. The ring of exposed casing can have a width 5586 of approximately 0.2 millimeters or can be from a range between 0.12 and 0.3 millimeters. All of the rings of exposed casing can have the same width (e.g., width 5586). Width 5586 can be advantageous because it is large enough to prevent contacts 5561, 5562, 5563 and 5564 from shorting with connector plate 5540, but small enough to not impact the size of connector plate 5540. The contacts can be arranged on the face of connector plate 5540 so that they are symmetrical about the centerline of headset 5500. Dimension 5585, which represents the distance from the centerline of each contact to the centerline of the headset, can be approximately 1 millimeter. The dimensions of contacts 5561-5564 can be advantageous because the dimensions can provide a sufficient surface for coupling with a corresponding connector while maintaining a small form-factor headset. For example, if the contacts were much larger, the size of housing 5510 may need to increase.

[0273] FIG. 55C includes a side view of headset 5500 in accordance with an embodiment of the present invention. The angle between the face of connector plate 5540 and the axis of primary housing 5510 can be represented by angle 5587, which can be approximately 55 degrees or from a range between 10 and 80 degrees. Angle 5587 can be advantageous because it can provide a suitable angle for mating headset 5500 with a corresponding connector. Angle 5587 may also provide an appropriate angle for reflecting sound from a user's mouth to the microphone of headset 5500 (see e.g., microphone 17 of FIG. 1). Angle 5587 can also be provided to block outside sounds from the microphone of headset 5500.

[0274] As measured along the surface of connector plate 5540, the height 5588 of each contact can be approximately 1.5 millimeters. Height 5588 can be advantageous because it provides a substantial surface area for headset 5500 to couple with corresponding headsets but does not necessarily cause an increase in the size of housing 5510.

[0275] The connector plate 5540 can be recessed in primary housing 5510 by a depth 5589 of approximately 0.25 to 0.3 millimeters. This depth can be determined by measuring the distance between the face of connector plate 5540 and a plane defined by the end of primary housing 5510 (e.g., a plane including three points on the connector end of primary housing 5510). Depth 5589 can be advantageous because it can provide a sufficient depth to strengthen the mechanical link between headset 5500 and a corresponding connector, but not be of such a large depth that it becomes difficult to align the headset with such a connector.

[0276] FIG. 55D includes a top view of headset 5500 in accordance with an embodiment of the present invention. Width 5590 of primary housing 5510 can be approximately 12.3 millimeters or can be from a range between 10 and 14 millimeters. Width 5591 of the interior cavity of primary housing 5510 can be approximately 11.1 millimeters or can be from a range between 7 and 13 millimeters. Width 5592 of the raised face of connector plate 5540 can be approximately 10.3 millimeters or can be from a range between 5 and 11 millimeters. Widths 5590, 5591, and 5592 can be advantageous because they can provide a large enough area for headset 5500 to securely couple with a complementary connector, while not being so large so as to prevent headset 5500 from having a small form-factor. The dimensions given above apply to the embodiments shown in 55A, 55B, 55C and 55D and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0277] FIG. 56 illustrates an assembly of electrical contacts for connector 1040 in accordance with an embodiment of the present invention. Assembly 5601 can include plurality of electrical contacts 5602 disposed in non-conductive (e.g., polymeric) casing 5603. Casing 5603 can include protruding members such that each protruding member can extend through a cavity in a connector plate. In FIG. 52, for example, casing 5244 includes four protruding members and connector plate 5240 includes four cavities (or apertures). When casing 5244 is coupled with connector plate 5240, the casing's protruding members will fill those cavities. Accordingly, each protruding member can be referred to as a protruding cavity member as well. Electrical contacts 5602 can extend through at least a portion of depth 5690. In an assembled headset, each electrical contact 5602 can have a portion disposed in electrical contact with electrical contact 5604 of circuit board 5605, which can be flexible or rigid.

[0278] FIGS. 57A and 57B illustrate an assembly of electrical contacts in accordance with one embodiment of the present invention. Assembly 5701 can include plurality of electrical contacts 5702 disposed in non-conductive casing 5703. Each electrical contact 5702 can have first portion 5705 and second portion 5704, each of which are manufactured independently and assembled together thereafter.

[0279] First portion 5705 can have head 5706 and

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shank 5707. Head 5706 can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on head 5706 can have a conductive, durable finish that also is aesthetically appealing, for example, nickel, tin cobalt, or a blackened finish. Shank 5707 can be integrally formed with head 5706 or formed independently and then attached to head 5706 using adhesive material (e.g., glue, solder, weld, surface mount adhesion material, etc.). For example, during manufacturing, first portion 5705 can be formed from a cylindrical block of conductive material, turned to create shank 5707, and stamped or milled to shape head 5706, for example, into an oval shape.

[0280] Second portion 5704 can have engagement segment 5709 and contact segment 5708. Engagement segment 5709 can have a hole configured for accepting shank 5707 of first portion 5705 during assembly of electrical contact 5702 to casing 5703. Conductive adhesive material can be applied during manufacturing to mechanically and electrically couple first portion 5705 and second portion 5704 of electrical contact 5702. Contact segment 5708 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when in an assembled headset. The engagement surface of contact segment 5708 also can have a finish (e.g., gold-plating) that has good properties for adhering electrical contact 5702 to circuit board 5605, storage, and corrosion-resistance.

[0281] In one embodiment of the present invention, the center of the internal contact surface of second portion 5704 can be offset from the center of the external surface of first portion 5705 when considered in a plane substantially defined by the external contact surface of first portion 5705. This can be useful when design constraints require electrical contacts 5702 to electrically couple electronic components that are not co-linearly aligned, as in one embodiment of the present invention illustrated in FIG. 56. In one embodiment of the present invention, second portion 5704 can have a hook-shape to position the internal contact surface of second portion 5704 in an offset configuration with respect to shank 5707. In manufacturing, second portion 5704 can be stamped from sheet metal, machined from a solid block of conductive material, molded, or formed using a different method known in the art or otherwise. In one embodiment of the present invention, second portion 5704 can be stamped from sheet metal in high volume production situations to save valuable time and money.

[0282] FIGS. 58A-58C illustrate an assembly of electrical contacts in accordance with another embodiment of the present invention. Assembly 5801 can include plurality of electrical contacts 5802 disposed in non-conductive casing 5803. Similar to the embodiment illustrated in FIGS. 57A-57B, each electrical contact 5802 can have first portion 5805 and second portion 5804, each of which are manufactured independently and assembled together thereafter.

[0283] First portion 5805 can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on first portion 5805 can have a conductive, durable finish that also is aesthetically appealing.

[0284] Second portion 5804 can have engagement segment 5806, shank 5807, and contact segment 5808. Engagement segment 5806 can be electrically and mechanically coupled to first portion 5805 using, for example, surface mount technology, solder, weld, or another conductive adhesive. Shank 5807 can couple engagement segment 5806 to contact segment 5808. Contact segment 5808 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when headset assembly 5801 is installed in a headset (e.g., headset 10 of FIG. 1). The engagement surface of contact segment 5808 also can have a finish that has good properties for soldering, storage, and corrosion-resistance.

[0285] In one embodiment of the present invention, the center of the internal contact surface of contact segment 5808 can be offset from the center of the external surface of first portion 5805 when considered in a plane substantially defined by the external contact surface of first portion 5805. In one embodiment of the present invention, second portion 5804 also can have a hook-shape to position the internal contact surface of second portion 5804 in an offset configuration with respect to the external contact surface of first portion 5805.

[0286] FIG. 58C illustrates how assembly 5801 can be manufactured in accordance with one embodiment of the present invention. Initially, second portions 5804 of one or more electrical contacts 5802 can be stamped from single piece of sheet metal 5809 and folded into, e.g., a hook-shape as described above. This can create fingers 5810 in sheet metal 5809 that mechanically and electrically couple all electrical contacts 5802. First portions 5805, which also can be stamped in a separate operation, then can be adhered to engagement segments 5806 of each second portion 5804. This assembly then can be placed in an injection molding machine to injection-mold casing 5803 around the assembly. Once the injection molding procedure is complete, a blade can sever second portions 5804 of electrical contacts 5802 from the rest of sheet metal 5809, thereby mechanically and electrically decoupling each electrical contact 5802 from the other electrical contacts. Advantageously, because first portions 5805 and second portions 5804 can be formed from a stamping process, assembly 5801 can be used in high volume production situations by saving valuable time and money.

[0287] FIGS. 59A and 59B illustrate electrical contacts in accordance with further embodiments of the present invention. Electrical contacts 5901 and 5905 can be similar to that described above with respect to FIGS. 57A-58C, except that electrical contacts 5901 and 5905 can

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be formed as one unitary piece.

[0288] Electrical contact 5901 can have external contact portion 5902, shank 5903, and internal contact portion 5904. External contact portion 5902 can have an external surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. Shank 5903 can couple external contact portion 5902 to internal contact portion 5904. Internal contact portion 5904 can have an internal surface for engagement with electrical contact 5604 on circuit board 5605 (see FIG. 56) when electrical contact 5901 is installed in a headset (e.g., headset 10 of FIG. 1). As in the above-described embodiments, the center of the internal contact surface of internal contact portion 5904 can be offset from the center of external contact portion 5902 when considered in a plane substantially defined by the external contact surface of external contact portion 5902. Electrical contact 5901 also can have a hook-shape to position the internal contact surface of internal contact portion 5904 in an offset configuration with respect to the center of external contact portion 5902. In one embodiment of the present invention, electrical contact 5901 can be machined from a single block of conductive material.

[0289] Similar to electrical contact 5901, electrical contact 5905 also can have external contact portion 5906, shank 5907, and internal contact portion 5908. Rather than being machined from a conductive material, however, electrical contact 5905 can be stamped from sheet metal and folded to form the hook-shape. Again, because the electrical contact can be manufactured using a stamping procedure, it can be used in high volume production situations.

[0290] FIGS. 60A and 60B show two views of connector plate 6040 of a headset connector in accordance with an embodiment of the present invention. Recessed step 6042 can run around the edge of connector plate 6040 in order to create a groove when the plate is installed in a primary housing (see e.g., primary housing 1110 of FIG. 11). Microphone port 6050 can be cut out of step 6042 in order to create an opening for sound to reach cavity 6051 where a microphone or microphone boot (see e.g., microphone boot 5220) can be located. In FIG. 60B, surface 6045 of connector plate 6040 can be used to compress the perimeter of a microphone boot so that an airtight seal is made.

[0291] Tabs 6047 and threaded cavities 6046 can be used to mount other elements onto connector plate 6040. For example, tabs 6047 can mate with a bracket that wraps around the entire connector assembly (see e.g., bracket 5248 of FIG. 52). This same bracket can include apertures for use in conjunction with threaded cavities 6046 so that inserts (e.g., screws) can fix the bracket against connector plate 6040. Bracket 5248 of FIG. 52 is an example of a bracket that is suitable for use with connector plate 6040.

[0292] In accordance with one aspect of the present invention, connector plate 6040 can be made of a material with magnetic properties. By incorporating magnetic properties into connector plate 6040, magnetic effects can be used to enhance the coupling between connector plate 6040 and a complementary connector (see e.g., FIG. 62B). Connector plate 6040 can include, for example, a ferromagnetic material such as a steel alloy. In another embodiment, connector plate 6040 can include a permanent rare-earth magnet that produces a magnetic field. Moreover, an embodiment of connector plate 6040 can include an electromagnet which produces a magnetic field as a result of the application of electric current. In the electromagnetic embodiment, the magnetic field can be controlled (e.g., through the application of an electric current) so that it is only present when necessary. In the embodiments where connector plate 6040 includes a permanent magnet or an electromagnet, a complementary connector (see e.g., FIG. 62B) can include a ferromagnetic material or a complementarily positioned permanent magnet or electromagnet.

[0293] FIG. 61A shows array 6180 of magnetic components which can be embedded in a connector in accordance with an embodiment of the present invention. Array 6180 can include components 6181, 6182, 6183, 6184 and 6185 which can be made of, for example, a permanent rare-earth magnetic material. An example of a suitable material for magnetic components 6181-6185 is magnetized Neodymium and, more specifically, N50 magnets. The magnetic components 6181-6185 can be shaped so that a substantially flat mating face 6186 is formed along one side. This mating face 6186 can, for example, be at an angle complementary to the angle of a headset's connector plate (see e.g., angle 5587 of FIG. 55D).

[0294] FIG. 61B shows a view of how connector plate 6140 can be used in combination with array 6180 of magnetic components in accordance with an embodiment of the present invention. If connector plate 6140 is made of a ferromagnetic material and array 6180 includes permanent magnets, the magnetic fields of array 6180 will generate magnetic forces biasing connector plate 6140 and array 6180 together. If array 6180 is embedded within a connector that mates with connector plate 6140, these magnetic forces can reinforce the connection.

[0295] In order to maximize the magnetic field generated by array 6180, it can be advantageous to arrange components 6181- 6185 (e.g., magnets) so that the polarity of each component is in a particular orientation. For example, the components can be arranged so that the south pole of the outer two magnets are closest to the mating face, and the north pole of the inner three magnets are closest to the mating face. In this configuration, if one were to list the polarities encountered when passing horizontally over the mating face, the list would read south- north- north- north- south. This maximization of the magnetic field is one reason why it might be desirable to use an array of magnets as opposed to one large magnet.

[0296] While the embodiments described above include a ferromagnetic connector plate and an array of

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permanent magnets embedded in a complementary connector (see e.g., FIG. 62B), it is contemplated that any other magnetic configurations can be used without deviating from the spirit of the present invention. For example, an electromagnet element can be included in the connector plate and a ferromagnetic material can be located in a complementary connector. A detailed discussion about the use of electromagnetic and magnetic elements in connectors can be found in U.S. Patent Application No. 11/235,873 entitled "Electromagnetic Connector for Electronic Device" and U.S. Patent Application NO. and 11/235,875 entitled "Magnetic Connector for Electronic Device," which are both incorporated herein.

[0297] FIGS. 62A and 62B show connector 6200 that is complementary to and capable of mating with connector 1040 of FIG. 10A in accordance with an embodiment of the present invention. Connector 6200 can, for example, correspond to headset engaging connector 220 of FIG. 2. Connector 6200 can be integrated into, for example, a charger (see e.g., docking station 6400 of FIG. 64, device 6600 of FIG. 66, and docking station 6700 of FIG. 67B) which charges a battery in a headset or other apparatus that facilitates the charging of the headset (such as an apparatus discussed in U.S. Patent Application No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein).

[0298] The view of connector 6200 in FIG. 62A does not include connector housing 6210 so that magnetic array 6280 and contacts 6290, 6292, 6294 and 6296 can be seen. Array 6280 can be installed in connector 6200 such that it forms a magnetic array structure, and each magnet of the array can be separated by a gap of predetermined size. Array 6280 of magnetic components can be embedded in connector housing 6210 so that the surface of components 6282, 6283 and 6284 can be flush with mating face 6286. These exposed components can extended all of the way to the surface of a corresponding connector plate so that the strongest magnetic forces are generated. However, a connector can have no exposed magnetic elements without deviating from the spirit of the present invention. For example, it can be desirable to recess magnetic components 6281 and 6285 in order to create a smaller connector.

[0299] Contacts 6290, 6292, 6294 and 6296 can be included in connector 6200. In order to integrate the contacts with the array 6280 of magnetic components, each contact can be placed in the gaps between magnetic components. In this manner, contact 6290 can be located in between magnetic components 6281 and 6282, contact 6292 can be located between components 6282 and 6283, etc. This integrated distribution of contacts can allow for a smaller connector. This is another example of a reason why it might be desirable to use multiple magnetic components that are spaced apart as opposed to a single, large magnetic component.

[0300] Each contact can include a spring mechanism, such as coil 6297 of contact 6296. Coil 6297 can bias contact tip 6296 to extend out of connector housing 6210. The coils 6291, 6293, 6295 and 6297 included in the contacts can be substantially planar or flat. A flat coil can allow for minimal spacing between magnetic components 6281-48815. This reduced spacing can result in a generally smaller connector. However, other types of coils and contacts can be used in accordance with the principles of the present invention. For example, a cylindrical spring biasing a cylindrical contact, commonly called a "pogo pin," can be used without deviating from the spirit of the present invention.

[0301] Contacts 6290, 6292, 6294 and 6296 can be position to electrically couple with, for example, the contacts located on the face of a connector plate of a headset. Connector housing 6210 can include an elevated face 6212 which can, for example, fit into a cavity in a complementary connector. For example, if connector 6200 were to mate with headset 1000 of FIGS. 10A and 10B, the elevated face 6212 can fit against recessed connector plate 1041 while the edge of primary housing 1010 can fit against the recessed perimeter 6214 of connector 6200. In this mating configuration, contacts 6290, 6292, 6294 and 6296 can be electrically coupled with contacts 1042 of headset 1000.

[0302] Connector 6200 can include contacts or wires (not shown) on the rear of housing 6210 so that the connector can be electrically coupled with other circuitry. For example, connector 6200 can be mounted onto a circuit board that includes power supply circuitry (such as circuitry discussed in U.S. Patent Application No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein) that can be used to transmit power to a headset through one or more contacts.

[0303] FIGS. 63A and 63B show connector 6300 that is complementary to and capable of mating with connector 1040 of FIG. 10A in accordance with an embodiment of the present invention. Connector 6300 is substantially similar to connector 6200 in FIGS. 62A and 62B. For example, magnetic components 6382, 6383 and 6384 of FIG. 63A are similar, respectively, to magnetic component 6282, 6283, and 6284 of FIG. 62A.

[0304] Connector 6300 can include four contact tips 6390, 6392, 6394 and 6396 that can be biased to extend from housing 6310. Each contact tip can have a width 6303 of approximately 0.5 millimeters. Width 6303 may be advantageously sized to be large enough to easily connect with connectors on headsets (e.g., connector 16 of FIG. 1) while not being so large that contact tips 6390, 6392, 6394, and 6396 are stiff and cannot be depressed by a headset coupling with connector 6300.

[0305] The centerline of each contact tip can be separated from the centerline of an adjacent contact tip by pitch 6302. Pitch 6302 can be chosen so that the contacts of connector 6300 are capable of electrically coupling with the contacts of a headset connector (e.g., connector 1040 of FIG. 10A). Accordingly, pitch 6302 can be ap-

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proximately 1.97 millimeters so that it corresponds to pitch 5583 shown in FIG. 55A. Moreover, pitch 6302 can be selected from a range between 1.75 and 2.25 millimeters. The size of pitch 6302 may also be advantageous for placing magnetic components (e.g., components 6382, 6383, and 6384) in between the contacts of connector 6300. The centerline of outer contact tips 6390 and 6396 can be separated by width 6301, which can be approximately 5.1 millimeters or from a range between 4.7 millimeters and 5.4 millimeters. Width 6301 can be selected such that contact tips 6390 and 6394 can couple with the outer contacts of a headset (see e.g., contacts 5561 and 5564 of FIG. 55A). In some embodiments, the outer contacts of a headset may be configured to receive power, and a connector, similar to connector 6300 but not including contact tips 6392 and 6394, can be provided to transmit only power to the headset. Such a connector may be easier to manufacture and cheaper than connector 6200.

[0306] Connector 6300 can have a raised face 6312 that is capable of coupling with a headset connector (e.g., connector 1040 of FIG. 10A). The housing 6310 of connector 6300 can have a total height 6304, which can be approximately 5.1 millimeters or from a range between 4.9 millimeters and 5.3 millimeters. The total height 6304 of a connector may be advantageously selected to corresponding with the total height of a headset's primary housing (see e.g., height 5580 of FIG. 55B) such that connector 6300 can receive a headset's primary housing. The raised face 6312 of housing 6310 can have a height 6305, which can be approximately 3.43 millimeters or from a range between 3.2 and 3.7 millimeters. Height 6305 can be selected such that it is less than the height of an internal cavity inside of a headset's primary housing (see e.g., height 5581) such that connector 6300 can easily couple with a headset. In summary, heights 6304 and 6305 can be selected in order to complement heights 5580 and 5581 of FIG. 55B. Thereby allowing headset 5500 to mate with connector 6300. It is understood that the mating face of connector 6300 is angled with respect to the rest of the connector. This angle can, for example, range from ten to thirty degrees. Heights 6304 and 6305 reference the orthogonal heights of the corresponding elements. This is similar to the radial dimensions that are shown in FIG. 55B.

[0307] In order to apply pressure to the contacts of a complementary connector, the contact tips 6390, 6392, 6394 and 6396 can be biased to extend from connector housing 6310. When no complementary connector is present, contact tips 6390, 6392, 6394 and 6396 can extend from the housing by distance 6306 of approximately 0.7 millimeters. Distance 6306 can be selected such that the contact tips can advantageously apply enough pressure to a headphone's contacts such that the tips can reliably couple with the headphone's contacts.

[0308] Connector 6300 can also include contacts or wires (not shown) that allow the connector to route electrical signals from contact tips 6390, 6392, 6394 and 6396 to other circuitry. The dimensions given above apply to the embodiments shown in 63A and 63B and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0309] FIG. 64 shows a view of headset 6498 coupled with connector 6499 in accordance with an embodiment of the present invention. Headset 6498 can be substantially similar to headset 1000 of FIGS. 10A and 10B and can include the features shown on connector 1040. Connector 6499 can be installed in, for example, docking station 6400 which can include a socket in which a headset can be inserted. Docking stations substantially similar to or the same as docking station 6400 are discussed in U.S. Patent Application No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein. The socket in docking station 6400 can be shaped to align headset 6498 properly with respect to connector 6499. Connector 6499 can include raised face 6412 and lower perimeter 6414 to further align headset 6498. Raised face 6412 can extend into the cavity created by a recessed headset connector while the headset's primary housing abuts perimeter 6414.

[0310] This alignment can result in the contacts of headset 6498 (see e.g., contacts 1042 of FIG. 10A) being approximately centered over the tip of contact 6490. Contact 6490 can be biased to extend beyond raised face 6412 by coil 6491. This bias can be represented by a force exerted in the direction of arrow 6401. Additionally, arrow 6402 can represent the magnetic force generated by the proximity of the connector plate of headset 6498 (see e.g., connector plate 1041 of FIG. 10A) to the array of magnetic components of connector 6499 (see e.g., array 6180 of FIGS. 61A and 61B). This magnetic force can cause contact 6490 to electrically couple with a contact on headset 6498. Connector 6499 can include additional contacts (see e.g., contacts 6290, 6292, 6294 and 6296) which can couple with the remaining contacts of headset 6498. Connector 6499 can be mounted on circuit board 6480 in docking station 6400 such that circuit board 6480 can route signals to and from headset 6498 when it is coupled with connector 6499.

[0311] FIG. 65 shows graph 6500 which depicts the approximate change of the two forces described above as the separation between the magnetic components and the connector plate varies in accordance with an embodiment of the present invention. In graph 6500, x-axis 6502 can represent the approximate force, and y-axis 6504 can represent the distance between the magnetic components and the connector plate. The separation where the x-axis intercepts the y-axis is zero, and this point can represent when the connector plate is in contact with the magnetic components. As the separation increases, approximate force 6508 from spring contacts pushing on a connector plate in a headset can decrease linearly because of the substantially linear nature of coil springs. While the spring force decreases linearly, the approxi-

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mate magnetic force 6506 can decrease exponentially due to the behavior of magnetic materials.

[0312] It can be desirable to choose magnetic components (e.g., magnets, connector plates) and design spring components (e.g., contact coils) such that the magnetic force biasing a headset's connector plate to a complementary connector is greater than the force of the spring contacts pushing back on the connector plate at all possible distances of separation between the two parts. If there are situations where the spring force is greater than the magnetic force, it might be necessary to apply an external force in order to properly couple a headset with a complementary connector. Applying this external force might require intervention from a user, and therefore, it can be desirable to design a connection system so that the magnetic force is always greater that the spring force.

[0313] FIG. 66 shows charging device 6600 that can be used in conjunction with a headset in accordance with an embodiment of the present invention. In some embodiments, connector 6601 can be integrated into device 6600, thereby allowing device 6600 to be electrically coupled with a headset. Connector 6601 is similar to the connectors discussed in connection with FIGS. 61-65.

[0314] In some embodiments, auxiliary connector 6610 can be integrated into charging device 6600. As such, auxiliary connector 6610 can be used to couple an additional device, such as a cellular phone which can be used with a headset, to device 6600. In order to connect a headset or additional device to an external power supply (e.g., wall outlet or computer), device 6600 can include cable 6620. Circuitry 6630 can be integrated into device 6600 to facilitate charging of both a headset and an additional device. Circuitry 6630 can also provide a communications interface for data to be shared between a headset and an additional device. An example of a charging device similar to device 6600 is discussed in detail within U.S. Patent Application No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices," which is incorporated herein.

[0315] FIGS. 67A and 67B show connector 6710 in accordance with an embodiment of the present invention. The face of connector 6710 can be shaped to include peak 6711. By incorporating peak 6711 into the connector face, connector 6710 is capable of mating with a headset in two different interface orientations (e.g., physical orientations). When connector 6710 is installed in docking station 6700 (see FIG. 67B), peak 6711 creates cavities 6702 and 6704 which can each accept the long side 6721 of headset 6720. In the interface orientation shown in FIG. 67B, side 6721 of headset 6720 is in cavity 6704. However, if headset 6720 were inserted in another orientation, long side 6721 of the headset may be in cavity 6702. In either of these orientations, the contacts of connector 6710 can be electrically coupled with the contacts on headset 6720.

[0316] In some embodiments, switching circuitry can be included in headset 6720 to compensate for these different interface orientations. Such switching circuitry can determine the interface orientation of headset 6720 and connector 6710 and route signals received from the connector to pathways inside the headset (e.g., electrical traces) based on the determined orientation. In other embodiments, switching circuitry can be provided in docking station 6700 that can determine the interface orientation of connector 6710 and headset 6720 and route signals to the connector based on the determined orientation. A detailed discussion of similar switching circuitry can be found in U.S. Patent Application No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein.

[0317] Similar to the elevated face 6212 and recessed perimeter 6214 shown in FIG. 62B, raised face 6712 and recessed perimeter 6714 can be advantageous when coupling a headset (see e.g., headset 1000 of FIGS. 10A and 10B) to connector 6710. For example, raised face 6712 and recessed perimeter 6714 can provide structural features that strengthen the mechanical coupling of connector 6710 and a headset.

[0318] FIG. 68 shows chart 6800 listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. With regards to chart 6800, a communications system can include a headset (e.g,. headset 10 of FIG. 1) and a host device (e.g., a cellular telephone, a laptop computer, etc.). Further defining the communications system referenced in chart 6800, the headset can be in communication with the host device and the host device can be communicating with other devices through a cellular network or other communications network (e.g., Voice over Internet Protocol).

[0319] Chart 6800 includes rows describing exemplary modes and functions of the system and columns identifying inputs and outputs that correspond to each mode or function. Some of the functions listed in column 6810 typically occur when a system is in a certain mode, and therefore, these functions can be listed under their respective modes. For example, the answer call function 6812 and the reject call function 6813 are typically executed when a system is in incoming call mode 6811 and chart 6800 can reflect this by listing functions 6812 and 6813 directly under incoming call mode 6811.

[0320] For each row corresponding to a function, column 6820 can be used to identify an input that can cause that function to occur. For example, column 6820 may identify a manner in which a user can press a single button on a headset (see e.g., button 14 of FIG. 1) to initiate a corresponding function. It is understood that the initiated function may further depend on the mode in which a headset is in. For example, a long button press may initiate the reject call function 6813 if a system is in incoming call mode 6811, while the same type of button press may initiate function 6814 if the system is in another mode. Examples of using a single button to control an electronic device can be found in U.S. Provisional Patent

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Application No. _____ entitled "Single User Input Mechanism for Controlling Electronic Device Operations," which is incorporated herein.

[0321] Outputs can be associated with each mode or function so that, for example, a user can be aware of a system's operation. Such outputs may be provided through a headset display system (see e.g., display system 18 of FIG. 1), a headset audio system (e.g., speaker system 13 of FIG. 1), and/or host device user interface (UI). A display screen and a speaker on a host device can, for example, be part of a host device UI used to provide outputs. Column 6830 lists outputs that can be provided by a headset display system to correspond with modes or functions listed in column 6810. For example, if a headset's display system includes an indicator that can output different colors using LEDs, column 6830 can include different colors and/or flashing patterns that the indicator can output based on the communication systems mode or function. Column 6840 lists outputs that can be provided by a headset audio system (e.g., a speaker) based on the communication system's mode or function. Column 6840 can, for example, include beeps, tones, or other noises that can be used to notify the operation of the communications system. Column 6850 lists outputs that can be provided by a Host Device UI. For example, column 6850, may include outputs that can be presented through a display screen on a host device.

[0322] In summary, chart 6800 identifies the inputs and outputs corresponding to various exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. For example, when a communications system is in incoming call mode 6811, the system's headset (e.g., headset 10 of FIG. 1) can display a slow blinking green light and output two beeps while the system's host device can display an incoming call screen (e.g., a graphic displaying information about the incoming call). Continuing the example, if a user presses a button on the headset (e.g., button 14 of FIG. 1) for a short amount of time, the system can answer the call while the headset displays a green light and outputs a short low tone followed by a short high tone. While the system is answering the call, the host device can display a call answer screen. It is understood that the modes and functions shown in FIG. 68 and discussed above are merely exemplary and that communication systems can operate using other modes and functions without deviating from the spirit and scope of the present invention.

[0323] Although particular embodiments of the present invention have been described above in detail, it will be understood that this description is merely for purposes of illustration. Alternative embodiments of those described herein are also within the scope of the present invention. For example, while one embodiment can include a Bluetooth headset, one or more features of the present invention also can be incorporated into headsets employing other wired and/or wireless communication protocols. Also, while some embodiments of the present invention can include headsets configured for communication with a cellular phone and/or personal media device (e.g., a portable media player similar to that sold under the trademark iPod® by Apple Inc. of Cupertino, California), one or more features of the present invention can also be incorporated into headsets configured for communication with any electronic device. Furthermore, while one embodiment illustratively described above can include a headset and methods for fabricating the same, one or more features of the present invention can also be incorporated into other electronic devices that require, e.g., circuit boards distributed within small acoustic volumes, symmetric connectors, extruded housings having one or more internal features, microperforations, co-located microphones and connectors, magnetic connectors, or any combination thereof.

[0324] Various configurations described herein may be combined without departing from the present invention. The above described embodiments of the present invention are presented for purposes of illustration and not of limitation. The present invention also can take many forms other than those explicitly described herein. Accordingly, it is emphasized that the invention is not limited to the explicitly disclosed methods, systems and apparatuses, but is intended to include variations to and modifications thereof which are within the scope of the following claims

Additional Statements Relevant to the Invention

[0325] There is provided a wireless headset device comprising: an earbud assembly comprising an earbud flexible circuit board having mounted thereon a receiver and processing circuitry; and a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a microphone and a primary housing flexible circuit board electrically coupled to the earbud circuit board and the microphone.

[0326] Preferably further comprising a neck assembly that fixes the earbud assembly to the primary housing assembly. Preferably the neck assembly comprising a through-hole through which a portion of the earbud flexible circuit board passes through to electrically connect to the primary housing circuit board .

[0327] Preferably wherein the earbud circuit board comprises traces for electrically coupling at least the receiver and the processing circuitry.

[0328] Preferably wherein the processing circuitry is operative to execute wireless communication processes.

[0329] Preferably wherein the processing circuitry is operative to process Bluetooth communication processes.

[0330] Preferably wherein the primary-housing assembly further comprises: an antenna electrically coupled to the primary housing circuit board.

[0331] Preferably wherein the primary housing assembly further comprises: a switch electrically coupled to the

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primary housing circuit board.

[0332] Preferably wherein the primary housing assembly further comprises: a connector assembly electrically coupled to the primary housing circuit board, the connector assembly operative to interface with a device other than the wireless headset device. Preferably wherein the connector assembly comprises: a multiple-pin symmetrical magnetic connector.

[0333] Preferably wherein the primary housing assembly further comprises: a battery electrically coupled to the primary housing circuit board.

[0334] Preferably further comprising: a thermistor in communication with and operative to provide the processing circuitry with a battery temperature signal. Preferably wherein the processing circuitry is operative to adjust a battery-charging rate based on the battery temperature signal.

[0335] Preferably wherein the primary housing circuit board comprises circuitry mounted thereon.

[0336] Preferably wherein the circuitry mounted on the primary housing circuit board comprises switching circuitry. Preferably wherein the circuitry mounted on the primary housing circuit board comprises adaptive battery charging circuitry.

[0337] There is provided a wireless headset device comprising: an earbud assembly comprising an earbud flexible circuit board; and a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a battery retaining region and a primary housing flexible circuit board, wherein circuit board components and circuitry are selectively mounted on the earbud flexible circuit board and the primary housing flexible circuit board to maximize a size of the battery retaining region.

[0338] Preferably wherein the earbud flexible circuit board is electrically coupled to the primary housing flexible circuit board.

[0339] There is provided a wireless headset device comprising: an earbud assembly; and a primary housing assembly having predetermined dimensions fixed to the earbud assembly, wherein the earbud assembly and the primary housing assembly each have mounted therein a flexible circuit board comprising circuitry.

[0340] Preferably wherein a distribution of circuitry among each flexible circuit board minimizes the predetermined dimensions.

[0341] Preferably wherein the wireless headset device is a Bluetooth wireless headset.

[0342] There is provided a headset device comprising: an earbud assembly; a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising a connector assembly; and at least one flexible circuit board electrically coupled to the connector assembly, the at least one flexible circuit board comprising: Universal Serial Bus (USB) circuitry operative to process USB protocol communications; and serial circuitry operative to process serial protocol communications .

[0343] Preferably wherein the connector assembly is operative to interface with a device other than the headset device .

Claims

1. A wireless headset device (10) comprising:

   an earbud assembly (12) comprising an earbud flexible circuit board (522); and
   a primary housing assembly (510) coupled via a neck portion to the earbud assembly (12), the primary housing assembly (510) comprising:

      a battery (19);
      a microphone (17); and
      a primary housing flexible circuit board (512) electrically coupled to the earbud flexible circuit board (522), the battery (19), and the microphone (17), the primary housing flexible circuit board (512) being bent around the battery (19) so as to conserve space.

2. The device of claim 1, wherein the earbud flexible circuit board (522) is electrically coupled to the primary housing flexible circuit board (512).

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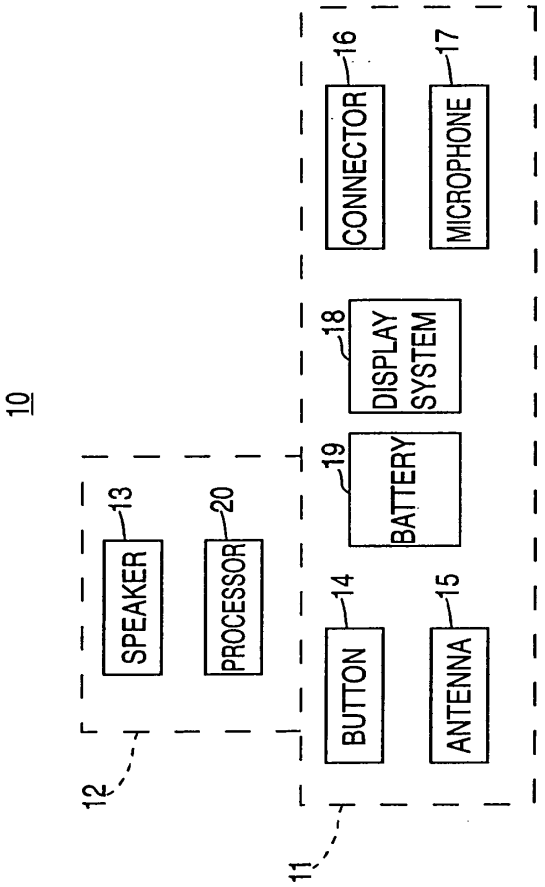


FIG. 1

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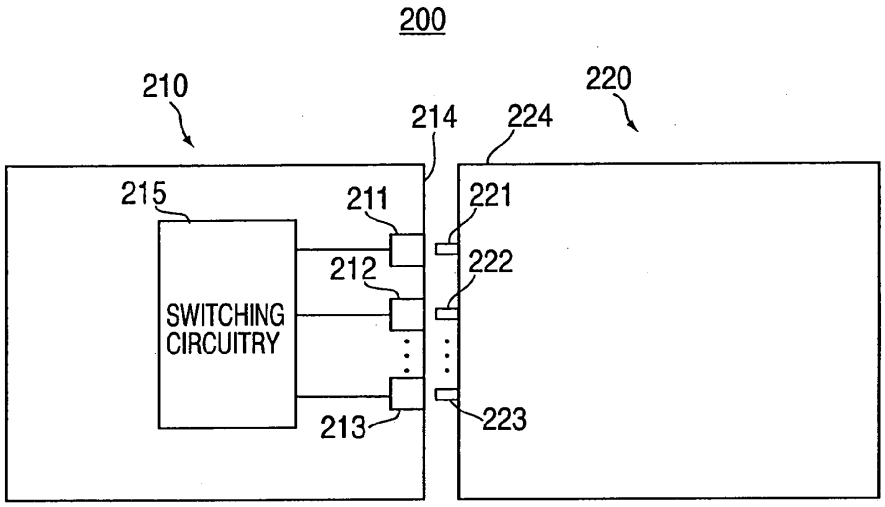


FIG. 2

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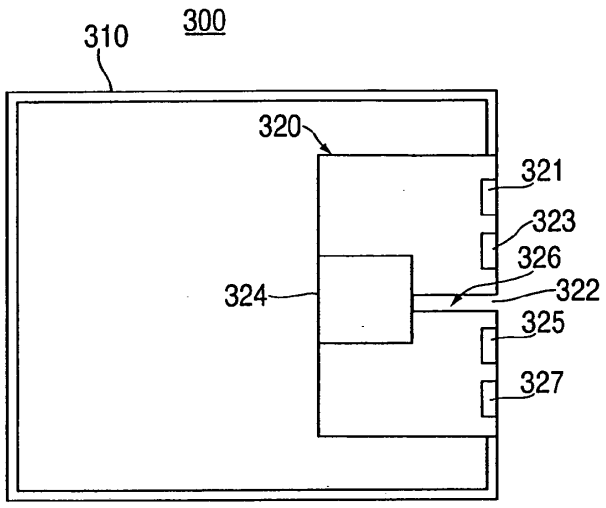


FIG. 3

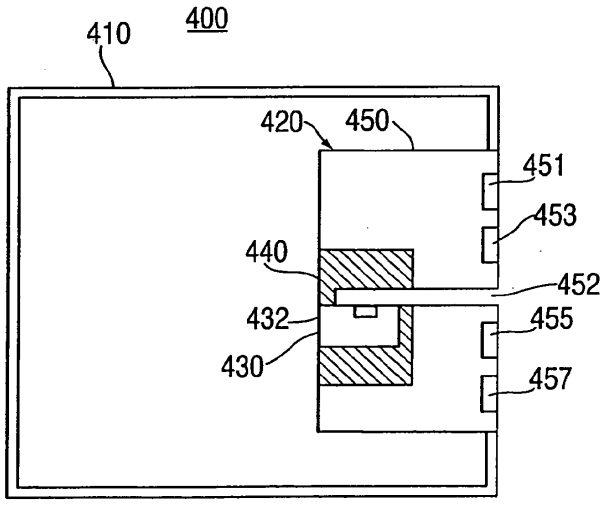


FIG. 4

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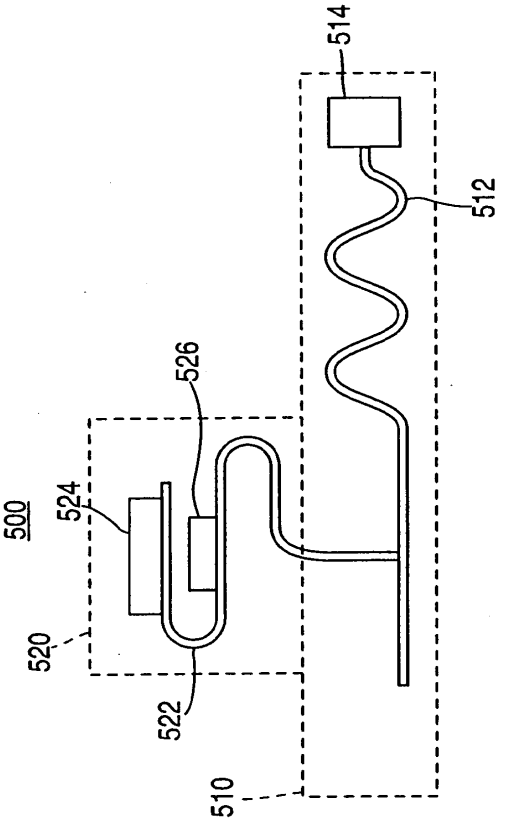


FIG. 5

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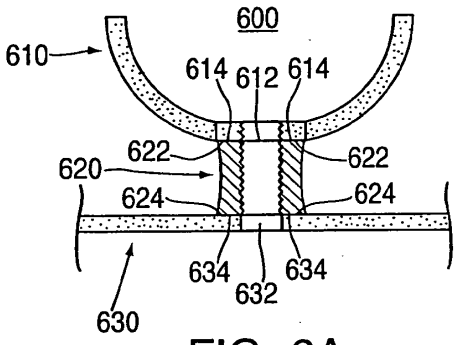


FIG. 6A

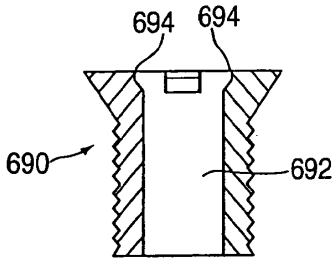


FIG. 6B

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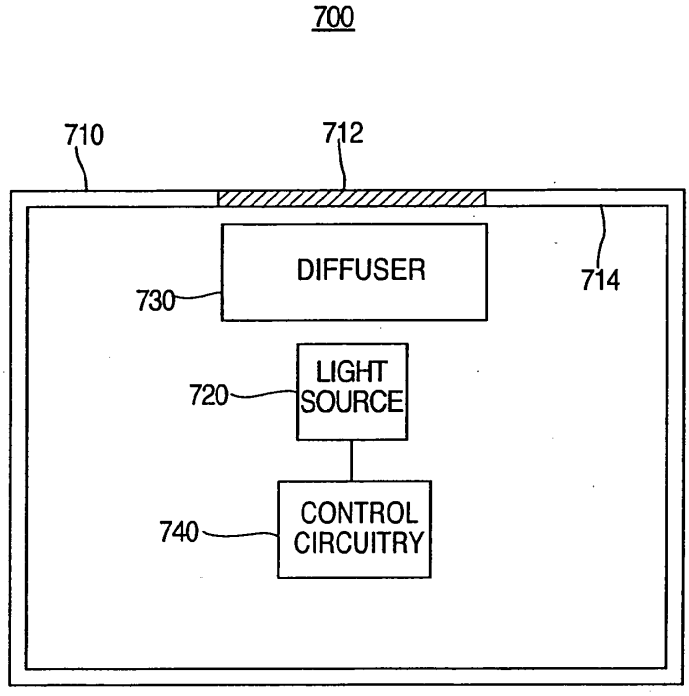


FIG. 7

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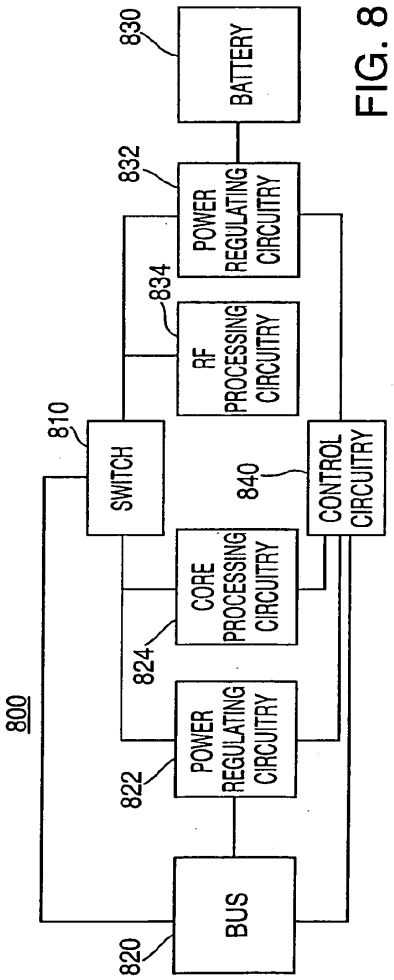

800
820
BUS
822
POWER REGULATING CIRCUITRY
824
CORE PROCESSING CIRCUITRY
810
SWITCH
840
CONTROL CIRCUITRY
834
RF PROCESSING CIRCUITRY
832
POWER REGULATING CIRCUITRY
830
BATTERY

FIG. 8

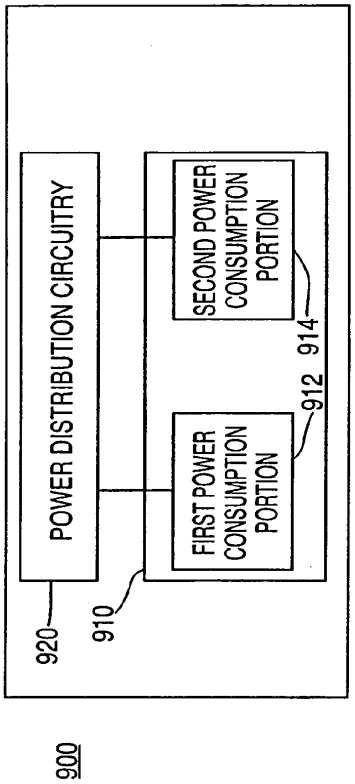

900
920
POWER DISTRIBUTION CIRCUITRY
910
FIRST POWER CONSUMPTION PORTION
912
SECOND POWER CONSUMPTION PORTION
914

FIG. 9

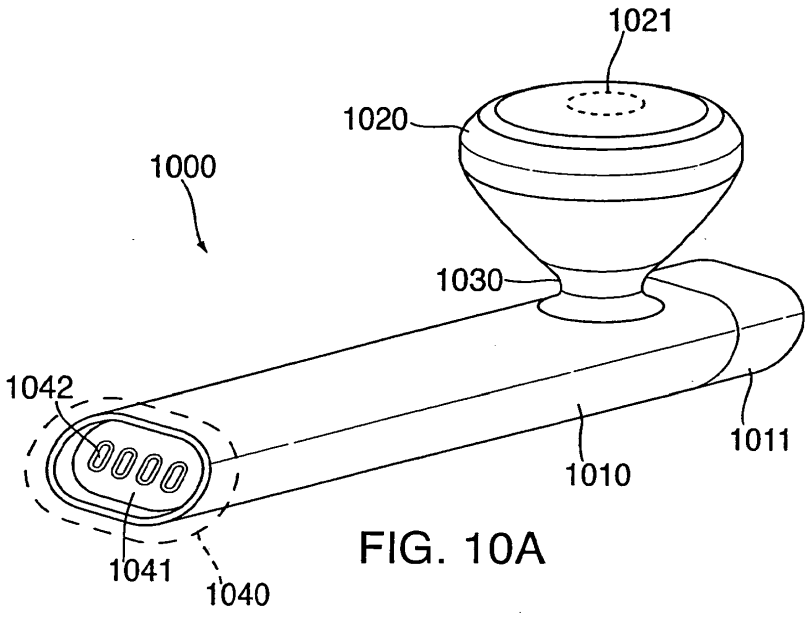


FIG. 10A

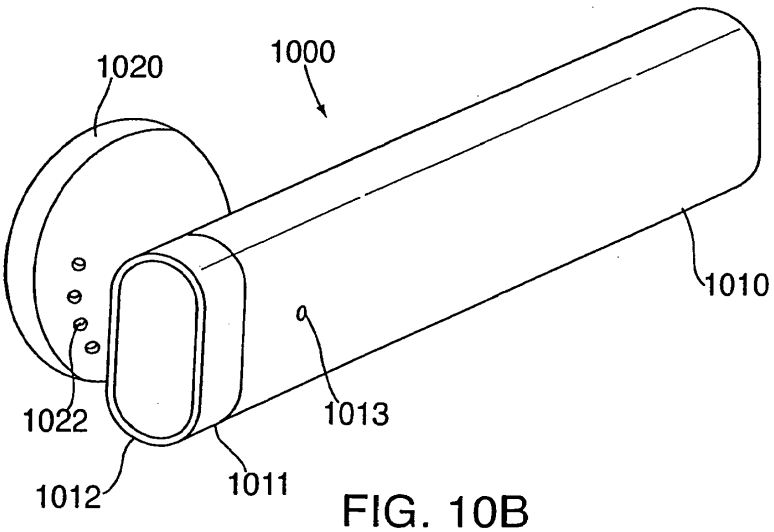


FIG. 10B

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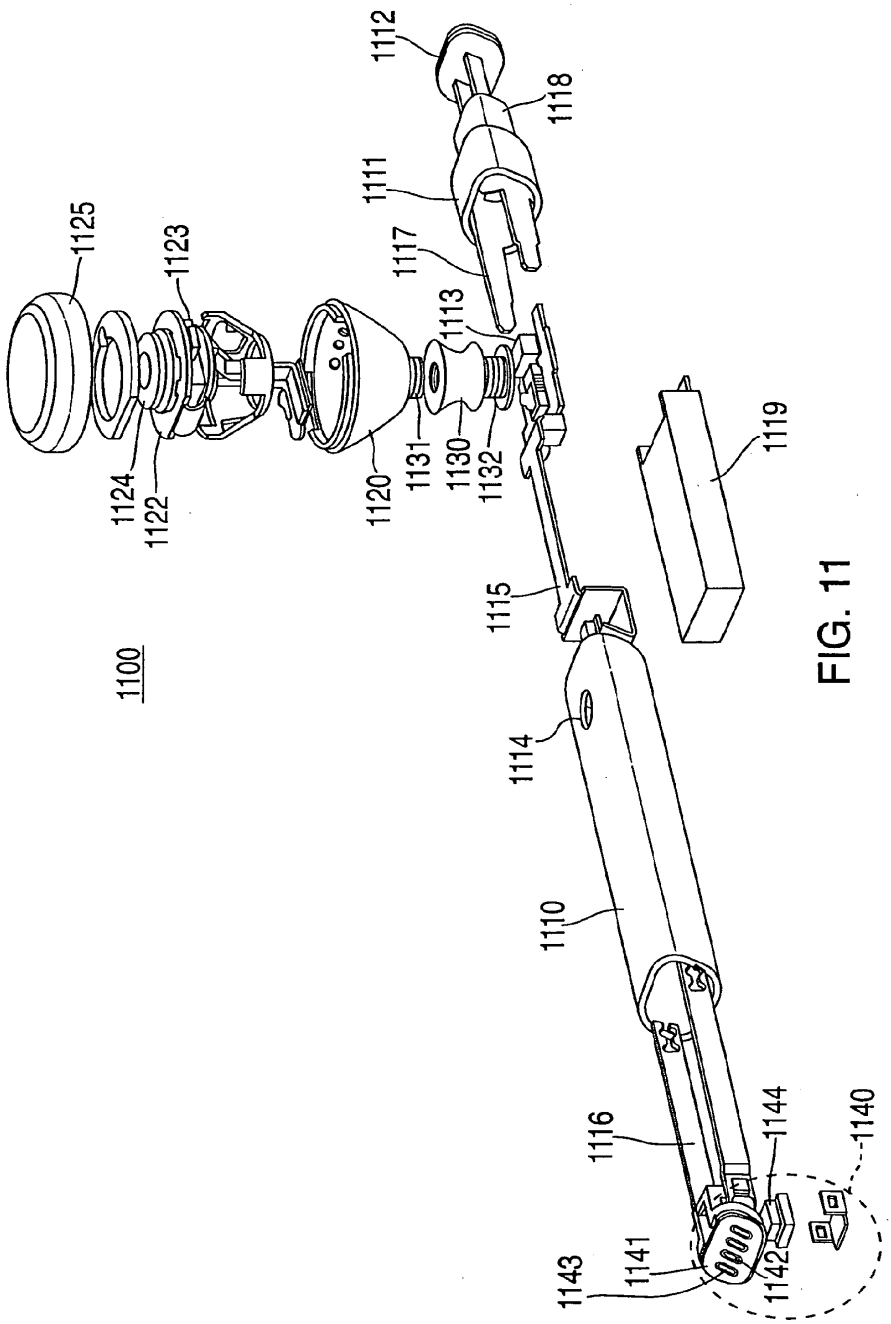

1100
1112
1118
1111
1117
1113
1125
1123
1124
1122
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FIG. 11

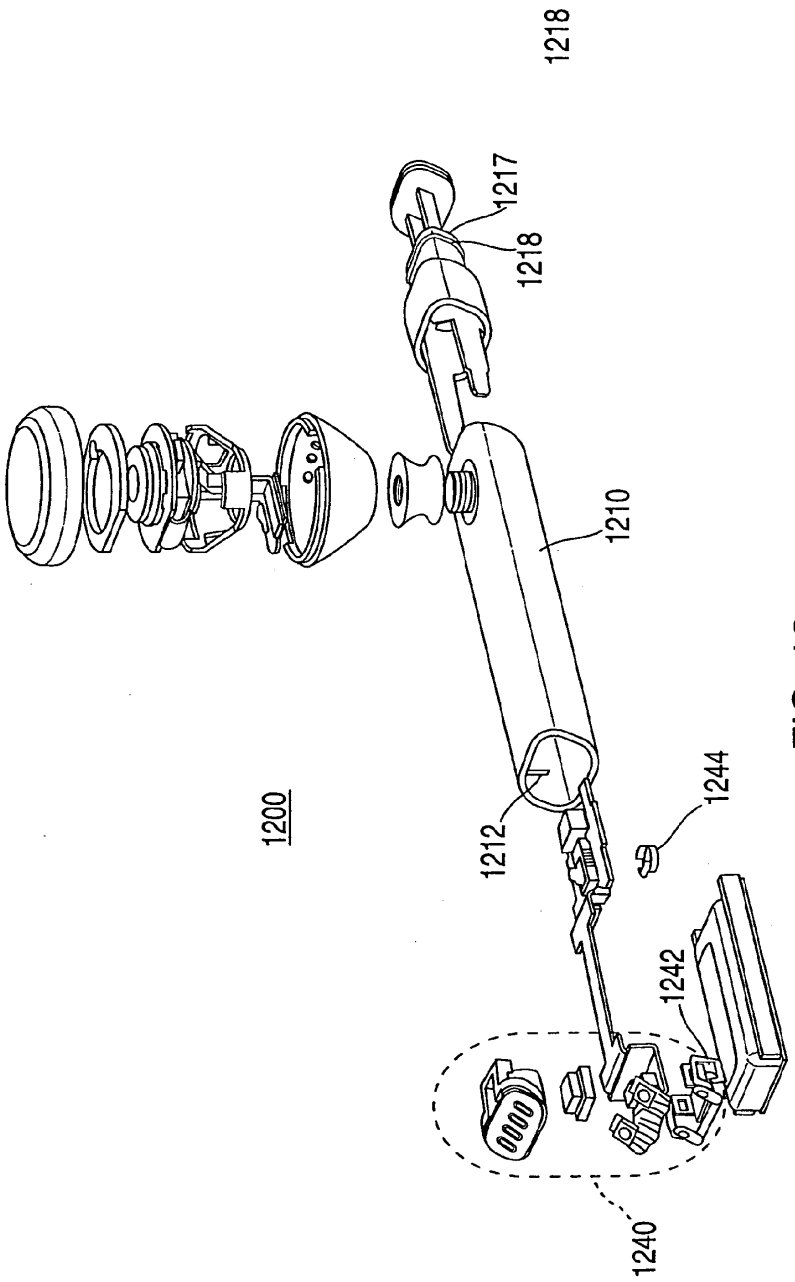


FIG. 12

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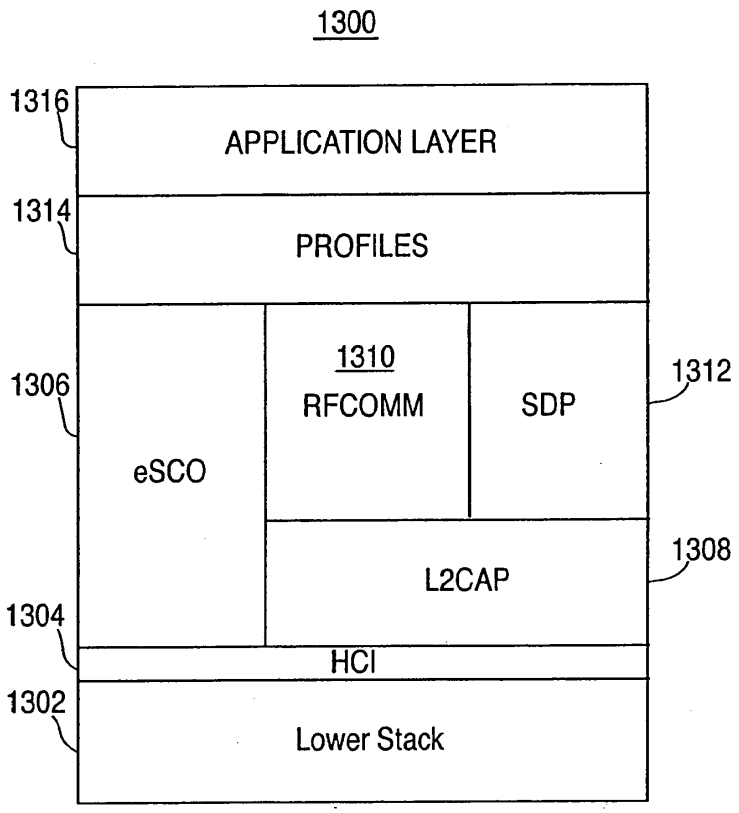


FIG. 13

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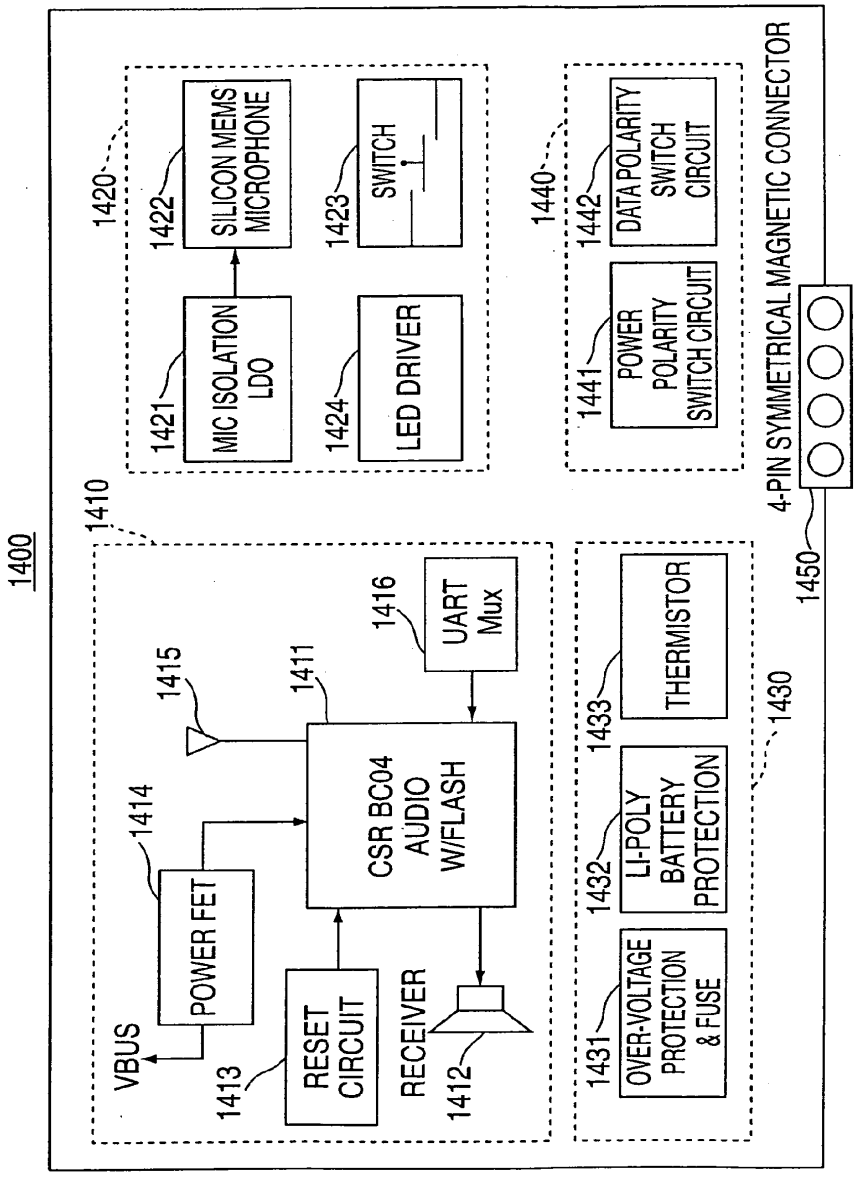


FIG. 14

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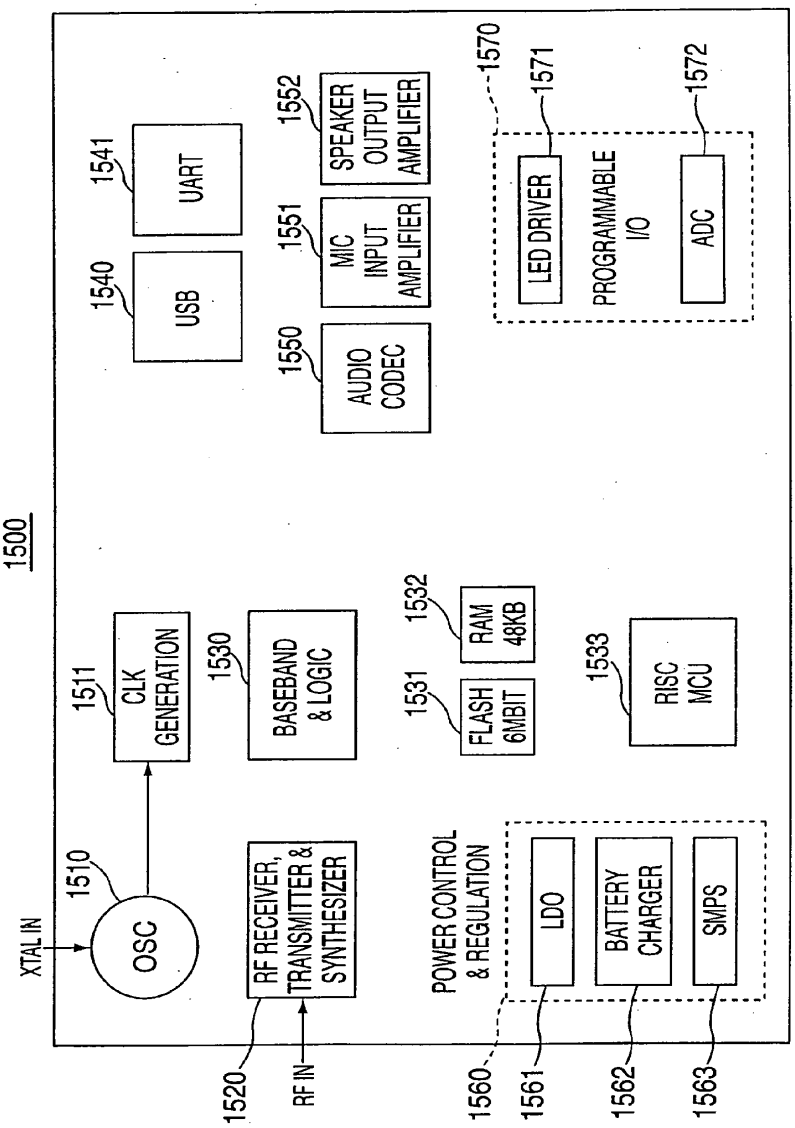


FIG. 15

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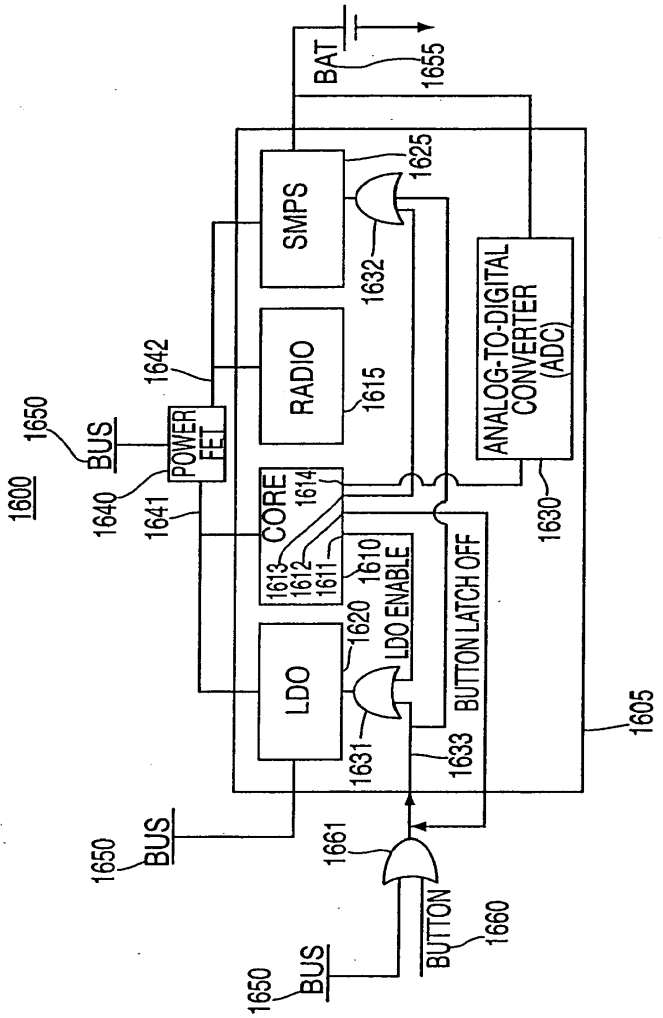

1600
1650
BUS
1640
POWER FET
1641
1642
SMPS
1625
1632
RADIO
1615
CORE
1614
1613
1612
1611
1610
LDO ENABLE
1620
LDO
1631
1633
BUTTON LATCH OFF
1605
ANALOG-TO-DIGITAL CONVERTER (ADC)
1630
BAT
1655
1650
BUS
1661
BUTTON
1660
1650
BUS

FIG. 16

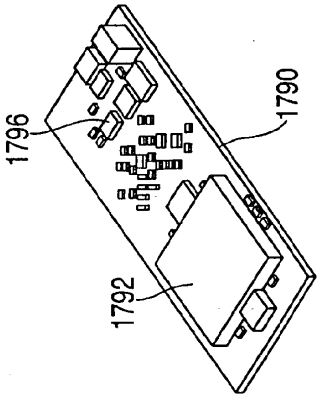


FIG. 17A
PRIOR ART

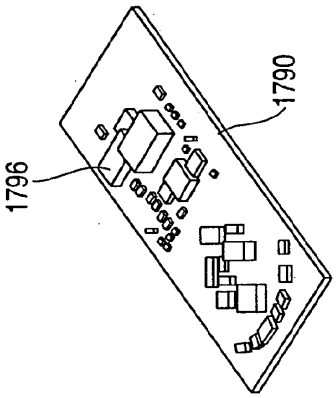


FIG. 17B
PRIOR ART

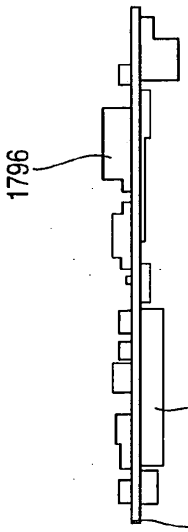


FIG. 17C
PRIOR ART

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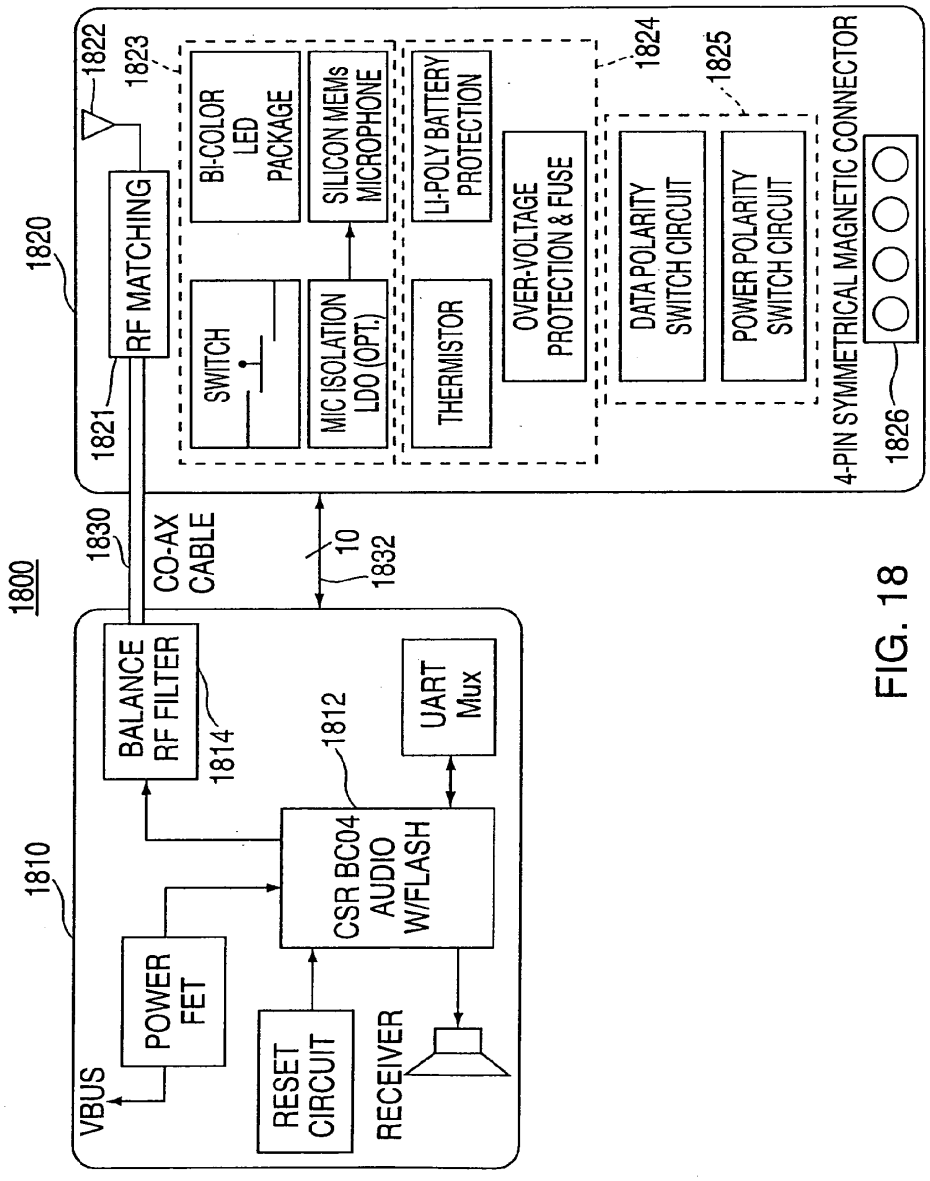


FIG. 18

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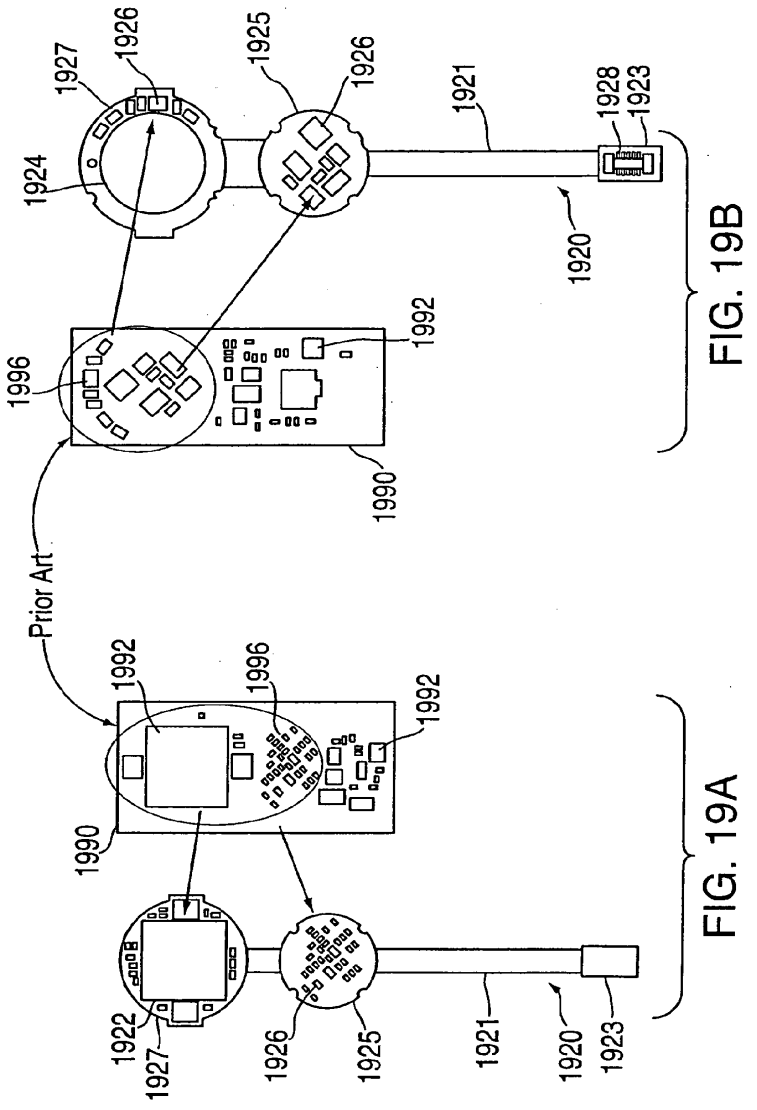


FIG. 19B

FIG. 19A

SONOVA EX1018
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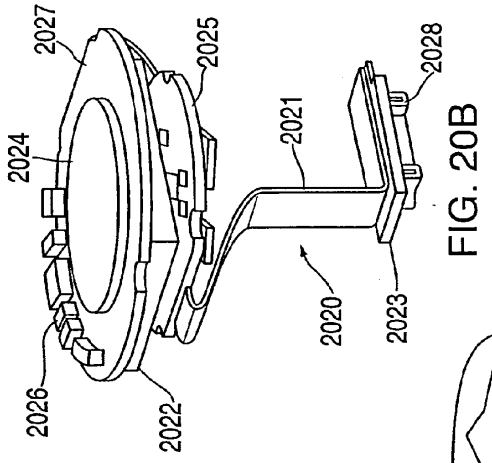


FIG. 20B

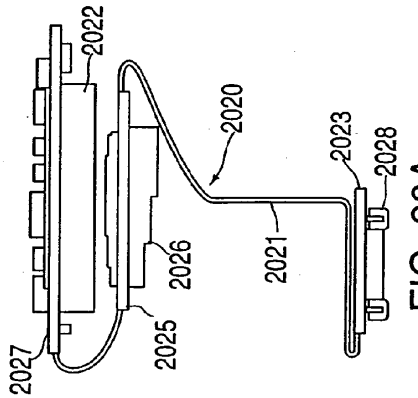


FIG. 20A

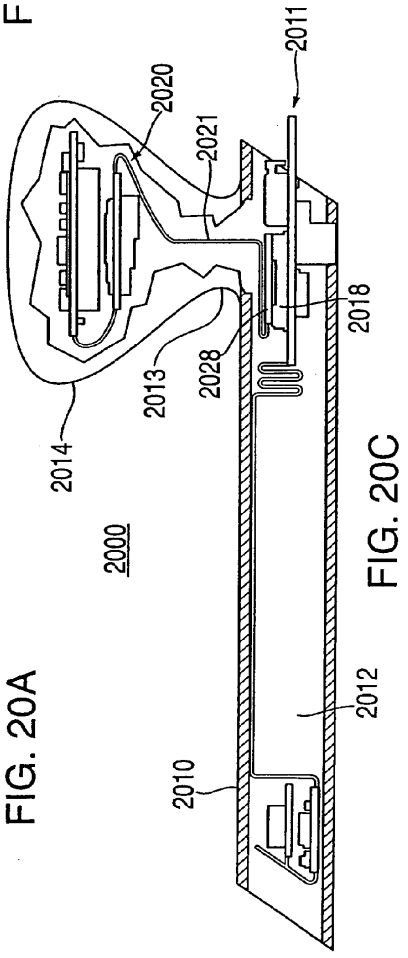


FIG. 20C

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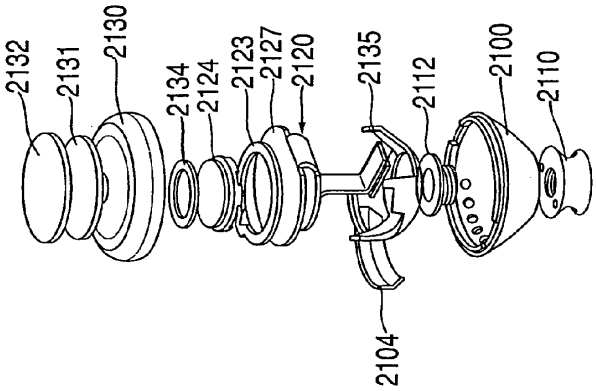


FIG. 21B

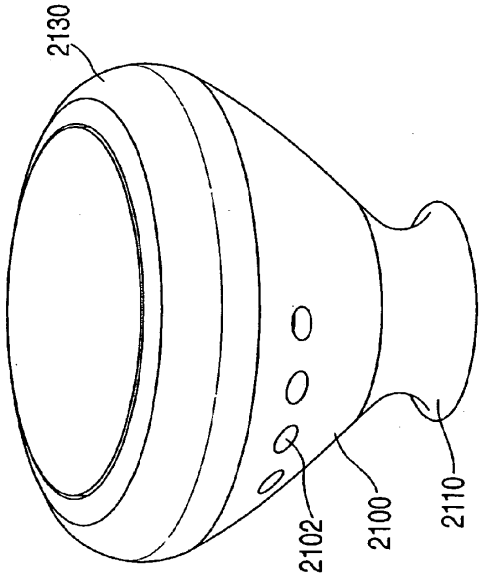


FIG. 21A

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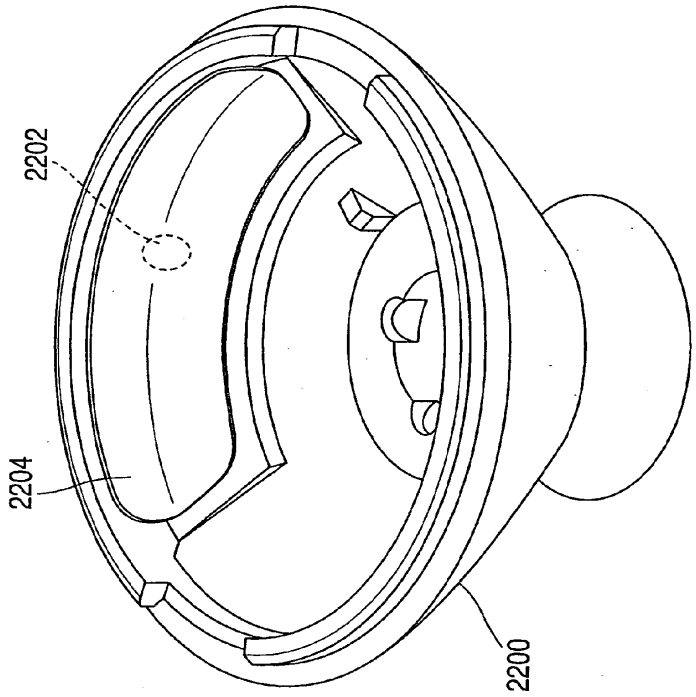


FIG. 22

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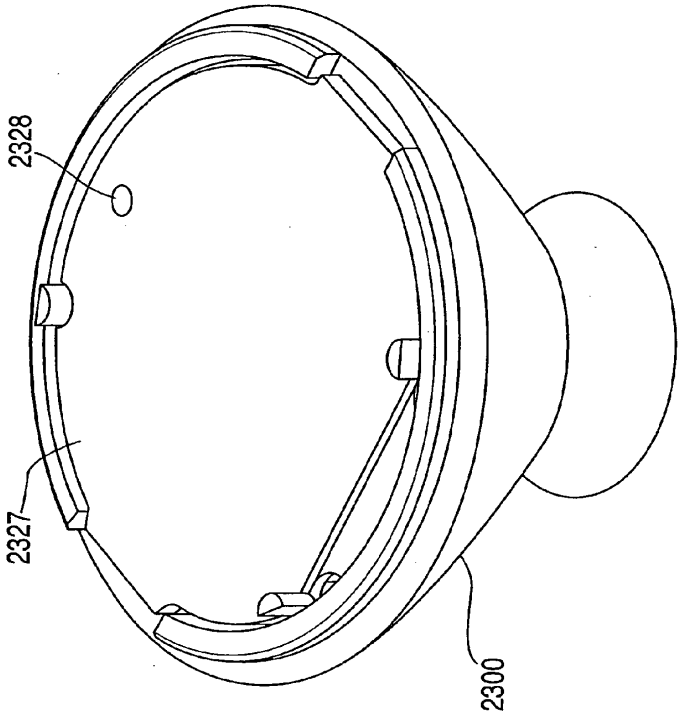


FIG. 23

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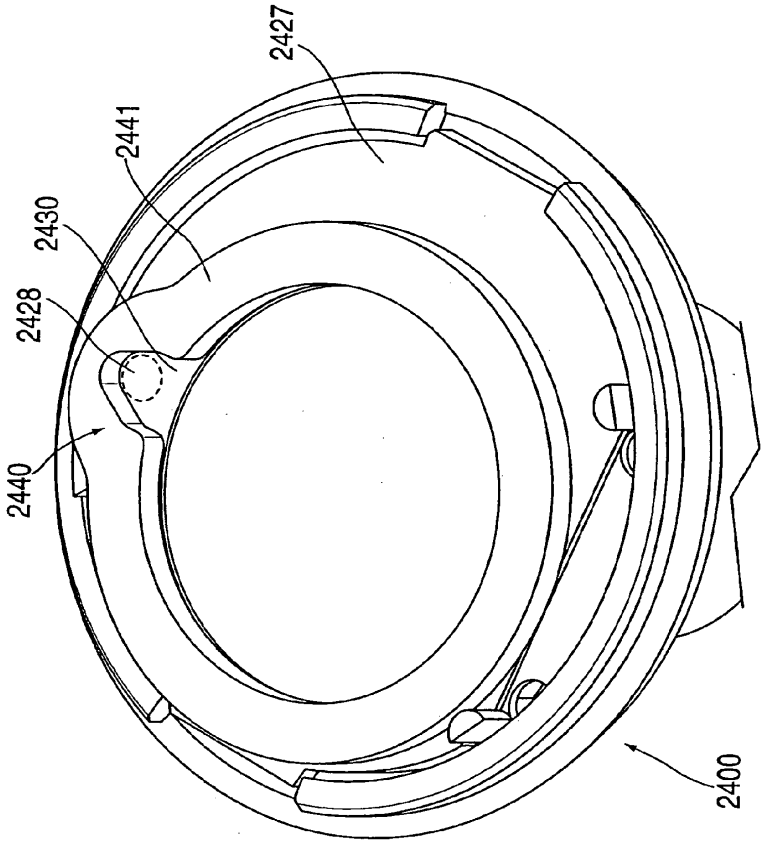


FIG. 24

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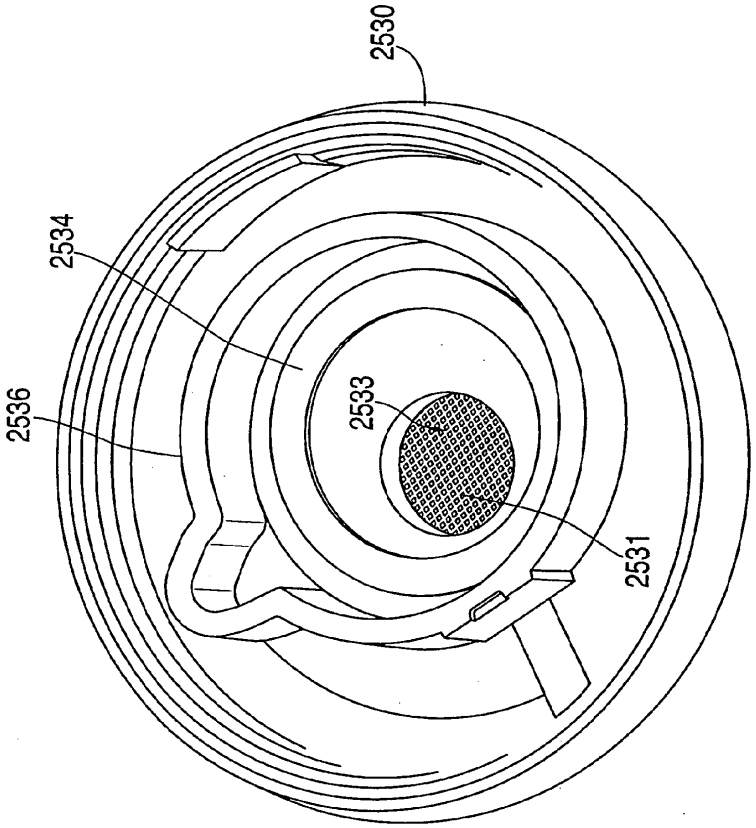


FIG. 25

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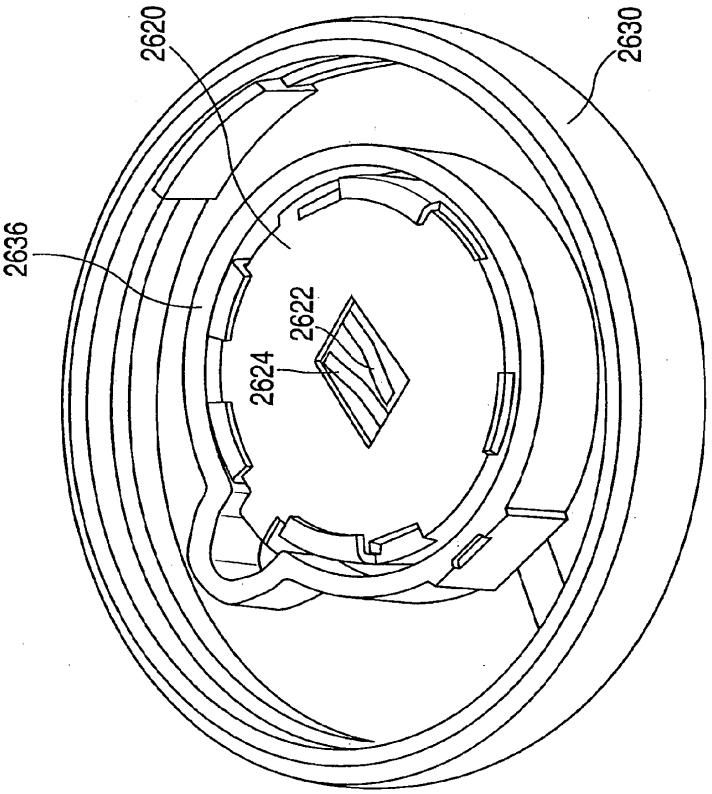


FIG. 26A

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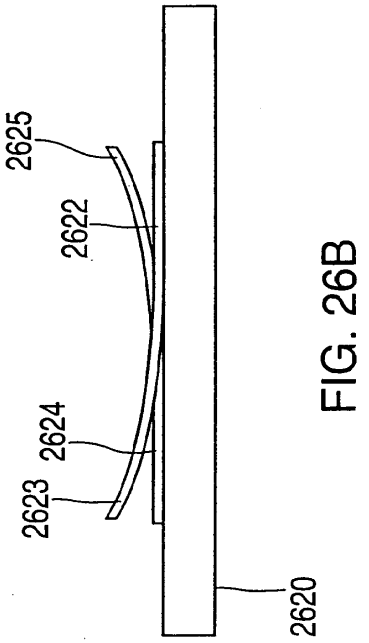


FIG. 26B

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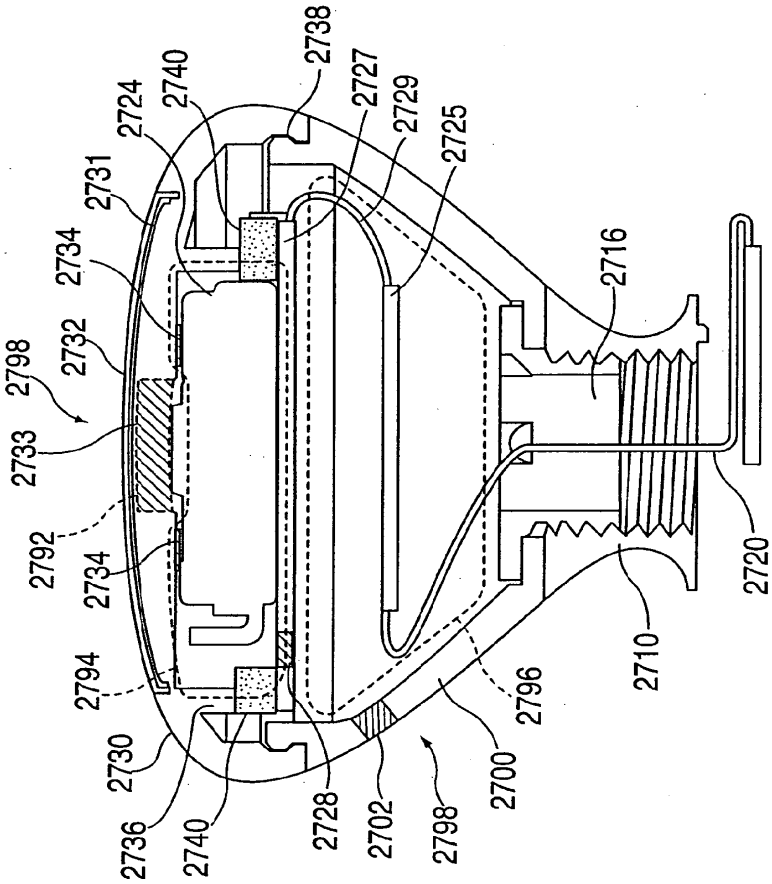


FIG. 27A

SONOVA EX1018
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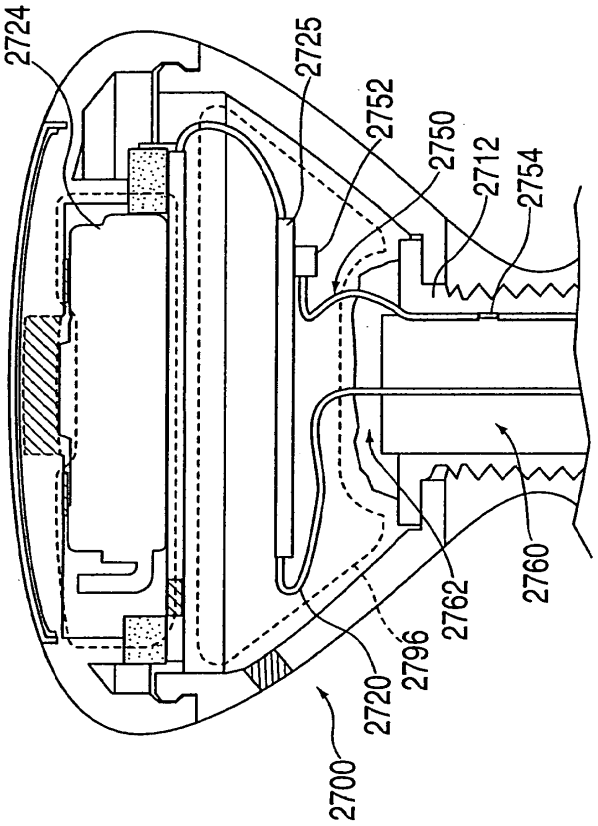


FIG. 27B

SONOVA EX1018
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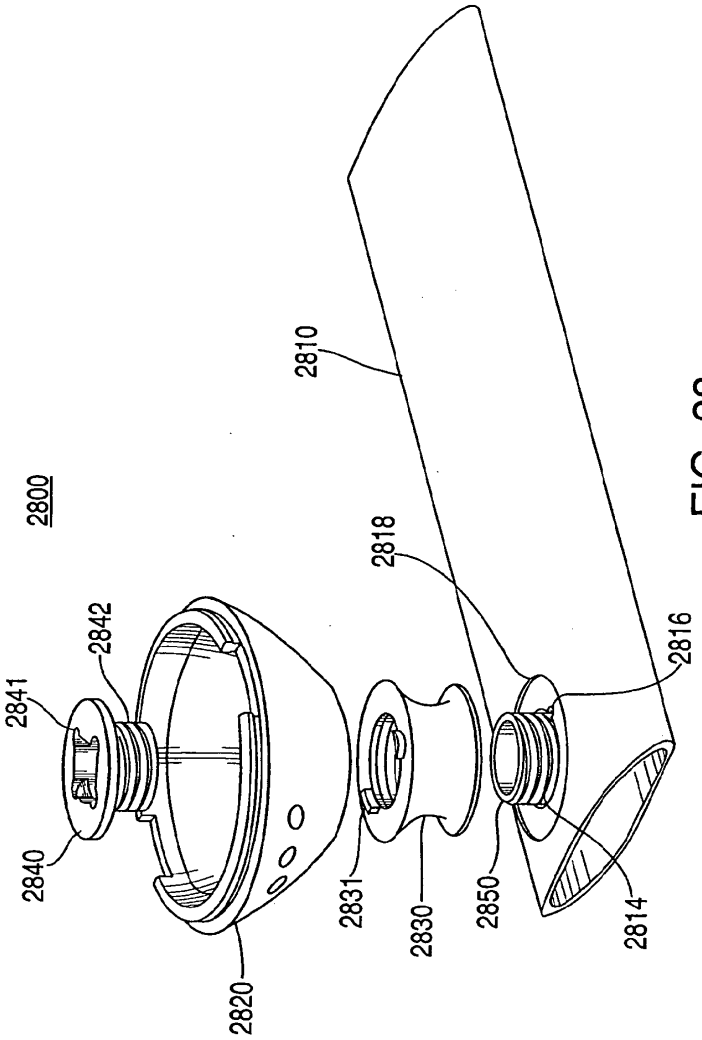


FIG. 28

SONOVA EX1018
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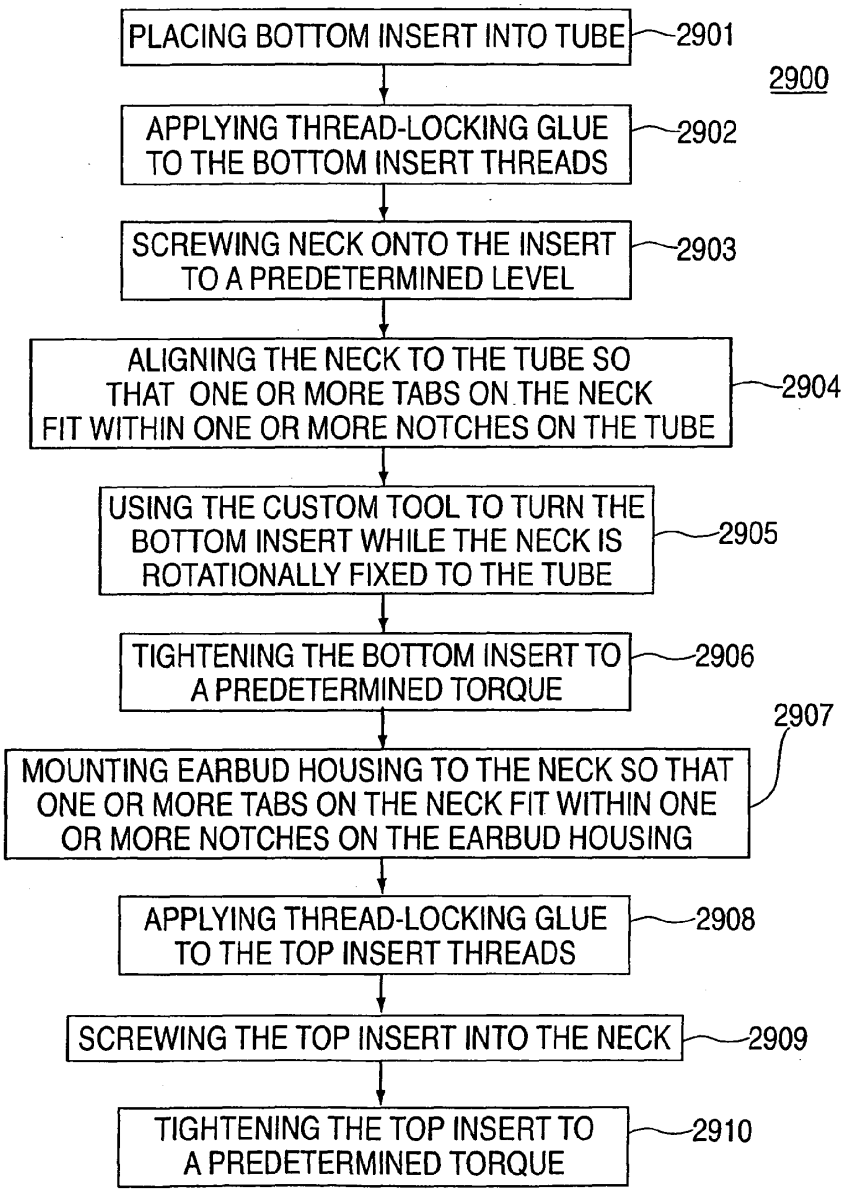


FIG. 29

SONOVA EX1018
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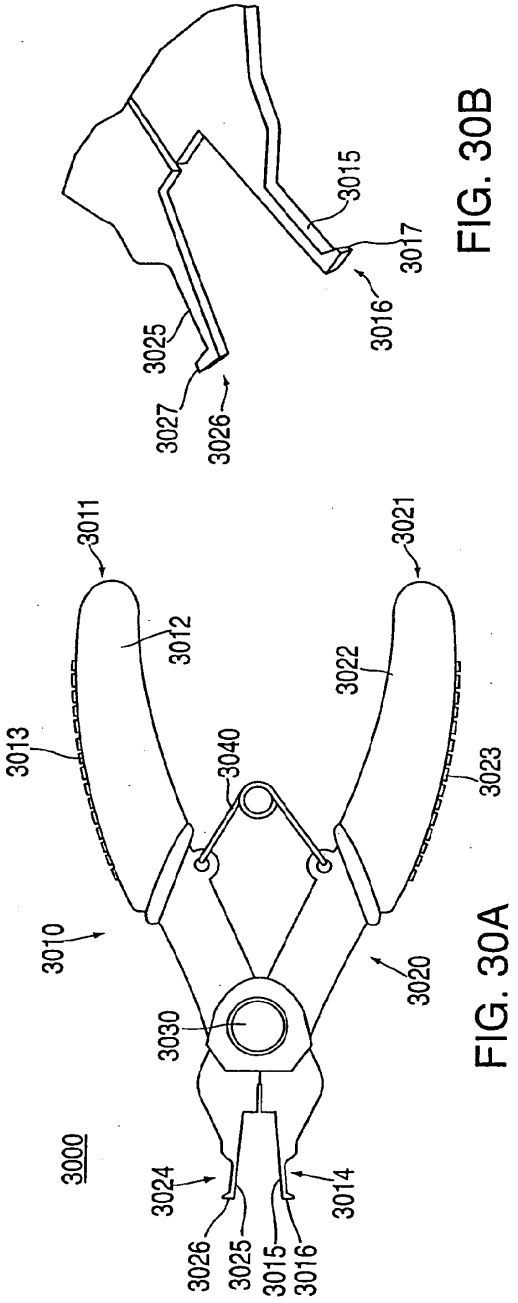


FIG. 30A

FIG. 30B

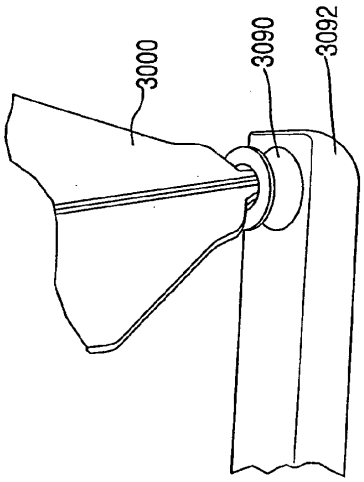


FIG. 30C

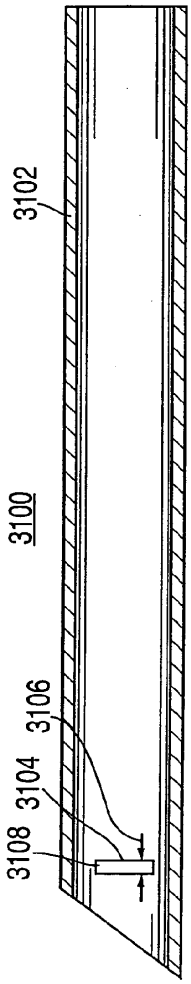


FIG. 31

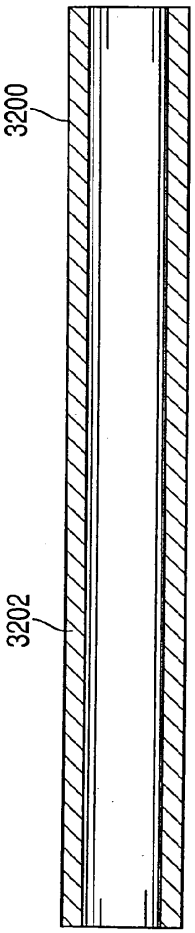


FIG. 32

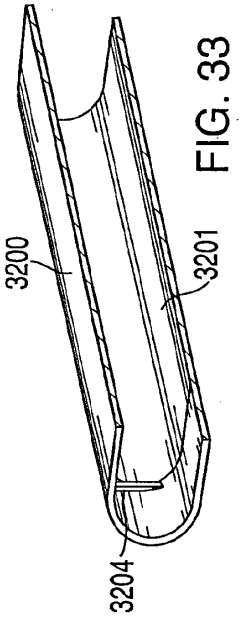


FIG. 33

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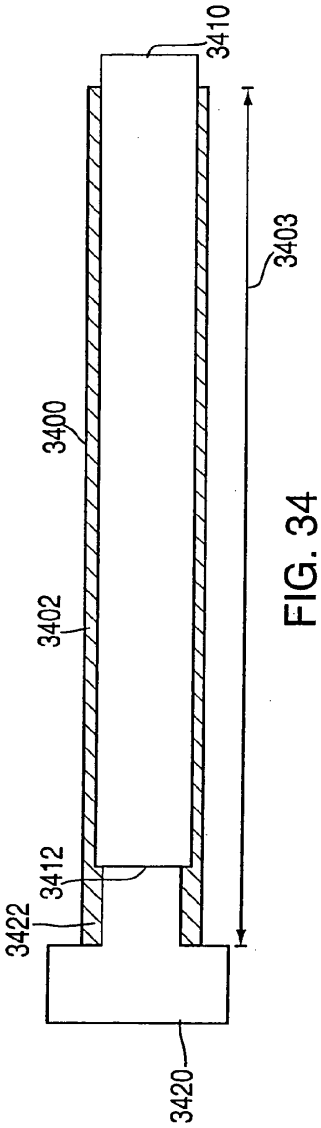


FIG. 34

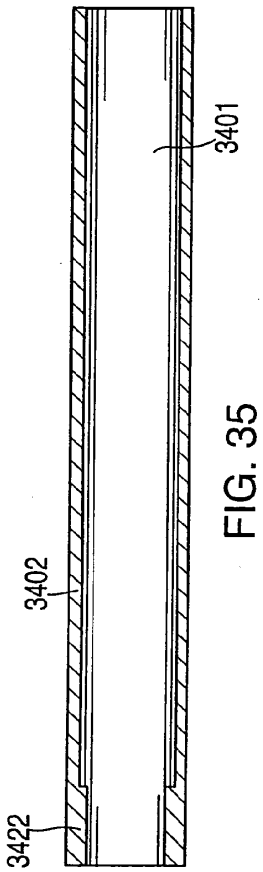


FIG. 35

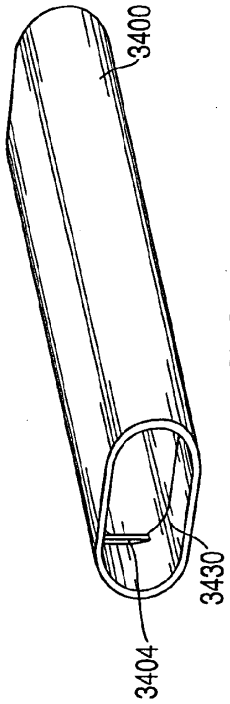


FIG. 36

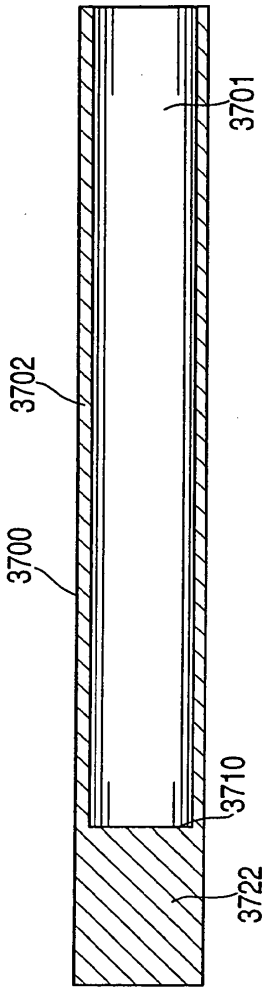


FIG. 37

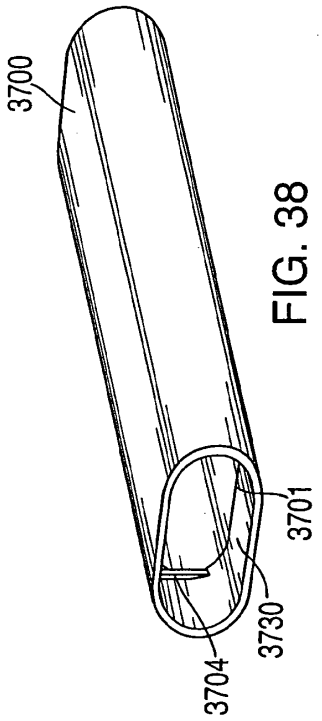


FIG. 38

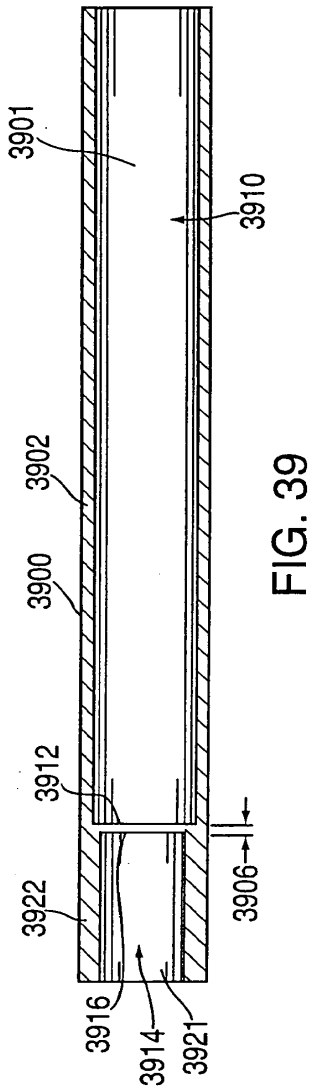


FIG. 39

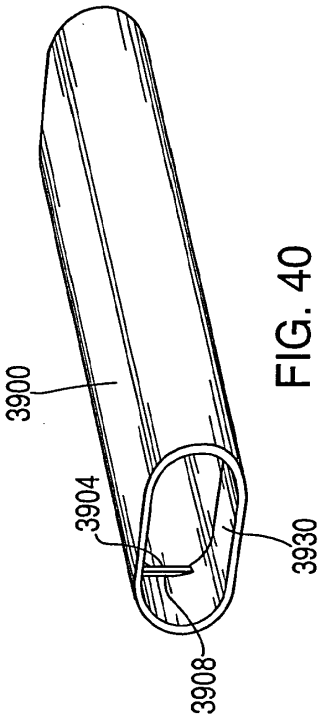


FIG. 40

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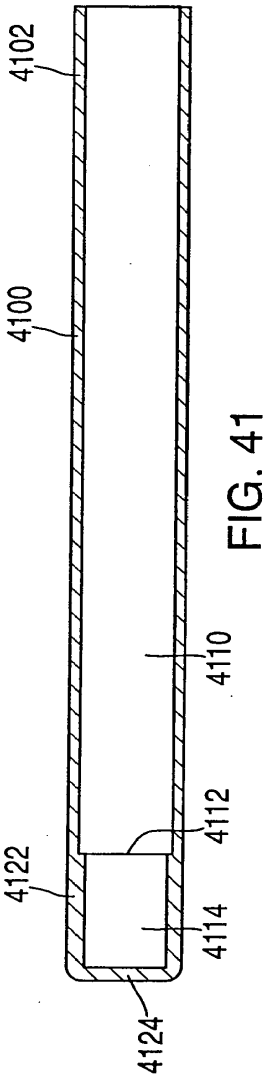


FIG. 41

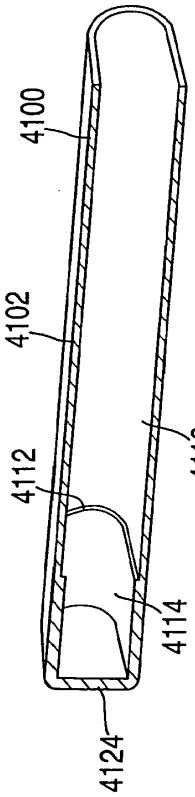


FIG. 42

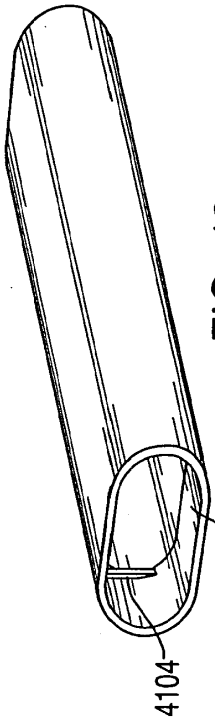


FIG. 43

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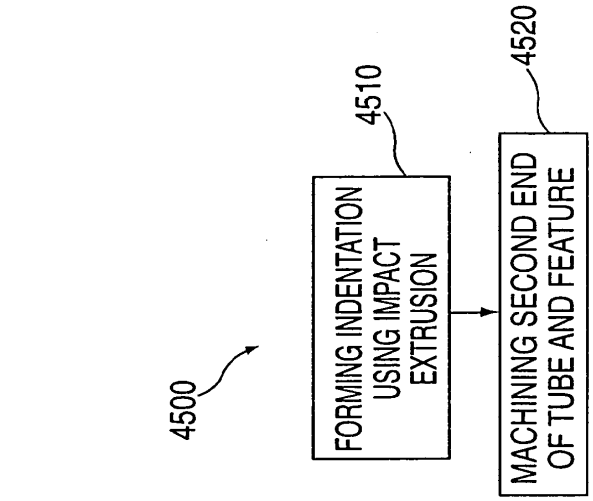


FIG. 45

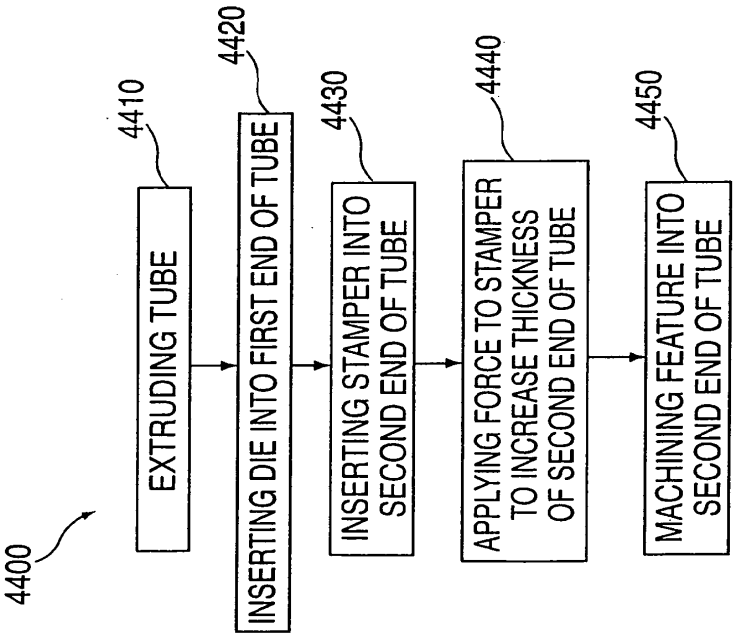


FIG. 44

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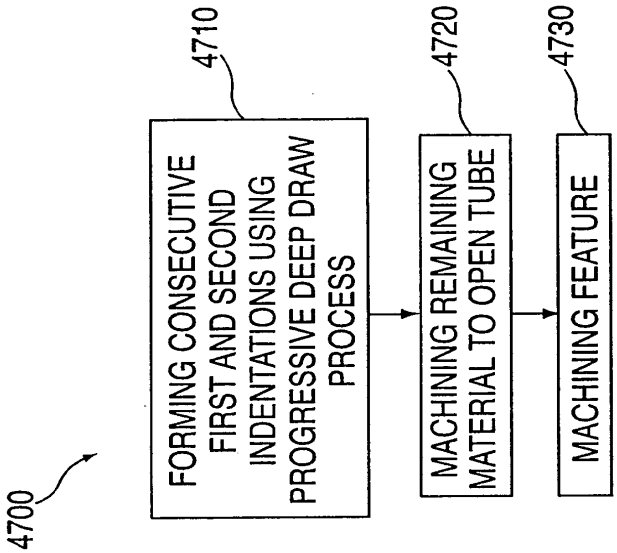


FIG. 47

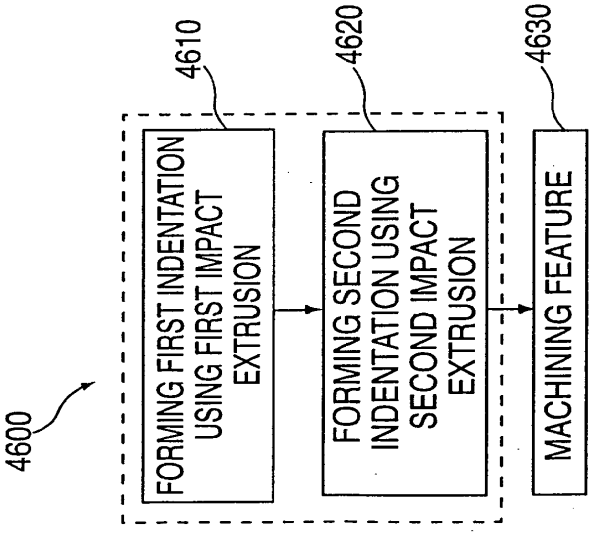


FIG. 46

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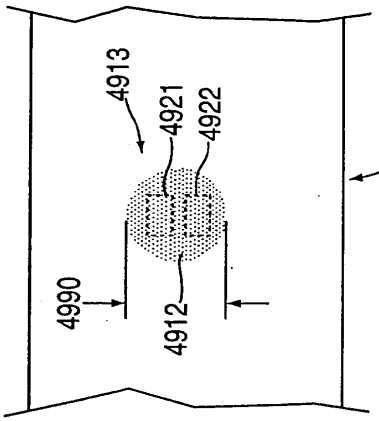

4913
4921
4922
4910
4990
4912

FIG. 49

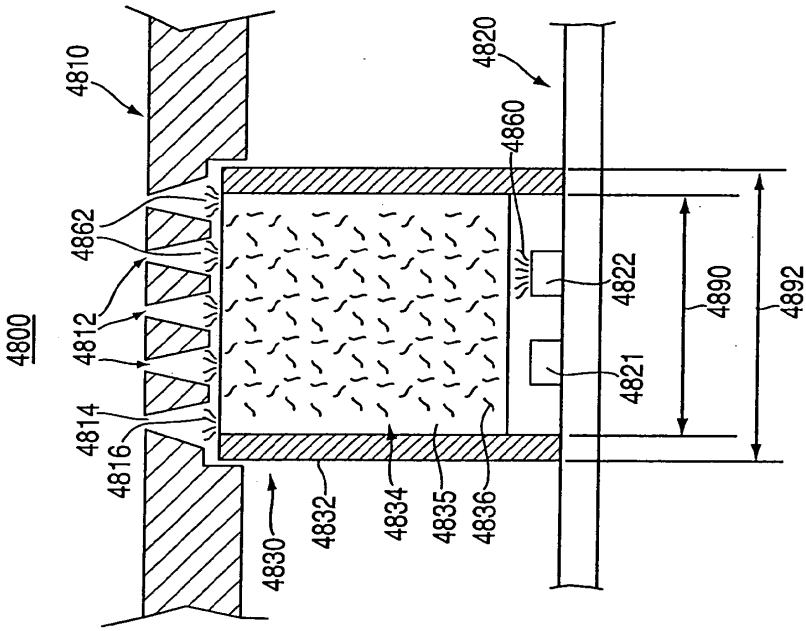

4800
4810
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4830

FIG. 48

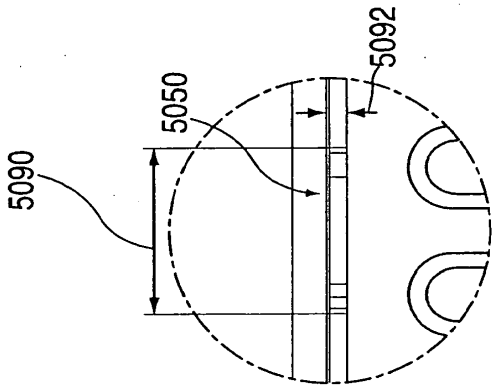


FIG. 50B

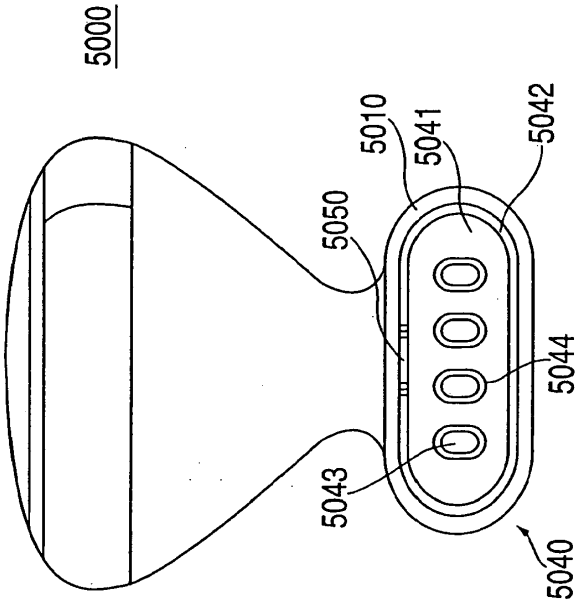


FIG. 50A

SONOVA EX1018
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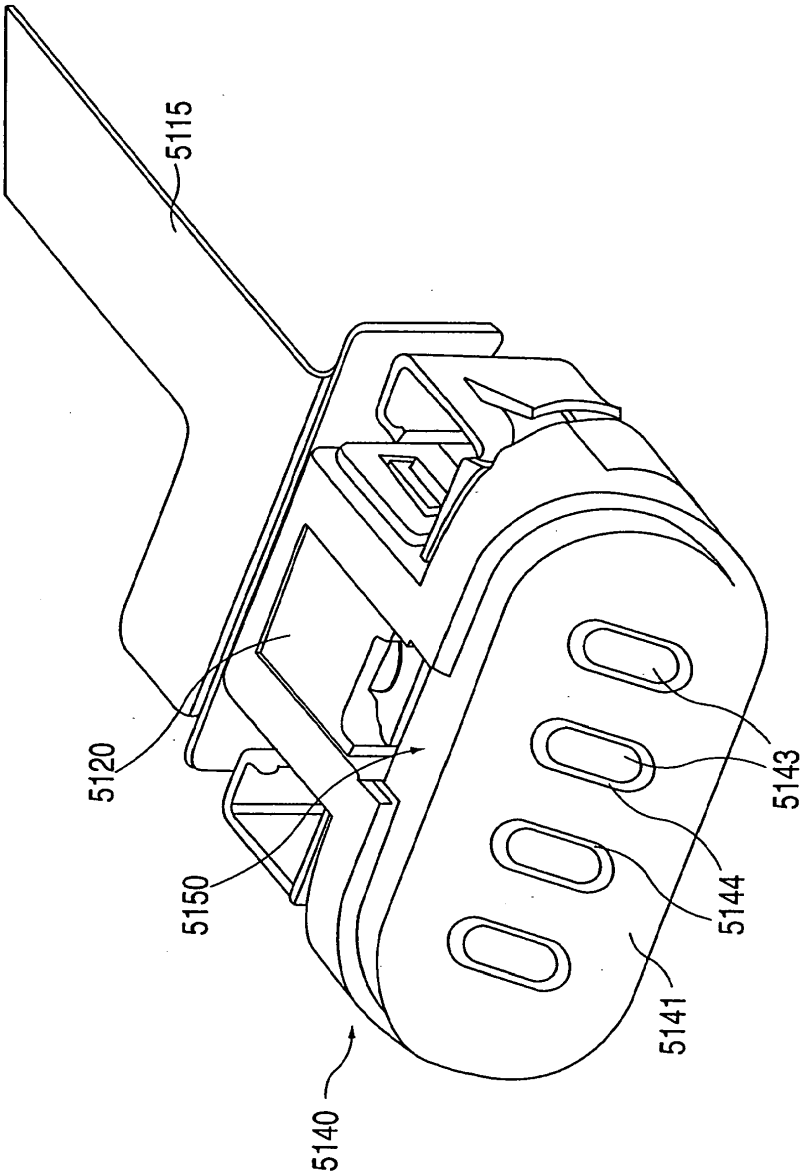


FIG. 51

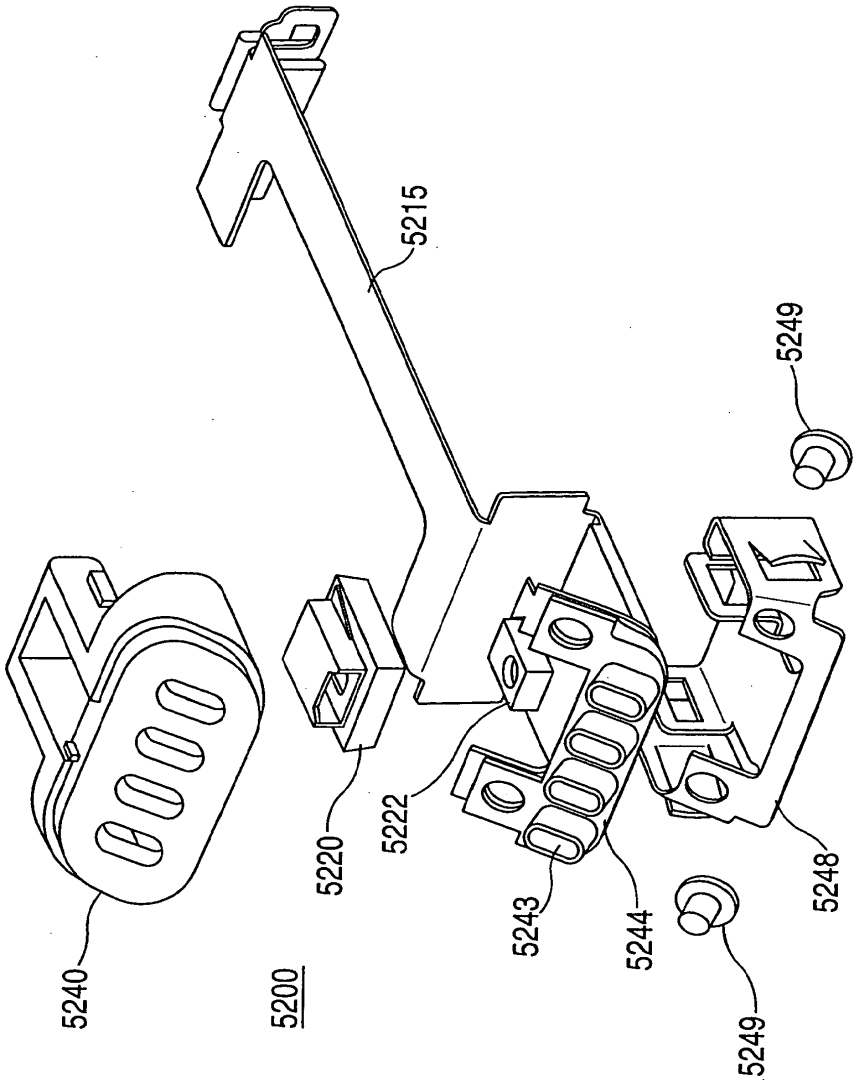


FIG. 52

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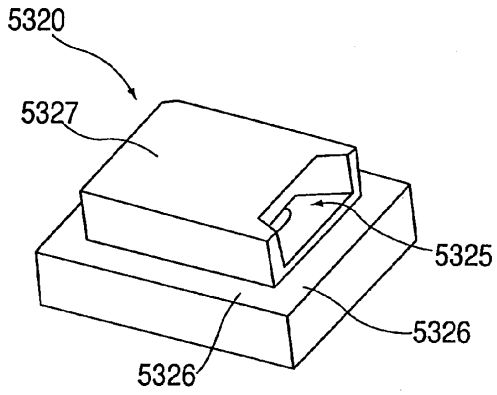

5320
5327
5325
5326
5326

FIG. 53

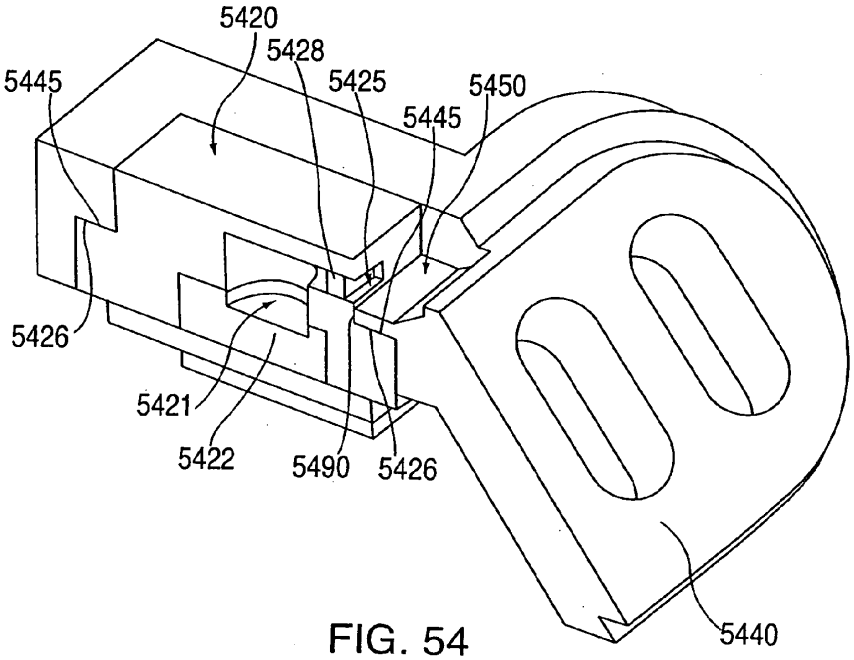

5420
5428
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5445
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5426
5440

FIG. 54

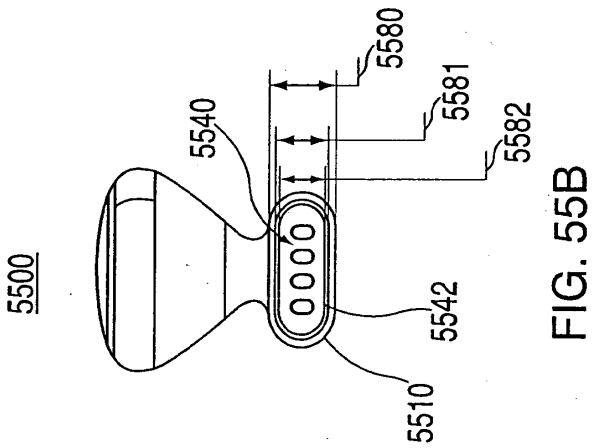


FIG. 55B

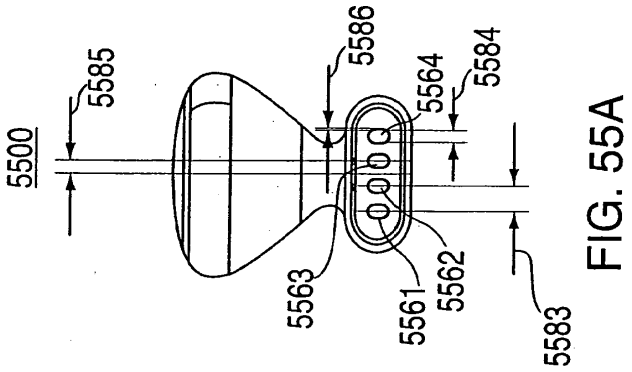


FIG. 55A

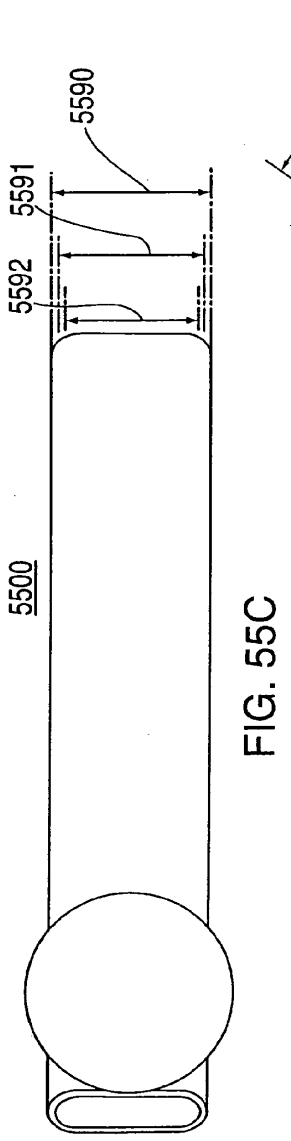


FIG. 55C

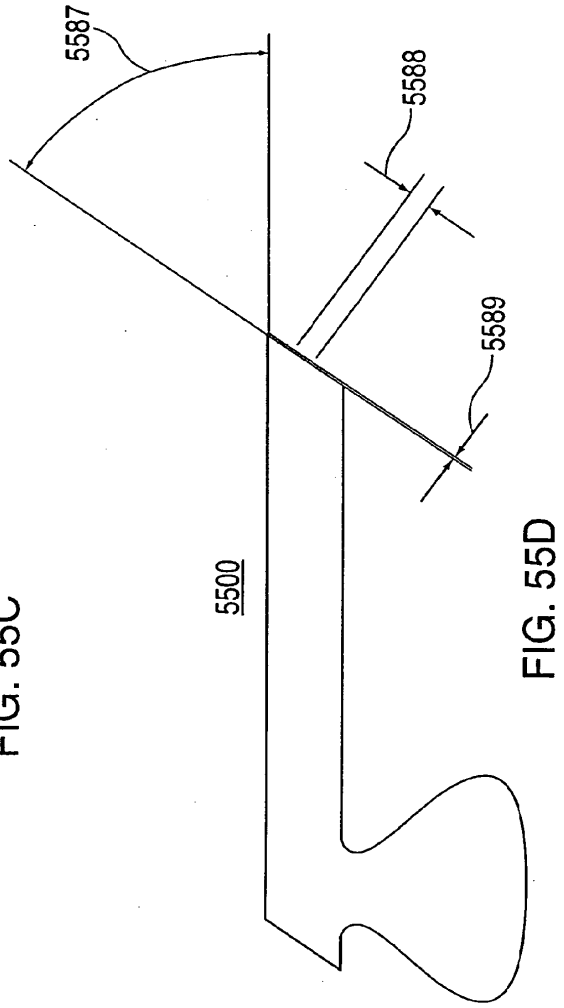


FIG. 55D

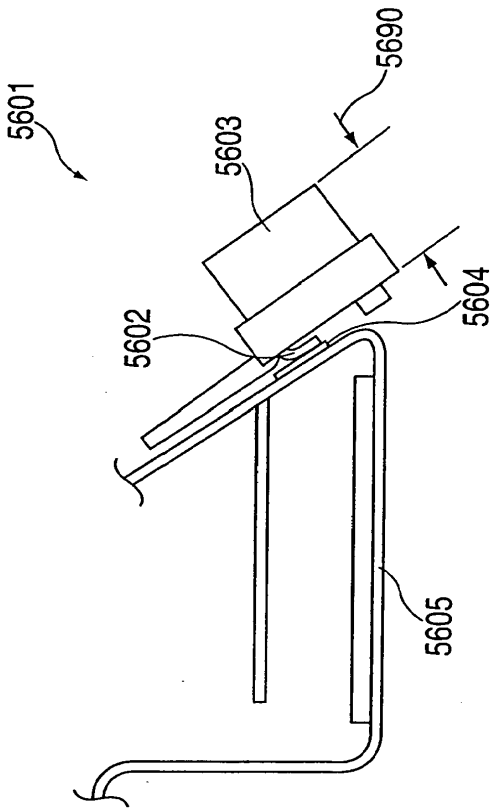


FIG. 56

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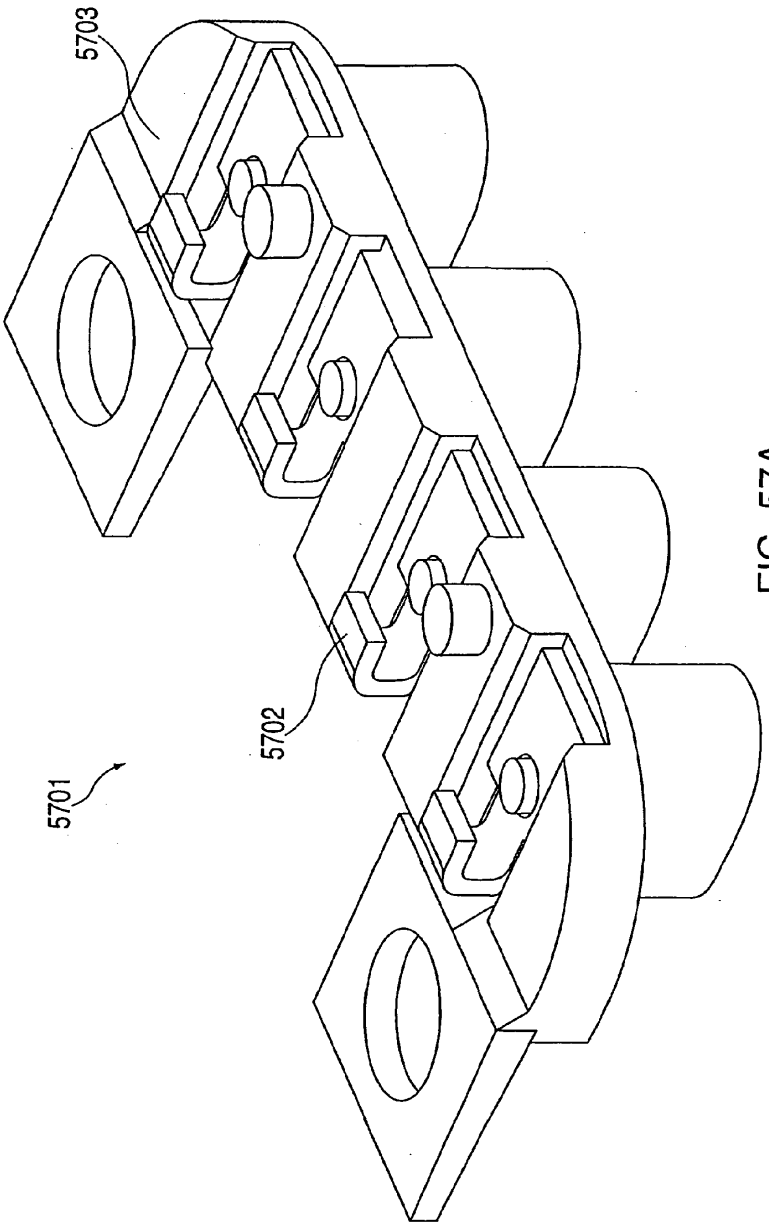


FIG. 57A

SONOVA EX1018
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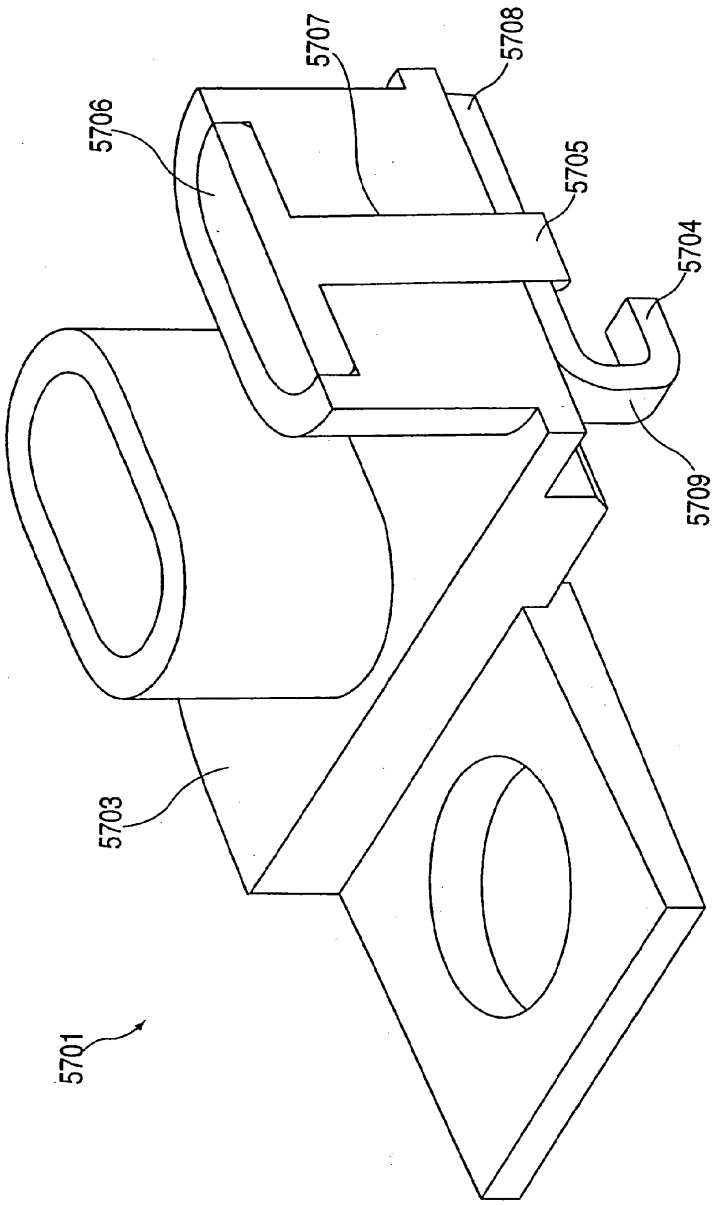


FIG. 57B

SONOVA EX1018
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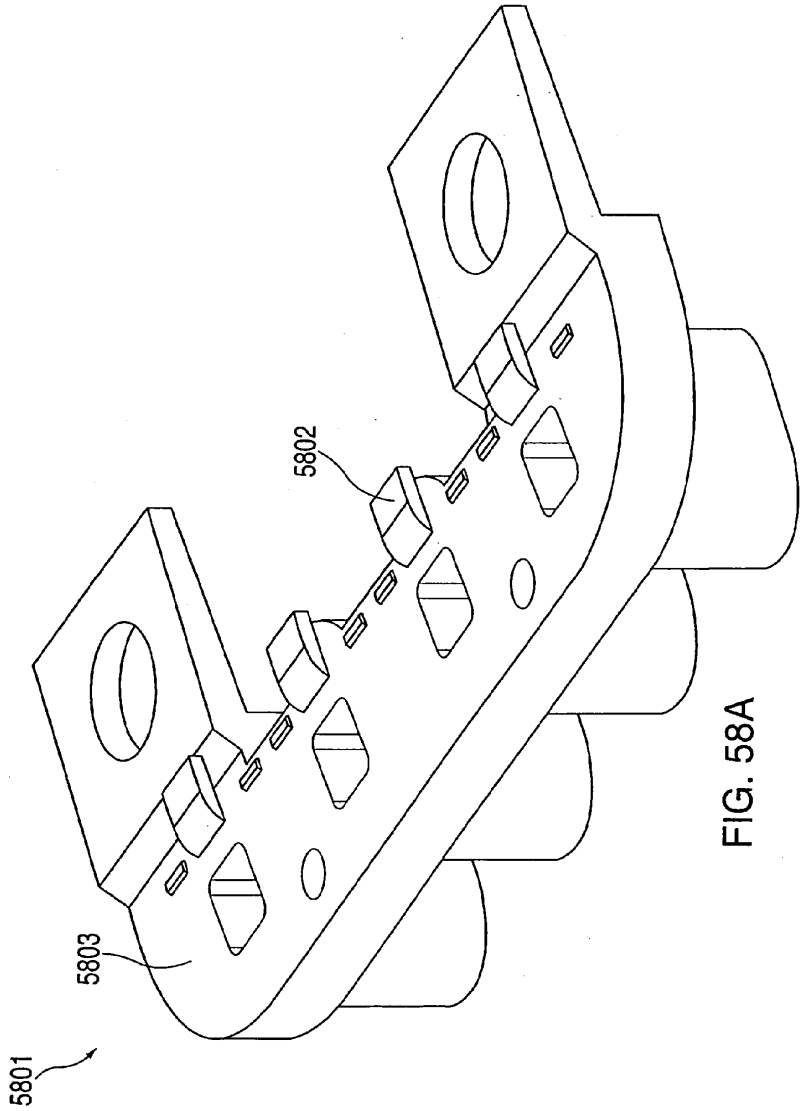


FIG. 58A

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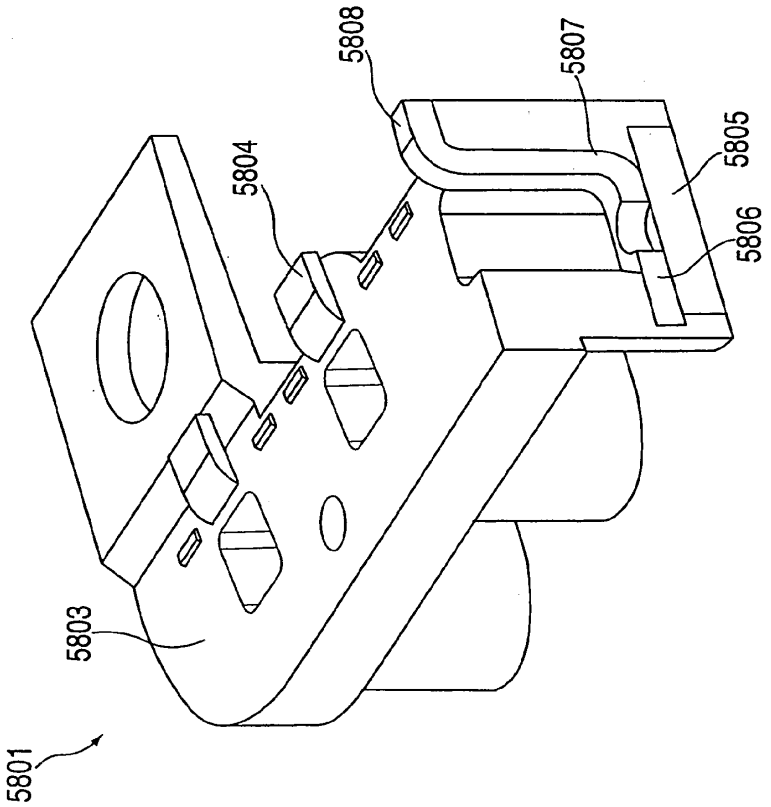


FIG. 58B

SONOVA EX1018
Page 425

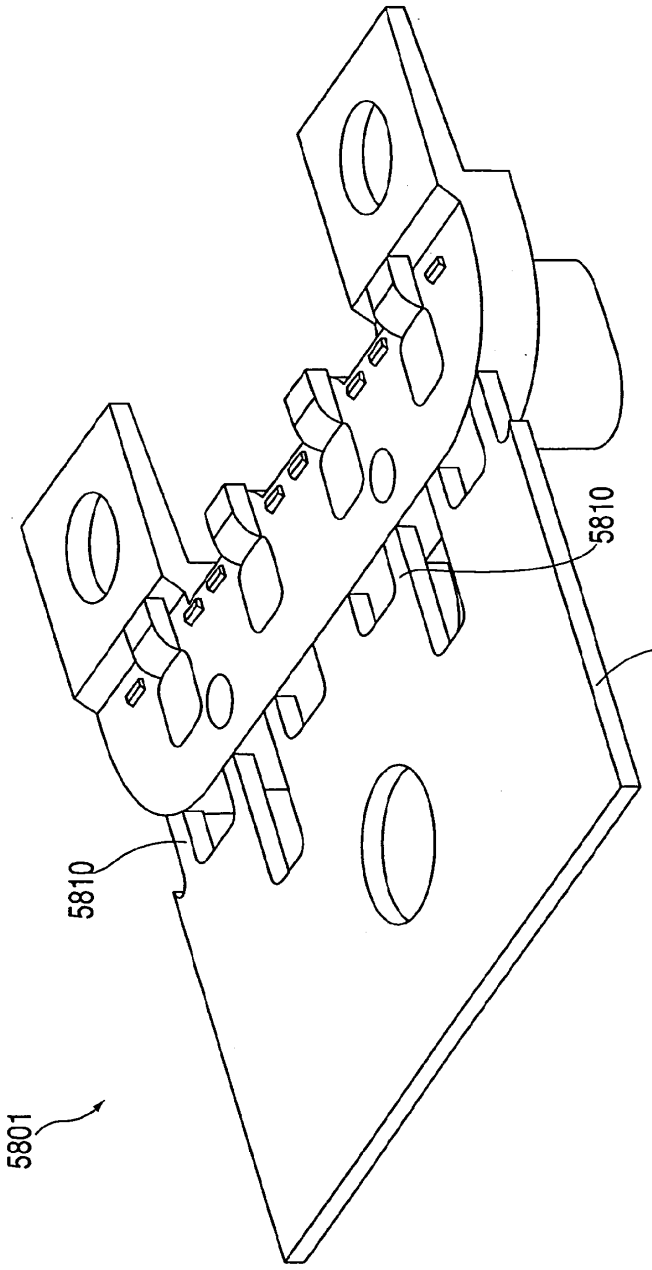


FIG. 58C

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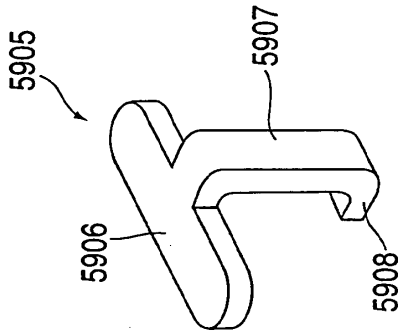


FIG. 59B

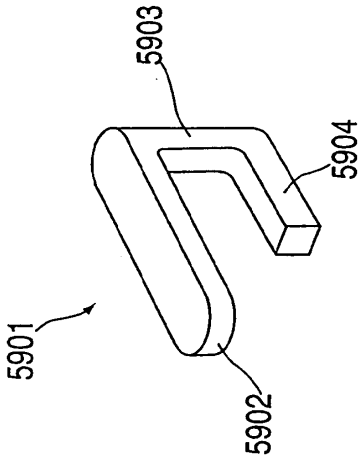


FIG. 59A

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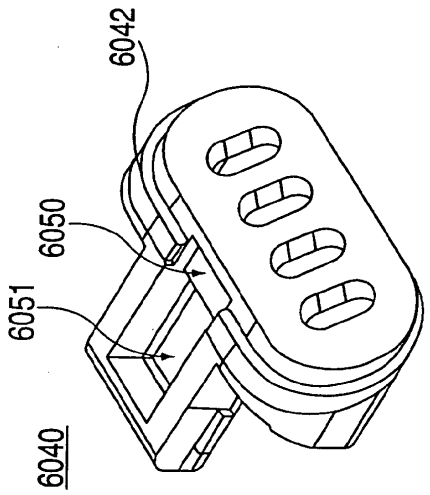


FIG. 60A

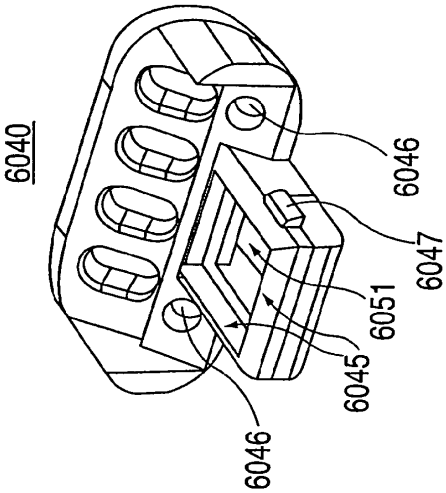


FIG. 60B

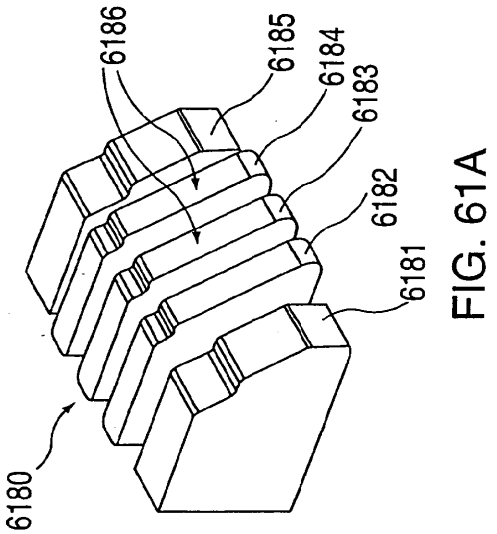


FIG. 61A

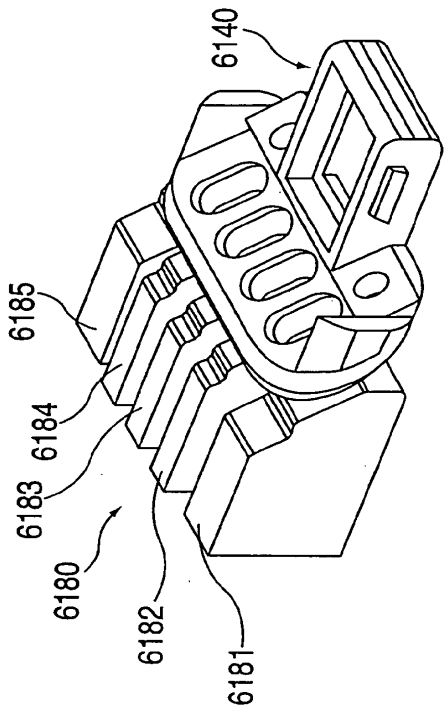


FIG. 61B

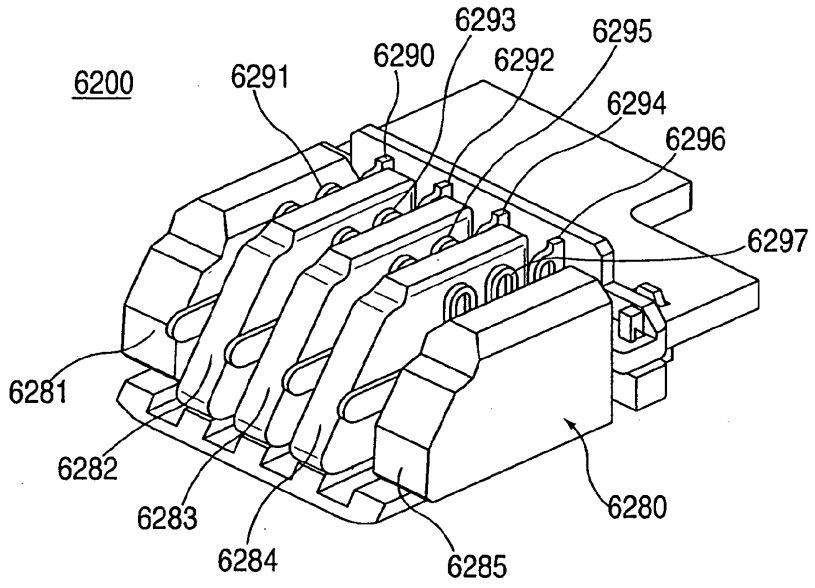


FIG. 62A

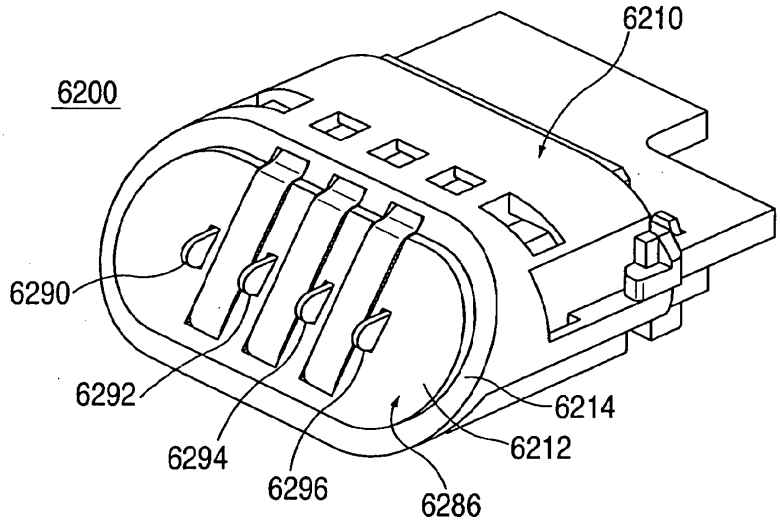


FIG. 62B

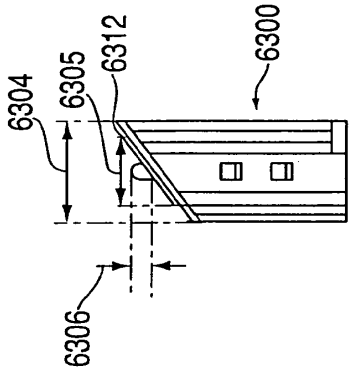


FIG. 63B

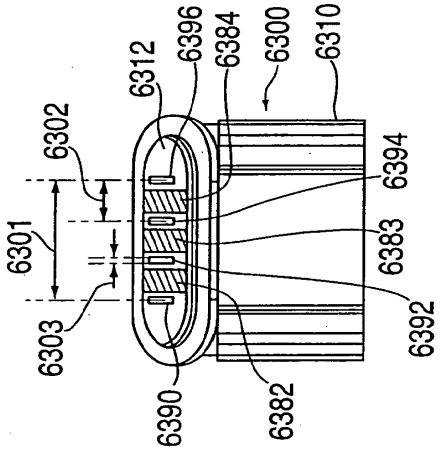


FIG. 63A

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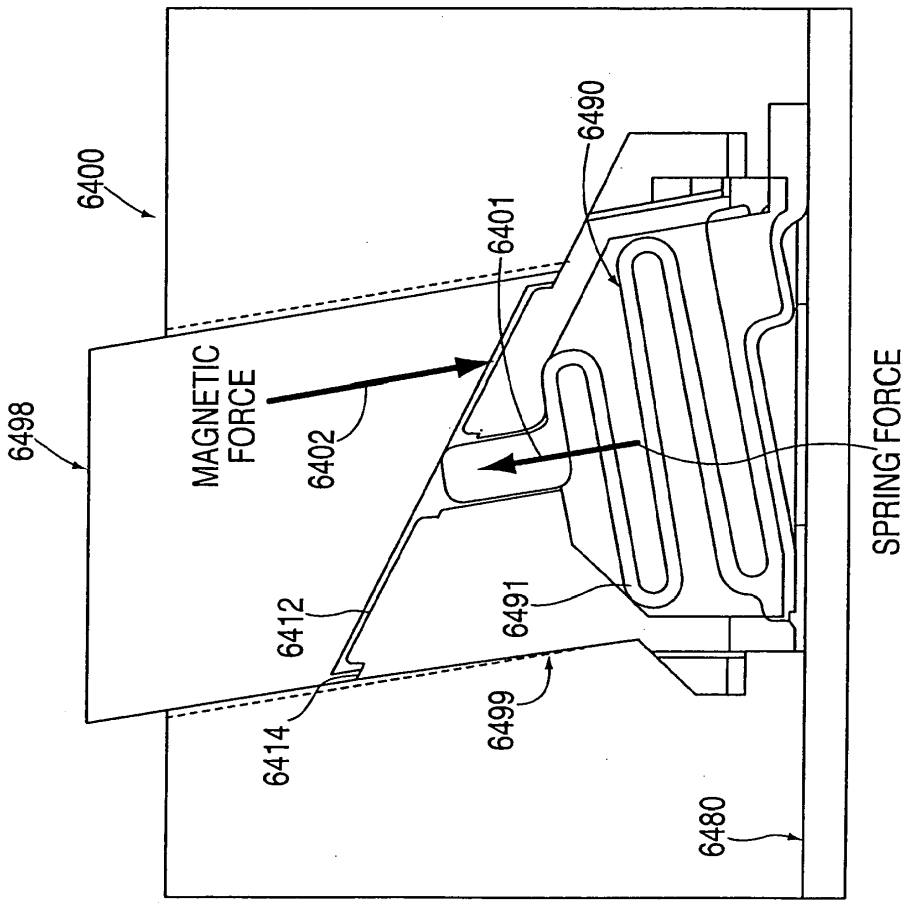

6400
6490
6401
MAGNETIC FORCE
6402
6498
SPRING FORCE
6412
6491
6414
6499
6480

FIG. 64

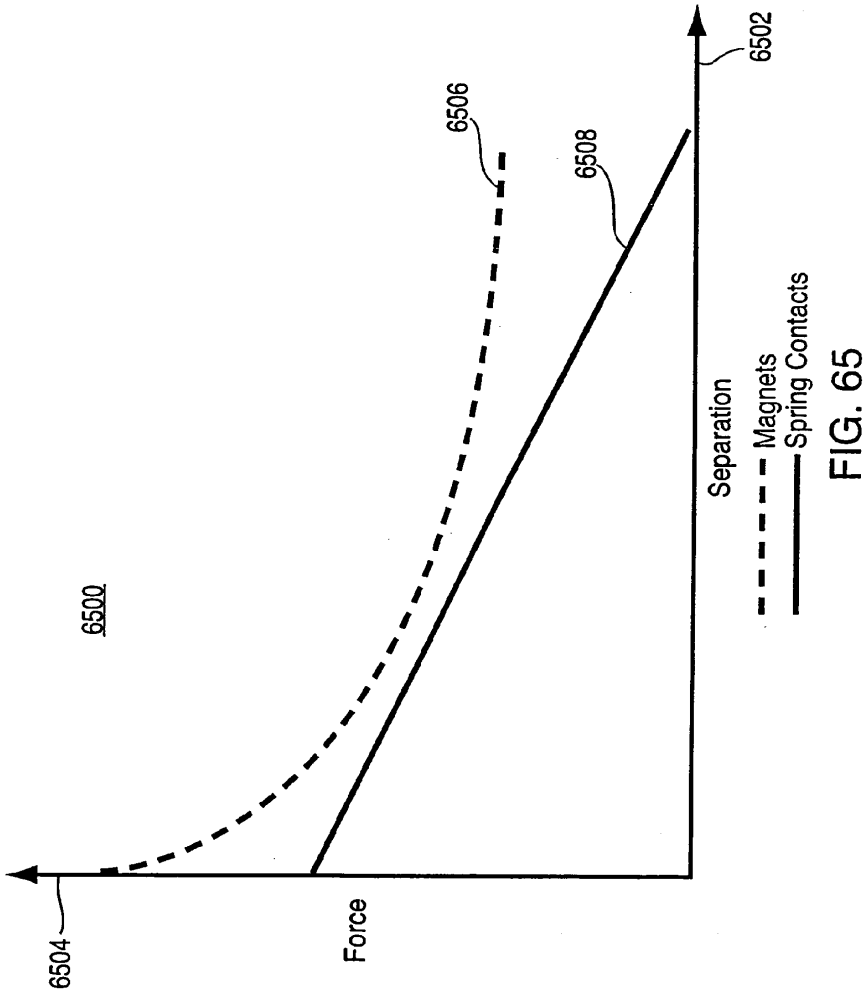

6500
6502
6504
6506
6508
Force
Separation
Magnets
Spring Contacts

FIG. 65

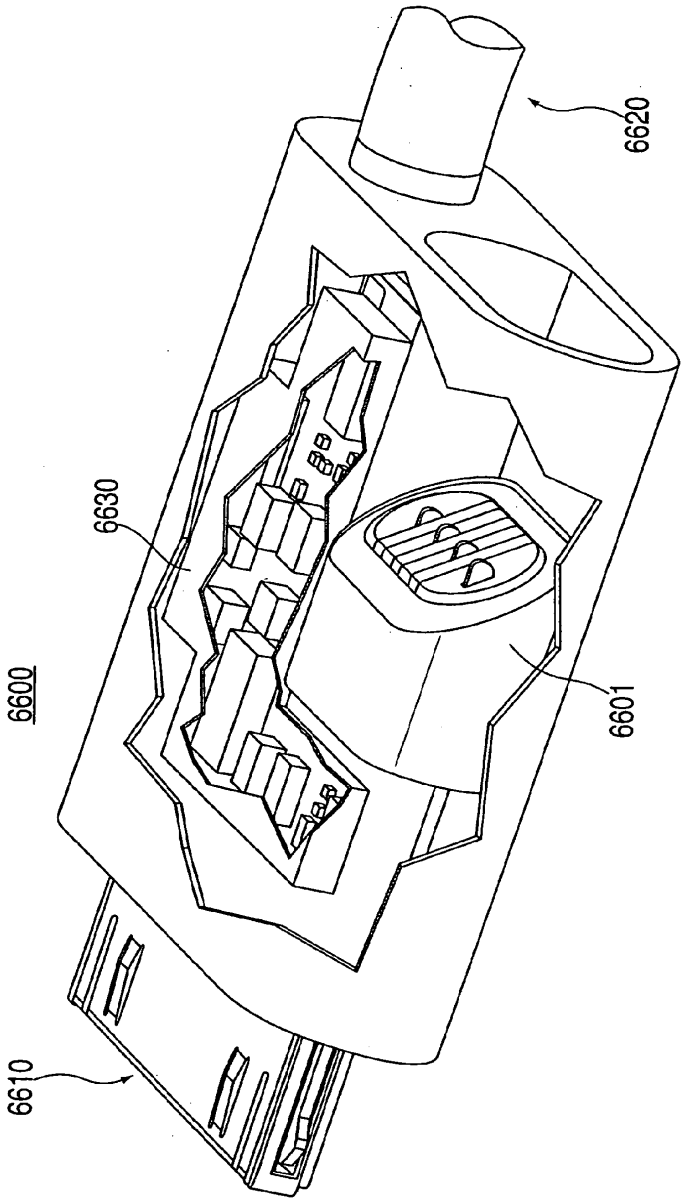


FIG. 66

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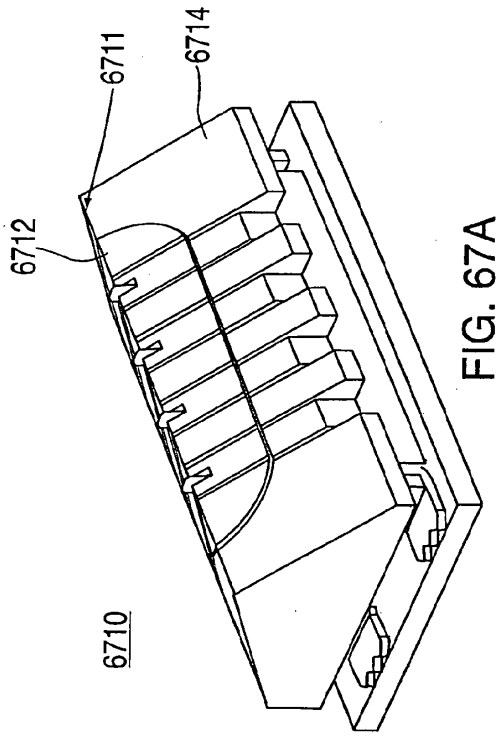


FIG. 67A

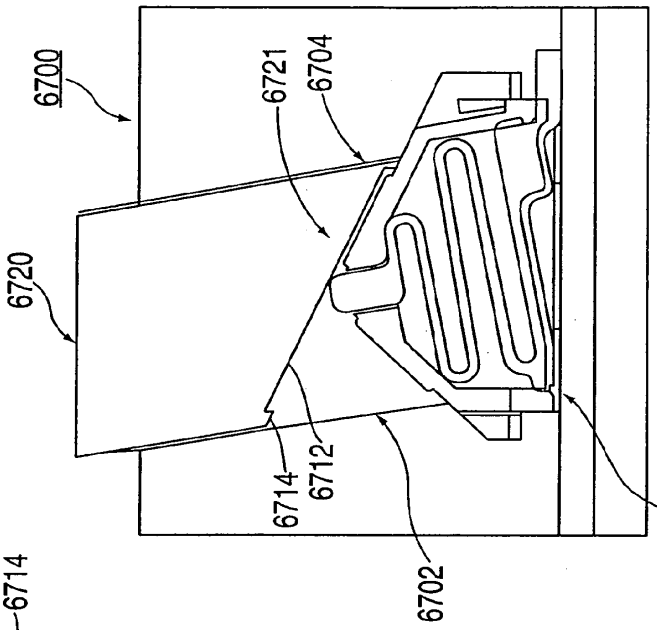
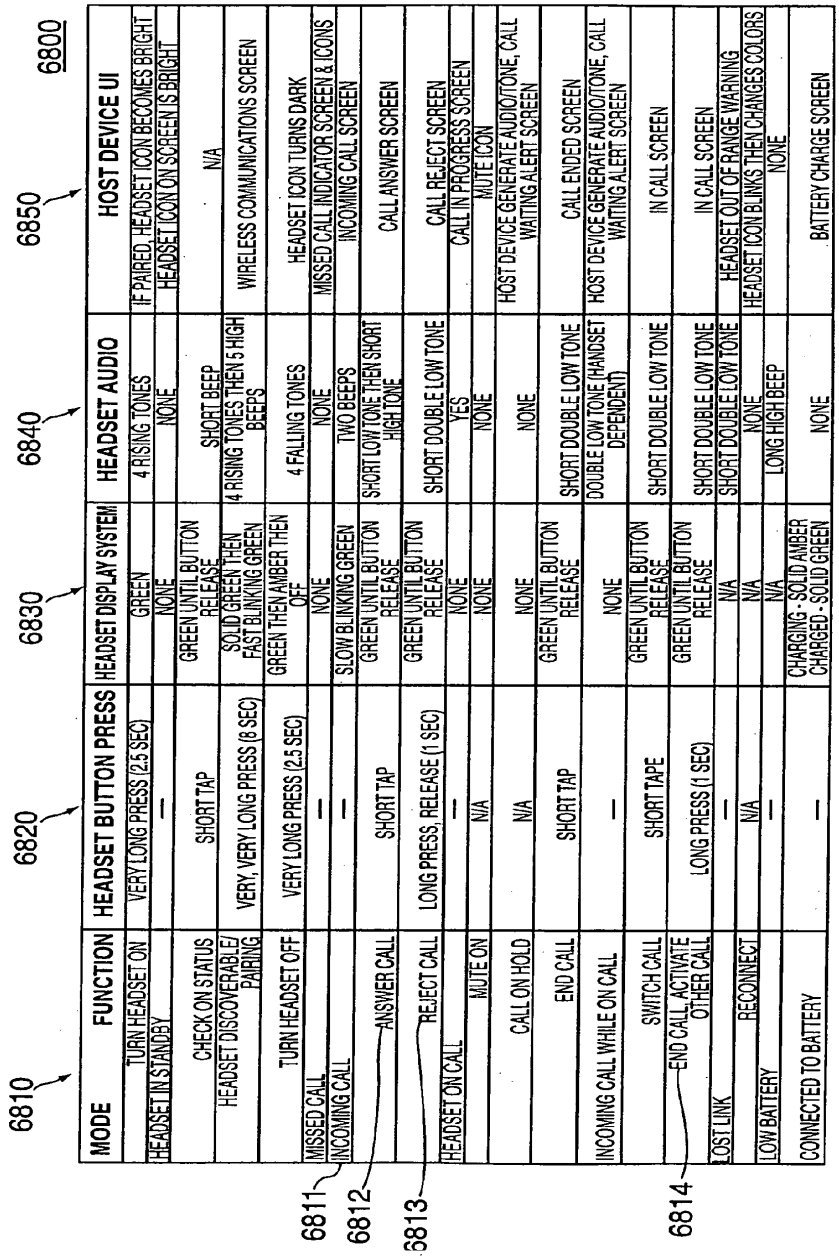


FIG. 67B



MODE	FUNCTION	HEADSET BUTTON PRESS	HEADSET DISPLAY SYSTEM	HEADSET AUDIO	HOST DEVICE UI
HEADSET IN STANDBY	TURN HEADSET ON	VERY LONG PRESS (2.5 SEC)	GREEN	4 RISING TONES	IF PAIRED, HEADSET ICON BECOMES BRIGHT
	TURN HEADSET OFF	VERY LONG PRESS (2.5 SEC)	GREEN THEN AMBER THEN OFF	4 FALLING TONES	HEADSET ICON TURNS DARK
	CHECK ON STATUS	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT BEEP	N/A
	HEADSET DISCOVERABLE/ PAIRING	VERY, VERY LONG PRESS (8 SEC)	SOLID GREEN THEN FAST BLINKING GREEN	4 RISING TONES THEN 5 HIGH BEEPS	WIRELESS COMMUNICATIONS SCREEN
		—	NONE	NONE	HEADSET ICON ON SCREEN IS BRIGHT
MISSED CALL		—	NONE	NONE	MISSED CALL INDICATOR SCREEN & ICONS
INCOMING CALL		—	SLOW BLINKING GREEN	TWO BEEPS	INCOMING CALL SCREEN
	ANSWER CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT LOW TONE THEN SHORT HIGH TONE	CALL ANSWER SCREEN
	REJECT CALL	LONG PRESS, RELEASE (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL REJECT SCREEN
HEADSET ON CALL		—	NONE	YES	CALL IN PROGRESS SCREEN
	MUTE ON	N/A	NONE	NONE	MUTE ICON
	CALL ON HOLD	N/A	NONE	NONE	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
	END CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL ENDED SCREEN
INCOMING CALL WHILE ON CALL		—	NONE	DOUBLE LOW TONE (HANDSET DEPENDENT)	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
	SWITCH CALL	SHORT TAPE	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
	END CALL, ACTIVATE OTHER CALL	LONG PRESS (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
LOST LINK		—	N/A	SHORT DOUBLE LOW TONE	HEADSET OUT OF RANGE WARNING
	RECONNECT	N/A	N/A	NONE	HEADSET ICON BLINKS THEN CHANGES COLORS
LOW BATTERY		—	N/A	LONG HIGH BEEP	NONE
CONNECTED TO BATTERY		—	CHARGING - SOLID AMBER CHARGED - SOLID GREEN	NONE	BATTERY CHARGE SCREEN

FIG. 68

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 1970

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A	EP 0 918 357 A2 (ITT MFG ENTERPRISES INC [US]) 26 May 1999 (1999-05-26) * paragraph [0015]; figures 1,2 *	1	
A	US 5 245 269 A (TOOLEY THOMAS P [US] ET AL) 14 September 1993 (1993-09-14) * abstract; figure 3 *	1	
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A	WO 01/86923 A1 (GN NETCOM AS [DK]; RATH KLAUS [DK]; PEDERSEN CHARLES L [DK]) 15 November 2001 (2001-11-15) * page 8, line 16 - page 17, line 2; figures 1-11 *	1,2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 July 2013	Agreda Labrador, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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16-07-2013

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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H04N 21/218 (2011.01)

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(74) Agent: **STRÖM & GULLIKSSON AB**; P.O. Box 4188, 203 13 Malmö (SE).

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[Continued on next page]

(54) Title: LONGITUDINAL ARRANGED WIRELESS EARBUDS AND THE CHARGING THEREOF

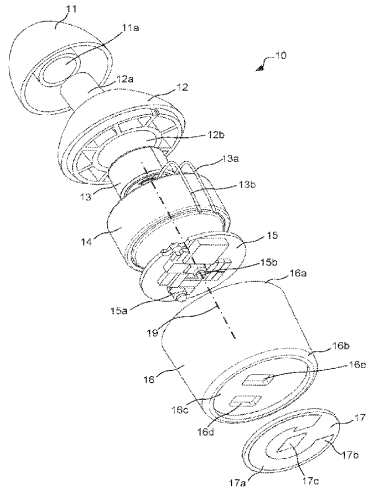


Fig 6

(57) Abstract: A wireless earbud (10) has an earbud housing (12, 16) having a longitudinal main axis (19) and an essentially circular cross section, a loudspeaker element (13), a rechargeable battery (14), at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114), and a charging interface member (17). The loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

WO 2016/036309 A1

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

IMPROVEMENTS IN WIRELESS EARBUDS AND THE CHARGING THEREOF

Technical Field

The present invention generally relates to the field of wireless audio playback equipment, and more particularly to wireless earbuds and to storage and charging of such earbuds.

Background

Wireless earbuds, also known as wireless in-ear headphones or earphones, are expected to become increasingly popular. The advent and rapid growth of digital audio streaming services, such as Spotify, Pandora, Rhapsody, Google Play Music All Access, iTunes Radio, Music Unlimited, Rdio, Xbox Music and Beats Music, are likely drivers behind the expected growing popularity and desire for wireless earbuds.

Important characteristics of wireless earbuds are physical size, convenience and user-friendliness, duration between battery chargings, operational reliability and, of course, the perceived acoustic quality of the streamed audio.

Summary

It is an object of the invention to offer improvements in the technical field of wireless earbuds.

One aspect of the present invention is a wireless earbud, comprising an earbud housing having a longitudinal main axis and an essentially circular cross section, a loudspeaker element, a rechargeable battery, at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control, and a charging interface member, wherein the loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

Another aspect of the present invention is a storage and charging capsule for a pair of wireless earbuds, the storage and charging capsule comprising a base part, an elongate intermediate part, the intermediate part having a longitudinal major axis, and a cover part being retractable over the intermediate part, wherein the intermediate part has a first end attached to the base part, a second end, and an earbud chamber formed between the first and second ends, the earbud chamber being adapted to receive the pair of wireless earbuds arranged one after another along the longitudinal major axis of the

intermediate part, and wherein the capsule further has a power source for charging the pair of wireless earbuds when placed in the earbud chamber in the intermediate part.

Yet another aspect of the present invention is a wireless earbud having an idle mode and an operational mode, the wireless earbud comprising an earbud housing, a loudspeaker element, a rechargeable battery, and at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control, wherein the circuitry is configured for automatic power preservation by:

detecting connection of said battery to a charger and in response entering the idle mode, wherein existing connections to a second wireless earbud and to a wireless audio streaming host device will be disconnected; and

detecting disconnection of said battery from said charger and in response entering the operational mode by:

attempting a true wireless stereo, TWS, reconnection with the second wireless earbud;

if the attempt is successful, operating the wireless earbud as a TWS audio receiver and otherwise operating the wireless earbud as a mono wireless audio receiver;

if operated as a TWS audio receiver, determining whether the wireless earbud is a master device or a slave device with respect to the second wireless earbud;

if the wireless earbud is determined to be a master device, attempting to reconnect with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable; and

if reconnection with the wireless audio streaming host device fails, initiate a pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable.

Still another aspect of the present invention is a wireless audio streaming host device for use with a first wireless earbud and a second wireless earbud, the wireless audio streaming host device having a controller configured for:

receiving, by wireless communication, a message from the first earbud, the message indicating a current battery charge status for the first earbud;

receiving, by wireless communication, a message from the second earbud, the message indicating a current battery charge status for the second earbud;

determining which one of the first and second earbuds has a current master device role and a current slave device role, respectively;

assessing, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device; and, if a switch in roles is found appropriate:

causing, by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role; and

causing, by wireless communication, the other one among the first and second earbuds to assume a master device role.

Embodiments of the invention are defined by the appended dependent claims and are further explained in the detailed description section as well as on the drawings.

It should be emphasized that the term “comprises/comprising” when used in this specification is taken to specify the presence of stated features, integers, steps, or components, but does not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof. All terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of the element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Brief Description of the Drawings

Objects, features and advantages of embodiments of the invention will appear from the following detailed description, reference being made to the accompanying drawings.

Fig 1 is a schematic isometric view of a storage and charging capsule for a pair of wireless earbuds, one of the earbuds being shown positioned in the capsule while the other earbud being shown outside of the capsule.

Fig 2 is a schematic isometric view of the storage and charging capsule, now showing both earbuds positioned in the capsule, a cover part of the capsule being retracted to expose the earbuds.

Fig 3 is a schematic isometric view of the storage and charging capsule, showing it in a situation where the cover part has been moved towards a closed position to encapsulate the earbuds.

Fig 4 is a schematic exploded view of the storage and charging capsule.

Fig 5 is a schematic isometric view of a wireless earbud.

Fig 6 is a first, schematic, exploded view of the wireless earbud.

Fig 7 is a second, schematic, exploded view of the wireless earbud.

Figs 8-10 are schematic top views of a main printed circuit board in the wireless earbud.

Fig 11 is a schematic block diagram of circuitry on the main printed circuit board.

Fig 12 is a schematic flowchart diagram illustrating a procedure for switching between idle and operational modes for the wireless earbud.

Detailed Description

Embodiments of the invention will now be described with reference to the accompanying drawings. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed description of the particular embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

Figs 1-4 illustrate an embodiment of a storage and charging capsule 20 for a pair of wireless earbuds 10a, 10b. An embodiment of a wireless earbud 10, which may be one of the wireless earbuds 10a, 10b and is thus suitable for use with the storage and charging capsule 20, is illustrated in more detail in Figs 5-12.

As seen in Figs 1-4, the storage and charging capsule 20 comprises a base part 22, an elongate intermediate part 24 and a cover part 26 which is retractable over the intermediate part 24. A first end 25a of the intermediate part 24 is attached to the base part 22. An earbud chamber 31 is formed in the intermediate part 24 between its first and second ends 25a, 25b. The earbud chamber 31 is adapted to receive the pair of wireless earbuds 10a, 10b arranged one after another along a longitudinal major axis 60 of the intermediate part 24.

In Fig 1, a first earbud 10a of the earbud pair is shown outside of the capsule 20, while the second earbud 10b of the earbud pair is shown positioned in the capsule 20, and more specifically in the earbud chamber 31 formed in the intermediate part 24. Fig 2 shows both earbuds 10a, 10b positioned in the capsule 20, or more specifically in the earbud chamber 31.

The cover part 26 of the storage and charging capsule 20 is shaped essentially as a cylinder having an open end 27a for receiving the intermediate part 24, and a closed end 27b. The cover part 26 can be placed in a first, or open, position in which the cover part 26 is retracted by a user from the intermediate part 24 to allow insertion or removal of the earbuds 10a, 10b in or from the earbud chamber 31. In Figs 1 and 2, the cover part 26 of the capsule 20 is retracted to its first position and exposes the earbud 10b and the earbuds 10a, 10b, respectively.

The cover part 26 can moreover be placed in a second, or closed, position in which the cover part 26 encapsulates the intermediate part 24 with the open end 27a of the cover part 26 abutting against the proximal end 23b of the base part 22. Fig 3 shows the storage and charging capsule 20 in a situation where the cover part 26 has been moved by a user towards the second, or closed, position to encapsulate the earbuds 10a, 10b in the earbud chamber 31. The capsule 20 is not fully closed in Fig 3; the cover part 26 still has to be moved a distance 62 to abut against the base part 22.

When the capsule 20 is fully closed, the base part 22 and the cover part 26 will together essentially take the form of a cylinder. A ring 30 is affixed to the distal end 23a of the base part 22 to facilitate carrying of the storage and charging capsule 20 in for instance a necklace, a waist belt or a key ring. Thus, accidental loss or damage of the capsule 20 and the earbuds 10a, 10b contained therein may be prevented. The ring 30 may also act as a handle for the user when retracting the cover part 26 from the base part 22 to insert or remove the earbuds 10a, 10b.

To keep the cover part 26 safely engaged with the base part 22, the storage and charging capsule 20 further comprises a first magnet 58 mounted at the second end 25b of the intermediate part 24, and a second magnet (not shown) mounted at the closed end 27b of the cover part 26. The first and second magnets will thus urge the cover part 26 against the base part 22 in the second position of the cover part 26. Hence, accidental retraction of the cover part 26 and resulting potential loss or damage of the earbuds 10a, 10b in the capsule 20 may be prevented.

As is best seen in the exploded view of Fig 4, the storage and charging capsule 20 has a power source for charging the pair of wireless earbuds 10a, 10b when placed in the earbud chamber 31 in the intermediate part 24. In the disclosed embodiment, the power source comprises a rechargeable battery 40 which is accommodated in the base part 22 and which can be charged by a cable connection interface 46, 47, such as a micro Universal Serial Bus (USB) interface.

The storage and charging capsule 20 further comprises a power transmission arrangement for feeding electric power from the rechargeable battery 40 to the earbuds 10a, 10b when placed in the earbud chamber 31 in the intermediate part 24. As seen in Fig 4, the power transmission arrangement comprises a first charging connector disc 42 at the first end 25a of the intermediate part 24. The first charging connector disc 42 comprises a plurality of charging connector elements 44a, 44b, 44c which are symmetrically distributed over a surface of the charging connector disc 42 to allow electric contact with a charging interface of the nearest earbud (earbud 10a in Figs 1-4), irrespective of the radial orientation of the earbud in the earbud chamber 31.

In the disclosed embodiment, there are three charging connector elements 44a, 44b, 44c in the form of pogo pins soldered onto the surface of the charging connector disc 42, being a circuit board substrate. The resilient tips of the pogo pins 44a, 44b, 44c extend through respective openings 54a, 54b, 54c at the first end 25a of the intermediate part 24. The earbuds 10a, 10b are to be placed "nose to nose" in the earbud chamber 31 in the intermediate part 24, with their respective foam tips 11 at the front ends thereof (Fig 6) abutting each other.

The resiliency of the foam tips 11 will urge the rear end of the earbud 10a towards the resilient tips of the pogo pins 44a, 44b, 44c. As a result, they will reach electric contact with a conductive pattern 17a provided at the rear end of the earbud 10a (see Fig 6). One of the pogo pins 44a, 44b, 44c, such as the center pogo pin 44b, will provide a first power supply potential, such as ground or 0 V. The other two of the pogo pins 44a, 44b, 44c, such as the leftmost and rightmost pogo pins 44a and 44c, will provide a second power supply potential, such as $+ V_{cc}$. The opposite order is of course also possible. Particulars of the charging procedure for the earbud will be described in more detail in a later section of this document.

To allow charging also of the other earbud 10b, the power transmission arrangement in the storage and charging capsule 20 further comprises a second charging connector disc 48 at the second end 25b of the intermediate part 24. Like the first disc 42, the second charging connector disc 48 comprises a plurality of charging connector elements symmetrically distributed over a surface of the second charging connector disc 48 to allow electric contact with a charging interface of the other earbud 10b, irrespective of its radial orientation in the earbud chamber 31.

In the disclosed embodiment, the second charging connector disc 48 has three charging connector elements in the form of pogo pins soldered onto the surface of the charging connector disc 48, being a circuit board substrate. The resilient tips of these

pogo pins extend through respective openings at the second end 25b of the intermediate part 24. In Fig 4, only one of the pogo pins are seen at 50c, and only two of the openings are seen at 56a, 56b. The charging functions of the pogo pins of the second charging connector disc 48 are analogous to what has been described above for the pogo pins 44a, 44b, 44c of the first charging connector disc 42.

The charging connector elements 44a, 44b, 44c of the first charging connector disc 42 are connected to the rechargeable battery 40. The charging connector elements 50c of the second charging connector disc 48 are connected to the charging connector elements 44a, 44b, 44c of the first charging connector disc 42, or directly to the rechargeable battery, by an interconnector 52 extending between the first and second ends 25a, 25b of the intermediate part 24.

An embodiment of a wireless earbud 10, which may be one of the wireless earbuds 10a, 10b as referred to above in conjunction with the storage and charging capsule 20, will now be described in more detail with reference to Figs 5-12.

Figs 5 to 7 show the wireless earbud 10 in schematic isometric and exploded views. Even though shown in isolation, the earbud 10 will typically be used together with a second earbud to form a pair of earbuds, like the earbud pair 10a, 10b as previously referred to. One of the earbuds may then be used for playing left-channel stereo audio into one ear of the user, whereas the other earbud will be used for playing right-channel stereo audio into the other ear.

For the illustrated embodiment, the principal components of the wireless earbud 10 are as follows.

The wireless earbud 10 comprises an earbud housing 12, 16 having a longitudinal main axis 19 and an essentially circular cross section. The wireless earbud 10 further comprises a loudspeaker element 13, a rechargeable battery 14 and at least one main printed circuit board 15 having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control. The main printed circuit board 15 and its circuitry will be described in more detail later with reference to the remaining drawings.

Moreover, the wireless earbud 10 comprises a charging interface member 17. As seen in Figs 6 and 7, the loudspeaker element 13, the rechargeable battery 14, the main printed circuit board 15 and the charging interface member 17 are arranged in a successive order along the longitudinal main axis of the earbud housing 12, 16. More specifically, in this embodiment, the loudspeaker element 13, the rechargeable battery 14, the main printed circuit board 15 and the charging interface member 17 all have a

generally circular cross section and are coaxially disposed around the longitudinal main axis 19 of the earbud housing 12, 16.

The earbud housing comprises a tapered front housing portion 12 and a rear housing portion 16. The tapered front housing portion 12 comprises a loudspeaker chamber 12b for accommodating the loudspeaker element 13. Further, the tapered front housing portion 12 comprises a sound guiding channel forming element 12a for receiving an earbud foam tip 11 by threading a flexible hollow engagement portion 11a thereof onto the sound guiding channel forming element 12a. Preferably, the frictional engagement between the sound guiding channel forming element 12a and the foam tip 11 is designed to be firm but yet possible to interrupt. This will make sure that the foam tip 11 stays in place during normal use but may be removed for replacement by another foam tip for reasons of wear and tear or user preference.

The loudspeaker element 13 is operatively connected to the audio codec circuitry on the main printed circuit board 15 via two connecting wires 13a, 13b. In the disclosed embodiment, the loudspeaker element 13 is a magnetic balanced armature (BA) receiver, such as an SR-31843-000 mini siren which is provided by Knowles Electronics, Itasca, Illinois, USA. Using a balanced armature receiver for the loudspeaker element 13 is advantageous, since it offers high audio performance at a small physical size. As a result, it has been made possible to design the earbud 10 to have a compact overall size.

In the illustrated embodiment, the rear housing portion 16 is essentially cylindrical or frusto-conical. The rear housing portion 16 comprises a first end 16a proximate to the front housing portion 12, and a second distal end 16b. Together with the front housing portion 12, the rear housing portion 16 accommodates the main printed circuit board 15 inside the rear housing portion 16 nearest its second distal end 16b, then the rechargeable battery 14 and the loudspeaker element 13 in successive order towards the front housing portion 12 along the longitudinal main axis 19 of the earbud housing. Thus, a very compact physical size is obtained.

In the illustrated embodiment, the rear housing portion 16 has a wall 16c at the second distal end 16b. The main printed circuit board 15 is mounted at an internal surface of the wall 16c. Moreover, the charging interface member 17 is mounted at an external surface of the wall 16c in a shallow protective recess formed by the wall 16c and the surrounding parts of the second distal end 16b of the rear housing portion 16.

As seen in Fig 6, the wall 16c comprises first and second openings 16d, 16e for providing access from the outside of the wall to the main printed circuit board 15 inside

the wall 16c, i.e. inside the earbud housing. In the disclosed embodiment, the openings 16d, 16e in the wall 16c at the second distal end 16b of the rear housing portion 16 have dual purposes – to allow charging of the rechargeable battery 14, and to allow programming or writing of data to the circuitry of the main printed circuit board 15 during product manufacture or upgrade.

Hence, the main printed circuit board 15 has mounted thereon first and second charging connectors 15a, 15b which are aligned with the first and second openings 16d, 16e in the wall 16c to provide electric contact with the charging interface member 17 at the external surface of the wall 16c through contact areas 17d, 17e (Fig 7). In the disclosed embodiment, the charging connectors 15a, 15b are elongated resilient members, such as pogo pins, which protrude partly through the first and second openings 16d, 16e in the wall 16c. In other embodiments, elongated resilient connecting members may protrude from the charging interface member 17 through the first and second openings 16d, 16e in the wall 16c to the main printed circuit board 15.

In the disclosed embodiment, the charging interface member 17 comprises a circuit board substrate which is mounted to the external surface of the wall 16c of the rear housing portion 16. A conductive pattern 17a is printed on the external surface of the circuit board substrate, i.e. the surface which faces away from the wall 16c. The conductive pattern is designed for electric contact with a power transmission arrangement in a storage and charging capsule for the wireless earbud, typically the storage and charging capsule 20 previously described with reference to Figs 1 to 4.

The conductive pattern 17a on the charging interface member 17 (i.e. circuit board substrate) comprises a first sub-pattern 17b adapted to reach electrical contact with a first charging connector element of the power transmission arrangement in the storage and charging capsule, i.e. the pogo pin 44a or 44c when the earbud 10a in Figs 1 to 4 implements the earbud 10. The conductive pattern 17a also comprises a second sub-pattern 17c electrically isolated from the first sub-pattern 17b and being adapted to reach electrical contact with a second charging connector element of the power transmission arrangement in the storage and charging capsule (e.g. the pogo pin 50c when the earbud 10b in Figs 1 to 4 implements the earbud 10).

Advantageously, the conductive pattern 17a may be designed as a graphical symbol representing the individual earbud 10, a product type of the earbud 10, or a producer or supplier of the earbud 10. Such a graphical symbol may convey technical or commercial information pertaining to the individual earbud 10, its product type, or its producer or supplier. When used together with the storage and charging capsule 20

shown in Figs 1 to 4, the symmetrical distribution of the charging connector elements (e.g. 44a, 44b, 44c) over the surface of the charging connector disc (e.g. 42) will guarantee electrical contact with the conductive pattern 17a on the earbud 10, irrespective of the radial orientation of the earbud 10 in the earbud chamber 31 of the storage and charging capsule 20. As a result, great flexibility in the layout of the graphical symbol formed by the conductive pattern 17a is achieved together with a reliable charging procedure.

As already indicated, in the disclosed embodiment, the first and second openings 16d, 16e in the wall 16c of the rear housing portion 16 of the earbud 10 are aligned with a programming or data writing interface on the main printed circuit board 15. When assembling the earbud 10 during manufacture, at a late stage in the assembly process, all parts of the earbud 10 may have been assembled except for the charging interface member 17. Hence, at this stage, the openings 16d, 16e in the wall 16c are available for insertion of probes or electrodes of a programming or data writing device. The probes or electrodes may access the programming or data writing interface on the main printed circuit board 15 to fill memories and registers thereof with software or firmware instructions, and/or data. Such a procedure is commonly referred to as "flashing" (of flash memories). In one embodiment, the earbuds 10a and 10b are paired with each other by writing the Bluetooth address of the first wireless earbud 10a into a memory or register of the second wireless earbud 10b, and vice versa.

Once the programming or data writing has been completed, the assembly procedure may be finalized by a step of affixing the charging interface member 17 on the wall 16c of rear housing portion 16 of the earbud 10 by means of for instance an adhesive. A medium-strong adhesive may be chosen, in some embodiments, to provide a balance between safe mounting of the charging interface member 17 on the one hand, and the ability of a non-destructive removal thereof at a later time in the event of a need for a product repair or software/firmware/data upgrade.

One inventive aspect can be seen in a kit of parts comprising a storage and charging capsule 20 and two wireless earbuds 10/10a, 10b as referred to above.

Reference is now made to Figs 8 to 11 which illustrate the main circuit board 15 and its circuitry in more detail. Starting with Fig 11, the main circuit board 15 comprises circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114. Other circuitry may also be included on the main circuit board 15 in different embodiments.

Earbud operation control 114 may include general control of the wireless radio communication 110 e.g. for establishing, maintaining and communicating over a wireless link 111 to a wireless audio streaming host device 100. The wireless audio streaming host device 100 may for instance be a mobile terminal (e.g. smartphone), personal digital assistant, palmtop computer, tablet computer (a.k.a. surfpad), laptop computer, stationary computer, smart TV or video game console, without limitation. The wireless audio streaming host device 100 may, for instance, be capable of connecting to a mobile telecommunication network in compliance with a mobile telecommunication standard, such as (without limitation) GSM, UMTS, LTE, LTE Advanced, D-AMPS, CDMA2000, FOMA or TD-SCDMA, and/or to a data communication network, such as the Internet.

Earbud operation control 114 may also include power management 116 for receiving power from the rechargeable battery 14 and for charging the rechargeable battery 14 by means of, for instance, the storage and charging capsule 20.

The main printed circuit board 15 has a front surface 15_f, a rear surface 15_r and a circumferential edge surface 15_e. In the disclosed embodiment, components are provided on all three surfaces, as is seen in Fig 8, Fig 9 and Fig 10, respectively. This is beneficial since it allows a size-efficient implementation, as will be clear from the following disclosure. It is moreover beneficial since it allows an efficient implementation of an antenna function for the wireless radio communication 110.

In the disclosed embodiment, the main printed circuit board 15 has an essentially circular sectional shape, which again is beneficial for the reasons given above. In other embodiments, the main printed circuit board 15 may have another shape. In still other embodiments, the main printed circuit board 15 may be divided into two or more printed circuit boards. The term "main printed circuit board" as used herein shall therefore include a single printed circuit board but also a plurality of printed circuit board jointly carrying the components disclosed in this document.

Fig 8 illustrates the schematic layout of the front surface 15_f of the main printed circuit board 15. Fig 9 illustrates the schematic layout of the read surface 15_r of the main printed circuit board 15. Component D1, Fig 8, is a BlueCore CSR8670 WLCSP System on a Chip (SoC) integrated circuit device for Bluetooth 4.0. The device is available from Cambridge Silicon Radio Ltd, Churchill House, Cambridge Business Park, Cowley Road, Cambridge, CB4 0WZ, UK. Component D1 features Bluetooth 4.0 software, a radio with an integrated balun, an 80 MHz RISC MCU (application processor) and an 80 MIPS DSP (digital signal processor), internal flash memory, a

stereo audio codec, noise reduction, audio interfaces, serial interfaces, integrated switch-mode regulators, linear regulators and battery charger, LED controllers, etc.

In the disclosed embodiment, component D1 implements the circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114 as seen in Fig 11. In other embodiments, these functions may be implemented by different components, including but not limited to central processing units (CPUs), digital signal processor (DSPs), application-specific integrated circuits (ASICs) or field-programmable gate arrays (FPGAs).

In other embodiments, in addition or as an alternative to Bluetooth 4.0, the wireless earbud 10 may be compliant with other Bluetooth versions, or with AirPlay, PlayFi, Miracast, WiDi, DLNA or Wi-Fi Direct, for instance, or any combinations thereof.

The various elements labeled TPn (n being integer numbers) are input and output terminals for the component D1, and serial interfaces. The various capacitors Cn, Rn and Ln (n being integer numbers) are provided for decoupling and noise filtering purposes. Component XT1 is a 26 MHz Bluetooth® crystal oscillator. Component SAW90 is an antenna filter. Components Q80 and D80 form a battery safety control circuit. SP1 and SP2 are soldering pads for the charging connectors 15a, 15b (Fig 6). Recesses M1 and M2 are for receiving power from the rechargeable battery 14.

Reference is now made to Fig 10 which illustrates an efficient implementation of an antenna function for the wireless radio communication 110. The antenna comprises an elongate radiator pattern 70 disposed at the circumference of the main printed circuit board. More specifically, in the disclosed embodiment the elongate radiator pattern 70 of the antenna is disposed on the actual circumferential edge surface 15_e of the circular main printed circuit board 15 along a portion of its circumference, as is seen in Fig 10. The elongate radiator pattern 70 is formed by means of gold plating in the disclosed embodiment; other conductive materials are of course possible as an alternative.

The antenna is an inverted F antenna, and the elongate radiator pattern 70 provided on the portion of the circular circumferential edge surface 15_e of the main printed circuit board 15 is tuned for resonance at a quarter-wave length suitable for the circuitry for wireless radio communication 110. The feeding point is indicated at 71 in Fig 10.

The antenna design is efficient for several reasons. First, since a circular geometrical shape represents the largest possible ratio between circumference and area,

a sufficient length of the elongate radiator pattern 70 on the circular circumferential edge surface 15_e is available even when the area of the front and rear surfaces 15_f, 15_r is limited. Thus, the main printed circuit board 15 can be made compact and still accommodate a sufficiently long antenna 70 for the circuitry for wireless radio communication 110. Hence, antenna performance can be optimized in the smallest possible space.

Also, since the circuitry for wireless radio communication 110, audio codec 112 and earbud operation control 114 is disposed on the front and rear surfaces 15_f, 15_r of the main printed circuit board 15 with a component concentration towards the center of the front and rear surfaces, a maximum distance 72 is enabled to the component ground plane, as indicated by 74. Again, antenna performance is optimized.

Further, by integrating the antenna 70 on the main printed circuit board 15 (as opposed to having a separate antenna), the risk is reduced for potential losses due to interconnection. Once more, antenna performance is optimized.

Fig 12 schematically illustrates a procedure for switching between idle and operational modes for a wireless earbud. The wireless earbud, for instance any of the earbuds 10, 10a, 10b referred to above, has an idle mode and an operational mode. The wireless earbud comprises an earbud housing (for instance housing 12, 16), a loudspeaker element (for instance loudspeaker element 13), a rechargeable battery (for instance rechargeable battery 14), and at least one main printed circuit board having disposed thereon circuitry for wireless radio communication, audio codec and earbud operation control (for instance the main printed circuit board 15 with its circuitry 110-116 as previously described). The circuitry is configured for automatic power preservation by performing the following steps.

First, connection of the battery to a charger is detected (not seen in Fig 12). This may for instance involve insertion of the earbud into the storage and charging capsule 20 as described above. The detection may be based on a comparison of voltage levels. If the charger supplies charging at a higher voltage, such as 5 V, than the nominal voltage of the rechargeable battery in the earbud, such as 3.3 V, then the higher voltage will indicate connection to a charger.

In response to detecting connection to a charger, the earbud (e.g. earbud 10a) will enter idle mode, wherein existing connections to a second wireless earbud (e.g. earbud 10b) and to a wireless audio streaming host device (e.g. device 100) will be disconnected.

Then, at a later point of time when the wireless earbud is removed from the charger, disconnection of the battery from the charger will be detected, see 122 in Fig 12. In response, the wireless earbud will enter operational mode by the following steps:

Firmware in the circuitry on the main printed circuit board will boot, see 124 in Fig 12. In step 126, a true wireless stereo, TWS, reconnection with the second wireless earbud will be attempted.

If the attempt is successful, the wireless earbud will be operated as a TWS audio receiver, see 166, in association with the second wireless earbud. Otherwise, the wireless earbud will be operated as a mono wireless audio receiver, see 144, if the failure persists after repeated additional attempts, as seen at 132 and 164.

When the wireless earbud is operated as a TWS audio receiver, as verified at 140 and 142, it is determined at 146 and 148 whether the wireless earbud is a master device ("inquiry bud") or a slave device with respect to the second wireless earbud.

If the wireless earbud is determined to be a master device, attempts are made at 150 and 154 to reconnect with the wireless audio streaming host device (e.g. device 100), and other known wireless audio streaming host devices if applicable.

If reconnection with the wireless audio streaming host device (e.g. device 100) has been successful, see 156 and 158, then the execution ends at 162 with a successful automatic reconnection both with the second earbud and with the wireless audio streaming host device completely without any use of manual intervention by the earbud user (other than removing the earbud from the charger). Hence, a power-efficient and automatic procedure for switching between idle and operational modes for a wireless earbud, without requiring any manual actuators like buttons, etc, is provided.

Should reconnection with the wireless audio streaming host device (e.g. device 100) on the other hand fail, a more time and power consuming pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices, if applicable, will be initiated, see 158 and 160 in Fig 12.

When a pair of earbuds, such as earbuds 10a and 10b, is used for true wireless stereo streaming from a wireless audio streaming host device, such as device 100 in Fig 11, one of the earbuds will have a role as master device with respect to the other one of the earbuds, which will correspondingly be a slave device. This is for instance the case with Bluetooth-based wireless audio streaming. Another inventive power preservation scheme has therefore been provided which compensates for the fact that the master device will consume more power than the slave device. Therefore, after some time, the

master device will run out of power and need to be recharged, even though the slave device still may have a decent remaining battery charge status.

According to this inventive aspect, a wireless audio streaming host device is provided for use with a first wireless earbud and a second wireless earbud, for instance earbuds 10a and 10b according to the previous description. The wireless audio streaming host device may for instance be any of the example devices 100 shown in Fig 11 and will have a controller in the form of a CPU, DSP, ASIC, FPGA, etc. The controller will be configured to receive a message from the first earbud by wireless communication, such as Bluetooth. The message will indicate a current battery charge status for the first earbud. Correspondingly, the controller will be configured to receive a message from the second earbud by wireless communication. This message will indicate a current battery charge status for the second earbud.

The controller will determine which one of the first and second earbuds has a current master device role and a current slave device role, respectively.

The controller will then assess, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device. The assessment may for instance be based on absolute or relative threshold values. For instance, if the master earbud device has below x % of remaining battery charge, or if the difference in remaining battery charge between the two earbuds exceeds a certain value, a switch of roles may be concluded as appropriate.

If a switch in roles is found appropriate, the controller will cause, again by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role. The controller will also cause, by wireless communication, the other one among the first and second earbuds to assume a master device role. The causing may be done by control messages sent by the controller of the wireless audio streaming host device to both earbuds directly, or by a control message sent to the master earbud device that will then in turn send a control message to the slave earbud device, etc. Other ways of causing the switch in roles are also possible, as is believed to be understood *per se* by those skilled in the art.

The invention has been described above in detail with reference to embodiments thereof. However, as is readily understood by those skilled in the art, other embodiments are equally possible within the scope of the present invention, as defined by the appended claims.

CLAIMS

1. A wireless earbud (10), comprising:

an earbud housing (12, 16) having a longitudinal main axis (19) and an essentially circular cross section;

a loudspeaker element (13);

a rechargeable battery (14);

at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114); and

a charging interface member (17),

wherein the loudspeaker element, the rechargeable battery, the main printed circuit board and the charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

2. The wireless earbud (10) as defined in claim 1, wherein the loudspeaker element (13), the rechargeable battery (14), the main printed circuit board (15) and the charging interface member (17) all have a generally circular cross section and are coaxially disposed around the longitudinal main axis (19) of the earbud housing (12, 16).

3. The wireless earbud (10) as defined in claim 1 or 2, wherein the earbud housing (12, 16) comprises a tapered front housing portion (12) and a rear housing portion (16), the tapered front housing portion comprising:

a loudspeaker chamber (12b) for accommodating the loudspeaker element (13); and

a sound guiding channel forming element (12a) for receiving an earbud foam tip (11).

4. The wireless earbud (10) as defined in claim 3, wherein the loudspeaker element (13) is a magnetic balanced armature (BA) receiver.

5. The wireless earbud (10) as defined in claim 1 or 2, wherein the earbud housing (12, 16) comprises a front housing portion (12) and an essentially cylindrical or frusto-conical rear housing portion (16), the rear housing portion comprising a first end

(16a) proximate to the front housing portion and a second distal end (16b), the rear housing portion together with the front housing portion accommodating the main printed circuit board (15) inside the rear housing portion nearest its second distal end, then the rechargeable battery (14) and the loudspeaker element (13) in successive order towards the front housing portion along the longitudinal main axis (19) of the earbud housing.

6. The wireless earbud (10) as defined in claim 5, the rear housing portion (16) having a wall (16c) at the second distal end (16b), wherein the main printed circuit board (15) is mounted at an internal surface of said wall, and wherein the charging interface member (17) is mounted at an external surface of said wall.

7. The wireless earbud (10) as defined in claim 6, the wall (16c) at the second distal end (16b) of the rear housing portion (16) comprising first and second openings (16d, 16e) for providing access from the outside of said wall to the main printed circuit board (15) inside said wall.

8. The wireless earbud (10) as defined in claim 7, the main printed circuit board (15) having mounted thereon first and second charging connectors (15a, 15b) being aligned with the first and second openings (16d, 16e) in said wall (16c) for providing electric contact with the charging interface member (17) at the external surface of said wall.

9. The wireless earbud (10) as defined in claim 7 or 8, the first and second openings (16d, 16e) in said wall (16c) being aligned with a programming or data writing interface on the main printed circuit board (15).

10. The wireless earbud (10) as defined in any of claims 7-9, wherein the charging interface member (17) comprises a circuit board substrate mounted to the external surface of said wall (16c), and a conductive pattern (17a) printed on an external surface of the circuit board substrate facing away from said wall, the conductive pattern being designed for electric contact with a power transmission arrangement in a storage and charging capsule (20) for the wireless earbud.

11. The wireless earbud (10) as defined in claim 10, wherein the conductive pattern (17a) of the charging interface member (17) comprises a first sub-pattern (17b) adapted to reach electrical contact with a first charging connector element (44a/44c) of the power transmission arrangement in the storage and charging capsule (20), and a second sub-pattern (17c) electrically isolated from the first sub-pattern and being adapted to reach electrical contact with a second charging connector element (50c) of the power transmission arrangement in the storage and charging capsule.

12. The wireless earbud (10) as defined in claim 10 or 11, wherein the conductive pattern () is designed as a graphical symbol representing the individual earbud (10), a product type of said earbud, or a producer or supplier of said earbud.

13. The wireless earbud (10) as defined in any preceding claim, the main printed circuit board (15) having a front surface (15_f), a rear surface (15_r) and a circumferential edge surface (15_e), wherein the main printed circuit board further comprises an antenna for the circuitry for wireless radio communication (110), the antenna comprising an elongate radiator pattern (70) disposed at the circumference of the main printed circuit board.

14. The wireless earbud (10) as defined in claim 13, wherein the elongate radiator pattern (70) of the antenna is disposed on the circumferential edge surface (15_e) of the main printed circuit board (15).

15. The wireless earbud (10) as defined in claim 14, the main printed circuit board (15) having an essentially circular sectional shape and thus an essentially circular circumference, wherein the elongate radiator pattern (70) of the antenna is provided on the circular circumferential edge surface (15_e) of the main printed circuit board along a portion of its circumference.

16. The wireless earbud (10) as defined in claim 15, wherein the antenna is an inverted F antenna, and wherein the elongate radiator pattern (70) provided on the portion of the circular circumferential edge surface (15_e) of the main printed circuit board (15) is tuned for resonance at a quarter-wave length suitable for the circuitry for wireless radio communication (110).

17. The wireless earbud (10) as defined in claim 16, wherein the circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114) is disposed on one or both of the front and rear surfaces (15_f, 15_r) of the main printed circuit (15) and with a component concentration towards the center of the front and rear surfaces.

18. A storage and charging capsule (20) for a pair of wireless earbuds (10a, 10b), the storage and charging capsule comprising:

a base part (22);

an elongate intermediate part (24), the intermediate part having a longitudinal major axis (60); and

a cover part (26) being retractable over the intermediate part,

wherein the intermediate part has a first end (25a) attached to the base part, a second end (25b), and an earbud chamber (31) formed between the first and second ends, the earbud chamber being adapted to receive the pair of wireless earbuds arranged one after another along the longitudinal major axis of the intermediate part, and

wherein the capsule further has a power source (40) for charging the pair of wireless earbuds when placed in the earbud chamber in the intermediate part.

19. The storage and charging capsule (20) as defined in claim 18, wherein the power source comprises a rechargeable battery (40) and wherein the capsule (20) further comprises a power transmission arrangement for feeding electric power from the rechargeable battery to both earbuds (10a, 10b) when placed in the earbud chamber (31) in the intermediate part (24).

20. The storage and charging capsule (20) as defined in claim 19, the rechargeable battery (40) being accommodated in the base part (22), wherein the power transmission arrangement comprises a first charging connector disc (42) at the first end (25a) of the intermediate part (24), the first charging connector disc comprising a plurality of charging connector elements (44a-44c) symmetrically distributed over a surface of the charging connector disc to allow electric contact with a charging interface of one (10a) of the earbuds (10a, 10b) irrespective of its radial orientation in the earbud chamber (31).

21. The storage and charging capsule (20) as defined in claim 20, wherein the plurality of charging connector elements (44a-44c) are adapted to reach electric contact with a conductive pattern (17a) provided at a rear end of the earbud (10a).

22. The storage and charging capsule (20) as defined in claim 20 or 21, wherein the power transmission arrangement further comprises a second charging connector disc (48) at the second end (25b) of the intermediate part (24), the second charging connector disc comprising a plurality of charging connector elements symmetrically distributed over a surface of the second charging connector disc to allow electric contact with a charging interface of the other earbud (10b) irrespective of its radial orientation in the earbud chamber, wherein the charging connector elements (44a-c) of the first charging connector disc (42) are connected to the rechargeable battery (40), and wherein the charging connector elements of the second charging connector disc (48) are connected to the charging connector elements of the first charging connector disc or to the rechargeable battery by an interconnector (52) extending between the first and second ends (25a, 25b) of the intermediate part (24).

23. The storage and charging capsule (20) as defined in any of claims 18-22, the cover part (26) being shaped essentially as a cylinder having an open end (27a) for receiving the intermediate part (24), and a closed end (27b), the cover part being placeable in a first position in which the cover part is retracted from the intermediate part to allow insertion or removal of the earbuds (10a, 10b) in/from the earbud chamber (31), and in a second position in which the cover part encapsulates the intermediate part with the open end of the cover part abutting against the base part (22).

24. The storage and charging capsule (20) as defined in claim 23, further comprising a first magnet (58) mounted at the second end (25b) of the intermediate part (24) and a second magnet mounted at the closed end (27b) of the cover part (26), the first and second magnets urging the cover part against the base part (22) in the second position of the cover part.

25. A wireless earbud (10/10a) having an idle mode and an operational mode, the wireless earbud comprising:

an earbud housing (12, 16);

a loudspeaker element (13);

a rechargeable battery (14); and

at least one main printed circuit board (15) having disposed thereon circuitry for wireless radio communication (110), audio codec (112) and earbud operation control (114);

wherein the circuitry is configured for automatic power preservation by:

detecting connection of said battery to a charger and in response entering the idle mode, wherein existing connections to a second wireless earbud (10b) and to a wireless audio streaming host device (100) will be disconnected; and

detecting (122) disconnection of said battery from said charger and in response entering the operational mode by:

attempting (126) a true wireless stereo, TWS, reconnection with the second wireless earbud;

if the attempt is successful, operating (166) the wireless earbud as a TWS audio receiver and otherwise operating (144) the wireless earbud as a mono wireless audio receiver;

if operated as a TWS audio receiver, determining (146, 148) whether the wireless earbud is a master device or a slave device with respect to the second wireless earbud;

if the wireless earbud is determined to be a master device, attempting (150, 154) to reconnect with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable; and

if reconnection with the wireless audio streaming host device fails, initiating (158, 160) a pairing procedure with the wireless audio streaming host device and other known wireless audio streaming host devices if applicable.

26. The wireless earbud as defined in claim 25, wherein the circuitry for wireless radio communication (110) is compliant with one or more of Bluetooth, AirPlay, PlayFi, Miracast, WiDi, DLNA or Wi-Fi Direct.

27. A wireless audio streaming host device (100) for use with a first wireless earbud (10a) and a second wireless earbud (10b), the wireless audio streaming host device having a controller configured for:

receiving, by wireless communication, a message from the first earbud, the message indicating a current battery charge status for the first earbud;

receiving, by wireless communication, a message from the second earbud, the message indicating a current battery charge status for the second earbud;

determining which one of the first and second earbuds has a current master device role and a current slave device role, respectively;

assessing, based on the determined battery charge statuses for the first and second earbuds and on the determined current roles as master device and slave device, whether a switch in roles is appropriate for the master device and slave device; and, if a switch in roles is found appropriate:

causing, by wireless communication, the one among the first and second earbuds that currently has the master device role, to assume a slave device role; and

causing, by wireless communication, the other one among the first and second earbuds to assume a master device role.

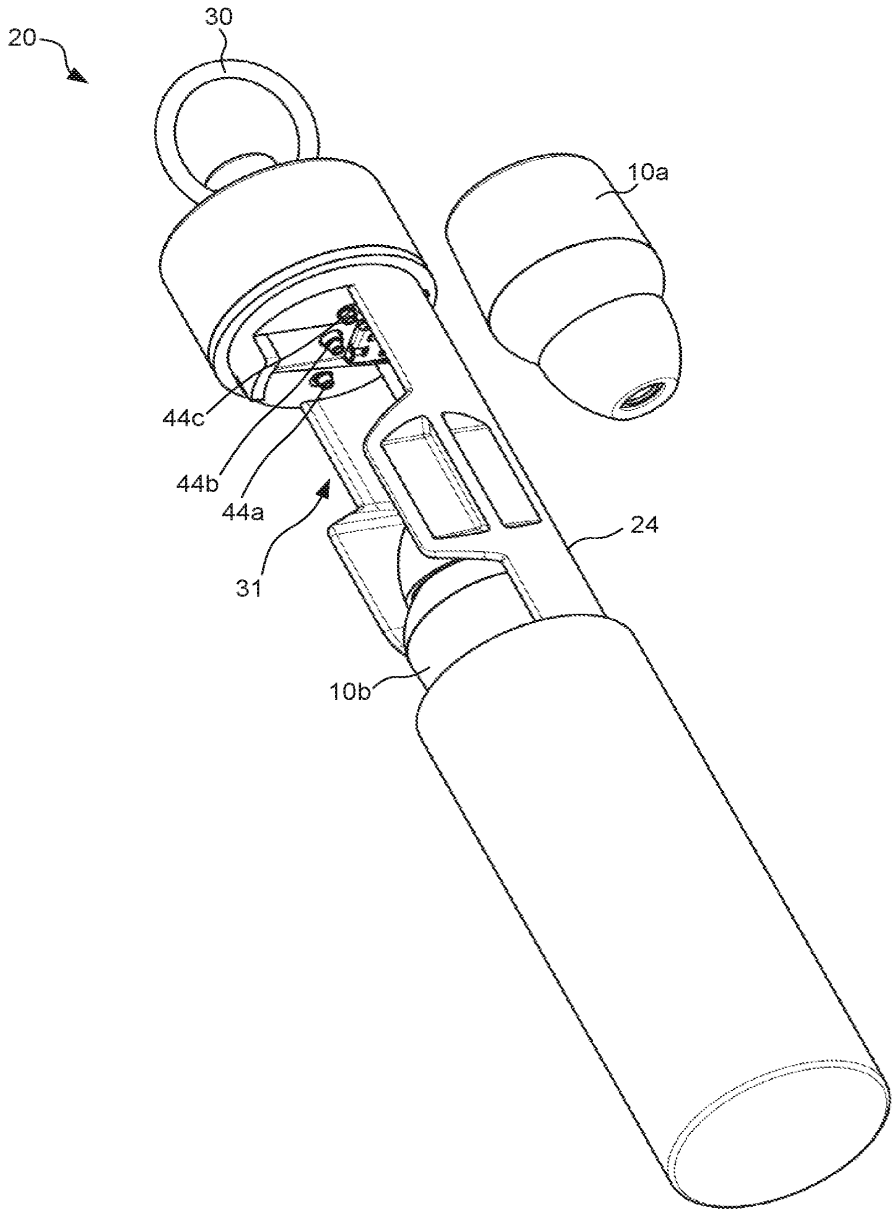


Fig 1

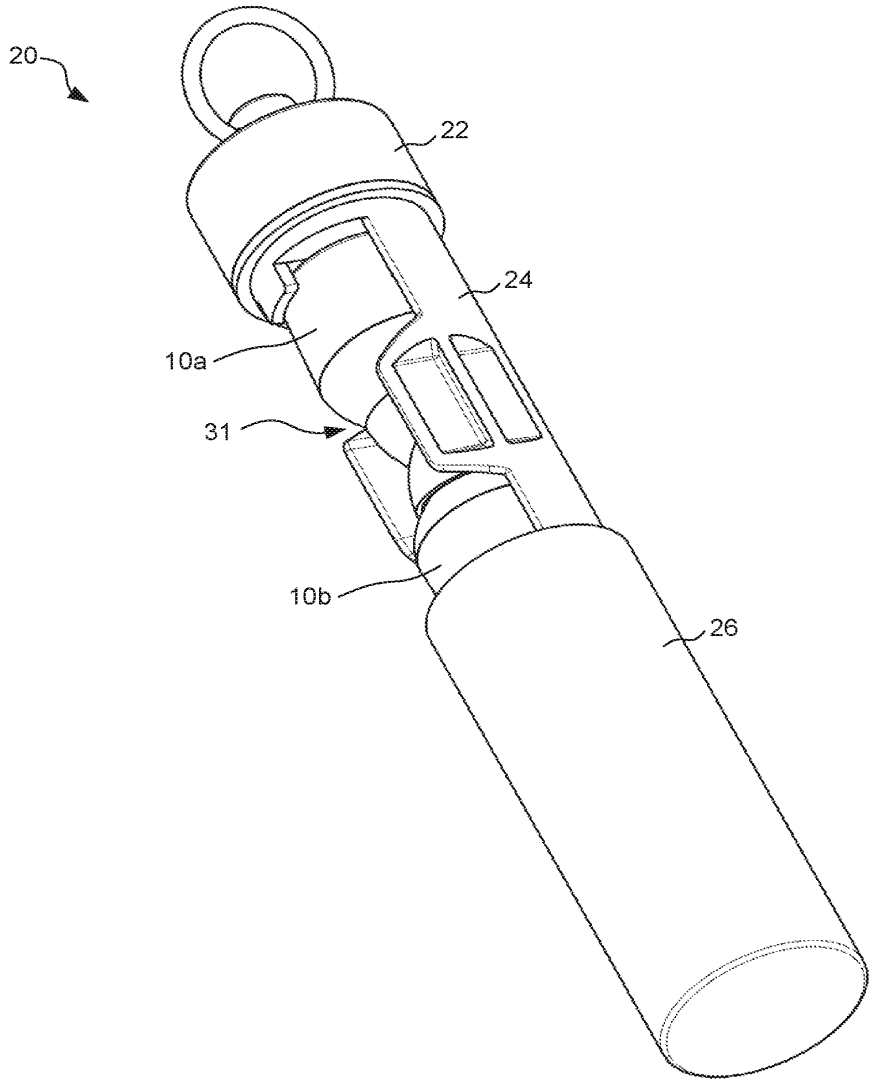


Fig 2

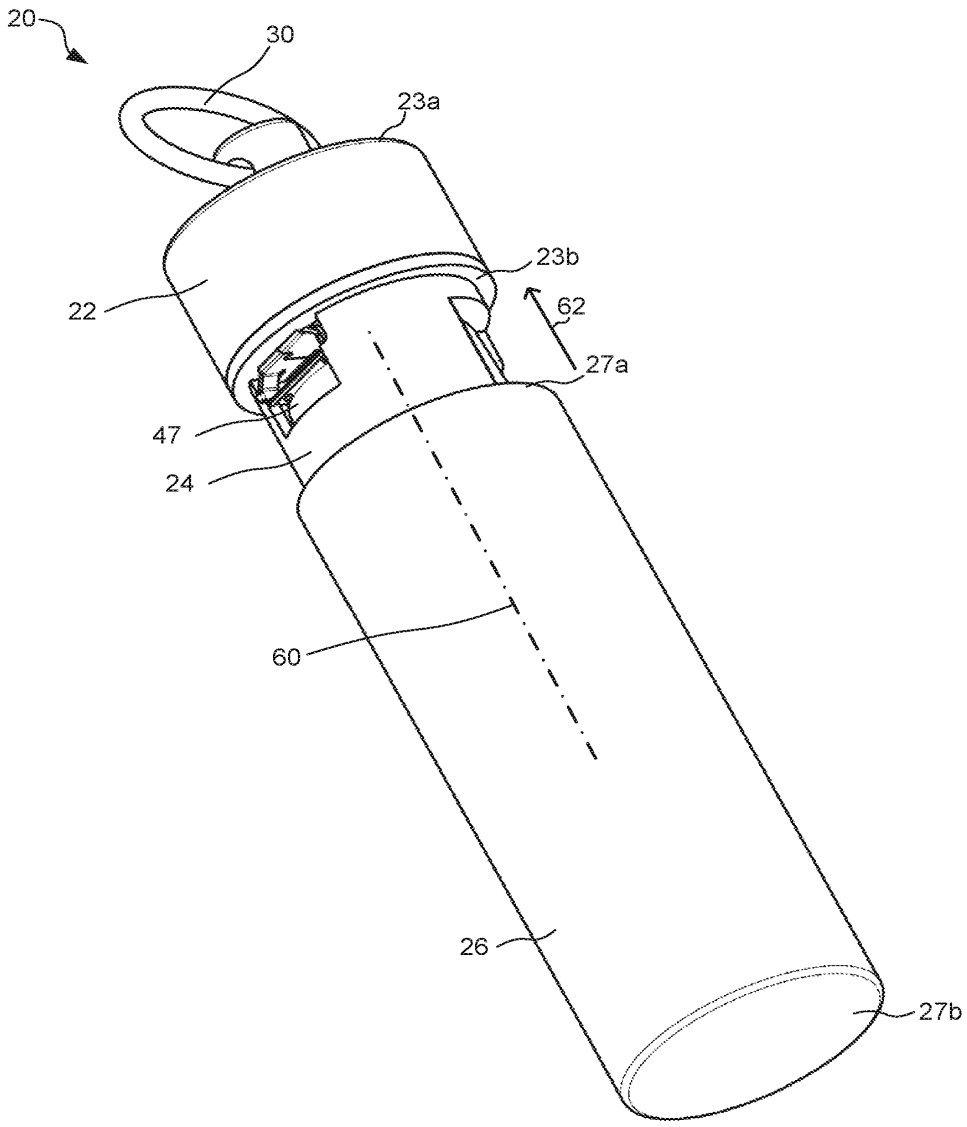


Fig 3

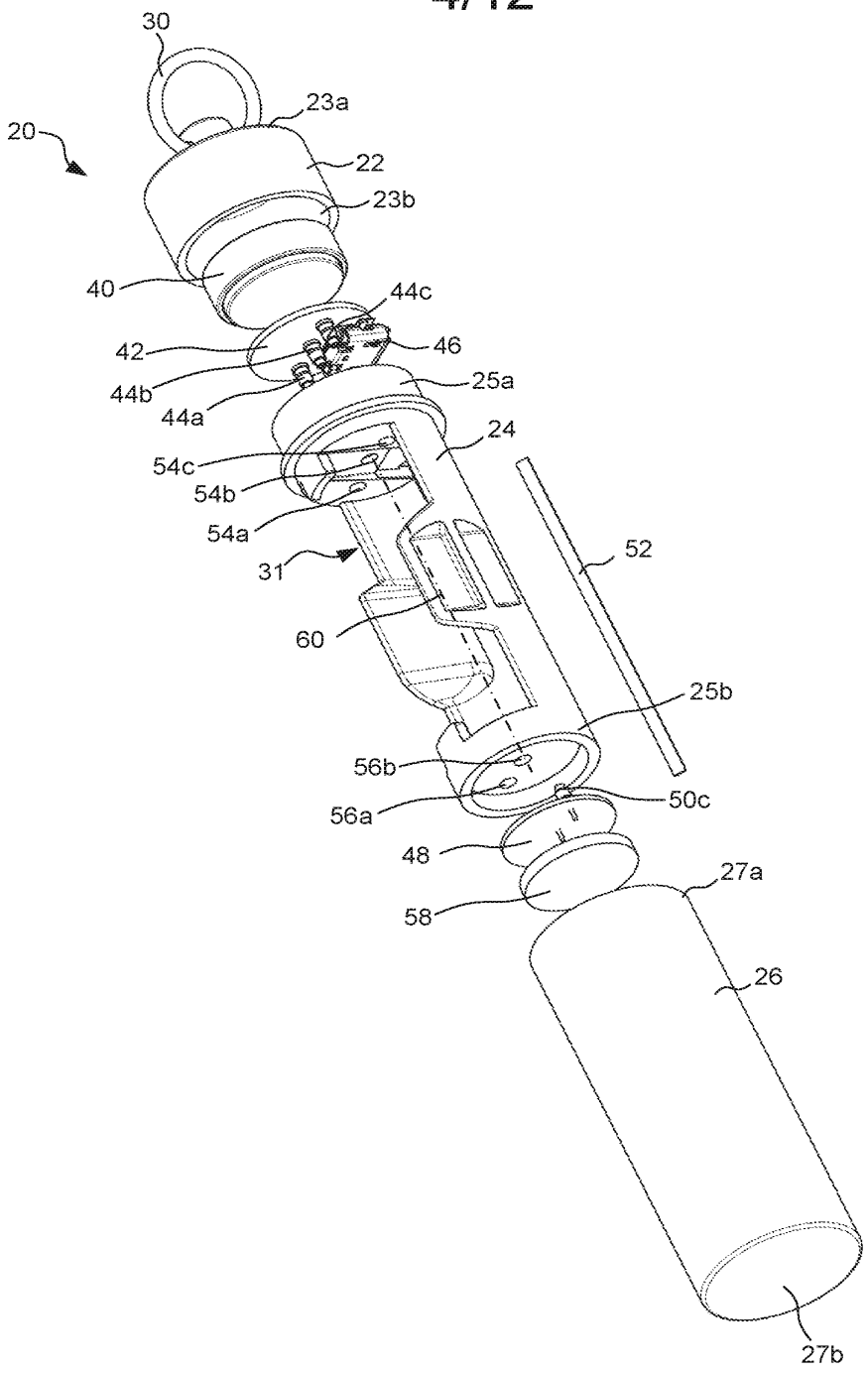

30
23a
20
22
23b
40
44c
42
46
44b
25a
44a
24
54c
54b
54a
52
31
60
25b
56b
50c
56a
48
27a
58
26
27b

Fig 4

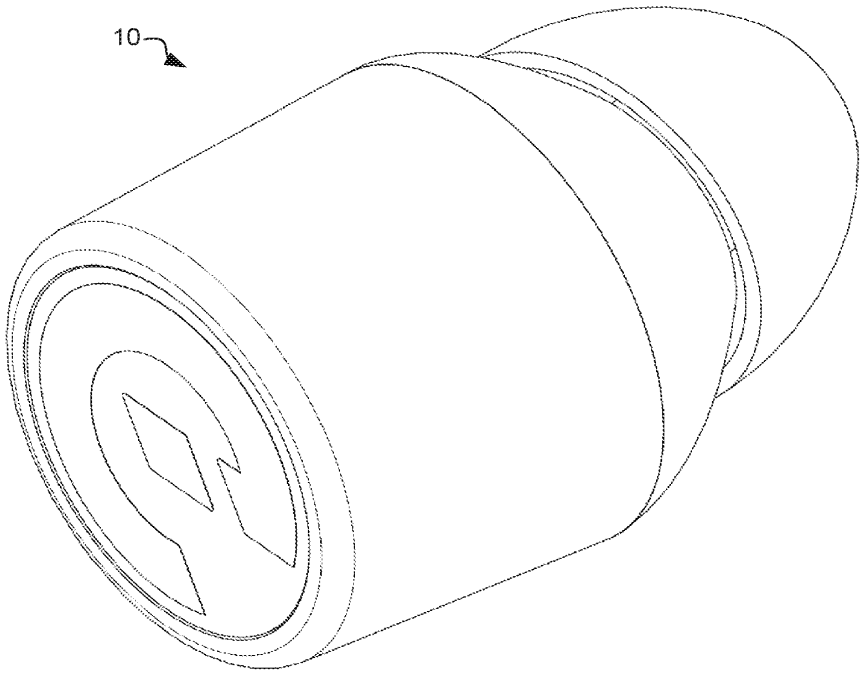


Fig 5

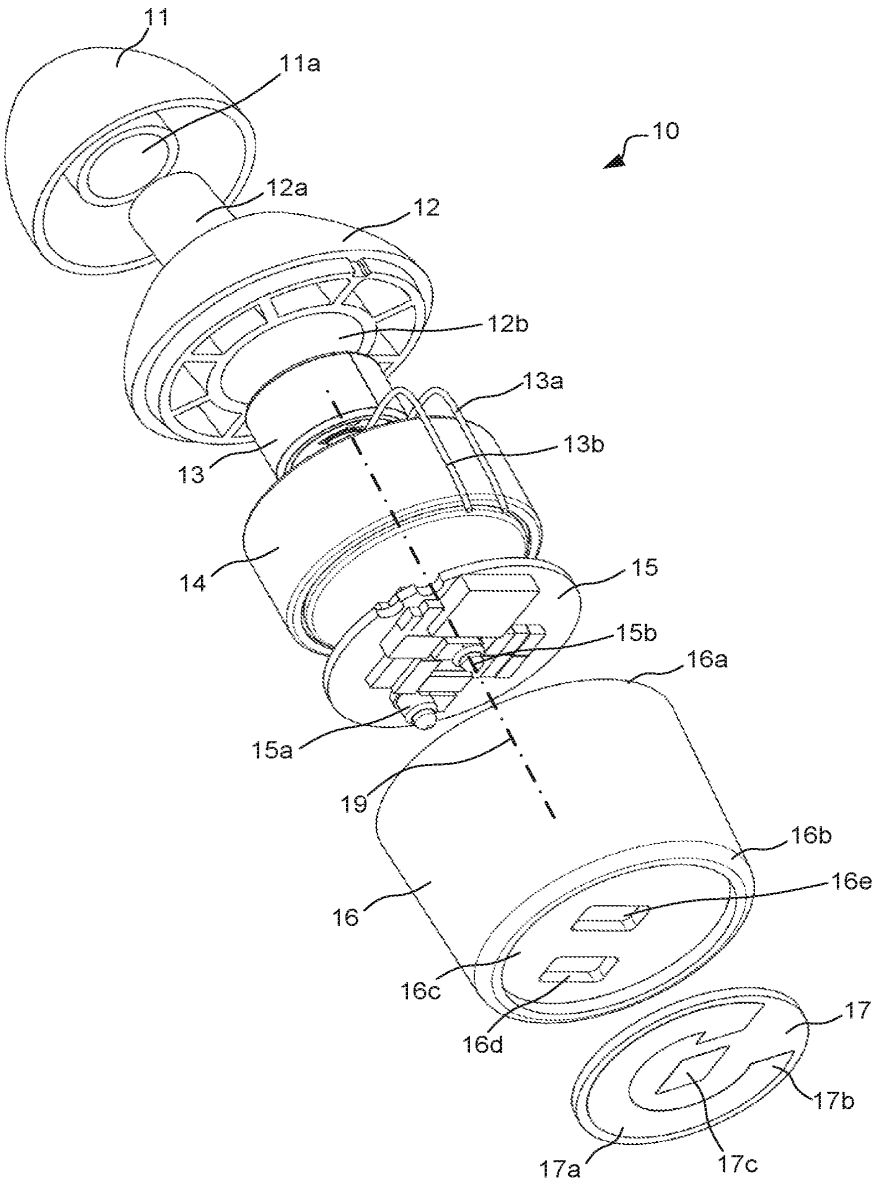

11
11a
10
12a
12
12b
13a
13b
13
14
15
15b
16a
15a
19
16b
16e
16
16c
16d
17
17b
17a
17c

Fig 6

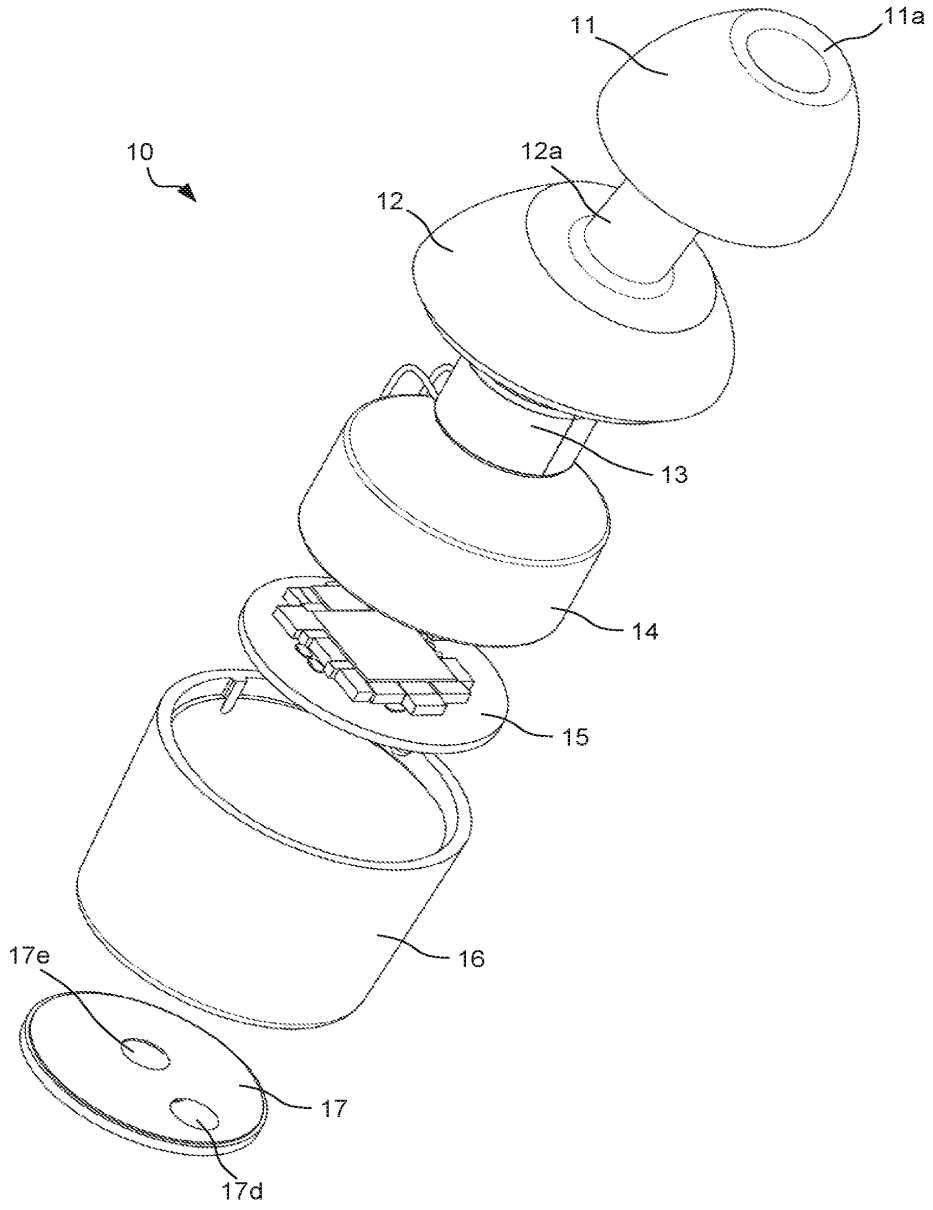


Fig 7

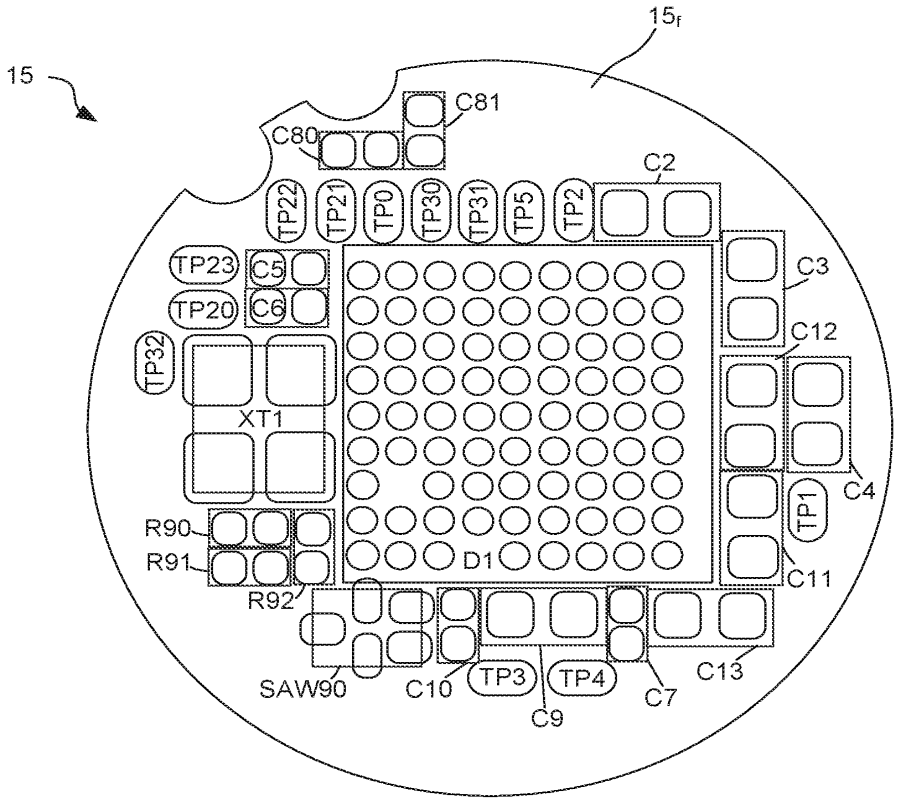

15
15f
C81
C80
C2
TP22
TP21
TP0
TP30
TP31
TP5
TP2
TP23
C5
C3
TP20
C6
C12
TP32
XT1
C4
TP1
R90
R91
D1
C11
R92
SAW90
C10
TP3
TP4
C7
C13
C9

Fig 8

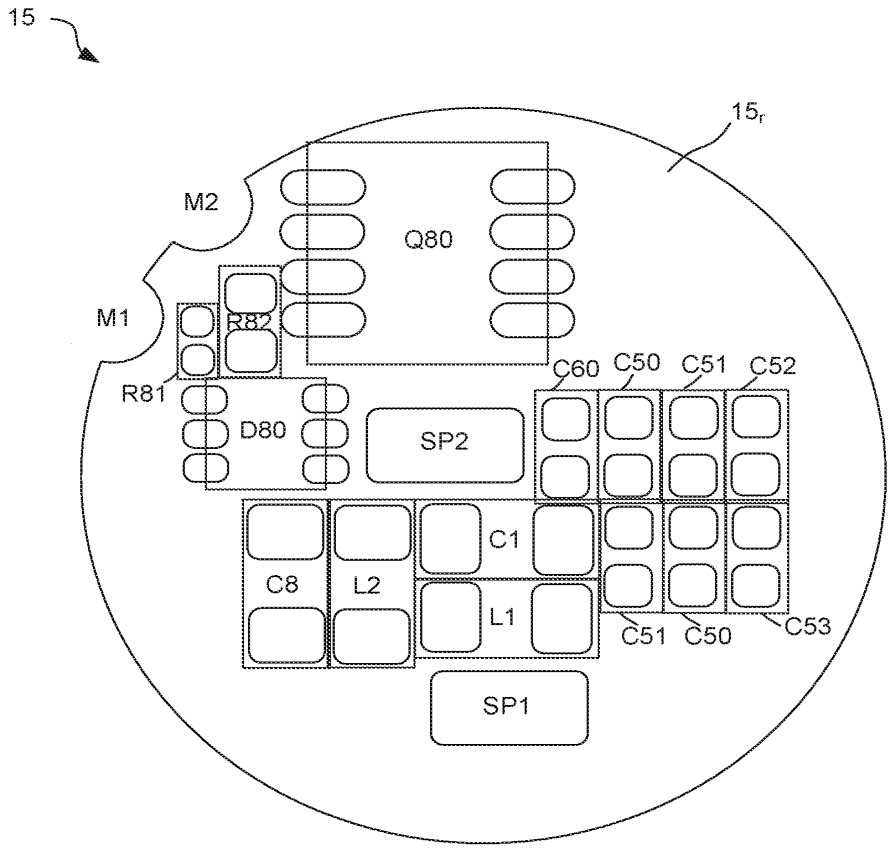

15
15r
M2
M1
Q80
R82
R81
D80
SP2
C60
C50
C51
C52
C1
C8
L2
L1
C51
C50
C53
SP1

Fig 9

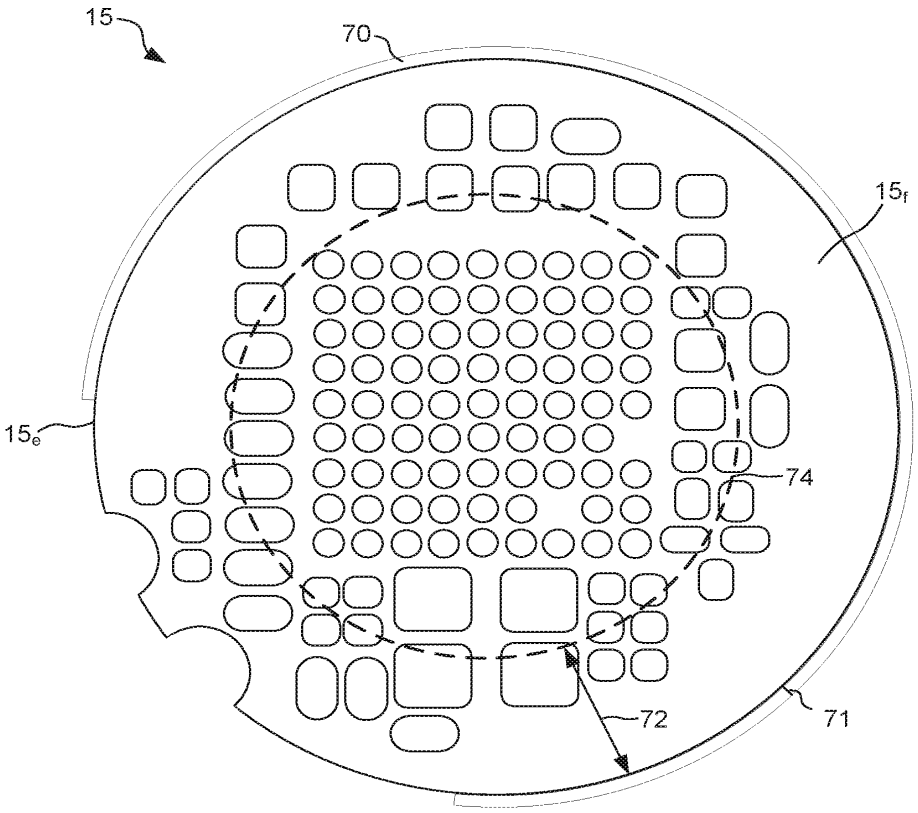


Fig 10

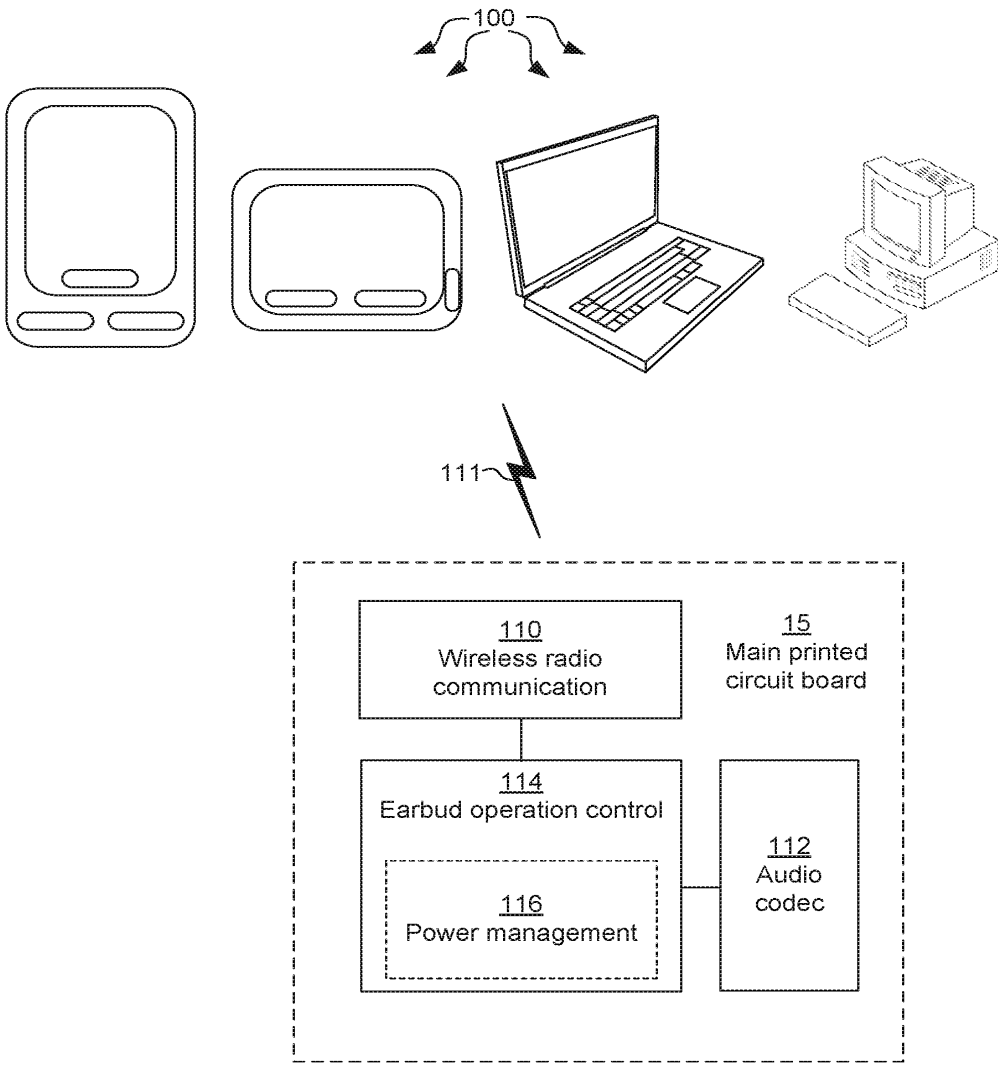

100
111
110
Wireless radio communication
15
Main printed circuit board
114
Earbud operation control
116
Power management
112
Audio codec

Fig 11

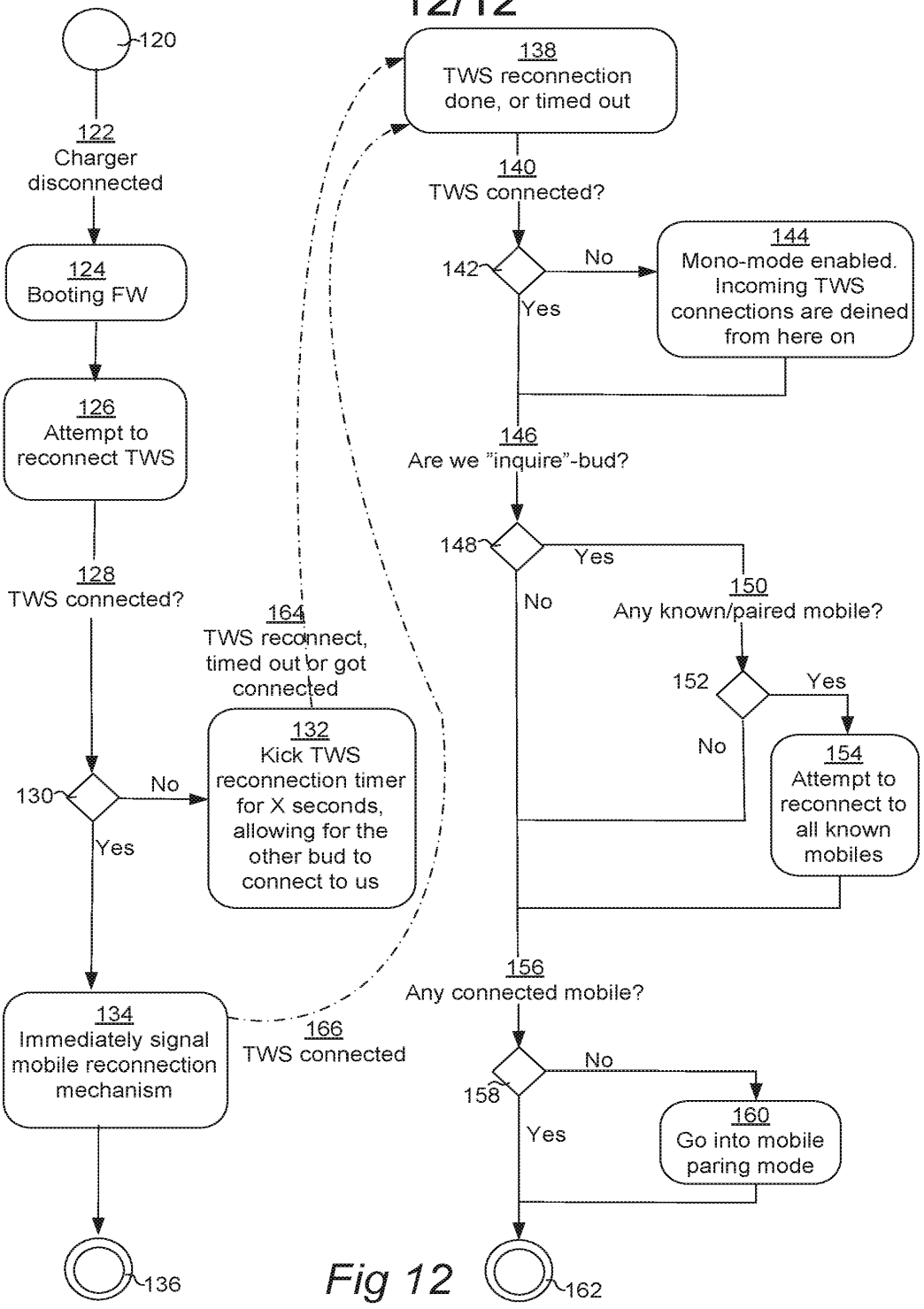

120
122
Charger disconnected
124
Booting FW
126
Attempt to reconnect TWS
128
TWS connected?
130
No
Yes
132
Kick TWS reconnection timer for X seconds, allowing for the other bud to connect to us
164
TWS reconnect, timed out or got connected
134
Immediately signal mobile reconnection mechanism
166
TWS connected
136
138
TWS reconnection done, or timed out
140
TWS connected?
142
No
Yes
144
Mono-mode enabled. Incoming TWS connections are deined from here on
146
Are we "inquire"-bud?
148
Yes
No
150
Any known/paired mobile?
152
Yes
No
154
Attempt to reconnect to all known mobiles
156
Any connected mobile?
158
No
Yes
160
Go into mobile paring mode
162

Fig 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050941

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: H02J, H04N, H04R

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20100290637 A1 (LERNER NOA), 18 November 2010 (2010-11-18)	1-4, 13-15
A	--	5-12, 16-17, 25-26
Y	US 20080181442 A1 (GOLDSTEIN STEVEN W ET AL), 31 July 2008 (2008-07-31)	1-4, 13-15
A	--	5-12, 16-17, 25-26

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01-02-2016	02-02-2016
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Henrik Andersson Telephone No. + 46 8 782 28 00

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050941

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 20140166122 A1 (GOLDSTEIN STEVEN W ET AL), 19 June 2014 (2014-06-19)	1-4, 13-15
A	--	5-12, 16-17, 25-26
A	EP 2640170 A1 (APPLE INC), 18 September 2013 (2013-09-18)	1-17, 25-26
	--	
A	WO 2010132359 A2 (ASIUS TECHNOLOGIES LLC ET AL), 18 November 2010 (2010-11-18)	1-17, 25-26
	--	
P, X	US 20150245127 A1 (SHAFFER JONATHAN EVERETT), 27 August 2015 (2015-08-27)	1-17, 25-26
	--	
E	US 20150350762 A1 (BIRGER JOHAN ET AL), 3 December 2015 (2015-12-03)	1-17, 25-26
	--	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050941

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

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

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

2. ☐ Claims Nos.:
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:

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: Claims 1-17, 25-26 directed to a wireless earbud and its construction.

2: Claims 18-24 directed to a storage and charging capsule and its construction.

3: Claim 27 directed to a wireless audio streaming host device for streaming wireless audio and communication.

.../...

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 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.: 1-17,25-26

A wireless earbud and its construction.

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.

Continuation of: Box No. III

A partial search has been carried out, which relates to the invention 1 mentioned above.

The present application has been considered to contain 3 inventions which are not linked such that they form a single general inventive concept, as required by Rule 13 PCT for the following reasons:

Claims 1-17, 25-26 relates to the problem of providing a wireless earbud with improved construction. This problem appears to be solved by an apparatus where a wireless earbud has a housing having a longitudinal main axis and an essentially circular cross section, where a speaker element, a rechargeable battery, a printed circuit board and a charging interface member are arranged in a successive order along the longitudinal main axis of the earbud housing.

Claims 18-24 relates to the problem of providing a storage and charging capsule for earbuds with improved construction. This problem is solved by an apparatus where a capsule has a base part, an elongate intermediate part that has a longitudinal major axis and a cover part being retractable over the intermediate part and wherein the intermediate part has a first end attached to the base part and a second end and an earbud chamber formed between the first and second ends and wherein the capsule also has a power source for charging earbuds placed in the chamber.

Claim 27 relates to the problem of streaming wireless audio from a host device to earbuds. This problem is solved by an apparatus where a wireless audio streaming host device for use with earbuds has a controller for receiving a message from a earbud indicating a current battery charge status and receiving a message from another earbud indicating a current battery charge status for that second earbud and determining which one of them that has a current master device role and slave role and assessing whether a switch in roles is appropriate and causing that switch.

As both the problems and solutions are technically different, no single general concept can be formulated based on the technical features of the inventions. Consequently, the requirements of Rule 13.1 PCT are not met.

Continuation of: second sheet
International Patent Classification (IPC)

H04R 1/10 (2006.01)
H02J 7/00 (2006.01)
H04N 21/218 (2011.01)
H04R 5/033 (2006.01)
H04R 25/02 (2006.01)

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US	20140166122	A1	19/06/2014	NONE			
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				CN	102547514	B	10/09/2014
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				CN	102738652	B	10/09/2014
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				HK	1136423	A1	22/03/2013
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				CA	2761585	A1	18/11/2010
				CN	102484761	A	30/05/2012
				EP	2514220	A2	24/10/2012
				JP	2012526498	A	25/10/2012
				KR	20120068767	A	27/06/2012
US	20150245127	A1	27/08/2015	US	20150373448	A1	24/12/2015
				US	9148717	B2	29/09/2015
US	20150350762	A1	03/12/2015	EP	2953377	A1	09/12/2015

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	17/553,716	Attorney Docket No.:	ST0806US1 / 532.000806US03
Confirmation No.:	1905	Customer No.:	142537
Filing Date:	December 16, 2021	Examiner Name:	George C. Monikang
First Named Inventor:	Erik Carlson	Group Art Unit:	2651
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97(b) – (d) and 1.98, Applicant brings the materials enclosed herewith to the attention of the Examiner as possibly being of interest in connection with the above-identified patent application. Pursuant to M.P.E.P. § 609 and 37 C.F.R. § 1.97(h), the information cited in the present Information Disclosure Statement shall not be construed to be an admission that the information is, or is considered to be, material to patentability. Applicant requests that the Examiner consider each of the documents listed on the attached list of documents. Pursuant to the provisions of M.P.E.P. § 609, Applicant further requests that a copy of the list of documents marked as being considered and initialed by the Examiner, be returned along with the next official communication.

Since this Information Disclosure Statement is being submitted after the receipt of a Non-Final Office Action in the above-identified patent application, Applicant hereby authorizes a charge of $260 to Deposit Account No. 13-4895 to cover the fee required under 37 C.F.R. §§ 1.97(c)(2) and 1.17(p). Please charge any additional fees or credit any overpayment to Deposit Account No. 13-4895.

Applicant invites the Examiner to contact the undersigned Applicant's Representative at the telephone number listed below if doing so may advance prosecution of this application.

Respectfully submitted by

Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
Phone: (612) 305-1220
Facsimile: (612) 305-1228

August 2, 2023
Date

/Jay R. Pralle/
Jay R. Pralle
Reg. No. 52,131
Direct Dial: 612-305-0083

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International Bureau

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24 August 2017 (24.08.2017)

(25) Filing Language: English

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(71) Applicant: **SONOVA AG** [CH/CH]; Patent & Design Rights Team, Laubisrütistrasse 28, 8712 Stäfa (CH).

(72) Inventors: **BALTENSPERGER, Christian**; Weiermatt 10, 8708 Männedorf (CH). **LAUNER, Stefan**; Im Trichtisal 39, 8053 Zürich (CH).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

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(54) **Title:** HEARING DEVICE CHARGER WITH INSERTION/EJECTION CONTROL

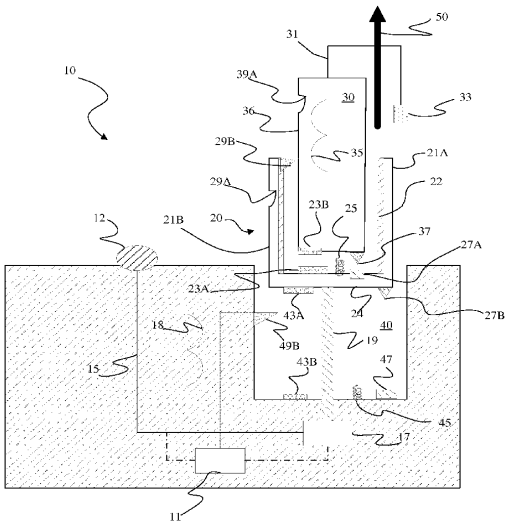


Figure 1

(57) **Abstract:** A charger for a hearing device that provides a user with control of insertion and/or ejection of the hearing device into or out of the charger. A user may use a user control to move the hearing device in the charger from a position where the hearing device can be charged by the charger and a removal position where the user may easily, manually remove the hearing device from the charger.

HEARING DEVICE CHARGER WITH INSERTION/EJECTION CONTROL

BACKGROUND

Embodiments of the present disclosure provide a hearing device charger comprising a mechanism for inserting and/or ejecting a hearing device into/from the hearing device charger.

Hearing devices are often fitted with rechargeable batteries and may be recharged either using wireless charging or direct charging of the rechargeable batteries using charging terminals, while the batteries are still in the hearing device. For effective charging of the hearing device, either wirelessly of by providing a charging current to the hearing device, the hearing device may be held in a charging position in the hearing device charger.

United States Patent No. 8,253,377 (the '377 patent') describes a hearing aid battery charger for a hearing aid equipped with rechargeable batteries. In the '377 patent, the hearing aid is held in a charging position in the hearing aid battery charger while a charging current is provided to the hearing aid batteries. The '377 patent discloses charging the rechargeable batteries while the batteries are still disposed in the hearing aid.

SUMMARY

In embodiments of the present disclosure, a hearing device charger is provided with insertion/ejection control. In some embodiments, the hearing device comprises a rechargeable battery that is configured to be recharged by a charging current provided by the charger via electrical contacts. In some embodiments, the charger and the hearing device comprise induction coils or the like to provide for wireless charging of the hearing device.

In embodiments of the present disclosure, the charging device comprises a user control configured to receive an input from a user to either insert the hearing device into the charger or to eject the hearing device from the charger and a mechanism that can insert and/or eject the hearing device from the charger in response to the user input.

In some embodiments, the hearing device is held in the charger to provide for electrical communication of a charging current supplied by the charger to the hearing device. In some embodiments, the charger is configured so that when the hearing device is inserted in the charger, an induction coil in the hearing device is aligned with an induction coil in the charger to provide for wireless charging.

In some embodiments of the present disclosure, the hearing device is ejected from the charger to provide that a user can grasp the hearing device. In some embodiments, the hearing device is completely ejected from a hearing dock of the charger. In some embodiments, after ejection from the charger, a longitudinal length of the hearing device extends beyond a top of the hearing dock such that a user can grasp the hearing device with their fingers to remove it from the charger.

These and further objects, features and advantages of the present invention will become apparent from the following description when taken in connection with the accompanying drawings which, for purposes of illustration only, show several embodiments in accordance with the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

In the figures, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

Figure 1 illustrates a charger for charging a re-chargeable ear worn communication device comprising a cradle configured for inserting and/or ejecting the ear worn communication device from the charger, in accordance with some embodiments of the present disclosure.

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Figure 2 illustrates a hearing device charger comprising a cradle configured to insert a re-chargeable ear worn communication device into the charger and/or eject the re-chargeable ear worn communication device from the charger using a mechanical mechanism, in accordance with some embodiments of the present disclosure.

Figure 3 illustrates a system for inserting a re-chargeable ear worn communication device into and/or ejecting a re-chargeable ear worn communication device from a charger, in accordance with an embodiment of the present disclosure.

Figure 4 illustrates a mechanically controlled system for inserting/ejecting a re-chargeable ear worn communication device from a charging dock, in accordance with some embodiments of the present disclosure.

Figure 5 is a flow-type illustration of a method for inserting and/or ejecting a re-chargeable ear worn communication device into/out of a charger, in accordance with some embodiments of the present disclosure.

DESCRIPTION

The ensuing description provides some embodiment(s) of the invention, and is not intended to limit the scope, applicability or configuration of the invention or inventions. Various changes may be made in the function and arrangement of elements without departing from the scope of the invention as set forth herein. Some embodiments maybe practiced without all the specific details. For example, circuits may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

Some embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A

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process is terminated when its operations are completed, but could have additional steps not included in the figure and may start or end at any step or block. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

Moreover, as disclosed herein, the term "storage medium" may represent one or more devices for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash memory devices and/or other machine readable mediums for storing information. The term "computer-readable medium" includes, but is not limited to portable or fixed storage devices, optical storage devices, wireless channels and various other mediums capable of storing, containing or carrying instruction(s) and/or data.

Furthermore, embodiments may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium such as storage medium. A processor(s) may perform the necessary tasks. A code segment may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class or any combination of instructions, data structures or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters or memory contents. Information, arguments, parameters, data, *etc*. may be passed, forwarded or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The phrases "in some implementations," "according to some implementations," "in the implementations shown," "in other implementations," and generally mean the particular feature, structure, or characteristic following the phrase is included in at least one implementation of the disclosed technology, and may be included in more than one

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implementation. In addition, such phrases do not necessarily refer to the same embodiments or different implementations.

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings and figures. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the subject matter herein. However, it will be apparent to one of ordinary skill in the art that the subject matter may be practiced without these specific details. In other instances, well known methods, procedures, components, and systems have not been described in detail so as not to unnecessarily obscure features of the embodiments. In the following description, it should be understood that features of one embodiment may be used in combination with features from another embodiment where the features of the different embodiment are not incompatible.

Hearing devices include hearing instruments – such as behind-the-ear hearing aids, in-the-ear hearing aids *etc*. – earphones, in-ear headphones, noise protection systems worn on/in the ear that include a speaker, and/or the like.

Many hearing devices are configured to be rechargeable to avoid the inefficient and problematic issue of replacing batteries. Moreover, charging systems are often designed to charge the rechargeable batteries *in-situ*, *e.g.*, while installed in the hearing device. For example, the '377 patent describes systems and methods for charging a hearing aid in a charger without removing the hearing aid's rechargeable batteries.

Hearing devices, especially hearing devices equipped with rechargeable batteries, are being designed to smaller scales to make the instruments less bulky and to provide that the instruments can be comfortably and unobtrusively positioned in and/or proximal to the ear. Hearing device designs often comprise miniaturized systems that are almost invisible on the wearer.

Wireless/Bluetooth technology means that the earpiece of the hearing device may be miniaturized and wireless/Bluetooth signals may be transmitted to the miniature earpiece for

delivery to the ear. Further, hearing devices are being made of materials, such as metal, polymers and/or the like, that increase the durability and/or wear resistance of the instrument and/or make the hearing device cosmetically appealing.

The smaller size of hearing devices and/or the properties of the new fabrication materials often make the hearing devices difficult to handle. This is especially true when it comes to a user inserting or removing the hearing device from a charger, where the hearing device needs to be positioned inside a charging dock in a charging position for effective charging. The insertion/removing problem is further compounded because, in general, chargers include a mechanism to hold hearing devices in the charging position in the charger. For example: for wireless chargers, for effective charging, an induction coil in the hearing device needs to be aligned with an induction coil in the wireless charger; and for wired charging, charging terminals on the hearing device need to be contacted with/held in contact with charging terminals in the charger/charging dock.

Mechanisms for holding hearing devices in a charging position may be mechanical and require the user to apply a force to insert and/or remove the hearing device from the holding mechanism. Moreover, a significant problem with insertion/removal of hearing devices from chargers by a user of the hearing device is the use by the user of cables/conduits or the like extending from the hearing device. Such use of the cables/conduits, especially when repeated, can cause serious damage to the hearing devices. Often the cables/conduits extending from the hearing device are some of the most fragile components of the hearing device.

For example, many in-ear communication devices include a wire(s) connecting outer-ear and in-ear parts of the hearing device and many hearing devices, such as for example behind-the-ear hearing instruments, include a sound delivery system that communicates sound detected by a microphone situated external to the ear into the inner-ear, both of which, the wire – especially at the connection point with the earphone – and/or the sound delivery system may be easily damaged by being used by a user to insert/eject the hearing device into/from the charger.

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Embodiments of the present disclosure provide a charger for a hearing device comprising a user control and an insertion and/or an ejection mechanism for inserting the hearing device into and/or ejecting the hearing device out of the charger. More particularly, but not by way of limitation, some embodiments of the present disclosure provide for insertion of the hearing device into the charger and into a charging position and/or ejection of the hearing device from the charging position out of the charging device/to a removal position in the charging device, without the user applying a force or applying only a minimal force to the hearing device.

Figure 1 illustrates a hearing device charger comprising a cradle configured to insert a hearing device into the charger and/or eject the hearing device from the charger, in accordance with some embodiments of the present disclosure.

In Fig. 1, a charger 10 comprises a cradle 20. The cradle 20 is configured to receive a hearing device 30. The hearing device 30 comprises batteries (not shown) or the like that provide for powering operation of the hearing device when worn by a user. The batteries are drained as a result of operation of the hearing device 30 and may be recharged by the charger 10.

The hearing device 30 may comprise a communication component 31, for example an electronic cable, an electronic cable attached to a speaker for in-ear operation, a sound tube and/or the like, that extends from the hearing device 30. The communication component 31 may in some aspects be configured in use to deliver sound from the hearing device 30 to a user's ear. In other aspects, the hearing device 30 may be configured to be worn in the ear and the communication component 31 may provide communication outside of the ear, such as via an antenna, communication device, wireless communication receiver, microphone and/or the like.

In some embodiments, the hearing device 30 may comprise an in-ear component 33, such as an ear-tip, speaker and/or the like, which in some embodiments may provide sound output in the inner-ear. Where the hearing device 30 is configured to be worn behind a user's ear (a behind-the-ear "BTE" hearing device), the communication component 31 and/or the in-ear component 33, which in combination may comprise a sound delivery system 31, 33, may comprise a sound

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tube, ear hook, electric cable, ear-tip, speaker and/or the like that is configured to deliver sound from the hearing device into the user's ear.

In certain embodiments, the cradle 20 is configured to insert the hearing device 30 to a charging position in the charger 10. For example, for wireless charging, the cradle 20 may move the hearing device 30 to a position in the charger 10 where a wireless induction coil 35 in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the cradle 20 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, the cradle 20 can be configured to eject the hearing device 30 from the charging position to an ejected position in the charger 10; where the hearing device 30 is accessible to the user for removal from the cradle 20 with little or no force and/or for grasping by the user by a body/housing of the hearing device 30.

For charging of the rechargeable batteries using a charging current, the cradle 20 may comprise a first terminal 27A that is configured to contact a charging terminal 37 of the hearing device 30. The cradle 20 may be configured to accommodate the hearing device 30, such that when the hearing device 30 is inserted into the cradle 20, the charging terminal 37 contacts the first terminal 27A providing for electrical communication between the charging terminal 37 and the first terminal 27A.

While the following description describes inserting/holding the hearing device 30 in the charger 10 to provide for use of a charging current, it is to be understood that the insertion/holding techniques/systems can also apply to insertion/holding the hearing device 30 in the charger 30 in a charging position for wireless charging.

In some embodiments of the present disclosure, the cradle 20 is shaped to provide that the hearing device can only be inserted into the cradle 20 in a single orientation, and this single orientation is configured to provide that the charging terminal 37 contacts the first terminal 27A when the hearing device 30 is inserted into the cradle 20.

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In some embodiments, the cradle 20 is configured to provide that in excess of 50% of a longitudinal length of the hearing device 30 extends beyond walls 21A, 21B of the cradle 20 when the hearing device 30 is inserted into the cradle 20. The longitudinal length of the hearing device 30 comprises a length of the hearing device 30 aligned with a longitudinal axis 50 of the charging dock 40. Preferably, in some embodiments greater than 60%, 70% or 80% of the longitudinal length of the hearing device 30 extends beyond the walls 21A, 21B of the cradle 20 when the hearing device 30 is inside the cradle 20 with the charging terminal 37 in contact with/held in contact with the first terminal 27A. Having this amount of the hearing device 30 extends beyond the walls 21A, 21B of the cradle 20 provide for ease of handling of the hearing device 30 by a user of the hearing device 30. It has been found that where a large surface area of the housing 36 of the hearing device 30 is accessible to a user, the user will grip the hearing device 30 by the housing 36 of the hearing device 30 to insert/remove the hearing device 30 from the cradle 20, rather than using the communication component 31.

The cradle 20 may be shaped to provide that there is space between an outer-surface 36 of the hearing device 30 and an inner-surface 22 of the cradle 20. In such embodiments, gravity may provide for holding the charging terminal 37 and the first terminal 27A in contact. In some embodiments, magnets 23A and 23B may be used to hold the hearing device 30 in the cradle so that the charging terminal 37 and the first terminal 27A are held in contact. In some embodiments, one of the magnets 23A and 23B may not be a magnet but comprise a metallic compound to provide for the magnetic coupling. In this way, using only one magnet, the magnetic coupling force is reduced lessening the force needed to remove the hearing device 30 from the cradle 20. In some embodiments, the inner-surface 22 and or the outer-surface 36 may comprise an elastic and/or grippy/adhesive material that may hold the hearing device 30 in the cradle 20 after insertion by a user.

In some embodiments, a latch system may be used to hold the hearing device 30 in the cradle 20 such that the charging terminal 37 and the first terminal 27A are held in contact. The latch system may comprise a notch 39A or the like in the hearing device 30 and a nose 29B extending from the inner-surface 22 of the cradle. In some embodiments, the notch 39A may

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be a notch in the inner-surface 22 of the cradle and the nose 29B may extend from the outer-surface 36 of the hearing device 30. When the hearing device 30 is inserted into the cradle 20, such that the notch 39A and the nose 29B align, the notch 39A and the nose 29B interact to hold the hearing device 30 in the cradle 20 so that charging terminal 37 and the first terminal 27A are in contact.

In some embodiments, the charger 10 comprises a user input 12. The user input 12 may comprise an electrical switch or the like such that a user input may be electronically conveyed via electrical communicator 15 to an electrical actuator 17. The electrical actuator 17 may comprise a motor, a pump and/or the like and may interact with the cradle 20 via an interaction element 19. As such, in some embodiments of the present disclosure, the electrical actuator 17 receives communication of a user input to the user input 12 and generates motion of the cradle 20 into or out of the charger 10 via the interaction element 19. The interaction element 19 may in some embodiments comprise a screw-type mechanism a geared mechanism, a combination of coupled substrates, a hydraulic system and/or the like that is configured to translate an output from the electrical actuator 17 into motion of the cradle 20 into or out of the charger 10. In some embodiments of the present disclosure, the user input 12, the electrical communicator 15, the electrical actuator 17 and the interaction element 19 provide insertion/ejection of the hearing device 30 into/from the charger 10.

In some embodiments, the user input 12 may comprise an electrical switch or the like that can control the electrical actuator 17 to either insert the cradle 20 into the charger 10 or to eject the cradle 20 from the charger 10. In some embodiments, the user input 12 may comprise two separate inputs, one to control insertion of the cradle 20 and one to control ejection of the cradle 20. In some embodiments, the user input 12 may include a light or the like to identify the user input 12 to a user and/or to identify a status of the cradle 20, *e.g.*, whether the cradle is inserted, ejected and/or whether the hearing device 30 is being charged/is fully charged.

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In some embodiments, a controller 11 or the like may control the operation of the electrical actuator 17. The controller 11 may comprise processing circuitry that controls the operation of the electrical actuator 17 based upon a user's input.

The controller 11 may, in some embodiments, control the latch system such that when a user input is received by the controller 11 to insert the hearing device 30 in the charger 10, the controller 11 may control the latch system such that the latch, nose 29B or the like, is activated to position and/or hold the hearing device 30 in the cradle 20. Similarly, when a user input is received by the controller 11 to eject the hearing device 30 from the charger 10, the controller 11 may control the latch system such that the latch, nose 29B or the like, is retracted.

In some embodiments, an elastic element 25, such as a spring or the like, may be used to assist or provide for ejection of the hearing device 30 from the cradle 20. For example, if a user applied a force to the hearing device 30 to remove the hearing device 30 from the cradle 20, a force generated in response to compression of the elastic element 25 will assist the user's force. In some embodiments using a latch system, where the latch system is deactivated or its holding force is overcome, the elastic element 25 may at least partially eject the hearing device 30 from the cradle 20.

In some embodiments, the electrical actuator 17 is configured to move the cradle 20 into and out of a charging dock 40 in the charger 10 that is configured to accommodate the cradle 20. Like the cradle 20, the charging dock 40 may comprise: a magnet 43B for interacting with a magnet 43A on the cradle 20; a nose 49B or the like for coupling with a notch 29A or the like on the cradle to provide a latch system; an elastic element 45 to assist in removing the cradle 20 from the charging dock 40; an electrical terminal 47 for contacting with an electrical terminal 27B on the cradle 20, which is in conductive communication with the first terminal 27A; and a magnet 43B for interacting with a magnet 43A on the cradle 20 and holding the electrical terminal 47 in contact with electrical terminal 27B.

In some embodiments, the walls 21A, 21B may be moveably attached to a base of the cradle 24. For example, the walls 21A, 21B may be attached by a hinge to the base 24, may be

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attached so that the walls 21A, 21B may translate over the base 24 and/or the like. In such embodiments, when the cradle 20 is moved into or out of the charging dock 40, the walls 21A, 21B may be configured to move with respect to the base 24. For example, in some embodiments, the walls 21A, 21B may be configured to move inwards with respect to the base 24 and in so doing 'grip' the hearing device 30 as the hearing device 30 is inserted into the charging dock 40. This gripping of the hearing device 30 may be achieved by a transducer moving the walls 21A, 21B, by a spring loaded mechanism where interior walls of the charging dock 40 'push' the walls 21A, 21B inwards, by contact between the walls 21A, 21B of the cradle 20 and the charging dock 40, and/or the like. Conversely, when the cradle 20 is ejected from the charging dock 40, the walls 21A, 21B may move outward relative to the base 24 releasing the hearing device 30. In such embodiments, there may be no retaining force being applied to the hearing device 30 when the cradle 20 is in an ejected position for a user to overcome when removing the hearing device 30 from the cradle 20. Moreover, access to the hearing device 30 may be improved.

Figure 2 illustrates a hearing device charger comprising a cradle configured to insert an hearing device instrument into the charger and/or eject the hearing device from the charger with a mechanical input, in accordance with some embodiments of the present disclosure.

As described with respect to Fig. 1, the cradle 20 may be used to insert/eject the hearing device 30 from the charger 10. In some embodiments, the user input 12 may comprise a switch, a button, a lever or a lid moveably coupled to the charger. The lid (not shown) may comprise a hinged lid or the like that covers the charging dock 40. In some embodiments, the user input 12 is configured to translate a user input force – *e.g.*, a force that moves the switch, the button, the lever or the lid – to a mechanical insertion/ejection system.

For example, in some embodiments, the user input 12 may be coupled with a first lever 210A that is in turn coupled to a second lever 210B. The first lever 201A may be coupled with a pivot point 205A, which may comprise an axle, a gear and/or the like, such that movement of the first lever 210A causes the second lever to pivot around the pivot point 205A. The

coupling of the first and second levers 210A & B is configured to provide for translating a direction of the force applied by the user to the user input 12. The second lever 210B is coupled in turn with an insertion/ejection mechanism 220. The second lever 210B may be coupled with the insertion/ejection mechanism 220 and may pivot around a pivot point 205B, which may comprise an axle, a gear and/or the like. The coupling of the second levers 210B and the insertion/ejection mechanism 220 is configured to provide for translating a direction of the force acting on the second lever 210B, such that the insertion/ejection mechanism 220 moves in a longitudinal direction in the charging dock 40.

In some embodiments, the insertion/ejection mechanism 220 is coupled with the cradle 20 and moves the cradle 20 longitudinally, in and out of the charging dock 40. The insertion/ejection mechanism 220 may comprise a lever/rod or the like or a plurality of separate components and/or levers/rods. In different embodiments, different numbers of levers and pivots may be used to provide for translation of a force applied to the user input 12 into movement of the cradle 20 into/out of the charging dock 40. For example, the user input 12 may comprise a switch or the like where the user input 12 may move along the surface of the charger 10 and a series of mechanical connections may translate this sliding motion into movement of the cradle 20 into/out of the charging dock 40. It is to be understood that the hearing device 30 is a small, light device, and the the charging dock 40 is also a small volume, such that only small input forces are needed at the user input 12 to cause the cradle 20 to move into/out of the charging dock 40.

In some embodiments, the insertion/ejection mechanism described in Fig. 2 may be used in reverse, *e.g.*, the user may pull on the user input 12, rather than push the user input 12, to move the user input 12 in an opposite direction relative to an initial input to provide for insertion of the hearing device 30 in contrast to ejection of the hearing device 30. In other embodiments, two user inputs may be used, one to provide for insertion of the hearing device 30 and one to provide for ejection 30 of the hearing device 30.

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In certain embodiments, the cradle 20 can be configured to insert the hearing device 30 to a charging position in the charger 10. For example, for wireless charging, the cradle 20 may move the hearing device 30 to a position in the charger 10 where a wireless induction coil 35 in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the cradle 20 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, the cradle 20 can be configured to eject the hearing device 30 from the charging position to an ejected position in the charger 10, where the hearing device 30 is accessible to the user for removal from the cradle 20 with little or no force and/or for grasping by a body/housing of the hearing device 30.

Figure 3 illustrates a system for inserting a hearing device into and/or ejecting an hearing device from a charger, in accordance with an embodiment of the present disclosure.

In Fig. 3, a charger 10 comprises a charging dock 140. The charging dock 140 is configured to receive a hearing device 30. The hearing device 30 may comprise a communication component 31, for example an electronic cable, a sound tube or the like, that extends from the hearing device 30. The communication component 31 being configured in use to deliver sound from the hearing device 30 to a user's ear. In some embodiments, the hearing device 30 may comprise an in-ear component 33, such as an ear-tip, speaker and/or the like. Where the hearing device 30 is configured to be worn behind a user's ear (a BTE hearing device), the communication component 31 and/or the in-ear component 33, which in combination may comprise a sound delivery system 31, 33, may comprise a sound tube, ear hook, electric cable, ear-tip, speaker and/or the like that is configured to deliver sound from the hearing device into the user's ear.

In certain embodiments, the charging dock 140 is configured so that when the hearing device 30 is inserted into the charging dock it is positioned/held in a charging position in the charger 10. For example, for wireless charging, the hearing device 30 may be inserted by the insertion mechanism described herein to a position in the charger 10 where a wireless induction coil 35

in the hearing device is aligned with a wireless induction coil 18 in the charger 10. In some embodiments, the charger 10 and/or the charging dock 140 may comprise a holding mechanism for holding the hearing device 30 in the charging position in the charger 10. Similarly, after charging, insertion/ejection mechanism described herein is configured to eject the hearing device 30 from the charging position to an ejected/removing position in the charger 10, where the hearing device 30 is accessible to the user for removal from the charger 10 with little or no force and/or for grasping by a body/housing of the hearing device 30. In some embodiments, the hearing device 30 may be completely ejected from the charger 10, such that after ejection, the hearing device is completely outside of the charging dock 140 after ejection so that the complete hearing device 30 is accessible to the user.

While the following description describes inserting/holding the hearing device 30 in the charger 10 to provide for application of a charging current, it is to be understood that the insertion/holding techniques/systems can also apply to insertion/holding the hearing device 30 in the charger 30 in a charging position for wireless charging.

In some embodiments, the charging dock 140 comprises a docking terminal 147 that is configured to contact a charging terminal 37 of the hearing device 30. In some embodiments, the charging dock 140 is configured to accommodate the hearing device 30 such that when the hearing device 30 is inserted into the charging dock 140 the charging terminal 37 contacts the docking terminal 147 providing for electrical communication between the charging terminal 37 and the docking terminal 147.

In some embodiments of the present disclosure, the charging dock 140 is shaped to provide that the hearing device can only be inserted into the charging dock 140 in a single orientation, and this single orientation is configured to provide that the charging terminal 37 contacts the first docking terminal 147 when the hearing device 30 is inserted into the charging dock 140.

The charging dock 140 may be shaped to provide that there is space between an outer-surface 36 of the hearing device 30 and an inner-surface 22 of charging dock walls 111A and 111B. In such embodiments, gravity may provide the force for holding the charging terminal 37 in

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contact with the docking terminal 147. In some embodiments, magnets 143B and 23B (one of the magnets 143B and 23B may comprise a metallic compound instead of a magnet to provide for metallic coupling) may be used to hold the hearing device 30 in the charging dock 140 so that the charging terminal 37 and the docking terminal 147 are held in contact. In some embodiments, an inner-surface of the charging dock walls 111A and 111B and or the outer-surface 36 may comprise an elastic and/or grippy material that may hold the hearing device 30 in the charging dock 140 after insertion by a user.

In some embodiments, a latch system (nose 149B and notch 39A) may be used to hold the hearing device 30 in the charging dock 140 such that the docking terminal 147 and the first terminal 27A are held in contact. In some embodiments, the location of the nose 149B on the charging dock 140 and the notch 39A on the hearing device 30 may be reversed. In some embodiments of the present disclosure, the nose 149B may be retractable into a cavity (not shown) and may be spring loaded so that as the hearing device 30 is inserted in the charging dock 140, the nose 149B slides along an outer-surface of the hearing device 30 until it is inserted by a spring-type mechanism into the notch 39A. When the hearing device 30 is inserted into the charging dock 140, such that the notch 39A and the nose 29B align, the notch 39A and the nose 29B interact to hold the hearing device 30 in the charging dock 140, such that charging terminal 37 and the first terminal 147 are in contact.

In some embodiments, the charger 10 comprises a user input 112. The user input 112 may comprise an electrical switch or the like such that a user input may be electronically conveyed via electrical communicator 115 to an electrical actuator 117. The electrical actuator 117 may comprise a motor or the like and may interact with the hearing device 30 via an interaction element 119. As such, in some embodiments of the present disclosure, the electrical actuator 117 may receive communication of a user input to the user input 112 and generate motion of the hearing device into or out of the charging dock 140 via the interaction element 119.

In some embodiments, an end of the interaction element (not shown) may comprise a magnet, a grippy material, a latch and/or the like to provide for coupling of the interaction element 119

with the hearing device 30. In some embodiments, however, the hearing device 30 may be inserted into the charging dock 140 by the user pushing on the hearing device 30.

The interaction element 119 may in some embodiments comprise a screw-type mechanism, a geared mechanism, a combination of coupled substrates and/or the like that are configured to translate mechanical motion of the electrical actuator 117 into motion of the hearing device 30 into or out of the charging dock 140. In some embodiments of the present disclosure, the user input 112, the electrical communicator 115, the electrical actuator 117 and the interaction element 119 can provide insertion/ejection of the hearing device 30 into/from the charging dock 140.

The user input 112 may comprise an electrical switch or the like that can communicate with the electrical actuator 117 to either insert the hearing device 30 into the charger 10 or to eject the hearing device 30 from the charging dock 140. In some embodiments, the user input 112 may comprise two separate inputs one to control insertion of the hearing device 30 and one to control ejection of the hearing device 30. In some embodiments, the user input 112 may include a light or the like to identify the user input 112 to a user and/or to identify a status of the hearing device 30, *e.g.*, whether the hearing device 30 is inserted, ejected, in contact with the charging terminals and/or whether the hearing device 30 is being charged or is fully charged.

In some embodiments, a controller 111 or the like that may control the operation of the electrical actuator 117. The controller 111 may comprise processing circuitry that controls the operation of the electrical actuator 117 based upon a user's input and/or a charging state of the hearing device 30, for example the controller 111 may control ejection of the hearing device 30 from the charger 10 when the hearing device 30 is fully charged.

The controller 111 may, in some embodiments, control the latch system such that when a user input is received by the controller 111 to insert the hearing device 30 in the charger 10, the controller 111 may control the latch system such that the nose 149B or the like, is activated to position and/or hold the hearing device 30 in the charging dock 140. Similarly, when a user

input is received by the controller 111 to eject the hearing device 30 from the charging dock 140, the controller 111 may control the latch system such that the latch, nose 149B or the like, is retracted.

In some embodiments, an elastic element (not shown) such as a spring or the like, may be used to assist or provide for ejection of the hearing device 30 from the charging dock 140. For example, the controller 111 may control the nose 149B to retract from the notch 39A so that the elastic element may eject the hearing device 30 from the charging dock 140.

In some embodiments of the present disclosure, the charger 10 may comprise a protection device for the communication component 31 and/or the in-ear component 33. In some embodiments, the protection device may comprise a recess 143 into which the communication component 31 and/or the in-ear component 33 may be stored when the hearing device is in the charging dock 140 and/or a guard (not shown) that may prevent/make it difficult for the user of the hearing device 30 to access the communication component 31 and/or the in-ear component 33 when the hearing device 30 is in the charging dock 140.

In some embodiments, the charging dock 140 is configured to provide that after ejection in excess of 50% of the length of the hearing device 30 extends beyond walls 111A, 111B of the charging dock 140. Preferably, in some embodiments greater than 60%, 70% or 80% of the length of the hearing device 30 extends beyond the walls 111A, 111B of the charging dock 140 when the hearing device 30 is ejected from the charging dock 140 to provide for handling of the hearing device 30 by a user of the hearing device 30. It has been found that where a large surface area of the side of the hearing device 30 is accessible to a user, the user will grip the hearing device 30 by the sides of the hearing device 30 to insert/remove the hearing device 30 from the charging dock 140, rather than using the communication component 31.

Figure 4 illustrates a mechanically controlled system for inserting/ejecting an hearing device from a charging dock, in accordance with some embodiments of the present disclosure.

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As described with respect to Fig. 3, some embodiments of the present disclosure provide a system for inserting/ejecting the hearing device 30 from the charging dock 140 using the user input 112. In some of these embodiments, the user input 112 may comprise a switch or a button configured to translate a user input force – *e.g.*, a force that moves the switch or button – to a mechanical arrangement of levers.

For example, the user input 112 may be coupled with a first lever 210A that is in turn coupled to a second lever 210B. The first lever 201A may be coupled with a pivot point 205A, which may comprise an axle, a gear and/or the like, such that movement of the first lever 210A causes the second lever to pivot around the pivot point 205A. The coupling of the first and second levers 210A & B is configured to provide for translating a direction of the force applied by the user to the user input 112.

In some embodiments of the present disclosure, the second lever 210B is coupled with an insertion/ejection mechanism 220. The second lever 210B may be coupled with the insertion/ejection mechanism 220 and may pivot around a pivot point 205B, which may comprise an axle, a gear and/or the like. The coupling of the second levers 210B and the insertion/ejection mechanism 220 is configured to provide for translating a direction of the force acting on the second lever 210B such that the insertion/ejection mechanism 220 moves in a longitudinal direction in the charging dock 140.

The insertion/ejection mechanism 220 may comprise a lever/rod or the like or a plurality of separate components. In different embodiments, different numbers of levers and pivots may be used to provide for translation of a force applied to the user input 112 into movement of the hearing device 30 into/out of the charging dock 140. For example, the user input 112 may comprise a switch or the like where the user input 112 may move along the surface of the charger 10 and a series of mechanical connections may translate this sliding motion into movement of the insertion/ejection mechanism 220 into/out of the charging dock 140. It is to be understood that the hearing device 30 is a small, light device and as such the charging dock

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140 comprises a small volume such that only small input forces are needed at the user input 112 to cause the hearing device 30 to move into/out of the charging dock 140.

In some embodiments, the insertion/ejection mechanism described in Fig. 4 may be used in reverse, *e.g.*, the user may pull on the user input 112 rather than push the user input 112, move the user input 112 in an opposite direction relative to an initial input to provide for insertion of the hearing device 30 in contrast to ejection of the hearing device 30. In other embodiments, two user inputs may be used, one to provide for insertion of the hearing device 30 and one to provide for ejection of the hearing device 30.

In some embodiments, however, the hearing device 30 may be inserted into the charging dock 140 by the user pushing on the hearing device 30. Similarly, rather than using the user input 112 to eject the hearing device 30, a user may push the hearing device 30 downwards so that the latch system is released and a compliant element 145 may, as a result, provide for ejection of the hearing device 30 from the charging dock 140.

Figure 5 is a flow-type illustration of a method for inserting and/or ejecting a hearing device into/out of a charger, in accordance with some embodiments of the present disclosure.

In step 305, a user places a hearing device in a charger. The user may place the hearing device in a cradle or in a charging dock of the charger. In some embodiments, the user may simply place the hearing device into the cradle/charging dock where the internal dimensions of the cradle charging dock are greater than that of the hearing device so that little or no force is required for the placement. In other embodiments, the user may need to apply a force to the hearing device so that the hearing device is held in the cradle/charging dock by friction with walls of the cradle/charging dock, a latch system and/or the like. Requiring application of force to the hearing device for placing in the charger has in general not been found to be detrimental to the hearing device.

In some embodiments, where the charger is a wireless charger, the charging dock may comprise sloping sides leading to a charging cavity shaped to receive the hearing device in a

certain alignment, where the certain alignment aligns a receiving induction coil in the hearing device with a charging induction coil in the charger. In such embodiments, a user may simply 'drop' the hearing device in a top of the charging dock and let gravity 'insert' the hearing device in the charging cavity.

In step 310, the user inputs an insertion command into the charger. In some embodiments, this may comprise pushing a button, a switch or the like. In other embodiments, the user may push the hearing devise itself.

In step 315, the hearing device is inserted into a charging position in the charger. In mechanical systems, according to embodiments of the present disclosure, a force applied by a user to an input in step 310 is translated by the mechanical system into movement of the cradle or an insertion mechanism into a charging dock in the charger. In this way, the hearing device is inserted into a charging position in the charging dock. In some embodiments, a holding system may hold the hearing device in the charging dock. The holding mechanism may comprise walls of a docking cradle that may retract and clamp the hearing device such that it is held in the cradle and the cradle is moved to a charging position in the charger.

In some embodiments, a user's input in step 310 is electronically communicated to an actuator and the actuator may provide for insertion of the hearing device into the charger. The electronic communication with the actuator may be made via processing circuitry that controls the actuator. The actuator may comprise an electrical motor, a mechanical actuator configured to convert an electronic signal to mechanical motion, a controlled compliant coupling, a hydraulic actuator and/or the like.

In some embodiments, the charger may not require steps 310 or 315 as the user may insert the hearing device directly in the charger into a charging position. Or as described above, where the charger comprises a wireless charger, gravity may insert the hearing device in the charger. In yet other embodiments, the charger may comprise a box like structure and the lid may serve as a user input, such that closing the lid of the charging box either causes an electrical

communication to insert the hearing device in the charger or provides an input force that drives a mechanical system to insert the hearing device into the charger.

In step 320, the charger chargers the hearing device, where charging may be via electrical connections or wireless charging. Indicators may be provided that provide optical signals regarding the charging status of the hearing device, *e.g.*, charging, charged, and/or the like and/or the status of the hearing device in the charger, *e.g.,* inserted, in charging position, ejected and/or the like.

In step 325, a user inputs an ejection command. The ejection command may be made by pushing a button, operating a switching mechanism, pushing on the hearing device in the charger and/or the like. In some embodiments where the charger comprises a box like structure with a lid, the user input for ejecting the hearing device may comprise opening the lid of the box.

In step 330 the hearing device is ejected from the charger. In embodiments where the user ejection command is communicated electronically an electro-to-mechanical actuator may be used to eject the hearing device from the charger. In embodiments, where the user ejection command is communicated via mechanical means, the force of the user input may be translated via a mechanical system to a force the hearing device causing it to eject from the charger. For example, kinetic motion of a button, switch, a lid of the charger and/or the like may be translated via a mechanical system to a force on the hearing device in direction such that the hearing device is ejected from the charger. In some embodiments, where the hearing device is inserted in a charging cradle, the force may be applied to the charging cradle to eject the cradle and the hearing device from the charger.

In embodiments, where the charger includes a holding device to hold the hearing device in the charger, the user command may also be communicated to the holding mechanism to release the hearing device. In some embodiments, ejection of the hearing device from the charger comprises moving the hearing device and/or a charging cradle in a charging dock such that at least 60%, 70% or preferably 80% of a length of the hearing device is accessible to a user

above the walls of the charging dock. In some embodiments, the whole hearing device may be ejected from the charging dock such that it lays on top of the ejection mechanism and can easily be picked up by a user.

In some embodiments, the ejection mechanism is configured to provide that at least 0.5 centimetres. 0.75 centimetres or in excess of 1.0 centimetres in length of the hearing device housing extends outside of the hearing device holder/ charging dock when the hearing device is ejected from the charger.

While the principles of the disclosure have been described above in connection with specific apparatuses and methods, it is to be clearly understood that this description is made only by way of example and not as limitation on the scope of the invention.

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CLAIMS:

1. A hearing device charger configured to charge a rechargeable hearing device, which comprises a hearing device housing, a sound delivery system and a rechargeable battery, the hearing device charger comprising:

a power supply for supplying a charging current to the rechargeable hearing device;

a charging dock configured to accommodate at least a portion of the hearing device;

characterised in that the hearing device charger comprises:

a user control configured to receive an input from a user to either insert the hearing device into a charging position in the charging dock or eject the hearing device to a removing position in the charging dock; and

an insertion/ejection mechanism configured to move the hearing device between the charging position and the removing position.

2. The hearing device charger according to claim 1, wherein the user control comprises one of a switch, a button, a lever or a lid that is moveably coupled with the hearing device charger.

3. The hearing device charger according to any of the preceding claims, wherein the insertion/ejection mechanism comprises a mechanical insertion/ejection mechanism comprising a plurality of levers in mechanical communication with the user control and configured to mechanically translate an input force applied by the user to the user control to an insertion/ejection force applied to the hearing device.

4. The hearing device charger according to claim 3, wherein the mechanical insertion/ejection mechanism comprises one or more gears.

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5. The hearing device charger according to claims 1 or 2, wherein the injection/insertion mechanism comprises an electrical actuator in electrical communication with the user control and configured to move the hearing device between the charging position and the removing position.

6. The hearing device charger according to claim 9, wherein the electrical actuator comprises one of an electrical motor and a hydraulic pump.

7. The hearing device charger according to claims 1 or 2, wherein the injection/insertion mechanism comprises a hydraulic actuator in fluid communication with the user control and configured to move the hearing device between the charging position and the removing position.

8. The hearing device charger according to any of the previous claims, wherein the insertion/injection mechanism further comprises a cradle configured to hold the hearing device.

9. The hearing device charger according to claim 8, wherein the cradle comprises moveable side walls that move inward to squeeze against the hearing device housing during insertion and/or move outwards to release the hearing device during ejection.

10. The hearing device charger according to any of the preceding claims, wherein:

the rechargeable battery comprises battery terminals for charging the rechargeable battery;

the charging dock comprises charging terminals electrically connected with the power supply and configured to provide an electrical connection with the battery terminals; and

the charging dock comprises a holding mechanism for holding the hearing device in the charging position, such that in the charging position the battery terminals contact the charging terminals.

11. The hearing device charger of claim 10, wherein the holding mechanism comprises at least one of a latch system, an elastic element and a magnet.

12. The hearing device charger according to claims 10 or 11, wherein the holding mechanism further comprises a release mechanism for releasing the holding mechanisms when the hearing device is moved from the charging position to the removing position.

13. The hearing device charger according to any of the preceding claims, wherein in the removing position at least 0.5 centimetres. 0.75 centimetres or in excess of 1.0 centimetres in length of the hearing device housing extends outside of the hearing device holder.

14. The hearing device charger according to any of the preceding claims, wherein in the removing position less than 30% or preferably less than 20% of a longitudinal length of the hearing device body is disposed within the hearing device holder.

15. The hearing device charger according to any of the preceding claims, further comprising a guard section configured to receive at least a portion of the sound delivery mechanism.

16. The hearing device charger according to any of the preceding claims, further comprising:

an indicator light configured to indicate a status of the hearing device.

17. The hearing device charger according to any one of claims 1 through 10 or 13 through 16, wherein:

the hearing device charger comprises a charging induction coil;

the hearing device comprises a hearing device induction coil; and

in the charging position, the charging induction coil and the hearing device induction coil are aligned for wireless charging of the hearing device.

18. A method for inserting/injecting a hearing device into/out of a charging dock of a hearing device charger, comprising:

using a user control to receive a user input;

communicating the user input to an actuator; and

using the actuator to move the hearing device between a charging position and a removing position in the charging dock, wherein the charging position comprises a position configured for charging the hearing device and the removing position comprises a position configured for removal of the hearing device by the user.

19. The method of claim 18, wherein in the removing position greater than 70% or preferably greater than 80% of a longitudinal length of the hearing device extends outside of the charging dock.

20. The method of one of claims 18 or 19, wherein in the removing position the hearing device is completely ejected from the charging dock.

21. The method of any one of claims 18 through 20, wherein:

the user control comprises one of a switch, a button, an input lever and a lid of the hearing device charger that is moveably coupled with the hearing device charger;

communicating the user input to the actuator and using the actuator to move the hearing device between the charging position and the removing position in the charging dock comprises mechanically communicating a force applied by the user to the user control to the

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hearing device to move the hearing device between the charging position and the removing position.

22. The method according to any one of claims 20 through 22, wherein:

communicating the user input to the actuator comprises electronically communicating the user input to the actuator; and

using the actuator to move the hearing device between the charging position and the removing position in the charging dock comprises controlling the actuator to move the hearing device between the charging position and the removing position.

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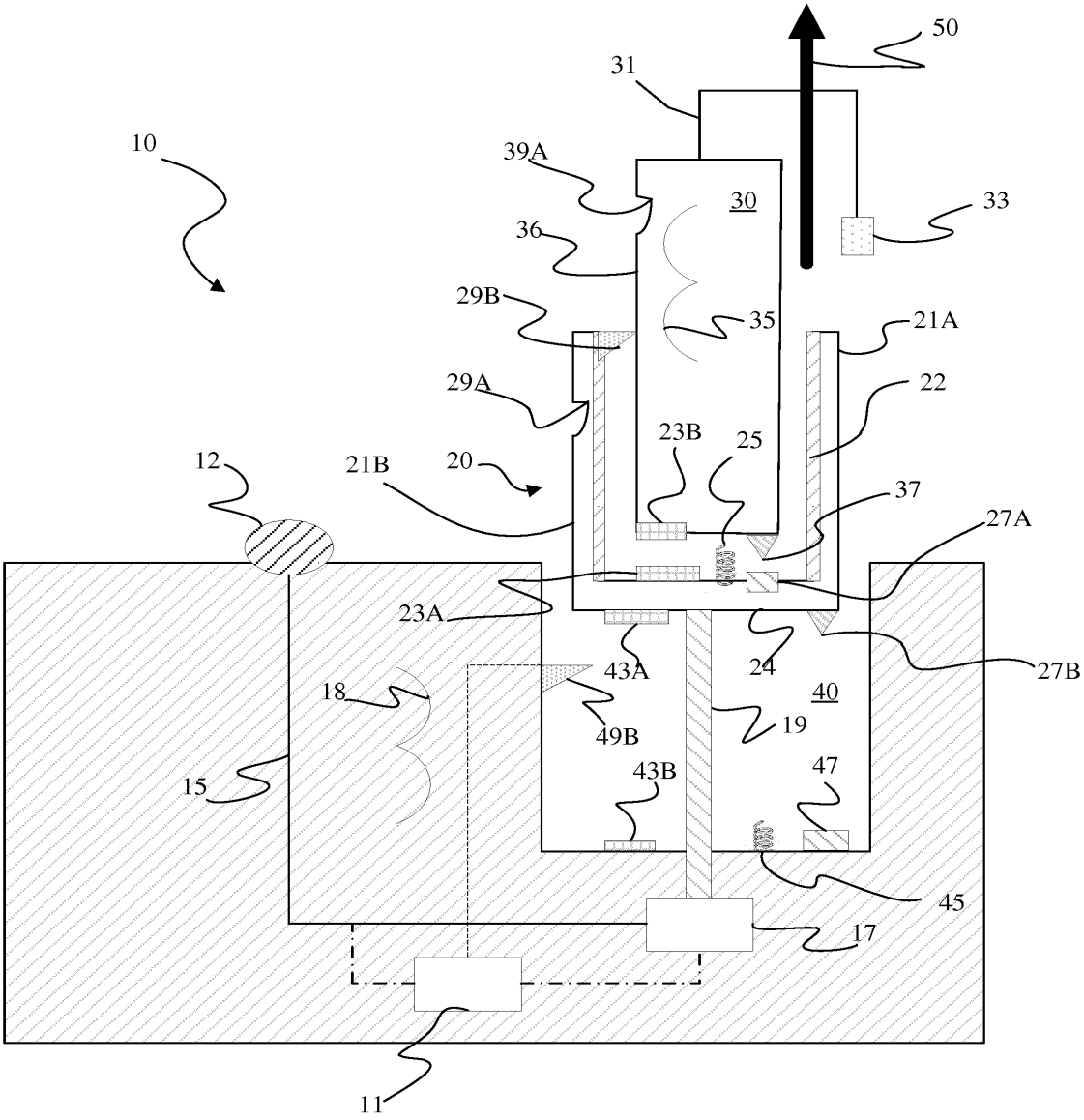

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39A
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29B
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Figure 1

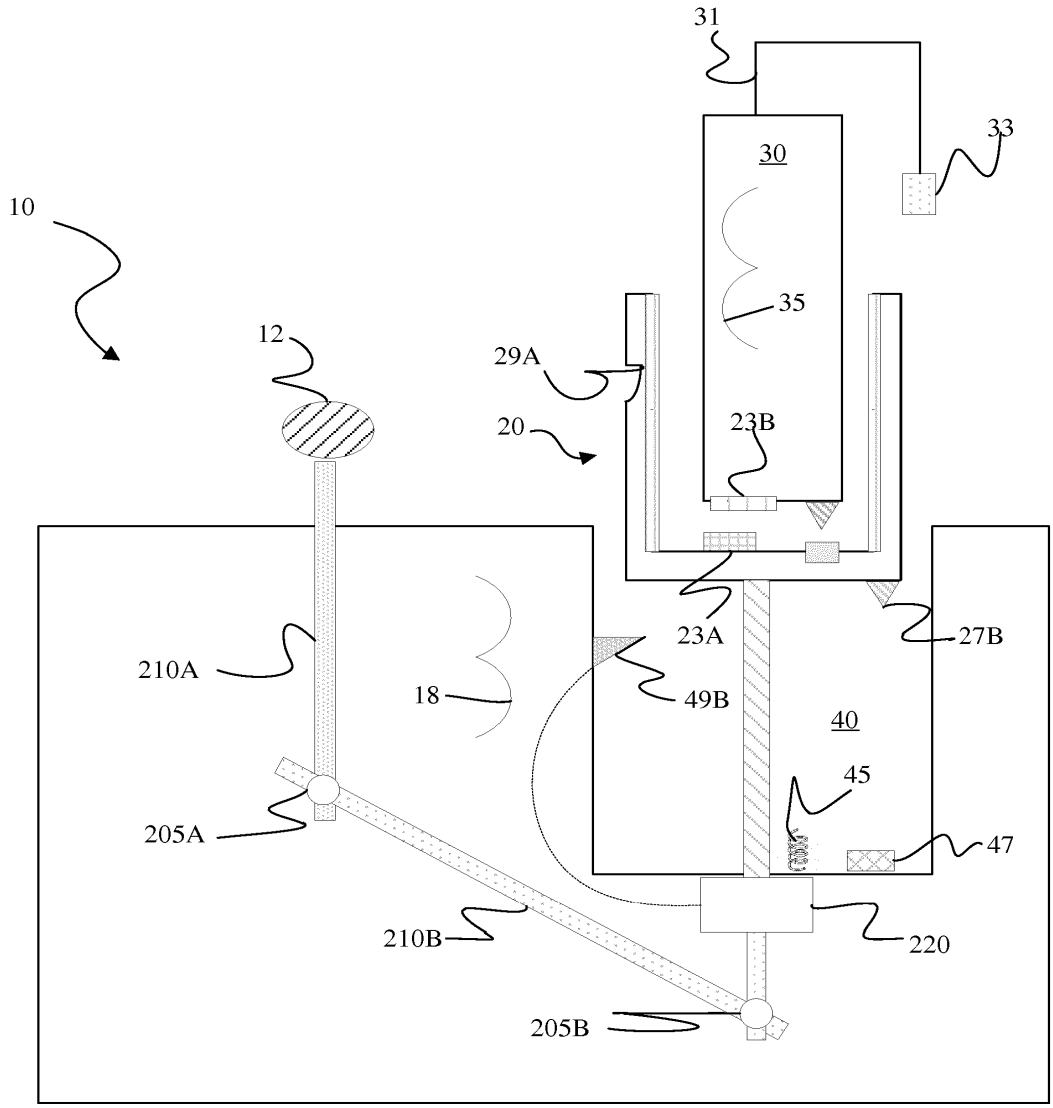

31
33
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29A
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210A
18
49B
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205A
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210B
220
205B

Figure 2

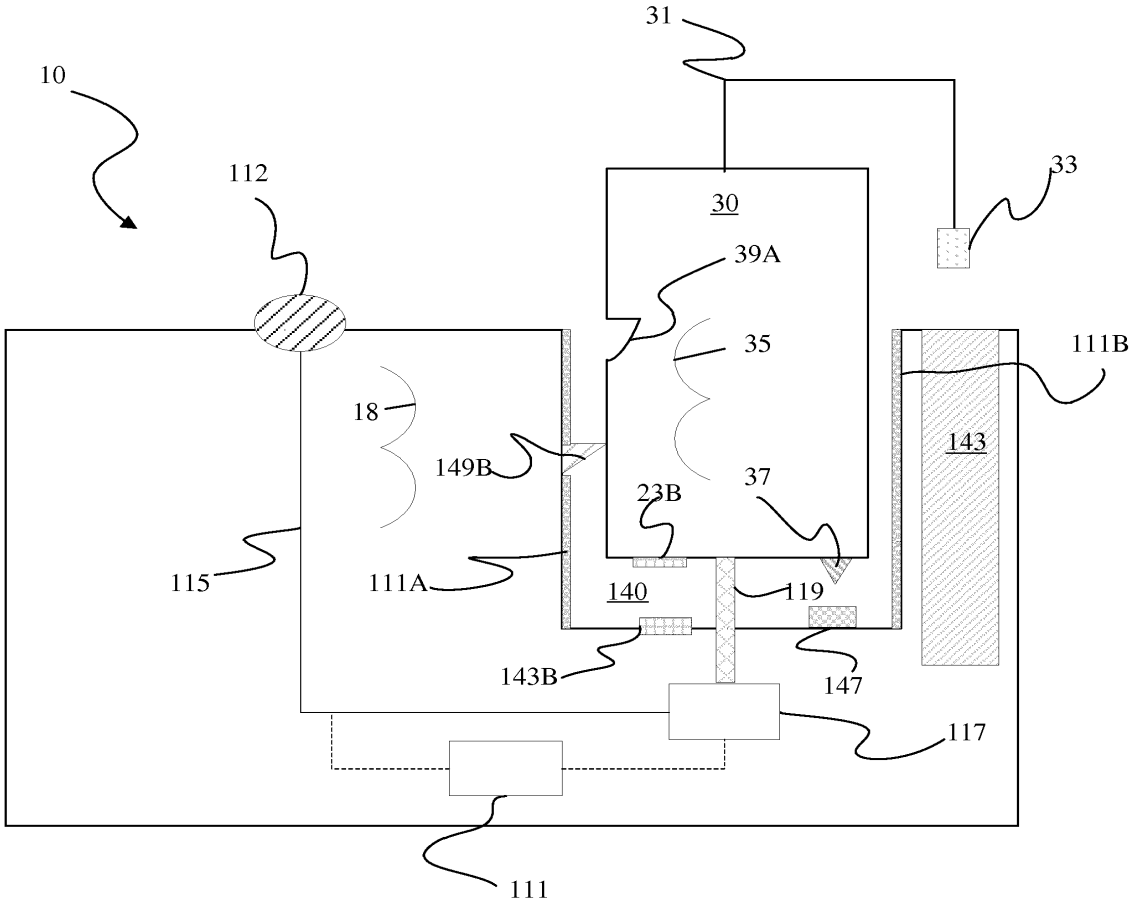

31
10
112
33
30
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149B
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117
111

Figure 3

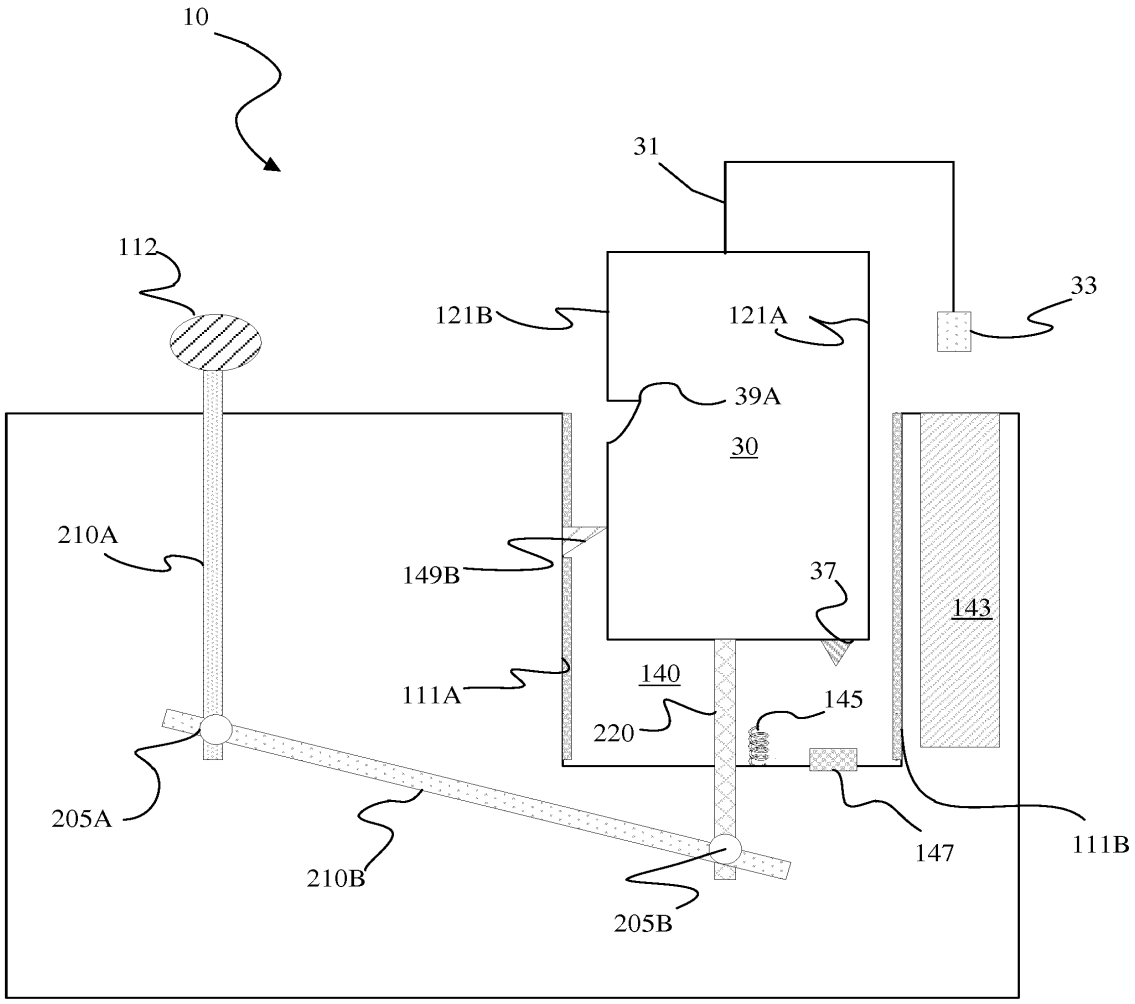

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111B
210B
205B

Figure 4

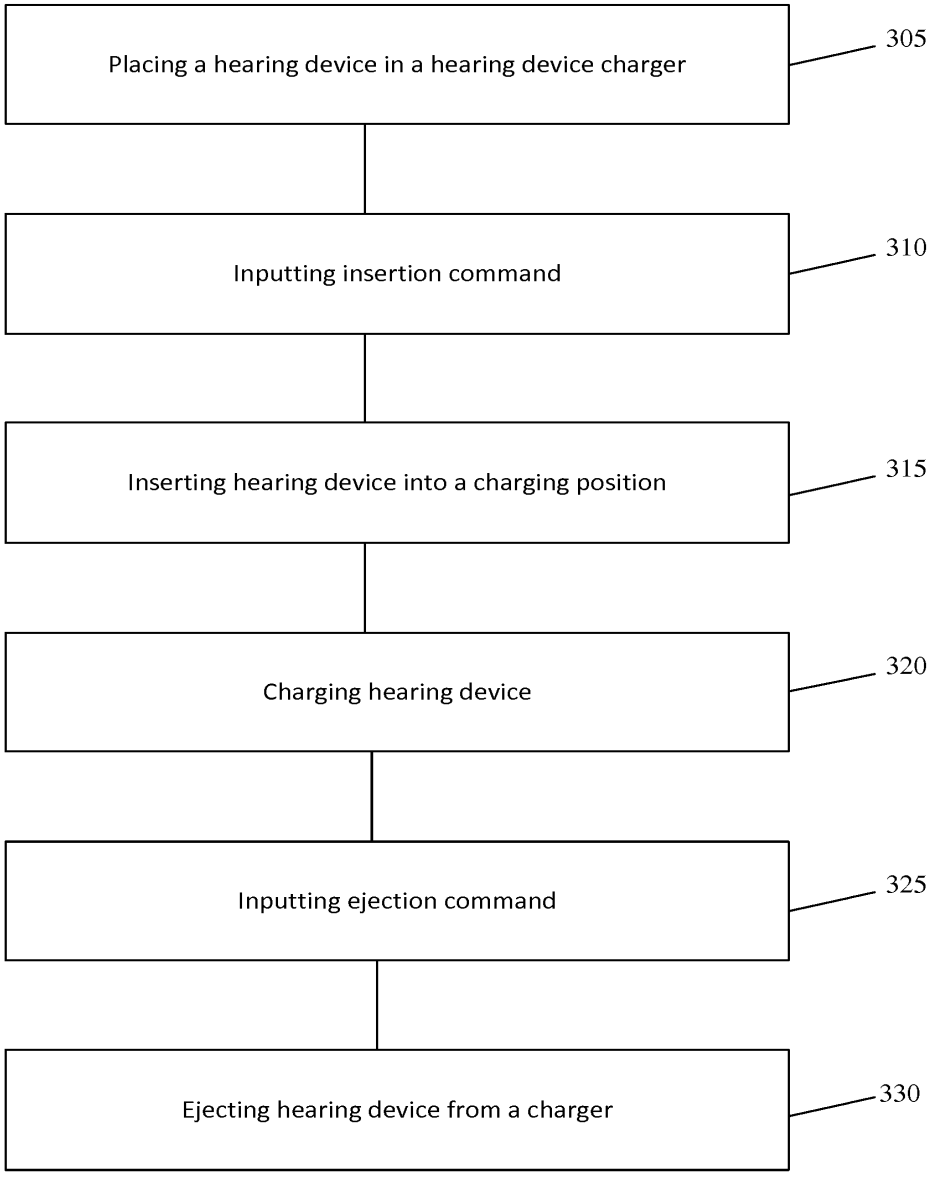

Placing a hearing device in a hearing device charger
305
Inputting insertion command
310
Inserting hearing device into a charging position
315
Charging hearing device
320
Inputting ejection command
325
Ejecting hearing device from a charger
330

Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/071325

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/10 H04R25/00
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)
H04R

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	US 2009/200984 A1 (MEINCKE HANS [DK] ET AL) 13 August 2009 (2009-08-13)	1-4, 8-16, 18-21
Y	page 2, paragraph 21 - page 4, paragraph	17
A	71; figures 5, 7, 8-11, 15, 17	5-7,22
A	US 2008/007217 A1 (RILEY LOUIS F [US]) 10 January 2008 (2008-01-10) page 1, paragraph 16 - page 1, paragraph 18; figures 1-3	1-22
Y	US 2002/113572 A1 (ZINK UWE [US] ET AL) 22 August 2002 (2002-08-22) page 2, paragraph 18 - page 3, paragraph 39; figures 1-4	17

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

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2018	01/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Duffner, Orla

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/071325

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Form PCT/ISA/210 (patent family annex) (April 2005)

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
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	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Art Unit:	2651
	Examiner Name:	George C. Monikang
	Attorney Docket No.:	ST0806US1 / 0532.000806US03
Sheet 1 of 1	**IDS filed on:**	*August 02, 2023*

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Examiner Initial	Patent Number (Number - Kind Code)	Issue Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
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	D924207 S1	07-06-2021	Li	
	D941475 S1	01-18-2022	Burns	

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Examiner Initial	Publication Number (Number - Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
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U.S. PATENT APPLICATIONS BY SERIAL NUMBER

Examiner Initial	Copy Enclosed	Document Number (Number - Kind Code)	Filing Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
		None			

FOREIGN PATENT DOCUMENTS

Examiner Initial	Copy Enclosed	Country Code	Foreign Document Number	Kind Code	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments	translation yes	translation no
		EP	2640170	A1	09-18-2013	Sanford			
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		WO	2016/126476	A1	08-11-2016	Fletcher			
		WO	2019/037854	A1	02-28-2019	Baltensperger			

Examiner Signature		Date Considered	

***EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.**

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(74) **Agents**: **NOWAK, Sandra K.,** et al.; 3M Center, Office of Intellectual Property Counsel Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on next page]

(54) **Title**: HEARING PROTECTOR WITH COMPARTMENT FOR RECHARGEABLE BATTERY PACK

(57) **Abstract**: A hearing protection device is provided. The hearing protection device can include a speaker to relay sounds, such as conversations, to the user of the hearing protection. The hearing protection device can be powered by a rechargeable battery pack or separately by standard batteries.

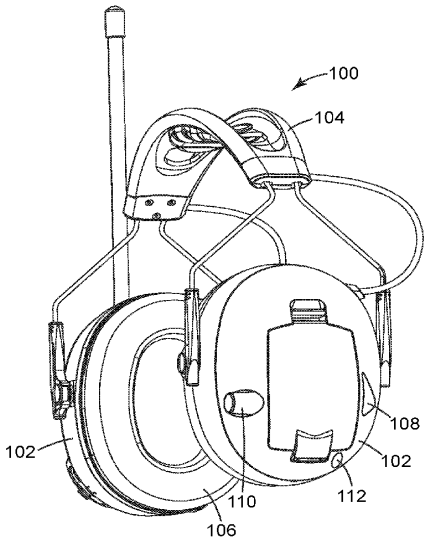


Fig. 1

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HEARING PROTECTOR WITH COMPARTMENT FOR RECHARGEABLE BATTERY PACK

Background

People frequently wear hearing protection when they are in loud or noisy environments. Hearing protection can reduce the amount of noise the user's ears are exposed to. In some cases the user might want to hear some noises, such as a conversations or commands from people around them, music, other entertainment or other communication (e.g. AM/FM radio transmissions, Bluetooth transmissions, or communication from other transceivers) delivered through an input sound source. If the user is wearing hearing protection, hearing these desirable noises can be difficult or impossible. Therefore, there is a need to allow the user of hearing protection to still be able to hear some external noises, while still reducing the loud or undesirable noises.

Hearing protectors often require power to operate the apparatus. Batteries are often used to power these products. Users of hearing protection products can appreciate the convenience of using different battery types in the same apparatus. However, the different form factors of rechargeable batteries compared to standard cylindrical batteries often makes it difficult for a single apparatus to be powered by either type of battery without modifications that change the appearance and/or size of the apparatus. For safety reasons, it is also desired that products which can use rechargeable batteries have a means of preventing charging from occurring if a non-rechargeable battery or wrong type of rechargeable battery is used in the apparatus.

Summary

Sound external to a hearing protection headset can be input by one or more microphones on the headset. The ambient external sound or background noises can be monitored, analyzed and filtered so that a user of the headset can better hear human voices.

In one example, an apparatus for hearing protection includes a sound input source, such as a microphone, disposed on the apparatus. The sound input source is configured to pick up an input sound wave from the environment and to convert the input sound wave to an incoming signal. The apparatus also includes a processor that is configured to receive the incoming signal and create an output signal. The apparatus can further include a speaker disposed on the apparatus. The speaker is configured to produce the output from the processor.

In one example, an apparatus for hearing protection includes a microphone disposed on the apparatus and configured to pick up an input sound wave from the environment and convert the input sound wave to an incoming signal. The apparatus also includes a processor, configured to receive the incoming signal and create an output signal. The apparatus also includes a speaker disposed on the apparatus, the speaker configured to produce the output from the processor. The apparatus also includes a battery compartment that comprises three contacts: a first positive contact configured to make electrical

contact with a positive terminal of a battery or battery pack, a second negative contact configured to make electrical contact with a negative terminal of a battery or battery pack, and a third contact configured to facilitate charging of a rechargeable battery pack. The hearing protection device apparatus can be configured to prevent recharging unless there is a contact of a rechargeable battery pack making contact with the third contact. In an embodiment, the hearing protection apparatus can be powered by two standard cylindrical batteries alone, or the hearing protection device can be powered by a rechargeable battery pack alone.

One embodiment of the present disclosure is an apparatus for hearing protection comprising: two ear cups, each ear cup defining a cavity configured to fit a user's ear; a processor, configured to receive an incoming signal and create an output signal; a speaker disposed within at least one of the two ear cups, the speaker configured to produce the output from the processor; wherein one of the two ear cups comprises a battery compartment configured to house one or more batteries or battery packs, wherein the battery compartment further comprises:

a first positive contact configured to make electrical contact with a positive terminal of one of the one or more batteries or battery packs,

a second negative contact configured to make electrical contact with a negative terminal of one of the one or more batteries or battery packs, and

a third contact configured to facilitate charging of a rechargeable battery pack selected from one of the one or more batteries or battery packs; and

wherein the battery compartment defines an open battery-receiving space configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes, wherein the apparatus further comprises a charging port, wherein the charging port is configured to receive a cable for recharging the rechargeable battery pack. In an embodiment, the apparatus is configured to prevent charging to the one or more batteries or battery packs unless there is a contact of a rechargeable battery pack contacting the third contact.

Brief Description of the Drawings

The present disclosure may be more completely understood in connection with the following drawings, in which:

FIG. 1 is a perspective view of the headset, according to an embodiment.

FIG. 2 is a perspective view of the headset, according to an embodiment.

FIG. 3 is a schematic of certain headset components, according to an embodiment.

FIG. 4 is a perspective view of a headset embodiment with a rechargeable battery pack, according to an embodiment.

FIG. 5 is a perspective view of the headset with two standard batteries, according to an embodiment.

FIG. 6 is a perspective view of the empty battery compartment of the headset, according to an embodiment.

FIG. 7 is a schematic diagram of certain elements of a rechargeable battery pack and hearing protector, according to an embodiment.

FIG. 8 is a perspective cut-away view of a rechargeable battery pack of FIG. 7, according to an embodiment.

FIG. 9a is a perspective view of a rechargeable battery pack, according to an embodiment.

FIG. 9b is a perspective view of a rechargeable battery pack, according to an embodiment.

While the present disclosure is susceptible to various modifications and alternative forms, specifics thereof have been shown by way of example and drawings, and will be described in detail. It should be understood, however, that the present disclosure is not limited to the particular embodiments described. On the contrary, the intention is to cover modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure.

Detailed Description

The embodiments of the present disclosure described herein are not intended to be exhaustive or to limit the present disclosure to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art can appreciate and understand the principles and practices of the present disclosure.

All publications and patents mentioned herein are hereby incorporated by reference. The publications and patents disclosed herein are provided solely for their disclosure. Nothing herein is to be construed as an admission that the inventors are not entitled to antedate any publication and/or patent, including any publication and/or patent cited herein.

FIG. 1 is a perspective view of a headset 100. In an embodiment, the headset 100 can include an ear cup 102 and a headband 104. The headset 100 can include two ear cups 102. The headband 104 can couple a first ear cup 102 with a second ear cup 102. The headband 104 can be arced, such as to extend over the top of a user's head while the headset 100 is in use. The headband 104 can be flexible, such as to allow the user to spread the first ear cup 102 from the second ear cup 102 when the user is putting on the headset 100. The headband 104 can include padding, such as to at least partially conform to the user's head and increase the user's comfort.

The ear cups 102 can be configured to fit at least partially around a user's ear, and be disposed on the side of a user's head while in use. The ear cup 102 can define a cavity. The cavity can be configured for a user's ear, a human ear, to fit within the cavity, while the user is wearing the headset 100. The ear cup 102 can include a seal ring 106. The seal ring 106 can be ring shaped, such as to extend around the user's ear. The seal ring 106 can be flexible and able to conform to the user's head. The seal ring 106

can provide a seal between the ear cup 102 and the user's head, such as to reduce the amount of noise or sound waves that reach the user's ear, thereby at least partially protecting the user's ear from external noises. The seal ring 106 can include leather, cloth, rubber, plastic, or a polymer, such as polyurethane.

The headset 100 can include a sound input source 108. In one embodiment, one or both of the ear cups 102 can include a sound input source 108. In an embodiment, the sound input source 108 can comprise a microphone. In an embodiment, there is one microphone 108 on each of two ear cups 102. In an embodiment, there can be more than one microphone 108 on one or both of the ear cups 102. In one embodiment, one or more microphones 108 are located at other locations on the headset 100. The microphone 108 can be disposed on the outside surface of the ear cup 102 opposite the cavity. The microphone 108 can pick up sound and noise from the surrounding environment. The microphone 108 can be inset, such that the microphone 108 does not extend past the outer surface of the ear cup 102. In an embodiment with two ear cups 102, each ear cup 102 can include a microphone 108. In another embodiment with two ear cups 102, only one ear cup 102 includes a microphone 108. In another embodiment with two ear cups 102, one microphone 108 is positioned on a headband portion. The noises and sounds picked up by the microphone 108 can be relayed to the user through a speaker in the cavity of the ear cup 102.

One of the ear cups 102 can include a knob 110. The user can rotate the knob 110 to control the electronics of the headset 100, such as to turn the electronics "ON" or "OFF", or to increase or decrease the volume from the speakers in the ear cups 102.

The ear cups 102 can include an input connection 112. The input connection 112 can allow a user to connect an external audio device into the headset 100, such as an AM/FM radio, a two-way radio, an MP3 player, a cellphone, or the like. The user can hear the external audio device through the one or more speakers disposed in the ear cups 102. In an embodiment, the input connection 112 can accommodate a 3.5 mm audio input. In an embodiment, an external audio device can be connected to the headset 100 through a wireless connection, such as Bluetooth connection. In an embodiment, the headset includes a Bluetooth receiver. In an embodiment, the external audio device can be built in or integral with the headset 100.

A perspective view of the headset 100 is shown in FIG. 2, from a different perspective angle than what is shown in FIG. 1. The ear cups 102 can include a battery compartment 214. The battery compartment 214 can house one or more batteries or battery packs.

As used herein, the term battery means a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. As used herein, the term battery pack means a set of any number of preferably identical batteries, including a single battery. A battery pack may also include other components, such as a temperature sensor or charging circuitry. A battery pack also includes a housing for containing the battery or batteries and other components.

The batteries can be used to power the electronic components of the headset 100. In an embodiment, two AA batteries can be disposed within the battery compartment 214. In an embodiment, the AA batteries can include an alkaline AA battery, a carbon AA battery, a lithium AA battery, a nickel-metal hydride AA battery, or a nickel-cadmium AA battery. In an embodiment, a rechargeable battery pack can be disposed within the battery compartment. In an embodiment, the rechargeable battery pack can use a lithium ion battery. A charging port 215 can be disposed on one or more of the ear cups. In an embodiment, the charging port can be configured to receive a cable for recharging the rechargeable battery pack. In an embodiment, the charging port is disposed on the headset in a location that permits the rechargeable battery pack to be charged while the rechargeable battery pack is inside the battery compartment. In an embodiment, the charging port is disposed on an exterior surface of the ear cup, not within the battery compartment. A battery door 216 can at least partially enclose the battery compartment 214. The battery door 216 can be configured to be removed from the headset 100 when access to the batteries are desired, such as to replace the batteries. In an embodiment, the compartment door can fully enclose the batteries or battery pack within the battery compartment without protruding above the adjacent outer surfaces of ear cup 102. In embodiments, the battery compartment door protrudes no more than 5 millimeters above adjacent outer surfaces of the ear cup when the battery compartment houses the one or more batteries or battery pack and the battery compartment door is closed. The battery compartment door can comprise a hinge. In an embodiment, the battery door 216 is a separate element from the batteries or battery packs. In an embodiment, the battery door is a separate element from the remainder of the headset 100.

Each ear cup 102 can include a speaker 218, shown in FIG. 3. The speaker 218 can produce an output, such as a sound wave. Incoming sound and noise from sound input 108 can be input into a processor 220 and be processed, such as to eliminate at least some of the noise, to produce an output through the speaker 218. As used herein, the term sound refers to desirable audio information while the term noise refers to undesirable audio information. The speaker 218 can provide sound to the user, such as desirable audio. Desirable audio can include conversations, commands, warnings or other communications, such as communications between two people. The input from each microphone can be processed to eliminate at least some of the noise, such as undesirable noises. Undesirable noises can include mechanical noises, noises from ventilation systems, distant conversations, impulse noises, grinding, squeaking, engine noises, gun shots, explosions and the other similar noises.

The headset 100 can include digital electronic components, analog electronic components or a mix of both types.

The speaker 218 can relay sounds from the surrounding environment picked up by the sound input 108. The speaker 218 can relay sounds from an external audio device connected from the input connection 112. The output from the speaker 218 can be limited to a maximum output level, such as to protect the user's ears. In different embodiments, the maximum output level from the speaker 218 due to

sound from the microphone can be at least 80 dB(A), not more than 90 dB(A), at least 70 dB(A), not more than 100 dB(A), and combinations of these constraints. In an embodiment, the output from the speaker 218 is limited to 82 dB(A) when the ambient sound level is less than 106 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 85 dB(A) when the ambient sound level is less than 106 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 82 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 is limited to 85 dB(A), regardless of how high the user has the volume turned up. In an embodiment, the output from the speaker 218 can be limited to 82 dB(A) when an external audio device is connected to the input connection 112. The sounds picked up by the microphone 108 can be processed before they are produced as output from the speaker 218. The processing can increase the quality or clarity of what the user hears, such as by reducing background noise, suppressing impulse noises or keeping an input level constant. In one embodiment where each of two ear cups 102 has a microphone 108, the incoming sound and noise is processed by a single processor. In another embodiment where each of the two ear cups 102 has a microphone 108, the incoming sound and noise is processed by separate processors.

The individual features described herein can be present in various embodiments. Also combinations of the individual features described herein can be present in various embodiments. In an embodiment, a hearing protection apparatus can include a battery compartment that comprises three contacts: a first positive contact configured to make electrical contact with a positive terminal of a battery or battery pack, a second negative contact configured to make electrical contact with a negative terminal of a battery or battery pack, and a third contact configured to facilitate charging of a rechargeable battery pack. The hearing protection device apparatus can be configured to prevent recharging unless there is a contact of a rechargeable battery pack making contact with the third contact. In an embodiment, the hearing protection apparatus can be powered by two standard cylindrical batteries alone, or the hearing protection device can be powered by a rechargeable battery pack alone.

The hearing protection apparatus comprises a battery compartment that is configured to house one or more batteries or battery packs. The user has the option to power the apparatus with either a rechargeable battery pack alone or two standard cylindrical batteries alone as the power source; the battery compartment is configured to secure either power source within the compartment. The ability to use standard cylindrical batteries provides users with a power option that is readily available in commercial outlets and inexpensive to purchase. The ability to use a rechargeable battery pack carries many benefits also, including longer use times and lower operational costs than standard batteries can provide. The ability for the rechargeable battery pack to be recharged by charging circuitry built into the hearing protection apparatus lowers a user's costs by not requiring an external charger unit. In some embodiments, the rechargeable battery pack can be substituted for the standard cylindrical batteries within

the same battery compartment, where the same battery compartment door is able to close over the rechargeable battery pack as over the standard cylindrical batteries.

FIG. 4 and FIG. 5 show embodiments of the apparatus where different types of batteries or battery packs are used to provide power to the apparatus. In FIG. 4, a rechargeable battery pack 222 is disposed in the battery compartment 214. The rechargeable battery pack has contact 225 for its positive terminal that makes contact with positive contact 224 of the battery compartment, and the rechargeable battery pack has a contact 227 for its negative terminal that makes contact with negative contact 226 of the battery compartment. In addition, the rechargeable battery pack also includes a third contact 229 which contacts a third contact 228 of the battery compartment that is configured to facilitate recharging of the rechargeable battery pack. There are many different options for how the third contact can facilitate recharging of the battery pack, as will be described herein. In an embodiment, the third contact 228 in the battery compartment is electrically connected to charging port 215. FIG. 4 also shows compartment door 216 which can fully enclose rechargeable battery pack 222 within the battery compartment.

FIG. 5 shows the battery compartment 214 with two AA batteries 230 used to power the apparatus instead of the rechargeable battery pack. One battery has a contact 225 on one end for a positive terminal that makes contact with positive contact 224 of the battery compartment, and one battery has a contact 227 on one end for a negative terminal that makes contact with negative contact 226 of the battery compartment. Additional positive terminal 226P and negative terminals 224N are disposed on the battery compartment to make contact with the opposite end of each battery. When two AA batteries are used instead of the rechargeable battery pack, there is no contact on either of the AA batteries that makes contact with third contact 228 of the battery compartment. The batteries 230 cannot be recharged in the apparatus because they do not make contact with third contact 228.

FIG. 6 shows a perspective of the battery compartment 214 without any batteries or battery packs inside it. First contact 224, a positive contact configured to make electrical contact with a positive terminal, second contact 226, a negative contact configured to make electrical contact with a negative terminal, and third contact 228 can be seen in the figure. In an embodiment, third contact 228 is configured to make electrical contact with a positive charging contact of a rechargeable battery pack. In an embodiment, third contact 228 is configured to make electrical contact with a negative charging contact of a rechargeable battery pack. In such embodiments, the third contact is electrically connected to a charging port within the housing of the headset or an ear cup of the apparatus. The electrical connection of the third contact with the charging port may be via some circuitry. In an embodiment, the third contact is electrically connected to a charging port, wherein the charging port is located somewhere on the headset, and charging of the rechargeable battery pack occurs through a circuit that includes the third contact 228 and either the first positive contact 224 or the second negative contact 226. In an embodiment, charging to the one or more battery packs occurs through either a circuit that includes the

third contact and the first positive contact and excludes the second negative contact or a circuit that includes the third contact and the second negative contact and excludes the first positive contact.

The third contact 228 can also be connected to other systems or devices for monitoring or protecting the rechargeable battery in the battery pack. In an embodiment, these systems or devices can be in the rechargeable battery pack. In other embodiments, these systems or devices are within the housing of the headset or an ear cup of the apparatus. In an embodiment, portions of these systems or devices are in the rechargeable battery pack and portions of these systems or devices are within the housing of the headset or an ear cup of the device.

In an embodiment, the third contact is configured to make electrical contact with a temperature monitoring device. In such embodiments, the apparatus could prevent current from flowing or issue a warning to the user if the temperature of the battery pack approaches an unsafe level. In one embodiment, the battery pack includes a temperature sensor while the headset includes a temperature monitoring circuit that receives input from the temperature sensor via the third contact.

In embodiments, the third contact 228 can be configured to make contact with an identification device or circuit within the headset and rechargeable battery pack. In such embodiments, the identification circuit is configured to identify if an improper battery type is placed into the compartment and prevent current flow in the apparatus, issue a warning to the user or both. The identification circuit could prevent or allow current flow based on an electrical connection to the third contact of the rechargeable battery pack. Alternatively, or in addition, the identification device could prevent or allow current flow based on a mechanical connection to the third contact of the rechargeable battery pack. In alternative embodiments, such as where a mechanical connection to the third contact provides the indication that the correct rechargeable battery is in the compartment, the identification device could be located entirely within the headset.

The charging port 215 can also be electrically connected to the first positive contact 224 and the second negative contact 226 with the third contact 228 being electrically connected to a device or system that controls the charging circuit, such as an identification device, a monitoring device, or other control device. In such embodiments, charging can only occur if a rechargeable battery pack also has a separate contact that is electrically connected to the third contact 228. In an embodiment, the charging circuit is electrically connected to the first positive contact and the second negative contact, and the third contact is electrically connected to an identification device within the rechargeable battery pack. In an embodiment, the charging port is electrically connected to the first positive contact and the second negative contact, and the charging of the rechargeable battery pack occurs through a circuit that includes the first positive contact and the second negative contact. In an embodiment, the charging circuit is electrically connected to the first positive contact and the second negative contact, the third contact is electrically connected to an identification or a protection device within the rechargeable battery pack, and the charging of the rechargeable battery pack occurs through a circuit that includes the first positive contact and the second

negative contact. In an embodiment, the identification system is located within the rechargeable battery pack. In other embodiments, the identification system or device is located within the housing of the headset or an ear cup of the apparatus. In an embodiment, portions of the identification system are located in the rechargeable battery pack and portions of the identification systems are located within the housing of the headset or an ear cup of the device.

The battery compartment 214 defines an open battery-receiving space wherein the space includes a first region 232 having at least a portion of the first region adjacent to the first positive contact 224, a second region 234 having at least a portion of the second region adjacent to the second negative contact 226, and a third region 236, the third region at least partially overlapping both the first region and the second region; wherein the first, second, and third regions together are configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes. In an embodiment, the third region is wider than double the diameter of the standard cylindrical battery shape. The battery compartment can accommodate the form factors of different batteries or battery packs. First region 232 and second region 234 are cylindrical regions that are defined by portions of the battery compartment that include curved surfaces that can help secure at least a portion of the one or more batteries or rechargeable battery pack against the battery compartment. The curved surfaces may comprise portions of cylindrical shapes that conform to an outside surface of a standard cylindrical battery. In an embodiment, the battery compartment surfaces may define one or more curved surfaces, adjacent to the positive and negative contacts of the battery compartment, that are configured to secure the batteries or battery packs against the compartment. The battery compartment can comprise a bottom surface having at least a first curved surface and a second curved surface, wherein the first curved surface is adjacent to the first positive contact of the battery compartment and the second curved surface is adjacent to the second negative contact of the battery compartment. In embodiments, a bottom surface of the battery compartment may comprise one or more curved surfaces that bound at least a portion of the first and second regions.

In an embodiment, the curved surfaces 239 on the bottom surface of the battery compartment may extend below an adjacent flat section 240 disposed on the bottom surface of the battery compartment. The width of the flat section 240 can vary depending on the desired spacing between the cylindrical batteries. One curved surface is also adjacent to positive contact 224 and the other curved section is also adjacent to negative contact 226. The curved surfaces can extend from 0.5 to 3-mm below the flat section, or 1 to 2 mm below the flat section. In other embodiments, a top surface of the battery compartment may comprise one or more curved surfaces that bound at least a portion of the first and second regions. In an embodiment, the curved surfaces on the top surface of the battery compartment may extend above an adjacent flat section disposed on the top surface of the battery compartment. One curved surface is also adjacent to a positive contact and the other curved surface is also adjacent to a negative contact. The curved surface can extend from 0.5 to 3-mm above the flat section, or 1 to 2 mm above the flat section. In an embodiment, the thickness of the rechargeable battery pack is less than the

diameter of a standard cylindrical battery shape. Though curved surfaces are present in some embodiments, other embodiments do not include any curved surfaces in the battery compartment.

The rechargeable battery pack can comprise a protection monitoring circuit (PMC) which protects the rechargeable battery from different conditions that may occur during use, including overcharging, over discharging, overcurrent, and load short circuiting. In an embodiment, the protection monitoring circuit in the rechargeable battery pack makes electrical contact with the third contact 228 in the battery compartment. In an embodiment, the protection monitoring circuit is configured to make electrical contact with the third contact 229 of the rechargeable battery pack. The PMC can include aspects of the identification circuit and temperature monitoring circuit described herein.

FIG. 7 shows elements of a schematic design for the rechargeable battery pack and headset using a protection monitoring circuit. The rechargeable battery pack 222 comprises a lithium ion cell245 that has a positive terminal 225 connected to contact 224 and a negative terminal 227 connected to contact 226 The rechargeable battery pack also includes third contact 229. When the rechargeable battery is positioned in the battery compartment 214, then the first contact 225, second contact 227 and third contact 229 of the rechargeable battery pack 222 are in contact with the first contact 224, second contact 226 and third contact 226 of the battery compartment 214. The battery compartment 214 is located in one of the ear cups 102, which is electrically connected to the other ear cup 102 by a headband cable. In an embodiment, the rechargeable battery pack 222 includes a charger circuit 254 and a protection monitoring circuit 250. In the embodiment of FIG. 7, the third contact 228 of the battery compartment is electrically connected to the charging port 215 in the opposite ear cup 102 by the headset cable. Additional elements including fuses 251, 252, and 253 and diodes 255 can be included to work in conjunction with the PMC 250 and the charger circuit 254 to provide protection and recharging functions to the rechargeable battery and the headset.

A perspective cut-away view of an embodiment of the rechargeable battery pack is shown in FIG. 8. In FIG. 8, the rechargeable battery pack 222 can include a lithium ion cell 260 and a printed circuit board 270 containing circuitry that is configured to control the charging and protection functions of the battery pack. The circuitry on the printed circuit board 270 can also be configured to control temperature monitoring and identification functions as well. The battery pack includes a top surface 280 and a bottom surface 290. In FIG. 8, the lithium ion battery is positioned towards the top portion of the battery pack. In other embodiments, the lithium ion battery can be positioned towards the bottom portion of the battery pack, from the perspective of FIG. 8. In FIG. 8, the rechargeable battery pack has contact 225 for its positive terminal that makes contact with a positive contact of the battery compartment, and the rechargeable battery pack has a contact 227 for its negative terminal that makes contact with a negative contact of the battery compartment. In addition, the rechargeable battery pack also includes a third contact 229 which contacts a third contact of the battery compartment that is configured to facilitate recharging of the rechargeable battery pack. The third contact may be disposed on the same surface of

the rechargeable battery pack as the contacts for the positive and negative terminals are disposed on, or the third contact may be disposed on a surface that extends from the surface that the contacts for the positive and negative terminals are disposed on. In embodiments, the third contact could be recessed from the contacts for the positive and negative terminals.

Additional features for the shape of the rechargeable battery pack are shown in FIG. 9a and FIG 9b. The shape features of the rechargeable battery pack can be used to secure the rechargeable battery pack inside the battery compartment.

A perspective view of the rechargeable battery pack is shown in FIG. 9a. The rechargeable battery back includes top surface 280, bottom surface 290, curved portions 291 and 292, and sides 300. The top surface 280 is wider than the bottom surface 290, and sides 300 extend past curved portions 291 and 292 in order to accommodate the rechargeable battery positioned towards the top portion of the pack in this embodiment. When installed in the battery compartment, curved portions 291 and 292 are secured against the battery compartment in the first and second regions of the battery compartment so that the rechargeable battery pack stays in place during recharging and use. At least a portion of the bottom surface 290 is also secured against the battery compartment. Portions of the top surface 280 and sides 300 are secured against the battery compartment in the third region. FIG. 9b also shows extensions 310 and 320. In an embodiment, the extension 310 and 320 are configured to secure one or more portions of the rechargeable battery pack against the battery compartment. Extensions can be included on any side or surface of the rechargeable battery pack to help secure the rechargeable battery pack against the battery compartment. Such extensions can be useful when the length, width, and height dimensions of a rechargeable battery in the battery pack are different from the length, width, and height dimensions of standard cylindrical batteries. In an embodiment, extensions protrude from the sides 300 of the battery pack to secure one or more portions of the rechargeable battery pack against the battery compartment. In other embodiments, the extensions can protrude from one or more of the top, bottom, or side surfaces of the rechargeable battery pack.

In an embodiment, at least a portion of the third contact 229 may be disposed on at least a portion of extension 310. The extensions 310 can extend 0.5 to 3 mm from the surfaces or sides of the rechargeable battery pack, more preferably from 1-2 mm.

The apparatus can use different batteries or battery packs as power sources. When standard cylindrical battery shapes are used, the apparatus can operate on AA-sized or AAA-sized batteries. The standard cylindrical batteries can be rechargeable or non-rechargeable batteries. However, in an embodiment, the apparatus will not recharge standard cylindrical rechargeable batteries. A typical AA battery measures 49.2 to 50.5 mm in length, including the button terminal, and 13.5 to 14.5 mm in diameter. The positive terminal button contact can be about 1 mm high and about 5.5 mm in diameter. The flat negative terminal contact can be about 7 mm in diameter. Examples of cylindrical batteries that can be used include alkaline AA batteries, carbon AA batteries, non-rechargeable lithium AA batteries,

rechargeable nickel-metal hydride AA batteries, and rechargeable nickel-cadmium AA batteries. The voltage of the AA batteries that can be used in the apparatus can be between 1 and 2 V, preferably between 1.1 and 1.6 V. When a rechargeable battery pack is used to power the apparatus, the rechargeable battery pack can comprise a rechargeable lithium- ion battery, a lithium-polymer battery, or other rechargeable battery. The voltage provided by the rechargeable battery can be between 2.5 to 5 V, preferably 3 to 4 V.

The rechargeable battery pack can have several different shapes, depending on the desired dimensions of the space defined in the battery compartment. The rechargeable battery pack can have an overall width no more than 38 mm, no more than 42 mm, or no more than 50 mm. The rechargeable battery pack can have an overall width no less than 25 mm, no less than 28 mm, or no less than 35 mm. The rechargeable battery pack can have an overall length no more than 55 mm, no more than 52 mm, or no more than 46 mm. The rechargeable battery pack can have an overall length no less than 35 mm, no less than 40 mm, or no less than 45 mm. The rechargeable battery pack can have an overall thickness no more than 20 mm, no more than 16 mm, or no more than 14 mm. The rechargeable battery pack can have an overall thickness no less than 8 mm, no less than 10 mm, or no less than 15 mm.

It should be noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a composition containing "a compound" includes a mixture of two or more compounds. It should also be noted that the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise.

It should also be noted that, as used in this specification and the appended claims, the phrase “configured” describes a system, apparatus, or other structure that is constructed or configured to perform a particular task or adopt a particular configuration to. The phrase "configured" can be used interchangeably with other similar phrases such as arranged and configured, constructed and arranged, constructed, manufactured and arranged, and the like.

All publications and patent applications in this specification are indicative of the level of ordinary skill in the art to which this present disclosure pertains. All publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated by reference.

The present disclosure has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the present disclosure.

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Claims:

We claim

1. An apparatus for hearing protection, comprising:

two ear cups, each ear cup defining a cavity configured to fit a user's ear;

a processor, configured to receive an incoming signal and create an output signal;

a speaker disposed within at least one of the two ear cups, the speaker configured to produce the output from the processor;

wherein one of the two ear cups comprises a battery compartment configured to house one or more batteries or battery packs, wherein the battery compartment further comprises:

a first positive contact configured to make electrical contact with a positive terminal of one of the one or more batteries or battery packs,

a second negative contact configured to make electrical contact with a negative terminal of one of the one or more batteries or battery packs, and

a third contact configured to facilitate charging of a rechargeable battery pack selected from one of the one or more batteries or battery packs; and

wherein the battery compartment defines an open battery-receiving space configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes,

wherein the apparatus further comprises a charging port, wherein the charging port is configured to receive a cable for recharging the rechargeable battery pack.

2. The apparatus of claim 1 wherein the apparatus is configured to prevent charging to the one or more batteries or battery packs unless there is a contact of a rechargeable battery pack contacting the third contact.

3. The apparatus of claim 2 wherein charging to the one or more batteries or battery packs occurs through either a circuit that includes the third contact and the first positive contact and excludes the second negative contact or a circuit that includes the third contact and the second negative contact and excludes the first positive contact.

4. The apparatus of claim 2 wherein charging to the one or more batteries or battery packs occurs through a circuit that includes the first positive contact and the second negative contact.

5. The apparatus of claim 1 wherein the wherein the battery-receiving space comprises:

a first region having at least a portion of the region adjacent to the first positive contact,

a second region having at least a portion of the region adjacent to the second negative contact, and

a third region, the third region at least partially overlapping both the first region and the second region; and

wherein the first, second, and third regions together are configured to accommodate either a single rechargeable battery pack or two standard cylindrical battery shapes.

6. The apparatus of claim 5, wherein third region has a width wider than double the diameter of the standard cylindrical battery shape.

7. The apparatus of claim 1 wherein the battery compartment further comprises a bottom surface having at least a first curved surface and a second curved surface, wherein the first curved surface is adjacent to the first positive contact of the battery compartment and the second curved surface is adjacent to the second negative contact of the battery compartment.

8. The apparatus of claim 1 wherein the standard cylindrical battery shape is a standard AA battery shape or a standard AAA battery shape.

9. The apparatus of claim 5 wherein the first and second regions of the battery compartment are located closer to the user's head than the third region.

10. The apparatus of claim 5 wherein the third region of the battery compartment is located closer to the user's head than the first and second regions.

11. The apparatus of claim 1 wherein the third contact is configured to make electrical contact with a positive charging contact of a rechargeable battery pack selected from one of the one or more batteries or battery packs.

12. The apparatus of claim 11 wherein the third contact is electrically connected to the charging port.

13. The apparatus of claim 11 further comprising a fuse and a charging device wherein the third contact is electrically connected to the fuse and charging device.

14. The apparatus of claim 1 further comprising a temperature monitoring device wherein the third contact is electrically connected to the temperature monitoring device.

15. The apparatus of claim 1 further comprising an identification device wherein the third contact is configured to make contact with an identification device.

16. The apparatus of claim 1 further comprising the rechargeable battery pack, wherein the rechargeable battery pack comprises a lithium ion cell .

17. The apparatus of claim 1 further comprising a standard cylindrical battery, wherein the standard cylindrical battery comprises an alkaline AA battery, a carbon AA battery, a lithium AA battery, a nickel-metal hydride AA battery, or a nickel-cadmium AA battery.

18. The apparatus of claim 1 wherein the battery compartment is at least partially enclosed by a battery compartment door.

19. The apparatus of claim 18 wherein the battery compartment door protrudes no more than 5 millimeters above adjacent outer surfaces of the ear cup when the battery compartment houses the one or more batteries or battery pack and the battery compartment door is closed.

20. The apparatus of claim 1 further comprising a microphone disposed on the apparatus, the microphone configured to pick up an input sound wave from the environment and convert the input sound wave to an incoming signal.

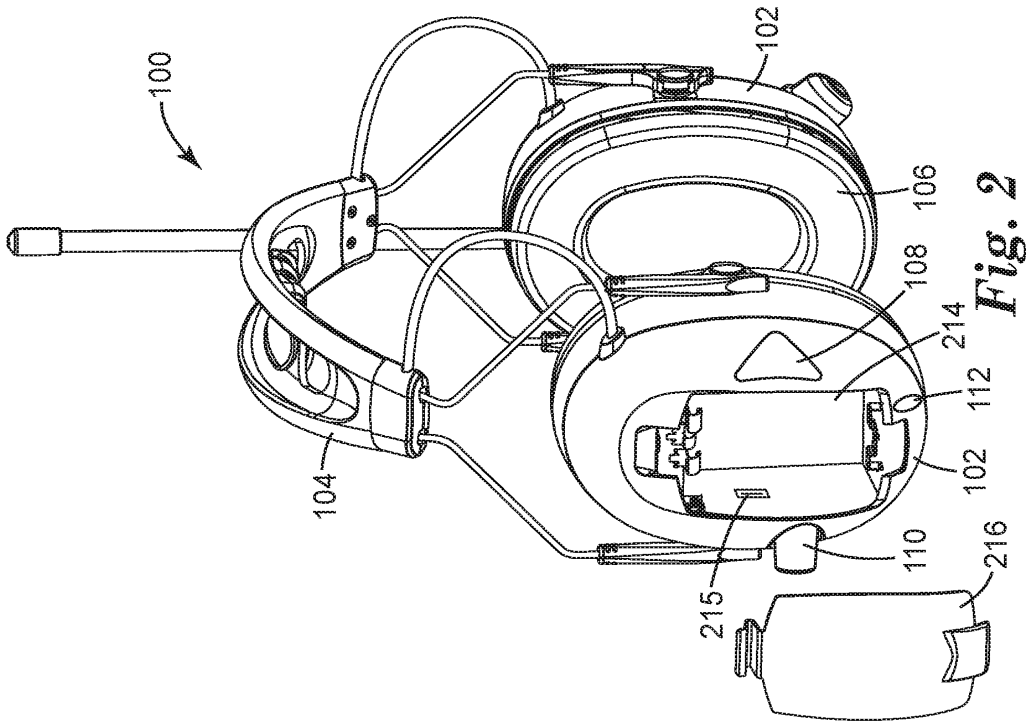

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Fig. 2

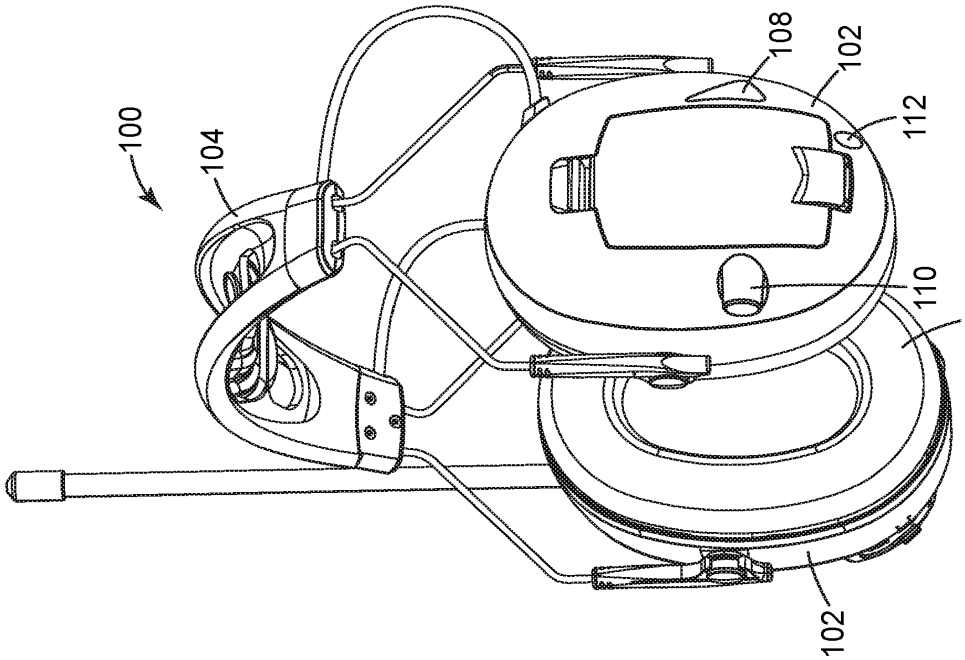

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Fig. 1

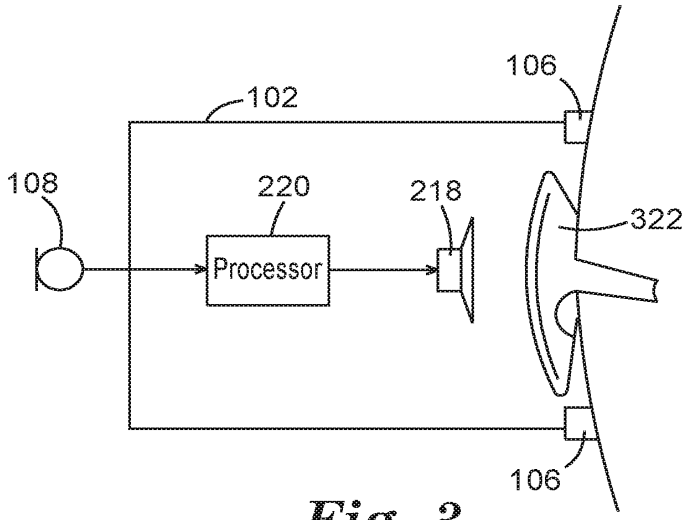

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Fig. 3

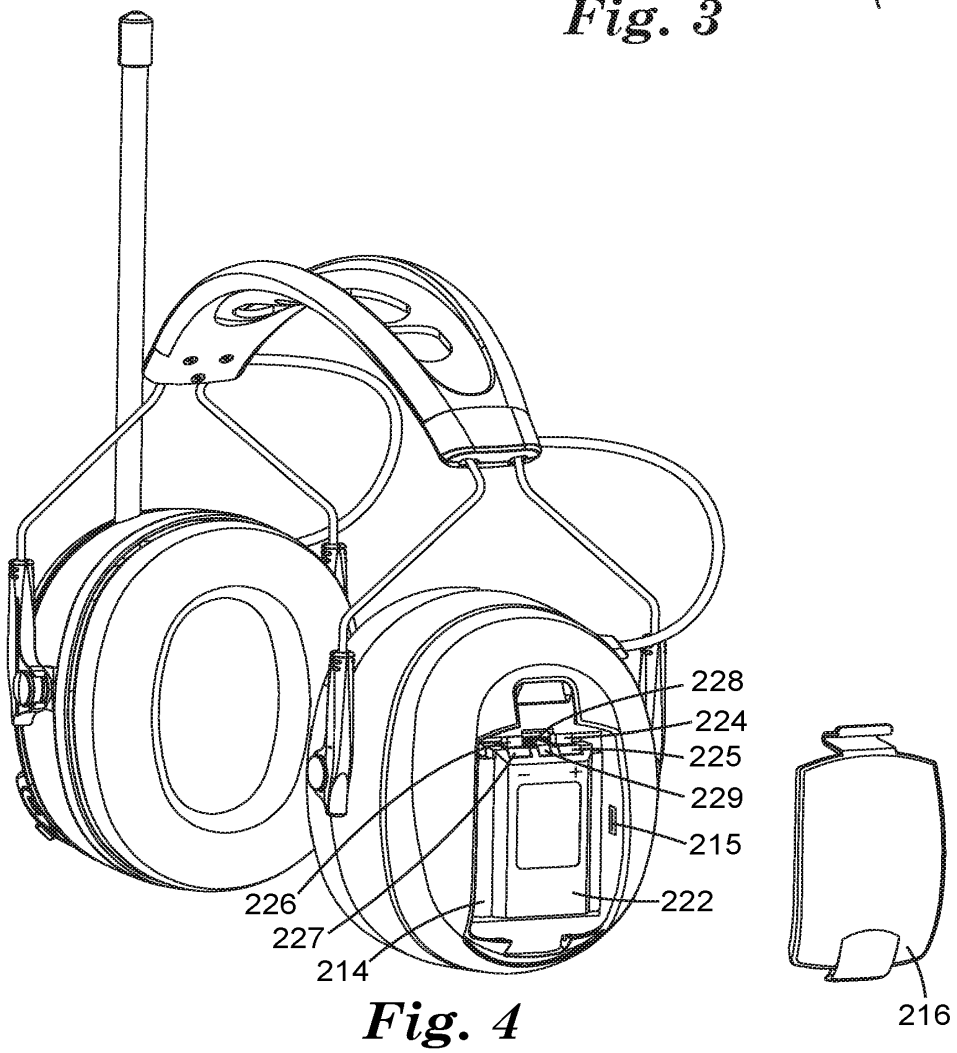

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Fig. 4

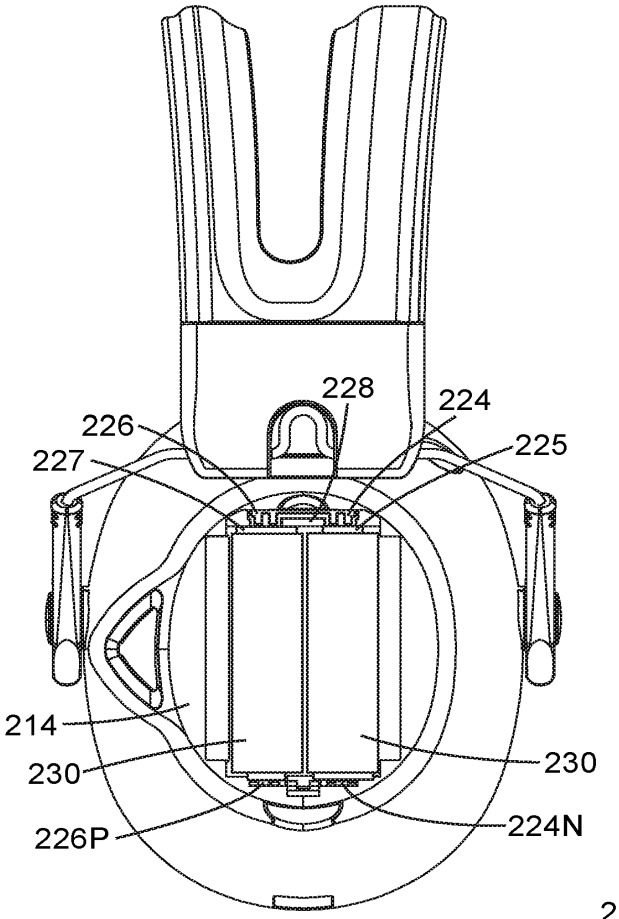

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Fig. 5

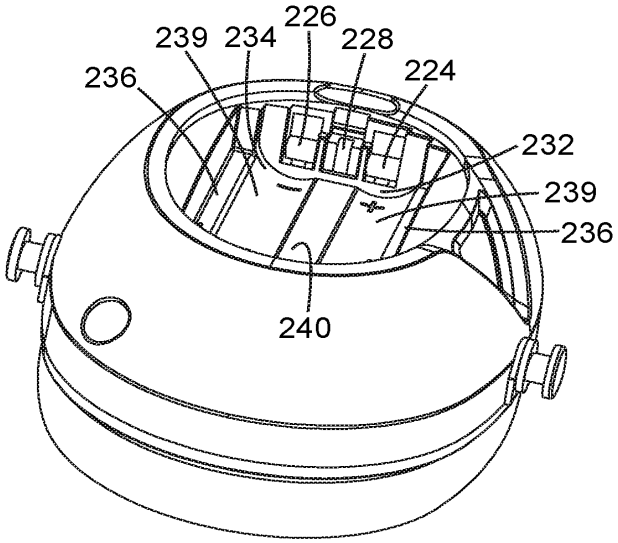

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Fig. 6

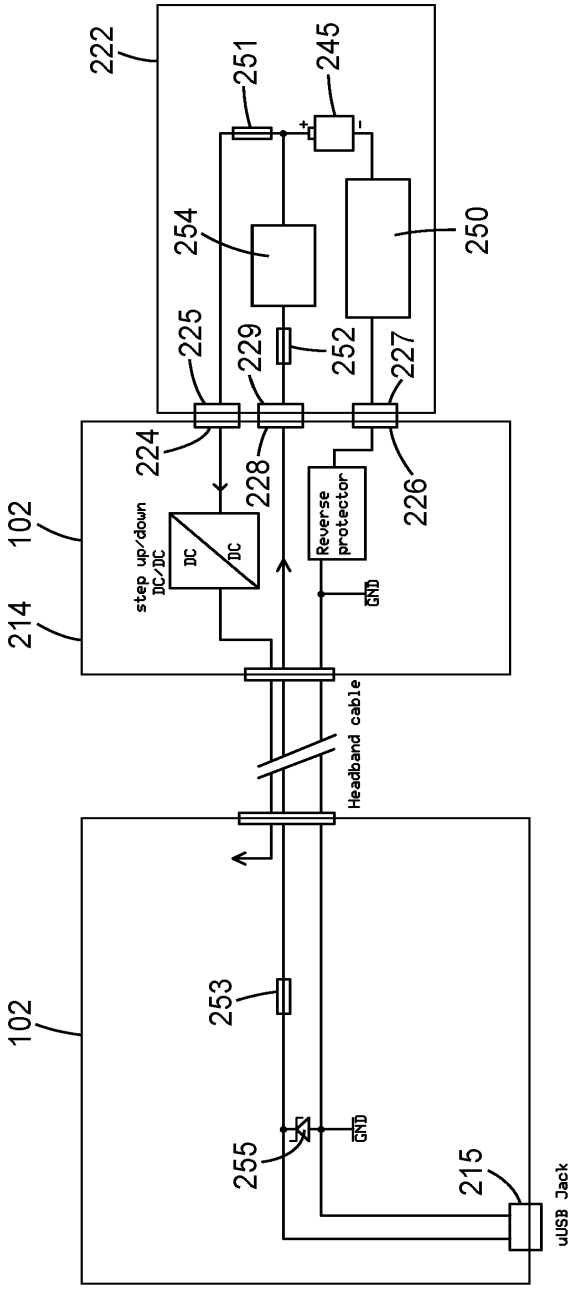

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Reverse protector
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Headband cable
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GND
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uUSB Jack

Fig. 7

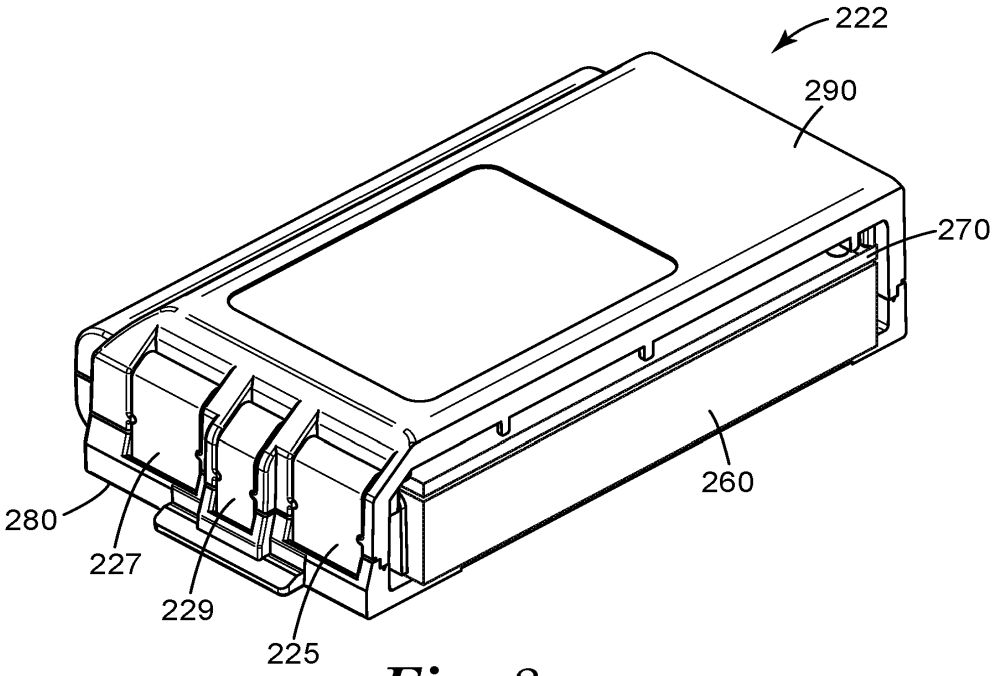


Fig. 8

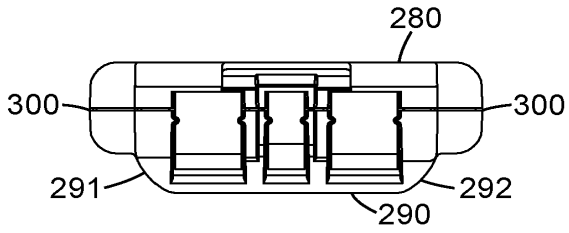


Fig. 9a

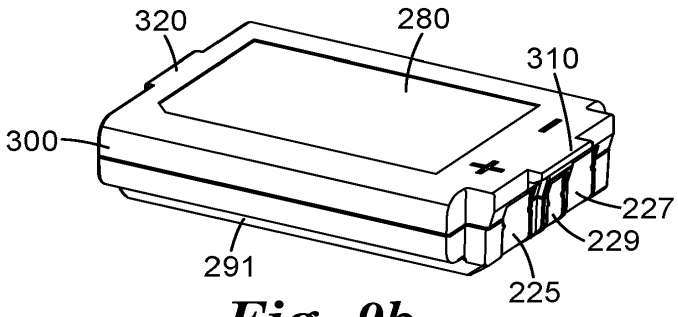


Fig. 9b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/15037

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G10K 11/16; A61F 11/14 (2016.01)
CPC - G10K 11/1788; H04R 1/1091; A61F 11/06
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)
IPC(8): H04R 1/10, 3/00, 5/033, 25/00; G10K 11/16, 11/178, 11/36; A61F 11/06, 11/12, 11/14; A42B 3/16 (2016.01); CPC: H04R 1/1008, 1/033, 1/1091, 5/033, 5/0335, 2201/107; G10K 11/002, 11/16, 11/1788; A61F 11/06, 11/12, 11/14, 2011/145; A42B 3/163

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); EBSCO Discovery Service IP.com; Google Scholar; KEYWORDS: headphone*, headset*, ear*, hearing*, protecti*, batteries*, battery*, housing*, enclosure*, compartment*, *charge*, earcup, terminal*, contact*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0180874 A1 (GAUGER, D et al.) July 31, 2008; abstract; figures 1-7; paragraphs [0001-0003, 0018, 0019, 0028]	1
A	US 7,457,649 B1 (WILSON, J) November 25, 2008; abstract; figures 1-7; column 2, lines 35-44; column 4, lines 28-35 and 45-64; column 5, lines 39-60	1
A	US 2014/0219465 A1 (ZEIKOS, INC.) August 07, 2014; abstract; figure 2; paragraphs [0021, 0032]	1
A	US 2014/0211976 A1 (BEATS ELECTRONICS, LLC.) July 31, 2014; entire document	1-20
A	US 2011/0142249 A1 (SHINOZAKI, R) June 16, 2011; entire document	1-20
A	US 2010/0310093 A1 (SEMEKEN, K) December 09, 2010; entire document	1-20
A	US 2009/0279711 A1 (HERINGSLACK, H) November 12, 2009; entire document	1-20
A	US 2008/0069391 A1 (STEYN, A et al.) March 20, 2008; entire document	1-20

☐ 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	Date of mailing of the international search report
15 March 2016 (15.03.2016)	08 APR 2016

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**08/02/2023 11:29:23 AM ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	62546801	FILING DATE	12/16/2021
CUSTOMER #	142537	FIRST NAMED INVENTOR	Erik Carlson
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Jay Pralle

Documents

TOTAL DOCUMENTS: 6

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2023-08-02-IDS-Letter.pdf	2	Transmittal Letter	99 KB
2023-08-02-SIDS-DocumentList_SB08.pdf	1	Information Disclosure Statement (IDS) Form (SB08)	116 KB
Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
FOR_WO2016126476A1.pdf	23	Foreign Reference	1805 KB
FOR_WO2019037854A1.pdf	36	Foreign Reference	2164 KB
FOR_WO2016036309A1.pdf	42	Foreign Reference	2590 KB

FOR_EP2640170A1.pdf	98	Foreign Reference	6923 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**11/09/2023 09:18:39 AM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	63203402	FILING DATE	12/16/2021
CUSTOMER #	142537	FIRST NAMED INVENTOR	Erik Carlson
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Mark Hollingsworth

Documents

TOTAL DOCUMENTS: 0

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C.

371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES
PATENT AND TRADEMARK OFFICE

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	11/09/2023 09:18:39 AM Z ET	ST0806US1/532.000806US03

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	63203402	AUTHORIZED BY	Mark Hollingsworth
CUSTOMER #	142537	FILING DATE	12/16/2021
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Erik Carlson

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 134895	E2023A9019057031	Margaret Rausch

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
134895	37 CFR 1.16 (National application filing, search, and examination fees); 37 CFR 1.17 (Patent application and reexamination processing fees); 37 CFR 1.19 (Document supply fees); 37 CFR 1.20 (Post Issuance fees); 37 CFR 1.21 (Miscellaneous fees and charges)

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1251	EXTENSION FOR RESPONSE WITHIN FIRST MONTH	220.00	1	220.00
			TOTAL AMOUNT:	$220.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	17/553,716	Attorney Docket No.:	ST0806US1 / 0532.000806US03
Confirmation No.:	1905	Customer No.:	142537
Filing Date:	December 16, 2021	Examiner Name:	George C. Monikang
First Named Inventor:	Erik Carlson	Group Art Unit:	2651
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

AMENDMENT AND RESPONSE

Commissioner for Patents
Mail Stop Amendment
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the non-final Office Action of July 27, 2023, please consider the following.

Amendments to the Claims begin on the page entitled "Amendments to the Claims."

Remarks begin on the page entitled "Remarks."

Authorization is given to charge Deposit Account No. 13-4895 any necessary fees for this filing and all required extension of time fees.

Amendments to the Claims

This listing of claims replaces all prior versions, and listings, of claims in the above-identified application:

Listing of Claims

1. (Original) A system, comprising:

at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact;

an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

2. (Original) The system of claim 1, wherein

the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and

the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

3. (Original) The system of claim 2, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

4. (Original) The system of claim 2, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

5. (Original) The system of claim 1, comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

6. (Original) The system of claim 5, wherein the retention arrangement comprises:

one or more magnets; or

a mechanical retention arrangement.

7. (Original) The system of claim 1 according, wherein:

the first anode contact is configured to communicate power and one or more disparate information signals;

the second anode contact is configured to communicate power and the one or more disparate information signals; and

the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

8. (Original) The system of claim 7, wherein the one or more disparate information signals comprise one or more of:

data signals generated by one or both of the charging module and the hearing device;

audio signals generated by one or both of the charging module and the hearing device; and

signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

9. (Original) The system of claim 1, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

10. (Original) The system of claim 1, wherein:

the first anode contact comprises a plurality of electrode elements; and

the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

11. (Original) The system of claim 10, wherein:

the second anode contact comprises a plurality of electrode elements; and

the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

12. (Original) The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact; and

the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

13. (Original) The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact; and

the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

14. (Original) The system of claim 1 according to any of the preceding claims, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

15. (Currently Amended) The system of claim 1, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0C when a state of charge (SoC) of the rechargeable power source[[s]] is within a predetermined SoC range.

16. (Original) A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact, the first anode contact comprising a plurality of electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole;

a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device; and

a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

17. (Original) The system of claim 16, wherein the first cathode contact is surrounded by the electrode elements of the first anode contact.

18. (Original) The system of claim 16, wherein the electrode elements of the first anode contact are arranged in a substantially triangular pattern.

19. (Original) The system of claim 16, wherein:

the first cathode contact is surrounded by the first electrode elements of the first anode contact; and

the second cathode contact is surrounded by the second electrode elements of the second anode contact.

20. (Original) The system of claim 16, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

21. (Original) The system of claim 16, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

22. (Original) The system of claim 16, wherein the retention arrangement comprises a mechanical retention mechanism configured to:

restrain the second cathode contact at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces; and

release the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism.

23. (Currently Amended) A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising:

a rechargeable power source; and

a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact, the first anode contact comprising a plurality of first

electrode elements configured to communicate power and one or more disparate information signals, the ~~first anode contact comprising a~~ plurality of first electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprising a second cathode contact and a second anode contact, the second anode contact comprising a plurality of second electrode elements configured to communicate power and the one or more disparate information signals; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device;

wherein the first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

Remarks

The non-final Office Action of July 27, 2023 has been received and reviewed. In this Response, claims 15 and 23 are amended to enhance an understating of these claims, no claims are cancelled, and no claims are added. Therefore, claims 1-23 are pending. Applicant respectfully requests that the Examiner reconsider and withdraw the rejections.

The 35 U.S.C. § 102 Rejection

Claims 1, 5-6, and 9-14 are rejected under 35 U.S.C. § 102(a)(1) as being anticipated by Linden (WO 2016036309). Applicant respectfully traverses this rejection.

To anticipate a claim, the asserted reference must clearly and unequivocally disclose every element of the claimed invention. "Because the hallmark of anticipation is prior invention, the prior art reference—in order to anticipate under 35 U.S.C. § 102—must not only disclose all elements of the claim within the four corners of the document, but must also disclose those elements 'arranged as in the claim.'" *Net Moneyin, Inc. v. Verisign, Inc*., 545 F.3d 1359, 1369 (Fed. Cir. 2008) (quoting *Connell v. Sears, Roebuck & Co*., 722 F.2d 1542, 1548 (Fed. Cir. 1983)). "[R]ejections under 35 U.S.C. § 102 are proper only when the claimed subject matter is *identically* disclosed or described in the prior art." *Net Moneyin, Inc.* at 1371 (emphasis added) (quoting *In re Arkley*, 455 F.2d 586 (CCPA 1972)).

Among other features, the hearing device of claim 1 comprises a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The charging module of claim 1 comprises a second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Linden fails to teach at least these features of claim 1.

Applicant's specification teaches that, when placing a hearing device into a charging fixture, it can be advantageous to connect the cathodes prior to connecting the anodes. Connecting the cathodes of the hearing devices and the charging fixture prior to connecting the anodes can serve to provide a consistent inrush current waveform when coupling the hearing devices and charger fixture together. Provision of a consistent inrush current waveform from the charger to the hearing devices informs the charging circuitry of the charger that the hearing devices are properly attached to the proper charging fixture and that a charging procedure can be initiated. Connecting the cathodes of the hearing devices and charger fixture prior to connecting the anodes can serve to establish a ground, which can reduce or minimize spurious electrical spikes in the circuitry. *See* Specification, page 13, lines 6-22.

Linden discloses a storage and charging capsule 20 for recharging a pair of earbuds. As shown in Fig. 4, the capsule 20 includes first charging connector disc 42 comprising a plurality of charging connector elements 44a, 44b, 44c to allow electrical contact with a charging interface of the nearest earbud. The three charging connector elements 44a, 44b, 44c are provided in the form of pogo pins soldered onto the surface of the charging connector disc 42. According to Linden, the resiliency of the foam tips 11 urge the rear end of the earbud 10a towards the resilient tips of the pogo pins 44a, 44b, 44c. As a result, they will reach electric contact with a conductive pattern 17a provided at the rear end of the earbud 10a (Linden, page 6, lines 1-25).

Linden is silent on the order in which the charging connector elements 44a, 44b, 44c make contact with the charging interface of the earbud 10a. Linden clearly fails to teach that the cathode of the charging connector elements 44a, 44b, 44c makes contact with the cathode of the earbud's charging interface prior to establishing contact between the anode of the charging connector elements 44a, 44b, 44c and the anode of the earbud's charging interface. From the teachings on page 6, lines 1-25 of Linden, one of ordinary skill in the art would conclude that the charging connector elements 44a, 44b, 44c make electrical contact with the charging interface of the earbud at the same time. The teaching in Linden that the charging connector elements 44a, 44b, 44c may be pogo pins is not a teaching of an arrangement the provides for connecting a

cathode of a hearing device with a cathode of a charger fixture prior to connecting the respective anodes, as is recited in claim 1.

It is respectfully submitted that Linden has not been shown to disclose each and every element of the subject matter recited in claim 1, and therefore fails to anticipate claim 1. Dependent claims 5-6 and 9-14, which depend from independent claim 1, were also rejected as being anticipated by Linden. While Applicant does not acquiesce to the particular rejections of these dependent claims, it is believed that these rejections are now moot in view of the remarks made in connection with claim 1. These dependent claims include all of the features of claim 1 and any intervening claims, and recite additional features which further distinguish these claims from Linden. Therefore, dependent claims 5-6 and 9-14 are also not anticipated by Linden. Accordingly, Applicant respectfully requests that the anticipation rejection of claims 1, 5-6, and 9-14 be withdrawn.

Concerning the anticipation rejection of claims 5 and 6, these claims recite a retention arrangement (e.g., one or more magnets) configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device. The cited portion of Linden (page 5, lines 22-28) teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26. The magnets described in the cited portion of Linden do not maintain engagement between the charging connector elements 44a, 44b, 44c and the charging interface (conductive pattern 17a) of the earbud 10a during charging. Linden fails to teach magnetic retention of the charging connector elements 44a, 44b, 44c against the charging interface of earbud 10a during charging.

Dependent claim 10 recites a first anode contact of the hearing device which comprises a plurality of electrode elements. A first cathode contact of the hearing device is surrounded by the plurality of electrode elements of the first anode contact. The Office Action, on page 4, contends that the features of claim 10 are taught by Linden's pogo pin contacts (see Fig. 4). Applicant respectfully submits that this contention is in error. Linden's pogo pins are disposed on a charging

connector disc 42 of the charging capsule 20, not the earbud 10a. Notably, the conductive pattern 17a of the earbud 10 shown in Fig. 6 does not include a cathode contact surrounded by a *plurality* of electrode elements of an anode contact. The Office Action has not shown that Linden teaches the features of claim 10.

Dependent claim 11 recites a second anode contact of the charging module which comprises a plurality of electrode elements. A second cathode contact of the charging module is surrounded by the plurality of electrode elements of the second anode contact. The Office Action, on page 4, contends that the features of claim 11 are taught by Linden's pogo pin contacts (see Fig. 4). Applicant respectfully submits that this contention is in error. Linden's pogo pins 44a, 44b, 44c are arranged in a straight line (see Fig. 4). None of the pogo pins shown in Fig. 4 is *surrounded* by other ones of the pogo pins. The Office Action has not shown that Linden teaches the features of claim 11.

Concerning the anticipation rejection of claim 13, the Office Action, on page 4, argues that pogo pin 50c shown in Fig. 4 of Linden is illustrated to be in a rectangular format vis-à-vis the other pogo pins 44. Claim 13, in contrast, recites a triangular pattern of anode contact electrodes relative to a cathode contact. Linden does not teach the triangular pattern of anode contacts recited in claim 13.

The 35 U.S.C. § 103 Rejection

Claims 2-4 and 16-22 are rejected under 35 U.S.C. § 103 as being unpatentable over Linden (WO 2016036309) as applied to claim 1, in view of Shi (U.S. Patent No. 10,798,500). Applicant respectfully traverses this rejection.

Concerning the rejection of claims 2-4, these claims depend from claim 1 which is not obvious in view of the combination of Linden and Shi. As discussed above, Linden fails to teach or suggest an arrangement that facilitates electrical contact between first and second cathode contacts prior to electrical contact between first and second anode contacts, as recited in claim 1. Shi fails to supply the features of claim 1 which are missing in Linden. As such, claims 2-4 are

not obvious in view of the combination of Linden and Shi. "If an independent claim is nonobvious under 35 U.S.C. §103, then any claim depending therefrom is nonobvious." MPEP §2143.03; citing *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988).

Concerning the rejection of claim 16, the Office Action indicates that claim 16 has been analyzed and rejected according to claims 1-2, 5, and 9. Applicant traverses this rejection. As previously argued, Linden fails to teach or suggest an arrangement that facilitates electrical contact between first and second cathode contacts prior to electrical contact between first and second anode contacts. Shi fails to supply the features of claim 16 which are missing in Linden.

The combination of Linden and Shi fails to teach or suggest an anode contact of a hearing device which comprises a plurality of electrode elements each having a curvilinear shape. The conductive pattern 17a shown in Fig. 6 of Linden does not include a plurality of anode electrode elements, and clearly does not include a plurality of anode electrode contacts each having a curvilinear shape. Shi fails to supply this feature of claim 16.

The asserted combination also fails to teach or suggest a retention arrangement configured to maintain engagement between first and second charging interfaces during charging of a rechargeable power source of the hearing device, as is recited in claim 16. Linden, as previously argued, teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26. The magnets described in Linden do not maintain engagement between the charging connector elements 44a, 44b, 44c and the charging interface (conductive pattern 17a) of the earbud 10a during charging. The asserted combination fails to teach or suggest magnetic retention of the charging connector elements 44a, 44b, 44c against the charging interface of earbud 10a during charging.

Because the combination of Linden and Shi fails to teach or suggest all features of claim 16, this claim in not obvious in view of the asserted combination. While Applicant does not acquiesce to the particular rejections of dependent claims 17-22, it is believed that these rejections are now moot in view of the remarks made in connection with claim 16. Claims 17-22 include all of the limitations of base claim 16 and any intervening claims, and recite additional

features which further distinguish these claims from the asserted combination. Therefore, claims 17-22 are also not obvious in view of Linden and Shi. *See* MPEP §2143.03. Accordingly, Applicant respectfully requests that the obviousness rejections of claims 16-22 be withdrawn.

Concerning the rejection of claim 17, the Office Action indicates that this claim has been analyzed and rejected according to claims 1-2, 5, and 9-11. As was previously argued, Linden fails to teach a first cathode contact of a hearing device surrounded by a plurality of electrode elements of a first anode contact. As shown in Fig. 6, the conductive pattern 17a does not include a cathode contact surrounded by a plurality of electrode elements of an anode contact. Shi fails to supply the features of claim 17 missing from Linden.

Regarding the rejection of claim 18, the Office Action indicates that this claim has been analyzed and rejected according to claims 1-2, 5, 9, and 13. As was previously argued, the Office Action argues that pogo pin 50c shown in Fig. 4 of Linden is illustrated to be in a rectangular format vis-à-vis the other pogo pins 44. Claim 18, in contrast, recites a triangular pattern of anode contact electrodes relative to a cathode contact. Linden does not teach the triangular pattern of anode contacts recited in claim 18. Shi fails to supply the features of claim 18 missing from Linden.

According to dependent claim 19, the first cathode contact of the hearing device is surrounded by the first electrode elements of the first anode contact. As previously argued, and as shown in Fig. 6, Linden's conductive pattern 17a does not include a cathode contact surrounded by a plurality of electrode elements of an anode contact. Claim 19 also recites that the second cathode contact of the charging module is surrounded by the second electrode elements of the second anode contact. As previously argued, Linden's pogo pins 44a, 44b, 44c are arranged in a straight line (see Fig. 4). None of the pogo pins shown in Fig. 4 is *surrounded* by other ones of the pogo pins. The Office Action has not shown that Linden teaches the features of claim 19. Shi fails to supply the features of claim 19 missing from Linden.

Concerning the rejection of claims 20 and 21, these claims depend from claim 16 which is nonobvious in view of the combination of Linden and Shi. Claims 20 and 21 include all of the limitations of base claim 16 and recite additional features which further distinguish these claims

from the asserted combination. "If an independent claim is nonobvious under 35 U.S.C. §103, then any claim depending therefrom is nonobvious." *See* MPEP §2143.03; citing *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988).

Regarding the rejection of claim 22, this claim recites a mechanical retention arrangement that restrains the second cathode contact of the charging module at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces, and releases the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism. The Office Action, on page 7, refers to lines 22-28 of page 5 of Linden for purportedly disclosing the features of claim 22. The cited portion Linden teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26.

Applicant submits that the one of ordinary skill in the art would not consider the magnet arrangement of Linden to constitute a *mechanical* retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device. The magnets disclosed in Linden do not operate to *restrain and release* a second cathode contact of a charging unit in the manner specified in claim 22. As discussed above, the first and second magnets of Linden keep the cover part 26 of the capsule 20 safely engaged with the base part 22.

Claims 7-8 and 23 are rejected under 35 U.S.C. § 103 as being unpatentable over Linden as applied to claim 1, in view of Sanford (EP 2640170). Applicant respectfully traverses this rejection.

According to claims 7 and 8, the first and second anode contacts of the hearing device and charging module, respectively, are configured to communicate power and one or more disparate information signals between the charging module and the hearing device. The Office Action acknowledges that Linden is silent on these features of claims 7 and 8. Sanford is relied on for purportedly supplying these features which are missing from Linden. Applicant respectfully submits that this reliance is misplaced.

Sanford discloses a headset 10 which includes a primary housing 11 and an earbud 12 (paragraph [0101], FIG. 1). A connector 16 is provided in the primary housing 11. Notably, the connector 16 is not provided at the earbud 12. The primary housing 11 does not constitute a hearing device configured to be worn at, in or on an ear of a wearer, as is recited in claim 1 from which claims 7 and 8 depend. The earbud 12 (e.g., a hearing device configured to be worn at, in or on an ear of a wearer) does not include a charging interface (see paragraph [0107], FIG. 1). As such, the asserted combination fails to teach or suggest a hearing device comprising a first anode contact of a charging interface configured to communicate power and one or more disparate information signals via a second anode contact of a charging module.

The Office Action contends that it would have been obvious to modify the Linden hearing device such that its positive/negative pogo pin contacts could also transfer data as taught in Sanford along with power for the purpose of obtaining a device that can transfer power as well as data via its connectors. Applicant respectfully submits that this contention is in error. The rationale for modifying the Linden earbud 10a using the teachings of Sanford is deficient, because Linden's positive/negative pogo pins (charging connector elements 44a, 44b, 44c) are components of the storage and charging capsule 20, not the earbud 10a, and Sanford's earbud 12 is devoid of a charging interface. One of ordinary skill in the art would not be motivated to modify the Linden hearing device using the teachings of Sanford in the manner proposed in the Office Action because such modifications would apply to the storage and charging capsule 20, not the earbud 10a.

Because all elements of claims 7 and 8 are not taught or suggested by the combination of Linden and Sanford, and because the requisite motivation to combine reference teachings is missing, claims 7 and 8 are not obvious in view of the asserted combination. Accordingly, Applicant respectfully requests that the obviousness rejection of claims 7 and 8 be withdrawn.

Concerning the rejection of claim 23, Applicant reiterates that the combination of Linden and Sanford fails to teach or suggest a hearing device comprising first electrode elements of a first anode contact and a charging module comprising second electrode elements of a second anode contact, wherein the first and second electrode elements are configured to communicate

power and one or more disparate information signals between the charging module and the hearing device (see discussion regarding claims 7 and 8 above). The asserted combination also fails to teach or suggest a hearing device comprising plurality of anode electrode elements each having a curvilinear shape. The conductive pattern 17a of the earbud 10a shown in Fig. 6 of Linden does not include a plurality of anode electrode elements, and therefore does not include a plurality of anode electrode contacts each having a curvilinear shape. Sanford's earbud 12 is devoid of a charging interface.

Because all elements of claim 23 are not taught or suggested by the combination of Linden and Sanford, and because the requisite motivation to combine reference teachings is missing, claim 23 is not obvious in view of the asserted combination.

Claim 15 is rejected under 35 U.S.C. § 103 as being unpatentable over Linden as applied to claim 1, in view of Collins (U.S. Patent Publication No. 2018/0370522). Applicant respectfully traverses this rejection.

On page 8 of the Office Action, it is acknowledged that Linden fails to disclose charging circuitry configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power source is within a predetermined SoC range. Collins is relied on for teaching this feature of claim 15. Respectfully, Collins fails to disclose this feature of claim 15 which is missing from Linden.

The relied on portion of Collings (paragraph [0005]) fails to teach charging a rechargeable power source (of a hybrid electric vehicle) at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power source is within a predetermined SoC range. Paragraph [0005] of Collins teaches an energy storage system (ESS), such as a battery, that has an instantaneous and maximum state of charge (SoC) limit, and a maximum recharge rate at which SoC can be recovered. Collins fails to disclose an accelerated charge rate above 1.0 C when the SoC of its ESS battery is within a predetermined SoC range. Because the structure of claim 15 performs differently from that in Collins, a finding of obvious design choice or preference is precluded (see *In re Gal*, 980 F.2d 717, 719 (Fed. Cir. 1992) (finding of obvious

design choice precluded when claimed structure and the function it performs are different from the prior art)). Withdrawal of the rejection is respectfully requested.

Summary

Applicant submits that the claims are in condition for allowance and requests notification to that effect. Applicant invites the Examiner to contact the undersigned Applicant's Representative at the telephone number listed below if doing so may advance prosecution of this application.

Respectfully submitted by

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November 9, 2023
Date

/Mark A. Hollingsworth/

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ■ United States application or PCT international application number 17/553,716 filed on December 16, 2021.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Erik Carlson Date (Optional): 8/3/2023

Signature: / Erik Carlson /

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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LEGAL NAME OF INVENTOR

Inventor: Thomas Burns Date (Optional): 8/3/2023

Signature: / Thomas N. Burns /

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LEGAL NAME OF INVENTOR

Inventor: Kyle Olson Date (Optional): 8/2/2023

Signature: /Kyle Olson/

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ■ United States application or PCT international application number 17/553,716 filed on December 16, 2021.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Kent Giswold Date (Optional): 10/13/2023

Signature: / Kent Giswold /

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**11/09/2023 09:08:52 AM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	63203289	FILING DATE	12/16/2021
CUSTOMER #	142537	FIRST NAMED INVENTOR	Erik Carlson
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Mark Hollingsworth

Documents

TOTAL DOCUMENTS: 4

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
2023-11-09-Amendment and Response.pdf		17	-	165 KB
2023-11-09-Amendment and Response-A....pdf	(1-1)	1	Amendment/Request for Reconsideration-After Non-Final Rejection	80 KB
2023-11-09-Amendment and Response-CLM.pdf	(2-7)	6	Claims	109 KB
2023-11-09-Amendment and Response-REM.pdf	(8-17)	10	Applicant Arguments/Remarks Made in an Amendment	148 KB
ST0806US1 -		4	Oath or Declaration filed	496 KB

Declarations.pdf

Warning: The PDF file has been signed with a digital signature and the legal effect of the document will be based on the contents of the file not the digital signature.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
2023-11-09-Amendment and Response.pdf	AAF1CE0562C42E8C95BE3EC51D1D1EFE354C4BE702F73030 FED82A663C085ED02D9B075729B2DAC7769BAE7FFB704C1A 8665F7E4B9F16739303E023A460726D2
2023-11-09-Amendment and Response-A....pdf	0D884F47BC164EF38C1BD5B41E8A54C578E88B05ADD58BCD 0742ECC385702DEC7710E65F7B45782BC831A0CA02DB685F1 4541E00E96EE5F5FDD91D21523A5FF6
2023-11-09-Amendment and Response-CLM.pdf	22463260A0D30C29A0DD3258531005AADC8A510BFBC7A8AC D2300289B55F843F60C59C78BB0D518F45D54A95B28E41111A 5E71350B6AD4C8805E827810C8EC7E
2023-11-09-Amendment and Response-REM.pdf	8A9861BFB1D2DB152DD34B6E746866A73BA0E5CEE266C6EB 82B94EDC6EC8973AA8DB00D6EB7C705086292D3C5C44FF21 438C73B813C65EF01C6D566DF82B78AD
ST0806US1 - Declarations.pdf	73F12CF8FB4E7373E0F1C7074995EA85B8C362B889AA8B95A 1F8E68392F0576D0FD747F4F16B96AECCB8E0A5BD6A9F5372 B60DBD3C34E034B5580DA78A229E12

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage

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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	17/553,716	Attorney Docket No.:	ST0806US1 / 0532.000806US03
Confirmation No.:	1905	Customer No.:	142537
Filing Date:	December 16, 2021	Examiner Name:	George C. Monikang
First Named Inventor:	Erik Carlson	Group Art Unit:	2651
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

AMENDMENT AND RESPONSE

Commissioner for Patents
Mail Stop Amendment
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the non-final Office Action of July 27, 2023, please consider the following.

Amendments to the Claims begin on the page entitled "Amendments to the Claims."

Remarks begin on the page entitled "Remarks."

Authorization is given to charge Deposit Account No. 13-4895 any necessary fees for this filing and all required extension of time fees.

Amendments to the Claims

This listing of claims replaces all prior versions, and listings, of claims in the above-identified application:

Listing of Claims

1. (Original) A system, comprising:

at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact;

an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

2. (Original) The system of claim 1, wherein

the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and

the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

3. (Original) The system of claim 2, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

4. (Original) The system of claim 2, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

5. (Original) The system of claim 1, comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

6. (Original) The system of claim 5, wherein the retention arrangement comprises:

one or more magnets; or

a mechanical retention arrangement.

7. (Original) The system of claim 1 according, wherein:

the first anode contact is configured to communicate power and one or more disparate information signals;

the second anode contact is configured to communicate power and the one or more disparate information signals; and

the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

8. (Original) The system of claim 7, wherein the one or more disparate information signals comprise one or more of:

data signals generated by one or both of the charging module and the hearing device;

audio signals generated by one or both of the charging module and the hearing device; and

signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

9. (Original) The system of claim 1, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

10. (Original) The system of claim 1, wherein:

the first anode contact comprises a plurality of electrode elements; and

the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

11. (Original) The system of claim 10, wherein:

the second anode contact comprises a plurality of electrode elements; and

the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

12. (Original) The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact; and

the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

13. (Original) The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact; and

the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

14. (Original) The system of claim 1 according to any of the preceding claims, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

15. (Currently Amended) The system of claim 1, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0C when a state of charge (SoC) of the rechargeable power source[[s]] is within a predetermined SoC range.

16. (Original) A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact, the first anode contact comprising a plurality of electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole;

a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device; and

a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

17. (Original) The system of claim 16, wherein the first cathode contact is surrounded by the electrode elements of the first anode contact.

18. (Original) The system of claim 16, wherein the electrode elements of the first anode contact are arranged in a substantially triangular pattern.

19. (Original) The system of claim 16, wherein:

the first cathode contact is surrounded by the first electrode elements of the first anode contact; and

the second cathode contact is surrounded by the second electrode elements of the second anode contact.

20. (Original) The system of claim 16, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

21. (Original) The system of claim 16, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

22. (Original) The system of claim 16, wherein the retention arrangement comprises a mechanical retention mechanism configured to:

restrain the second cathode contact at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces; and

release the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism.

23. (Currently Amended) A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising:

a rechargeable power source; and

a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact, the first anode contact comprising a plurality of first

electrode elements configured to communicate power and one or more disparate information signals, the ~~first anode contact comprising a~~ plurality of first electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprising a second cathode contact and a second anode contact, the second anode contact comprising a plurality of second electrode elements configured to communicate power and the one or more disparate information signals; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device;

wherein the first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

Remarks

The non-final Office Action of July 27, 2023 has been received and reviewed. In this Response, claims 15 and 23 are amended to enhance an understating of these claims, no claims are cancelled, and no claims are added. Therefore, claims 1-23 are pending. Applicant respectfully requests that the Examiner reconsider and withdraw the rejections.

The 35 U.S.C. § 102 Rejection

Claims 1, 5-6, and 9-14 are rejected under 35 U.S.C. § 102(a)(1) as being anticipated by Linden (WO 2016036309). Applicant respectfully traverses this rejection.

To anticipate a claim, the asserted reference must clearly and unequivocally disclose every element of the claimed invention. "Because the hallmark of anticipation is prior invention, the prior art reference—in order to anticipate under 35 U.S.C. § 102—must not only disclose all elements of the claim within the four corners of the document, but must also disclose those elements 'arranged as in the claim.'" *Net Moneyin, Inc. v. Verisign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008) (quoting *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983)). "[R]ejections under 35 U.S.C. § 102 are proper only when the claimed subject matter is *identically* disclosed or described in the prior art." *Net Moneyin, Inc.* at 1371 (emphasis added) (quoting *In re Arkley*, 455 F.2d 586 (CCPA 1972)).

Among other features, the hearing device of claim 1 comprises a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The charging module of claim 1 comprises a second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Linden fails to teach at least these features of claim 1.

Applicant's specification teaches that, when placing a hearing device into a charging fixture, it can be advantageous to connect the cathodes prior to connecting the anodes. Connecting the cathodes of the hearing devices and the charging fixture prior to connecting the anodes can serve to provide a consistent inrush current waveform when coupling the hearing devices and charger fixture together. Provision of a consistent inrush current waveform from the charger to the hearing devices informs the charging circuitry of the charger that the hearing devices are properly attached to the proper charging fixture and that a charging procedure can be initiated. Connecting the cathodes of the hearing devices and charger fixture prior to connecting the anodes can serve to establish a ground, which can reduce or minimize spurious electrical spikes in the circuitry. *See* Specification, page 13, lines 6-22.

Linden discloses a storage and charging capsule 20 for recharging a pair of earbuds. As shown in Fig. 4, the capsule 20 includes first charging connector disc 42 comprising a plurality of charging connector elements 44a, 44b, 44c to allow electrical contact with a charging interface of the nearest earbud. The three charging connector elements 44a, 44b, 44c are provided in the form of pogo pins soldered onto the surface of the charging connector disc 42. According to Linden, the resiliency of the foam tips 11 urge the rear end of the earbud 10a towards the resilient tips of the pogo pins 44a, 44b, 44c. As a result, they will reach electric contact with a conductive pattern 17a provided at the rear end of the earbud 10a (Linden, page 6, lines 1-25).

Linden is silent on the order in which the charging connector elements 44a, 44b, 44c make contact with the charging interface of the earbud 10a. Linden clearly fails to teach that the cathode of the charging connector elements 44a, 44b, 44c makes contact with the cathode of the earbud's charging interface prior to establishing contact between the anode of the charging connector elements 44a, 44b, 44c and the anode of the earbud's charging interface. From the teachings on page 6, lines 1-25 of Linden, one of ordinary skill in the art would conclude that the charging connector elements 44a, 44b, 44c make electrical contact with the charging interface of the earbud at the same time. The teaching in Linden that the charging connector elements 44a, 44b, 44c may be pogo pins is not a teaching of an arrangement the provides for connecting a

cathode of a hearing device with a cathode of a charger fixture prior to connecting the respective anodes, as is recited in claim 1.

It is respectfully submitted that Linden has not been shown to disclose each and every element of the subject matter recited in claim 1, and therefore fails to anticipate claim 1. Dependent claims 5-6 and 9-14, which depend from independent claim 1, were also rejected as being anticipated by Linden. While Applicant does not acquiesce to the particular rejections of these dependent claims, it is believed that these rejections are now moot in view of the remarks made in connection with claim 1. These dependent claims include all of the features of claim 1 and any intervening claims, and recite additional features which further distinguish these claims from Linden. Therefore, dependent claims 5-6 and 9-14 are also not anticipated by Linden. Accordingly, Applicant respectfully requests that the anticipation rejection of claims 1, 5-6, and 9-14 be withdrawn.

Concerning the anticipation rejection of claims 5 and 6, these claims recite a retention arrangement (e.g., one or more magnets) configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device. The cited portion of Linden (page 5, lines 22-28) teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26. The magnets described in the cited portion of Linden do not maintain engagement between the charging connector elements 44a, 44b, 44c and the charging interface (conductive pattern 17a) of the earbud 10a during charging. Linden fails to teach magnetic retention of the charging connector elements 44a, 44b, 44c against the charging interface of earbud 10a during charging.

Dependent claim 10 recites a first anode contact of the hearing device which comprises a plurality of electrode elements. A first cathode contact of the hearing device is surrounded by the plurality of electrode elements of the first anode contact. The Office Action, on page 4, contends that the features of claim 10 are taught by Linden's pogo pin contacts (see Fig. 4). Applicant respectfully submits that this contention is in error. Linden's pogo pins are disposed on a charging

connector disc 42 of the charging capsule 20, not the earbud 10a. Notably, the conductive pattern 17a of the earbud 10 shown in Fig. 6 does not include a cathode contact surrounded by a *plurality* of electrode elements of an anode contact. The Office Action has not shown that Linden teaches the features of claim 10.

Dependent claim 11 recites a second anode contact of the charging module which comprises a plurality of electrode elements. A second cathode contact of the charging module is surrounded by the plurality of electrode elements of the second anode contact. The Office Action, on page 4, contends that the features of claim 11 are taught by Linden's pogo pin contacts (see Fig. 4). Applicant respectfully submits that this contention is in error. Linden's pogo pins 44a, 44b, 44c are arranged in a straight line (see Fig. 4). None of the pogo pins shown in Fig. 4 is *surrounded* by other ones of the pogo pins. The Office Action has not shown that Linden teaches the features of claim 11.

Concerning the anticipation rejection of claim 13, the Office Action, on page 4, argues that pogo pin 50c shown in Fig. 4 of Linden is illustrated to be in a rectangular format vis-à-vis the other pogo pins 44. Claim 13, in contrast, recites a triangular pattern of anode contact electrodes relative to a cathode contact. Linden does not teach the triangular pattern of anode contacts recited in claim 13.

The 35 U.S.C. § 103 Rejection

Claims 2-4 and 16-22 are rejected under 35 U.S.C. § 103 as being unpatentable over Linden (WO 2016036309) as applied to claim 1, in view of Shi (U.S. Patent No. 10,798,500). Applicant respectfully traverses this rejection.

Concerning the rejection of claims 2-4, these claims depend from claim 1 which is not obvious in view of the combination of Linden and Shi. As discussed above, Linden fails to teach or suggest an arrangement that facilitates electrical contact between first and second cathode contacts prior to electrical contact between first and second anode contacts, as recited in claim 1. Shi fails to supply the features of claim 1 which are missing in Linden. As such, claims 2-4 are

not obvious in view of the combination of Linden and Shi. "If an independent claim is nonobvious under 35 U.S.C. §103, then any claim depending therefrom is nonobvious." MPEP §2143.03; citing *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988).

Concerning the rejection of claim 16, the Office Action indicates that claim 16 has been analyzed and rejected according to claims 1-2, 5, and 9. Applicant traverses this rejection. As previously argued, Linden fails to teach or suggest an arrangement that facilitates electrical contact between first and second cathode contacts prior to electrical contact between first and second anode contacts. Shi fails to supply the features of claim 16 which are missing in Linden.

The combination of Linden and Shi fails to teach or suggest an anode contact of a hearing device which comprises a plurality of electrode elements each having a curvilinear shape. The conductive pattern 17a shown in Fig. 6 of Linden does not include a plurality of anode electrode elements, and clearly does not include a plurality of anode electrode contacts each having a curvilinear shape. Shi fails to supply this feature of claim 16.

The asserted combination also fails to teach or suggest a retention arrangement configured to maintain engagement between first and second charging interfaces during charging of a rechargeable power source of the hearing device, as is recited in claim 16. Linden, as previously argued, teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26. The magnets described in Linden do not maintain engagement between the charging connector elements 44a, 44b, 44c and the charging interface (conductive pattern 17a) of the earbud 10a during charging. The asserted combination fails to teach or suggest magnetic retention of the charging connector elements 44a, 44b, 44c against the charging interface of earbud 10a during charging.

Because the combination of Linden and Shi fails to teach or suggest all features of claim 16, this claim in not obvious in view of the asserted combination. While Applicant does not acquiesce to the particular rejections of dependent claims 17-22, it is believed that these rejections are now moot in view of the remarks made in connection with claim 16. Claims 17-22 include all of the limitations of base claim 16 and any intervening claims, and recite additional

features which further distinguish these claims from the asserted combination. Therefore, claims 17-22 are also not obvious in view of Linden and Shi. *See* MPEP §2143.03. Accordingly, Applicant respectfully requests that the obviousness rejections of claims 16-22 be withdrawn.

Concerning the rejection of claim 17, the Office Action indicates that this claim has been analyzed and rejected according to claims 1-2, 5, and 9-11. As was previously argued, Linden fails to teach a first cathode contact of a hearing device surrounded by a plurality of electrode elements of a first anode contact. As shown in Fig. 6, the conductive pattern 17a does not include a cathode contact surrounded by a plurality of electrode elements of an anode contact. Shi fails to supply the features of claim 17 missing from Linden.

Regarding the rejection of claim 18, the Office Action indicates that this claim has been analyzed and rejected according to claims 1-2, 5, 9, and 13. As was previously argued, the Office Action argues that pogo pin 50c shown in Fig. 4 of Linden is illustrated to be in a rectangular format vis-à-vis the other pogo pins 44. Claim 18, in contrast, recites a triangular pattern of anode contact electrodes relative to a cathode contact. Linden does not teach the triangular pattern of anode contacts recited in claim 18. Shi fails to supply the features of claim 18 missing from Linden.

According to dependent claim 19, the first cathode contact of the hearing device is surrounded by the first electrode elements of the first anode contact. As previously argued, and as shown in Fig. 6, Linden's conductive pattern 17a does not include a cathode contact surrounded by a plurality of electrode elements of an anode contact. Claim 19 also recites that the second cathode contact of the charging module is surrounded by the second electrode elements of the second anode contact. As previously argued, Linden's pogo pins 44a, 44b, 44c are arranged in a straight line (see Fig. 4). None of the pogo pins shown in Fig. 4 is *surrounded* by other ones of the pogo pins. The Office Action has not shown that Linden teaches the features of claim 19. Shi fails to supply the features of claim 19 missing from Linden.

Concerning the rejection of claims 20 and 21, these claims depend from claim 16 which is nonobvious in view of the combination of Linden and Shi. Claims 20 and 21 include all of the limitations of base claim 16 and recite additional features which further distinguish these claims

from the asserted combination. "If an independent claim is nonobvious under 35 U.S.C. §103, then any claim depending therefrom is nonobvious." *See* MPEP §2143.03; citing *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988).

Regarding the rejection of claim 22, this claim recites a mechanical retention arrangement that restrains the second cathode contact of the charging module at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces, and releases the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism. The Office Action, on page 7, refers to lines 22-28 of page 5 of Linden for purportedly disclosing the features of claim 22. The cited portion Linden teaches first and second magnets that keep the cover part 26 of the capsule 20 safely engaged with the base part 22. The first and second magnets urge the cover part 26 against the base part 22 to prevent accidental retraction of the cover part 26.

Applicant submits that the one of ordinary skill in the art would not consider the magnet arrangement of Linden to constitute a *mechanical* retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device. The magnets disclosed in Linden do not operate to *restrain and release* a second cathode contact of a charging unit in the manner specified in claim 22. As discussed above, the first and second magnets of Linden keep the cover part 26 of the capsule 20 safely engaged with the base part 22.

Claims 7-8 and 23 are rejected under 35 U.S.C. § 103 as being unpatentable over Linden as applied to claim 1, in view of Sanford (EP 2640170). Applicant respectfully traverses this rejection.

According to claims 7 and 8, the first and second anode contacts of the hearing device and charging module, respectively, are configured to communicate power and one or more disparate information signals between the charging module and the hearing device. The Office Action acknowledges that Linden is silent on these features of claims 7 and 8. Sanford is relied on for purportedly supplying these features which are missing from Linden. Applicant respectfully submits that this reliance is misplaced.

Sanford discloses a headset 10 which includes a primary housing 11 and an earbud 12 (paragraph [0101], FIG. 1). A connector 16 is provided in the primary housing 11. Notably, the connector 16 is not provided at the earbud 12. The primary housing 11 does not constitute a hearing device configured to be worn at, in or on an ear of a wearer, as is recited in claim 1 from which claims 7 and 8 depend. The earbud 12 (e.g., a hearing device configured to be worn at, in or on an ear of a wearer) does not include a charging interface (see paragraph [0107], FIG. 1). As such, the asserted combination fails to teach or suggest a hearing device comprising a first anode contact of a charging interface configured to communicate power and one or more disparate information signals via a second anode contact of a charging module.

The Office Action contends that it would have been obvious to modify the Linden hearing device such that its positive/negative pogo pin contacts could also transfer data as taught in Sanford along with power for the purpose of obtaining a device that can transfer power as well as data via its connectors. Applicant respectfully submits that this contention is in error. The rationale for modifying the Linden earbud 10a using the teachings of Sanford is deficient, because Linden's positive/negative pogo pins (charging connector elements 44a, 44b, 44c) are components of the storage and charging capsule 20, not the earbud 10a, and Sanford's earbud 12 is devoid of a charging interface. One of ordinary skill in the art would not be motivated to modify the Linden hearing device using the teachings of Sanford in the manner proposed in the Office Action because such modifications would apply to the storage and charging capsule 20, not the earbud 10a.

Because all elements of claims 7 and 8 are not taught or suggested by the combination of Linden and Sanford, and because the requisite motivation to combine reference teachings is missing, claims 7 and 8 are not obvious in view of the asserted combination. Accordingly, Applicant respectfully requests that the obviousness rejection of claims 7 and 8 be withdrawn.

Concerning the rejection of claim 23, Applicant reiterates that the combination of Linden and Sanford fails to teach or suggest a hearing device comprising first electrode elements of a first anode contact and a charging module comprising second electrode elements of a second anode contact, wherein the first and second electrode elements are configured to communicate

power and one or more disparate information signals between the charging module and the hearing device (see discussion regarding claims 7 and 8 above). The asserted combination also fails to teach or suggest a hearing device comprising plurality of anode electrode elements each having a curvilinear shape. The conductive pattern 17a of the earbud 10a shown in Fig. 6 of Linden does not include a plurality of anode electrode elements, and therefore does not include a plurality of anode electrode contacts each having a curvilinear shape. Sanford's earbud 12 is devoid of a charging interface.

Because all elements of claim 23 are not taught or suggested by the combination of Linden and Sanford, and because the requisite motivation to combine reference teachings is missing, claim 23 is not obvious in view of the asserted combination.

Claim 15 is rejected under 35 U.S.C. § 103 as being unpatentable over Linden as applied to claim 1, in view of Collins (U.S. Patent Publication No. 2018/0370522). Applicant respectfully traverses this rejection.

On page 8 of the Office Action, it is acknowledged that Linden fails to disclose charging circuitry configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power source is within a predetermined SoC range. Collins is relied on for teaching this feature of claim 15. Respectfully, Collins fails to disclose this feature of claim 15 which is missing from Linden.

The relied on portion of Collings (paragraph [0005]) fails to teach charging a rechargeable power source (of a hybrid electric vehicle) at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power source is within a predetermined SoC range. Paragraph [0005] of Collins teaches an energy storage system (ESS), such as a battery, that has an instantaneous and maximum state of charge (SoC) limit, and a maximum recharge rate at which SoC can be recovered. Collins fails to disclose an accelerated charge rate above 1.0 C when the SoC of its ESS battery is within a predetermined SoC range. Because the structure of claim 15 performs differently from that in Collins, a finding of obvious design choice or preference is precluded (see *In re Gal*, 980 F.2d 717, 719 (Fed. Cir. 1992) (finding of obvious

design choice precluded when claimed structure and the function it performs are different from the prior art)). Withdrawal of the rejection is respectfully requested.

Summary

Applicant submits that the claims are in condition for allowance and requests notification to that effect. Applicant invites the Examiner to contact the undersigned Applicant's Representative at the telephone number listed below if doing so may advance prosecution of this application.

Respectfully submitted by

Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
Phone: (612) 305-1220
Facsimile: (612) 305-1228

November 9, 2023
Date

/Mark A. Hollingsworth/
Mark A. Hollingsworth
Reg. No. 38,491
Direct Dial: 612-767-5000

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/553,716	Filing Date 12/16/2021	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $480 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	11/09/2023	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 23	Minus	** 23	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $480 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ANGELA S WHITE/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

142537 7590 01/31/2024

MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

EXAMINER	
MONIKANG, GEORGE C	
ART UNIT	PAPER NUMBER
2692	

DATE MAILED: 01/31/2024

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

TITLE OF INVENTION: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	04/30/2024

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 11/23)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

142537 7590 01/31/2024
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

TITLE OF INVENTION: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	04/30/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
MONIKANG, GEORGE C	2692	381-323000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

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Page 594

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

142537 7590 01/31/2024

MRG/HD - Starkey
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111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

EXAMINER	
MONIKANG, GEORGE C	
ART UNIT	PAPER NUMBER
2692	

DATE MAILED: 01/31/2024

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 11/23)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).
https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to:

1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
2) a federal, state, local, or international agency, in response to its request;
3) a contractor of the USPTO having need for the information in order to perform a contract;
4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
8) another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c));
9) the Office of Personnel Management (OPM) for personnel research purposes; and
10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	Application No. 17/553,716	Applicant(s) Carlson et al.	
	Examiner GEORGE C MONIKANG	Art Unit 2692	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 11/9/2023.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-23 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/GEORGE C MONIKANG/
Primary Examiner, Art Unit 2692

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Allowable Subject Matter

Claims 1-23 are allowed.

The following is an examiner's statement of reasons for allowance:

Claim 1 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 8-10.

Claims 2-15 depend on claim 1.

Claim 16 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 8-10 & 12.

Claims 17-22 depend on claim 16.

Claim 23 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 15-16.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Contact

Any inquiry concerning this communication or earlier communications from the examiner should be directed to GEORGE C MONIKANG whose telephone number is (571)270-1190. The examiner can normally be reached Mon. - Fri., 9AM-5PM, ALT. Fridays off.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carolyn R. Edwards can be reached on 571-270-7136. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GEORGE C MONIKANG/
Primary Examiner, Art Unit 2692 1/19/2024

Notice of References Cited	Application/Control No. 17/553,716	Applicant(s)/Patent Under Reexamination Carlson et al.	
	Examiner GEORGE C MONIKANG	Art Unit 2692	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-10798500-B1	2020-10-06	Shi; Yiquan	H04R25/02	1/1
*	B	US-20180370522-A1	2018-12-27	COLLINS; Patrick Gordon	B60W10/08	1/1
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

CPC						
Symbol					**Type**	**Version**
H04R	/	1	/	1025	F	2013-01-01
H01M	/	10	/	46	I	2013-01-01
H04R	/	25	/	602	I	2013-01-01
H04R	/	2225	/	57	A	2019-05-01
H04R	/	2225	/	31	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	19 January 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240119

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04R	/	1	/	1025
H01M	/	10	/	46
H04R	/	25	/	602
H04R	/	2225	/	31

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
381	323

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					
381	322	312				

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	19 January 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240119

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11		20										
	3		12		21										
	4		13		22										
	5		14		23										
	6		15												
	7		16												
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	19 January 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240119

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2692

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04R1/1025; H01M10/46; H04R25/602; H04R2225/31	07/21/2023	GM
H04R1/1025; H01M10/46; H04R25/602; H04R2225/31	01/19/2024	GM

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**
381	312, 322, 323	07/21/2023	GM
381	312, 322, 323	01/19/2024	GM

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
No double patenting issues. Inventor search completed in EAST.	07/21/2023	GM

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	Interference search completed in EAST.	01/19/2024	GM
	Same class/subclass as above.	01/19/2024	GM

/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	1/19/2024

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2692

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/21/2023	01/19/2024							
	1	✓	=							
	2	✓	=							
	3	✓	=							
	4	✓	=							
	5	✓	=							
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	21	✓	=							
	22	✓	=							
	23	✓	=							

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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BIB DATA SHEET

CONFIRMATION NO. 1905

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
17/553,716	12/16/2021 RULE	381	2692	ST0806US1/532.000806US03

APPLICANTS
Starkey Laboratories, Inc., Eden Prairie, MN;

INVENTORS
Erik Carlson, Stillwater, MN;
Thomas Burns, Minneapolis, MN;
Kyle Olson, St. Louis Park, MN;
Kent Giswold, Minnetonka, MN;

**** CONTINUING DATA ***************************
This application is a CON of PCT/US2020/041956 07/14/2020
which claims benefit of 62/876,454 07/19/2019
and claims benefit of 62/943,375 12/04/2019

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
12/29/2021

Foreign Priority claimed	❑ Yes ☑ No		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	❑ Yes ☑ No	❑ Met after Allowance	MN	15	23	3
Verified and Acknowledged	/GEORGE C MONIKANG/ Examiner's Signature	GM Initials				

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c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
UNITED STATES

TITLE
SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

FILING FEE RECEIVED		
0.00	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

BIB (Rev. 05/07).

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application Number:	17/553,716
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Art Unit:	2651
	Examiner Name:	George C. Monikang
	Attorney Docket No.:	ST0806US1 / 0532.000806US03
Sheet 1 of 1	**IDS filed on:**	*August 02, 2023*

U.S. PATENTS

Examiner Initial	Patent Number (Number - Kind Code)	Issue Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
/G.C.M/	D397796 S	09-01-1998	Yabe	
/G.C.M/	D554756 S1	11-06-2007	Sjursen	
/G.C.M/	D611606 S1	03-09-2010	Vaterlaus	
/G.C.M/	D728107 S1	04-28-2015	Torres Martin	
/G.C.M/	D857650 S	08-27-2019	Hardi	
/G.C.M/	D895806 S1	09-08-2020	Zheng	
/G.C.M/	D896969 S1	09-22-2020	Yu	
/G.C.M/	D924207 S1	07-06-2021	Li	
/G.C.M/	D941475 S1	01-18-2022	Burns	

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial	Publication Number (Number - Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
/G.C.M/	20160353216 A1	12-01-2016	Ruzicka	

U.S. PATENT APPLICATIONS BY SERIAL NUMBER

Examiner Initial	Copy Enclosed	Document Number (Number - Kind Code)	Filing Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
		None			

FOREIGN PATENT DOCUMENTS

Examiner Initial	Copy Enclosed	Country Code	Foreign Document Number	Kind Code	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments	translation yes	translation no
/G.C.M/		EP	2640170	A1	09-18-2013	Sanford			
/G.C.M/		WO	2016/036309	A1	03-10-2016	Lindén			
/G.C.M/		WO	2016/126476	A1	08-11-2016	Fletcher			
/G.C.M/		WO	2019/037854	A1	02-28-2019	Baltensperger			

Examiner Signature	/GEORGE C MONIKANG/	Date Considered	01/19/2024

***EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.**

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1	"17553716"	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 03:50 PM
L2	1	(hearing SAME aid SAME charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L3	576	(charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L4	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L5	0	(charg$8 SAME pogo SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L6	0	(charg$8 SAME pogo SAME positive SAME negative) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L7	6	(charg$8 SAME pogo SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:14 PM
L8	69	(charg$8 SAME pogo SAME positive SAME negative)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:19 PM
L9	1	(charg$8 SAME pogo SAME positive SAME negative SAME hearing)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:20 PM
L10	0	(charg$8 SAME pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:20 PM
L11	75	(pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
L12	0	(pogo SAME pin$1 SAME triang$6) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
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		recharg$6 WITH accelerate)					
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L19	3	carlson-erik$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L20	5	burns-thomas$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:43 PM
L21	14	olson-kyle$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:44 PM
L22	1	giswold-kent$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:47 PM
L23	0	(state WITH charge WITH rate WITH recharg$6) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L24	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L25	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/323	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:03 PM
L26	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L27	4	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h01m10/46	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L28	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r25/602	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L29	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L30	20	(charg$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L31	21	(charg$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:08 PM

L32	3	"20160353216"	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 09:21 PM
L33	1	(cathode SAME anode SAME power SAME source SAME charg$5 SAME interface SAME prior).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 09:46 PM
L34	1	"17553716"	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 10:06 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

TO: patents@starkey.com,eofficeaction@appcoll.com,ptodocketing@mrgs.com
FROM: noreply@uspto.gov
CC: patentcenter_eofficeaction@uspto.gov
SUBJECT: USPTO: Patent Electronic System - e-Postcard Notification for Customer Number 142537

Wed Feb 07 05:43:12 EST 2024

Dear Patent Center Customer:

Correspondence Address:

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c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis,MINNESOTA,55401
UNITED STATES

An email notification regarding the correspondence was sent to the following email address(es) associated with customer number 142537:

patents@starkey.com
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This is a courtesy reminder that new correspondence is available for the application. If you have not done so already, please review the correspondence listed below. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

Application	Document	Mailroom Date	Attorney Docket No.
17553716	NOA	01/31/2024	ST0806US1/532.000806US03
17553716	1449	01/31/2024	ST0806US1/532.000806US03
17553716	892	01/31/2024	ST0806US1/532.000806US03

To view your correspondence online, please sign in to Patent Center and then select Workbench/View correspondence. Or to update your email addresses, select Manage/Manage customer numbers.

If you have any questions, please contact the Patent Electronic Business Center (EBC) at ebc@uspto.gov or 866-217-9197 Monday – Friday, 6 a.m. to midnight ET.

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Sincerely,

The Patent Center Team

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PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**03/05/2024 04:30:51 PM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	64559630	FILING DATE	12/16/2021
CUSTOMER #	142537	FIRST NAMED INVENTOR	Erik Carlson
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Mark Hollingsworth

Documents

TOTAL DOCUMENTS: 3

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2024-03-05-SIDS 1449 and LETTER.pdf	3	Information Disclosure Statement (IDS) Form (SB08)	110 KB
Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
2024-03-05-RCE.pdf	3	Request for Continued Examination (RCE)	1628 KB
NPL_EP_OA_2023-10-27.pdf	8	Non Patent Literature	309 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

2024-03-05-SIDS 1449 and LETTER.pdf	4274C060CFC82AEEE61694E3C5ABAD20C71137E73A6DD055F9F844CA4BB367D80DE0BDCFFE15A1F5F7A31561DBB4F1993C70B135B7A3960C3C5714CD3EC0B790
2024-03-05-RCE.pdf	687F941837724393DA5C3CC2855A831655839A86ACB371B433C924F36BA993E78F6C80645D1FF1B783E7F73A09C758168C24B2ABAFDFA582ABC0F351B56490B2
NPL_EP_OA_2023-10-27.pdf	66EAC5FB8CE56FFA4038A78B0B49D5E68F4F2B1AF6F0D915BF17C77E26B65F138CA9FE4AD354CA6B195169FB6D306B443107F003145F0B1594CE3F39579B764C

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**03/05/2024 04:30:51 PM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	64559630	AUTHORIZED BY	Mark Hollingsworth
CUSTOMER #	142537	FILING DATE	12/16/2021
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Erik Carlson

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
DA / 134895	**E202435G31487760**	**Margaret Rausch**

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
134895	**37 CFR 1.16 (National application filing, search, and examination fees); 37 CFR 1.17 (Patent application and reexamination processing fees); 37 CFR 1.19 (Document supply fees); 37 CFR 1.20 (Post Issuance fees); 37 CFR 1.21 (Miscellaneous fees and charges)**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1801	REQUEST FOR CONTINUED EXAMINATION (RCE) - 1ST REQUEST (SEE 37 CFR 1.114)	1360.00	1	1360.00
			TOTAL AMOUNT:	**$1,360.00**

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 1 of 3	**IDS filed on: March 5, 2024**	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

U.S. PATENTS

Patent Number (Number - Kind Code)	Issue Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
US 8,213,651	07-03-2012	Schmidt	

U.S. PATENT APPLICATION PUBLICATIONS

Publication Number (Number - Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
US 2008/0118093	09-27-2011	Klemenz	

U.S. PATENT APPLICATIONS BY SERIAL NUMBER

Copy Enclosed	Document Number (Number - Kind Code)	Filing Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
	None			

FOREIGN PATENT DOCUMENTS

Copy Enclosed	Country Code	Foreign Document Number	Kind Code	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments	translation	
							yes	no
		None						

NON-PATENT LITERATURE DOCUMENTS

Copy Enclosed	Document Description
X	European Patent Application No. 20 750 976.1 (Attorney Docket No. 0532.000806WO01), filed July 14, 2020, European Office Action issued October 27, 2023, 8 pages.

Examiner Signature		Date Considered	

***EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.**

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 2 of 3	IDS filed on: March 5, 2024	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97(b) – (d) and 1.98, Applicant brings the materials enclosed herewith to the attention of the Examiner as possibly being of interest in connection with the above-identified patent application. Pursuant to M.P.E.P. § 609 and 37 C.F.R. § 1.97(h), the information cited in the present Information Disclosure Statement shall not be construed to be an admission that the information is, or is considered to be, material to patentability. Applicant requests that the Examiner consider each of the documents listed on the attached list of documents. Pursuant to the provisions of M.P.E.P. § 609, Applicant further requests that a copy of the list of documents marked as being considered and initialed by the Examiner, be returned along with the next official communication.

Applicant wishes to bring to the Examiner's attention that the materials indicated on the attached list of documents include documents cited in a foreign search report. A copy of this search report is enclosed with this Information Disclosure Statement.

Applicant believes that no fee is due, as this Information Disclosure Statement is filed with a Request for Continued Examination. However, in the event a fee is due, please charge any fee or credit any overpayment to Deposit Account No. 13-4895.

Applicant invites the Examiner to contact the undersigned Applicant's Representative at the telephone number listed below if doing so may advance prosecution of this application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 3 of 3	**IDS filed on: March 5, 2024**	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

Respectfully submitted by

Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
Phone: (612) 305-1220
Facsimile: (612) 305-1228

March 5, 2024
Date

/Mark A. Hollingsworth/
Mark A. Hollingsworth
Reg. No. 38,491
Direct Dial: 612-767-5000

PTO/SB/30EFS (01-22)
Approved for use through 05/31/2024. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	17/553,716	Filing Date	2021-12-16	Docket Number (if applicable)	ST0806US1/532.000806US0	Art Unit	2692
First Named Inventor	Erik Carlson			Examiner Name	George C. Monikang		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 134895

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (01-22)
Approved for use through 05/31/2024. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/Mark A. Hollingsworth/	Date (YYYY-MM-DD)	2024-03-05
Name	Mark A. Hollingsworth	Registration Number	38,491

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

142537 7590 05/13/2024

MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

EXAMINER	
MONIKANG, GEORGE C	
ART UNIT	PAPER NUMBER
2692	

DATE MAILED: 05/13/2024

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

TITLE OF INVENTION: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	08/13/2024

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 11/23)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

142537 7590 05/13/2024
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

TITLE OF INVENTION: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	08/13/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
MONIKANG, GEORGE C	2692	381-323000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

SONOVA EX1018
Page 624

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

142537 7590 05/13/2024

MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

EXAMINER	
MONIKANG, GEORGE C	
ART UNIT	PAPER NUMBER
2692	

DATE MAILED: 05/13/2024

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 11/23)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/ owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).
https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to:

1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
2) a federal, state, local, or international agency, in response to its request;
3) a contractor of the USPTO having need for the information in order to perform a contract;
4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
8) another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c));
9) the Office of Personnel Management (OPM) for personnel research purposes; and
10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	Application No. 17/553,716	Applicant(s) Carlson et al.	
	Examiner GEORGE C MONIKANG	Art Unit 2692	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 3/5/2024.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-23 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/GEORGE C MONIKANG/
Primary Examiner, Art Unit 2692

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Information Disclosure Statement

The information disclosure statement (IDS) submitted on 3/5/2024 was filed after the mailing date of the Notice of Allowance on 1/31/2024. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Allowable Subject Matter

Claims 1-23 are allowed.

The following is an examiner's statement of reasons for allowance:

Claim 1 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 8-10.

Claims 2-15 depend on claim 1.

Claim 16 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 8-10 & 12.

Claims 17-22 depend on claim 16.

Claim 23 is allowed for the reasons set forth in applicants arguments filed 11/09/2023 pages 15-16.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Contact

Any inquiry concerning this communication or earlier communications from the examiner should be directed to GEORGE C MONIKANG whose telephone number is (571)270-1190. The examiner can normally be reached Mon. - Fri., 9AM-5PM, ALT. Fridays off.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carolyn R. Edwards can be reached on 571-270-7136. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is

available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GEORGE C MONIKANG/
Primary Examiner, Art Unit 2692 5/3/2024

Notice of References Cited	Application/Control No. 17/553,716	Applicant(s)/Patent Under Reexamination Carlson et al.	
	Examiner GEORGE C MONIKANG	Art Unit 2692	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-10798500-B1	2020-10-06	Shi; Yiquan	H04R25/02	1/1
*	B	US-20180370522-A1	2018-12-27	COLLINS; Patrick Gordon	B60W10/08	1/1
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2692

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04R1/1025; H01M10/46; H04R25/602; H04R2225/31	07/21/2023	GM
H04R1/1025; H01M10/46; H04R25/602; H04R2225/31	01/19/2024	GM

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**
381	312, 322, 323	07/21/2023	GM
381	312, 322, 323	01/19/2024	GM

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
No double patenting issues. Inventor search completed in EAST.	07/21/2023	GM

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	Interference search completed in EAST.	01/19/2024	GM
	Same class/subclass as above.	01/19/2024	GM

/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	5/3/2024

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

CPC						
Symbol					**Type**	**Version**
H04R	/	1	/	1025	F	2013-01-01
H01M	/	10	/	46	I	2013-01-01
H04R	/	25	/	602	I	2013-01-01
H04R	/	2225	/	57	A	2019-05-01
H04R	/	2225	/	31	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	03 May 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240503

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04R	/	1	/	1025
H01M	/	10	/	46
H04R	/	25	/	602
H04R	/	2225	/	31

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
381	323

CROSS REFERENCES(S)							
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**						
381	322	312					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	03 May 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240503

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	**Art Unit**
	GEORGE C MONIKANG	2692

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11		20										
	3		12		21										
	4		13		22										
	5		14		23										
	6		15												
	7		16												
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	23	
/GEORGE C MONIKANG/ Primary Examiner, Art Unit 2692	03 May 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1, 16, 23	fig. 2A

U.S. Patent and Trademark Office — Part of Paper No.: 20240503

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/553,716	Carlson et al.
	Examiner	Art Unit
	GEORGE C MONIKANG	2692

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/21/2023	01/19/2024	05/03/2024						
	1	✓	=	=						
	2	✓	=	=						
	3	✓	=	=						
	4	✓	=	=						
	5	✓	=	=						
	6	✓	=	=						
	7	✓	=	=						
	8	✓	=	=						
	9	✓	=	=						
	10	✓	=	=						
	11	✓	=	=						
	12	✓	=	=						
	13	✓	=	=						
	14	✓	=	=						
	15	✓	=	=						
	16	✓	=	=						
	17	✓	=	=						
	18	✓	=	=						
	19	✓	=	=						
	20	✓	=	=						
	21	✓	=	=						
	22	✓	=	=						
	23	✓	=	=						

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 1 of 3	**IDS filed on: March 5, 2024**	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

U.S. PATENTS

Patent Number (Number - Kind Code)	Issue Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
/G.C.M/US 8,213,651	07-03-2012	Schmidt	

U.S. PATENT APPLICATION PUBLICATIONS

Publication Number (Number - Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
/G.C.M/US 2008/0118093	09-27-2011	Klemenz	

U.S. PATENT APPLICATIONS BY SERIAL NUMBER

Copy Enclosed	Document Number (Number - Kind Code)	Filing Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments
	None			

FOREIGN PATENT DOCUMENTS

Copy Enclosed	Country Code	Foreign Document Number	Kind Code	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Comments	translation	
							yes	no
		None						

NON-PATENT LITERATURE DOCUMENTS

Copy Enclosed	Document Description
/G.C.M/ X	European Patent Application No. 20 750 976.1 (Attorney Docket No. 0532.000806WO01), filed July 14, 2020, European Office Action issued October 27, 2023, 8 pages.

Examiner Signature	/GEORGE C MONIKANG/	Date Considered	05/03/2024

***EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.**

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 2 of 3	IDS filed on: March 5, 2024	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97(b) – (d) and 1.98, Applicant brings the materials enclosed herewith to the attention of the Examiner as possibly being of interest in connection with the above-identified patent application. Pursuant to M.P.E.P. § 609 and 37 C.F.R. § 1.97(h), the information cited in the present Information Disclosure Statement shall not be construed to be an admission that the information is, or is considered to be, material to patentability. Applicant requests that the Examiner consider each of the documents listed on the attached list of documents. Pursuant to the provisions of M.P.E.P. § 609, Applicant further requests that a copy of the list of documents marked as being considered and initialed by the Examiner, be returned along with the next official communication.

Applicant wishes to bring to the Examiner's attention that the materials indicated on the attached list of documents include documents cited in a foreign search report. A copy of this search report is enclosed with this Information Disclosure Statement.

Applicant believes that no fee is due, as this Information Disclosure Statement is filed with a Request for Continued Examination. However, in the event a fee is due, please charge any fee or credit any overpayment to Deposit Account No. 13-4895.

Applicant invites the Examiner to contact the undersigned Applicant's Representative at the telephone number listed below if doing so may advance prosecution of this application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application Number:	17/553,716
	Confirmation No:	1905
	Filing Date:	December 16, 2021
	First Named Inventor:	Erik Carlson
	Attorney Docket No.:	ST0806US1/532.000806US03
	Examiner Name:	George C. Monikang
	Art Unit:	2692
Sheet 3 of 3	**IDS filed on: March 5, 2024**	
Title: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

Respectfully submitted by

Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
Phone: (612) 305-1220
Facsimile: (612) 305-1228

March 5, 2024
Date

/Mark A. Hollingsworth/
Mark A. Hollingsworth
Reg. No. 38,491
Direct Dial: 612-767-5000

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 1905

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
17/553,716	12/16/2021 RULE	381	2692	ST0806US1/532.000806US03

APPLICANTS
Starkey Laboratories, Inc., Eden Prairie, MN;

INVENTORS
Erik Carlson, Stillwater, MN;
Thomas Burns, Minneapolis, MN;
Kyle Olson, St. Louis Park, MN;
Kent Giswold, Minnetonka, MN;

**** CONTINUING DATA ***************************
This application is a CON of PCT/US2020/041956 07/14/2020
which claims benefit of 62/876,454 07/19/2019
and claims benefit of 62/943,375 12/04/2019

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
12/29/2021

Foreign Priority claimed	❑ Yes ☑ No		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	❑ Yes ☑ No	❑ Met after Allowance	MN	15	23	3
Verified and Acknowledged	/GEORGE C MONIKANG/ Examiner's Signature	GM Initials				

ADDRESS
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
UNITED STATES

TITLE
SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

FILING FEE RECEIVED		
0.00	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

BIB (Rev. 05/07).

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1	"17553716"	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 03:50 PM
L2	1	(hearing SAME aid SAME charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L3	576	(charg$8 SAME displac$8 SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L4	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/19 04:43 PM
L5	0	(charg$8 SAME pogo SAME anode SAME cathode) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L6	0	(charg$8 SAME pogo SAME positive SAME negative) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:13 PM
L7	6	(charg$8 SAME pogo SAME anode SAME cathode)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:14 PM
L8	69	(charg$8 SAME pogo SAME positive SAME negative)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:19 PM
L9	1	(charg$8 SAME pogo SAME positive SAME negative SAME hearing)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/20 06:20 PM
L10	0	(charg$8 SAME pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:20 PM
L11	75	(pogo SAME pin$1 SAME triang$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
L12	0	(pogo SAME pin$1 SAME triang$6) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 04:21 PM
L13	623	(state WITH charge WITH rate WITH recharg$6)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:28 PM
L14	0	(state WITH charge WITH rate WITH recharg$6) AND 381/$.ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:29 PM
L15	2	(state WITH charge WITH rate WITH	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:30 PM

		recharg$6 WITH accelerate)					
L16	11	(state SAME charge SAME rate SAME recharg$6 SAME accelerate)	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 05:33 PM
L17	133	carlson-erik$.in.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L18	0	carlson-erik$.in. AND (battery).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L19	3	carlson-erik$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:42 PM
L20	5	burns-thomas$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:43 PM
L21	14	olson-kyle$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:44 PM
L22	1	giswold-kent$.in. AND (charg$6).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 06:47 PM
L23	0	(state WITH charge WITH rate WITH recharg$6) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L24	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND (381/312,322,323).ccls.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:02 PM
L25	0	(charg$8 SAME displac$8 SAME anode SAME cathode) AND 381/323	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:03 PM
L26	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L27	4	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h01m10/46	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:04 PM
L28	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r25/602	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L29	1	(charg$8 SAME displac$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L30	20	(charg$8 SAME anode SAME cathode) AND h04r2225/31	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:05 PM
L31	21	(charg$8 SAME anode SAME cathode) AND h04r1/1025	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/21 07:08 PM

L32	3	"20160353216"	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 09:21 PM
L33	1	(cathode SAME anode SAME power SAME source SAME charg$5 SAME interface SAME prior).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 09:46 PM
L34	1	"17553716"	(US-PGPUB; USPAT)	OR	ON	ON	2024/01/19 10:06 PM
L35	4	"8213651"	(US-PGPUB; USPAT)	OR	ON	ON	2024/05/03 06:18 PM
L36	3	"20080118093"	(US-PGPUB; USPAT)	OR	ON	ON	2024/05/03 06:18 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	17/553,716	Attorney Docket No.:	ST0806US1 / 532.000806US03
Confirmation No.:	1905	Customer No.:	142537
Filing Date:	December 16, 2021	Examiner Name:	George C. Monikang
First Named Inventor:	Erik Carlson	Group Art Unit:	2692
Title of Invention:	SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE		

Comments on Statement of Reasons for Allowance

Commissioner for Patents
Mail Stop Issue Fee
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

This communication is in response to the Notice of Allowance mailed May 13, 2024, in the above-noted application. Applicant appreciatively acknowledges the allowance of claims 1-23.

Applicant notes that there may be one or more additional or alternative reasons for allowance that have not been specifically recited by the Examiner, which apply to one or more of the allowed claims. Applicant respectfully asserts that each of the allowed claims is patentable in its own right for the reasons indicated by the Examiner and for other reasons, such as those raised during the prosecution and those explained or implied in the specification of this application. Applicant expressly traverses the Examiner's Statement of Reasons for Allowance to the extent that any comment is intended or has the effect of limiting a claim scope, explicitly or implicitly, by not reciting verbatim the respective claim language, or is intended or has the effect of limiting a claim scope by stating or implying that all the reasons for patentability are in any way fully enumerated. Further, Applicant does not concede the interpretation of any claim elements implicitly relied on or explicitly recited in the Statement of the Reasons for Allowable Subject Matter.

It is believed that no fee is due; however, in the event a fee is required, please charge any fee due for such extension or any other fee required in connection with this paper to Deposit Account No. 13-4895.

Respectfully submitted by
Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401
Phone: (612) 305-1220

August 13, 2024
Date

/Mark A. Hollingsworth/
Mark A. Hollingsworth
Reg. No. 38,491
Direct Dial: 612-767-5000

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

142537 7590 05/13/2024
MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

Margaret H. Rausch	(Typed or printed name)
/Margaret H. Rausch/	(Signature)
August 13, 2024	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	12/16/2021	Erik Carlson	ST0806US1/532.000806US03	1905

TITLE OF INVENTION: SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	08/13/2024

EXAMINER	ART UNIT	CLASS-SUBCLASS
MONIKANG, GEORGE C	2692	381-323000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Mueting Raasch Group
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Starkey Laboratories, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Eden Prairie, MN

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ☒ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 134895

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Mark A. Hollingsworth/ Date August 13, 2024

Typed or printed name Mark A. Hollingsworth Registration No. 38,491

PTOL-85 Part B (11/23) Approved for use through 03/31/2026 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**08/13/2024 08:36:26 AM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1905	FILED BY	Margaret Rausch
PATENT CENTER #	66759844	AUTHORIZED BY	Mark Hollingsworth
CUSTOMER #	142537	FILING DATE	12/16/2021
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Erik Carlson

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 7647	**E20248C937226205**	**Margaret Rausch**

PRE-AUTHORIZED ACCOUNT	PRE-AUTHORIZED CATEGORY
134895	**37 CFR 1.16 (National application filing, search, and examination fees); 37 CFR 1.17 (Patent application and reexamination processing fees); 37 CFR 1.19 (Document supply fees); 37 CFR 1.20 (Post Issuance fees); 37 CFR 1.21 (Miscellaneous fees and charges)**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1501	UTILITY ISSUE FEE	1200.00	1	1200.00
			TOTAL AMOUNT:	**$1,200.00**

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Receipt will establish the filing date of the application

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/553,716	**08/13/2024 08:36:26 AM Z ET**	**ST0806US1/532.000806US03**

Title of Invention

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CONFIRMATION #	1905	FILED BY	Margaret Rausch
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CUSTOMER #	142537	FIRST NAMED INVENTOR	Erik Carlson
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Mark Hollingsworth

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2024-08-13-Comments on Statement of Reasons for Allowance.pdf	2	Post Allowance Communication - Incoming	98 KB
2024-08-13-Issue Fee Transmittal.pdf	1	Issue Fee Payment (PTO-85B)	130 KB

Warning: The attached file contains comments or annotations. Comments are not recommended and may cause processing problems with the document.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
2024-08-13-Comments on	24C1ECB03740A92F307688513A6BD266259C77DDF406C7AE9

Statement of Reasons for Allowance.pdf	11D9D433EAA3A689AFC06E5CED01FB9EBED0DC3FE2D5A4964334300CBFD75815A6399F8BD7D601D
2024-08-13-Issue Fee Transmittal.pdf	0D126B2645286FE9B0A2B738142780F06F9E6BFAAA8CAD31387B0D62E5F5A0C524932FF04C16128A78ABD317F49489B93A96560EB770C6ABCE652ADA11409484

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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/553,716	09/24/2024	12101588	ST0806US1/532.000806US03	1905

142537 7590 09/04/2024

MRG/HD - Starkey
c/o Mueting Raasch Group
111 Washington Ave. S., Suite 700
Minneapolis, MN 55401

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 114 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (https://patentcenter.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional inventors):

Erik Carlson, Stillwater, MN;
Thomas Burns, Minneapolis, MN;
Kyle Olson, St. Louis Park, MN;
Kent Giswold, Minnetonka, MN;

APPLICANT(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional applicants):

Starkey Laboratories, Inc., Eden Prairie, MN;

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To Promote the Progress of Science and Useful Arts

The Director

of the United States Patent and Trademark Office has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this United States

Patent

grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Katherine Kelly Vidal

Director of the United States Patent and Trademark Office

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Patent Term Notice

If the application for this patent was filed on or after June 8, 1995, the term of this patent begins on the date on which this patent issues and ends twenty years from the filing date of the application or, if the application contains a specific reference to an earlier filed application or applications under 35 U.S.C. 120, 121, 365(c), or 386(c), twenty years from the filing date of the earliest such application ("the twenty-year term"), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b), and any extension as provided by 35 U.S.C. 154(b) or 156 or any disclaimer under 35 U.S.C. 253.

If this application was filed prior to June 8, 1995, the term of this patent begins on the date on which this patent issues and ends on the later of seventeen years from the date of the grant of this patent or the twenty-year term set forth above for patents resulting from applications filed on or after June 8, 1995, subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b) and any extension as provided by 35 U.S.C. 156 or any disclaimer under 35 U.S.C. 253.

Form **PTO-377C** (Rev 09/17)

US012101588B2

(12) **United States Patent**
Carlson et al.

(10) **Patent No.: US 12,101,588 B2**
(45) **Date of Patent: Sep. 24, 2024**

(54) **SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE**

(71) Applicant: **Starkey Laboratories, Inc.**, Eden Prairie, MN (US)

(72) Inventors: **Erik Carlson**, Stillwater, MN (US); **Thomas Burns**, Minneapolis, MN (US); **Kyle Olson**, St. Louis Park, MN (US); **Kent Giswold**, Minnetonka, MN (US)

(73) Assignee: **Starkey Laboratories, Inc.**, Eden Prairie, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 114 days.

(21) Appl. No.: **17/553,716**

(22) Filed: **Dec. 16, 2021**

(65) **Prior Publication Data**

US 2022/0109924 A1 Apr. 7, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/US2020/041956, filed on Jul. 14, 2020.
(Continued)

(51) **Int. Cl.**
H01M 10/46 (2006.01)
H04R 1/10 (2006.01)
H04R 25/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 1/1025*** (2013.01); ***H01M 10/46*** (2013.01); ***H04R 25/602*** (2013.01); *H04R 2225/31* (2013.01); *H04R 2225/57* (2019.05)

(58) **Field of Classification Search**
CPC H04R 1/1025; H04R 25/602; H04R 2225/31; H01M 10/46
(Continued)

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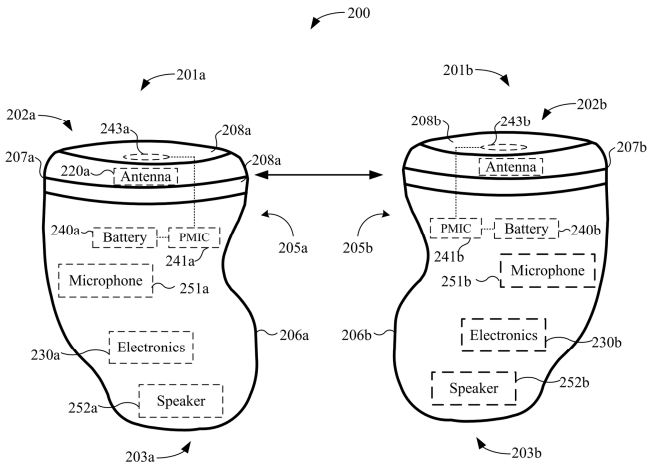
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(Continued)

Primary Examiner — George C Monikang
(74) *Attorney, Agent, or Firm* — Mueting Raasch Group

(57) **ABSTRACT**

A system includes a hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

23 Claims, 15 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/876,454, filed on Jul. 19, 2019, provisional application No. 62/943,375, filed on Dec. 4, 2019.

(58) **Field of Classification Search**
USPC 381/312, 322, 323
See application file for complete search history.

(56) **References Cited**

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* cited by examiner

Figure 1A

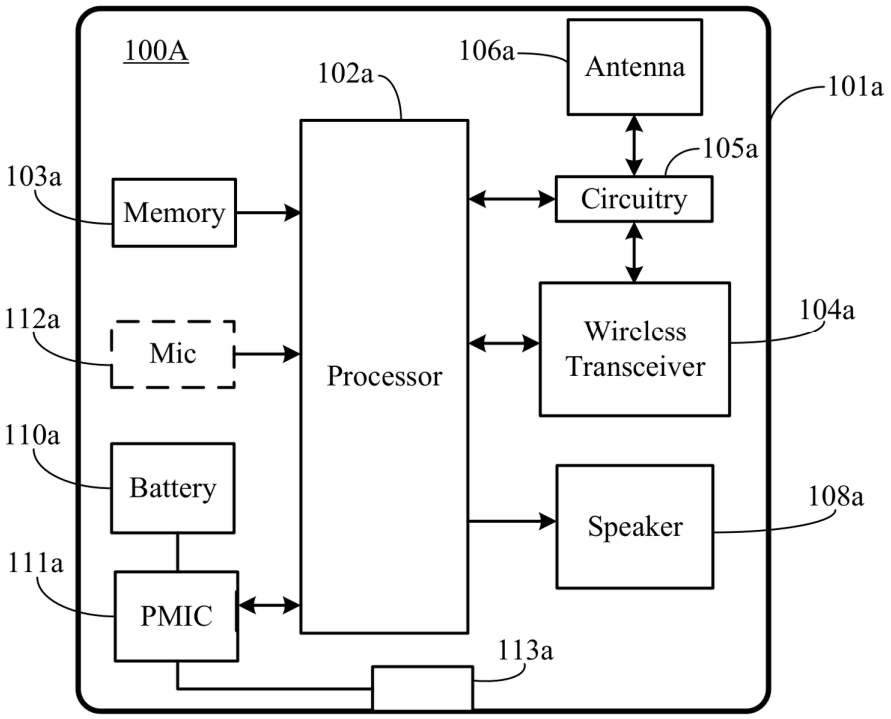
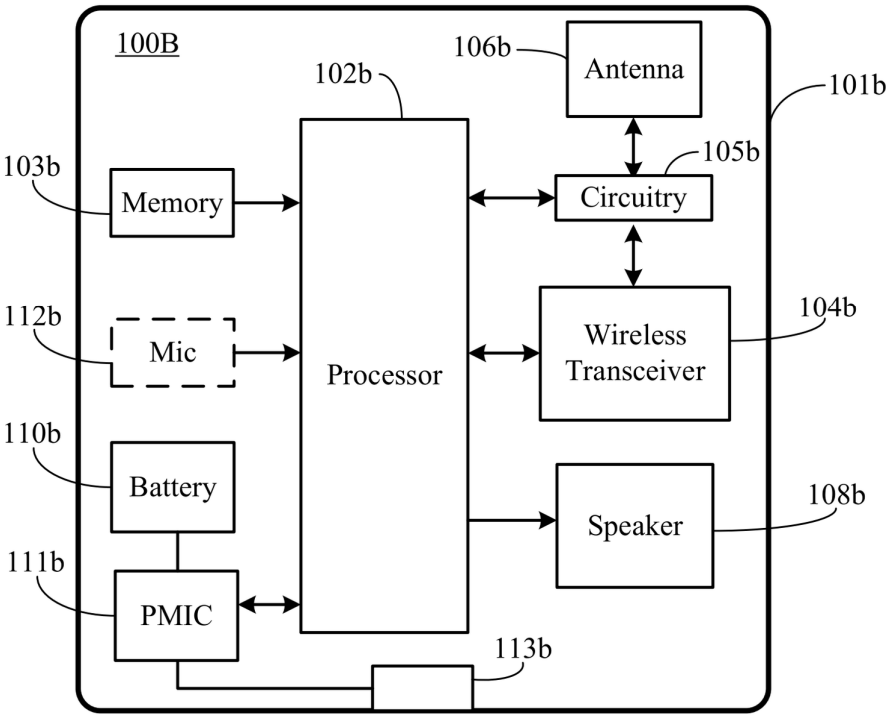


Figure 1B



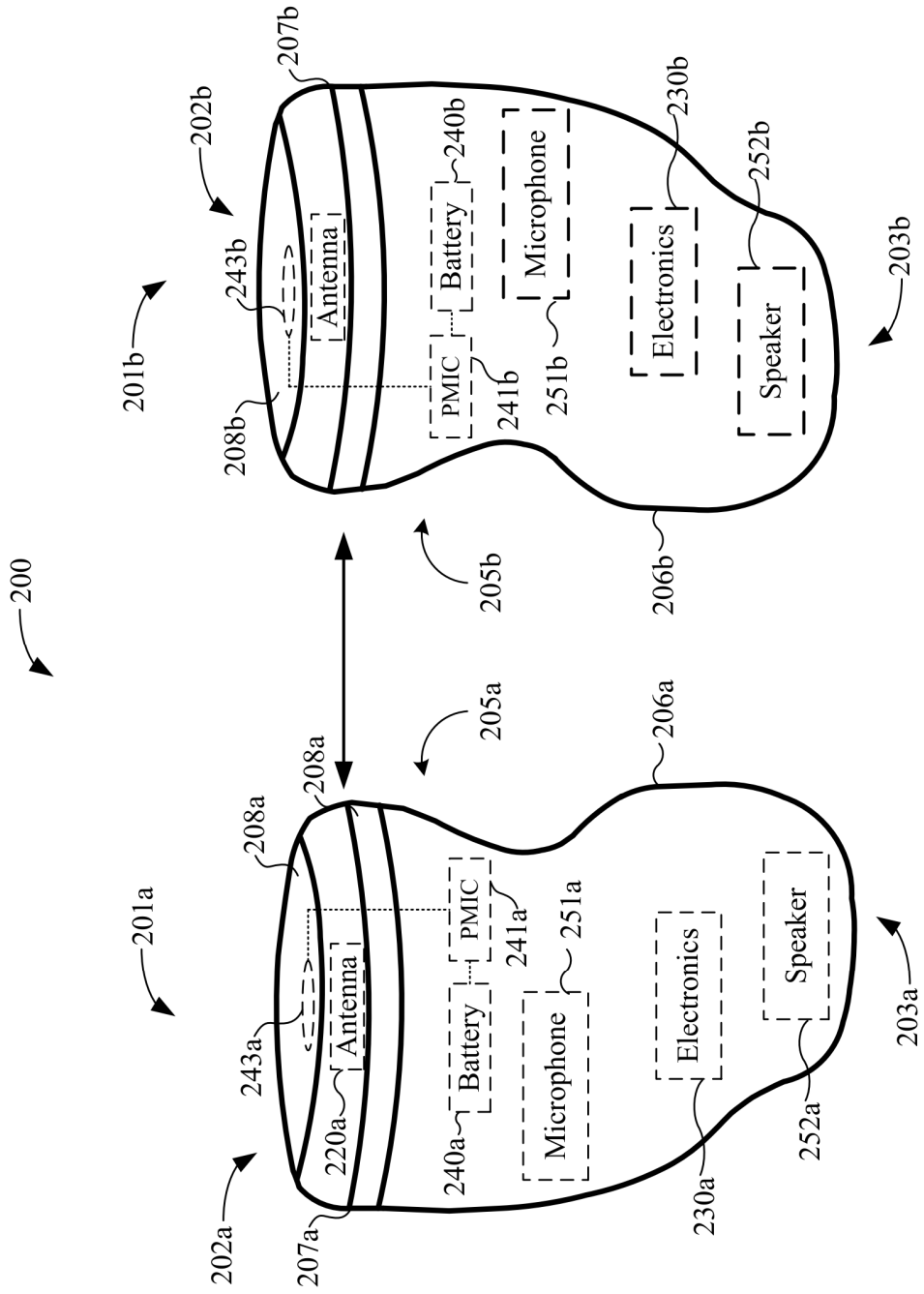

200
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252b
Antenna
Battery
PMIC
Microphone
Electronics
Speaker

Figure 2A

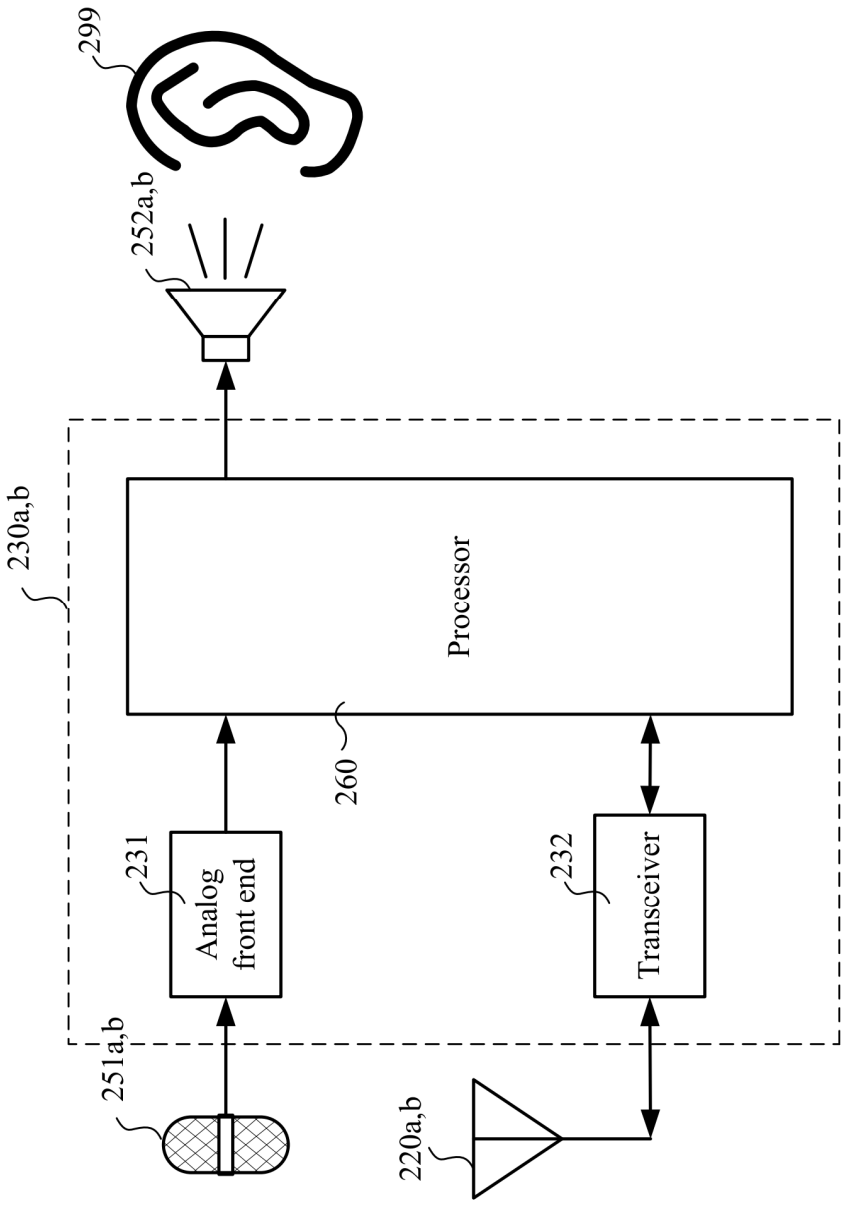

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230a,b
Processor
260
231
Analog front end
232
Transceiver
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220a,b

Figure 2B

Figure 3

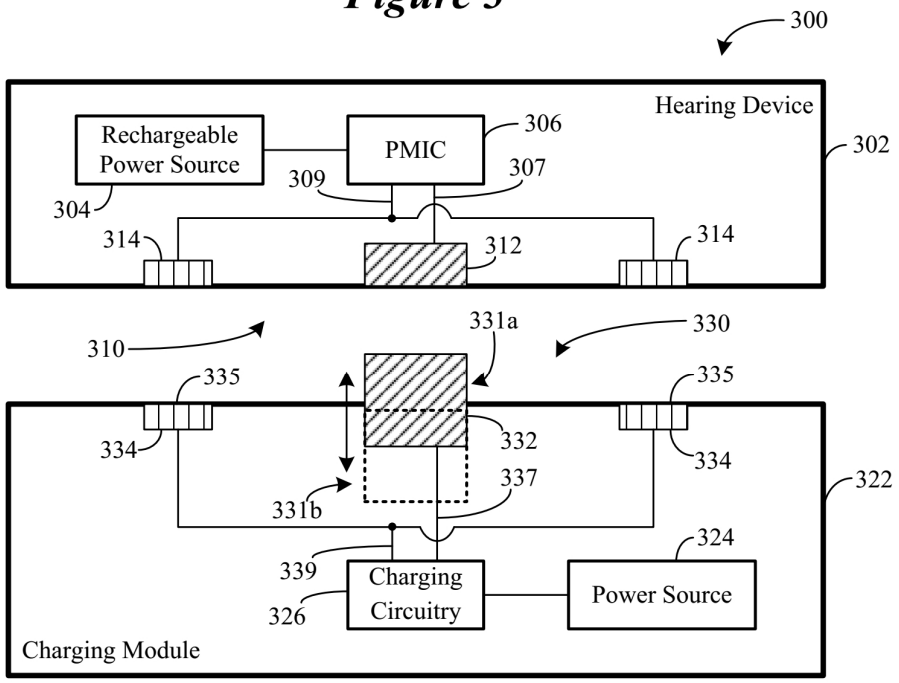


Figure 4

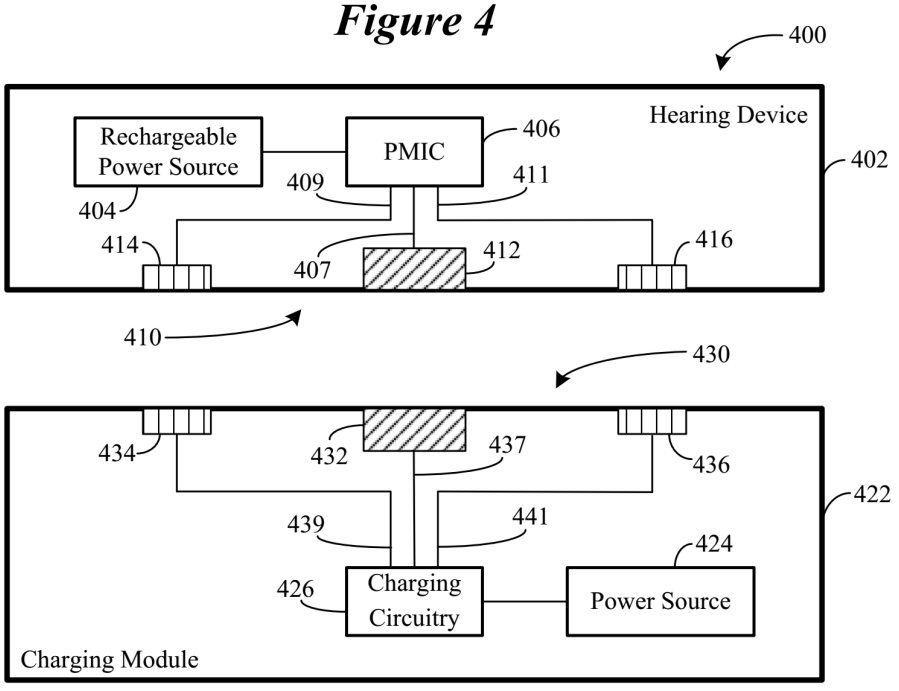


Figure 5

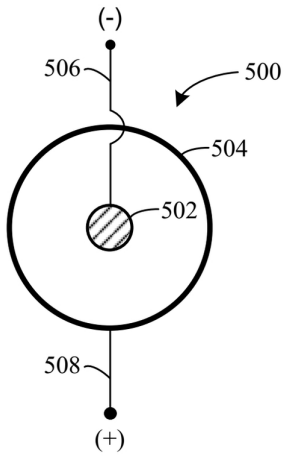


Figure 6

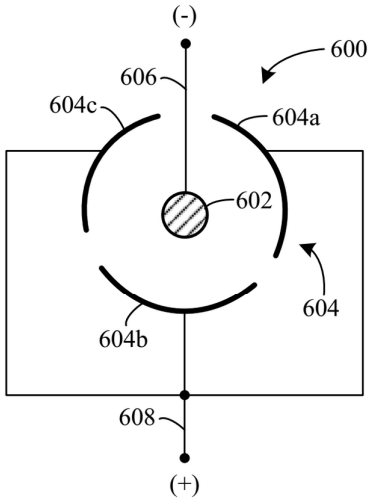


Figure 7

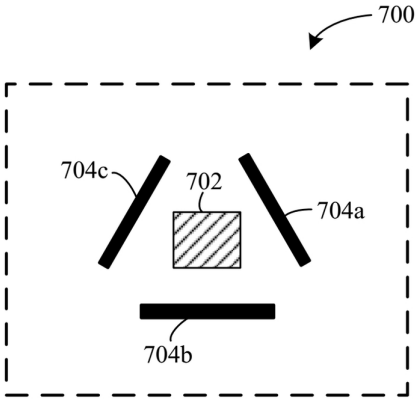


Figure 8A

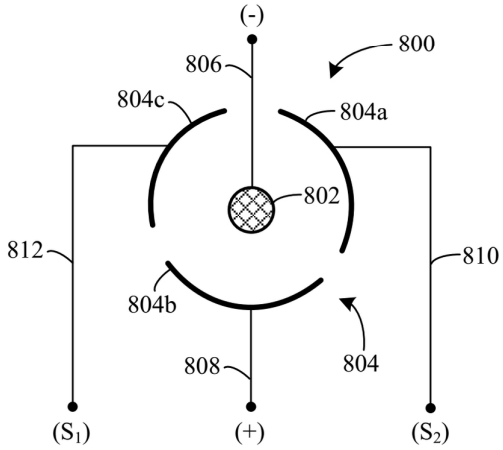


Figure 8B

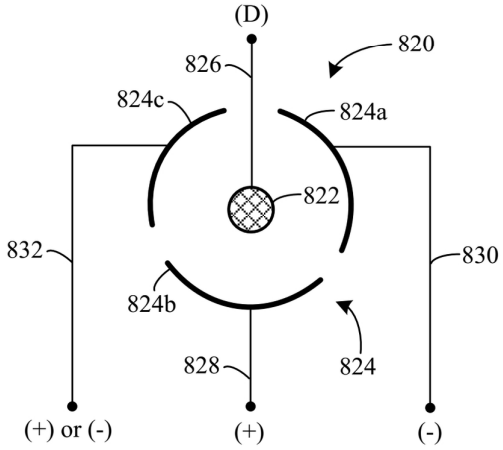


Figure 8C

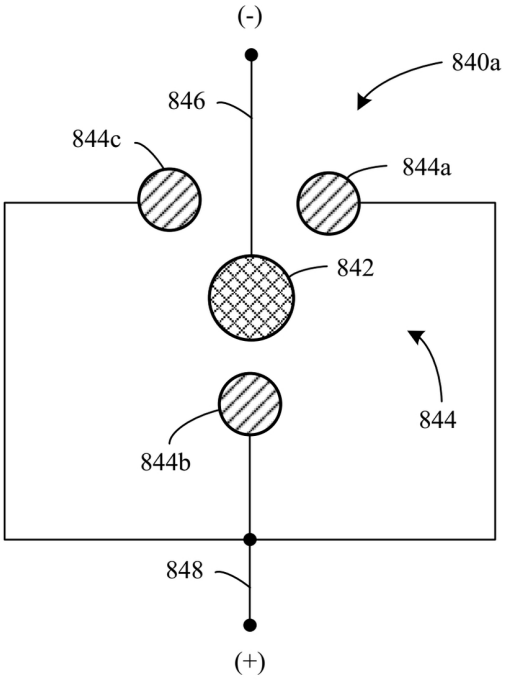


Figure 8D

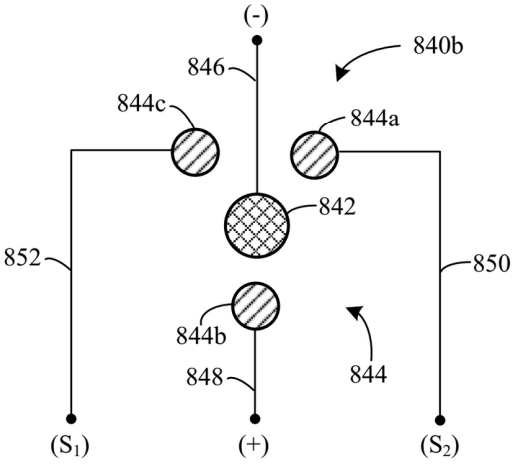
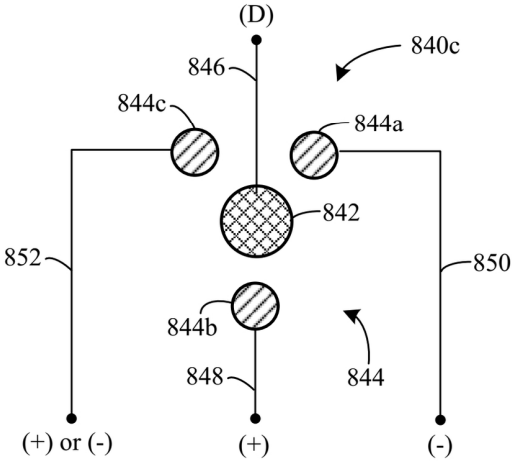


Figure 8E



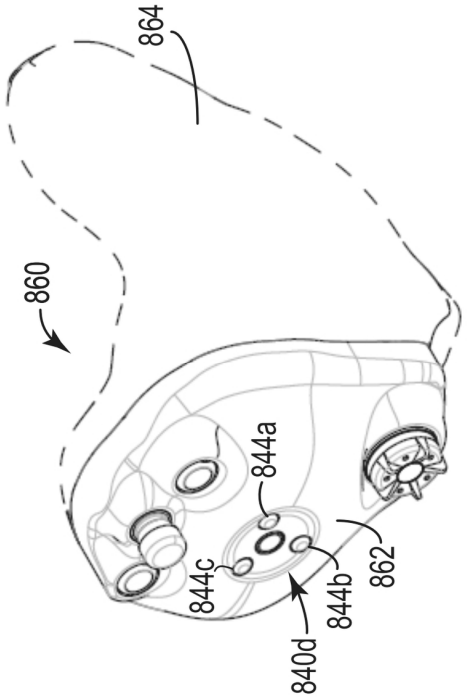


Figure 8G

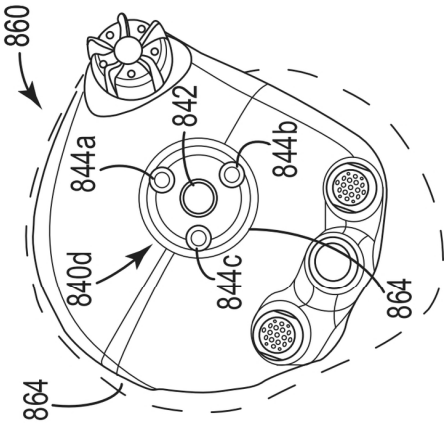


Figure 8I

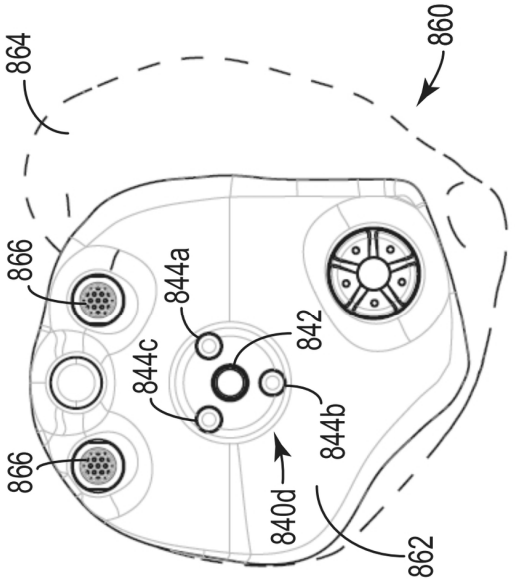


Figure 8F

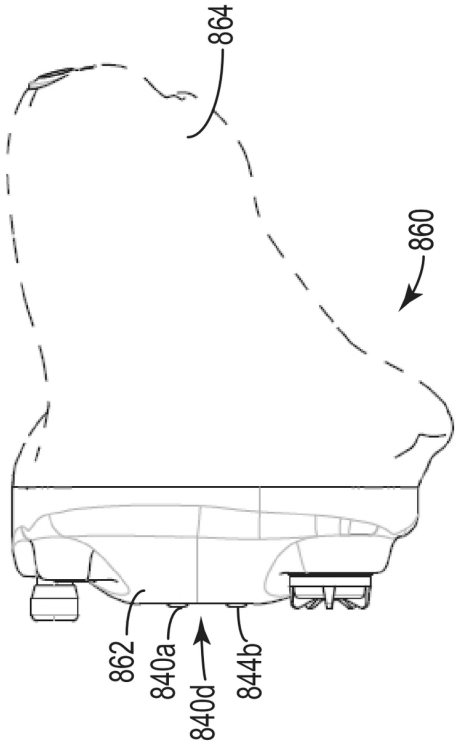


Figure 8H

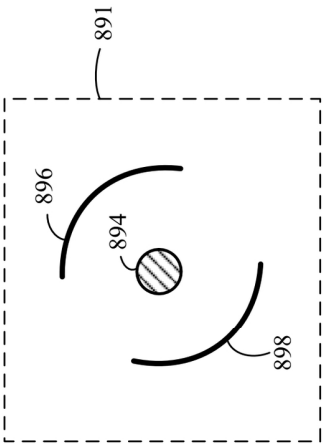


Figure 8K

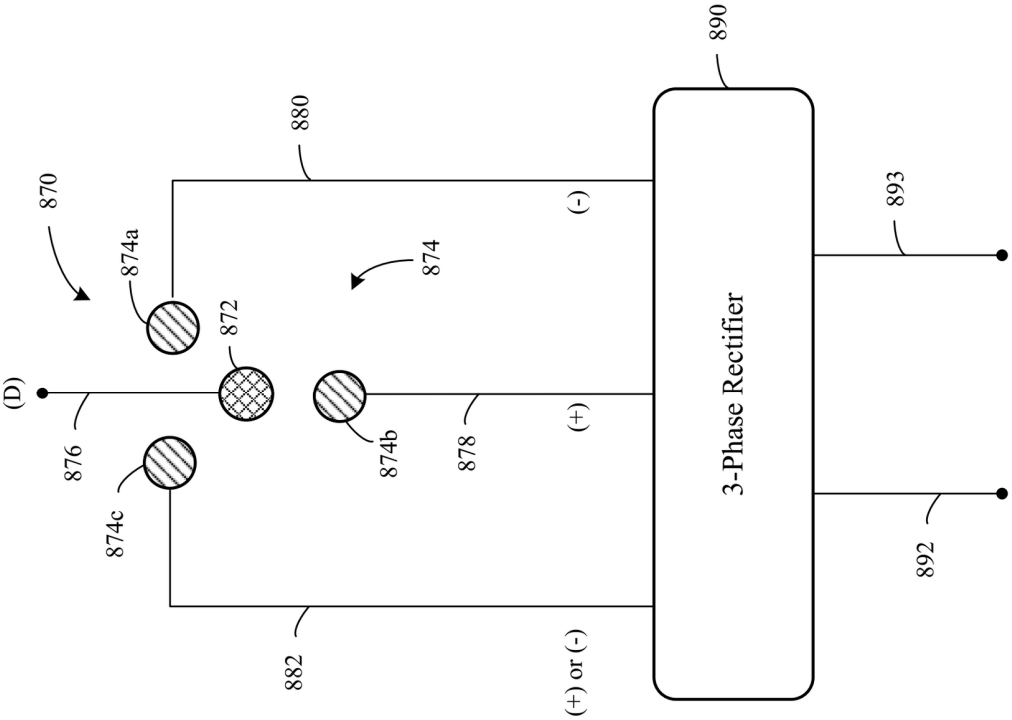
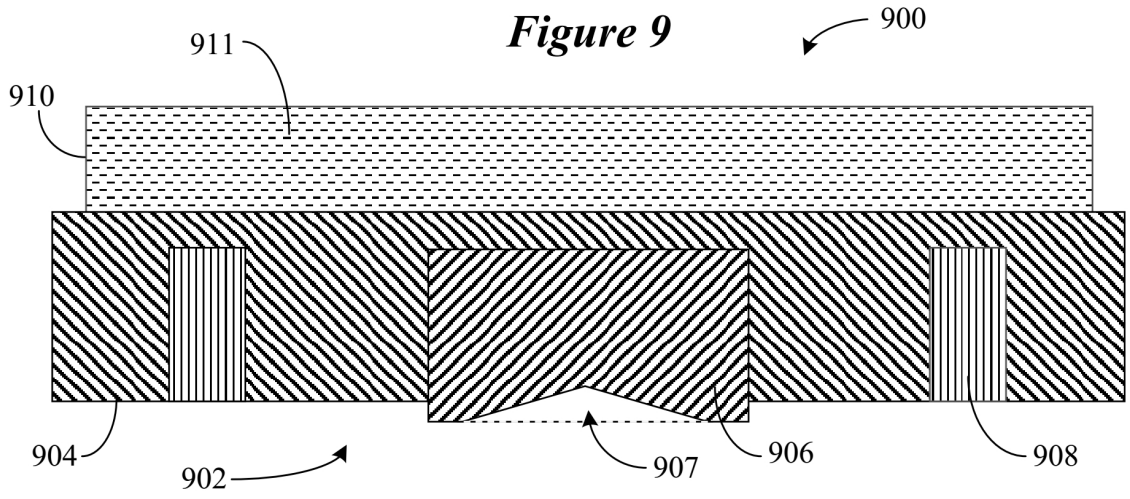


Figure 8J

Figure 9



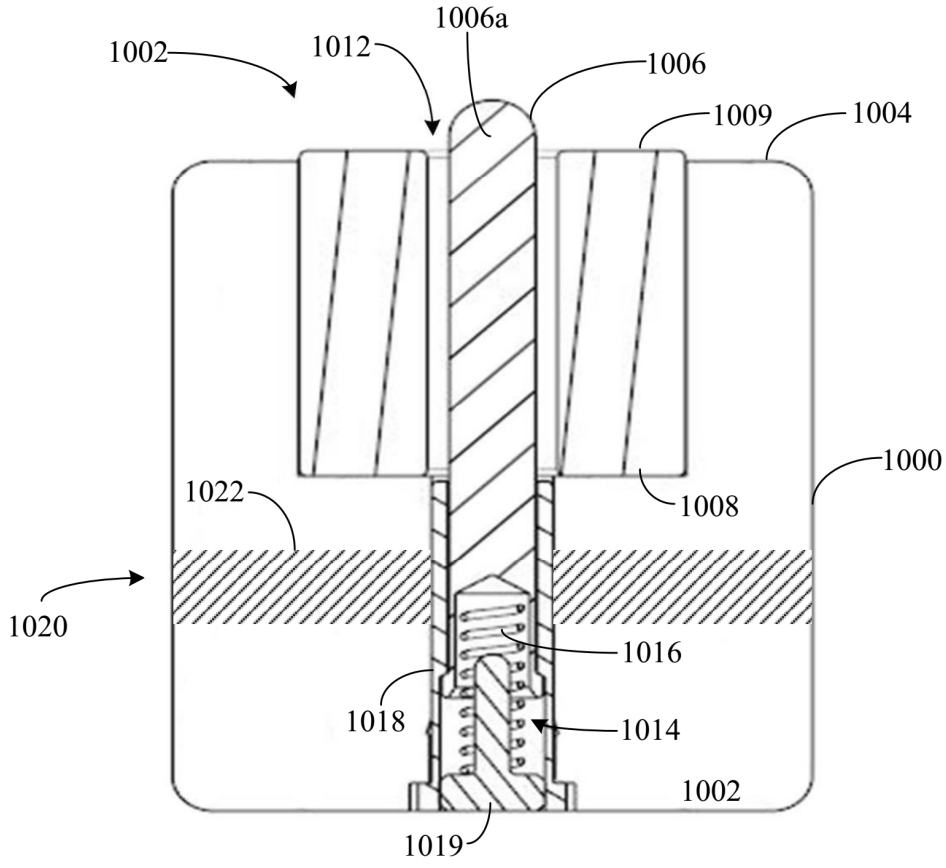


Figure 10

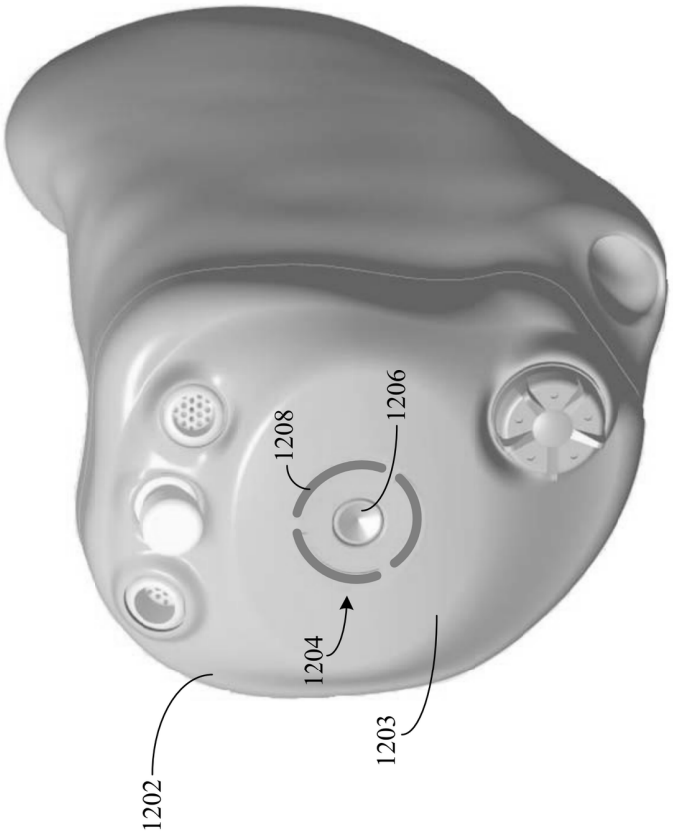


Figure 12

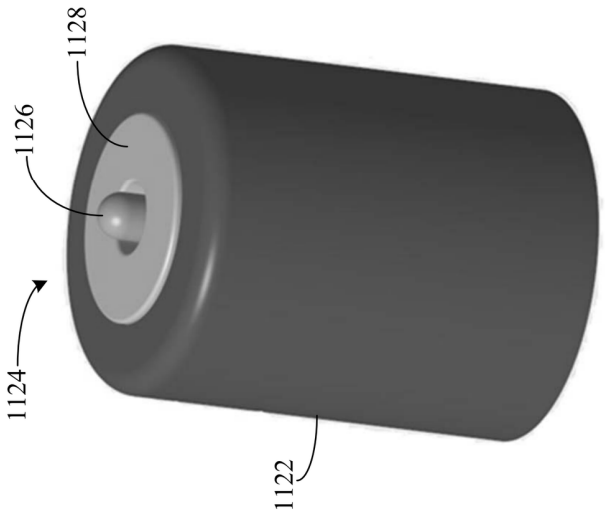


Figure 11

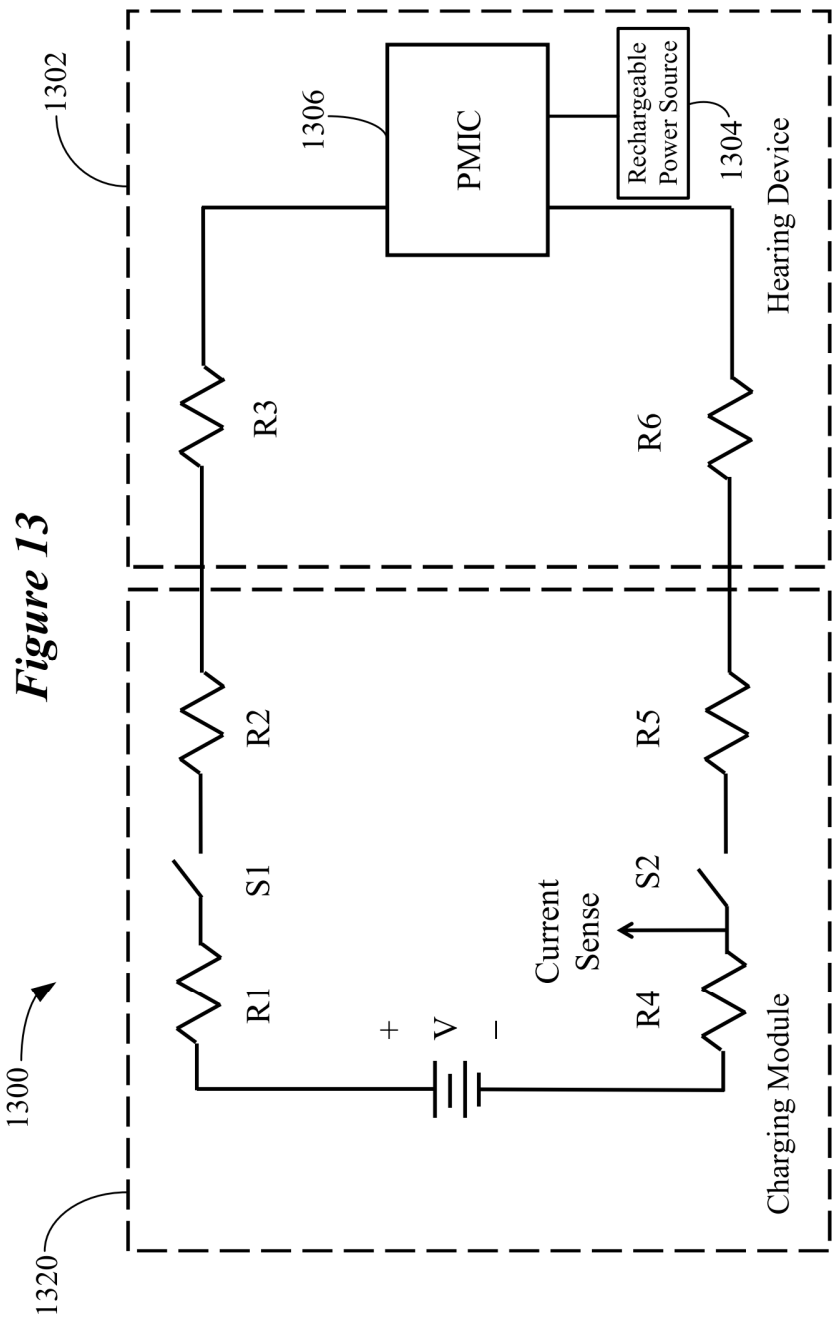

1302
1306
PMIC
Rechargeable Power Source
1304
Hearing Device
R3
R6
R2
R5
S1
S2
Current Sense
R1
R4
+
V
–
1300
1320
Charging Module

Figure 13

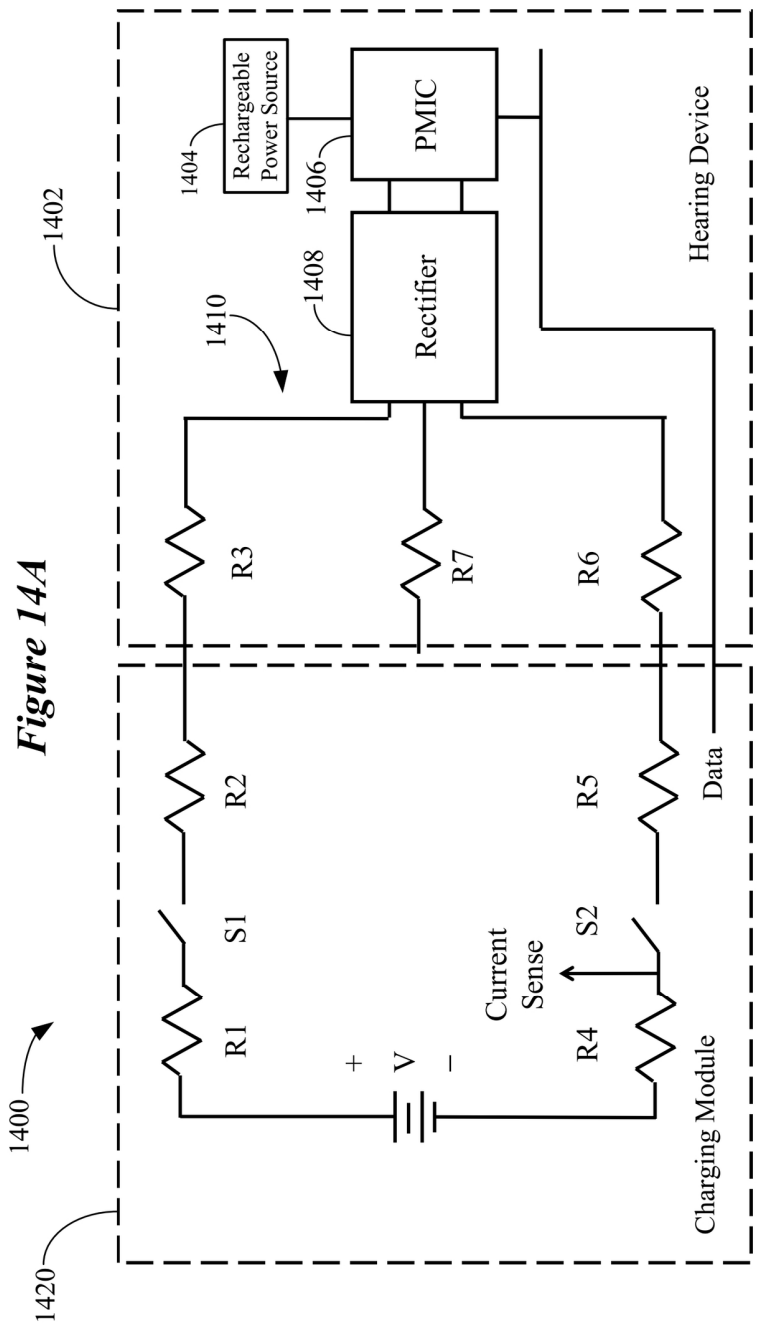


Figure 14A

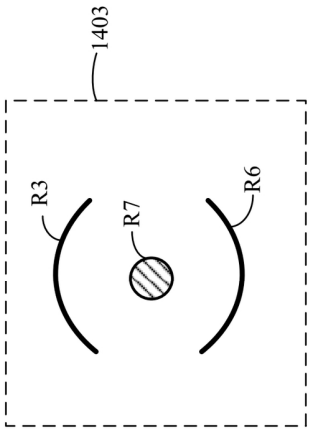


Figure 14B

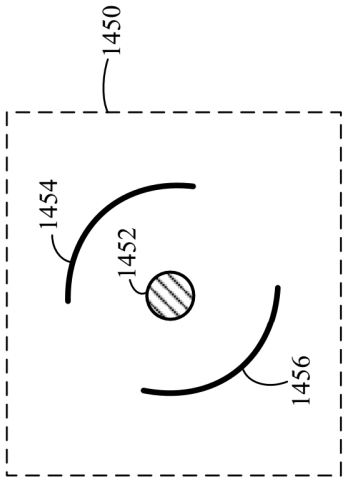


Figure 14D

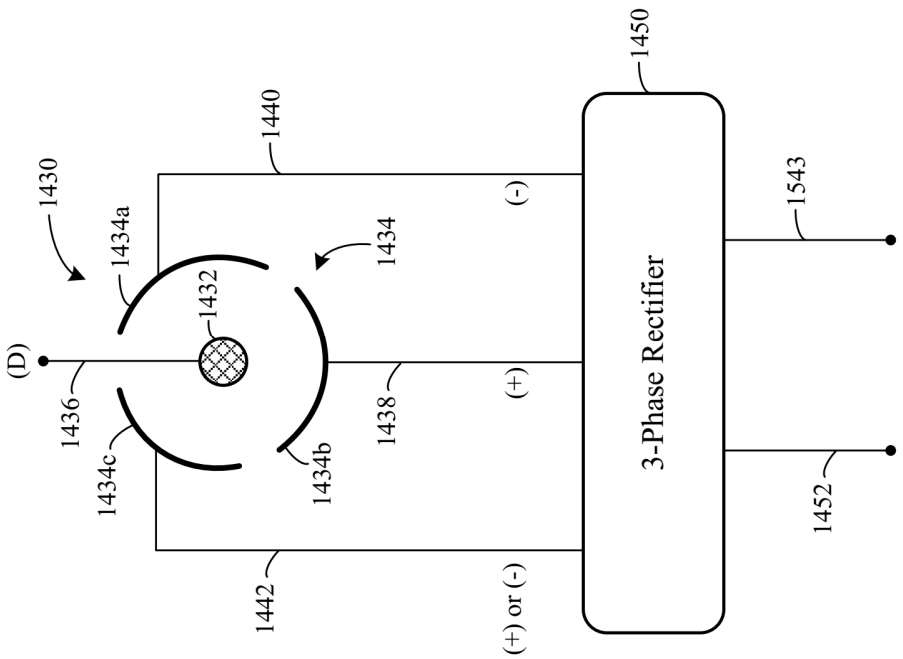


Figure 14C

Figure 15

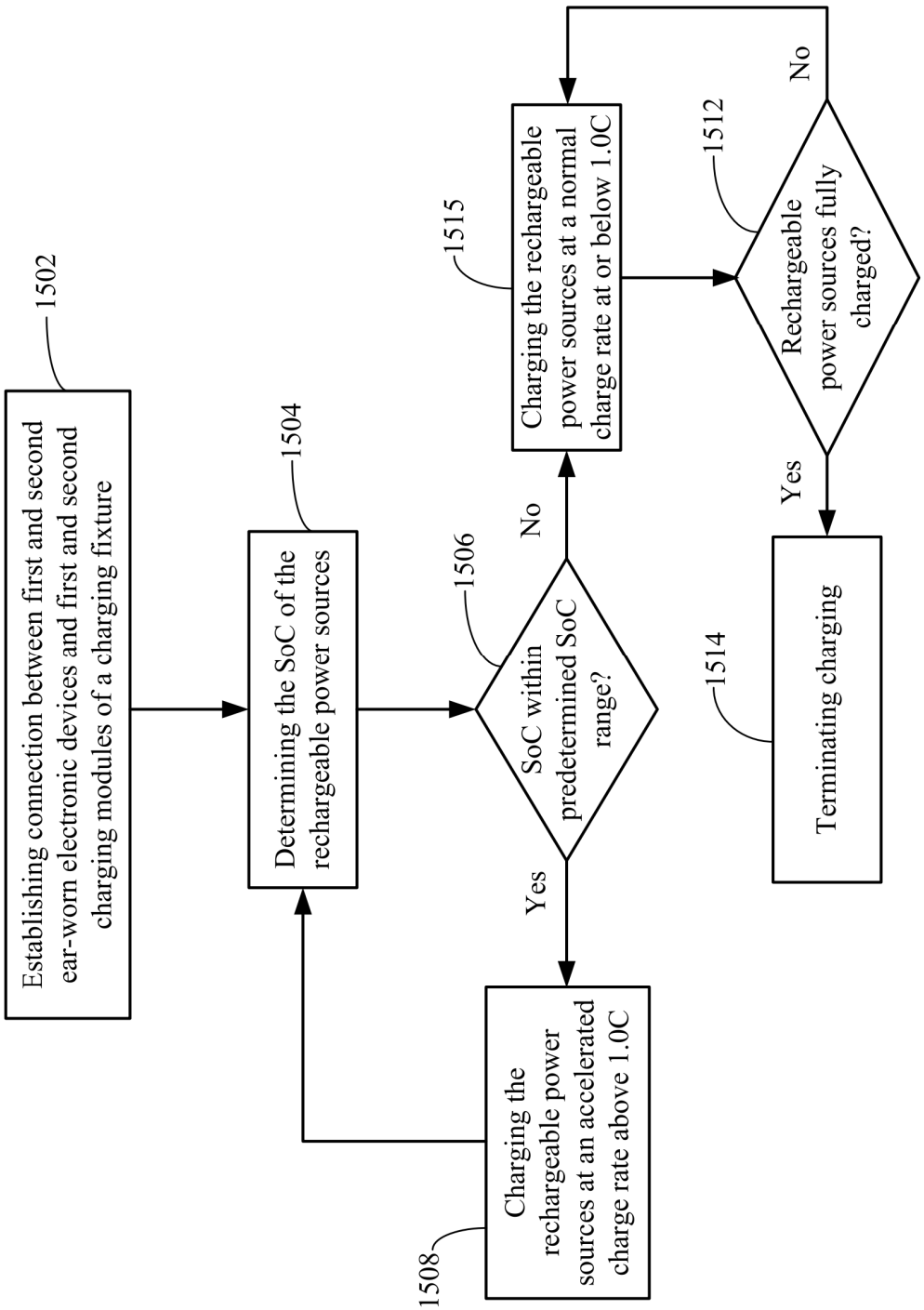
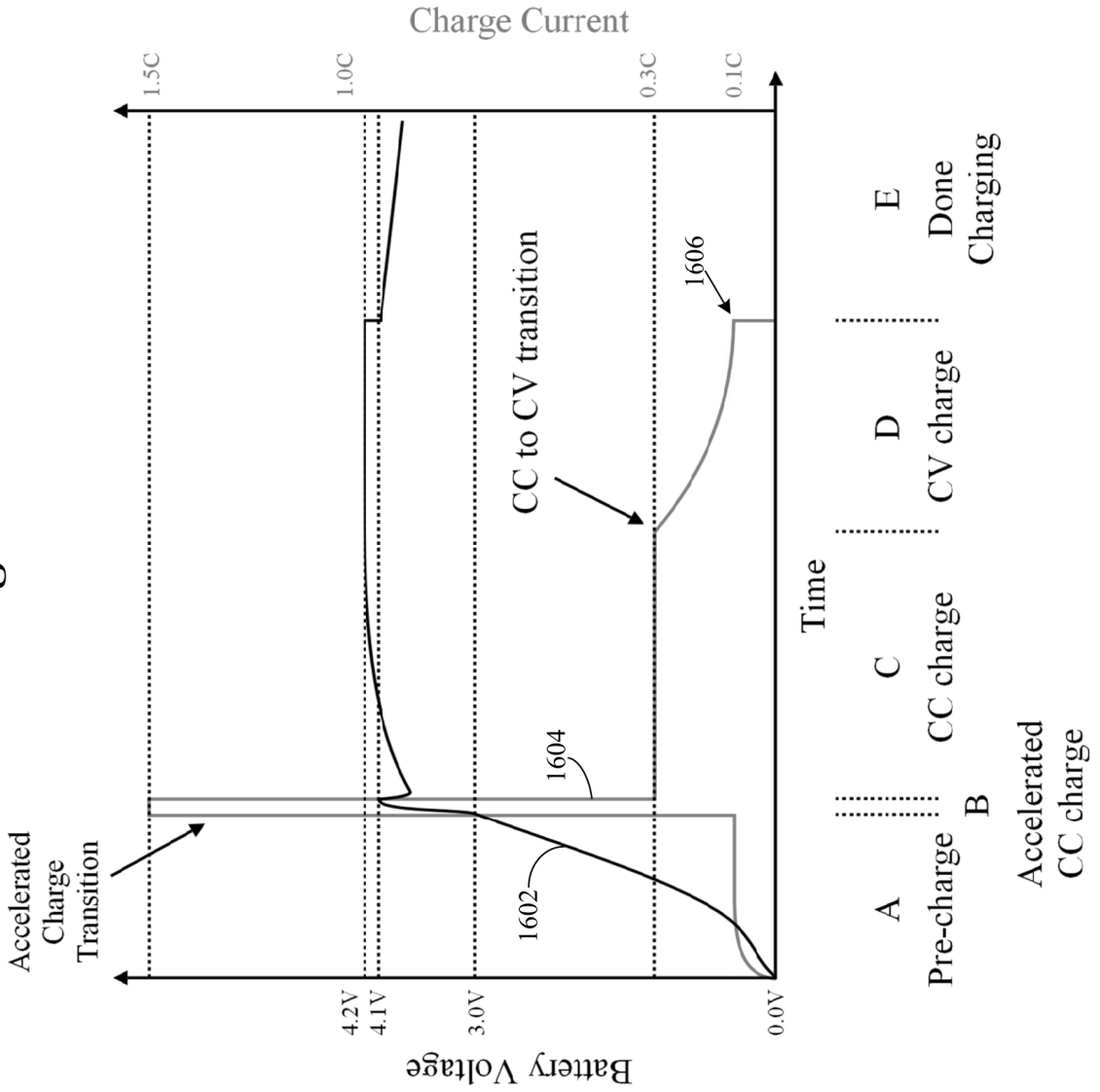

1502
Establishing connection between first and second ear-worn electronic devices and first and second charging modules of a charging fixture
1504
Determining the SoC of the rechargeable power sources
1506
SoC within predetermined SoC range?
Yes
No
1508
Charging the rechargeable power sources at an accelerated charge rate above 1.0C
1515
Charging the rechargeable power sources at a normal charge rate at or below 1.0C
1512
Rechargeable power sources fully charged?
Yes
No
1514
Terminating charging

Figure 16


Charge Current
1.5C
1.0C
0.3C
0.1C
Accelerated Charge Transition
CC to CV transition
1606
1604
1602
4.2V
4.1V
3.0V
0.0V
Battery Voltage
Time
A
Pre-charge
B
Accelerated CC charge
C
CC charge
D
CV charge
E
Done Charging

SYSTEM FOR CHARGING AN EAR-WORN ELECTRONIC DEVICE

RELATED APPLICATIONS

This application is a continuation of PCT Application No. PCT/US2020/041956, filed Jul. 14, 2020, which claims priority to U.S. Provisional Application No. 62/876,454, filed Jul. 19, 2019, and U.S. Provisional Application No. 62/943,375, filed Dec. 4, 2019, the content of which are hereby incorporated by reference in their entireties.

TECHNICAL FIELD

This application relates generally to ear-worn electronic devices, including hearing devices, hearing aids, personal amplification devices, and other hearables.

BACKGROUND

Hearing devices provide sound for the wearer. Some examples of hearing devices are headsets, hearing aids, speakers, cochlear implants, bone conduction devices, and personal listening devices. For example, hearing aids provide amplification to compensate for hearing loss by transmitting amplified sounds to a wearer's ear canals. Hearing devices may be capable of performing wireless communication with other devices, such as receiving streaming audio from a streaming device via a wireless link. Wireless communication may also be performed for programming the hearing device and transmitting information from the hearing device. For performing such wireless communication, hearing devices such as hearing aids can include a wireless transceiver and an antenna. In order to provide power to electronic circuitry of a hearing device, a rechargeable battery is often housed within the hearing device, which requires routine charging to ensure proper operation of the hearing device.

SUMMARY

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Embodiments are directed to a system, comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface and a displaceable second cathode contact. An arrangement is configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device. The second charging interface comprises a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole. A biasing arrangement is configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device. A retention arrangement is disposed on one or both of the hearing device and the charging module. The retention arrangement is configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality

of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. The first anode contact comprises a plurality of first electrode elements configured to communicate power and one or more disparate information signals. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprises a second cathode contact and a second anode contact. The second anode contact comprises a plurality of second electrode elements configured to communicate power and the one or more disparate information signals. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device. The first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

Embodiments are directed to a system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer. The hearing device comprises a rechargeable power source and a first charging interface comprising a plurality of first electrode elements. The plurality of first electrode elements comprises first cathode and anode contacts configured to communicate power and a first data contact configured to communicate one or more disparate information signals. The first anode contact can comprise a plurality of electrode elements each having a non-polygonal shape such a curvilinear, round, elliptical, oval or other closed curved shape comprising only or predominately curved lines. The first anode contact can comprise a plurality of electrode elements each having a polygonal shape such as a square, rectangular, triangular or any other closed plane shape formed with three or more straight lines (e.g., polygonal shapes having from three to twelve sides). The first anode contact can comprises a plurality of electrode elements having a combination of non-polygonal and polygonal shapes. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprises a plurality of second electrode elements. The plurality of second electrode elements comprises second cathode and anode contacts configured to communicate power and a second data contact configured to communicate one or more disparate information signals. Charging circuitry of the charging module is coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

The above summary is not intended to describe each disclosed embodiment or every implementation of the present disclosure. The figures and the detailed description below more particularly exemplify illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Throughout the specification reference is made to the appended drawings wherein:

FIGS. **1**A and **1**B illustrate an ear-worn electronic device arrangement incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIGS. **2**A and **2**B illustrate a custom hearing aid system which incorporates charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **3** illustrates an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **4** illustrates an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **5** illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **6** illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **7** illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **8**A illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **8**B illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **8**C illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **8**D illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIG. **8**E illustrates a charging interface of one or both of an ear-worn electronic device and a charging module in accordance with any of the embodiments disclosed herein;

FIGS. **8**F-**8**I illustrate a charging interface of an ear-worn electronic device in accordance with any of the embodiments disclosed herein;

FIG. **8**J illustrates a charging interface of a hearing device comprising a central data contact surrounded by a triangular arrangement of curvilinear-shaped peripheral contacts coupled to a multi-phase rectifier in accordance with any of the embodiments disclosed herein;

FIG. **8**K illustrates a charging interface of a charging module comprising a central data pin surrounded by a pair of arcuate contacts in accordance with any of the embodiments disclosed herein;

FIG. **9** is a cross-sectional view of a portion of a hearing device comprising charging circuitry in accordance with any of the embodiments disclosed herein;

FIG. **10** is a cross-sectional view of a portion of a charging module comprising charging circuitry in accordance with any of the embodiments disclosed herein;

FIGS. **11** and **12** illustrate a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **13** is a schematic showing electrical components of a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **14**A is a schematic showing electrical components of a system comprising an ear-worn electronic device and a charging module respectively incorporating charging circuitry and functionality in accordance with any of the embodiments disclosed herein;

FIG. **14**B illustrates a charging interface of a hearing device comprising a central cathode pin surrounded by split-ring pin connectors in accordance with any of the embodiments disclosed herein;

FIG. **14**C illustrates a charging interface of a hearing device comprising a central data pin surrounded by split-ring pin connectors coupled to a multi-phase rectifier in accordance with any of the embodiments disclosed herein;

FIG. **14**D illustrates a charging interface of a charging module comprising a central data pin surrounded by split-ring pin connectors in accordance with any of the embodiments disclosed herein;

FIG. **15** illustrates a method of implementing accelerated charging of one or more hearing devices using a charging module in accordance with any of the embodiments disclosed herein; and

FIG. **16** is a graph that characterizes accelerated charging of a lithium-ion battery of a hearing device in accordance with any of the embodiments disclosed herein.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

DETAILED DESCRIPTION

It is understood that the embodiments described herein may be used with any ear-worn or ear-level electronic device without departing from the scope of this disclosure. The devices depicted in the figures are intended to demonstrate the subject matter, but not in a limited, exhaustive, or exclusive sense. Ear-worn electronic devices (also referred to herein as "hearing devices"), such as hearables (e.g., wearable earphones, ear monitors, and earbuds), hearing aids, hearing instruments, and hearing assistance devices, typically include an enclosure, such as a housing or shell, within which internal components are disposed. Typical components of a hearing device can include a processor (e.g., a digital signal processor or DSP), memory circuitry, power management circuitry, one or more communication devices (e.g., a radio, a near-field magnetic induction (NFMI) device), one or more antennas, one or more microphones, and a receiver/speaker, for example. Hearing devices can incorporate a long-range communication device, such as a Bluetooth® transceiver or other type of radio frequency (RF) transceiver. A communication device (e.g., a radio or NFMI device) of a hearing device can be configured to facilitate communication between a left ear device and a right ear device of the hearing device.

Hearing devices of the present disclosure can incorporate an antenna coupled to a high-frequency transceiver, such as a 2.4 GHz radio. The RF transceiver can conform to an IEEE 802.11 (e.g., WiFi®) or Bluetooth® (e.g., BLE, Bluetooth® 4. 2 or 5.0) specification, for example. It is understood that hearing devices of the present disclosure can employ other transceivers or radios, such as a 900 MHz radio. Hearing devices of the present disclosure can be configured to receive streaming audio (e.g., digital audio data or files) from an electronic or digital source. Representative electronic/digital sources (e.g., accessory devices) include an assistive listening system, a TV streamer, a radio, a smartphone, a laptop, a cell phone/entertainment device (CPED) or other electronic device that serves as a source of digital audio data or other types of data files. Hearing devices of the present disclosure can be configured to effect bi-directional communication (e.g., wireless communication) of data with an external source, such as a remote server via the Internet or other communication infrastructure. Hearing devices that include a left ear device and a right ear device can be configured to effect bi-directional communication (e.g., wireless communication) therebetween, so as to implement ear-to-ear communication between the left and right ear devices.

The term hearing device of the present disclosure refers to a wide variety of ear-level electronic devices that can aid a person with impaired hearing. The term hearing device also refers to a wide variety of devices that can produce processed sound for persons with normal hearing. Hearing devices of the present disclosure include hearables (e.g., wearable earphones, headphones, earbuds, virtual reality headsets), hearing aids (e.g., hearing instruments), cochlear implants, and bone-conduction devices, for example. Hearing devices include, but are not limited to, behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC), receiver-in-canal (RIC), receiver-in-the-ear (RITE) or completely-in-the-canal (CIC) type hearing devices or some combination of the above. Throughout this disclosure, reference is made to a "hearing device," which is understood to refer to a system comprising a single left ear device, a single right ear device, or a combination of a left ear device and a right ear device.

FIGS. **1**A and **1**B illustrate various components of a representative hearing device arrangement in accordance with various embodiments. FIGS. **1**A and **1**B illustrate first and second hearing devices **100**A and **100**B configured to be supported at, by, in or on left and right ears of a wearer. In some embodiments, a single hearing device **100**A or **100**B can be supported at, by, in or on the left or right ear of a wearer. As illustrated, the first and second hearing devices **100**A and **100**B include the same functional components. It is understood that the first and second hearing devices **100**A and **100**B can include different functional components. The first and second hearing devices **100**A and **100**B can be representative of any of the hearing devices disclosed herein.

The first and second hearing devices **100**A and **100**B include an enclosure **101***a*, **101***b* configured for placement, for example, over or on the ear, entirely or partially within the external ear canal (e.g., between the pinna and ear drum) or behind the ear. Disposed within the enclosure **101***a*, **101***b* is a processor **102***a*, **102***b* which incorporates or is coupled to memory **103***a*, **103***b*. The processor **102***a*, **102***b* can include or be implemented as a multi-core processor, a digital signal processor (DSP), an audio processor or a combination of these processors. For example, the processor **102***a*, **102***b* may be implemented in a variety of different ways, such as with a mixture of discrete analog and digital components that include a processor configured to execute programmed instructions contained in a processor-readable storage medium (e.g., solid-state memory, e.g., Flash).

The processor **102***a*, **102***b* is coupled to a wireless transceiver **104***a*, **104***b* (also referred to herein as a radio), such as a BLE transceiver or other IEEE 802.11 compliant transceiver. The wireless transceiver **104***a*, **104***b* is operably coupled to an antenna **106***a*, **106***b* configured for transmitting and receiving radio signals. Impedance matching circuitry **105***a*, **105***b* can be operably coupled to the wireless transceiver **104***a*, **104***b* and the antenna **106***a*, **106***b*. The antenna **106***a*, **106***b* is disposed in, on, or extends from the enclosure **101***a*, **101***b*. The wireless transceiver **104***a*, **104***b* and the antenna **106***a*, **106***b* can be configured to operate in the 2.4 GHz ISM frequency band or other applicable communication band (referred to as the "Bluetooth® band" herein). The wireless transceiver **104***a*, **104***b* and antenna

106*a*, 106*b* can be configured to enable ear-to-ear communication between the two hearing devices 100A and 100B, as well as communications with an external device (e.g., a smartphone or a digital music player).

A battery 110*a*, 110*b* or other power source (rechargeable or conventional) is provided within the enclosure 101*a*, 101*b* and is configured to provide power to the various components of the hearing devices 100A and 100B. The battery 110*a*, 110*b* is coupled to power management circuitry 111*a*, 111*b*, such as a power management integrated circuit (PMIC). The power management circuitry 111*a*, 111*b* is coupled to a charging interface 113*a*, 113*b*, which is configured to physically and electrically couple to a corresponding charging interface of a charging module. A speaker or receiver 108*a*, 108*b* is coupled to an amplifier (not shown) and the processor 102*a*, 102*b*. The speaker or receiver 108*a*, 108*b* is configured to generate sound which is communicated to the wearer's ear.

In some embodiments, the hearing devices 100A and 100B include a microphone 112*a*, 112*b* mounted on or inside the enclosure 101*a*, 101*b*. The microphone 112*a*, 112*b* may be a single microphone or multiple microphones, such as a microphone array. The microphone 112*a*, 112*b* can be coupled to a preamplifier (not shown), the output of which is coupled to the processor 102*a*, 102*b*. The microphone 112*a*, 112*b* receives sound waves from the environment and converts the sound into an input signal. The input signal is amplified by the preamplifier and sampled and digitized by an analog-to-digital converter of the processor 102*a*, 102*b*, resulting in a digitized input signal. In some embodiments (e.g., hearing aids), the processor 102*a*, 102*b* (e.g., DSP circuitry) is configured to process the digitized input signal into an output signal in a manner that compensates for the wearer's hearing loss. When receiving an audio signal from an external source, the wireless transceiver 104*a*, 104*b* may produce a second input signal for the DSP circuitry of the processor 102*a*, 102*b* that may be combined with the input signal produced by the microphone 112*a*, 112*b* or used in place thereof. In other embodiments, (e.g., hearables), the processor 102*a*, 102*b* can be configured to process the digitized input signal into an output signal in a manner that is tailored or optimized for the wearer (e.g., based on wearer preferences). The output signal is then passed to an audio output stage that drives the speaker or receiver 108*a*, 108*b*, which converts the output signal into an audio output.

Some embodiments are directed to a custom hearing aid, such as an ITC, CIC, or IIC hearing aid, for example. For example, some embodiments are directed to a custom hearing aid which includes a wireless transceiver and an antenna arrangement configured to operate in the 2.4 GHz ISM frequency band (referred to as the "Bluetooth® band" herein). FIGS. 2A and 2B illustrate a custom hearing aid system which includes two hearing devices, e.g., left 201*a* and right 201*b* side hearing devices, configured to wirelessly communicate with each other and external devices and systems. FIG. 2A conceptually illustrates functional blocks of the hearing devices 201*a*, 201*b*. The position of the functional blocks in FIG. 2A does not necessarily indicate actual locations of components that implement these functional blocks within the hearing devices 201*a*, 201*b*. FIG. 2B is a block diagram of components that may be disposed at least partially within the enclosure 205*a*, 205*b* of the hearing device 201*a*, 201*b*.

Each hearing device 201*a*, 201*b* includes a physical enclosure 205*a*, 205*b* that encloses an internal volume. The enclosure 205*a*, 205*b* is configured for at least partial insertion within the wearer's ear canal. The enclosure 205*a*, 205*b* includes an external side 202*a*, 202*b* that faces away from the wearer and an internal side 203*a*, 203*b* that is inserted in the ear canal. The enclosure 205*a*, 205*b* comprises a shell 206*a*, 206*b* and a faceplate 207*a*, 207*b*. The faceplate 207*a*, 207*b* may include a battery door 208*a*, 208*b* or drawer disposed near the external side 202*a*, 202*b* of the enclosure 205*a*, 205*b* and configured to allow the battery 240*a*, 240*b* to be inserted and removed from the enclosure 205*a*, 205*b*. An antenna 220*a*, 220*b* can be mounted to the faceplate 207*a*, 207*b* or elsewhere in the enclosure 205*a*, 205*b*. The antenna arrangement 220*a*, 220*b* can include a matching circuit that compensates for a smaller size antenna which allows the antenna arrangement 220*a*, 220*b* to fit within a customized device, such as a device that fits partially or fully within the ear canal of the wearer. The matching circuit can be designed so that the power transfer from the transceiver of the electronics 230*a*, 230*b* to the antenna arrangement 220*a*, 220*b*, provides a specified antenna efficiency, e.g., an optimal antenna efficiency for the customized environment.

The battery 240*a*, 240*b* powers electronic circuitry 230*a*, 230*b* which is also disposed within the shell 206*a*, 206*b*. As illustrated in FIGS. 2A and 2B, the hearing device 201*a*, 201*b* may include one or more microphones 251*a*, 251*b* configured to pick up acoustic signals and to transduce the acoustic signals into microphone electrical signals. The electrical signals generated by the microphones 251*a*, 251*b* may be conditioned by an analog front end 231 (see FIG. 2B) by filtering, amplifying and/or converting the microphone electrical signals from analog to digital signals so that the digital signals can be further processed and/or analyzed by the processor 260. The processor 260 may perform signal processing and/or control various tasks of the hearing device 201*a*, 201*b*. In some implementations, the processor 260 comprises a DSP that may include additional computational processing units operating in a multi-core architecture.

The processor 260 is configured to control wireless communication between the hearing devices 201*a*, 201*b* and/or an external accessory device (e.g., a smartphone, a digital music player) via the antenna 220*a*, 220*b*. The wireless communication may include, for example, audio streaming data and/or control signals. The electronic circuitry 230*a*, 230*b* of the hearing device 201*a*, 201*b* includes a transceiver 232. The transceiver 232 has a receiver portion that receives communication signals from the antenna arrangement 220*a*, 220*b*, demodulates the communication signals, and transfers the signals to the processor 260 for further processing. The transceiver 232 also includes a transmitter portion that modulates output signals from the processor 260 for transmission via the antenna arrangement 220*a*, 220*b*. Electrical signals from the microphone 251*a*, 251*b* and/or wireless communication received via the antenna 220*a*, 220*b* may be processed by the processor 260 and converted to acoustic signals played to the wearer's ear 299 via a speaker 252*a*, 252*b*.

The battery 240*a*, 240*b* is of a rechargeable type, such as a lithium-ion battery for example. Power management circuitry 241*a*, 241*b* (e.g., a PMIC) is operatively coupled to the battery 240*a*, 240*b* and to a charging interface 243*a*, 243*b*. The charging interface 243*a*, 243*b* is configured to physically and electrically couple to a corresponding charging interface of a charging module.

The use of rechargeable batteries in hearing devices (e.g., hearing aids) has been well-received in the marketplace. Self-contained batteries require electrical contacts for recharging. One complication of contact charging is the difficulty of placing a relatively small hearing device in a

charger. Traditional approaches for charging hearing devices often require the wearer to fiddle with the hearing device to achieve the proper connection for charging. There is a need to provide a connection arrangement that allows the wearer to properly attach the hearing device to the charging fixture of the charger with relative ease.

Contact charging requires two electrical connections, namely, an anode (positive) connection and a cathode (negative) connection. When placing a hearing device into a charging fixture, it can be advantageous to connect the cathodes prior to connecting the anodes. For example, connecting the cathodes of the hearing devices and the charging fixture prior to connecting the anodes can serve to provide a consistent inrush current waveform when coupling the hearing devices and charger fixture together. Provision of a consistent inrush current waveform from the charger to the hearing devices informs the charging circuitry of the charger that the hearing devices are properly attached to the proper charging fixture and that a charging procedure can be initiated. If the hearing devices are properly connected to the charging fixture, full charging power can be supplied by the charging fixture to the hearing devices. If one or both of the hearing devices are not properly connected to the charging fixture, charging through the improper connection can be disabled. This can protect against the presence of foreign objects (e.g., keys, coins, other hearing devices) that can be intentionally or unintentionally introduced into the charging fixture. In some implementations, connecting the cathodes of the hearing devices and charger fixture prior to connecting the anodes can serve to establish a ground, which can reduce or minimize spurious electrical spikes in the circuitry.

A system comprising a charging module and at least one hearing device in accordance with any of the embodiments disclosed herein provides a number of technical advantages over conventional charging arrangements. As discussed above, a charging system according to any of the embodiments disclosed herein facilitates connection between charger and hearing device cathodes prior to connection between anodes, which provides for a consistent inrush current waveform when coupling the hearing devices and charger fixture together. A charging system according to any of the embodiments disclosed herein provides enhanced detection of incorrect placement of hearing devices and/or presence of foreign conductive objects at the charging interface, which results in disabling of charging through the improper connection. A charging system according to any of the embodiments disclosed herein significantly reduces or minimizes spurious electrical spikes in the circuitry, by ensuring that the cathodes of the hearing devices and charger fixture are connected prior to connecting the anodes.

Embodiments of the disclosure are defined in the claims. However, below there is provided a non-exhaustive listing of non-limiting examples. Any one or more of the features of these examples may be combined with any one or more features of another example, embodiment, or aspect described herein.

Example Ex1. A system comprising at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact. A charging module comprises a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact; an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

Example Ex2. The system according to Ex1, wherein the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

Example Ex3. The system according to Ex2, wherein the second cathode contact comprises an elongated electrode; and the biasing arrangement comprises a spring.

Example Ex4. The system according to Ex2 or Ex3, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

Example Ex5. The system according to one or more of Ex1 to Ex4 comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

Example Ex6. The system according to Ex5, wherein the retention arrangement comprises one or more magnets or a mechanical retention arrangement.

Example Ex7. The system according to one or more of Ex1 to Ex6, wherein the first anode contact is configured to communicate power and one or more disparate information signals, the second anode contact is configured to communicate power and the one or more disparate information signals, and the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

Example Ex8. The system according to Ex7, wherein the one or more disparate information signals comprise one or more of data signals generated by one or both of the charging module and the hearing device, audio signals generated by one or both of the charging module and the hearing device, and signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

Example Ex9. The system according to one or more of Ex1 to Ex8, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

Example Ex10. The system according to one or more of Ex1 to Ex9, wherein the first anode contact comprises a plurality of electrode elements, and the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

Example Ex11. The system according to Ex10, wherein the second anode contact comprises a plurality of electrode elements, and the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

Example Ex12. The system according to Ex10 or Ex11, wherein one of both of the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact, and the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

Example Ex13. The system according to Ex10 or Ex11, wherein one of both of the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact, and the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

Example Ex14. The system according to one or more of Ex1 to Ex13, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

Example Ex15. The system according to one or more of Ex1 to Ex14, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0 C when a state of charge (SoC) of the rechargeable power sources is within a predetermined SoC range.

FIG. **3** illustrates a system in accordance with any of the embodiments disclosed herein. FIG. **3** shows a cross-sectional view of a portion of an ear-worn electronic hearing device **302** and a portion of a charging module **322**. The components of the hearing device **302** shown in FIG. **3** are disposed in or on a housing configured to be worn at, in or on an ear of a wearer. The hearing device **302** includes a rechargeable power source **304** (e.g., a lithium-ion battery) coupled to power management circuitry **306** (e.g., a PMIC). The power management circuitry **306** is coupled to a first charging interface **310** comprising a first cathode contact **312** and a first anode contact **314** spaced apart from the first cathode contact **312**. In the embodiment shown in FIG. **3**, the power management circuitry **306** is coupled to the first cathode contact **312** via a first connection **307** and to the first anode contact **314** via a second connection **309**. The first anode contact **314** can comprise a single contact or a multiplicity of contacts coupled to the second connection **309**.

The charging module **322** includes a second charging interface **330** configured to detachably couple (e.g., mechanically and electrically) with the first charging interface **310** of the hearing device **302**. The second charging interface **330** includes a second anode contact **334** having a contact surface **335** and a displaceable second cathode contact **332**. The charging module **322** includes charging circuitry **326** coupled to the second charging interface **330** and a power source **324**. The power source **324** can be configured to receive power from a standard wall outlet and/or can include a rechargeable or a conventional battery. In some embodiments, the power source **324** can be configured to receive wireless power from an external power source (e.g., inductive, radiofrequency, optical). For example, the power source **324** can be configured to implement inductive charging in accordance with the Qi open interface standard developed by the Wireless Power Consortium. In the embodiment shown in FIG. **3**, the charging circuitry **326** is coupled to the second cathode contact **332** via a connection **337** and to the second anode contact **334** via a second connection **339**. The second anode contact **334** can comprise a single contact or a multiplicity of contacts coupled to the second connection **339**.

The second cathode contact **332** is configured for displacement between a first position **331***a* above the contact surface **335** of the second anode contact **334** and a second position **331***b* at or below the contact surface **335** of the second anode contact **334**. In some configurations, the second cathode contact **332** can be configured for displacement between the first position **331***a* above the contact surface **335** and a second position **331***b* above the contact surface **335** but below the first position **331***a*.

When the hearing device **302** and the charging module **322** are in a non-contacting relationship, such as shown in FIG. **3**, the second cathode contact **332** is positioned at the first position **331***a* above the contact surface **335** of the second anode contact **334**. When the hearing device **302** and the charging module **322** are in a contacting relationship, the second cathode contact **332** is movable from the first position **331***a* to the second position **331***b* and establishes electrical contact with the first cathode contact **312** prior to electrical contact being established between the second anode contact **334** and the first anode contact **314**.

More particularly, when the hearing device **302** and the charging module **322** are brought into contact with one another, the second cathode contact **332** positioned at the first position **331***a* establishes electrical contact with the first cathode contact **312** of the hearing device **302** prior to electrical contact being established between the first and second anode contacts **314**, **334**. After first establishing electrical contact between the first and second cathode contacts **312**, **332**, the second cathode contact **332** is displaced into the body of the charging module **322** as the hearing device **302** is forcibly advanced onto the charging module **322**. After displacing the second cathode into the body of the charging module **322** partially or entirely, electrical contact is then established between the first and second anode contacts **314**, **334**.

The charging module **322** includes an arrangement (shown in other figures) configured to displace at least a portion of the second cathode contact **332** above the contact surface **335** to facilitate electrical contact between the first and second cathode contacts **312**, **332** prior to electrical contact between the first and second anode contacts **314**, **334**. The charging module **322** can also include a retention arrangement (shown in other figures) configured to maintain engagement between the first and second charging interfaces **310**, **330** during charging of the rechargeable power source **304** of the hearing device **302**. In some embodiments, the retention arrangement can comprise one or more magnets disposed at or near one or both of the first and second charging interfaces **310**, **330**. In other embodiments, the retention arrangement can comprise a mechanical retention arrangement configured to mechanically maintain engagement between the first and second charging interfaces **310**, **330**.

FIG. **4** illustrates a system in accordance with any of the embodiments disclosed herein. FIG. **4** shows a cross-sectional view of a portion of an ear-worn electronic hearing device **402** and a portion of a charging module **422**. The components of the hearing device **402** shown in FIG. **4** are disposed in or on a housing configured to be worn at, in or on an ear of a wearer. The hearing device **402** includes a rechargeable power source **404** (e.g., a lithium-ion battery) coupled to power management circuitry **406** (e.g., a PMIC). The power management circuitry **406** is coupled to a first charging interface **410**. In the embodiment shown in FIG. **4**, the first charging interface **410** comprises a first cathode contact **412** and a multiplicity of anode contacts, **414**, **416**. In the illustrative example shown in FIG. **4**, the first charging interface **410** includes two anode contacts **414**, **416**, it being understood that the first charging interface **410** can include more than two spaced-apart anode contacts (e.g., 3, 4, 5 or 6 anode contacts).

In the embodiment shown in FIG. **4**, the power management circuitry **406** is coupled to the first cathode contact **412**

via a first connection **407** and to the first and second anode contacts **414**, **416** via separate connections. As shown, the power management circuitry **406** is coupled to the first anode contact **414** via a connection **409** and to the second anode contact **416** via a connection **411**. It is understood that each physically separate anode contact of the first charging interface **410** can be coupled to the power management circuitry **406** via a separate electrical conductor. It is also understood that, in some configurations, the first charging interface **410** can include anode contacts coupled to the power management circuitry **406** via separate connections in combination with two or more anode contacts coupled to the power management circuitry **406** via a common connection.

The charging module **422** includes a second charging interface **430** configured to detachably couple (e.g., mechanically and electrically) with the first charging interface **410** of the hearing device **402**. The charging module **422** includes charging circuitry **426** coupled to the second charging interface **430** and a power source **424**. The power source **424** can be configured to receive power from a standard wall outlet and/or can include a rechargeable or a conventional battery. In some embodiments, the power source **424** can be configured to receive wireless power from an external power source (e.g., inductive, radiofrequency, optical). For example, the power source **424** can be configured to implement inductive charging in accordance with the Qi open interface standard developed by the Wireless Power Consortium. The second charging interface **430** includes a second cathode contact **432** and a multiplicity of anode contacts **434**, **436**. In the embodiment shown in FIG. **4**, the second cathode contact **432** is fixed in terms of its position on the charging module **422**. In this regard, the second cathode contact **432** shown in FIG. **4** it is not a displaceable cathode contact. However, it is understood that, in a variant embodiment of FIG. **4**, the second cathode contact **432** can be implemented as a displaceable cathode contact in the manner illustrated and described with reference to FIG. **3**.

In the illustrative example shown in FIG. **4**, the second charging interface **430** includes two anode contacts **434**, **436**, it being understood that the second charging interface **430** can include more than two spaced-apart anode contacts (e.g., 3, 4, 5 or 6 anode contacts). The number of anode contacts of the second charging interface **430** may or may not be equal to the number of anode contacts of the first charging interface **410**. In the embodiment shown in FIG. **4**, the charging circuitry **426** is coupled to the second cathode contact **432** via a connection **437** and to the first and second anode contacts **434**, **436** via separate connections. More particularly, the first anode contact **434** is coupled to the charging circuitry **426** via connection **439**, and the second anode contact **436** is coupled to the charging circuitry **426** via connection **441**.

The charging module **422** can include a retention arrangement (shown in other figures) configured to maintain engagement between the first and second charging interfaces **410**, **430** during charging of the rechargeable power source **404** of the hearing device **402**. In some embodiments, the retention arrangement can comprise one or more magnets disposed at or near one or both of the first and second charging interfaces **410**, **430**. In other embodiments, the retention arrangement can comprise a mechanical retention arrangement configured to mechanically maintain engagement between the first and second charging interfaces **410**, **430**.

Provision of electrically separate anode contacts at the first and second charging interfaces **410**, **430** provides for the communication of power and one or more disparate information signals between the charging module **422** and the hearing device **402**. For example, charging of the rechargeable power supply **404** can be accomplished via first and second cathode contacts **412**, **432** and anode contacts **414**, **434**. Data signals generated by one or both of the charging module **422** and the hearing device **402** can be communicated via anode contacts **416**, **436**. Although referred to as anode contacts generally, it is understood that the contacts of the first and second charging interfaces **410**, **430** that are used for communicating information signals can be any form of electrical contact. Various types of disparate information signals can be communicated between respective pairs of anode contacts of the first and second charging interfaces **410**, **430**. The disparate forms of information signals can include state of charge and charging status data, control or command signals, audio signals, video signals, and signals from one or more accessory devices (e.g., smartphone, tablet, wearable sensor) configured to communicatively couple to one or both of the hearing device **402** and charging module **422**.

FIG. **5** illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **500** shown in FIG. **5** includes a cathode contact **502**, which is typically coupled to a negative contact charging connection **506**. The charging interface **500** also includes an anode contact **504**, which is typically coupled to a positive contact charging connection **508**. In the embodiment shown in FIG. **5**, the cathode contact **502** is surrounded by the anode contact **504**, which has a continuous annular configuration.

In some embodiments, the hearing device and the charging module can have a charging interface that generally corresponds to the charging interface **500** shown in FIG. **5**. When implemented on a hearing device, for example, a region of the cathode contact **502** (e.g., central region) can be recessed relative to a contact surface of the anode contact **504** (see, e.g., FIGS. **9** and **12**). When implemented on a charging module, and according to some embodiments, the cathode contact **502** can be displaceable (see, e.g., FIGS. **3**, **10**, and **11**) and proud relative to a contact surface of the anode contact **504**. In other embodiments, the cathode contact **502** is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact **504**. Although shown as having a generally circular shape, the cathode and anode contacts **502**, **504** can have any curvilinear or polygonal shape.

FIG. **6** illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **600** shown in FIG. **6** includes a cathode contact **602**, which is typically coupled to a negative contact charging connection **606**. The charging interface **600** also includes an anode contact **604**, which is typically coupled to a positive contact charging connection **608**. In the embodiment shown in FIG. **6**, the anode contact **604** comprises a multiplicity of electrode elements **604***a*, **604***b*, **604***c*, each of which is coupled to connection **608**. The anode contact **604** has a concentric tri-trace anode configuration. As shown, the cathode contact **602** is surrounded by the concentric tri-trace anode **604** comprising arcuate electrode elements **604***a*, **604***b*, **604***c*. The arcuate electrode elements **604***a*, **604***b*, **604***c* are situated at substantially the same radius (e.g., ~4-5 mm) relative to the cathode contact **602** (e.g., ~2-3 mm diameter). Although three arcuate electrode elements are shown in FIG. **6**, the concentric anode **604** can comprise two, four, five or more electrode elements, for example.

In some embodiments, the hearing device and the charging module can have a charging interface that generally

corresponds to the charging interface **600** shown in FIG. **6**. When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact **602** (e.g., central region) can be recessed relative to a contact surface of the anode contact **604** (see, e.g., FIGS. **9** and **12**). When implemented on a charging module, for example, the cathode contact **602** can be displaceable (see, e.g., FIGS. **10** and **11**) and proud relative to a contact surface of the anode contact **604**. Although shown as having a generally circular or arcuate shape, the cathode and anode contacts **602**, **604** can have any curvilinear or polygonal shape.

It is understood that the charging interface of the hearing device and that of the charging module can be substantially the same or different in configuration. For example, and in accordance with some embodiments, the charging module can have a charging interface corresponding to the charging interface **500** shown in FIG. **5** (cathode contact surrounded by an annular anode contact). In such embodiments, the hearing device can have a charging interface corresponding to the charging interface **600** shown in FIG. **6** (cathode contact surrounded by tri-trace anode contact).

FIG. **7** illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **700** shown in FIG. **7** includes a cathode contact **702** surrounded by a multiplicity of anode elements **704***a*, **704***b*, **704***c*. In the embodiment shown in FIG. **7**, the cathode contact **702** and anode elements **704***a*, **704***b*, **704***c* have a polygonal shape. For example, the cathode contact **702** has a generally square shape, and each of the anode elements **704***a*, **704***b*, **704***c* has a generally rectangular shape. It is understood that a charging interface can include cathode and anode contact elements having the same or different curvilinear or polygonal shape.

FIG. **8**A illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **800** shown in FIG. **8**A includes a cathode contact **802**, which is typically coupled to a negative contact charging connection **806**. The charging interface **800** also includes an anode contact **804**, which comprising a contact element typically coupled to a positive contact charging connection **808**. In the embodiment shown in FIG. **8**A, the anode contact **804** has a concentric tri-trace anode configuration comprising a multiplicity of electrode elements **804***a*, **804***b*, **804***c*. As shown, the cathode contact **802** is surrounded by the concentric tri-trace anode **804** comprising individual arcuate electrode elements **804***a*, **804***b*, **804***c*. The arcuate electrode elements **804***a*, **804***b*, **804***c* are situated at substantially the same radius relative to the cathode contact **802**. Although three arcuate electrode elements are shown in FIG. **8**A, the concentric anode **804** can comprise two, four, five or more electrode elements, for example.

According to various embodiments, a hearing device and a charging module incorporate the charging interface **800** shown in FIG. **8**A. Each of the electrode elements of the anode contact **804** is coupled to a separate electrical connection. More particularly, electrode element **804***a* is coupled to connection **810**, electrode element **804***b* is coupled to connection **808**, and electrode element **804***c* is coupled to connection **812**. Electrode element **804***b* represents an anode contact of the charging interface **800**. The electrode element **804***b* and the cathode contact **802** are configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device and the charging module via electrode elements **804***a*, **804***c* and connections **810**, **812**. For example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device.

When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact **802** (e.g., central region) can be recessed relative to a contact surface of the anode contact **804** (see, e.g., FIGS. **9** and **12**). Alternatively, the cathode contact **802** and the anode contact **804** can be substantially coplanar. When implemented on a charging module, and in accordance with some embodiments, the cathode contact **802** is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact **804**. In accordance with other embodiments, the cathode contact **802** can be displaceable (see, e.g., FIGS. **10** and **11**) and proud relative to a contact surface of the anode contact **804**. Although shown as having a generally circular or arcuate shape, the cathode and anode contacts **802**, **804** can have any curvilinear or polygonal shape.

FIG. **8**B illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **820** shown in FIG. **8**B includes an arrangement of electrodes **824** comprising at least one cathode contact **824***a* and at least one anode contact **824***b*. The electrode arrangement **824** can include additional electrodes, such as electrode **824***c*, which can be a cathode contact or an anode contact. It is understood that the electrodes of the arrangement **824** can be configured as cathode or anode contacts, as long as the arrangement of electrodes **824** includes at least one cathode contact and at least one anode contact. A data contact **822** is shown surrounded by electrodes of the electrode arrangement **824**. In the representative embodiment shown in FIG. **8**B, the electrode arrangement **824** has a concentric tri-trace electrode configuration comprising contacts **824***a*, **824***b*, **824***c*, which surround data contact **822**. In some embodiments, the electrode arrangement **824** includes two arcuate electrodes, such as cathode contact **824***a* and anode contact **824***b*, which can be spaced apart from one another in the manner shown in FIG. **14**D, for example. The arcuate electrode elements **824***a*, **824***b*, **824***c* are situated at substantially the same radius relative to the data contact **822**. Although three arcuate electrode elements are shown in FIG. **8**B, the electrode arrangement **824** can comprise two, four, five or more electrode elements, for example.

According to various embodiments, a hearing device and a charging module incorporate the charging interface **820** shown in FIG. **8**B. Cathode contact **824***a* is typically coupled to a negative contact charging connection **830**, and anode contact **824***b* is typically coupled to a positive contact charging connection **828**. Electrical contact **824***c* can be coupled to either a negative or a positive charging connection **832**. The electrode arrangement **824** is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. One or more information signals can be communicated between the hearing device and the charging module via data contact **822** via signal connection **826**. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device.

FIG. **8**C illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **840***a* shown in FIG. **8**C includes a cathode contact **842**, which is typically coupled to a negative contact charg-

ing connection **846**. The charging interface **840***a* also includes an anode contact **844**, which is typically coupled to a positive contact charging connection **848**. In the embodiment shown in FIG. **8**C, the anode contact **844** comprises a multiplicity of electrode elements **844***a*, **844***b*, **844***c*, each of which is coupled to connection **848**. The anode contact **844** has a triangular configuration, and is arranged to surround the cathode contact **842**. The triangular anode contact **844** includes three electrode elements **844***a*, **844***b*, **844***c* each having a generally curvilinear shape. In some embodiments, the electrode elements **844***a*, **844***b*, **844***c* have a closed curved shape comprising only curved lines (e.g., no line segments). For example, the electrode elements **844***a*, **844***b*, **844***c* can have a non-polygonal shape (e.g., a geometric shape that does not conform to the definition of a polygon). Representative examples of electrode elements **844***a*, **844***b*, **844***c* having a generally curvilinear shape include those having a generally round (e.g., circular) shape, an elliptical shape, and an oval shape. It is understood that the electrode elements **844***a*, **844***b*, **844***c* can also have an arbitrary closed curvilinear shape (e.g., a meandering shape) and/or a closed curvilinear shape comprising predominately curved lines (e.g., a minor percentage (≤10-20%) of line segments).

The electrode elements **844***a*, **844***b*, **844***c* can be situated at substantially the same distance (e.g., ~2-6 mm, ~4-5 mm, ~3-5 mm) relative to the cathode contact **842**. The cathode contact **842** can have a diameter of about 1.5 mm to about 3 mm, and the electrode elements **844***a*, **844***b*, **844***c* can have the same or smaller diameter (e.g., about 1 mm to about 2.5 mm). Although three electrode elements **844***a*, **844***b*, **844***c* are shown in FIG. **8**C, the anode contact **844** can comprise one, two, four, five or more electrode elements, for example, arranged in a substantially triangular shape. Also, although the electrode elements **842**, **844***a*, **844***b*, **844***c* are shown having the same general shape in FIG. **8**C (and other figures), it is understood that the electrode elements **842**, **844***a*, **844***b*, **844***c* can have different shapes. For example, the electrode elements **842**, **844***a*, **844***b*, **844***c* can have different curvilinear shapes or any combination of generally curvilinear shapes and generally rectilinear shapes.

When implemented on a hearing device, and in accordance with some embodiments, a region of the cathode contact **842** (e.g., central region) can be recessed relative to a contact surface of the anode contact **844** (see, e.g., FIGS. **9** and **12**). Alternatively, the cathode contact **842** and the anode contact **844** can be substantially coplanar. When implemented on a charging module, and in accordance with some embodiments, the cathode contact **842** is a fixed electrical element (non-displaceable) and need not be proud relative to a contact surface of the anode contact **844**. In accordance with other embodiments, the cathode contact **842** can be displaceable (see, e.g., FIGS. **10** and **11**) and proud relative to a contact surface of the anode contact **844**.

FIG. **8**D illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **840***b* shown in FIG. **8**D includes a cathode contact **842**, which is typically coupled to a negative contact charging connection **846**. The charging interface **840***b* also includes an anode contact **844**, which is typically coupled to a positive contact charging connection **848**. In the embodiment shown in FIG. **8**D, the anode contact **844** has a triangular anode configuration comprising a multiplicity of electrode elements **844***a*, **844***b*, **844***c*. As shown, the cathode contact **842** is surrounded by the triangular anode **844** comprising individual electrode elements **844***a*, **844***b*, **844***c*. The electrode elements **844***a*, **844***b*, **844***c* are situated at substantially the same distance relative to the cathode contact **842**. Although three electrode elements **844***a*, **844***b*, **844***c* are shown in FIG. **8**D, the anode contact **844** can comprise one, two, four, five or more electrode elements, for example, arranged in a generally triangular shape. The electrode elements **842**, **844***a*, **844***b*, **844***c* can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to FIG. **8**C.

According to various embodiments, a hearing device and a charging module can incorporate the charging interface **840***b* shown in FIG. **8**D. Each of the electrode elements of the anode contact **844** is coupled to a separate electrical connection. More particularly, electrode element **844***a* is coupled to connection **850**, electrode element **844***b* is coupled to connection **848**, and electrode element **844***c* is coupled to connection **852**. Electrode element **844***b* represents an anode contact of the charging interface **840***b*. The electrode element **844***b* and the cathode contact **842** are configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device and the charging module via electrode elements **844***a*, **844***c* and connections **850**, **852**. For example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device.

FIG. **8**E illustrates a charging interface in accordance with any of the embodiments disclosed herein. The charging interface **840***c* shown in FIG. **8**E includes an arrangement of electrodes **844** comprising at least one cathode contact **844***a* and at least one anode contact **844***b*. The electrode arrangement **844** can include additional electrodes, such as electrode **844***c*, which can be a cathode contact or an anode contact. It is understood that any of the electrodes of the arrangement **844** can be configured as cathode or anode contacts, as long as the arrangement of electrodes **844** includes at least one cathode contact and at least one anode contact. A data contact **842** is shown surrounded by electrodes of the electrode arrangement **844**. The electrode elements **842**, **844***a*, **844***b*, **844***c* can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to FIG. **8**C.

In the representative embodiment shown in FIG. **8**E, the electrode arrangement **844** has a generally triangular configuration comprising contacts **844***a*, **844***b*, **844***c*, which surround data contact **842**. In some embodiments, the electrode arrangement **844** can include two electrodes, such as cathode contact **844***a* and anode contact **844***b*, which are shaped to generally form a triangular pattern and can be spaced apart (e.g., equidistantly) from the data contact **842**. The electrode elements **844***a*, **844***b*, **844***c* can be situated at substantially the same distance relative to the data contact **842**. Although three curvilinear shaped electrode elements **844***a*, **844***b*, **844***c* are shown surrounding the central data contact **842** in FIG. **8**E, the electrode arrangement **844** can comprise one, two, four, five or more curvilinear shaped electrode elements that having a generally triangular pattern and surround the data contact **842**.

According to various embodiments, a hearing device and a charging module can incorporate the charging interface **840***c* shown in FIG. **8**E. Cathode contact **844***a* is typically coupled to a negative contact charging connection **850**, and anode contact **844***b* is typically coupled to a positive contact charging connection **848**. Electrical contact **844***c* can be coupled to either a negative or a positive charging connection **852**. The electrode arrangement **844** is configured to

communicate power produced by the charging module when charging the rechargeable power source of the hearing device. One or more information signals can be communicated between the hearing device and the charging module via data contact **842** and signal connection **846**. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device.

When implemented on a hearing device, and in accordance with either of the embodiments shown in FIGS. **8**D and **8**E, a region of the central contact **842** (e.g., central region) can be recessed relative to a contact surface of the peripheral contacts **844***a*, **844***b*, **844***c* (see, e.g., FIGS. **9** and **12**). Alternatively, the central contact **842** and the peripheral contacts **844***a*, **844***b*, **844***c* can be substantially coplanar. In accordance with either of the embodiments shown in FIGS. **8**D and **8**E (and other embodiments shown in other figures), when implemented on a hearing device, a region of the central contact **842** (e.g., central region) can be elevated relative to a contact surface of the peripheral contacts **844***a*, **844***b*, **844***c*.

FIGS. **8**F-**8**I illustrate a custom hearing device (e.g., a custom hearing aid) in accordance with any of the embodiments disclosed herein. The hearing device **860** shown in FIGS. **8**F-**8**I is configured to be worn at least partially within the ear canal of a wearer's ear. The hearing device **860** is representative of any type of ITE hearing aid, such as an ITC, IIC or CIC hearing aid, for example. The hearing device **860** includes a faceplate **862** and a shell **864** connected to the shell **864**. The shell **864** houses the electronic and electrical components of the hearing device **860**, such as those previously described. The shell **864** is typically shaped to conform to a particular wearer's ear canal using a mold taken from the wearer's ear. In some configurations, the shell **864** can be constructed from semi-soft material (e.g., polymeric material) which can conform to the shape of the wearer's ear canal when the shell **864** is inserted therein. The faceplate **862** includes a charging interface **840***d* and other components/structures of the hearing device **860**, such as one or two microphones **866**.

The charging interface **840***d* disposed on the faceplate **862** comprises a central contact **842** surrounded by three peripheral contacts **844***a*, **844***b*, **844***c* arranged in a substantially triangular pattern. The peripheral contacts **844***a*, **844***b*, **844***c* can be situated at substantially the same distance (e.g., ~2-5 mm, ~4-5 mm, ~3-4 mm) relative to the central contact **842**. The central contact **842** can have a diameter of about 2 mm to about 3 mm, and the peripheral contacts **844***a*, **844***b*, **844***c* can have the same or smaller diameter (e.g., about 1 mm to about 2.5 mm, ~1.5-2 mm).

The charging interface **840***d* can be representative of any of the charging interfaces discussed herein. For example, charging interface **840***d* can be configured and wired in the manner of charging interface **840***a* shown in FIG. **8**C. In this representative configuration, the charging interface **840***d* includes a central cathode contact **842**, coupled to a negative charging connection, and three anode contacts **844***a*, **844***b*, **844***c*, each coupled to a positive charging connection. The anode contacts **844***a*, **844***b*, **844***c* are arranged in a substantially triangular pattern and surround the cathode contact **842**. The contacts **842**, **844***a*, **844***b*, **844***c* can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to FIG. **8**C.

According to another example embodiment, the charging interface **840***d* can be configured and wired in the manner of charging interface **840***b* shown in FIG. **8**D. In this representative configuration, central contact **842** is configured as a cathode contact and peripheral contact **844***b* is an anode contact of the charging interface **840***d*. Central cathode contact **842** and peripheral anode contact **844***b* are configured to communicate power produced by a charging module when charging the rechargeable power source of the hearing device **860**. Disparate information signals (e.g., signals S_1 and S_2) can be communicated between the hearing device **860** and the charging module via peripheral contacts **844***a*, **844***c*. For example, signals S_1 can constitute data signals (e.g., state of charge and charging status data signals) and signals S_2 can constitute control signals generated by the charging module and/or the hearing device **860**.

According to another example embodiment, the charging interface **840***d* can be configured and wired in the manner of charging interface **840***c* shown in FIG. **8**E. In this representative configuration, the charging interface **840***d* includes at least one cathode contact **844***a* and at least one anode contact **844***b*. Electrode **844***c* can be configured as a cathode contact or an anode contact (or a separate signal communicating contact). A central data contact **842** can be surrounded by contacts **844***a*, **844***b*, **844***c* arranged in a substantially triangular pattern. The contacts **842**, **844***a*, **844***b*, **844***c* can have a generally curvilinear shape or other shapes and/or combination of shapes discussed above with reference to FIG. **8**C.

In accordance with any of the embodiments shown in FIGS. **8**F-**8**I, a region of the charging interface **840***d* which includes the central contact **842** (e.g., central region) can be recessed relative to a contact surface of the peripheral contacts **844***a*, **844***b*, **844***c* (see, e.g., FIGS. **9** and **12**). Alternatively, the central contact **842** and the peripheral contacts **844***a*, **844***b*, **844***c* can be substantially coplanar. In accordance with alternative embodiments, the central region of the charging interface **840***d* which includes the central contact **842** can be elevated relative to a contact surface of the peripheral contacts **844***a*, **844***b*, **844***c*. In accordance with any of the embodiments disclosed herein, the peripheral contacts **844***a*, **844***b*, **844***c* can be surrounded by a peripheral wall having a height greater than that of an exposed surface of peripheral contacts **844***a*, **844***b*, **844***c*.

FIG. **8**J illustrates a charging interface of a hearing device in accordance with any of the embodiments disclosed herein. The charging interface **870** shown in FIG. **8**J includes an arrangement of peripheral electrodes **874** comprising at least one cathode contact **874***a* and at least one anode contact **874***b*. The peripheral electrode arrangement **874** can include additional electrodes, such as electrode **874***c*, which can be an anode contact or a cathode contact. A data contact **872** is shown surrounded by electrodes of the electrode arrangement **874**. In the representative embodiment shown in FIG. **8**J, each of the peripheral electrodes **874***a*, **874***b*, **874***c* and the data contact **872** has a generally curvilinear shape (e.g., rounded, circular, elliptical, oval).

The charging interface **870** is coupled to poly-phase rectification circuitry disposed in the housing of the hearing device, which is illustrated as a 3-phase rectifier **890** in FIG. **8**J. Contacts **874***a*, **874***b*, and **874***c* are coupled to the 3-phase rectifier **890** via charging connections **880**, **878**, and **882**, respectively. The electrode arrangement **874** is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. In the embodiment shown in FIG. **8**J, power is contained within the concentric electrode arrangement **874**. Using this electrode configuration, if at least one contact of the electrode arrangement **874** is connected to ground (GND) and at least one other contact of the electrode

arrangement **874** is connected to power (PWR), then the 3-phase rectifier **890** will supply the correct polarity with the correct voltage.

The charging interface **870** of the hearing device is configured to establish electrical connection with a charging interface **891** of a charging module, an example of which is shown in FIG. **8**K. The charging interface **870** of the hearing device includes at least two contacts **874***a*, **874***b* which serve as cathode and anode contacts. The two contacts **896**, **898** of the charging module's charging interface **891** are configured and arranged so that each contact **896**, **898** electrically connects with only one of the three contacts **874***a*, **874***b*, **874***c* of the hearing device's charging interface **870**. This arrangement ensures that anode and cathode contacts of the hearing device electrically connect with respective anode and cathode contacts of the charging module. In FIG. **8**K, the contacts **896**, **898** of the charging module's charging interface **891** are shown as having an arcuate shape. The contacts **896**, **898** may alternatively have a curvilinear shape, a rectilinear shape, or other shape.

One or more information signals can be communicated between the hearing device and the charging module via data contact **872** and signal connection **876**. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device. One or more disparate signals can be communicated over data contact **872** using a sequential or multiplexing data transmission technique (e.g., time-division multiplexing, frequency-division multiplexing, code-division multiplexing).

FIG. **9** is a cross-sectional view of a portion of a hearing device in accordance with any of the embodiments disclosed herein. The portion of the hearing device **900** shown in FIG. **9** includes a charging interface **902** incorporated on the shell or housing **904** of the hearing device **900**. The charging interface **902** is situated at or near an exterior surface of the housing **904**. For example, the charging interface **902** can be situated on a faceplate of an in-the-ear type hearing device (e.g., ITE, ITC, IIC, CIC device). In the case of an on-the-ear type hearing device (e.g., BTE, MC, RITE device), for example, the charging interface **902** can be situated at or near a bottom or top end surface of the housing **902**. The charging interface **902** is configured to physically and electrically coupled to a corresponding charging interface of a charging module (see, e.g., FIGS. **3**, **4**, **10**, and **11**).

The charging interface **902** includes a cathode contact **906** partially or entirely surrounded by an anode contact **908**. The anode contact **908** can be a single electrical contact or comprise a multiplicity of electrical contacts (see, e.g., FIGS. **3**-**8**). For example, the anode contact **908** can comprise a single annular electrical contact or two or more arcuate electrical contacts (e.g., a concentric tri-trace anode configuration). The cathode contact **906** is shown extending slightly beyond the exterior surface of the housing **904** relative to the anode contact **908**, which is shown as substantially coplanar with the exterior surface of the housing **904**. In some implementations, the cathode contact **906** can be substantially coplanar with exterior surface of the housing **904**. The cathode contact **906** can include a recessed region **907**, which is typically situated within a central region of the cathode contact **906**. The recessed region **907** serves to guide a corresponding cathode contact of a charging module into proper contact with the cathode contact **906**.

In the embodiment shown in FIG. **9**, the hearing device **900** includes a retention arrangement **910**. The retention arrangement **910** is configured to maintain engagement between the charging interface **902** and a corresponding charging interface of a charging module during charging of a rechargeable power source of the hearing device **900**. The retention arrangement **910** includes a magnet **911** or magnetizable structure which can interact with a corresponding magnet or magnetizable structure of the charging module. In some embodiments, the anode contact **908** partially or entirely comprises magnetic material, in which case the separate magnet **911** or magnetizable structure need not be included in the retention arrangement **910**.

FIG. **10** is a cross-sectional view of a portion of a charging module in accordance with any of the embodiments disclosed herein. The portion of the charging module **1000** shown in FIG. **10** includes a charging interface **1002** disposed on a charging surface **1004** of the charging module **1000**. The charging interface **1002** is configured to physically and electrically coupled to a corresponding charging interface of a hearing device (see, e.g., FIGS. **3**, **4**, **9**, and **12**). The charging interface **1002** includes a cathode contact **1006** partially or entirely surrounded by an anode contact **1008**. The anode contact **1008** can be a single electrical contact or comprise a multiplicity of electrical contacts (see, e.g., FIGS. **3**-**8**). For example, the anode contact **1008** can comprise a single annular electrical contact or two or more arcuate electrical contacts (e.g., a concentric tri-trace anode configuration).

The charging interface **1002** includes a through-hole **1012** within which the cathode contact **1006** is disposed. The cathode contact **1006** is displaceable within the through-hole **1012**. A biasing arrangement **1014** is configured to bias at least a portion **1006***a* of the cathode contact **1006** above a contact surface **1009** of the anode contact **1008**. As such, the cathode contact **1006** is proud relative to the anode contact **1008** prior to engagement with a corresponding charging interface of a hearing device. The biasing arrangement **1014** is configured to bias at least the portion **1006***a* of the cathode contact **1006** above the contact surface **1009** to facilitate electrical contact between the cathode contact **1006** and a corresponding cathode contact of a hearing device prior to electrical contact between the anode contact **1008** and corresponding anode contact of the hearing device.

According to some embodiments, the cathode contact **1006** comprises an elongated electrode, and the biasing arrangement **1014** comprises a spring **1016**. In some embodiments, the cathode contact **1006** and biasing arrangement **1014** define a spring-loaded pogo pin assembly. The pogo pin assembly **1014** includes a center post pogo pin **1006** which is seated into the housing of the charging module **1000** via pogo housing **1018**. The pogo housing **1018** contains a pogo spring **1016** and a pogo endstop **1019**.

The charging module **1000** also includes a retention arrangement **1020** configured to maintain engagement between the charging interface **1002** and a corresponding charging interface of a hearing device during charging of a rechargeable power source of the hearing device. The retention arrangement **1020** includes a magnet **1022** or magnetizable structure which can interact with a corresponding magnet or magnetizable structure of the hearing device. In some embodiments, the anode contact **1008** partially or entirely comprises magnetic material, in which case the separate magnet **1022** or magnetizable structure need not be included in the retention arrangement **1020**. In some embodiments, the anode contact **1008** can be implemented as a ring magnet plated with electrically conductive material. The ring magnet provides attraction to a different magnet or

magnetizable structure in the hearing device in order to align the electrical contacts. The plating provides corrosion resistance.

FIGS. **11** and **12** illustrate a system in accordance with any of the embodiments disclosed herein. The system includes a hearing aid **1202** (FIG. **12**) configured to be worn at least partially within the ear canal of a wearer's ear. The hearing aid **1202** is representative of any type of ITE hearing aid, such as an ITC, IIC or CIC hearing aid, for example. The hearing aid **1202** includes a charging interface **1204** comprising a cathode contact **1206** surrounded by an anode contact **1208**. Although shown as a concentric tri-trace anode in FIG. **12**, the anode contact **1208** can be configured as a single electrode element or a multiplicity of electrode elements. The charging interface **1204** is disposed on a faceplate **1203** of the hearing aid **1202**.

FIG. **11** shows a charging module **1122** which can be installed in, or be integral to, a charging fixture. The charging module **1122** includes a charging interface **1124** which includes a displaceable central cathode contact **1126** surrounded by a concentric anode contact **1128**. The displaceable central cathode contact **1126** can be implemented as a spring-loaded elongated electrode, such as that shown in FIG. **10** (e.g., a spring-loaded pogo pin assembly). It is understood that a charging fixture will typically include two of the charging modules **1122** configured to charge two of the hearing aids **1202**.

FIG. **13** is a schematic showing electrical components of a system in accordance with any of the embodiments disclosed herein. The schematic of system **1300** includes electrical components of a hearing device **1302** and electrical components of a charging module **1320**. The hearing device **1302** includes a rechargeable power source **1304**, such as a lithium-ion battery. The rechargeable power source **1304** is coupled to power management circuitry **1306**, such as a PMIC. The power management circuitry **1306** is coupled to an anode contact R**3** and a cathode contact R**6**. The anode contact R**3** and cathode contact R**6** of the hearing device **1302** can have a configuration and functionality described previously.

The charging module **1320** includes a power source V, which is represented as a battery in FIG. **13**. The power source V can include a rechargeable battery, a conventional battery, and/or an AC/DC converter configured to receive power from a standard wall outlet. In some embodiments, the power source V can be configured to receive wireless power from an external power source (e.g., Qi, inductive, radiofrequency, optical). The charging module impedance is represented by R**1**, which is shown coupled to an anode contact R**2** via anode switch S**1**. Resistor R**4** represents a pulldown resistor for current sensing. Resistor R**4** is coupled to a cathode contact R**5** via cathode switch S**2**. The anode contact R**2** and cathode contact R**5** of the charging module **1320** can have a configuration and functionality described previously. In some embodiments, the charging module **1320** is not configured to control anode switch S**1** and cathode switch S**2** independently, so mechanically ensuring a ground (GND) contact first provides for a more accurate and consistent inrush current profile as previously discussed.

FIG. **14**A is a schematic showing electrical components of a system in accordance with any of the embodiments disclosed herein. The schematic of system **1400** includes electrical components of a hearing device **1402** and electrical components of a charging module **1420**. The hearing device **1402** includes a rechargeable power source **1404**, such as a lithium-ion battery. The rechargeable power source **1404** is coupled to power management circuitry **1406**, such as a PMIC. The power management circuitry **1406** is coupled to a rectifier **1408**. The rectifier **1408** is coupled to a contact arrangement **1410** comprising a cathode contact, at least one anode contact, and one or more electrical contacts configured to communicate information signals between the hearing device **1402** and the charging module **1420**. The rectifier **1408** can be implemented as an N-phase rectifier, where N is equal to the number of electrical contacts of the contact arrangement **1410**.

Any of contacts R**3**, R**6**, and R**7** of the hearing device **1402** can be configured as an anode contact or a cathode contact. Any of contacts R**3**, R**6**, and R**7** can be configured as an electrical contact configured to communicate information signals. In some embodiments, contacts R**3**, R**6**, and R**7** can be configured as split-ring pin connectors, with the center pin connector being used for data signal transmission and the other two connectors being used as cathode and anode contacts for charging. Other electrical contact configurations are contemplated. For example, and with reference to the embodiment shown in FIG. **14**B, the hearing device **1402** can include a charging interface **1403** comprising a central cathode pin R**7** surrounded by split-ring pin connectors R**3** and R**6**. One of connectors R**3** and R**6** is configured as an anode contact for charging, and the other of connectors R**3** and R**6** is configured as an electrical contact configured for data signal transmission. The contact arrangement **1410** of the hearing device **1402** can have a configuration and functionality described previously.

The charging module **1420** includes a power source V, which is represented as a battery in FIG. **14**. The power source V can include a rechargeable battery, a conventional battery, and/or an AC/DC converter configured to receive power from a standard wall outlet. In some embodiments, the power source V can be configured to receive wireless power from an external power source (e.g., Qi, inductive, radiofrequency, optical). The charging module impedance is represented by R**1**, which is shown coupled to an anode contact R**2** via anode switch S**1**. Resistor R**4** represents a pulldown resistor for current sensing. Resistor R**4** is coupled to a cathode contact R**5** via cathode switch S**2**. The anode contact R**2** and cathode contact R**5** of the charging module **1420** can have a configuration and functionality described previously. In some embodiments, the charging module **1420** is not configured to control anode switch S**1** and cathode switch S**2** independently, so mechanically ensuring a ground (GND) contact first provides for a more accurate inrush current profile as previously discussed.

In addition to providing anode and cathode contacts for charging, the hearing device **1402** and charging module **1420** include one or more additional electrical contacts for communicating information signals between the hearing device **1402** and charging module **1420**. For example, data can be communicated via one or more contacts, which can be split into multiple contacts each providing a separate connection for disparate signal transmission. The type of signal transmitted over each contact can be detected automatically by the charging module **1420**, which can reconfigure the charger connections in real time. For example, the charging module **1420** can include circuitry for detecting whether a particular contact is being used to transmit power and/or data, such as by detecting the pull-up strength of the contacts. In some embodiments, the charging module **1420** can include circuitry configured to detect the connections by cycling through known protocol possibilities and using the one that works through a handshaking procedure.

FIG. **14**C illustrates a charging interface of a hearing device in accordance with any of the embodiments disclosed

herein. The charging interface **1430** shown in FIG. **14**C includes an arrangement of electrodes **1434** comprising at least one cathode contact **1434***a* and at least one anode contact **1434***b*. The electrode arrangement **1434** can include additional electrodes, such as electrode **1434***c*, which can be an anode contact or a cathode contact. A data contact **1432** is shown surrounded by electrodes of the electrode arrangement **1434**. In the representative embodiment shown in FIG. **14**C, the electrode arrangement **1434** has a concentric tri-trace electrode configuration comprising contacts **1434***a*, **1434***b*, **1434***c*, which surround data contact **1432**. In some embodiments, the electrode arrangement **1434** includes two arcuate electrodes, such as cathode contact **1434***a* and anode contact **1434***b*, which can be spaced apart from one another (e.g., see FIG. **14**D). The arcuate electrode elements **1434***a*, **1434***b*, **1434***c* are situated at substantially the same radius relative to the data contact **1432**. Although three arcuate electrode elements are shown in FIG. **14**C, the electrode arrangement **1434** can comprise two, four, five or more electrode elements, for example.

The charging interface **1430** is coupled to poly-phase rectification circuitry, which is illustrated as a 3-phase rectifier **1450** in FIG. **14**C. Contacts **1434***a*, **1434***b*, and **1434***c* are coupled to the 3-phase rectifier **1450** via charging connections **1440**, **1438**, and **1442**, respectively. The electrode arrangement **1434** is configured to communicate power produced by the charging module when charging the rechargeable power source of the hearing device. In the embodiments shown in FIG. **14**C, power is contained within the concentric electrode arrangement **1434**. Using this electrode configuration, if at least one contact of the electrode arrangement **1434** is connected to ground (GND) and at least one other contact of the electrode arrangement **1434** is connected to power (PWR), then the 3-phase rectifier **1450** will supply the correct polarity with the correct voltage.

The charging interface **1430** is configured to establish electrical connection with a charging interface of a charging module, an example of which is shown in FIG. **14**D. The charging interface **1450** includes at least two contacts **1454**, **1456** which serve as anode and cathode contacts. The two contacts **1454**, **1456** of the charging module's charging interface **1450** are configured and arranged so that each contact **1454**, **1456** electrically connects with only one of the three contacts **1434***a*, **1434***b*, **1434***c* of the hearing device's charging interface **1430**. This arrangement ensures that anode and cathode contacts of the hearing device **1430** electrically connect with respective anode and cathode contacts of the charging module.

One or more information signals can be communicated between the hearing device and the charging module via data contact **1432** and signal connection **1436**. For example, these information signals can constitute data signals (e.g., state of charge and charging status data signals) and control signals generated by the charging module and/or the hearing device. One or more disparate signals can be communicated over data contact **1432** using a sequential or multiplexing data transmission technique (e.g., time-division multiplexing, frequency-division multiplexing, code-division multiplexing).

FIG. **15** illustrates a method of implementing accelerated charging of one or more hearing devices using a charging module in accordance with any of the embodiments disclosed herein. In the illustrative method shown in FIG. **15**, two ear-worn electronic devices are subject to accelerated charging via two charging modules provided on the charging fixture. The method shown in FIG. **15** involves establishing connection **1502** between first and second ear-worn electronic devices and first and second charging modules of the charging fixture. The method involves determining **1504** the state of charge (SoC) of the rechargeable power sources of the ear-worn electronic devices. A check **1506** is made to determine if the SoC of the rechargeable power sources is within a predetermined SoC range (e.g., 5-35%). If the SoC of the rechargeable power sources fall within the predetermined SoC range, the method involves charging **1508** the rechargeable power sources at an accelerated charge rate above 1.0 C (e.g., 1.5 C-3.0 C). Accelerated charging continues while the SoC of the rechargeable power sources remain within the predetermined SoC range. Accelerated charging is discontinued when the SoC of the rechargeable power sources is beyond the predetermined SoC range. In some embodiments, accelerated charging is discontinued in response to expiration of a predetermined time limit (e.g., 15 minutes), reaching a predetermined voltage limit (e.g., 4.1V), or reaching a predetermined energy limit (e.g., 7.5 mAh).

At the termination of accelerated charging, the ear-worn electronic devices may be removed from the charging modules of the charging fixture for immediate use. In some embodiments, five minutes of accelerated charging allows the ear worn electronic devices to be used for between 2 and 6 hours of normal operation. Rather than using the ear worn electronic devices after termination of accelerated charging, the method can involve charging **1510** the rechargeable power sources at a normal charge rate at or below 1.0 C. A check **1512** is made to determine if rechargeable power sources are fully charged. If not, charging at the normal charge rate continues. When the rechargeable power sources are fully charged, the charging procedure is terminated **1514**. Accelerated charging can be implemented in accordance with the teachings disclosed in commonly-owned U.S. patent application Ser. No. 16/012,399 (Higgins et al.), filed on Jun. 19, 2018 and entitled PORTABLE CHARGING UNIT WITH ACCELERATED CHARGING FOR HEARING ASSISTANCE DEVICES, which is incorporated herein by reference.

FIG. **16** is a graph that characterizes accelerated charging of a lithium-ion battery of an ear-worn electronic device in accordance with any of the embodiments disclosed herein. The graph of FIG. **16** characterizes battery voltage **1602** and charge current **1604** as a function of time during different phases of a charging procedure. As is indicated below the time axis, the different phases of the charging procedure include a pre-charge phase (A), an accelerated constant current charge phase (B), a constant voltage charge phase (D), and a charge complete phase (E). During the pre-charge phase (A), the charge current **1604** is low (e.g., 0.1 C) and the battery voltage **1602** slowly increases. It is noted that a well-designed system should stay out of this regime. The pre-charge phase (A) continues until the battery voltage **1602** reaches 3.0 V, at which time the accelerated constant current charge phase (B) is initiated.

During the accelerated charging phase (B), the charge current **1604** rapidly increases to a charge rate above 1.0 C, such as 1.5 C. During the accelerated charging phase (B), high current is supplied to the battery which results in a rapid increase in battery voltage **1602**. For example, a charge current of 5 mA can be supplied to the battery during the latter part of the pre-charge phase (A) (e.g., at 0.3C). The charge current can be increased to between 17 and 24 mA during the accelerated charging phase (B). The accelerated charging phase (B) continues until a predetermined time limit (e.g., 5-15 min) has been reached. In some embodiments, the accelerated charging phase (B) continues until a

predetermined battery voltage **1602** (e.g., 4.1 V) or predetermined energy level (e.g., 7.5 mAh) has been reached.

At the conclusion of the accelerated charging phase (B), the charge current **1604** rapidly decreases to a normal charge current level (e.g., 5 mA at a charge rate of 0.3 C) at the initiation of the constant current charge phase (C). During the constant current charge phase (C), a normal charge current (e.g., 5 mA) is supplied to the battery resulting in a continued increase in the battery voltage **1602**. When the battery voltage **1602** reaches a predetermined level (e.g., 4.2 V), the charging procedure transitions from the constant current charge phase (C) to the constant voltage charge phase (D). During the constant voltage charge phase (D), the charge current **1604** decreases until a cutoff **1606** is reached, at which time the charging procedure is terminated. It is noted that at the charging complete phase (E), the battery voltage **1602** slightly drops over time (e.g., from 4.1 V to 3.9 V). In the embodiment shown in the FIG. **16**, the charge current **1604** supplied during the accelerated charging phase (B) changes in a step-wise fashion. It is understood that, in some embodiments, the charge current **1604** can decrease gradually as the accelerated charging phase (B) transitions to the constant current charge phase (C).

Although reference is made herein to the accompanying set of drawings that form part of this disclosure, one of at least ordinary skill in the art will appreciate that various adaptations and modifications of the embodiments described herein are within, or do not depart from, the scope of this disclosure. For example, aspects of the embodiments described herein may be combined in a variety of ways with each other. Therefore, it is to be understood that, within the scope of the appended claims, the claimed invention may be practiced other than as explicitly described herein.

All references and publications cited herein are expressly incorporated herein by reference in their entirety into this disclosure, except to the extent they may directly contradict this disclosure. Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims may be understood as being modified either by the term "exactly" or "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein or, for example, within typical ranges of experimental error.

The recitation of numerical ranges by endpoints includes all numbers subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5) and any range within that range. Herein, the terms "up to" or "no greater than" a number (e.g., up to 50) includes the number (e.g., 50), and the term "no less than" a number (e.g., no less than 5) includes the number (e.g., 5).

The terms "coupled" or "connected" refer to elements being attached to each other either directly (in direct contact with each other) or indirectly (having one or more elements between and attaching the two elements). Either term may be modified by "operatively" and "operably," which may be used interchangeably, to describe that the coupling or connection is configured to allow the components to interact to carry out at least some functionality (for example, a radio chip may be operably coupled to an antenna element to provide a radio frequency electromagnetic signal for wireless communication).

Terms related to orientation, such as "top," "bottom," "side," and "end," are used to describe relative positions of components and are not meant to limit the orientation of the embodiments contemplated. For example, an embodiment described as having a "top" and "bottom" also encompasses embodiments thereof rotated in various directions unless the content clearly dictates otherwise.

Reference to "one embodiment," "an embodiment," "certain embodiments," or "some embodiments," etc., means that a particular feature, configuration, composition, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. Thus, the appearances of such phrases in various places throughout are not necessarily referring to the same embodiment of the disclosure. Furthermore, the particular features, configurations, compositions, or characteristics may be combined in any suitable manner in one or more embodiments.

The words "preferred" and "preferably" refer to embodiments of the disclosure that may afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful and is not intended to exclude other embodiments from the scope of the disclosure.

As used in this specification and the appended claims, the singular forms "a," "an," and "the" encompass embodiments having plural referents, unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

As used herein, "have," "having," "include," "including," "comprise," "comprising" or the like are used in their open-ended sense, and generally mean "including, but not limited to." It will be understood that "consisting essentially of" "consisting of," and the like are subsumed in "comprising," and the like. The term "and/or" means one or all of the listed elements or a combination of at least two of the listed elements.

The phrases "at least one of," "comprises at least one of," and "one or more of" followed by a list refers to any one of the items in the list and any combination of two or more items in the list.

What is claimed is:

1. A system, comprising:

at least one hearing device configured to be worn at, in or on an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface and a displaceable second cathode contact;

an arrangement configured to displace at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device.

2. The system of claim 1, wherein

the second charging interface comprises a through-hole, and the second cathode contact is displaceable within the through-hole; and

the displacement arrangement comprises a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface.

3. The system of claim 2, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

4. The system of claim 2, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

5. The system of claim 1, comprising a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

6. The system of claim 5, wherein the retention arrangement comprises:

one or more magnets; or

a mechanical retention arrangement.

7. The system of claim 1 according, wherein:

the first anode contact is configured to communicate power and one or more disparate information signals;

the second anode contact is configured to communicate power and the one or more disparate information signals; and

the first and second anode contacts are configured to communicate power and the one or more disparate information signals between the charging module and the hearing device.

8. The system of claim 7, wherein the one or more disparate information signals comprise one or more of:

data signals generated by one or both of the charging module and the hearing device;

audio signals generated by one or both of the charging module and the hearing device; and

signals received from one or more accessory devices configured to communicatively couple to one or both of the charging module and the hearing device.

9. The system of claim 1, wherein the first and second anode contacts comprise electrodes having a curvilinear, annular, oval, elliptical or polygonal shape.

10. The system of claim 1, wherein:

the first anode contact comprises a plurality of electrode elements; and

the first cathode contact is surrounded by the plurality of electrode elements of the first anode contact.

11. The system of claim 10, wherein:

the second anode contact comprises a plurality of electrode elements; and

the second cathode contact is surrounded by the plurality of electrode elements of the second anode contact.

12. The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are substantially equidistant from the first cathode contact; and

the plurality of electrodes of the second anode contact are substantially equidistant from the second cathode contact.

13. The system of claim 10, wherein one of both of:

the plurality of electrodes of the first anode contact are arranged in a substantially triangular pattern relative to the first cathode contact; and

the plurality of electrodes of the second anode contact are arranged in a substantially triangular pattern relative to the second cathode contact.

14. The system of claim 1 according to any of the preceding claims, wherein the hearing device comprises an in-the-ear (ITE), in-the-canal (ITC), invisible-in-canal (IIC) or completely-in-the-canal (CIC) device comprising a housing having a preformed or formable shape that conforms to a shape of the wearer's ear canal.

15. The system of claim 1, wherein the charging circuitry is configured to charge the rechargeable power source of the hearing device at an accelerated charge rate above 1.0C when a state of charge (SoC) of the rechargeable power source is within a predetermined SoC range.

16. A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising a rechargeable power source, power management circuitry, and a first charging interface comprising a first cathode contact surrounded by a first anode contact, the first anode contact comprising a plurality of electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device, the second charging interface comprising a second anode contact having a contact surface, a through-hole, and a second cathode contact displaceable within the through-hole;

a biasing arrangement configured to bias at least a portion of the second cathode contact above the contact surface to facilitate electrical contact between the first and second cathode contacts prior to electrical contact between the first and second anode contacts; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device; and

a retention arrangement disposed on one or both of the hearing device and the charging module, the retention arrangement configured to maintain engagement between the first and second charging interfaces during charging of the rechargeable power source of the hearing device.

17. The system of claim 16, wherein the first cathode contact is surrounded by the electrode elements of the first anode contact.

18. The system of claim 16, wherein the electrode elements of the first anode contact are arranged in a substantially triangular pattern.

19. The system of claim 16, wherein:

the first cathode contact is surrounded by the first electrode elements of the first anode contact; and

the second cathode contact is surrounded by the second electrode elements of the second anode contact.

20. The system of claim 16, wherein:

the second cathode contact comprises an elongated electrode; and

the biasing arrangement comprises a spring.

21. The system of claim 16, wherein the second cathode contact and the biasing arrangement define a spring-loaded pogo pin assembly.

22. The system of claim **16**, wherein the retention arrangement comprises a mechanical retention mechanism configured to:

restrain the second cathode contact at or below the contact surface of the second anode in response to engagement between the first and second charging interfaces; and

release the second cathode contact to resume its biased position above the contact surface in response to wearer actuation of the retention mechanism.

23. A system, comprising:

at least one hearing device configured to be worn in, on or about an ear of a wearer, the hearing device comprising:

a rechargeable power source; and

a first charging interface comprising a first cathode contact and a first anode contact spaced apart from the first cathode contact, the first anode contact comprising a plurality of first electrode elements configured to communicate power and one or more disparate information signals, the plurality of first electrode elements each having a curvilinear shape; and

a charging module comprising:

a second charging interface configured to detachably couple with the first charging interface of the hearing device and comprising a second cathode contact and a second anode contact, the second anode contact comprising a plurality of second electrode elements configured to communicate power and the one or more disparate information signals; and

charging circuitry coupled to the second charging interface and configured to charge the rechargeable power source of the hearing device;

wherein the first and second electrode elements are configured to communicate power and the one or more information signals between the charging module and the hearing device.

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