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(71) Applicant (for all designated States except US): **BLUE-GEAR, LLC** [US/US]; 3131 Fernbrook Lane North, Ste. 224, Plymouth, MN 55447 (US).

(72) Inventors; and

(71) Applicants (for all designated States except US): **HAGEN, Lawrence T.** [US/US]; 4015 East Valley Road, Deephaven, MN 55391 (US). **CARLSON, Johan D.** [US/US]; 5028 Edinbrook Lane, Edina, MN 55436 (US). **ROBERTS, Randall Wayne** [US/US]; 7547 Kimberly Lane, Eden Prairie, MN 55346 (US). **NILSON, Margaret V.** [US/US]; 8079 Montgomery Ave, N.W., Annandale, MN 55302 (US).

(74) Agent: **FORREST, Peter**; Dicke, Billig & Czaja, PLLC, Fifth Street Towers - Suite 2250, 100 South Fifth Street, Minneapolis, MN 55402 (US).

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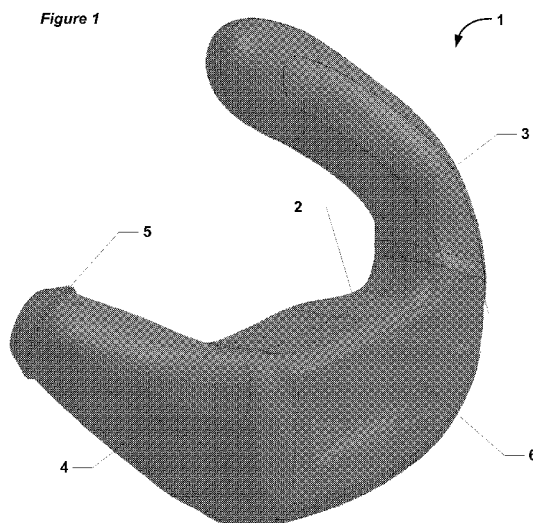
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(54) Title: UNIVERSAL EARPIECE

Figure 1



(57) Abstract: An earpiece designed to fit a substantial majority (over 90%) of people without customization to the outer ears, *i.e.*, without the need to make customized measurements or a mold of the actual ear of an individual. The device is generally C-shaped and contacts the outer ear in four locations.



UNIVERSAL EARPIECE

CROSS-REFERENCE

- 5 This application claims the benefit of United States Provisional Application Number 61/516,565 filed April 5, 2011 and United States Provisional Application Number 61/616,940 filed March 28, 2012.

TECHNICAL FIELD

- This application pertains to an ear insert designed to fit a substantial
10 majority of people without customization to the outer ears of individuals, *i.e.*, without custom molds of the outer ear being required.

BACKGROUND

- In this application, the term earpiece—including the term “ear mold” (sometimes expressed as the closed compound word “ earmold”)—refers
15 to any device placed into the outer ear for purposes of affecting hearing—whether by enhancement (*e.g.*, a hearing aid, an earphone, audio headphones) or by reduction (*e.g.*, protection against loud sounds such as would be experienced in the vicinity of guns, aircraft engines, concerts, *etc.*). Such purposes include affects on hearing which are not performed
20 by the earpiece *per se*; for example, a stethoscope (acoustical or electronic) which employs earpieces as described below for its eartips is within the scope of this application. Other applications include cell phone communication (*e.g.*, Bluetooth™ or other wireless protocols, or wired connection); wired or wireless computer, radio, TV, iPod®, iPad®, and
25 other similar types of audio listening (including consumer, professional, and “audiophile” applications); and in general any application in which there is a need for better fitting appliances for the outer ear for reasons of comfort, lasting fit, or both.

The hearing health care field and consumer electronic industry have long pursued without success a viable, single-physical-size earpiece.

Numerous standard fitting earpieces have been advocated to house hearing devices or communication devices or to be used with them,

5 respectively. To date, few of these have proven to provide a satisfactory universal fit. There are always some ears on which these devices do not fit properly, resulting in ear irritation and/or acoustic feedback produced by the lack of an adequate acoustic seal of the ear canal, occlusion problems or poor retention in the ear. For example, poorly-fitting earpieces are one
10 of the main causes for a large percentage of hearing aids being returned or not being used.

Some of these poor-fit problems are caused by the unforgiving, hard, incompressible acrylic material used to house the electronic components.

The difficulty applies to either custom or standard earpieces and occurs
15 when the wearer speaks or chews, exercises, or moves, any of which causes the ear canal to change shape significantly, thus causing an earpiece to no longer fit well. The result at these times of jaw movement is a poorly-fitting earpiece that causes the earpiece to fall out or allow slit leakage to occur, which produces acoustic feedback and is uncomfortable
20 to wear because it irritates the wearer's outer ear.

Numerous attempts have been made to solve the jaw moving-poorly fitting earmold/earpiece problem. For example, US Patent 6,434,248 B1

describes a custom in-the-ear type hearing aid made with a soft shell that conforms to the wearer's ear canal as jaw motion occurred. The soft shell
25 encapsulates the electronic components of the hearing aid and is bonded to a hard faceplate. While this approach provides a theoretical improvement over a hard-shell hearing device, difficulties were encountered in trying to reliably adhere the shell to the faceplate, and, in practice, the two parts often separated. In addition, the soft shell materials
30 tend to tear apart and the wires often break.

Universally-fitting or standard size earpieces were developed in the hearing industry for a number of reasons: product cost and time for device

delivery were reduced because there was no longer a two to three week wait between the time at which the ear impression was taken and delivery of a custom hearing aid. A proper universal fitting hearing device requires less follow-up care for the wearer, translating into less time in the hearing professional's office trying to solve fit problems, resulting in greater satisfaction with hearing devices.

There have been numerous attempts at developing and manufacturing standard fitting earpieces. For example, US Patent 6,205,227 describes a standard fit hearing device with a rigid shell and hollow, deformable tip.

The problem with this device was that the rigid shell was too large for some ears, and the flexible tip was either too large or too small for some ears, both problems resulting in an unacceptably low successful fitting rate. US Patent 6,097,825 describes a hearing aid packaged in standardized spheroidal housings having predetermined curvatures corresponding to that of typical ear canals. The problem with this approach was that there were many ear canals whose curvature did not correspond with those of the spheroidal housings. In another example, US Patent 5,002,151 describes a soft, disposable sleeve in several standard lengths that has threads which screw onto mating threads on an earpiece. The problem with this assembly was that a combination of the foam tip and earpiece was too long for most ear canals, resulting in the earpiece sticking out of the wearer's ear.

SUMMARY OF THE DISCLOSURE

In one aspect, this application discloses a standard fit, limited-contact earpiece designed to house any of a variety of hearing device components. In another aspect, this application discloses an earpiece to hold a hearing device in place on a wearer's ear. In either case, the hearing device may be a complete hearing aid, communication device, medical device, audio headphones/monitors, or an assistive listening device. In conjunction with any of these devices, if they are worn on the head, an earpiece is used to hold them in place on the wearer's ear. In another aspect, the earpiece may be a passive device for hearing

protection, such as when equipped with an occluding tip. In yet another aspect, the earpiece may be a replacement for a hearing aid earmold. Thus, one aspect of an earmold for any of the above purposes, is a one-size-fits-all crescent-shaped earpiece (or C-shell), in which four major points of the outer ear are in contact with the earpiece, the concha bowl, 5 tragus, anti-tragus and helix. This product can be used as an open ear device which prevents osculation for the end user.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a first embodiment.

10 Figure 2 is a front view of the first embodiment.

Figure 3 is a back view of the first embodiment.

Figure 4 is a top view of the first embodiment.

Figure 5 is a bottom view of the first embodiment.

Figure 6 is a right side view of the first embodiment.

15 Figure 7 is a left side view of the first embodiment.

Figure 8 is a schematic view of a left outer ear illustrating certain anatomical features.

Figure 9 is a schematic view similar to Figure 8, illustrating the placement of one embodiment in the outer ear.

20 Figures 10 and 11 are perspective views of an alternative embodiment.

Figures 12-14 are respective front, back, and left side views of the first embodiment, illustrating certain features of each.

Figures 15-18 are perspective schematic views of various alternative embodiments.

25 Figure 19 is a left side view supplementing the illustration of Figure 14.

Figures 20-23 are front views schematically depicting a series of alternative embodiments.

DETAILED DESCRIPTION

Throughout the following discussion it should be understood that
5 embodiments of the invention may be illustrated with respect to a device
suitable for use with the left ear, or with the right ear, without any loss of
generality. In the most preferred commercial applications of any
embodiment disclosed here, there will be a pair of devices, one for each of
the left and right ears, and they will be mirror images of each other with
10 respect to shape, size, and other “fit-related” physical structure. They may,
if necessary, be slightly different from each other despite one or
(preferably) both being fully within the scope of the invention. Also,
depending on the circumstances, functional components which are not “fit-
related,” such as electronic components, may also be identical (differing
15 only by the nature of the signals carried or processed by the electronic
components), or again if necessary the functional components may be
slightly different from each other as desired.

As illustrated in Figures 1-7, earpiece **1** comprises base **2**, helix extension
3, and ear canal extension **4**. The embodiment illustrated in Figures 1-7 is
20 suitable for use in the left ear, and thus is the mirror image of an
embodiment suitable for use in the right ear.

In general descriptive terms, base **2** is generally ellipsoidal, or barrel-like-
shaped (not considering any shape of outer face **6**, which is variable as
discussed further below). It is longer than it is tall (see also Figure 14,
25 illustrating that both **B** and **L** are greater than **H**) although not substantially
so. Base **2** has an inner face **19** which curves outwardly to contribute to
the barrel-like shape. Base **2** is also curved along its lowest portion, as can
be seen in Figures 2 and 3, although it is generally flat along its highest
portion, as can be seen in Figures 6 and 7, before it slopes upward to
30 smoothly join helix extension **3** and ear canal extension **4**.

Helix extension **3** is narrower in thickness than base **2** in both directions transverse to its longest extension. Helix extension **3** smoothly but substantially curves away from the rearward end of base **2**, curving back toward the forward direction in a near-U-shaped manner and also
5 extending upwardly by a substantial amount relative to the dimensions of base **2**. As best seen Figures 3 and 4, but also visible in other figures, helix extension **3** curves sharply upward but less so inwardly, and extends only enough that its distal end **32** lies approximately as far inward as the maximum extent in the same direction of inner face **19** of base **2** (note also
10 the discussion below of offset distances **A** and **B** as shown in Figures 12 and 13). Similarly, it can be seen from Figures 6 and 7 that helix extension **3** curves and extends upwardly by a substantial amount, enough that its distal end lies well above the maximum height of base **2**, above the height of all of ear canal extension **4**, thus contributing to the substantial gap
15 between the two at the mouth of open area **12** discussed below.

Ear canal extension **4** is generally shaped like a curved, tapered horn, having a larger diameter where it smoothly extends away from the forward end of base **2** than it does at its distal, forward end which extends into the external ear canal when worn. As best seen Figures 2 and 4, but also
20 visible in other figures, ear canal extension **4** curves and extends enough that its distal end lies farther inward than the maximum extent in the same direction of inner face **19** of base **2**, so much so that its distal end lies farther inward than the maximum extent in the same direction of helix extension **3** (note also the discussion below of offset distances **A** and **B** as
25 shown in Figures 12 and 13). Similarly, it can be seen from Figures 6 and 7 that ear canal extension **4** curves and extends upwardly enough that its distal end lies above the maximum height of base **2**, but not nearly so much as to approach the height of the lowest portion of the rounded end of helix extension **3**, thus contributing to the substantial gap between the two
30 at the mouth of open area **12** discussed below.

Optional feature **5** is provided at that distal (farthest into the ear canal) end of ear canal extension **4** so that, if desired, flexible and pliable ear buds of

conventional open or closed design (not shown) may be provided. In commercial embodiments, such ear buds are preferred for comfort, aesthetics, and other reasons not critical to the scope of this application. Thus, optional feature **5** is illustrated by way of example only as a ring-like
5 ridge or shoulder biased back toward base **2** but this approach is only preferred and not required.

Ear canal extension **4** often does, but need not, define an internal lumen or other open channel for passage of sound **33**; passage **33** is not necessary if earpiece **1** is being used for hearing protection or other forms of passive
10 noise suppression (in which case earpiece **1** may be constructed entirely of noise-suppressing foam or other conventional materials known for that purpose). In other cases, such as when active (typically electronic) noise masking, tinnitus protection or therapy (*e.g.*, providing white or pink noise to mask the tinnitus), volume level limiting, or other form of suppression is
15 provided, ear canal extension **4** will have an internal lumen or other open channel **33** for passage of sound to and from the ear canal. This will also be the case when earpiece **1** is used for hearing enhancement, such as for a personal sound amplification product (PSAP) or hearing aid of any type.

For purposes of this application, a hearing aid is any wearable instrument
20 or device that is intended to compensate for impaired hearing; and a PSAP is a wearable electronic product that is not intended to compensate for impaired hearing, but rather is intended for non-hearing impaired consumers to amplify sounds in the environment for a number of reasons, such as for recreational activities. PSAPs are devices which allow users to
25 amplify sound but are not programmable in the field, as distinguished from hearing aids which are programmable in the field to the wearer's specific hearing loss with the assistance of trained dispensers or audiologists (*i.e.*, the PSAP amplification level is set at the time of manufacture and cannot be reset by the user). Examples of their use include hunting (listening for
30 prey), bird watching, listening to lectures with a distant speaker, and listening to soft sounds that would be difficult for normal hearing individuals to hear (*e.g.*, distant conversations, performances).

Earpiece **1** may also be used for isolation or privacy (e.g., as part of a set of wired or wireless earphones or other receivers mounted in the outer ear) and again ear canal extension **4** will define an internal lumen or other open channel for passage of sound to and from the ear canal.

- 5 It should therefore be understood that earpiece **1** is predominantly a mechanical platform primarily designed for fit into the outer ear, with the other functionality of a product containing earpiece **1** determined essentially entirely by the material of earpiece **1** (in cases such as noise suppression) and the electronic/acoustic components which are used with
10 (or incorporated into) earpiece **1**. Such electronic components and functions may be combined together in any manner as desired. For example, both wireless (e.g., Bluetooth™) communications and audio functions may be combined as known in the art.

- Other types of functions which may be supported by earpiece **1** include
15 medical monitoring (including, but not limited to, temperature, heart rate, and other parameters) known to be possible from within or in the vicinity of the ear canal, whether such monitoring is done by electronic devices or conventional acoustic devices (e.g., a pair of earpieces **1** could be the earpieces of a traditional acoustic stethoscope). Any such function can be
20 incorporated using wired or wireless technology as required. Of course, such monitoring may be acute or chronic, and need not necessarily occur in a clinical setting (e.g., pulse rate monitoring combined with music listening is possible for long distance runners and other athletes).

- Earpiece **1** could support traditional communications equipment in
25 situations where comfort and/or discreteness are desirable, such as the personal communications equipment used by automobile drivers, motorcycle riders, football players (e.g., sidelines/helmet communication), automobile racing drivers (pit/helmet communication), pilots, television personalities, musicians, public safety (uniformed or undercover police,
30 firefighters, paramedics, emergency medical technicians and other first responders, private security personnel), translators, etc. Yet another application is consumer audio. For example, the comfort provided by

earpiece **1** over long periods of time suggests that one potential use is long term wear so that the user hears music which changes as their location changes, such as when walking from one room to another, or when speeding or slowing down during exercise, *etc.*

- 5 Thus, in commercial application, the outer face **6** of base **2** may vary in shape in various embodiments to accommodate any of a variety of electronic configurations (or mechanical features dictated by the same). It therefore is illustrated in Figures 1-6 as a relatively flat surface by way of example only. For example, turning briefly to Figures 10-11, it may be
10 seen that outer face **6** may define features such as an opening **7** to a hollow interior **30** of base **2**, or a socket **8** to accommodate electrical components and connections described further below. Turning briefly to Figures 20-23, it may be seen that the shape schematically indicated by the dashed lines in Figure 20 is variable, and can include (by way of
15 example and not limitation), a generally gently curved surface (Figure 21), a truncated cone or frustrum (Figure 23), a semi-spherical surface (Figure 23), and in general any surface extending transversely away from the ear.

- Returning to Figures 1-7, by contrast to the outer face **6**, inner face **19** of base **2** is curved toward the ear canal when viewed in both the longitudinal
20 (front/back) and transverse (upper/lower) directions, giving base **2** a barrel-like shape in the vicinity of inner face **19**. This allows earpiece **1** to conform to the concha bowl. Turning to Figure 8, the human outer ear is pliable at the four contact points identified: the concha bowl **13**, tragus **14**, helix **15** and anti-tragus **16**. The outer ear therefore has the ability to
25 stretch at these four contact points, allowing the hearing device to move in response to the wearer talking or chewing. Because these four points of the earpiece or shell are in contact with the wearer's ear, a custom device is not needed and an earpiece having standard size and shape works quite well. The result is greater wearer comfort, approaching that of a
30 custom earpiece, than would be provided by a standard-fit earpiece that contacts more surface area of the outer ear.

It is important to note, comparing Figures 8 and 9, that earpiece **1** does not contact the intertragal notch **17**; and further that the earpiece **1** is extremely concave (as described further below) so that it can accommodate (*i.e.*, does not substantially lie over) the crus of concha **18**.

- 5 Thus, earpiece **1** fits in the concha bowl but does not invade the ear canal and does not extend to the extremity of the ear lobe. It is also apparent from Figure 9, which shows earpiece **1** in place, that helix extension **3** does not support a wire or other external connection to earpiece **1**.

- The earpiece may be manufactured from a wide range of materials, including hard incompressible acrylic (such as polymethyl methacrylate or "PMMA" known by the brand name "Lucite"); plastic (including thermoplastics such as acrylonitrile butadiene styrene or "ABS"), or metal; and soft materials such as silicone or polyethylene. Multiple colors may be incorporated into these materials to provide increased cosmetic appeal, especially for younger wearers.

- The helix extension **3** can be made of different materials from the remainder of the earpiece, such as hard acrylic or flexible vinyl or silicon. The helix extension portion may be replaceable with tips having different length and shape. Earpiece **1** may be a single piece (neglecting, for this purpose, any contents of hollow interior **30** or any door or socket as described below), but a separate helix extension **3** may attach and detach to base **2** via a convenient mechanism such as a ball and socket assembly or other known features which mate together. It is also possible to form earpiece **1** (or any portion of it) from multiple pieces if desired.

- 25 Similarly, the ear canal extension **4** can be made of different materials from the remainder of the earpiece, such as hard acrylic or flexible vinyl or silicon. The ear canal extension portion may be replaceable with portions having different length and shape. A separate ear canal extension **4** may attach and detach to base **2** via a convenient mechanism such as a ball and socket assembly or other known features which mate together.

The earpiece may be manufactured such that a large portion of the ear canal is not occluded, providing a more natural sound quality by reducing the occlusion caused by unvented earpieces that result in wearers sometimes describing the sound quality of their own voices as “my head is
5 in a barrel” or “my voice sounds hollow.”

For purposes of retention of the earpiece in the outer ear, the ear canal is not one of the contact points for the earpiece by itself. The earpiece alone inherently leaves the ear canal unoccluded. Different size soft ear tips may be attached to the shell to provide a closed fitting by sealing the earpiece
10 to the ear canal.

Figures 10-13 illustrate various dimensional aspects of the preferred embodiment. Notably, as shown in Figures 10-11, for a given length **11** of base **2** taken along the plane generally corresponding to the top of base **2**, helix extension **3** rises above that plane and extends a substantial amount
15 until it ends a significant distance above the top of base **2**, thus creating a significantly large open area **12**. Using the forward end of length **11** as a reference, distance **10** is the same order of magnitude as distance **11**. In a preferred embodiment, distance **10** is approximately 12.2 mm and distance **11** is approximately 13.5 mm.

20 Turning to Figures 12 and 13, it can be seen that in general, distance **11** is on the order on one half of the entire height of earpiece **1**, or in the same preferred embodiment, approximately one half of the overall height of approximately 26.1 mm. Yet the base **2** of earpiece **1** is quite compact: in the preferred embodiment it is approximately 10 mm high (measured to
25 the same plane as length **11** is taken along, described above) and approximately the same thickness (depending somewhat on whether front face **6** is extended as described elsewhere); in the embodiment illustrated, the width is approximately 12.25 mm or the same order of magnitude as length **11**.

30 Figures 12 and 13 also illustrate the notable angles made by the central axes of helix extension **3** (Figure 13, angle α) and ear canal extension **4**

(Figure 12, angle β), resulting in offset distances X_1 and X_2 , respectively. Such angles are determinable even if it is not the case that front face **6** is flat (as illustrated) because the plane of front face **6** generally corresponds to the vertical plane when earpiece **1** is positioned within a human ear.

- 5 In the case of ear canal extension **4**, the axis of the extension as a whole is not necessarily the center line of any lumen **33** though which sound passes. It may be desirable to have such a lumen **33** define a turn or bend as opposed to being straight. For example, it may be necessary for a speaker or other transmitter to fit into a central cavity such that it is
- 10 "pointed" toward the proximal end of the lumen which lies in a first direction within ear canal extension **4**, while the distal portion of the lumen needs to be directed in a second direction within ear canal extension **4** so that it is "pointed" toward the center of the ear canal for maximum effectiveness. It is also not necessary for the lumen **33** to have a constant
- 15 diameter, although it is possible.

- Figure 14 illustrates one methodology for expressing the amount of open area **12** based dimensions of base **2**. As shown, the central portion of base **2** may be modeled as a rectangle of height H and length $L \sim 1.25 \cdot H$, with the reference point for length L taken from the deepest location of
- 20 area **12**. An approximately triangular shape can be used to measure area **12**, using a base $B \sim 1.5 \cdot L$ and height $A \sim L$, which yields the result that area **12** is approximately $0.94 \cdot H^2$. Thus, for $H \sim 10$ mm, the area is approximately 94 mm^2 . This substantial amount of open area **12** is due, in part, to the extreme depth to which open area **12** extends into the C-
 - 25 shaped opening defined by the base **2** and helix extension **3**, as well as the relatively small thickness of helix extension **3**. Another way to see this, turning briefly to Figure 19, is to consider that the radius of curvature of the joint between base **2** and helix extension **3** (*i.e.*, the deepest part of the C-shaped opening) extends a substantial amount around a circle having a
 - 30 radius of curvature on the order of only $0.2\text{-}0.25 \cdot H$, yet helix extension **3** has a thickness $T \sim 0.6 \cdot H$.

It should also be noted that open area **12** is not the “open area” as that term is used in US Patent 7,394,910, namely, an area completely surrounded by material or D-shaped (see especially Figure and column 6, lines 56-64). Such a closed-perimeter region cannot accomplish the
5 objective of avoiding coverage of the crus of concha **18** (Figure 9).

As noted before, as shown in Figure 10, the outer face **6** may define either or both of an optional opening **7** or optional socket **8** providing access to internal components, if present. Depending on the nature of such components, opening **7** may be closed by a door or similar feature (not
10 shown), such as a “battery door” commonly used in conventional hearing aids. Either opening **7** or socket **8** could be the location where a wire or similar conduit (e.g., an acoustical conduit such as the tube of a stethoscope) is connected to earpiece **1**. The size and shape of opening **7** and socket **8** are arbitrary and dictated by the function of the components
15 they accommodate. For example, a possible configuration for socket **8** is an industry standard connector such as that known as CS-44 (or CS-45), an example of the use of which is disclosed in US Patent 6,319,020. While socket **8** may be used for any purpose, a common use will be to support connection of remote programming equipment, or to perform functions
20 needed only on occasion, such as uploading data to any electronics supported by the earpiece platform, or downloading data gathered by such electronics, depending on the nature of the electronics. Socket **8** (or another socket not shown) could be a Direct Audio Input (DAI), or any other direct connection to an external audio source like a DVD/CD player
25 or an assistive listening device (ALD). Other possible uses for socket **8** include (without limitation) connections for BTE and wireless modules, battery or charging connections, connections between units in the left and right ears, microphones, eyeglasses (for hearing aids, 3D television, etc.), and any other suitable accessory.

30 Figures 15-18 are perspective schematic views of various alternative embodiments. Each embodiment uses a version of earmold **20** which has a sound channel within the ear canal extension so that sound may be

presented to the ear from electronics mounted at least partially within the hollow interior **30** of the base; for purposes of illustration only, a door or other portion of the base lying generally on the outer face of the base is omitted and the electronics are shown schematically, *i.e.*, the exact size and location of the electronic components may vary from those shown in the figures. (These figures also indicate a possible, but not required, joint **31** where a separate base and helix assembly may mate together, as described above.)

Such electronics include (depending on the alternative embodiment), a receiver (speaker) **21**; one or more omnidirectional or directional microphone systems **22**; a "behind the ear" (BTE) or other external module **23** which houses various electronic components and is shaped and sized according to conventional principles (*e.g.*, eyeglasses); battery **24**; digital signal processor (DSP) **25**; and one or more external microphones **26**, such as those that form components of a directional microphone system **22**. The directional microphone systems **22** may be those commercially available from Sonion A/S (Roskilde, Denmark), Knowles Electronics, Inc. (Itasca, Illinois, USA), and the like, including those used in commercially available products by companies such as Starkey Laboratories, Inc. (Eden Prairie, Minnesota, USA), Siemens Hearing Instruments, Inc. (Piscataway, New Jersey, USA and Erlangen, Germany), and others. Other components (*e.g.*, antenna, auxiliary battery, mounts for components within the earmold **20**, and so on) may be provided in a commercial application as understood in the art. Electrical and mechanical connections between such electronics and earmold **20** are not shown for clarity, and neither are electrical connections between or among components that would be understood to the person of ordinary skill in the art. For example, the BTE or other external module **23** may be electronically connected to earpiece **20** by a conventional wire [as illustrated] or a wireless signal which is not numbered. Such a wireless signal may be a Bluetooth™ connection, a near field magnetic induction signal, or a radio frequency (RF) signal of any conventional type.

In Figure 15, the receiver **21** and omnidirectional microphone **22** (one illustrated) are mounted within the earmold **20** and connected to an external module **23** which houses a battery **24** and DSP **25**. External module **23** could be Bluetooth™-enabled and/or housed in a BTE type of housing or shell (as that term is commonly understood in the art). This configuration of earmold **20** could be a replacement for the in-canal portion of the “MaRiC” architecture of hearing aids such as those known as “Ytango” and commercially available from ExSilent BV of Amsterdam, The Netherlands (or their functional equivalents), *i.e.*, designs in which the microphone and receiver are in the outer ear canal. This and other features which may be combined with earmold **20** are described in one or more of United States Published Patent Applications US 2009/0316940, US 2009/0262964, US 2011/0299709, US 2011/0166680, and US 2011/0316727.

In Figure 16, the receiver **21** is attached to an external module **23** that houses the battery **24**, DSP **25**, and (as illustrated) a single omnidirectional or directional microphone **26**. This configuration is suitable for replacement of the in-ear portion of existing R-I-C (receiver-in-canal) hearing aids. One variation on this approach, not specifically illustrated, would use one or more microphone systems **26** in the external module **23** as described with respect to Figure 18, below. Another variation, again not specifically illustrated, would use a wireless-connected microphone (omnidirectional or directional, as desired) incorporated into a neck loop communicating with the external module **23** and/or earmold **20**, according to principles understood by those skilled in the art.

In Figure 17, earmold **20** houses a receiver **21** and one or more directional microphone systems **22** (only one of which is shown for clarity). The external module **23** houses the battery **24** and digital signal processor **25**. External module **23** could be a Bluetooth™ module housed in a BTE module or a directional microphone version of the “MaRiC” unit of hearing aids noted above with respect to Figure 15.

In Figure 18, the external module **23** houses the battery **24**, DSP **25**, and at least one directional microphone system **26**. In addition, the earmold **20** houses both the receiver **21** and one or more directional microphone systems **22** (only one of which is shown for clarity). This configuration is like that shown in Figures 15 and 17 but adds at least second order directionality possible from use of directional microphone systems. It is also possible to incorporate further increases in directionality by use of smaller components which allow for use of additional microphones and associated components. For example, there could be more than one directional microphone system **22**, because two of them could be ganged with the directional microphone system **26** to create a higher order system.

In any embodiment of earpiece **1** (or earpiece **20**), if a battery (such as battery **26**) is used, it should be understood that such battery may be permanent, replaceable, or rechargeable; and if rechargeable that it may be recharged by directly connecting a power source (e.g., though a socket **8**, or through a wired connection such as could be included with wires connecting the earpiece to an audio source using an audio induction loop ["Telephone Coils" or "telecoils" or "T-coils"] to filter out background noise), or by wireless recharging techniques known in the art (including, but not limited to, inductive charging with or without resonant inductive coupling [electrodynamic induction]). See, for example, US Patent Application Publication US 2011/0069854 A1. If wireless recharging is employed, a preferred location for any near field coils (NFCs) required is within helix extension **3**.

Thus, the selection of what type of battery and/or recharging technique is employed dictates other non-critical design decisions, e.g., if the battery is not replaceable because it is wirelessly rechargeable, then a door in outer face **6** to access the battery is not required.

Example

A random sample of seventy-seven individuals in the United States were provided with an identically sized pair of (left, right) embodiments

manufactured from inflexible and incompressible acrylic material and produced from the molds created with the solid model CAD file used to generate Figures 1-7. The sample included forty-three males and thirty-four females of varying ages greater than ten. Each individual was asked
5 whether the embodiment fit comfortably in each ear. All subjects reported consistent bilateral results, *i.e.*, either both ears fit comfortably, or both ears did not fit comfortably. Comfortable fit in both ears was reported by forty-two of forty-three males (fit rate 97.7%) and thirty-one of thirty-four females (fit rate 91.2%) for a blended fit rate of 94.8%. This is substantial
10 improvement over the results reported in US Patent 4,878,560, which required "six different standard sizes [to] fit approximately 95% of normal ears." More importantly, these results were obtained with an inflexible material, in total contrast to the teaching of that patent that the fit rate of 95% "is made possible by the relative flexibility of the earmold. The
15 flexibility also helps keep the ear mold in position during normal activities of the user." The preferred material in that patent had a durometer softness of 42 (A scale) and was composed of styrene-rubber copolymer, but the patent specifically teaches a requirement that "the plastic is ... soft enough to be comfortable to the wearer." Thus, the embodiment tested
20 here unexpectedly achieved equally high fit rate despite use of a single size and despite using the exact opposite type of materials as taught by US Patent 4,878,560.

* * * * *

Unless disclosed and claimed otherwise, the construction of any
25 embodiment of the invention follows standard design criteria and parameters suitable for the intended purpose, including compliance with government or industry standards. It should also be understood that references in the drawings or their accompanying written description may refer to electrical "lines" or similar terms which are used to refer to not only
30 the electrical wires, traces, or lines themselves, but also the associated connections, circuitry and the like that would be understood by the person of ordinary skill in the art of electronic design to be desirable, necessary,

or included for any purpose, even if not specifically stated. For example, power supplies, ground connections, *etc.* that are not critical to the scope of the invention may be omitted from the drawings or description for purposes of clarity, even if such items would be employed in commercial

5 embodiments of the invention. There are no limitations on the scope of the invention, except as described in the following claims. In particular, the following claims may use the language “first,” “second,” “third,” and so on to specifically distinguish between various elements that are otherwise similarly named. These terms are not intended to imply any order of

10 importance or time sequence in manufacturing or use, unless other claim language specifically does so.

We claim:

1. An earpiece for a hearing device or communication device that touches the outer ear of a wearer in a minimum number of contact points.
- 5 2. The earpiece of claim 1 in which the number of contact points is four.
3. The earpiece of any preceding claim, in which the contact points of the outer ear are the helix, tragus, anti-tragus and concha bowl.
4. The earpiece of any preceding claim, in which the earpiece fits over
10 90% of people without modification.
5. The earpiece of any preceding claim, in which the earpiece is made of a hard material selected from acrylic, plastic, ABS, or metal.
6. The earpiece of any of claims 1 to 4, in which the earpiece is made of a soft material selected from vinyl or silicone.
- 15 7. The earpiece of any preceding claim, in which the earpiece comprises a replaceable helix extension.
8. The earpiece of claim 7, in which the replaceable helix extension attaches to the earpiece via a ball and socket assembly.
9. The earpiece of claim 7 or claim 8, in which the replaceable helix
20 extension is made of a different hardness material than the remainder of the earpiece.
10. The earpiece of any of claims 1 to 6, in which the earpiece comprises a replaceable ear canal extension.
11. The earpiece of claim 10, in which the replaceable ear canal
25 extension attaches to the earpiece via a ball and socket assembly.

12. The earpiece of claim 10 or claim 11, in which the replaceable ear canal extension is made of a different hardness material than the remainder of the earpiece.
13. The earpiece of any preceding claim, further comprising a feature
5 for attaching a soft eartip.
14. A system comprising an earpiece according to claim 1, in which the earmold comprises a base having a hollow interior, an ear canal extension of the base, a sound channel within the ear canal extension, and electronics mounted at least partially within the
10 hollow interior of the base of the earpiece, in which the electronics comprises a receiver within the hollow interior of the base, an external module electronically connected to the earpiece having a battery and a digital signal processor within the external module, and at least one microphone connected to at least one of the
15 electronics and the external module.
15. The system of claim 14, in which there is a single microphone mounted within the earpiece.
16. The system of claim 14, in which there is a single microphone mounted within the external module.
- 20 17. The system of claim 14, in which the external module is one of Bluetooth™-enabled, RF-enabled, and near-field-inductive enabled.
18. The system of claim 14, in which there are one or more directional microphone systems each mounted within the earpiece.
19. The system of claim 14, in which there are one or more directional
25 microphone systems each mounted within the external module.
20. The system of claim 14, in which the external module is electronically connected to the earpiece by a wired connection.

21. The system of claim 14, in which the external module is electronically connected to the earpiece by a wireless connection.
22. The system of claim 14, in which the external module is electronically connected to the earpiece by one of a Bluetooth
5 connection, a near field magnetic induction signal, or a radio frequency signal.
23. The system of claim 14, in which the external module is a behind-the-ear module.
24. The earpiece according to claim 1, in which the earpiece provides
10 passive hearing protection.
25. The earpiece according to claim 1, in which the earpiece comprises a base, an ear canal extension of the base, and a helix extension of the base.
26. The earpiece of claim 24, in which the base has a hollow interior.

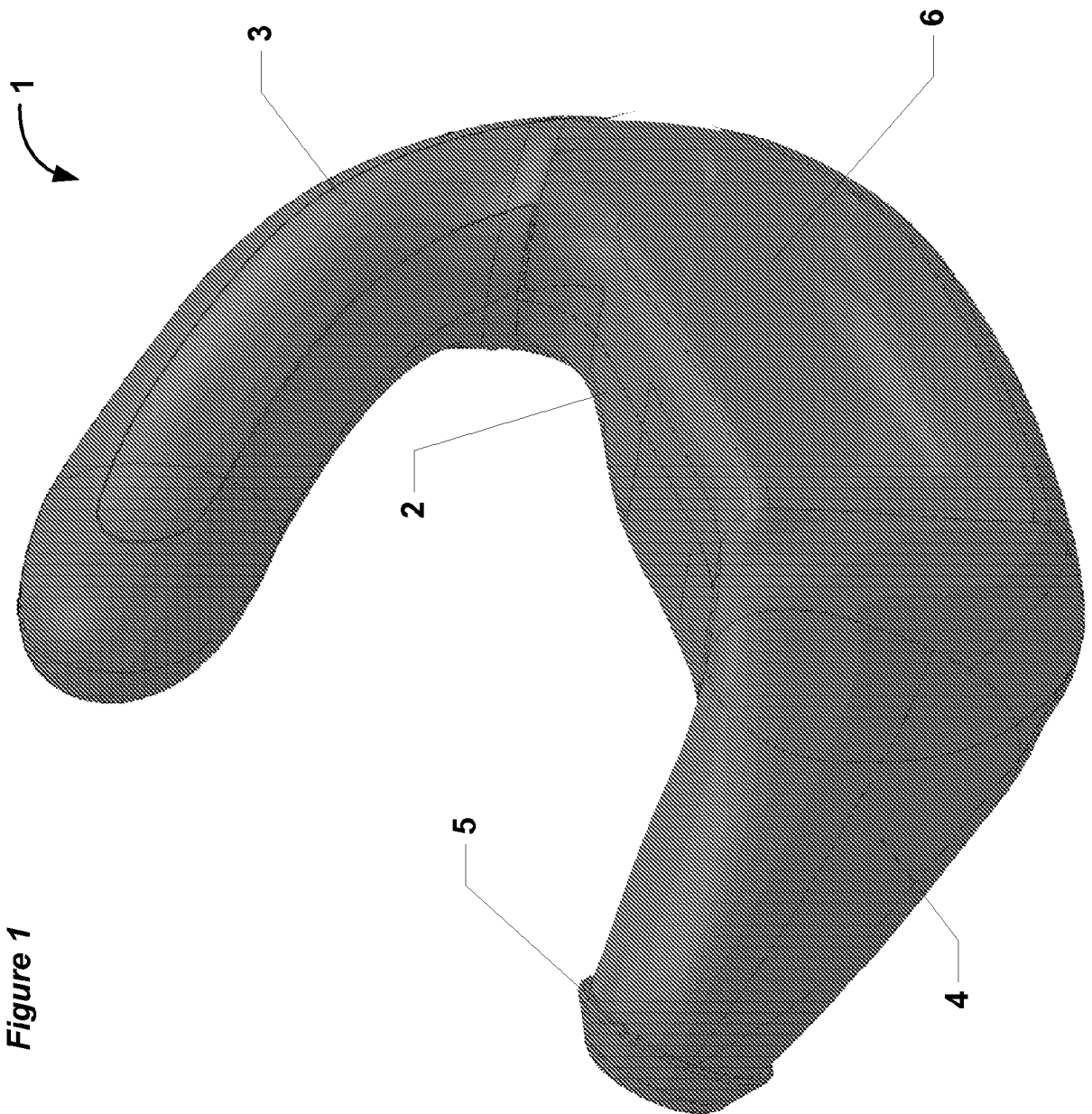
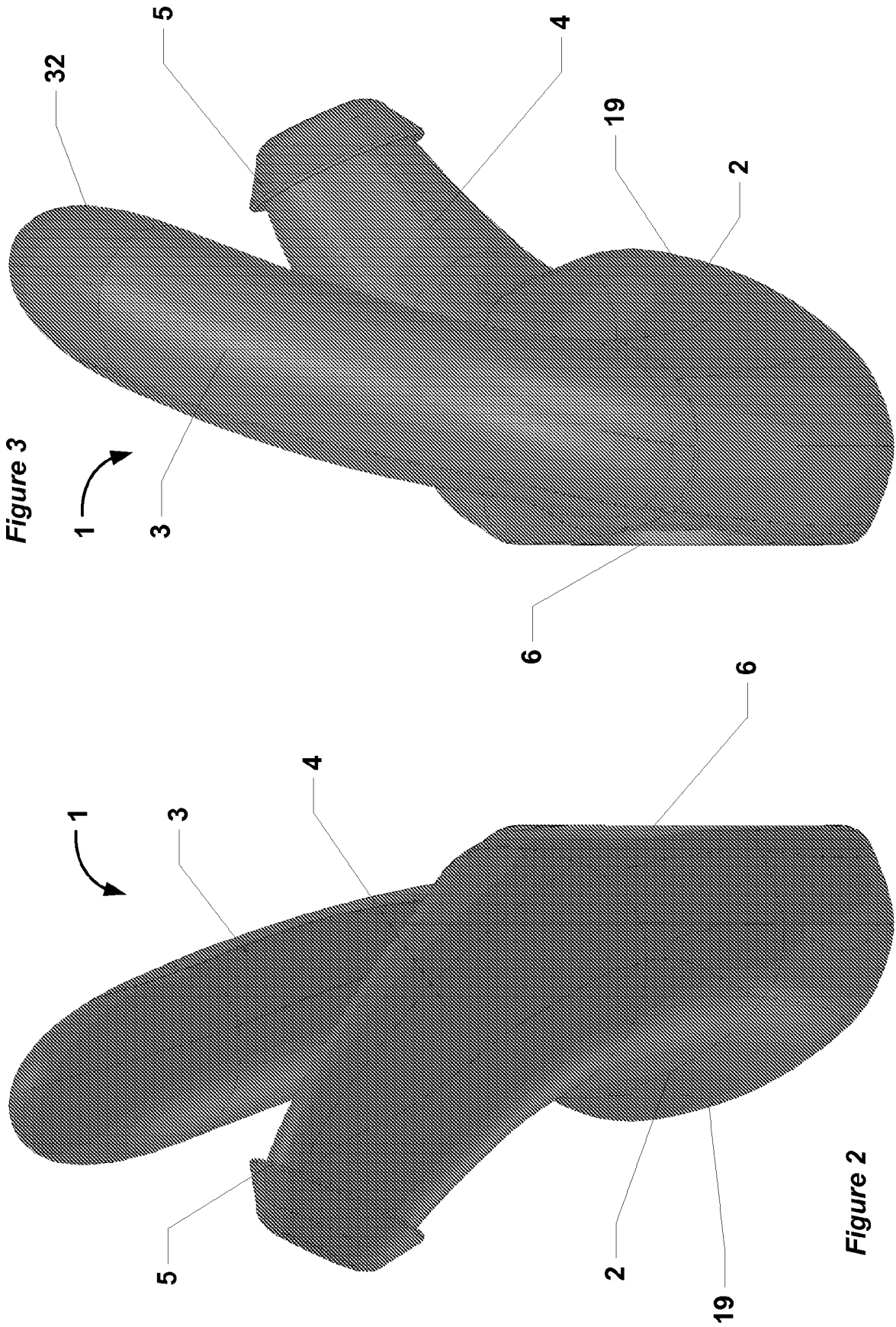
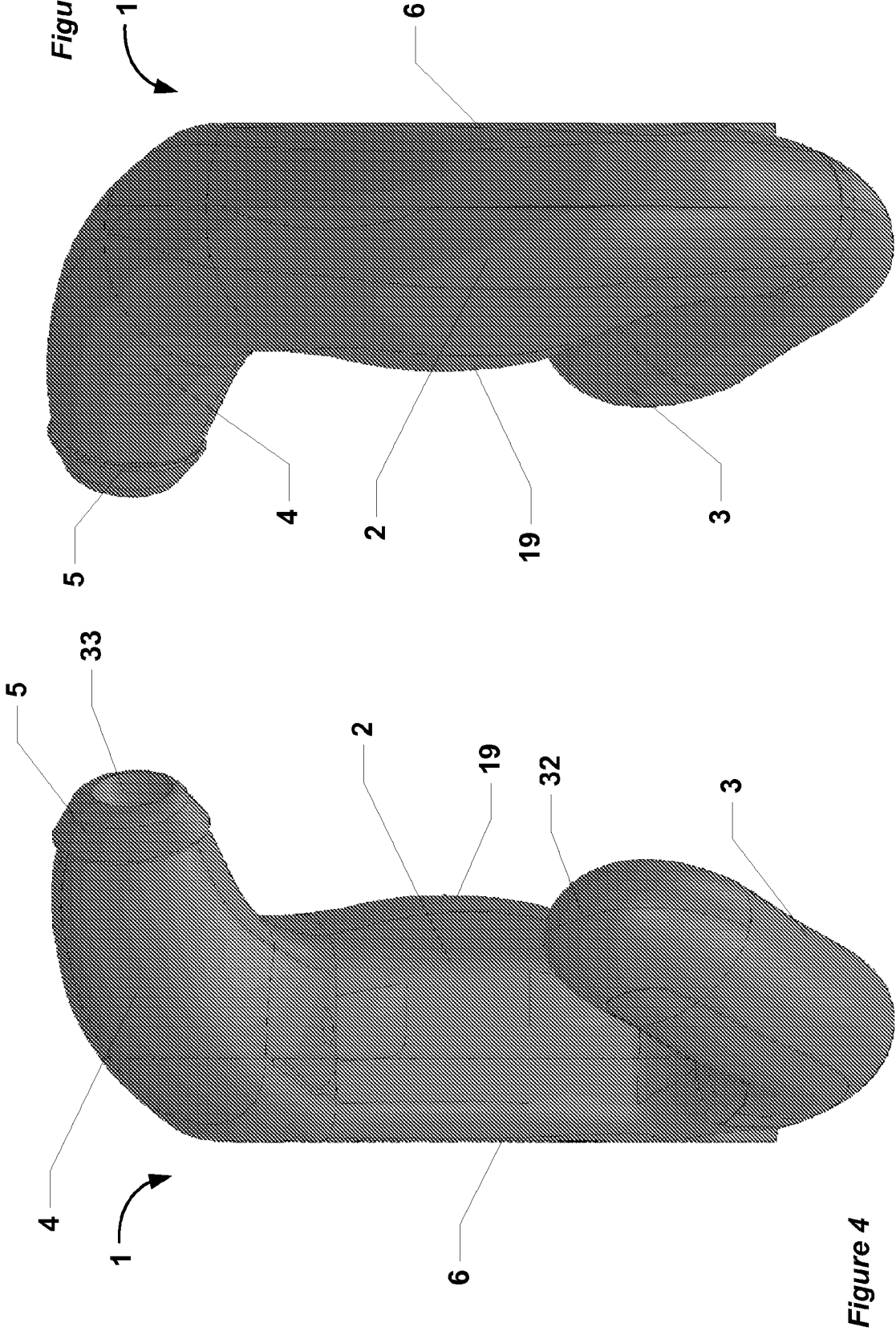
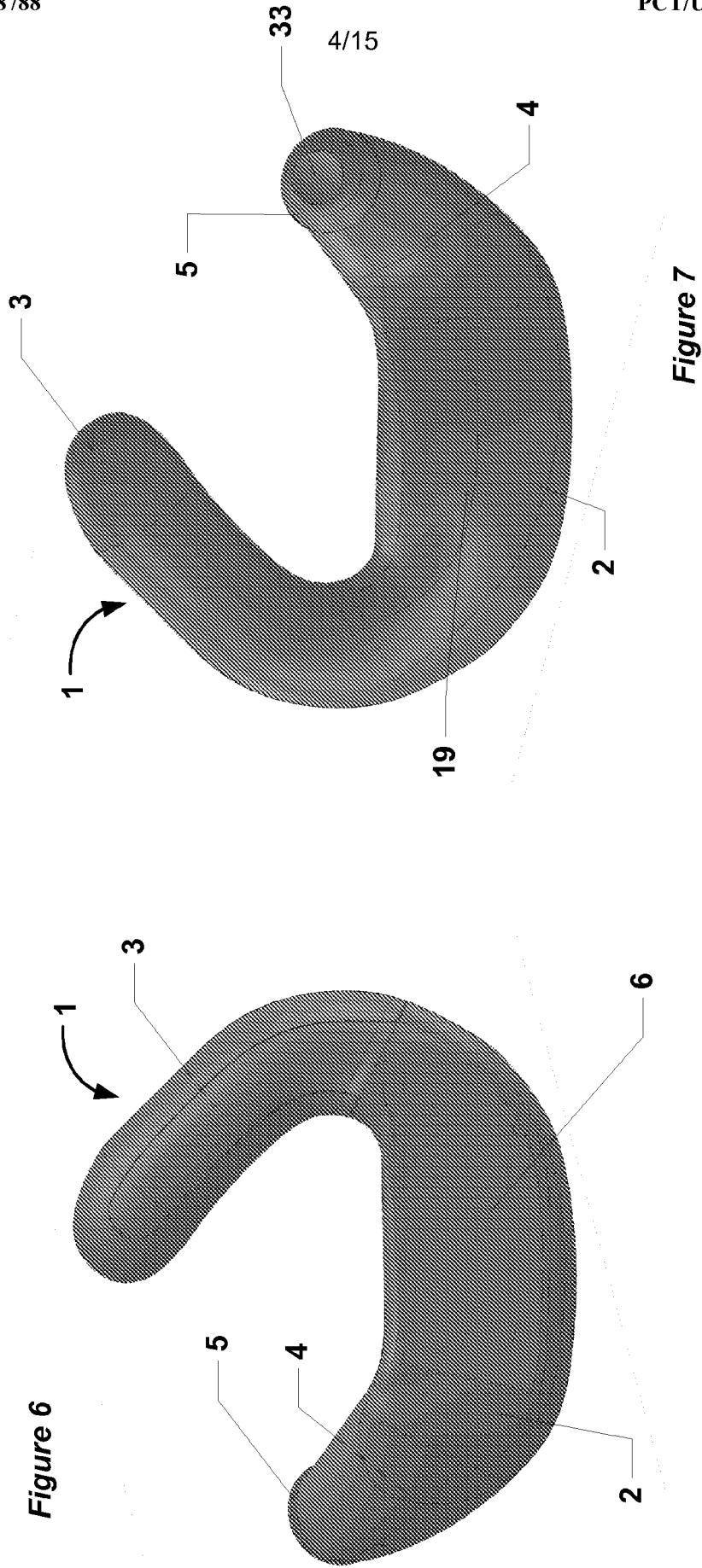


Figure 1







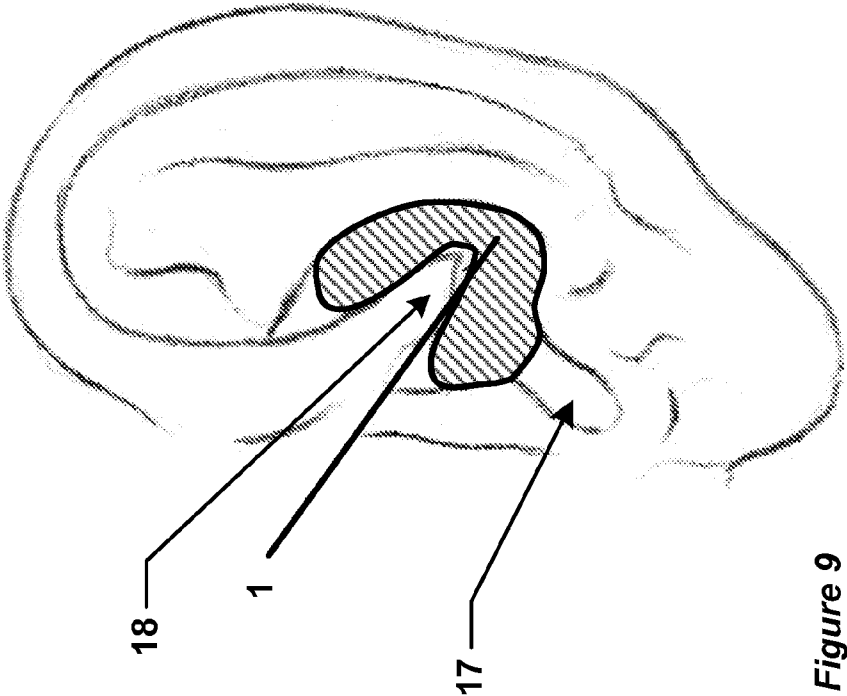


Figure 8

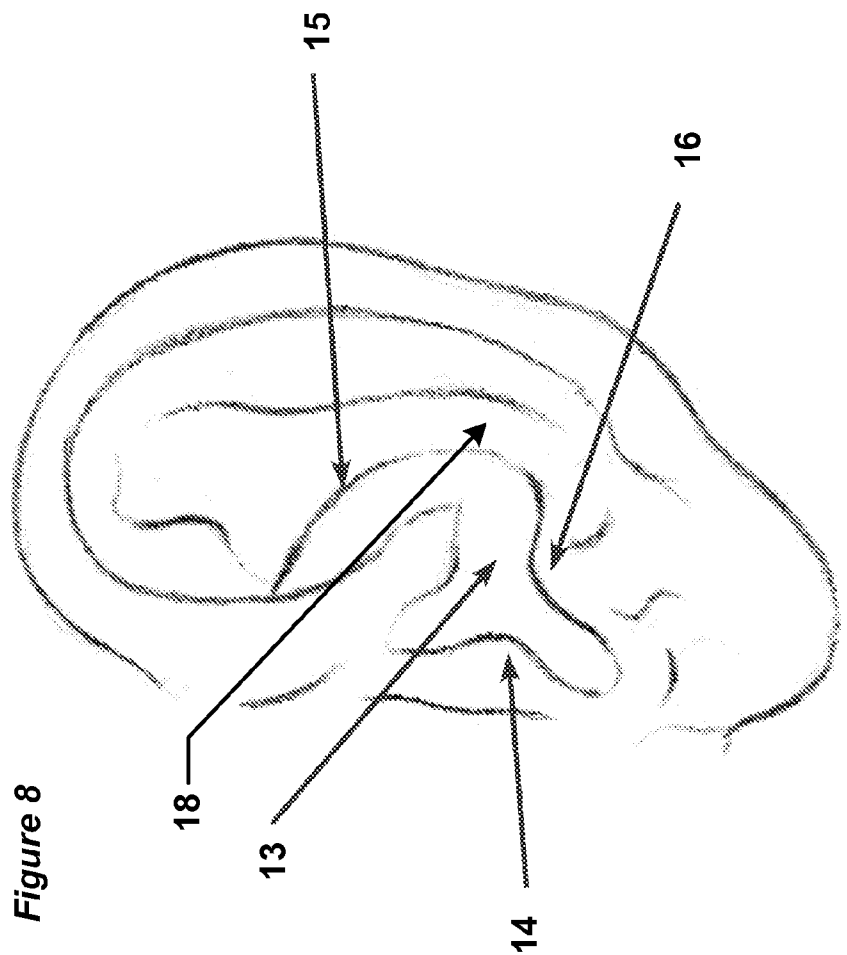
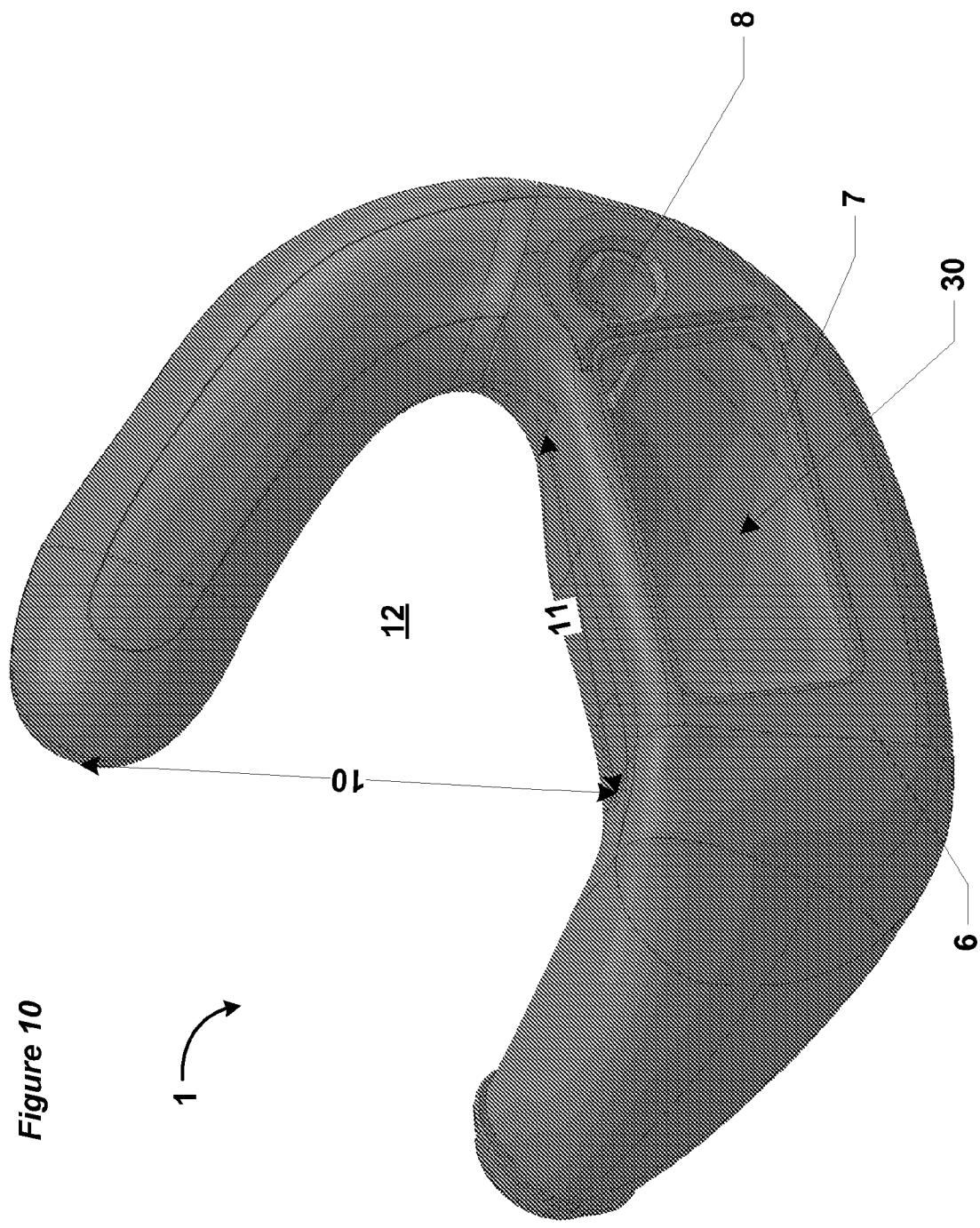


Figure 9



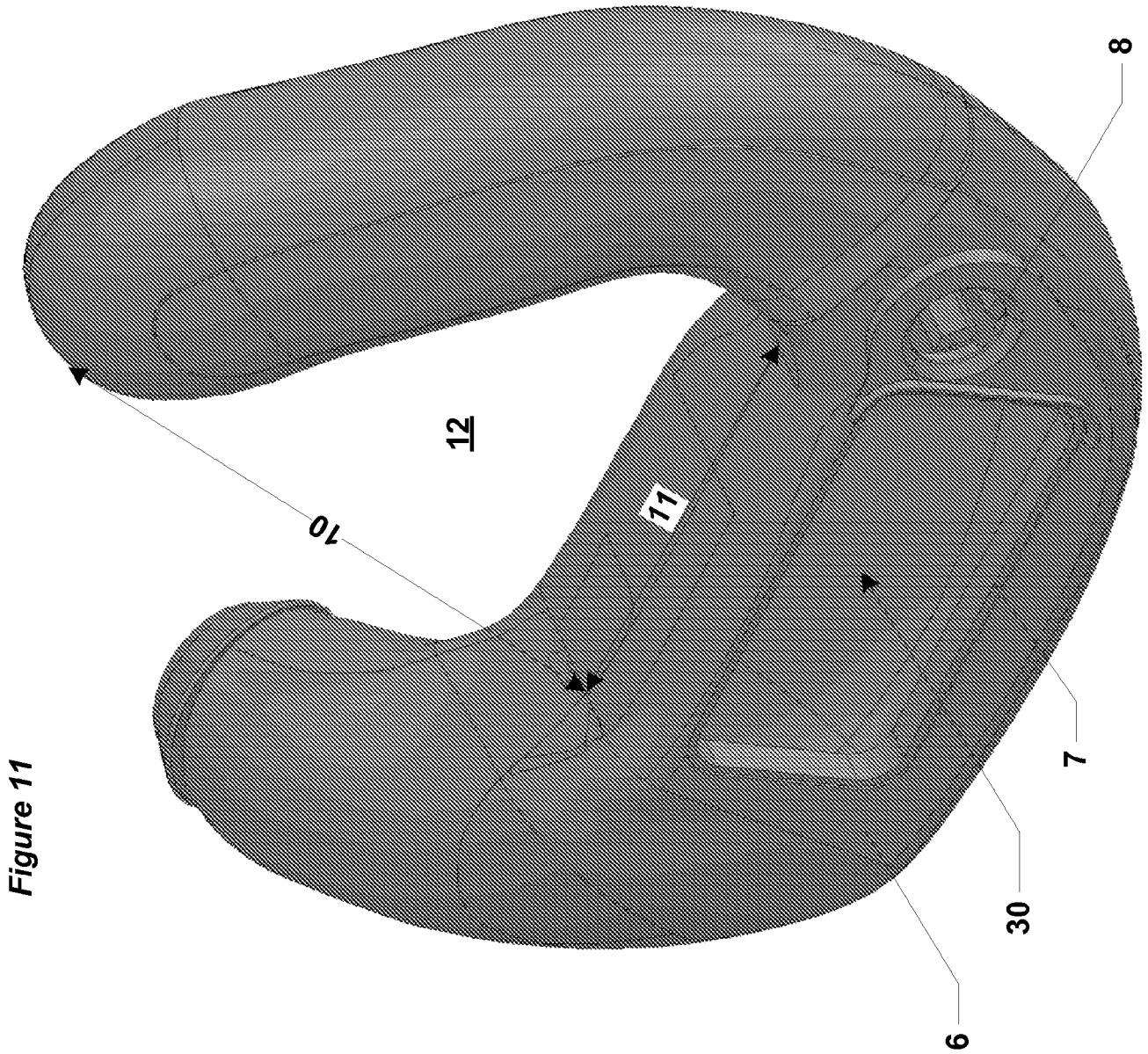


Figure 11

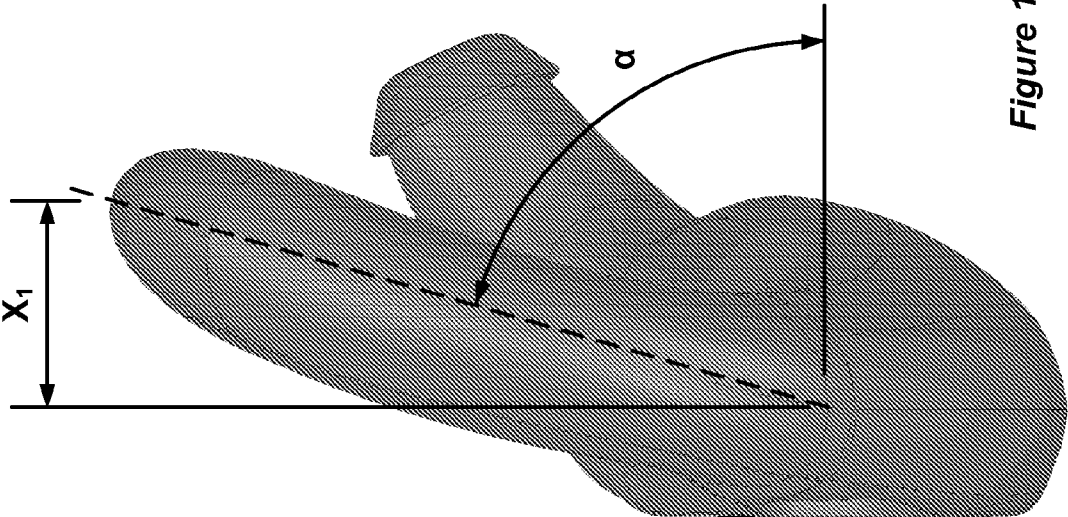


Figure 13

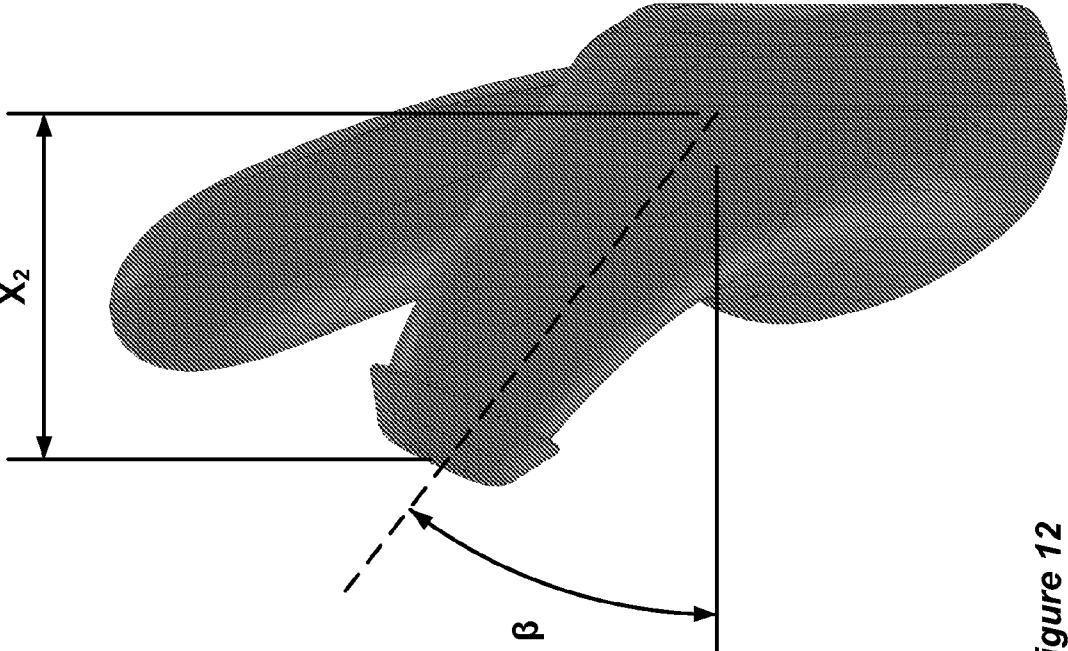
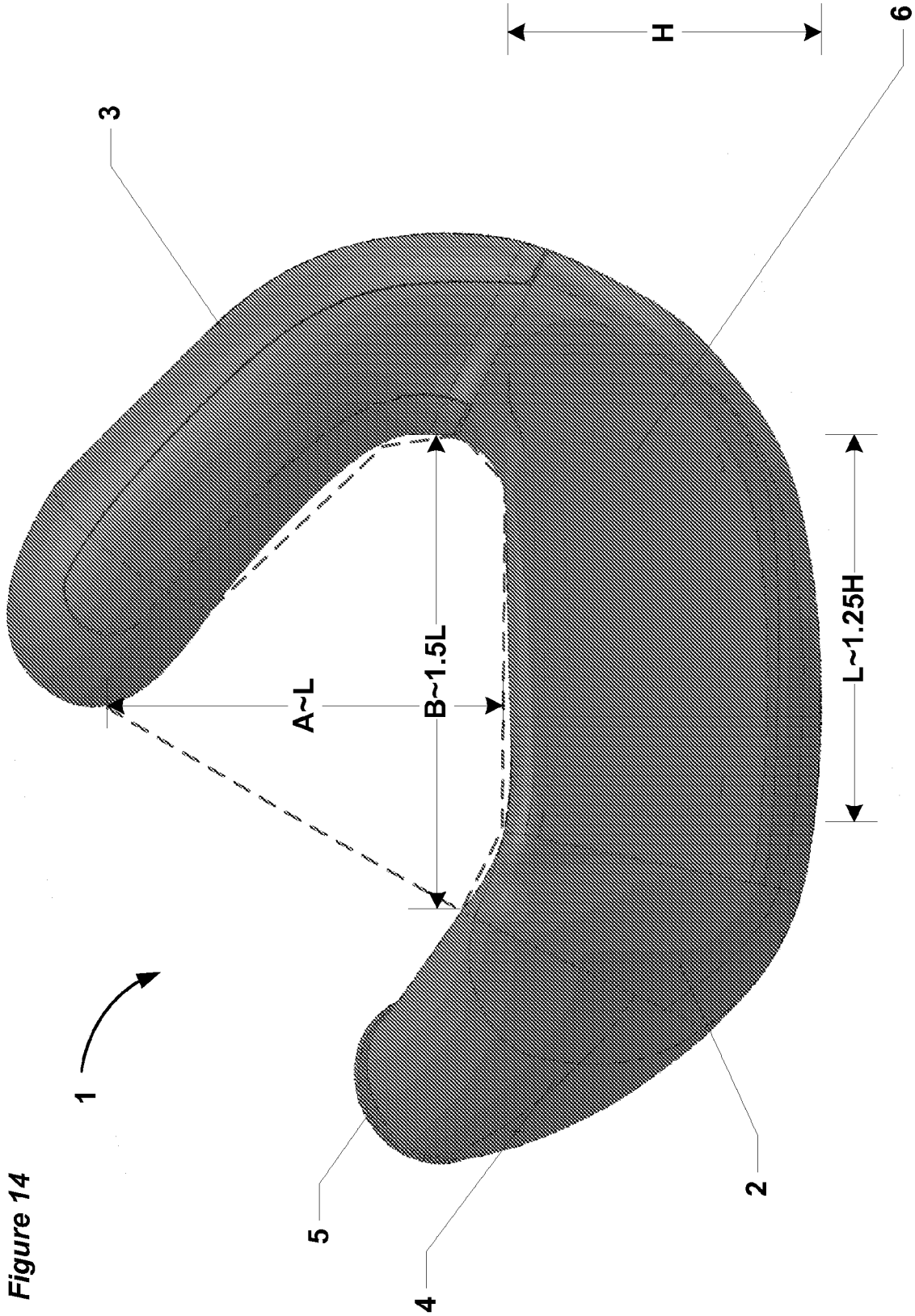
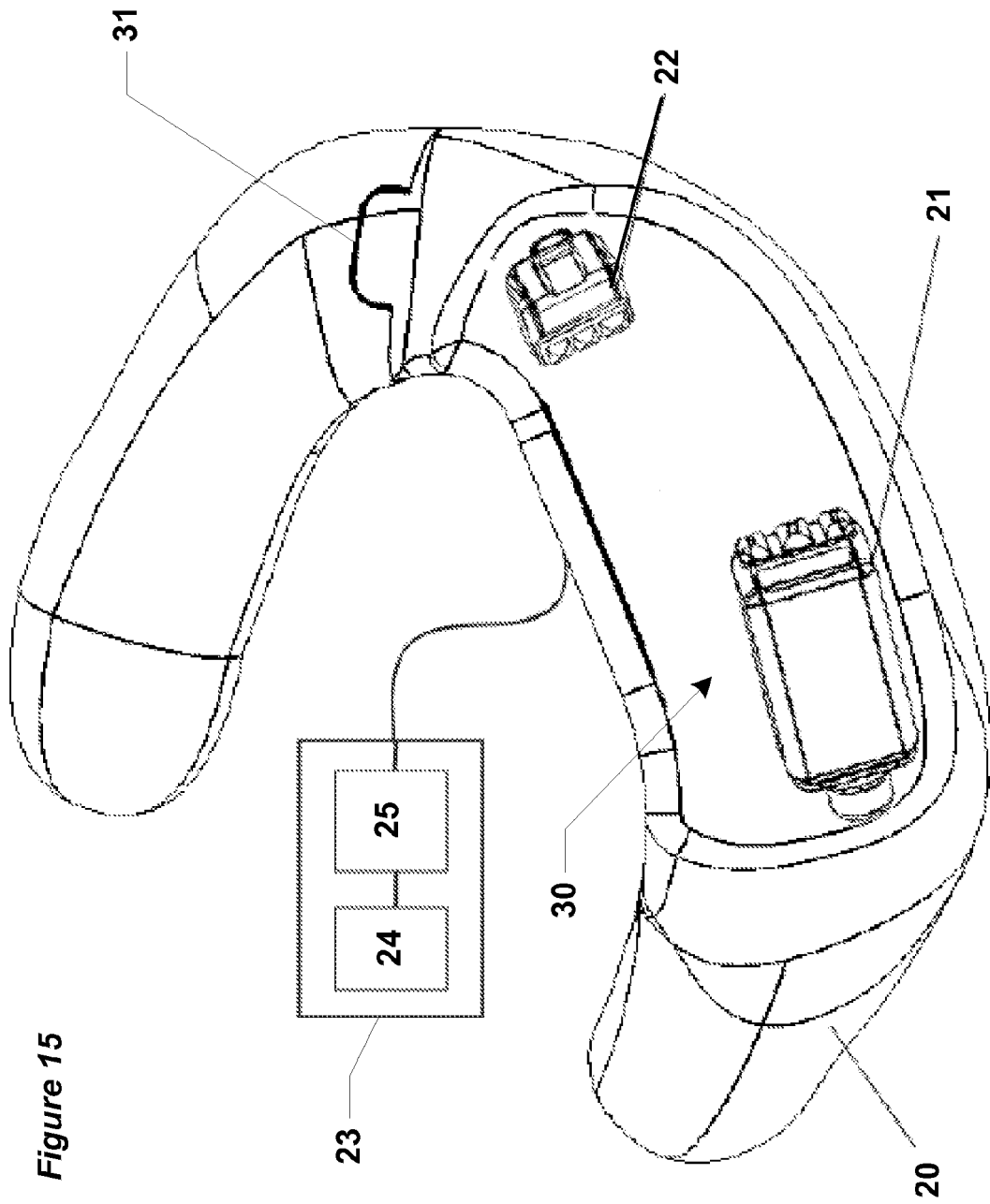


Figure 12





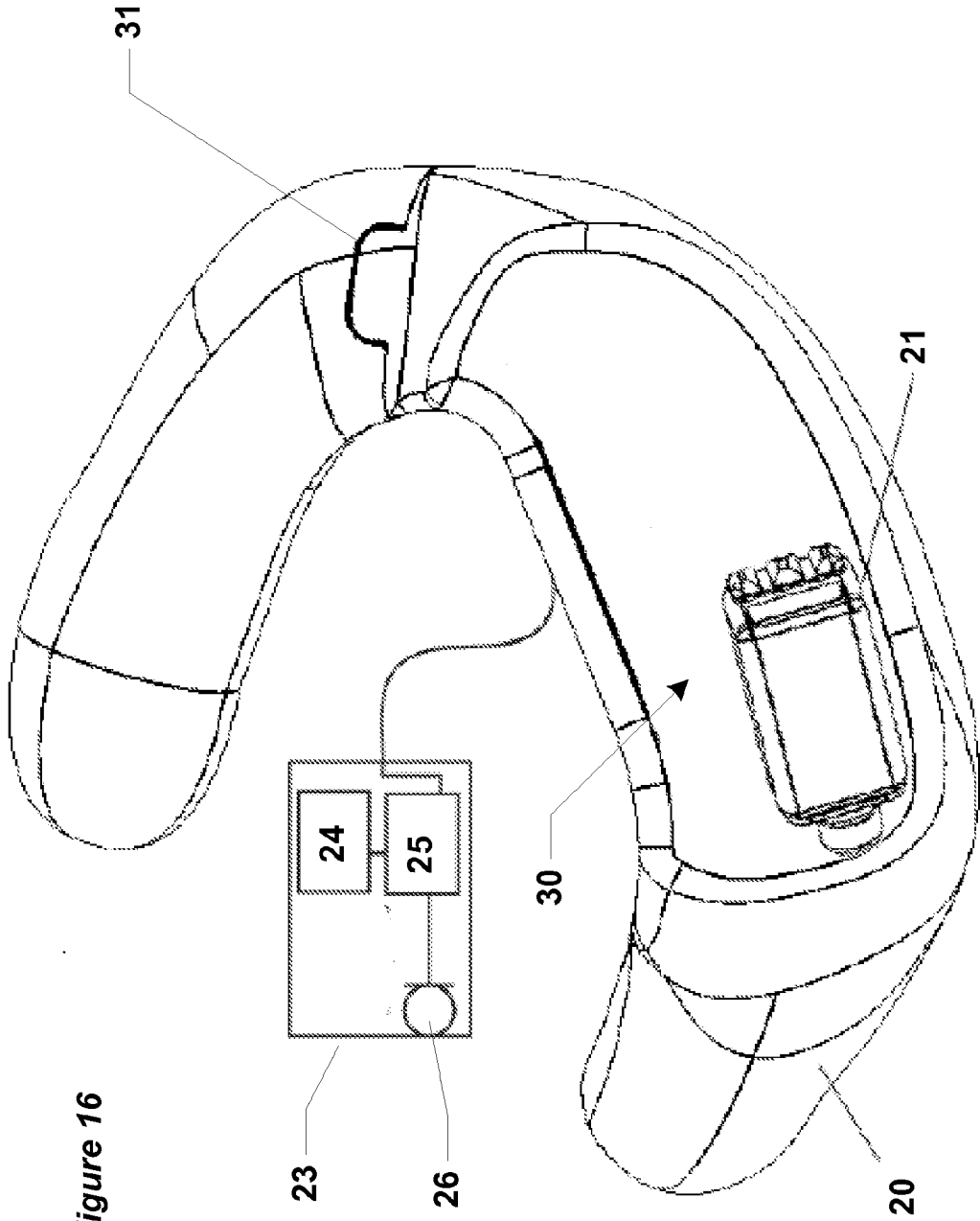


Figure 16

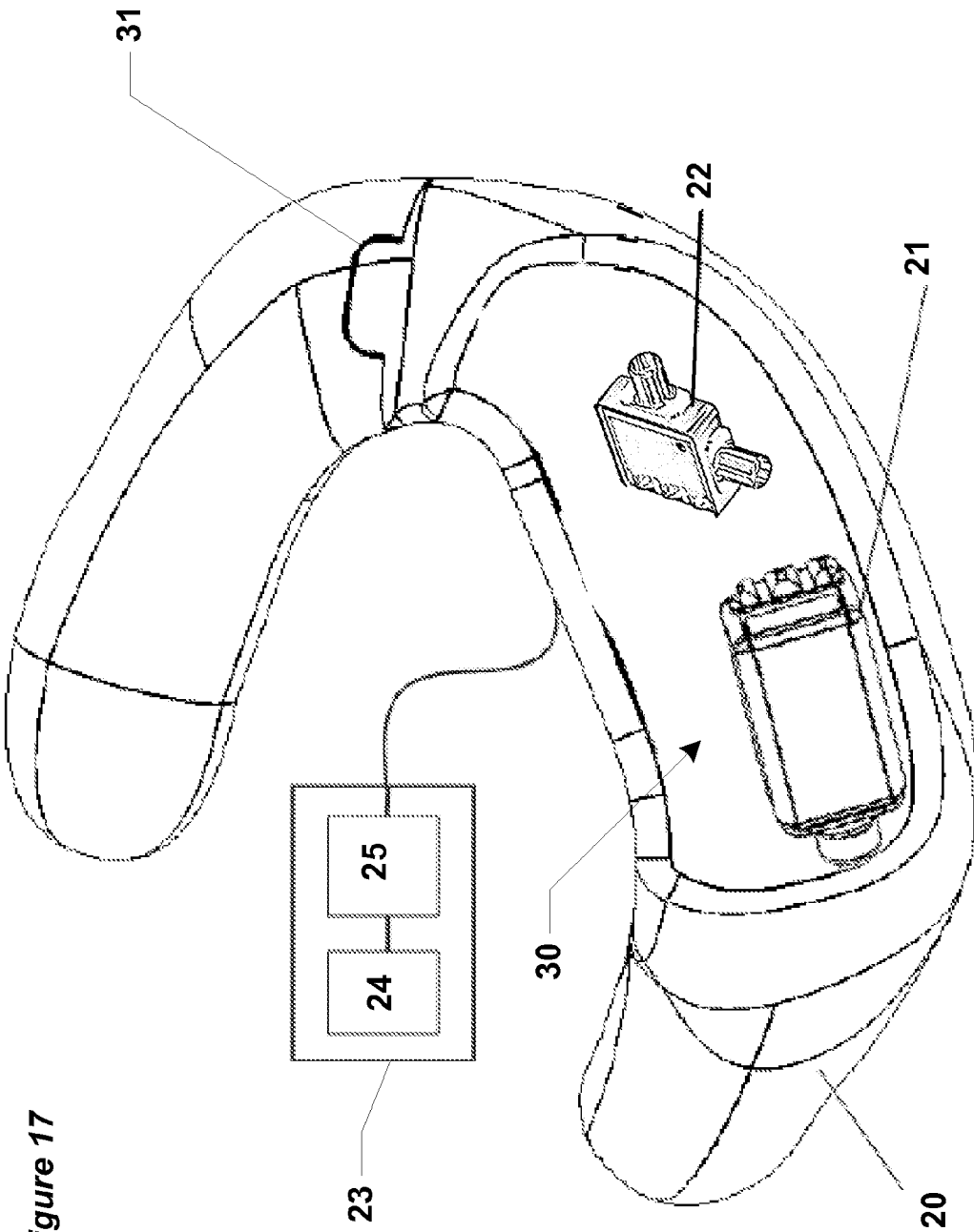


Figure 17

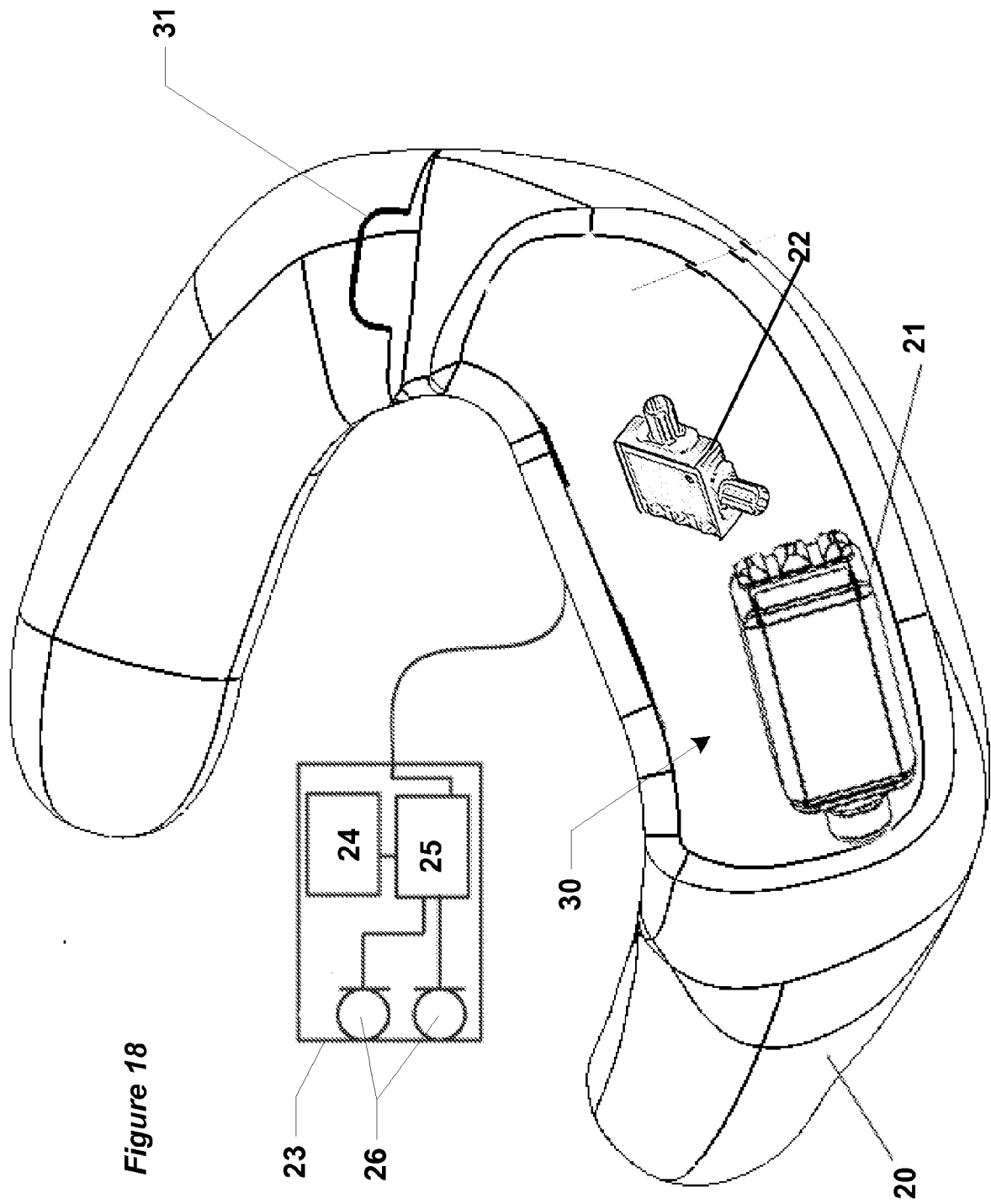


Figure 18

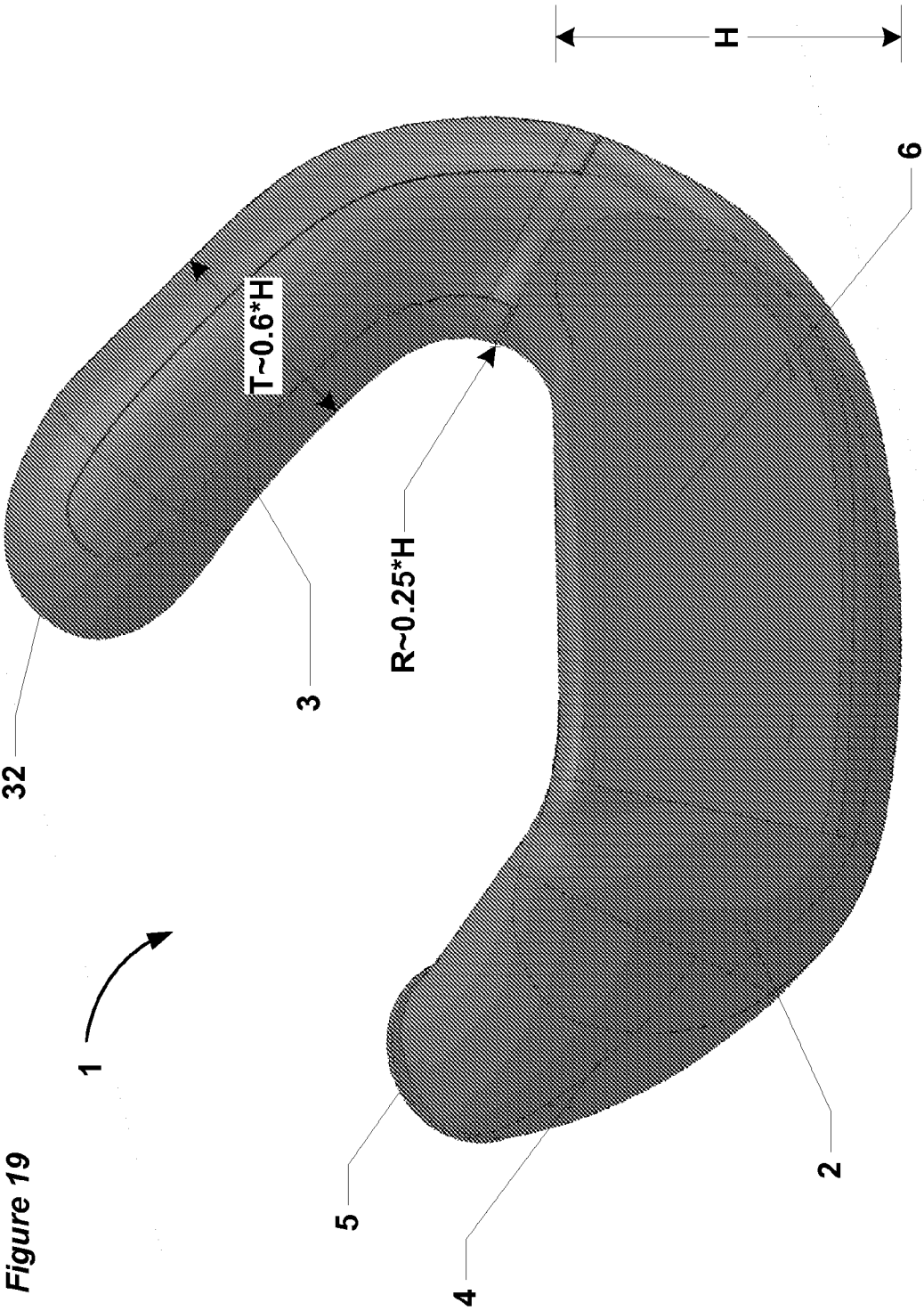


Figure 21

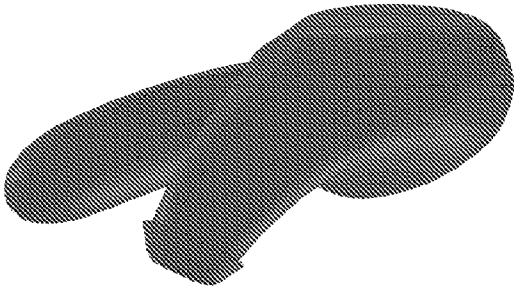


Figure 23

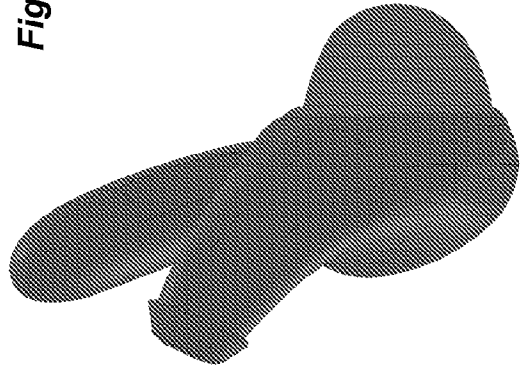


Figure 20

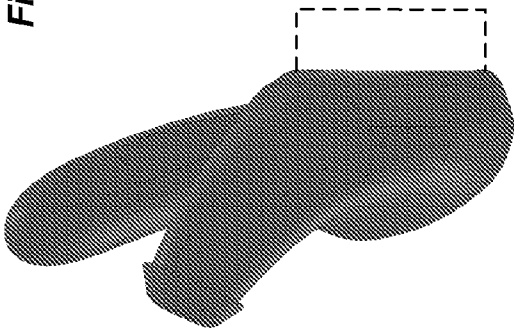


Figure 22

