

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
20 November 2003 (20.11.2003)

PCT

(10) International Publication Number
WO 03/096745 A1

(51) International Patent Classification⁷: **H04R 25/00**

(21) International Application Number: PCT/US03/14973

(22) International Filing Date: 12 May 2003 (12.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/379,871 10 May 2002 (10.05.2002) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.

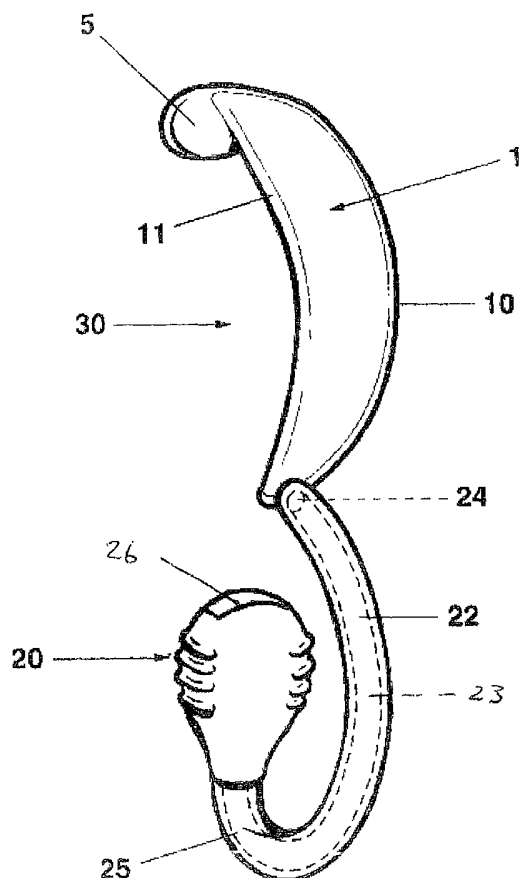
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- with amended claims

[Continued on next page]

(54) Title: EXTERNAL EAR INSERT FOR HEARING COMPREHENSION ENHANCEMENT



(57) Abstract: A simple hearing enhancement device (4A) that takes the normally adequately loud sound levels and optimizes selective frequency gain of the patient's ear passage to improve speech comprehension.



WO 03/096745 A1



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

EXTERNAL EAR INSERT FOR HEARING
COMPREHENSION ENHANCEMENT

TECHNICAL FIELD

5 The present invention relates a device for hearing enhancement, and more particularly, to a device inserted and attached to the outer ear, which may be used with or without electronic amplification to broadly or selectively enhance hearing ability and comprehension at higher audio frequencies. The invention also relates to a method of enhancing hearing using such a device.

BACKGROUND OF THE INVENTION

10 There are many devices and much background material pertaining to hearing aids that increase the amplitude of the sound impinging on the eardrum. Some of these operate by bone conduction. These are external amplifying devices which transmit sound through the bones behind the ears. As external devices, they can be unattractive, and can interfere with eyeglasses. Functionally, such devices have the
15 disadvantage of not providing more normal hearing and taking advantage of what adequate hearing a user has.

 Most hearing aids have their amplifying transducer fitted into the auditory meatus (the external auditory canal). This blocks the natural amplitude gain at the eardrum (tympanic membrane) produced by the auditory canal and causes
20 substantial or complete amplitude loss so the user must rely totally on electronic amplification.

 One problem with such devices is that it is hard to provide frequency band matched amplification electronically to match the patient's hearing where he still has reasonably normal hearing at least at lower frequencies of the natural sound field
25 around him without feedback distortion and over amplification of the background noise. For good or acceptable voice word comprehension, many patients need only

some boost at higher frequencies, which is where most of the hearing loss in later life occurs.

In particular, the hearing loss at higher frequencies is often in the range of 30 db or more. Amplification at such levels often results in whistle and feedback. This is generally dealt with by sealing the hearing aid to the wall of the auditory canal, and natural hearing even in the portions of the spectrum for which there is little or no impairment must be foregone. Vent holes are sometimes provided to allow some normal sound field through but there is still substantial attenuation.

As a consequence, many persons with only high frequency hearing impairment find electronic hearing aids to be unsatisfactory, and simply accept the impairment as an unavoidable consequence of aging.

Some passive devices have been considered. Among these are devices constructed in the form of a Helmholtz type resonator cavity box with a small opening and a small exit that was then inserted into the outer ear and ear auditory canal. This avoids use of amplifiers, but also limits other sound frequencies entering the ear. Also, such devices are bulky and unattractive.

It is therefore clear that a need exists for an improved hearing enhancement device usable by those with high frequency hearing impairment for whom existing amplified devices are not completely satisfactory.

SUMMARY OF THE INVENTION

The present invention meets this need by means of a passive device which can be inserted in the outer ear or pinna, and used with or without amplification to provide selective or broad-frequency enhanced ear passage gain at high frequencies.

The device is in the form of cup or scoop-shaped member that can be mounted against the back portion of the pinna and is held in place by the surrounding cartilaginous structures. Although the device may project slightly outward from the back portion of the outer ear, the distance is quite small, and the

device may be made of a clear relatively flexible plastic material, and is therefore its appearance is not a real impediment to its use.

5 The device appears to function by tuning the outer auditory passage leading to the eardrum. The shape and position in the outer portion of the pinna relative to the outer end of the auditory passage determines the amplitude and frequency gain response of the auditory passage with the tympanic membrane. By varying its front-to-back and inside-to-outside dimensions, both the peak resonant frequency and the width or sharpness of the resonance can be adjusted. It has been found that such adjustment of the natural resonance frequency response to incoming sound greatly improves speech comprehension, for example, for older individuals whose hearing loss is mainly at higher frequencies rather than across the entire sound spectrum.

10 Because the device does not block the auditory canal, the passage remains open for normal hearing at the frequency ranges for which there is no impairment. For such persons, amplification may not even be necessary, or if it is, the amplification needed will be considerably less. This avoids the need for very high gain and the consequent sensitivity to feedback which has heretofore required sealing the transducer into the ear.

15 In fact, since amplification may be not be needed at all times, an amplifying device may be provided in the form of a detachable unit held on the earlobe by a resilient clip with a sound tube that can be fitted into an opening in the earpiece, or electrically connected to a disc speaker element incorporated into the earpiece. This allows the user to remove the amplifier entirely when it is not needed.

20 The earpiece can be made in various standardized sizes and configurations to provide a range of predetermined response characteristics. The resonant characteristics of an individual's auditory passage, and thus his or her particular need can be determined by placement of a small microphone in the auditory canal and measuring the response to audio excitations from an external speaker at various frequencies and sound levels. One of the standardized earpieces can then be selected in this way

Accordingly, a primary object of this invention is to provide a simple passive device for enhancing the speech and other sound comprehension of persons having high frequency hearing impairment.

5 Another object of the invention is to provide such a device which occupies only a portion of the outer ear, and therefore does not block hearing at lower frequencies for which there is less or no impairment.

It is also an object of the invention is to provide a hearing enhancement device which can be used with or without amplification. A related object is to provide such a device which may be used with an amplifier which provides lower gain that is needed with conventional hearing aids, and therefore is less sensitive to feedback.

A further object of the invention is to provide a method for designing and/or optimizing the selection of an earpiece for overcoming high-frequency hearing impairment.

15 Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front view of a man's face and head showing the external ear, with hearing enhancement device in place in the external portions of both ears.

Figure 1A is a pictorial view of the hearing enhancement device for the left ear.

Figure 2 is a partial cross section of the human ear from the pinna into the auditory canal with a hearing enhancement device according to the invention in the outer ear at the entrance to the auditory canal.

Figure 3 is a side elevation of the left ear showing the placement of the hearing enhancement device in the pinna.

Figure 3A is a side elevation similar to Figure 3 which shows the hearing enhancement device coupled to a flexible tab that encapsulates a hearing aid electronic amplifier located behind the earlobe.

5 Figure 4 is a side view of the outer surface of a hearing enhancement device for the left ear according to the invention.

Figure 4A is a pictorial view of the hearing enhancement device for the left ear including a behind the earlobe electronic amplifier or wireless receiver for added selected frequency boost.

10 Figure 5 is a pictorial view of the behind the earlobe encapsulated electronic amplifier showing the side opposite that shown in Figure 4, in which the gain adjustment and battery compartment cover in the flexible leg connected to the hearing enhancement device are visible.

Like parts are given the same reference numeral in all figures.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

15 Figure 1 shows the front view of a man's face and head. Here, earpieces 1 which comprise the hearing enhancement devices according to the invention are positioned in the external portions of both ears 3. As may best be seen in Figures 1A, 2, 3, and 4, earpiece 1 is a scoop-like structure having variable three-dimensional curvature in a horizontal plane typified by line 6-6 in Figure 4, in a vertical plane typified by line 7-7 in Figure 4, and in the plane of the drawings. As
20 will be appreciated, the earpiece for the left ear has been illustrated. The right earpiece is the mirror image of the left earpiece.

25 Ear pieces 1 are formed of any suitable or desired plastic material, preferably one which can be made transparent (clear or flesh-toned) and flexible to the desired extent, such as silicone rubber or the like.

Earpiece 1 includes a forwardly facing concave surface 40, and a rearwardly facing convex surface 42, the front edges of which are delimited by forwardly facing edge 11, and outer marginal portions 10 around the outside which is captured by the outer ear cartilage ridge 3A (antihelix). These converge at the bottom end of the

earpiece to form a lower tip 44, and also converge at the top where they merge into an upper lug 5. Convex surface 42 is shaped to fit outwardly of the auditory meatus 2 (the opening of the auditory passage) in the concha against the cartilaginous antihelix 3A. Earpiece 1 is held in place by its inherent resiliency, and by lower tip 44 which engages with the lower end 3B of antihelix 3A, and by lug 5 which engages behind the upper end of outer ridge (helix) 46 in a cavity 5. Typically, marginal portion 10 will project slightly beyond antihelix 3A, as best illustrated in Figure 1. Edge 11 may also project beyond antihelix 3A as well.

As discussed below, it is believed that the curvature and linear dimensions of earpiece 1 provide the high frequency hearing enhancement characteristic of this invention by changing the resonant characteristics of the auditory meatus and outer auditory passage 2. The high frequency enhancement provided by the geometry of earpiece 1 may be entirely sufficient to overcome the hearing deficits of many users under most circumstances. However, if additional enhancement is desired, earpiece 1 can be coupled with an electronic amplifier.

Figure 3A shown how an amplifier unit 20 can be combined with earpiece 1 to form a composite hearing enhancement device 30. A flexible finger 22 attached to the lower end of marginal portion 10 at 9 extends downwardly along ear lobe 8, then bends sidewardly (i.e., toward the upper end of the jaw bone) at its lower end 48, then upwardly again behind earlobe 8. As best illustrated in Figures 4A and 5, finger 22 terminates at amplifier unit 20 which is small enough to be substantially hidden behind the earlobe. Finger 22 may itself be sufficiently resilient to hold amplifier unit 20 in place, or may include an embedded resilient member (not shown) to provide the necessary support.

Sound can be coupled from amplifier unit 20 to the auditory meatus 2 in any suitable or desired manner. For example, a transducer (not shown) at the lower end of amplifier housing 50 may be coupled through a passage 23 in flexible finger 22 which terminates in a fitting 24 which passes through opening 9 in earpiece margin 10. The connection between fitting 24 and opening 9 is preferably easily releasable (the connection being provided, for example, by making opening 9 slightly smaller

than fitting 24 to take advantage of the resiliency of the earpiece material) so that earpiece 1 can be separated from amplifier unit 20 for cleaning, or when use of the amplifier is not desired or necessary. The sound from passage 23 can be distributed, rather than directed into the ear, by shaping the opening in marginal portion 10, for example, to provide a hollowed-out area around opening 9, if desired.

Alternatively, the transducer may be embedded in the earpiece, and electrically connected to amplifier unit 20 by wires running through passage 23 terminating in a suitable plug connection.

Any suitable commercially available programmable digital type hearing aid amplifier and can be used for this purpose.

Amplifier unit 20 may advantageously be encapsulated with finger 22 as a single unit. As shown in Figure 5, suitable controls 21 for amplifier unit 20 may be provided in an easily accessible position on the rearwardly facing surface, and a compartment 26 for a suitable battery may be provided in any convenient location.

It has been found that earpiece 1 can be properly sized and shaped to modify the natural resonant characteristics of the users' open auditory canal. In this manner, substantial amplitude gain for higher frequencies at the tympanic membrane can be provided without amplification. This results in improved hearing in general, and in particular, better speech comprehension.

Specifically, by widening or narrowing opening 2 (see Figures 1 and 2) along the side of the head, and the length of edge 11 along the head in conjunction with the shape of the earpiece, sound level gain can be provided in auditory canal for the desired frequencies. The distance from marginal portion 10 forward to the auditory canal can be used in conjunction with the curvature of concave surface 40, to broaden or narrow the resonant peak. Both parameters can obviously be adjusted in a single device to meet the specific needs of a user.

Alternatively, it appears that a plurality of standardized shapes may be provided in different sizes for large and small ears. Earpieces can be designed for frequency gain response at selected frequencies within the lower end of the upper audio spectrum (e.g., approximately 4000-6000 Hz) and for broad or narrow

peaking at selected frequencies such as around 4000, 5000, or 6000 Hz. Narrower adjustment (fine tuning) can be obtained by providing either standardized or custom-made inserts for use in conjunction with the standardized earpieces and/or by selective amplification.

5 Use of standardized earpieces is presently preferred, as will be appreciated by those skilled in the art, since this simplifies and reduces the cost of manufacture, and allows the user to be fitted without having to wait for a custom part to be fabricated.

10 Auditory canal gain over selected frequency ranges as high as 30 db can be achieved in contrast to 20-30 db attenuation (loss) resulting from insertion of conventional hearing devices into the auditory canal. Since amplification just to overcome that attenuation is not needed, amplification, if needed at all, needonly be provided at the higher frequencies, and then, with substantially reduced gain. This, in turn, lessens or avoids the sensitivity to feedback.

15 In particular, if 10-30 db gain can be obtained by tuning the auditory canal in combination with the earpiece, providing an additional 10-20 db of gain through amplification at selected higher frequencies gives the user a total effective gain of 30-60 db at the ear drum without having to seal the speaker element into the auditory canal. The auditory canal is therefore open to the outside world for more normal
20 hearing of most of the sounds with better speech comprehension.

 Since feedback at gain levels below 30 db can be tolerated due to the absorption of surroundings, the limited amplification required substantially eliminates the problem of feedback encountered when the transducer unit is not sealed in the auditory canal.

25 It has also been found that the earpiece tends to shield the auditory canal from side and back noises to provide better signal to noise characteristic from the front i.e., in the direction the user is looking. This tends to further enhance speech comprehension.

30 Existing extremely small digital amplifiers can be used which provide multiple adjustable frequency gains to further match the user's hearing loss with

reduced amplifier power requirements. An attractive housing such as for an earring can be provided and can even be attached to the ear by a stud extending through a pierced ear lobe. A dummy housing can be provided where amplification is only needed for one ear.

5 The present invention also comprehends a procedure for designing and optimizing the shape of the earpieces. This is accomplished by placing a very small microphone 1 or 2 millimeters in the auditory canal near the eardrum and then measuring the received signal level of sound amplitude received for various frequencies of sound from a speaker transducer located outside of the ear.

10 The sound level gain for each frequency can be measured in the auditory canal and the shape of the earpiece adjusted to maximize the sound level gain at the frequencies that give the user the best hearing comprehension of words when tested at various sound levels. Average data can thus be obtained and used to design standardized earpieces with resonance peaks and shapes that can provide best fit on
15 a statistical basis for most users. Tuning for specific user's needs can be provided by standardized or customized inserts for use with the standardized earpieces or by selective amplification.

 Although the present invention has been described in relation to particular
embodiments thereof, many other variations and modifications and other uses will
20 become apparent to those skilled in the art. It is intended therefore, that the present invention be limited not by the specific disclosure herein, but is to be given the full scope indicated by the appended claims.

WHAT IS CLAIMED IS:

1. An external ear insert or attachment tuned to a patient's personal ear auditory meatus to provide an increased sound amplitude gain at the frequencies of sound most beneficial for the patient's speech comprehension.
2. An external ear insert or attachment as in Claim 1 where a small speaker element is added with an attached electronic amplifier.
3. A hearing enhancement device as in Claim 3 where the speaker element is a small disc in the surface of the device to impedance match the speaker to the air in the ear auditory meatus.
4. A hearing enhancement device comprising a shaped earpiece insertable in a user's outer ear, the earpiece being so shaped that it interacts with the auditory canal to modify the sound amplitude gain thereof as a function of frequency to improve the user's speech comprehension.
5. A hearing enhancement device according to claim 4, wherein the earpiece includes portions constructed to engage with the cartilaginous structures of the pinna to retain the earpiece in place.
6. A hearing enhancement device according to claim 4, further including an electronic amplifier and a speaker acoustically coupled to the user's ear.
7. A hearing enhancement device according to claim 6, wherein the speaker is comprised of a transducer element mounted in the earpiece.
8. A hearing enhancement device according to claim 7, wherein the transducer element is constructed to provide impedance matching to the air in the auditory canal.

9. A hearing enhancement device according to claim 6, wherein the transducer is detachably connected to the amplifier.
10. A hearing enhancement device according to claim 6, wherein the speaker is mounted remotely from the earpiece, and further including a sound conducting tube acoustically coupling the speaker to the user's ear.
11. A hearing enhancement device according to claim 10, wherein the sound conducting tube is acoustically coupled to the user's ear through an opening in the earpiece.
12. A hearing enhancement device according to claim 11, wherein the sound conducting tube is detachably coupled to the opening in the earpiece.
13. A hearing enhancement device according to claim 6, wherein the amplifier provides frequency dependent amplification.
14. A hearing enhancement device according to claim 4, further including an electronic amplifier and a speaker detachably coupled to the earpiece.
15. A hearing enhancement device according to claim 4, wherein the earpiece is so shaped that it interacts with the auditory canal at frequencies of about 4000 Hz and above.
16. A hearing enhancement device according to claim 4, wherein the earpiece is so shaped that it interacts with the auditory canal at frequencies in the range of about 4000 Hz to about 6000 Hz.
17. A hearing enhancement device according to claim 4, wherein the earpiece is so shaped that it interacts with the auditory canal to change the resonant frequency of the auditory canal.

18. A hearing enhancement device according to claim 4, wherein the earpiece is so shaped that it interacts with the auditory canal to change the peak resonant frequency of the auditory canal.
19. A hearing enhancement device according to claim 4, wherein the earpiece is so shaped that it interacts with the auditory canal to change the resonant frequency of the auditory canal.
20. A method for designing and optimizing the shape of an earpiece for a hearing enhancement device comprising the steps of:
placing a microphone in the auditory canal near the eardrum;
measuring the received signal level of sound amplitude received for various frequencies of sound from a speaker transducer located outside of the ear.
adjusting the shape of the earpiece to maximize the sound level gain at the frequencies that give the user the best hearing comprehension of words when tested at various sound levels.
21. The method according to claim 20 further including the steps of:
obtaining average data from testing a plurality of individuals;
employing the average data to design standardized earpieces with resonance peaks and shapes that can provide best fit on a statistical basis for a universe of users.
22. The method according to claim 21, further including the step of tuning for specific user's needs by providing inserts for use with the standardized earpieces and/or by selective amplification.

AMENDED CLAIMS

[received by the International Bureau on 30 September 2003 (30.09.03)
claims 1-22 replaced, claims 1-39 new]

1. A hearing enhancement device comprising a shaped earpiece insertable in a user's outer ear, the earpiece being so shaped that it interacts with the auditory canal to enhance the sound amplitude response thereof as a function of frequency to improve a user's speech comprehension.

2. A hearing enhancement device according to claim 1, wherein the earpiece is comprised of a resilient material, and includes:

a forwardly facing concave first surface;

a rearwardly facing convex second surface,

the first and second surfaces converging and joining at upper and lower ends thereof, with

terminal elements at the upper and lower ends of the first and second surfaces,

the earpiece being configured to be held in place in the ear by its inherent resiliency, and by

engagement of the terminal elements with cartilaginous portions of the outer ear, and

so shaped that it provides selective amplitude enhancement of incoming sound to improve a user's speech comprehension.

3. A hearing enhancement device according to claim 1, wherein the earpiece is comprised of a resilient material, and includes:

a forwardly facing concave first surface; and a rearwardly facing convex second surface,

the first and second surfaces defining a cavity which cooperates with a user's auditory canal to selectively enhance the amplitude of incoming sound at the eardrum.

4. A hearing enhancement device according to any of claims 1-3, further including an electronic amplifier and a speaker detachably coupled to the earpiece.

5. A hearing enhancement device according to any of claims 1-3, further including an electronic amplifier and a transducer acoustically coupled to the user's ear.

6. A hearing enhancement device according to claim 5, wherein the transducer element is mounted in the earpiece.

7. A hearing enhancement device according to claim 5, wherein the transducer is configured to provide impedance matching to the air in the auditory canal.

8. A hearing enhancement device according to claim 5, wherein the transducer is detachably connected to the amplifier.

9. A hearing enhancement device according to claim 5, wherein the amplifier is configured to be positioned behind a user's earlobe.

10. A hearing enhancement device according to claim 9, further including a resilient finger configured to attach the amplifier resiliently to a user's earlobe.

11. A hearing enhancement device according to claim 10, wherein the transducer is detachably connected to the amplifier by a coupling element mounted in the finger.

12. A hearing enhancement device according to claim 5, wherein the amplifier is mounted in an enclosure, the enclosure being so configured that it is resiliently attachable to a user's ear.

13. A hearing enhancement device according to claim 12, wherein the amplifier enclosure is configured to be positioned behind a user's earlobe.

14. A hearing enhancement device according to claim 12, further including a resilient finger extending from the amplifier enclosure configured to attach the amplifier enclosure resiliently to a user's earlobe.

15. A hearing enhancement device according to claim 5, wherein the transducer is mounted remotely from the earpiece, and further including a sound conducting tube acoustically coupling the transducer to the user's ear.

16. A hearing enhancement device according to claim 15, wherein the sound conducting tube is acoustically coupled to the user's ear through an opening in the earpiece.

17. A hearing enhancement device according to claim 15 or 16, wherein an end of the sound conducting tube extends through an opening in the earpiece.

18. A hearing enhancement device according to any of claims 15-17, wherein the sound conducting tube is detachably coupled to the opening in the earpiece.

19. A hearing enhancement device according to claim 5, wherein the amplifier provides frequency dependent amplification.

20. A hearing enhancement device according to any of claims 1-3, wherein the earpiece is so shaped that the ~~sound~~ amplitude response enhancement is at frequencies of about 4000 Hz and above.

21. A hearing enhancement device according to any of claims 1-3, wherein the earpiece is so shaped that the selective amplitude response enhancement is at frequencies in the range of about 4000 Hz to about 6000 Hz.

22. A hearing enhancement device according to any of claims 1-3, wherein the earpiece is so shaped that it interacts with the auditory canal to change the resonance characteristics thereof.

23. A hearing enhancement device according to any of claims 1-3, wherein the earpiece is so shaped that it interacts with the auditory canal to change the peak resonant frequency thereof.

24. A hearing enhancement device according to claim 2, wherein the terminal element at the lower end is shaped and positioned to engage with the lower end of the antihelix of the ear.

25. A hearing enhancement device according to claim 2, wherein the terminal element at the upper end is shaped and positioned to engage behind the upper end of the helix of the ear.

26. A hearing enhancement device according to claim 25, wherein the terminal element at the upper end is shaped and positioned for insertion in a cavity behind the upper end of helix.

27. A hearing enhancement device according to claim 2, wherein the second surface is shaped and positioned to fit outwardly of the opening of the auditory passage in the concha and against the antihelix.

28. A hearing enhancement device according to claim 2, wherein front edges of the first and second surfaces are delimited by forwardly facing first and second marginal portions, the first marginal portion extending more forwardly at a lower end thereof than the second marginal portion, and the second marginal portion extending more forwardly at an upper end thereof than the first marginal portion.

29. A hearing enhancement device according to claim 28, wherein the first marginal portion is shaped and dimensioned to project partially beyond the antihelix.

30. A hearing enhancement device according to claim 29, wherein the second marginal portion is shaped and dimensioned to project slightly beyond the antihelix.

31. A hearing enhancement device according to claim 28, wherein the first and second surfaces, and the first and second marginal portions are so shaped and dimensioned that the earpiece interacts with the auditory canal to modify the sound amplitude enhancement thereof as a function of frequency.

32. A hearing enhancement device according to claim 28, wherein front edges of the first and second surfaces are delimited by forwardly facing first and second marginal portions, and the selective amplitude enhancement of the earpiece is frequency dependent according to the shape and positioning of the first and second marginal portions.

33. A hearing enhancement device according to claim 32, wherein the frequency of maximum amplitude enhancement increases or decreases according to the extent that the position of the second marginal portion widens or narrows the effective opening of the auditory canal along the side of the head.

34. A hearing enhancement device according to claim 33, wherein the range of substantial frequency dependent amplitude enhancement increases or decreases according to increases or decreases of the distance from the first marginal portion forward along the head to the auditory canal.

35. The hearing enhancement device according to claim 3, wherein:
the first and second surfaces converge and are joined at their respective upper and lower ends to respective upper and lower terminal elements, and
the earpiece is configured to be held in place in the ear by its inherent resiliency, and by engagement of the terminal elements with cartilaginous portions of the outer ear.

36. A hearing enhancement device according to any of claims 1-3, wherein the earpiece includes portions configured to engage with the cartilaginous structures of the pinna to retain the earpiece in place.

37. A method for designing and optimizing the shape of an earpiece for a hearing enhancement device comprising the steps of:
placing a microphone in the auditory canal near the eardrum;
measuring the received signal level of sound amplitude received for various frequencies of sound from a speaker transducer located outside of the ear.
adjusting the shape of the earpiece to maximize the sound level gain at the frequencies that give the user the best hearing comprehension of words when tested at various sound levels.

38. The method according to claim 37, further including the steps of obtaining average data from testing a plurality of individuals; employing the average data to design standardized earpieces with resonance peaks and shapes that can provide best fit on a statistical basis for a universe of users.

39. The method according to claim 38, further including the step of tuning for specific user's needs by providing inserts for use with the standardized earpieces and/or by selective amplification.

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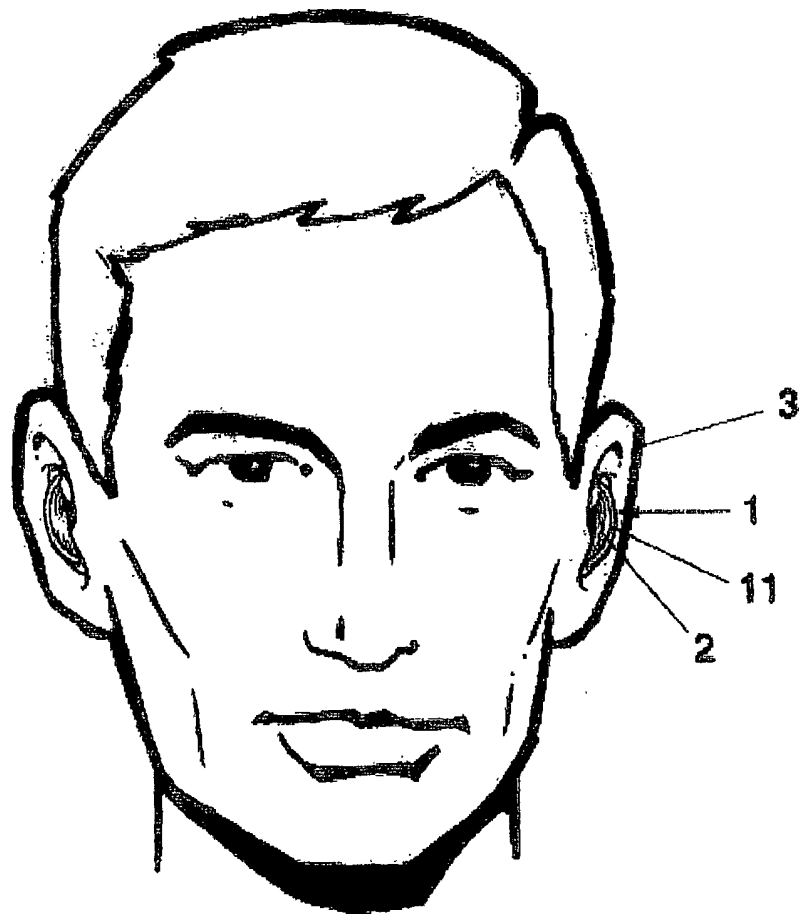


Fig. 1

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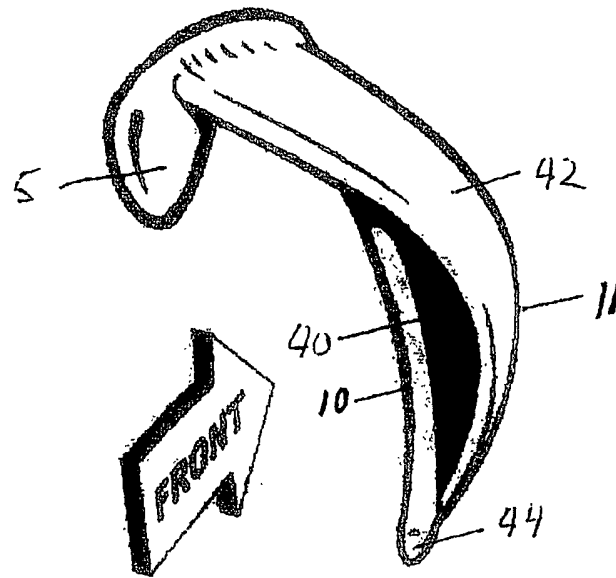


Fig. 1A

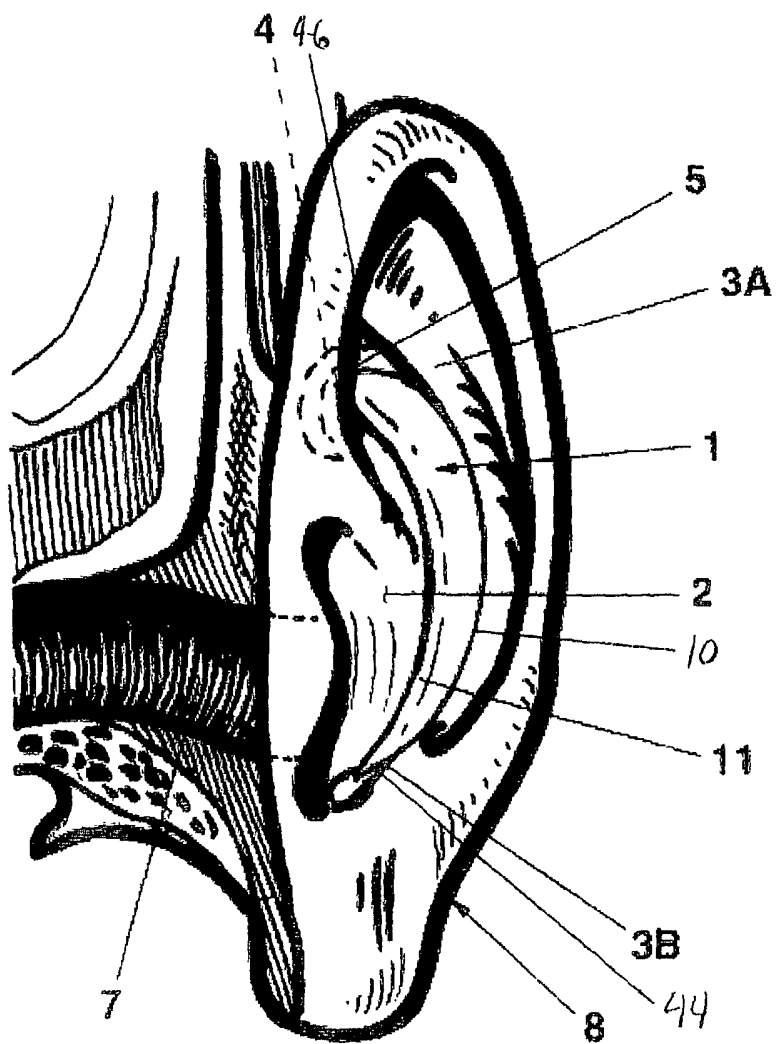


Fig. 2

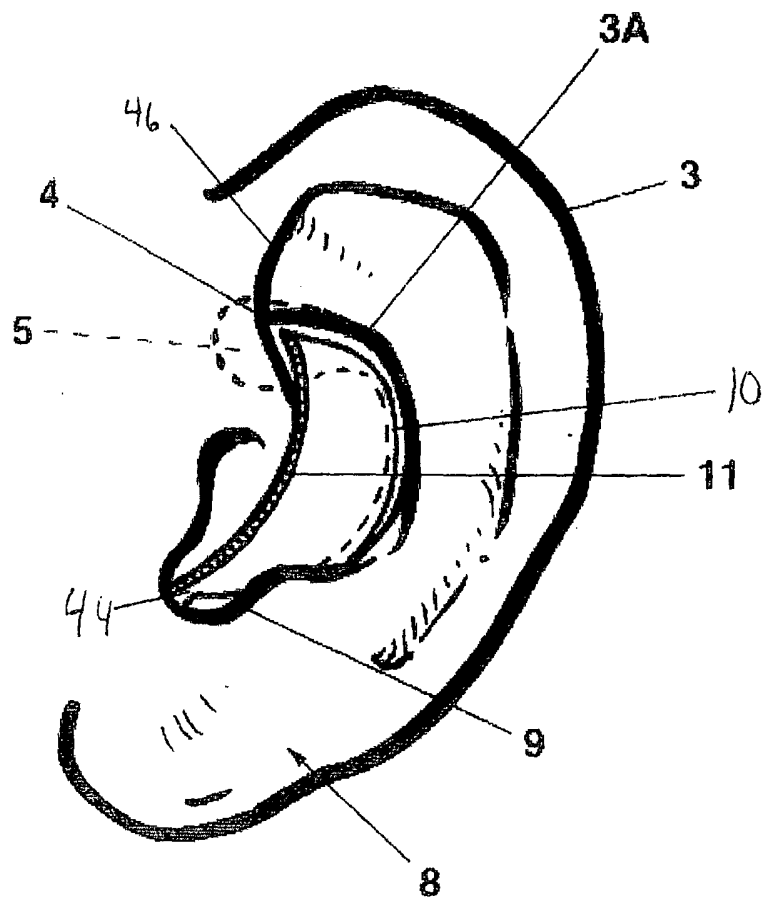


Fig. 3

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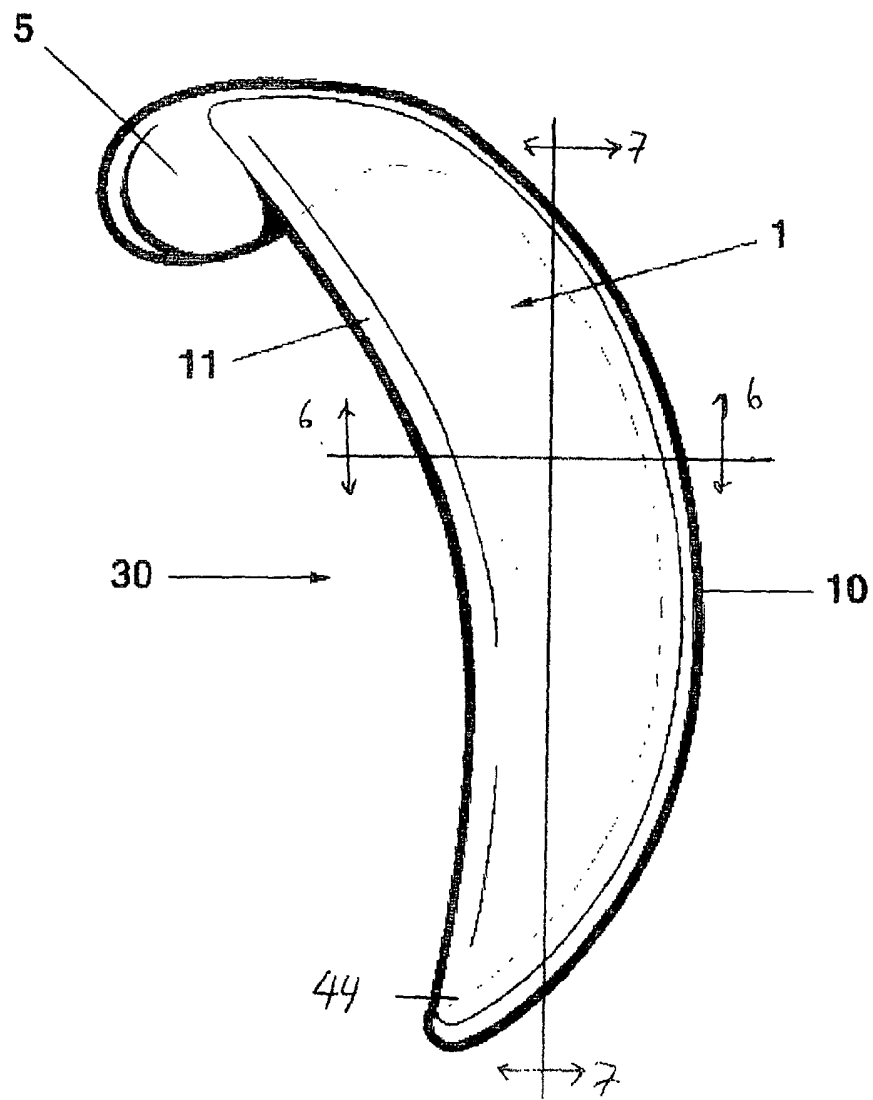


Fig. 4

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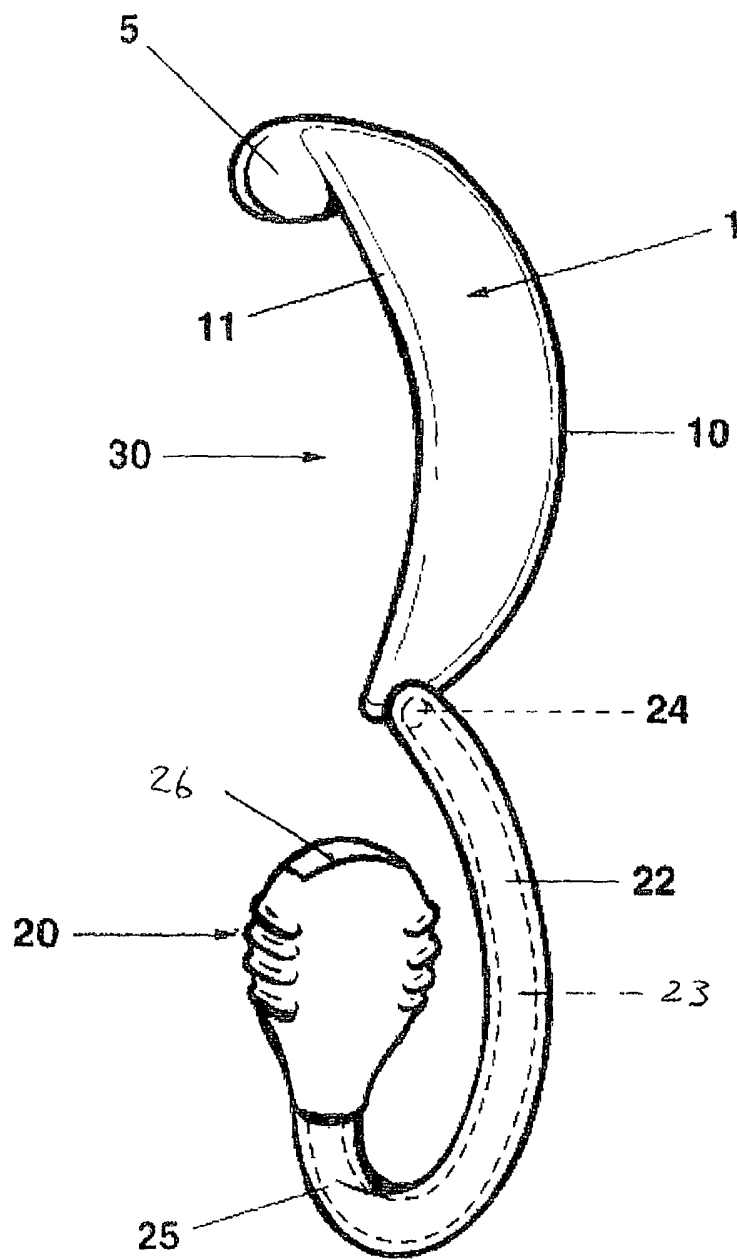


Fig. 4A

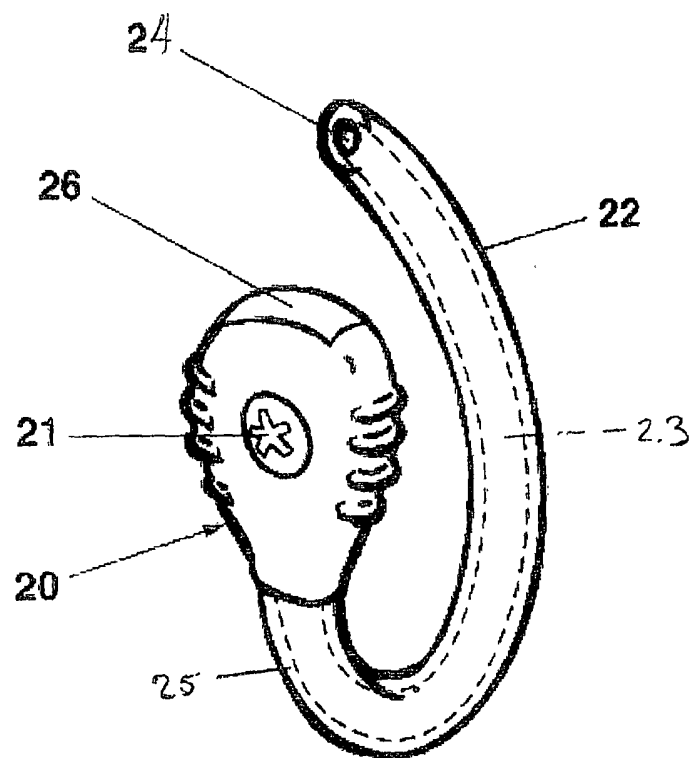


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/14973

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04R 25/00
 US CL : 381/330, 381/60

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)
 U.S. : 381/330, 381/60, 381/322

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,357,576 A (ARNDT) 18 October 1994 (18.10.1994), Fig. 4.	1-8, 13 and 15-19.
X	US 5,046,580 A (BARTON) 10 September 1991 (10.09.1991), Figs. 1-2	1-19.
X	US 4,759,070 A (VOROBA et al.) 19 July 1988 (19.07.1988), abstract and claim 6.	20 and 22.
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A		21
X	US 4,498,332 A (BRUCKHOFF) 12 February 1985 (12.02.1985), col. 2, lines 52-69.	20 and 21.

☐ 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 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

27 June 2003 (27.06.2003)

Date of mailing of the international search report

30 JUL 2003

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US
 Commissioner for Patents
 P.O. Box 1450
 Alexandria, Virginia 22313-1450

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Authorized officer

Sinh Tran

Telephone No. (703) 305-3900

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/14973

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

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

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claim 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. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Continuation Sheet

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

Remark on Protest

☐
☐

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of Group I is the housing structure of the hearing aid and the special technical feature of Group II is the method of testing a hearing aid. Since the special technical feature of Group I invention is not present in Group II being claimed, unity is lacking.