Title: AN EXTERNAL AUDITORY CANAL COMMUNICATION DEVICE

Abstract: An external auditory canal communication device comprising a sound capturing means (101) being configured for specifically capturing human vocal sounds directly from external auditory canal of a user where the user's voice is propagated in the air along the external auditory canal primarily caused by vibrations along the walls of the external auditory canal while the user is making sounds; a sound signal processing means for receiving and processing the captured sounds from the sound capturing means, wherein the captured sounds are converted into sound signals; a sound signal transmitting means for receiving and transmitting the sound signals from the sound signal processing means to a communication-based device; a sound emitting means (103) for receiving sound signals from the communication-based device and emitting the sound signals into the external auditory canal for the user to listen; an electrical power source; and a housing (102) customizable to optimally place, affix or apply the device to any region from pinna to tympanic membrane of the user, wherein any one or combination of the sound capturing means (101), sound signal processing means, sound signal transmitting means and sound emitting means (103) are disposed in the housing, characterized in that the housing allows occlusion of the external auditory canal.
AN EXTERNAL AUDITORY CANAL COMMUNICATION DEVICE

FIELD OF INVENTION

The present invention relates to an external auditory canal communication device. In more particular, the present invention relates to an external auditory canal communication device which captures the human vocal sounds directly from one's external auditory canal where one's voice is propagated in the air along the external auditory canal primarily caused by the vibrations along the walls of the external auditory canal while one is making vocal sounds.

BACKGROUND OF THE INVENTION

Sounds are produced when an object vibrates in matter. Vibration in the atmosphere sets the air molecules in motion, causing them to collide with each other and creates areas of compression and rarefaction. The collision of the air molecules enables waves of pressure fluctuation to be carried through the atmosphere. Our hearing system captures the sound waves directed from the atmosphere into our outer ears which consists of the pinna, concha and external auditory canal. From the pinna the sound waves move into the external auditory canal before being led into the middle ear and later into the inner ear in which the sound waves will be converted into nerve signals that the brain can recognize.

The abovementioned mechanism where sound waves are conducted into the inner ear through the external auditory canal is known as air conduction. According to scientific research, a person's own voice can be heard through two bending signals in which one of the signals come from the external auditory canal via air conduction and the other signals come from bone conduction. The bone conduction of the mastoid bones causes the posterior superior wall of the external auditory canal to vibrate. On the
other hand, vocal resonance enables voice sound waves that are possibly generated
from the chest, tracheal tree, larynx, pharynx, oral cavity, nasal cavity and sinuses to
pass to the outside air and later directed into the external auditory canal through air
conduction.

Vibration of the external auditory canal walls might also be due to vocal resonation.
The organic systems which have main roles to play in the human vocal sound
production consist of musculo-skeletal systems, folds, chambers, canals, cavities and
hollows. Vocal sound production is the summation of the interplay between air stream
flow, oscillation, resonance, frequency generation and amplification. When the air
stream flow along the laryngopharyngeal resonates, the musculo-skeletal system in
the vicinity will also resonate and it is this vibrational energy in the musculo-skeletal
system which will cause further resonance in the chambers, canals, cavities and
hollows. The vibrations in these chambers, canals, cavities and hollows are the part of
the key differentiators which make every individual's voice unique. The external
auditory canal is one of the many cavities where vocal sounds will be propagated as a
person speaks, thus producing sound waves at the external auditory canal.

To illustrate the existence of air conduction of one's voice speech in the external
auditory canal can be materially exploited, the following important points are taken
into consideration:

It is immediately demonstrable and provable that there is sound of one's voice in
one's external auditory canal: Take for example a person who has an intact sense of
hearing uses the fingers to occlude the external auditory canal while speaking, one's
voice becomes perceivable to be altered as having characteristics such as 'hollowness'
and loudness.

It is also easily and immediately demonstrable that the sounds coming from hitting a
plain piece of cow hide (no matter how hard and fast it is being hit) cannot parallel the
sounds coming from hitting a plain piece of cow hide which has been affixed on the mouth of an empty leak-proof vessel. It is this very fact that drums are made this way to create richer sounds and to carry sounds further and louder. In the same token, musical instruments were traditionally created to exploit the air conduction mode of sound propagation in chambers or hollows. Any guitarist will understand that an unplugged electric guitar without a hollow chamber cannot make sounds as rich and melodious as a traditional guitar with a hollow chamber. Another example is demonstrable with in-ear speakers: The sounds coming from the speakers are perceivable to be richer when they are plugged on the external auditory canal than when they are away from the auditory canal. All these phenomena proves the importance of the external auditory canal as an enhancer of the quality of sound and this naturally applies to one's own speech.

Several prior arts related to sound capturing and emitting device have been disclosed, including U.S. Patent No. 5295193 that reveals a device for picking up bone conducted sound in the external auditory meatus that comprises a fitting portion having an outer peripheral portion which can be accommodated in use in a navicular cavity formed between a tragus cartilage portion and the entrance portion of the external auditory meatus, the outer peripheral portion in use contacting a wall of the navicular cavity to support the fitting portion in the navicular cavity, a bone conduction microphone unit having a contact portion which in use is brought into contact with a wall of the external auditory meatus for picking up bone conducted sound and a resilient member between the bone conduction microphone unit and the fitting portion, by which the fitting portion holds said bone conduction microphone unit, the resilient member in use resiliently applying a force to the contact portion of the microphone unit to urge the contact portion into contact with the wall of the external auditory meatus substantially orthogonally to the wall, the contact portion contacting the wall along an arc comprising less than the entire circumference of the external auditory meatus.
Another patent of interest is U.S. Patent No. 6952483 which describes a voice communication device that comprises an earpiece housing, a speaker operatively connected to the earpiece housing, a bone conduction sensor for sensing voice sound vibrations operatively connected to the earpiece housing and an UWB transceiver operatively connected to the speaker and the bone conduction sensor as well as the earpiece housing.

Both the prior arts mentioned above contain drawbacks in which the bone conduction sensing means have to be fitted or attached to the posterior superior wall of the external auditory canal of the user in order to be able to detect the vibration caused by the bone conduction. Detection of the bone conduction might be weak or even fail if the earpiece is not snugly engaged to the ear and have close contact to the external auditory canal. Moreover, the external auditory canal can be easily hurt with the device being in contact to the walls of the canal. It is also a high possibility that the captured voice from bone conduction is weak.

Hence, it is desirable to develop an external auditory canal communication device that can capture air conduction vocal sounds inside the external auditory canal. In particular, an ideal external auditory canal communication device shall possess advantageous features including enabling two-way communication to be private and confidential with clear sound transmission even in a noisy environment and being compatible with a wide range of ICT (information, computing and telecommunication) devices such as headsets, cellular phones, wrist-watch phones, walkie-talkie and portable computers, and even consoles for intelligent habitat (smart homes) which uses voice-activated commands. The user ergonomics of the present invention is predictably simpler than bone conduction as it potentially obviates the need for ensuring proper direct contact between sensor and physical body parts such as skin and bone. Furthermore, physical protrusions of the vocal sound reception sensor close to the mouth or the bone mass close to the cheek in the case of bone conduction devices are not necessary.
SUMMARY OF INVENTION

The main aspect of the present invention is to realize an external auditory canal communication device that detects and captures the vocal sounds created in the external auditory canal as one speaks and allows human voice to be captured and transmitted with or without the external auditory canal being occluded from external environment.

Another aspect of the present invention is to provide an external auditory canal communication device that allows voice communication to be private, discreet and confidential and enhances the clarity and quality of the human voice received and transmitted.

Still another aspect of the present invention is to provide external auditory canal communication device that can be paired or linked to a wide range of ICT devices and be used like a handsfree set.

Yet another aspect of the present invention is to provide an external auditory canal communication device that is simple, secure, comfortable and safe with customizable dimensions.

Also another aspect of the present invention is to realize a device which can be reduced in size to provide a miniature sound capture, sound reception and emission device that require low operating power consumption as well as become economically affordable.

At least one of the preceding aspects is met, in whole or in part, by the present invention, in which the embodiment of the present invention describes an external
auditory canal communication device comprising a sound capturing means (101) being configured for specifically capturing human vocal sounds directly from external auditory canal of a user where the user's voice is propagated in the air along the external auditory canal primarily caused by vibrations along the walls of the external auditory canal while the user is making sounds; a sound signal processing means for receiving and processing the captured sounds from the sound capturing means, wherein the captured sounds are converted into sound signals; a sound signal transmitting means for receiving and transmitting the sound signals from the sound signal processing means to a communication-based device; a sound emitting means (103) for receiving sound signals from the communication-based device and emitting the sound signals into the external auditory canal for the user to listen; an electrical power source; and a housing (102) to optimally place, affix or apply the device to any region from pinna to tympanic membrane of the user, wherein any one or combination of the sound capturing means (101), sound signal processing means, sound signal transmitting means and sound emitting means (103) are disposed in the housing, characterized in that the housing allows occlusion of the external auditory canal.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 shows the external auditory canal which the present invention is exploiting, that is actually the region from the pinna to the tympanic membrane.

Figure 2 shows the side view of the external auditory canal communication device and how it snugly fits the ear.

Figure 3 shows another embodiment of the external auditory canal communication device which can be embedded or adhered to the inner face of the tragus.

Figure 4 shows the outer view of different embodiments of the external auditory canal
communication device.

Figure 5 shows the inner view of different embodiments of the external auditory canal communication device containing both the sound capturing means and the sound emitting means.

Figure 6 shows one of the embodiments of the external auditory canal communication device which come in a pair, one for each ear with one of the pair containing the sound capturing means and the other containing a sound emitting means.

Figure 7 shows one example of the external auditory canal communication device being paired or linked to a communication-based device which is a wrist-watch cellular phone.

DETAILED DESCRIPTION OF THE INVENTION

Before undertaking the DETAILED DESCRIPTION OF THE INVENTION, it is necessary to set forth definitions of certain words or phrases used throughout this disclosure:

1. Sound capturing means - A component integral to the external auditory canal communication device to capture the vocal sounds of the user via the sensing, detection and capturing of vocal sound signals within the external auditory canal. The sound capturing means could be a transducer that is able to detect, capture and convert sounds into electrical signals such as a microphone.

2. Sound signal processing means - A component integral to the external auditory canal communication device to clarify and filter unwanted noises to realise as much as possible the expected desired sounds which is of a higher clarity and quality. An
example of this component is a digital sound processor.

3. Sound transmitting means - The sending of digitized signals, which have been processed, from one physical location to another physical location, separated by geographical vector space via wireless or wired technologies. In this discloser, this term is specifically used for sending digitized signals from this invention to the communication-based device.

4. Sound emitting means - The receiving of sound signals from a communication-based device and the propagation of sound signals into the external auditory canal for the user to listen. An example of this could be a speaker which acts as an electroacoustic transducer that emits sound in response to an electrical signal.

5. Communication-based device - The main device to which this invention, the sound capturing means and the sound emitting means is paired or linked to operate. Examples of this device is a wrist-watch cellular phone as shown in Figure 7, smartphone, a computer notebook, and even consoles for intelligent habitat (smart homes).

The present invention discloses an external auditory canal communication device comprising a sound capturing means (101) being configured for specifically capturing human vocal sounds directly from external auditory canal of a user where the user's voice is propagated in the air along the external auditory canal primarily caused by vibrations along the walls of the external auditory canal while the user is making sounds; a sound signal processing means for receiving and processing the captured sounds from the sound capturing means, wherein the captured sounds are converted into sound signals; a sound signal transmitting means for receiving and transmitting the sound signals from the sound signal processing means to a communication-based device; a sound emitting means (103) for receiving sound signals from the communication-based device and emitting the sound signals into the external auditory
canal for the user to listen; an electrical power source; and a housing (102) to optimally place, affix or apply the device to any region from pinna to tympanic membrane of the user, wherein any one or combination of the sound capturing means (101), sound signal processing means, sound signal transmitting means and sound emitting means (103) are disposed in the housing, characterized in that the housing allows occlusion of the external auditory canal.

Placement and wearing of the device is easy and convenient. All the user need to do is just plug the device into the ear as shown in Figure 2 where the sound capturing means (101) is positioned inside the external auditory canal of the user. Although the housing (102) of the device can be made of plastic or light metal, it is preferred that soft, malleable and ductile materials that can be shaped or finger-kneaded to personally fit the ear size, especially the external auditory canal of the user are used so that the device can be comfortably worn. One of the embodiments of the device, as shown in Figure 3 can be adhered and/or embedded on the inner face of the tragus. Figure 4 shows some other examples of the shape of the device where it can be moulded into different shapes to accommodate the ear. Ear attachment elements for the device to be hooked over the ear is not necessary but could also be added to the device to secure it onto the ear.

Vibration of the posterior superior wall of the canal due to bone conduction produces sound waves at the external auditory canal. Besides bone conduction, voice resonance also contributes to the vibration of the external auditory wall. When the air stream flow along the laryngopharyngeal resonates, the musculoskeletal system in the vicinity will also resonate and this vibrational energy in the musculoskeletal system causes further resonance in the chambers, canals, cavities and hollows. The external auditory canal is one of the many cavities where vocal sounds propagate as a person speaks, producing sound waves at the external auditory canal. Hence, even if the ear is occluded from the external environment, there are still sound waves in the external auditory canal produced by the vibration of the external auditory canal wall due to
bone conduction and/or voice resonation.

The present invention aims to capture these sound waves, particularly the user's voice and transmit these sound signals to a communication-based device which is paired or linked to it, regardless of whether the ear is occluded. As shown in Figure 2, the device can have housings (102) that seal the ear to block sounds from the outside environment as well as housings (102) that do not seal the ear as illustrated in Figure 3 to enable sounds from the environment to be transmitted to the receiver.

Since the sound capturing means (101) is located in the external auditory canal, the sound waves can be easily detected without the need of the user to raise his voice. This is beneficial to the user especially when the user wishes his conversation to be confidential and discreet in public places. Additional components of the device such as an amplifier can be included to the sound signal transmitting means for increasing the power of the sound signals before they are transmitted by the sound signal transmitting means to enable stronger signals to be received even when for low voice decibel. Besides that, the sound signal processing means contains a filter for filtering away unwanted sounds such as noise from the external environment, noise generated in the auditory canal, noise from swallowing of saliva, cough etc. By filtering away unwanted sounds, sound clarity and quality can be ensured. Not only could the interference from ambient sounds be removed, the filter could also enhance the desired sound to be transmitted. Both the amplifier and the filter enhances the clarity and quality of the sound transmitted.

The present invention has a sound capturing means (101) as well as a sound emitting means (103) to enable the user to engage in a two-way communication, like existing handsfree sets for mobile ICT gadgets.

Since the present invention is a miniature device, electrical power consumption is low. Miniature batteries can be employed as the electrical power source of the device.
Beyond solar power research, current ongoing scientific research is indicating the possibility of electrical battery power to be tapped from unconventional sources such as human body heat and human physical movements (kinetic energy). The technologies to recharge the battery are not limited to wired charging systems that usually involve the use of adapters or docks. Wireless electrical transmission could also be utilized for recharging the battery of the device.

In another embodiment of the present invention, the device could come in pairs as shown in Figure 5 where the first device (Figure 5b) to be plugged on one of the ears contains just the sound capturing means (101), sound signal processing means and sound signal transmitting means; while the second device (Figure 5a) to be plugged on the other ear contains the sound emitting means (103). This could solve sound feedback issues in which sounds emitted by the sound emitting means (103) might be captured by the sound capturing means (101), when the latter should only capture sounds from the external auditory canal. Alternately, technologies that enable sound segregation on the basis of amplitude and frequencies could also be applied to differentiate between sounds created in the external auditory canal by the user speaking and sounds emitted to the external auditory canal by the sound emitting means (103).

The present invention offers a wide range of advantages to users. Due to the simplicity of the design and the miniature electrical components contained in it, the device is light and could be made to be small, thin and flexible around or near to the external auditory canal. Ductile, soft and flexible material for making the housing (102) of the device is preferred as it allows customization such that the device could fit the size of the external auditory canal of the user for safety and comfortable purposes. The present invention shall possess dimensions that allow it to be worn, adhered or embedded at any part of the outer ear.

Furthermore, the present invention can be used with a variety of ICT devices like
cellular phones, smartphones, personal digital assistants (PDAs), wristwatch mobile phones, audio headsets, wireless handsfree gadgets and computing devices such as personal notebooks, computer tablets and computer netbooks; and even consoles for intelligent habitat (smart homes). A one-way talk-or-listen function applicable to walkie-talkie handsets could also be employed. Using the present invention where the user can listen at one moment and talk at another moment. The wireless and portability features of the device enable users to perform other work while having hands free communication with others. The present invention is most useful when it is used in critical operations or when private conversation is desired as users need not raise their voice level to communicate with the receiver. Sound clarity is also ensured with the aid of signal processing methodologies within the sound signal processing means.

The present invention can either be binaural or monaural, in which it can contain both the sound capturing means (101) as well as the sound emitting means (103) as shown in Figure 4 or come in pairs as illustrated in Figure 5, where one of the pair contains the sound capturing means (101) for capturing sound waves, while the other device has the sound emitting means (103) for emitting sound waves. Most importantly, sound waves detected and transmitted for communication even when the device is in a concealed environment where the ear is occluded from the external environment and sound waves, particularly the user's voice cannot enter the ear through air conduction.

Although the description above contains many specifications, it is understood that the embodiment of the preferred form are not to be regarded as a departure from the invention and it may be modified within the scope of the appended claims.
CLAIMS

1. An external auditory canal communication device comprising
   a sound capturing means (101) being configured for specifically capturing
   human vocal sounds directly from external auditory canal of a user where the
   user's voice is propagated in the air along the external auditory canal primarily
   caused by vibrations along the walls of the external auditory canal while the
   user is making sounds;
   a sound signal processing means for receiving and processing the captured
   sounds from the sound capturing means, wherein the captured sounds are
   converted into sound signals;
   a sound signal transmitting means for receiving and transmitting the sound
   signals from the sound signal processing means to a communication-based
   device;
   a sound emitting means (103) for receiving sound signals from the
   communication-based device and emitting the sound signals into the external
   auditory canal for the user to listen;
   an electrical power source; and
   a housing (102) to optimally place, affix or apply the device to any region
   from pinna to tympanic membrane of the user, wherein any one or
   combination of the sound capturing means (101), sound signal processing
   means, sound signal transmitting means and sound emitting means (103) are
   disposed in the housing, characterized in that the housing allows occlusion of
   the external auditory canal.

2. An external auditory canal communication device according to claim 1,
   wherein the sound signal transmitting means contains an amplifier to
   increase the power of the sound signals.

3. An external auditory canal communication device according to claim 1,
wherein the sound signal processing means contains a filter for filtering away unwanted sounds and enhancing the quality of the sounds.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/10
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

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<th>Relevant to claim No.</th>
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<td>X</td>
<td>EP 1 640 972 Al (PHONAK AG [CH]) 29 March 2006 (2006-03-29) paragraphs [0029] - [0033]; figure 1</td>
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<tr>
<td>X</td>
<td>US 6 661 901 Bl (SVEAN JARLE [NO] ET AL) 9 December 2003 (2003-12-09) col umn 5, lines 26-49,54-60 col umn 1, lines 24-26 col umn 9, lines 27-48 figures 1-2</td>
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