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(71) Applicant: **SONOVA AG** [CH/CH]; Laubisrütistrasse 28, 8712 Stäfa (CH).

(72) Inventors: **LANDOLT, Christian**; Sytenweg 18, 8867 Niederurnen (CH). **WAGNER, Paul**; 544 Walnut St., San Carlos, California 94070 (US). **BAER, Daniel**; Nordstrasse 143, 8003 Zürich (CH). **VAN OERLE, Gerard**; Guschstrasse 50, 8610 Uster (CH). **KARAMUK, Erdal**; Weiernmatt 4, 8708 Männedorf (CH). **AU, Michael**; 4645 Dinuba Street, Union City, California 94587 (US).

(74) Agent: **TROESCH SCHEIDEGGER WERNER AG**; Peter D. Rigling, Schwäntenmos 14, 8126 Zumikon (CH).

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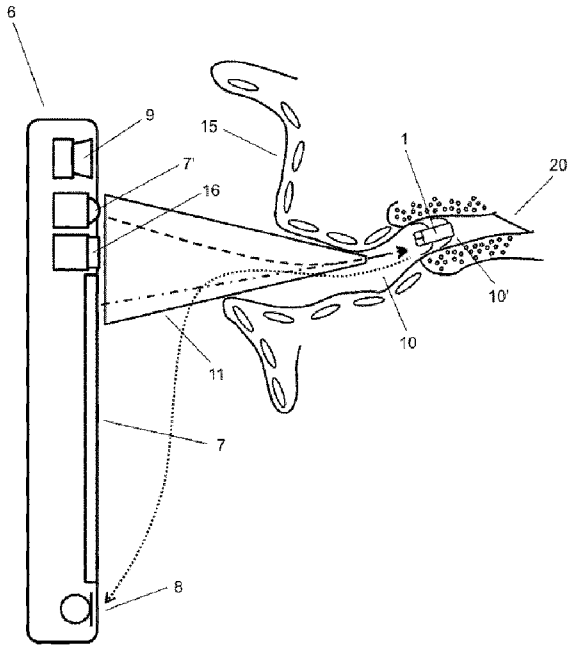

Fig. 1

(57) Abstract: The present invention relates to a system for adjusting and/or controlling a hearing aid (1), especially an extended wear hearing aid (1) intended to be worn deeply within an ear canal (10) of a user. The proposed system comprises a hearing aid (1) with an optical signal detector (5) for receiving signal processing settings and/or control data via an optical signal and a handheld device (6) with a display (7) and/or a flashlight (7'), whereby the handheld device (6) is adapted to execute a mobile application comprising code configured to generate an optical signal with the display (7) and/or the flashlight (7') representative of the signal processing settings and/or the control data. The invention further provides a mobile application for adjusting and/or controlling such a hearing aid (1) as well as a method for adjusting and/or controlling such a hearing aid (1).

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A SYSTEM FOR ADJUSTING AND/OR CONTROLLING A HEARING AID, A MOBILE APPLICATION FOR ADJUSTING AND/OR CONTROLLING A HEARING AID, AND A METHOD FOR ADJUSTING AND/OR CONTROLLING A HEARING AID VIA AN OPTICAL DATA LINK

TECHNICAL FIELD

The present invention relates to a system for adjusting and/or controlling a hearing aid, especially an extended wear hearing aid intended to be worn deeply within an ear canal of a user. The invention further pertains to a mobile application for adjusting and/or controlling such a hearing aid as well as to a method for adjusting and/or controlling such a hearing aid.

BACKGROUND OF THE INVENTION

Hearing aids, commonly also referred to as hearing prostheses or hearing instruments, are used by hard of hearing people, i.e. persons having a hearing loss, in order to improve their hearing capability. Extended wear hearing aids are positioned deep in the ear canal, typically within the bony portion of the ear canal, for instance residing approximately 4 mm from the eardrum (also referred to as the tympanic membrane). Due to the deep placement inside the ear canal, such hearing aids cannot be

seen from the outside, which is often desired by the user for aesthetical reasons. Furthermore, because the hearing aid is located deep in the ear canal the natural sound quality and directivity provided by the pinna is retained. Extended wear hearing aids are worn constantly without being removed during a prolonged period of time such as for two to four months (after which they cease to function, e.g. because the battery is depleted), so no daily insertion or removal is necessary. Usually such hearing aids are only used once and disposed of after removal from the ear canal. Thus no batteries need to be changed and no ongoing maintenance is required. Examples of such hearing aids are for instance the Philips XP Peritympanic deep canal CIC aid, the Starkey Tympanette and SoundLens, the Songbird Flexfit disposable hearing aid, and Phonak's Lyric hearing aid. US 6,205,227 B1 also relates to a peritympanic hearing instrument, WO 00/32009 A2 relates to a semi-permanent canal hearing aid, and WO 00/76271 A1 relates to an extended wear canal hearing aid. Deep-fitted hearing aids need to be particularly small and their insertion and extraction is a tricky and quite awkward procedure oftentimes requiring the help of a specialist, e.g. a trained hearing health care professional such as an ENT physician or audiologist.

As with most hearing aids the signal processing settings, i.e. fitting parameters, are adjusted according to the personal requirements and preferences of the user, e.g. dependent on the user's individual hearing loss.

Furthermore, the user is typically able to control the hearing aid such as to turn the device on and off (or to put it in a "sleep mode") and to increase or decrease the output loudness, i.e. the volume. The signal processing settings are for instance conveyed to the hearing aid by means of a magnetic field, which is detected by a magnetic sensor incorporated in the hearing aid. Hereto, a magnet, e.g. in the form of a magnetic "wand", has to be placed close to the hearing aid. The communication is one-way, i.e. data can be sent to the hearing aid, but this data cannot be read-out from the hearing aid. Furthermore, a remote control magnet, such as Phonak's SoundLync, is used to control the hearing aid. Turning the device on is simple, whereas changing the volume requires more complicated manual interactions of the magnet with the hearing aid, and is not intuitive. A specific problem with these hearing aids is when they are automatically reset and the signal processing settings are lost. This can for instance happen in the field when the user is in a humid environment and the zinc-air battery does not get enough oxygen, thus causing the supply voltage to drop below a critical threshold, resulting in the signal processing circuit being reset. When this happens the hearing aid no longer functions as required by the user and therefore must be returned to a fitter (e.g. an audiologist) in order to reload the personal signal processing settings of the user.

Hence, there is a need for improved means for adjusting the signal processing settings and controlling such hearing aids.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an improved, alternative system for adjusting and/or controlling a hearing aid. This object is achieved by the system according to claim 1.

It is a further object of the present invention to provide a mobile application capable of supporting adjusting and/or controlling of a hearing aid. Such a mobile application is specified in claim 14.

Moreover, it is yet another object of the present invention to provide a method for adjusting and/or controlling a hearing aid. Such a method is defined in claim 15.

Specific embodiments of the present invention are provided in the dependent claims.

In a first aspect, the present invention is directed to a system for adjusting and/or controlling a hearing aid, comprising:

- a hearing aid comprising:
  - a microphone of the hearing aid;
  - a receiver;
  - a signal processor and/or a controller;
  - an optical signal detector,

  wherein the signal processor is adapted to process an input signal from the microphone according to signal processing settings and to provide the processed input signal to the receiver, and/or

  wherein the controller is adapted to operate the hearing aid according to control data, and

  wherein the optical signal detector is structured and configured to receive an optical signal representative of the signal processing settings and/or the control data, and
- a handheld device, in particular a mobile phone, such as a smartphone, comprising:
  - a display and/or a flashlight, such as a light-emitting diode (LED),

  wherein the handheld device optionally further comprises a microphone of the handheld device and/or a loudspeaker, and

  wherein the handheld device is adapted to execute a mobile application comprising code configured to generate the optical signal with (at least a portion of) the

display and/or the flashlight representative of the signal processing settings and/or the control data.

In an embodiment of the system the optical signal detector comprises a photodiode, a phototransistor or a photovoltaic element for generating an electrical signal in dependence of incident light such as the optical signal. The optical signal detector may further comprise electronic circuitry for conversion of said electrical signal to a digital signal comprising the signal processing settings and/or the control data.

In a further embodiment of the system the hearing aid is an extended wear hearing aid intended to be worn deeply within an ear canal of a user of the hearing aid, in particularly within a bony portion of the ear canal.

In a further embodiment the system further comprises an optical adapter releasably attachable or fixedly attached to the handheld device and structured to guide the optical signal from at least a portion of the display and/or the flashlight into an ear canal of a user of the hearing aid.

In a further embodiment of the system the mobile application is further configured to provide a user interface (UI) to a user of the hearing aid, such as a graphical user interface (GUI), comprising control elements for inputting the signal processing settings and/or the

control data, and/or a speech-based user interface, comprising a voice command interpreter adapted to register the signal processing settings and/or the control data based on voice commands picked up by the microphone of the handheld device.

In a further embodiment of the system the handheld device further comprises a transceiver and the mobile application is further configured to receive (by means of the transceiver) the signal processing settings and/or the control data from a remote location, such as a remote device having a user interface or a remote server with a database.

In a further embodiment of the system the mobile application is further adapted to generate the optical signal when the handheld device is held against an ear of the user.

In a further embodiment of the system the handheld device further comprises a sensor, such as a proximity sensor or an image sensor, e.g. a camera.

In a further embodiment of the system the mobile application is further adapted to detect when the handheld device is held against the ear based on an output signal of the sensor, in particular based on an image provided by the image sensor.

In a further embodiment of the system the mobile application is further adapted to take at least one image/picture or a video sequence of the ear canal, and in particular to send the at least one image/picture to a remote location, for instance to a hearing health care provider, in particular to a database of the hearing health care provider, and more particularly wherein the mobile application is further adapted to determine data pertaining to the ear canal, in particular data pertaining to a state of health of the ear canal, or data pertaining to the location and/or orientation of the hearing aid within the ear canal, and to send the data to a remote location, for instance to a hearing health care provider, in particular to a database of the hearing health care provider.

In a further embodiment of the system the mobile application is further adapted to generate the optical signal or to take an image/picture of the ear canal when a corresponding voice command is detected.

In a further embodiment of the system the hearing aid is adapted to provide an acoustic response signal dependent on the received optical signal.

In a further embodiment of the system the hearing aid is adapted to determine whether the received signal processing settings and/or control data are valid and to provide an

indication whether the received signal processing settings and/or control data are valid in the acoustic response signal, and in particular to store in a memory and/or to apply the received signal processing settings and/or control data when the received signal processing settings and/or control data have been determined to be valid.

In a further embodiment of the system the mobile application is further adapted to detect the acoustic response signal and to continue or to stop generating the optical signal dependent on the acoustic response signal.

In a further embodiment of the system the mobile application is further adapted to encode the signal processing settings and/or the control data in the optical signal by means of wavelength-based (i.e. colour) encoding, signal modulation, e.g. on/off keying or intensity modulation, or state-machine encoding, and in particular wherein the mobile application is further adapted to add an error detection code, such as a cyclic redundancy check (CRC) code to the signal processing settings and/or the control data, in order to be able to verify that the signal processing settings and/or the control data where correctly received by the hearing aid.

In a second aspect, the present invention is directed to a mobile application for adjusting and/or controlling a hearing aid, adapted to be employed in the proposed system.

In a third aspect, the present invention is directed to a method for adjusting and/or controlling a hearing aid using the proposed system, in particular using the proposed mobile application, comprising the steps of:

- generating an optical signal representative of signal processing settings and/or control data with a display and/or a flashlight of a handheld device;
- receiving the signal processing settings and/or control data with an optical signal detector of the hearing aid; and
- operating the hearing aid according to the received signal processing settings and/or control data.

In an embodiment of the method the signal processing settings and/or the control data are received by the handheld device from a remote location, for instance from a hearing health care provider or a database of the hearing health care provider, such as to enable remote adjusting (or fitting) and/or remote control of the hearing aid by a person other than a user of the hearing aid.

It is pointed out that combinations of the above-mentioned embodiments may give rise to even further, more specific embodiments according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further explained below by means of non-limiting specific embodiments and with reference to the accompanying drawings, which show:

Fig. 1 a schematic illustration of a system for adjusting/controlling a hearing aid according to an embodiment of the present invention;

Fig. 2 a schematic illustration of an embodiment of a hearing aid to be employ in the system according to the present invention; and

Fig. 3 a schematic illustration of a setup employing an embodiment of the system according to the present invention.

In the figures, like reference signs refer to like parts.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 schematically depicts an embodiment of a system for adjusting/controlling a hearing aid 1 according to the present invention. The system comprises a handheld device 6, such as a remote control unit (RCU) or a smartphone, and a hearing aid 1 to be adjusted/controlled by or via the

handheld device 6. In a first simple embodiment the handheld device 6, e.g. a remote control unit, comprises one or more user control elements, such as push buttons (not shown in Fig. 1), for instance for turning the hearing aid 1 on or off and for increasing or decreasing the volume, a processor (not shown in Fig. 1) for converting the user inputs from the control elements into control data, which is applied to modulate a light source, such as a light-emitting diode (LED) 7', that generates an optical signal dependent on the control data, e.g. in the form of light pulses. When the handheld device 6 is held to the ear 15 of the user, such that the LED 7' is aligned with the entrance into the ear canal 10, the optical signal generated by the LED 7' passes through the ear canal 10, 10' to the hearing aid 1, which comprises an optical signal detector 5, such as a photo diode, capable of receiving the optical signal and retrieving the control data, e.g. for controlling the hearing aid's volume. In order to ensure accurate alignment of the LED 7' with the opening of the ear canal 10 and to help guide the optical signal into the ear canal 10, an appropriate optical adapter 11, such as a conically shaped insert made of a transparent material acting as an optical wave guide, may be utilised. Such an optical adapter 11 can be individually formed according to the inner shape of at least a portion of the user's ear canal 10 in order to optimise the transfer of the optical signal to the hearing aid 1, especially when the hearing aid 1 is positioned deep in the ear canal 10, in particular within the bony portion 10'. Moreover, the optical adapter 11 may be made of a flexible material in order to

facilitate its insertion into the ear canal 10. The optical adapter 11 can for instance be removably attached to the handheld device 6 at the LED 7', e.g. as a "clip-on", or permanently fixated thereto.

When the user wants to control the hearing aid 1, he will push the desired control element when the handheld device 6 is held against the ear 15, and the optional optical adapter 11 is inserted into the ear canal 10, upon which the optical signal is generated in dependence of the control data and emitted to the hearing aid 1. If the control data is correctly received by the hearing aid 1, an acoustic acknowledge signal is generated by the hearing aid 1, which indicates to the user that the transfer of the control data was successful. If the user does not hear the acoustic acknowledge signal from the hearing aid 1, he may push the desired control element again in order to retransmit the optical signal with the control data.

In a more advanced second embodiment of the handheld device 6, e.g. a smartphone, comprising a display 7, such as a touch screen, a microphone 8 and a loudspeaker 9, the display 7 or a portion thereof is used to generate the optical signal. Additionally, the smartphone 6 may also comprise a flashlight 7' (e.g. one or multiple LEDs) that may be alternatively used to generate the optical signal. The user can then control the hearing aid 1 with his smartphone 6 which is capable of executing a mobile application ("app") adapted to adjust/control the hearing

aid 1. The app provides a user interface, so that the user is able to input commands and data, e.g. via the touch screen 7. Like previously explained an optical signal is then generated either by the display 7 (cf. dash-dotted line arrow in Fig. 1) or the flashlight 7' (cf. dashed line arrow in Fig. 1) once the smartphone 6 is held against the ear 15. Generation of the optical signal can be initiated after a certain time delay following the user for instance pressing a start button (icon). Alternatively, the user can issue an appropriate voice command to start the transmission of the optical signal. The voice command is picked up by the microphone 8 of the smartphone 6, and processed by the app, in response to which the optical signal is generated. As a further alternative, the smartphone 6 may comprise a sensor 16 capable of detecting whether the smartphone 6 is being held against the ear 15, whereupon which transmission of the optical signal is started. The sensor 16 may be a proximity sensor or a photo diode, or even an image sensor (e.g. a camera). In the latter case, the app may be capable of guiding the user to correctly align the smartphone 6 over the opening of the ear canal 10, e.g. based on images taken with the camera 16 and by means of acoustic instructions to the user provided via the loudspeaker 9. Furthermore, the acoustic acknowledge signal generated by the hearing aid 1 may be picked up by the microphone 8 (cf. dotted line arrow in Fig. 1). Depending on whether the acoustic acknowledge signal was received or not, the app repeats transmission of the optical signal.

The camera 16 (along with the optional optical adapter 11, which may comprise one or more lenses) can be utilised to take one or more images/pictures or a video sequence of the ear canal 10, e.g. to determine the location and/or positioning of the hearing aid 1 within the ear canal 10, 10'. The image(s)/picture(s) or video sequence may be sent to a remotely located hearing health care provider for professional assessment.

Fig. 2 schematically depicts an embodiment of a hearing aid 1 to be employ in the system according to the present invention. It comprises a microphone 2, a signal processor 4 adapted to process the audio signal picked up by the microphone 2 based on the user's personal signal processing settings, and a receiver 3 (i.e. a miniature loudspeaker) which outputs the processed audio signal. Furthermore, the hearing aid 1 comprises a controller 4' adapted to operate the hearing aid 1 based on control data/input(s) provided by the user. The control data and signal processing settings are received from the handheld device 6 by means of the optical signal detector 5, e.g. a photo diode, which is incorporated in the hearing aid 1. The hearing aid 1 is typically very small in order to fit in the bony portion 10' of ear canal 10 close to the eardrum 21 and is adapted to form a seal that prevents sound from bypassing the hearing aid 1, e.g. by means of a lateral and medial seal 19, 19'. Additionally, the hearing aid 1 may comprise a further sensor 21, such as a magnetic sensor or switch, e.g. for turning on (from a completely powerless state) or

resetting the hearing aid 1. The hearing aid 1 also includes a battery 18 as a source of power.

Fig. 3 schematically illustrates a setup employing an embodiment of the system according to the present invention for remotely adjusting, i.e. fitting, or controlling a hearing aid 1. The handheld device 6, e.g. a smartphone equipped with a transceiver (not shown in the figures) for communicating over a communication network 22, is capable of sending signal processing settings and/or control data to the hearing aid(s) worn within the ear canal(s) of a user 12, as was previously described in conjunction with Fig. 1 and 2. Instead of the user 12 entering the adjustments of the signal processing settings and/or the control inputs via the user interface provided by an app executed on the smartphone 6, this data may also be transferred from a remote location, such as a database 14 or a remote device, for instance a computer 13 of a hearing health care provider 17 to the smartphone 6 via the communication network 22. This enables remote fitting of the hearing aid 1, or at least downloading of the user's stored personal signal processing settings, from a remote location, e.g. from a server with a database 14, as well as providing the possibility of remotely controlling the hearing aid 1 by a person other than the user of the hearing aid(s). Furthermore, the hearing health care provider 17 can for instance check if the hearing aid 1 is correctly positioned and oriented within the user's ear canal based on images of the ear canal taken by the

smartphone's camera. Moreover, these images may be helpful to remotely assess the state of health of the user's ear canal(s) by the hearing health care provider 17. Furthermore, audio samples can be downloaded from the database 14 to the smartphone 6, where they can be replayed to the user 12 via the loudspeaker in the smartphone 6 as part of a remote fitting procedure. Thereby, also the instructions given by the hearing health care provider 17 can be heard by the user 12 via the loudspeaker in the smartphone 6.

With the help of the present invention it is possible to adjust and/or control the user's hearing aid(s) either by the user 12 locally or by a remote hearing health care provided 17 in a simple manner by means of an optical data link between a handheld device 6 and the hearing aid 1, whereby an optional acoustic feedback link is provided from the hearing aid 1 to the handheld device 6, in order to ensure that the data sent to the hearing aid 1 was received correctly.

CLAIMS

1. A system for adjusting and/or controlling a hearing aid (1), comprising:

- a hearing aid (1) comprising:
  - a microphone (2) of the hearing aid (1);
  - a receiver (3);
  - a signal processor (4) and/or a controller (4');
  - an optical signal detector (5),

  wherein the signal processor (4) is adapted to process an input signal from the microphone (2) according to signal processing settings and to provide the processed input signal to the receiver (3), and/or

  wherein the controller (4') is adapted to operate the hearing aid (1) according to control data, and

  wherein the optical signal detector (5) is structured and configured to receive an optical signal representative of the signal processing settings and/or the control data, and
- a handheld device (6), in particular a mobile phone, such as a smartphone, comprising:
  - a display (7) and/or a flashlight (7'), such as a light-emitting diode,

wherein the handheld device (6) optionally further comprises a microphone (8) of the handheld device (6) and/or a loudspeaker (9), and

wherein the handheld device (6) is adapted to execute a mobile application comprising code configured to generate the optical signal with the display (7) and/or the flashlight (7') representative of the signal processing settings and/or the control data.

2. The system of claim 1, wherein the hearing aid (1) is an extended wear hearing aid (1) intended to be worn deeply within an ear canal (10) of a user (12) of the hearing aid (1), in particularly within a bony portion (10') of the ear canal (10).

3. The system of claim 1 or 2, further comprising an optical adapter (11) releasably attachable or fixedly attached to the handheld device (6) and structured to guide the optical signal from at least a portion of the display (7) and/or the flashlight (7') into an ear canal (10) of a user (12) of the hearing aid (1).

4. The system of one of claims 1 to 3, wherein the mobile application is further configured to provide a user interface to a user (12) of the hearing aid (1), such as a graphical user interface, comprising control elements for inputting the signal processing settings and/or the control data, and/or a speech-based user interface, comprising a

voice command interpreter adapted to register the signal processing settings and/or the control data based on voice commands picked up by the microphone (8) of the handheld device (6).

5. The system of one of claims 1 to 3, wherein the handheld device (6) further comprises a transceiver and the mobile application is further configured to receive the signal processing settings and/or the control data from a remote location, such as a remote device (13) having a user interface or a remote server (13') with a database (14).

6. The system of one of claims 1 to 5, wherein the mobile application is further adapted to generate the optical signal when the handheld device (6) is held against an ear (15) of the user (12).

7. The system of claim 6, wherein the handheld device (6) further comprises a sensor (16), such as a proximity sensor or an image sensor (16).

8. The system of claim 7, wherein the mobile application is further adapted to detect when the handheld device (6) is held against the ear (15) based on an output signal of the sensor (16), in particular based on an image provided by the image sensor (16).

9. The system of claim 8, wherein the mobile application is further adapted to take at least one image or a video sequence of the ear canal (10), and in particular to send the at least one image to a remote location, for instance to a health care provider (17), in particular to a database (14) of the health care provider (17), and more particularly wherein the mobile application is further adapted to determine data pertaining to the ear canal (10), in particular data pertaining to a state of health of the ear canal (10), or data pertaining to the location and/or orientation of the hearing aid (1) within the ear canal (10), and to send the data to a remote location, for instance to a health care provider (17), in particular to a database (14) of the health care provider (17).

10. The system of claim 4, wherein the mobile application is further adapted to generate the optical signal or to take an image of the ear canal (10) when a corresponding voice command is detected.

11. The system of one of claims 1 to 10, wherein the hearing aid (1) is adapted to provide an acoustic response signal dependent on the received optical signal.

12. The system of claim 11, wherein the hearing aid (11) is adapted to determine whether the received signal processing settings and/or control data are valid and to provide an indication whether the received signal

processing settings and/or control data are valid in the acoustic response signal, and in particular to store in a memory and/or to apply the received signal processing settings and/or control data when the received signal processing settings and/or control data have been determined to be valid.

13. The system of claim 11 or 12, wherein the mobile application is further adapted to detect the acoustic response signal and to continue or to stop generating the optical signal dependent on the acoustic response signal.

14. A mobile application for adjusting and/or controlling a hearing aid (1), adapted to be employed in the system according to one of claims 1 to 13.

15. A method for adjusting and/or controlling a hearing aid (1) using the system of one of claims 1 to 13, in particular using the mobile application of claim 14, comprising the steps of:

- generating an optical signal representative of signal processing settings and/or control data with a display (7) and/or a flashlight (7') of a handheld device (6);
- receiving the signal processing settings and/or control data with an optical signal detector (5) of the hearing aid (1); and

– operating the hearing aid (1) according to the received signal processing settings and/or control data.

16. The method of claim 15, wherein the signal processing settings and/or the control data are received by the handheld device (6) from a remote location, for instance from a health care provider (17) or a database (14) of the health care provider (17), so as to enable remote adjusting and/or remote control of the hearing aid (1) by a person (17) other than a user (12) of the hearing aid (1).

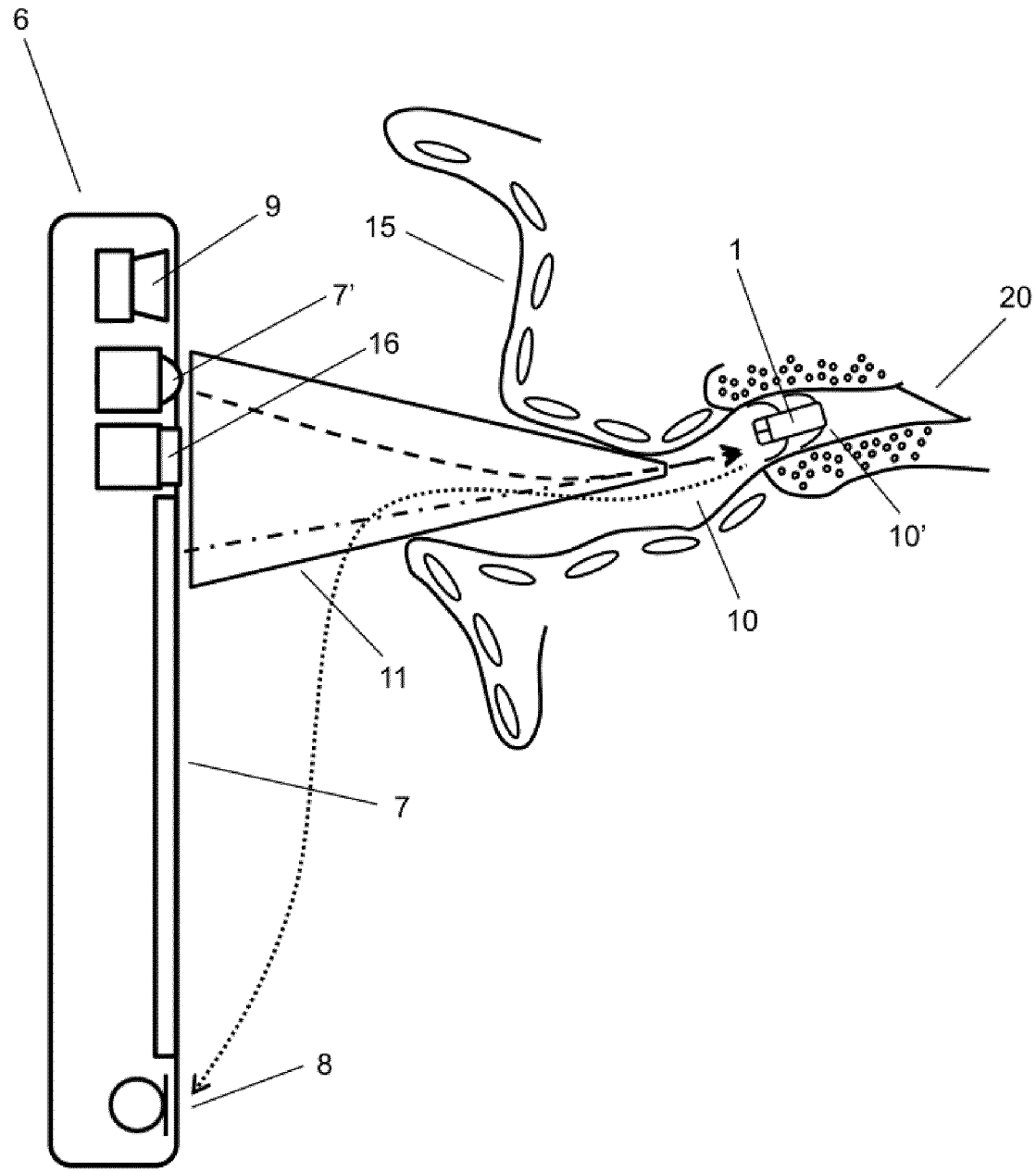

Fig. 1

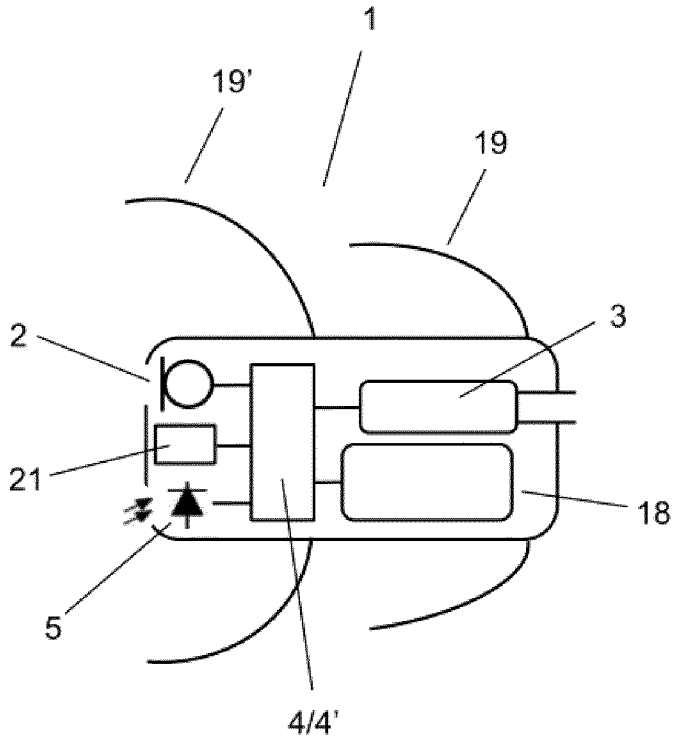

Fig. 2

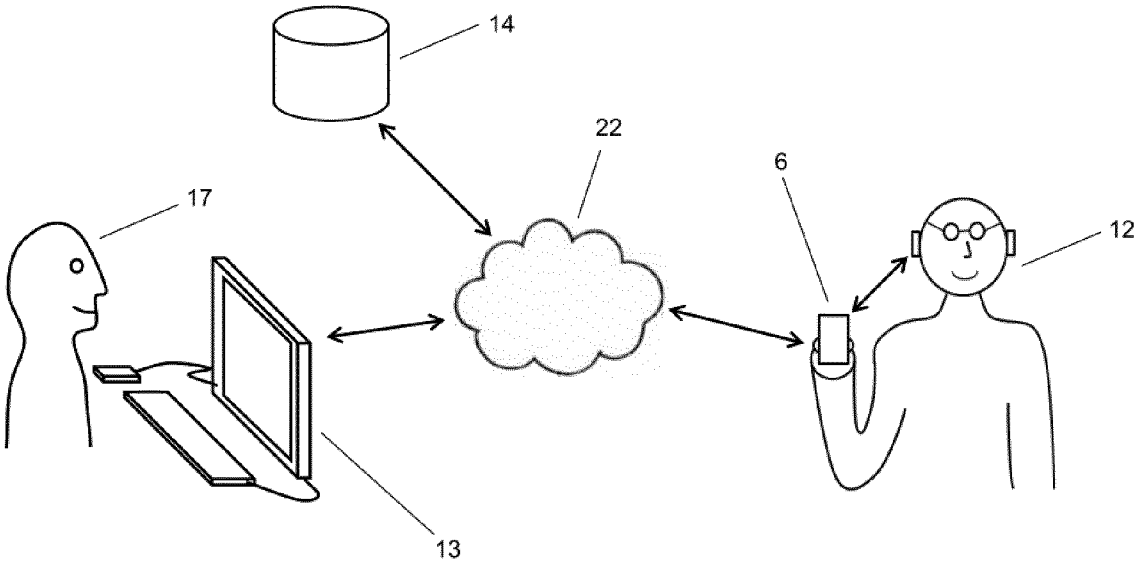

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/050156

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R25/00 H04B10/114
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 H04B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2006/062412 A1 (BERG CHRISTIAN [CH]) 23 March 2006 (2006-03-23) paragraph [0002] paragraph [0007] - paragraph [0012] paragraphs [0016], [0018] paragraph [0021] - paragraph [0025] paragraph [0031] - paragraph [0039] paragraph [0041] page 1; figure 1 -----	1,4-10, 14-16 3,11-13
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2017	31/08/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Valenzuela, Miriam

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A	EP 2 579 618 A1 (GN RESOUND AS [DK]) 10 April 2013 (2013-04-10) paragraph [0004] paragraph [0022] - paragraph [0029] paragraph [0033] - paragraph [0039] paragraphs [0048], [0066], [0075] figures 1, 2, 6,7, 10, 11, 13	1-16

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