



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 356 255 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
28.06.2006 Bulletin 2006/26

(21) Application number: **01271526.4**

(22) Date of filing: **16.11.2001**

(51) Int Cl.:
G01H 1/00 (2006.01)

(86) International application number:
PCT/CA2001/001618

(87) International publication number:
WO 2002/050499 (27.06.2002 Gazette 2002/26)

(54) **METHOD AND APPARATUS FOR DETERMINING IN SITU THE ACOUSTIC SEAL PROVIDED BY AN IN-EAR DEVICE**

VERFAHREN UND VORRICHTUNG ZUR IN-SITU BESTIMMUNG DES DURCH EINE IM OHR ANGEBRACHTE EINRICHTUNG BEREITGESTELLTEN AKUSTISCHEN VERSCHLUSSES

PROCEDE ET APPAREIL DE DETERMINATION IN SITU DE L'ETANCHEITE ACOUSTIQUE FOURNIE PAR UN DISPOSITIF PLACE DANS L'OREILLE

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**

(30) Priority: **20.12.2000 US 739962**

(43) Date of publication of application:
29.10.2003 Bulletin 2003/44

(73) Proprietor: **Sonomax Hearing Healthcare, Inc
Montreal, Quebec H4P 2E2 (CA)**

(72) Inventors:
• **VOIX, Jérémie
Montréal, Québec H2R 1X5 (CA)**

• **LAVILLE, Frédéric
Montréal, Québec H2B 1A5 (CA)**

(74) Representative: **Bonnetat, Christian
CABINET BONNETAT
29, rue de St. Pétersbourg
75008 Paris (FR)**

(56) References cited:
**EP-A- 0 381 608 US-A- 4 060 701
US-A- 5 317 273 US-A- 5 970 795**

EP 1 356 255 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

DescriptionFIELD OF THE INVENTION

[0001] The present invention relates to in-ear devices and more particularly to a method and an apparatus for determining in situ the acoustic seal provided by in-ear devices, such as hearing aid devices (HADs), ear protection devices (HPDs) and the like.

BACKGROUND OF THE INVENTION

[0002] The noisy environment in our industrial society is a health hazard to numerous workers as well as to people engaged in recreational activities generating loud noises.

[0003] Users often wear earplugs when operating light machinery such as chainsaws or heavy machinery such as paper industry, printing industry, aircraft industry machines, when participating in sporting activities such as shooting, and when attending various spectator events such as automobile races, truck pulls, and rock concerts, and the like.

[0004] Prior art mentions "universal fit" type earplugs, these plugs are often termed "universal fit" because they are intended to adapt to the contours of any person's ear canal to provide hearing protection. To install the "universal fit" earplug, the wearer must first compress and/or form the plug by kneading, wadding or rolling it up and then position the plug in his or her ear canal. In the case of the foam earplug, the plug must be inserted before it expands.

[0005] Those "universal fit" earplugs are difficult for many individuals to insert properly. If the plug is formed by the user incorrectly as it is inserted in the ear canal, wrinkles and voids may develop that allow sound leakage to the user's eardrum, thereby reducing the protective effectiveness of the plugs to the wearer. Also, some of the plugs typically are larger than people may need because it has been designed to fit ear canals that are larger than average in hopes of accommodating a wide range of users. Finally, some users find "universal fit" earplugs to be uncomfortable and touching the foam earplug, to roll it, with dirty fingers can lead to infection of the external and middle ear.

[0006] Custom-molded earplugs can be an attractive alternative to "universal fit" earplugs and have advantages in their comfort, more reliable fit and lower long-term costs due to longer usable life. Also, custom-molded earplugs may offer certain hygiene advantages in dirty environments since the user does not have to compress or form them with their fingers prior to insertion.

[0007] Casting an earplug in situ using a self-curing resin is not an ideal method for creating a custom-molded earplug. A doctor or a trained technician will be required to make the mold since the mould's manufacture requires a highly viscous resin or putty to be deposited deep in the patient's ear. The objective when taking the ear mold

is to obtain an impression, which follows all inner contours of the ear canal and which, has no voids or creases due to the trapped air pockets. Packing the resin in the ear canal to meet this objective can be very painful to the patient. After the resin is added to the ear, it may be necessary to manually apply some pressure from outside the ear to assure that the resin hardens within the canal. The patient must sit motionless, without jaw movement, for several minutes until the mold solidifies.

[0008] Besides severe pain being caused to many patients, casting an earplug in situ also suffers from the common problem of voids being formed therein which reduce the effectiveness of the final earplug produced.

[0009] Semi-custom-molded expandable earplug may also offer the same advantages. The person to be fitted with this earplug is first fitted with a pre-shaped earplug having the approximate shape of the ear canal of the individual. Preferably the pre-shaped device is made available in different basic sizes to obtain the closest size corresponding to the individual. The size chosen should allow a small gap to permit an optimum expansion accomplished with an injected settable compound material. It is very important in that case to be precise in the quantity of injected compound because a little excess can create an inflating pressure level that can be very painful to the patient and, at the same time, an earplug cannot provide an effective acoustic seal with less inflating pressure. It is very difficult or even impossible to attain that optimum expansion without determining in situ the acoustic seal provided by an earplug.

[0010] All the above specifically refer to earplugs but it is to be understood that it is similarly applicable to any in-ear device, the latter referring to either earplug device (or hearing protection device (HPD)) or hearing aid device (HAD) for which an attenuation level or an amplification performance level is seek respectively.

[0011] U.S. Patent No. 5,757,930 issued to Seidmann on May 26, 1998 and U.S. Patent No. 5,790,795 issued to Seidmann on October 26, 1999 disclose an apparatus being adapted only for in-ear sound level measurement without any comparison with an environmental sound. U.S. Patent No. 5,577,511 issued to Killion on November 26, 1996 discloses the occluding object and method for measuring its occlusion from existing surrounding noise without wide band measurement from any control sound sources. This measuring device cannot effectively be used to determine an accurate sound level difference provided by the object.

[0012] Furthermore U.S. Patent No. 5,044,373 issued to Northeved on September 3, 1991 relates to the method and apparatus for measuring of sound pressure levels in the auditory canal of a person in connection with the fitting of said apparatus. Authors used the reference microphone located far from in-ear device and moreover, this apparatus may be inserted only besides traditional in-ear device. As a result, this invention misrepresented a real sound level difference provided by the in-ear device inserted into an ear canal of an individual and is especially

unsuitable for measuring sound level difference provided by earplugs as opposed to amplification of hearing aid devices. According to this invention the best thing would be if its probe could be placed at a distance approx. 1 mm from the eardrum. However, it is difficult to do this while making sure that the probe does not touch the eardrum, the reason being that the length and shape of the auditory canal differ from person to person.

[0013] Another example of a apparatus which is able to determine the level of acoustic seal provided by an in-ear device is given in US Patent N° 5317273, J. Hauson, 31/3/1994.

[0014] Additionally, there is no objective way of measuring an insertion loss (IL) value provided by an in-ear device. The IL estimation described in all standards (ANSI, ISO, CSA, etc.) is subjectively determined by the individual wearing the in-ear device, as better described herebelow.

OBJECTS OF THE INVENTION

[0015] It is therefore a general object of the present invention to provide an improved method and an improved apparatus for determining in situ the acoustic seal provided by an in-ear device for either of a hearing protection or aid nature that obviates the above-mentioned disadvantages.

[0016] An advantage of the present invention is that the apparatus for determining in situ the acoustic seal provided by an in-ear device ensures a perfect fit and a good acoustic seal of the device easily obtainable with a good comfort for the potential user.

[0017] A further advantage of the present invention is that the method and apparatus for determining in situ the acoustic seal provided by an in-ear device allow for an effective protection against noise in the case of hearing protectors and an elimination of the noise feedbacks in the case of hearing communication/aid devices.

[0018] Still another advantage of the present invention is that the method and apparatus for determining in situ the acoustic seal provided by an in-ear device allow for a monitoring of the ear canal occlusion during the settable compound injection session of expandable in-ear devices.

[0019] Still a further advantage of the present invention is that the method and apparatus for determining in situ the acoustic seal provided by an in-ear device allow for an effective performance in the sound insulation, attenuation, communication, measurement and the like of in-ear devices.

[0020] Yet another advantage of the present invention is that the method and apparatus for determining in situ the acoustic seal provided by an in-ear device allow for an objective estimation of the insertion loss provided by in-ear devices, and an estimation value of any standard parameters that could be derived therefrom.

[0021] Other objects and advantages of the present invention will become apparent from a careful reading of

the detailed description provided herein, with appropriate reference to the accompanying drawings.

SUMMARY OF THE INVENTION

[0022] According to an aspect of the present invention, there is provided an apparatus for determining in situ an acoustic seal provided by an in-ear device inserted into an ear canal of an individual, said in-ear device having a sound bore with an environment opening and an ear opening outside and inside said ear canal respectively, said apparatus comprises a sound measurement device for removably engaging said environment opening of said sound bore of said in-ear device and including a probe microphone and a reference microphone isolated from each other and connected to a data processing unit having a control box and a reference sound source, both being connected to a computer unit, said probe and reference microphones measuring a sound pressure level inside said ear canal of said individual and a sound pressure level from said environment in close proximity of said in-ear device, respectively, said sound pressure levels corresponding to a known noise signal created by said reference sound source at an inlet to the individual's ear in a close proximity of said in-ear device, said data processing unit recording and processing said sound pressure levels read by both said probe and reference microphones to feed said computer unit, the latter providing a corresponding calculated value of a sound level difference induced by said in-ear device.

[0023] Preferably, the in-ear device is expandable and further has an injection channel with an opened end outside said ear canal and a closed end inside said in-ear device for receiving a settable compound material therein to allow for said in-ear device to properly assume said ear canal of said individual, said apparatus continuously monitoring said calculated value of said sound level difference during slow injection of said compound material into said expandable in-ear device via said injection channel, said data processing unit advising to stop injection of said compound material into said expandable in-ear device upon obtaining a calculated value of a sound pressure level difference of said in-ear device corresponding to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition.

[0024] Preferably, either said predetermined sound pressure level difference or said time stable sound level difference is determined over a pre-selected frequency range.

[0025] Preferably, the computer unit includes a display member displaying said calculated value of said sound level difference induced by said in-ear device.

[0026] Alternatively, the apparatus comprises a second measurement device for removably engaging an environment opening of a sound bore of a second in-ear device inserted into a second ear canal of said individual,

said second measurement device being simultaneously connected to said control box of said data processing unit, the latter recording and processing second pressure levels read by a second probe and a second reference microphones of said second sound measurement device, respectively, to simultaneously feed said computer unit, the latter providing a second corresponding calculated value of a second sound level difference induced by said second in-ear device.

[0027] Preferably, the computer unit includes a display member displaying said calculated values of said sound level differences induced by respective of said in-ear devices.

[0028] Preferably, the control box filters and sequentially sends said sound pressure levels read by said probe and reference microphones of said sound measurement device to said computer unit.

[0029] Preferably, the control box filters said sound pressure levels read by said probe and reference microphones of both said first and second sound measurement devices and has a multiplexer for sequentially sending the same to said computer unit.

[0030] Alternatively, the in-ear device has a second sound bore with an environment opening and an ear opening outside and inside said ear canal respectively, said apparatus includes a remote device for removably engaging said environment opening of said second sound bore during measurement of said sound pressure levels by said probe and reference microphones.

[0031] Preferably, the computer unit contains pre-determined correction factors and a transfer coefficient, said apparatus determining an estimated insertion loss value provided by said in-ear device from said calculated value of said sound level difference, said pre-determined correction factors and said transfer coefficient.

[0032] According to another aspect of the present invention, there is provided a method for determining in-situ the acoustic seal provided by an in-ear device inserted into an ear canal of an individual, said in-ear device having a sound bore with an environment opening and an ear opening outside and inside said ear canal respectively, said method comprises the steps of:

- a) providing a sound measurement device including a probe microphone and a reference microphone isolated from each other and a data processing unit having a control box and a reference sound source, both being connected to a computer unit,
- b) connecting said sound measurement device to said data processing unit;
- c) testing connection of said sound measurement device to said data processing unit by measuring a known noise signal from said reference sound source with said probe and reference microphones;
- d) engaging said sound measurement device into said environment opening of said sound bore, said probe and reference microphones for measuring a sound pressure level inside said ear canal of said

individual and a sound pressure level from said environment in close proximity of said in-ear device, respectively;

e) sending a known noise signal from said reference sound source;

f) recording sound pressure levels read by both said probe and reference microphones corresponding to said known noise source signal;

g) processing said measured sound pressure levels to feed said computer unit; and

h) obtaining a calculated value of a sound level difference induced by said in-ear device.

[0033] Preferably, the method comprises, after step a), the step of:

- a1) performing calibration of said data processing unit to check proper connection of said control box to said computer unit.

[0034] Preferably, the in-ear device being expandable and further having an injection channel with an opened end outside said ear canal for receiving an injection device filled with a settable compound material there-through and a closed end inside said in-ear device for receiving said settable compound material therein to allow for said in-ear device to properly assume said ear canal of said individual, said method comprises, after steps e) and h) respectively, the steps of:

e1) starting a slow injection of said compound material from said injection device into said expandable in-ear device via said injection channel;

h1) repeating steps e) through h) to continuously monitor said calculated value of said sound level while simultaneously keeping on injecting said compound material;

h2) advising to stop said injection upon obtaining a calculated value of a sound pressure level difference of said in-ear device corresponding to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition.

[0035] Preferably, either said predetermined sound pressure level difference or said time stable sound level difference is determined over a pre-selected frequency range, said method comprises, after step b), the step of:

- b1) performing selection of said pre-selected frequency range for obtaining a corresponding calculated value of a sound pressure level difference.

[0036] Preferably, the computer unit includes a display member, said method comprises, between steps h) and h1), the step of:

- h') displaying said calculated value of said sound

level difference induced by said in-ear device on said display member.

[0037] Preferably, the method comprises, after step h2), the steps of:

- i) disengaging said sound measurement device from said in-ear device;
- j) waiting for said settable compound material to properly set before performing any following step.

[0038] Alternatively, the in-ear device has a second sound bore with an environment opening and an ear opening outside and inside said ear canal respectively, said method comprises, after step a), the step of:

- a') engaging a remote device having a pre-selected frequency window into said environment opening of said second sound bore.

[0039] Alternatively, steps a) to h) are simultaneously performed for a second in-ear device inserted into a second ear canal of said individual and using a corresponding second sound measurement device for removably engaging an environment opening of a sound bore of said second in-ear device.

[0040] Preferably, the computer unit contains pre-determined correction factors and a transfer coefficient, said method comprises, after step h), the step of:

- h") estimating an insertion loss value induced by said in-ear device from said calculated value of said sound level difference, said pre-determined correction factors and said transfer coefficient.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] In the annexed drawings, like reference characters indicate like elements throughout.

Figure 1 shows an embodiment of an apparatus for determining in situ the acoustic seal provided by an in-ear device according to the present invention fitted into an ear canal of an individual;
 Figure 2 is a perspective view of an expandable in-ear device used with the embodiment of Fig. 1 showing its shape before (i) and after (ii) expansion;
 Figure 3 is a section view of a sound measurement device of the embodiment of Fig. 1;
 Figure 4 shows a block diagram of the method of using the embodiment of Fig. 1; and
 Figures 5a and 5b show pictorial representations of the different locations for sound pressure level measurement inside an individual's ear canal without and with an in-ear device respectively, in order to determine an insertion loss estimation from the acoustic seal provided by the in-ear device and determined by the embodiment of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] With reference to the annexed drawings the preferred embodiments of the present invention will be herein described for indicative purposes and by no means as of limitation.

[0043] Referring to Fig. 1, there is shown an embodiment 100 of an apparatus for determining in situ the acoustic seal, preferably leading to an attenuation or an amplification of the sound level, provided by an in-ear device 10, preferably a semi-custom-molded expandable earplug, inserted into an ear canal 20 of an individual.

[0044] As it is shown in Fig. 2, the in-ear device 10 has a sound bore 12 with an environment opening 13 and an ear opening 14 outside and inside the ear canal 20 respectively. The environment opening 13 is adapted to be removably engaged by a remote device 40 such as a sound measurement device, a filter device, an hearing aid (or amplifier) device, a plug device and the like.

[0045] The apparatus 100 comprises a sound measurement device 41 as a remote device 40 (see Fig. 3) that has a probe microphone 42 and a reference microphone 44 connected to a data processing unit 50 and isolated from each other by isolation barrier 46 located between the probe 42 and reference 44 microphones for fully canceling any mutual influence. Microphones 42, 44 are typical microphones known in the industry such as EA-1954 or FG-3329 types from Knowles Electronics, Inc. Obviously, both microphones 42, 44 are pre-calibrated with respect to their position relative to their respective opening 43, 45 of the sound measurement device 41. The barrier 46 is preferably made out of potting compound or epoxy like material being a sound insulating material securing each microphone 42, 44 in place.

[0046] Referring to Fig. 4 the data processing unit 50 has a control box 52 and a reference sound source or speaker 51, both connected to a computer unit 54. The probe 42 and the reference 44 microphones are adapted for measuring a sound pressure level inside the ear canal 20 of an individual and a sound pressure level from the environment in close proximity of the in-ear device 10 respectively (see Figs. 1 and 5). The sound pressure levels corresponding to a known noise pressure signal created by the reference sound source 51 at an inlet to the individual's ear in a close proximity of the in-ear device 10 and inside the individual's ear canal 20, in proximity to the tympanic membrane 22 next to the ear drum. The sound pressure levels correspond to a known noise source signal, preferably of wide band ranging from twenty Hertz (20 Hz) to twenty thousand Hertz (20000 Hz) for enhanced measurements, coming from the computer unit 54 via an audio amplifier 58 of the control box 52 and speaker 51. The control box 52 is preferably an electronic controller adapted for gathering the sound pressure levels read by both microphones 42, 44 before transmitting them to the computer unit 54 to be recorded and processed by the same. Although the use of a standard micro-

computer or a "laptop" computer is preferred, the computer unit 54 could be any other electronic system such as a dedicated system or larger computers.

[0047] The data processing unit 50 is adapted for recording and processing the sound pressure levels read by both probe 42 and reference 44 microphones corresponding to the known noise pressure signal to provide a corresponding calculated value of a sound level difference provided, or induced, by the in-ear device 10. The computer unit 54 preferably includes a display member 56 for displaying the sound level difference calculated value induced by the in-ear device 10, being either an attenuation or an amplification depending on the type of in-ear device 10.

[0048] Optionally, the apparatus 100 further comprises a second measurement device 41a adapted to engage an environment opening 13 of a sound bore 12 of a second in-ear device 10 inserted into a second ear canal 20 of the individual. The second measurement device 41a is also connected to the control box 52 of the data processing unit 50 for the same to simultaneously provide a corresponding calculated second value of a second sound level difference induced by that second in-ear device 10. Accordingly, the display member 56 displays the sound level difference calculated values induced by respective in-ear devices 10.

[0049] Consequently, the control box 52 is also adapted for properly filtering the sound pressure levels read by the probe 42, 42a and reference 44, 44a microphones of both in-ear devices 10 using a filter circuit 57 and has a multiplexer circuit 53 for sequentially sending the filtered measured sound pressure levels of the microphones 42, 42a, 44, 44a of both sound measurement devices 41, 41 a connected to both in-ear devices 10 to the computer unit 54 using an internal clock and tone reference trigger signal provided by a tone reference circuit 55, as shown in Fig. 4.

[0050] Preferably, the in-ear device 10b is expandable, from a first original shape (i) to a second final shape (ii) as shown in Fig. 2, and further has an injection channel 16 with an opened end 17 outside the ear canal 20 and a closed end 18 inside the in-ear device 10b adapted to receive a settable compound material (C) allowing for the in-ear device 10b to properly assume the ear canal 20 of the individual. Preferably, the compound material C, once set, has a hardness value between five (5) and forty (40) shore-A.

[0051] Consequently, the apparatus 100 is adapted for continuously monitoring the calculated value of the sound level difference while an operator is simultaneously slowly injecting the compound material C into the filling canal 16 of the expandable in-ear device 10b. The settable compound material C is preferably injected using a syringe 30 having two adjacent barrels 32, 34, each containing one of its two constituents A, B that are mixed during the injection (A+B=C). The data processing unit 50 is adapted for advising to stop injecting the compound material C into the expandable in-ear device 10b upon

obtaining a calculated value of a sound pressure level difference of the in-ear device that corresponds to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition. These conditions may be applicable to any frequency range selected by the operator before starting the injection. Obviously, the display member 56 continuously displays the sound pressure level difference calculated value induced by the in-ear device 10b in real time.

[0052] Optionally, the in-ear device 10 has a second sound bore 60 with an environment opening 62 and an ear opening 64 outside and inside the ear canal 20 respectively. The environment opening 62 is adapted to be removably engaged by a second remote device 40. That second remote device 40 is preferably either an amplifier device or filter device adapted for a pre-selected frequency window, or the like. The second remote device 40 does engage the environment opening 62 of the second sound bore 60 during the measurement of the sound pressure levels by the probe 42 and reference 44 microphones. When the second remote device 40 is an amplifier device, the measured sound pressure levels will show the amplification value of the signal and could serve to determine the absence of signal feedback because of a good acoustic seal between the in-ear device 10 and the individual's ear canal 20. In the case of a filter device or a plug, the measured sound pressure levels will show the attenuation value of the signal because of a good acoustic seal between the in-ear device 10 and the individual's ear canal 20. A plug 41 is preferably used to acoustically and physically close off the injection opening 62 during the injection, or occlusion, of the in-ear device 10 while the environment opening 13 is used for measurement.

[0053] Obviously, the data processing of any of the above sound pressure level measurements could provide a difference calculated value for any preselectable frequency range (any single frequency level included) that is either an average value or a frequency dependent variation over the selected range (such as discrete values for each octave over the frequency range).

[0054] The present invention also refers to a method for determining in-situ the acoustic seal provided by an in-ear device 10 inserted into an ear canal 20 of an individual. The in-ear device 10 has sound bore 12 with an environment opening 13 and an ear opening 14 outside and inside the ear canal 20 respectively. The environment opening 13 is adapted to be removably engaged by a remote device 40 such as a sound measurement device 41, a filter device, an hearing aid device, a plug device and the like.

[0055] The method preferably comprises the steps of:

- a) providing the sound pressure measurement device 41 having a probe microphone 42 and a reference microphone 44 isolated from each other and a data processing unit 50 having a control box 52 and

a) performing calibration of the data processing unit 50 to check proper connection of the control box 52 to the computer unit 54;

b) connecting the measurement device 41 to the data processing unit 50;

c) testing connection of the measurement device 41 to the data processing unit 50 by measuring a known noise pressure signal from the speaker 51 with the probe 42 and reference 44 microphones;

d) engaging the measurement device 41 into the environment opening 13 of the sound bore 12, the probe 42 and reference 44 microphones for measuring a sound pressure level inside the ear canal 20 of the individual and a sound pressure level from the environment in close proximity of the in-ear device 10 respectively;

e) sending a known noise pressure signal from the speaker 51;

f) recording sound pressure levels read by both probe 42 and reference 44 microphones corresponding to the known noise pressure source signal 51;

g) processing the measured sound pressure levels;

h) obtaining a calculated value of a sound level difference induced by the in-ear device 10.

[0056] Additionally, steps a) to h) of the method could be simultaneously performed for a second in-ear device 10 inserted into a second ear canal 20 of the individual and using a corresponding second sound measurement device 41 adapted to engage an environment opening 13 of a sound bore 12 of the second in-ear device 10.

[0057] Preferably, the in-ear device 10b is expandable and further has an injection channel 16 with an opened end 17 outside the ear canal 20 adapted to be removably engaged by a settable compound material injection device such as a syringe 30, and a closed end 18 inside the in-ear device adapted to receive a settable compound material C allowing for the in-ear device 10b to properly assume the ear canal 20 of the individual. The method further comprises, after steps e) and h), the steps of:

e1) starting a slow injection of the compound material C into the expandable in-ear 10b device via the injection channel 16;

h1) repeating steps e) through h) to continuously monitor the calculated value of the sound level while simultaneously keeping on injecting the compound material C;

h2) stopping the injection upon obtaining a calculated value of a sound pressure level difference of the in-ear device 10b corresponding to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition;

i) disengaging the measurement device 41 from the in-ear device 10;

j) waiting for the settable compound material C to properly set before removing the expandable in-ear device 10b from said ear canal 20 or performing any following step.

[0058] Optionally, either the predetermined sound pressure level difference or the time stable sound level difference is determined over a pre-selected frequency range. The method then further comprises, after step b), the step of:

b1) performing selection of the pre-selected frequency range for obtaining a corresponding calculated value of a sound pressure level difference.

[0059] Also, the computer unit 54 includes a display member 56, and the method further comprising, between steps h) and h1), the step of:

h') displaying the calculated value of the sound level difference induced by the in-ear device 10a on the display member 56.

[0060] Obviously, the above method could be performed along with an in-ear device 10 having a second sound bore 60 with an environment opening 62 and an ear opening 64 outside and inside the ear canal 20 respectively. The environment opening 62 is adapted to be removably engaged by a second remote device 40. That second remote device 40 is preferably either an amplifier device or filter device adapted for a pre-selected frequency window, or the like during measurement; or a plug during injection of the in-ear device 10.

[0061] Referring to Figs. 5a and 5b, there is shown pictorial representations of the different locations for sound pressure level measurement inside and outside an individual's ear canal 20 without and with an in-ear device 10 respectively. All standards, such as ANSI, ISO, CSA and the like, require an insertion loss (IL) subjective estimation, generally expressed in dB (decibels), of the acoustic seal provided by the in-ear device based on a ratio of Real Ear Attenuation Threshold (REAT) values determined at the tympanic membrane, or eardrum, by the individual himself (thereby subjective), with and without the in-ear device 10, i.e. $IL=20\log_{10}(P_4/P_4')$ in logarithmic notation.

[0062] Using the apparatus 100, the IL can be objectively determined by $IL=NR+TFOE$ where the noise ratio (NR) equals to $20\log_{10}(P_1/P_4')$ is determined by the sound pressure levels measured at the outer (P_2') and inner (P_3') extremities of the in-ear device and reported to P_1 and P_4' respectively using corresponding pre-determined correction factors contained within the computer unit 54, and the Transfer Function of the Outer Ear (TFOE) being also a transfer coefficient corresponding to $20\log_{10}(P_4/P_1)$ contained within the computer unit 54. The transfer coefficient of the TFOE is preferably a mean value of different and already measured values of differ-

ent sizes and shapes of ears available from many widely known publications by anyone familiar with the art. Since the variation of these different known TFOE values is relatively low below one thousand Hertz (1000 Hz), the determination of a mean TFOE value is suitable for the purpose of an objective estimation of IL in the present case.

[0063] Accordingly, the computer unit 54 containing the pre-determined correction factors and the transfer coefficient allows for the apparatus 100 to determine an estimated insertion loss IL value of the acoustic seal provided by the in-ear device 10 from the calculated value of the sound level difference leading to the NR using the pre-determined correction factors and the pre-determined transfer coefficient.

[0064] Finally, from this IL value, it is possible to extract other different standard parameters or indicators such as the noise reduction rating (NRR), the class, the single number rating (SNR) or the like, depending on the applicable standard.

Claims

1. An apparatus (100) for determining in situ an acoustic seal provided by an in-ear device (10) inserted into an ear canal (20) of an individual, said in-ear device (10) having a sound bore (12) with an environment opening (13) and an ear opening (14) outside and inside said ear canal (20) respectively, said apparatus (100) comprising a sound measurement device (41) for removably engaging said environment opening (13) of said sound bore (12) of said in-ear device (10) and including a probe microphone (42) and a reference microphone (44) isolated from each other and connected to a data processing unit (50) having a control box (52) and a reference sound source (51), both (52,51) being connected to a computer unit (54), said probe (42) and reference (44) microphones measuring a sound pressure level (P3') inside said ear canal (20) of said individual and a sound pressure level (P2') from said environment in close proximity of said in-ear device (10), respectively, said sound pressure levels (P3',P2') corresponding to a known noise signal created by said reference sound source (51) at an inlet to the individual's ear in a close proximity of said in-ear device (10), said data processing unit (50) recording and processing said sound pressure levels (P3',P2') read by both said probe (42) and reference (44) microphones to feed said computer unit (54), the latter (54) providing a corresponding calculated value of a sound level difference induced by said in-ear device (10).
2. The apparatus (100) of claim 1, wherein said in-ear device (10b) being expandable and further having an injection channel (16) with an opened end (17) outside said ear canal (20) and a closed end (18) inside said in-ear device (10b) for receiving a settable compound material (C) therein to allow for said in-ear device (10b) to properly assume said ear canal (20) of said individual, said apparatus (100) continuously monitoring said calculated value of said sound level difference during slow injection of said compound material (C) into said expandable in-ear device (10b) via said injection channel (16), said data processing unit (50) advising to stop injection of said compound material (C) into said expandable in-ear device (10b) upon obtaining a calculated value of a sound pressure level difference of said in-ear device (10b) corresponding to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition.
3. The apparatus (100) of claim 2, wherein either said predetermined sound pressure level difference or said time stable sound level difference being determined over a pre-selected frequency range.
4. The apparatus (100) of claim 1, comprising a second measurement device (41 a) for removably engaging an environment opening (13) of a sound bore (12) of a second in-ear device (10) inserted into a second ear canal (20) of said individual, said second measurement device (41 a) being simultaneously connected to said control box (52) of said data processing unit (50), the latter (50) recording and processing second pressure levels read by a second probe (42a) and a second (44a) reference microphones of said second sound measurement device (41a), respectively, to simultaneously feed said computer unit (54), the latter (54) providing a second corresponding calculated value of a second sound level difference induced by said second in-ear device (10).
5. The apparatus (100) of claim 1, wherein said computer unit (54) including a display member (56) displaying said calculated value of said sound level difference induced by said in-ear device (10).
6. The apparatus (100) of claim 4, wherein said computer unit (54) including a display member (56) displaying said calculated values of said sound level differences induced by respective of said in-ear devices (10).
7. The apparatus (100) of claim 3, wherein said computer unit (54) including a display member (56) continuously displaying said calculated value of said sound level difference induced by said in-ear device (10b).
8. The apparatus (100) of claim 5, wherein said control box (52) filtering and sequentially sending said

- sound pressure levels (P3',P2') read by said probe (42) and reference (44) microphones of said sound measurement device (41) to said computer unit (54).
9. The apparatus (100) of claim 6, wherein said control box (52) filtering said sound pressure levels (P3',P2') read by said probe (42,42a) and reference (44,44a) microphones of both said first (41) and second (41 a) sound measurement devices and having a multiplexer (53) for sequentially sending the same (P3', P2') to said computer unit (54). 5 10
10. The apparatus (100) of claim 1, wherein said in-ear device (10) having a second sound bore (60) with an environment opening (62) and an ear opening (64) outside and inside said ear canal (20) respectively, said apparatus (100) including a remote device (40) for removably engaging said environment opening (62) of said second sound bore (60) during measurement of said sound pressure levels (P3', P2') by said probe (42) and reference (44) microphones. 15 20
11. The apparatus (100) of claim 1, wherein said computer unit (54) containing pre-determined correction factors and a transfer coefficient, said apparatus (100) determining an estimated insertion loss value (IL) provided by said in-ear device (10) from said calculated value of said sound level difference, said pre-determined correction factors and said transfer coefficient. 25 30
12. A method for determining in-situ the acoustic seal provided by an in-ear device (10) inserted into an ear canal (20) of an individual, said in-ear device (10) having a sound bore (12) with an environment opening (13) and an ear opening (14) outside and inside said ear canal (20) respectively, said method comprising the steps of: 35 40
- a) providing a sound measurement device (41) including a probe microphone (42) and a reference microphone (44) isolated from each other and a data processing unit (50) having a control box (52) and a reference sound source (51), both (52,51) being connected to a computer unit (54); 45
 - b) connecting said sound measurement device (41) to said data processing unit (50);
 - c) testing connection of said sound measurement device (41) to said data processing unit (50) by measuring a known noise signal from said reference sound source (51) with said probe (42) and reference (44) microphones; 50
 - d) engaging said sound measurement device (41) into said environment opening (13) of said sound bore (12), said probe (42) and reference (44) microphones for measuring a sound pressure level (P3') inside said ear canal (20) of said individual and a sound pressure level (P2') from said environment in close proximity of said in-ear device (10), respectively; 55
 - e) sending a known noise signal from said reference sound source (51);
 - f) recording sound pressure levels (P3',P2') read by both said probe (42) and reference (44) microphones corresponding to said known noise source signal;
 - g) processing said measured sound pressure levels (P3',P2') to feed said computer unit (54); and
 - h) obtaining a calculated value of a sound level difference induced by said in-ear device (10).
13. The method of claim 12, comprising, after step a), the step of:
- a1) performing calibration of said data processing unit (50) to check proper connection of said control box (52) to said computer unit (54).
14. The method of claim 13, wherein said in-ear device (10b) being expandable and further having an injection channel (16) with an opened end (17) outside said ear canal (20) for receiving an injection device (30) filled with a settable compound material (C) therethrough and a closed end (18) inside said in-ear device (10b) for receiving said settable compound material (C) therein to allow for said in-ear device (10b) to properly assume said ear canal (20) of said individual, said method comprising, after steps e) and h) respectively, the steps of:
- e1) starting a slow injection of said compound material (C) from said injection device (30) into said expandable in-ear device (10b) via said injection channel (16);
 - h1) repeating steps e) through h) to continuously monitor said calculated value of said sound level while simultaneously keeping on injecting said compound material (C);
 - h2) advising to stop said injection upon obtaining a calculated value of a sound pressure level difference of said in-ear device (10b) corresponding to a first occurring of being either substantially equal to a predetermined sound pressure level difference or a substantially time stable sound level difference condition.
15. The method of claim 14, wherein either said predetermined sound pressure level difference or said time stable sound level difference being determined over a pre-selected frequency range, said method comprising, after step b), the step of:
- b1) performing selection of said pre-selected

frequency range for obtaining a corresponding calculated value of a sound pressure level difference.

16. The method of claim 15, wherein said computer unit (54) including a display member (56), said method comprising, between steps h) and h1), the step of:

h') displaying said calculated value of said sound level difference induced by said in-ear device (10b) on said display member (56).

17. The method of claim 16, comprising, after step h2), the steps of:

i) disengaging said sound measurement device (41) from said in-ear device (10); and
j) waiting for said settable compound material (C) to properly set before performing any following step.

18. The method of claim 12, wherein said in-ear device (10) having a second sound bore (60) with an environment opening (62) and an ear opening (64) outside and inside said ear canal (20) respectively, said method comprising, after step a), the step of:

a') engaging a remote device (40) having a pre-selected frequency window into said environment opening (62) of said second sound bore (60).

19. The method of claim 12, wherein steps a) to h) are simultaneously performed for a second in-ear device (10) inserted into a second ear canal (20) of said individual and using a corresponding second sound measurement device (41a) for removably engaging an environment opening (13) of a sound bore (12) of said second in-ear device (10).

20. The method of claim 12, wherein said computer unit (54) containing pre-determined correction factors and a transfer coefficient, said method comprising, after step h), the step of:

h') estimating an insertion loss value (IL) induced by said in-ear device (10) from said calculated value of said sound level difference, said pre-determined correction factors and said transfer coefficient.

Patentansprüche

1. Vorrichtung (100) zur In-Situ-Bestimmung eines durch eine in einen Gehörgang (20) eines Menschen eingesetzte Im-Ohr-Einrichtung (10) bereitgestellten akustischen Verschlusses, wobei die Im-Ohr-Ein-

richtung (10) eine Schallbohrung (12) mit einer Umgebungsöffnung (13) und einer Ohröffnung (14) ausserhalb bzw. innerhalb des Gehörgangs (20) aufweist, welche Vorrichtung (100) eine Schallmessenrichtung (41) aufweist, die in die Umgebungsöffnung (13) der Schallbohrung (12) der Im-Ohr-Einrichtung (10) lösbar in Eingriff bringbar ist und ein Messmikrophon (42) und ein Referenzmikrophon (44) umfasst, welche Mikrophone voneinander getrennt und mit einer Datenverarbeitungseinheit (50) verbunden sind, die ein Steuergerät (52) und eine Referenzschallquelle (51) aufweist, die beide (52, 51) an eine Rechneinheit (54) angeschlossen sind, wobei das Messmikrophon (42) und das Referenzmikrophon (44) einen Schalldruckpegel (P3') innerhalb des Gehörgangs des Menschen bzw. einen Schalldruckpegel (P2') aus der Umgebung in großer Nähe zur Im-Ohr-Einrichtung (10) messen, wobei die Schalldruckpegel (P3', P2') einem durch die Referenzschallquelle (51) an einem Eingang zum Ohr des Menschen in großer Nähe zur Im-Ohr-Einrichtung erzeugten bekannten Störsignal entsprechen, wobei die Datenverarbeitungseinheit (50) die sowohl von dem Messmikrophon (42) als auch von dem Referenzmikrophon (44) erfassten Schalldruckpegel (P3', P2') aufzeichnet und verarbeitet, um die Rechneinheit (54) zu versorgen, welche Rechneinheit (54) einen entsprechend berechneten Wert einer durch die Im-Ohr-Einrichtung (10) induzierten Schallpegeldifferenz bereitstellt.

2. Vorrichtung nach Anspruch 1, bei der die Im-Ohr-Einrichtung (10b) ausdehnbar ist und des Weiteren einen Einbringkanal (16) mit einem offenen Ende (17) ausserhalb des Gehörgangs (20) und einem geschlossenen Ende (18) innerhalb der Im-Ohr-Einrichtung (10b) aufweist, um darin ein ausreagierbares Materialgemisch (C) aufzunehmen, damit die Im-Ohr-Einrichtung (10b) den Gehörgang (20) des Menschen geeignet annehmen kann, wobei die Vorrichtung (100) während eines langsamen Einbringens des Materialgemisches (C) in die ausdehnbare Im-Ohr-Einrichtung (10b) über den Einbringkanal (16) den berechneten Wert der Schallpegeldifferenz fortwährend überwacht, wobei die Datenverarbeitungseinheit (50) beim Erhalt eines berechneten Werts einer Schalldruckpegeldifferenz der Im-Ohr-Einrichtung (10b), welche Schalldruckdifferenz einer zuerst auftretenden Bedingung entspricht, die entweder mit einer vorbestimmten Schalldruckpegeldifferenz im Wesentlichen übereinstimmt oder eine im Wesentlichen zeitkonstante Schallpegeldifferenz ist, ein Stoppen des Einbringens des Materialgemisches (C) in die ausdehnbare Im-Ohr-Einrichtung (10b) anzeigt.
3. Vorrichtung (100) nach Anspruch 2, bei der entweder die vorbestimmte Schalldruckpegeldifferenz oder

die zeitstabile Schallpegeldifferenz über einen vorausgewählten Frequenzbereich bestimmt werden.

4. Vorrichtung (100) nach Anspruch 1, mit einer zweiten Messeinrichtung (41 a), die in eine Umgebungsöffnung (13) einer Schallbohrung (12) einer in einen zweiten Gehörgang (20) des Menschen eingesetzten zweiten Im-Ohr-Einrichtung (10) lösbar in Eingriff bringbar ist, wobei die zweite Messeinrichtung (41a) gleichzeitig an das Steuergerät (52) der Datenverarbeitungseinheit (50) angeschlossen ist, welche Datenverarbeitungseinheit (50) zweite Druckpegel, die durch ein zweites Messmikrofon (42a) bzw. ein zweites Referenzmikrofon (44a) der zweiten Schallmesseinrichtung (41a) erfasst werden, aufzeichnet und verarbeitet, um gleichzeitig die Rechneinheit (54) zu versorgen, welche Rechneinheit (54) einen entsprechend berechneten zweiten Wert einer durch die zweite Im-Ohr-Einrichtung (10) induzierten zweiten Schallpegeldifferenz bereitstellt.
5. Vorrichtung (100) nach Anspruch 1, bei der die Rechneinheit (54) ein Anzeigeelement (56) umfasst, das den berechneten Wert der durch die Im-Ohr-Einrichtung (10) induzierten Schallpegeldifferenz anzeigt.
6. Vorrichtung (100) nach Anspruch 4, bei der die Rechneinheit (54) ein Anzeigeelement (54) umfasst, das die berechneten Werte der durch die jeweiligen Im-Ohr-Einrichtungen (10) induzierten Schallpegeldifferenzen anzeigt.
7. Vorrichtung (100) nach Anspruch 3, bei der die Rechneinheit (54) ein Anzeigeelement (56) umfasst, das den berechneten Wert der durch die Im-Ohr-Einrichtung (10) induzierten Schallpegeldifferenz fortwährend anzeigt.
8. Vorrichtung (100) nach Anspruch 5, bei der das Steuergerät (52) die durch das Messmikrofon (42) und das Referenzmikrofon (44) der Schallmesseinrichtung (41) erfassten Schalldruckpegel (P3', P2') filtert und sequenziell an die Rechneinheit (54) sendet.
9. Vorrichtung (100) nach Anspruch 6, bei der das Steuergerät (52) die durch das Messmikrofon (42, 42a) und das Referenzmikrofon (44, 44a) sowohl der ersten Schallmesseinrichtung (41) als auch der zweiten Schallmesseinrichtung (41a) erfassten Schalldruckpegel (P3', P2') filtert und einen Multiplexer (53) aufweist, um dieselben (P3', P2') sequenziell an die Rechneinheit (54) zu senden.
10. Vorrichtung (100) nach Anspruch 1, bei der die Im-Ohr-Einrichtung (10) eine zweite Schallbohrung (60) mit einer Umgebungsöffnung (62) und einer Ohröffnung (64) ausserhalb bzw. innerhalb des Gehörgangs (20) aufweist, wobei die Vorrichtung (100) eine Remote-Einrichtung (40) umfasst, die während einer Messung der Schalldruckpegel (P3', P2') durch das Messmikrofon (42) und das Referenzmikrofon (44) in die Umgebungsöffnung (62) der zweiten Schallbohrung (60) lösbar in Eingriff bringbar ist.

5

10

15

20

25

30

35

40

45

50

55

nung (64) ausserhalb bzw. innerhalb des Gehörgangs (20) aufweist, wobei die Vorrichtung (100) eine Remote-Einrichtung (40) umfasst, die während einer Messung der Schalldruckpegel (P3', P2') durch das Messmikrofon (42) und das Referenzmikrofon (44) in die Umgebungsöffnung (62) der zweiten Schallbohrung (60) lösbar in Eingriff bringbar ist.

11. Vorrichtung (100) nach Anspruch 1, bei der die Rechneinheit (54) vorbestimmte Korrekturfaktoren und einen Übertragungskoeffizienten enthält, wobei die Vorrichtung (100) einen durch die Im-Ohr-Einrichtung (10) bereitgestellten geschätzten Einfüguungsverlustwert (IL) aus dem berechneten Wert der Schallpegeldifferenz, den vorbestimmten Korrekturfaktoren und dem Übertragungskoeffizienten bestimmt.

12. Verfahren zur In-Situ-Bestimmung des durch eine in einen Gehörgang (20) eines Menschen eingesetzte Im-Ohr-Einrichtung (10) bereitgestellten akustischen Verschlusses, wobei die Im-Ohr-Einrichtung (10) eine Schallbohrung (12) mit einer Umgebungsöffnung (13) und einer Ohröffnung (14) ausserhalb bzw. innerhalb des Gehörgangs (20) aufweist, mit den Schritten:

- a) Bereitstellen einer Schallmesseinrichtung (41), die ein Messmikrofon (42) und ein Referenzmikrofon (44), welche Mikrofone voneinander getrennt sind, und eine Datenverarbeitungseinheit (50) umfasst, die ein Steuergerät (52) und eine Referenzschallquelle (51) aufweist, die beide (52, 51) an eine Rechneinheit (54) angeschlossen sind;
- b) Anschliessen der Schallmesseinrichtung (41) an die Datenverarbeitungseinheit (50);
- c) Testen einer Verbindung der Schallmesseinrichtung (41) mit der Datenverarbeitungseinheit (50) durch Messen eines bekannten Störsignals von der Referenzschallquelle (51) mit dem Messmikrofon (42) und dem Referenzmikrofon (44);
- d) In-Eingriff-Bringen der Schallmesseinrichtung (41) in die Umgebungsöffnung (13) der Schallbohrung (12), wobei das Messmikrofon (42) und das Referenzmikrofon (44) zum Messen eines Schalldruckpegels (P3') innerhalb des Gehörgangs (20) des Menschen bzw. eines Schalldruckpegels (P2') aus der Umgebung in grosser Nähe zur Im-Ohr-Einrichtung (10) vorgesehen sind;
- e) Aussenden eines bekannten Störsignals von der Referenzschallquelle (51);
- f) Aufzeichnen von sowohl durch das Messmikrofon (42) als auch durch das Referenzmikrofon (44) erfassten Schalldruckpegeln (P3', P2'), die dem bekannten Störquellensignal ent-

- sprechen;
g) Verarbeiten der gemessenen Schalldruckpegel (P3', P2'), um die Rechneinheit (54) zu versorgen; und
h) Erhalten eines berechneten Werts einer durch die Im-Ohr-Einrichtung (10) induzierten Schallpegeldifferenz.
- 5
13. Verfahren nach Anspruch 12, das nach dem Schritt a) folgenden Schritt umfasst:
- 10
- a1) Durchführen einer Kalibrierung der Datenverarbeitungseinheit (50), um eine korrekte Verbindung des Steuergeräts (52) mit der Rechneinheit (54) zu prüfen.
- 15
14. Verfahren nach Anspruch 13, bei dem die Im-Ohr-Einrichtung (10b) ausdehnbar ist und des Weiteren einen Einbringkanal (16) mit einem ausserhalb des Gehörgangs (20) vorgesehenen offenen Ende (17), um hierdurch eine mit einem ausreagierbaren Materialgemisch (C) gefüllte Einbringeinrichtung (30) aufzunehmen, und mit einem innerhalb der Im-Ohr-Einrichtung (10b) vorgesehenen geschlossenen Ende aufweist, um darin das ausreagierbare Materialgemisch (C) aufzunehmen, damit die Im-Ohr-Einrichtung (10b) den Gehörgang (20) des Menschen geeignet annehmen kann, wobei das Verfahren nach den Schritten e) bzw. h) folgende Schritte umfasst:
- 20
- 25
- 30
- e1) Starten eines langsamen Einbringens des Materialgemisches (C) aus der Einbringeinrichtung (30) in die ausdehnbare Im-Ohr-Einrichtung (10b) über den Einbringkanal (16):
h1) Wiederholen der Schritte e) bis h), um den berechneten Wert des Schallpegels fortwährend zu überwachen, während das Materialgemisch (C) weiterhin eingebracht wird;
h2) Anzeigen eines Stoppens des Einbringens, wenn ein berechneter Wert einer Schallpegeldifferenz der Im-Ohr-Einrichtung (10b) erhalten wird, welche Schallpegeldifferenz einer zuerst auftretenden Bedingung entspricht, die entweder mit einer vorbestimmten Schalldruckpegeldifferenz im Wesentlichen übereinstimmt oder eine im Wesentlichen zeitkonstante Schallpegeldifferenz ist.
- 35
- 40
- 45
- 50
- 55
15. Verfahren nach Anspruch 14, bei dem entweder die vorbestimmte Schalldruckpegeldifferenz oder die zeitstabile Schallpegeldifferenz über einen vorausgewählten Frequenzbereich bestimmt werden, wobei das Verfahren nach dem Schritt b) folgenden Schritt umfasst:
- b1) Durchführen einer Auswahl eines vorausgewählten Frequenzbereichs, um einen entsprechend berechneten Wert einer Schalldruckpegeldifferenz zu erhalten.
16. Verfahren nach Anspruch 15, bei dem die Rechneinheit (54) ein Anzeigeelement (56) umfasst, wobei das Verfahren zwischen den Schritten h) und h1) folgenden Schritt umfasst:
- h') Anzeigen des berechneten Werts der durch die Im-Ohr-Einrichtung (10b) induzierten Schallpegeldifferenz auf dem Anzeigeelement (56).
17. Verfahren nach Anspruch 16, das nach dem Schritt h2) die folgenden Schritte umfasst:
- i) Ausser-Eingriff-Bringen der Messeinrichtung (41) von der Im-Ohr-Einrichtung (10); und
ii) Abwarten, bis das ausreagierbare Materialgemisch (C) vollständig ausreagiert hat, bevor irgendein folgender Schritt durchgeführt wird.
18. Verfahren nach Anspruch 12, bei dem die Im-Ohr-Einrichtung (10) eine zweite Schallbohrung (60) mit einer Umgebungsöffnung (62) und einer Ohröffnung (64) ausserhalb bzw. innerhalb des Gehörgangs (60) aufweist, wobei das Verfahren nach dem Schritt a) folgenden Schritt umfasst:
- a') In-Eingriff-Bringen einer Remote-Einrichtung (40) mit einem vorausgewählten Frequenzfenster in die Umgebungsöffnung (62) der zweiten Schallbohrung (60).
19. Verfahren nach Anspruch 12, bei dem die Schritte a) bis h) gleichzeitig für eine in einen zweiten Gehörgang (20) des Menschen eingesetzte zweite Im-Ohr-Einrichtung (10) und unter Verwendung einer entsprechenden zweiten Schallmesseinrichtung (4,1a), die in eine Umgebungsöffnung (13) einer Schallbohrung (12) der zweiten Im-Ohr-Einrichtung (10) lösbar in Eingriff bringbar ist, durchgeführt werden.
20. Verfahren nach Anspruch 12, bei dem die Rechneinheit (54) vorbestimmte Korrekturfaktoren und einen Übertragungskoeffizienten enthält, wobei das Verfahren nach dem Schritt h) folgenden Schritt umfasst:
- h') Schätzen eines durch die Im-Ohr-Einrichtung (10) induzierten Einfügungsverlustwertes (IL) aus dem berechneten Wert der Schallpegeldifferenz, den vorbestimmten Korrekturfaktoren und dem Übertragungskoeffizienten.

Revendications

1. Un appareil (100) pour la détermination in situ d'un joint acoustique fourni par un dispositif à mettre dans une oreille (10) inséré dans un canal auditif (20) d'un individu, ledit dispositif à mettre dans une oreille (10) comportant un alésage sonore (12) comportant une ouverture sur l'environnement (13) et une ouverture dans l'oreille (14) à l'extérieur et à l'intérieur dudit canal auditif (20) respectivement, ledit appareil (100) comprenant un dispositif de mesure sonore (41) pouvant s'engager de façon amovible avec ladite ouverture sur l'environnement (13) dudit alésage sonore (12) dudit dispositif à mettre dans une oreille (10) et incluant un microphone sonde (42) et un microphone témoin (44), isolés l'un de l'autre et reliés à une unité de traitement de données (50) comportant une boîte de commande (52) et une source sonore témoin (51), les deux (52,51) étant reliées à un bloc d'ordinateur (54), lesdits microphones sonde (42) et témoin (44) mesurant un niveau de pression sonore (P3') dans ledit canal auditif (20) dudit individu et un niveau de pression sonore (P2') dudit environnement tout près dudit dispositif à mettre dans l'oreille (10), respectivement, lesdits niveaux de pression sonore (P3',P2') correspondant à un signal de bruit connu produit par ladite source sonore témoin (51) à une entrée de l'oreille de l'individu tout près dudit dispositif à mettre dans une oreille (10), ladite unité de traitement de données (50) enregistrant et traitant lesdits niveaux de pression sonore (P3',P2') lus à la fois par lesdits microphones sonde (42) et témoin (44) pour alimenter ledit bloc d'ordinateur (54), ce dernier (54) assurant une valeur calculée correspondante d'une différence de niveau sonore induite par ledit dispositif à mettre dans une oreille (10).
2. L'appareil (100) de la revendication 1, dans lequel ledit dispositif à mettre dans une oreille (10b) étant expansible et comportant de plus un canal d'injection (16) ayant une extrémité ouverte (17) à l'extérieur dudit canal auditif (20) et une extrémité fermée (18) à l'intérieur dudit dispositif à mettre dans une oreille (10b) pour y recevoir un matériau composite durcissable (C) permettant audit dispositif à mettre dans une oreille (10b) d'assumer convenablement ledit canal auditif (20) dudit individu, ledit appareil (100) surveillant ladite valeur calculée de ladite différence de niveau sonore pendant une lente injection dudit composite (C) dans ledit dispositif expansible à mettre dans une oreille (10b) via ledit canal d'injection (16), ladite unité de traitement de données (50) ordonnant de cesser l'injection dudit composite (C) dans ledit dispositif expansible à mettre dans une oreille (10b) sur obtention d'une valeur calculée d'une différence de niveau de pression sonore dans ledit dispositif à mettre dans une oreille (10b) correspondant à la première incidence où elle est substantiellement égale à une différence prédéterminée de niveau de pression sonore ou à une condition où la différence de niveau sonore est substantiellement stable dans le temps.
3. L'appareil (100) de la revendication 2, dans lequel soit ladite différence prédéterminée de niveau de pression sonore ou soit ladite différence de niveau sonore stable dans le temps sont déterminées sur une gamme de fréquence pré-sélectionnée.
4. L'appareil (100) de la revendication 1, comprenant un second dispositif de mesure (41a) fait pour s'engager de façon amovible sur une ouverture d'environnement (13) d'un alésage sonore (12) d'un second dispositif à mettre dans une oreille (10) inséré dans un second canal auditif (20) dudit individu, ledit second dispositif de mesure (41a) étant simultanément relié à ladite boîte de commande (52) de ladite unité de traitement de données (50), cette dernière (50) enregistrant et traitant des deuxièmes niveaux de pression lus par un second (42a) microphone sonde et un second (44a) microphone témoin dudit second dispositif de mesure sonore, respectivement, pour alimenter simultanément ledit bloc d'ordinateur (54), ce dernier (54) fournissant une seconde valeur calculée correspondante d'une seconde différence de niveau sonore déclenchée par le second dispositif à mettre dans une oreille (10).
5. L'appareil (100) de la revendication 1, dans lequel ledit bloc d'ordinateur (54) comporte un organe d'affichage (56) affichant ladite valeur calculée de ladite différence de niveau sonore déclenchée par ledit dispositif à mettre dans une oreille (10).
6. L'appareil (100) de la revendication 4, dans lequel ledit bloc d'ordinateur comporte un organe d'affichage (56) affichant ladite valeur calculée de ladite différence de niveau sonore déclenchée par ledit dispositif à mettre dans une oreille (10).
7. L'appareil (100) de la revendication 3, dans lequel ledit bloc d'ordinateur (54) comporte un organe d'affichage (56) affichant de façon continue ladite différence de niveau sonore déclenchée par ledit dispositif à mettre dans une oreille (10).
8. L'appareil (100) de la revendication 5, dans lequel ladite boîte de commande (52) filtre et envoie séquentiellement lesdits niveaux de pression sonore (P3',P2') lus par lesdits microphones sonde (42) et témoin (44) dudit dispositif de mesure sonore (42) audit bloc d'ordinateur (54),
9. L'appareil (100) de la revendication 6, dans lequel ladite boîte de commande (52) filtre lesdits niveaux de pression sonore (P3',P2') lus par lesdits micro-

- phones sondes (42,42a) et témoins (44,44a) des deux dits premier (41) et second (41a) dispositifs de mesure sonore et comportant un multiplexeur (53) adapté à séquentiellement envoyer les mêmes (P3', P2') audit bloc d'ordinateur (54). 5
10. L'appareil (100) de la revendication 1, dans lequel ledit dispositif à mettre dans une oreille (10) comporte un second alésage sonore (60) muni d'une ouverture sur l'environnement (62) et d'une ouverture dans l'oreille (64) à l'extérieur et à l'intérieur dudit canal auditif (20) respectivement, ledit appareil (100) comportant un dispositif éloigné (40) pouvant engager de façon amovible ladite ouverture sur l'environnement (62) dudit second alésage sonore (60) pendant la mesure desdits niveaux de pression sonore (P3', P2') par lesdits microphone sonde (42) et témoin (44). 10
11. L'appareil (100) de la revendication 1, dans lequel ledit bloc d'ordinateur (54) contient des facteurs de correction et un coefficient de transfert, ledit appareil (100) déterminant une valeur estimée de perte d'insertion (IL) fournie par ledit dispositif à mettre dans une oreille (10) à partir de ladite valeur calculée de ladite différence de niveau de son, desdits facteurs de corrections pré-déterminés et dudit coefficient de transfert. 15
12. Une méthode pour déterminer in situ le joint acoustique fourni par un dispositif à mettre dans une oreille (10) inséré dans un canal auditif (20) d'un individu, ledit dispositif à mettre dans une oreille (10) comportant un alésage sonore (12) muni d'une ouverture sur l'environnement (13) et une ouverture vers l'oreille (14) à l'extérieur et à l'intérieur dudit canal auditif (20) respectivement, ladite méthode comprenant les étapes suivantes : 20
- a) on se muni d'un dispositif de mesure sonore (41) incluant un microphone sonde (42) et un microphone témoin (44) isolés l'un de l'autre et une unité de traitement de données (50) comportant une boîte de commande (52) et une source sonore témoin (51), les deux (52,51) étant reliées à un bloc d'ordinateur (54); 25
- b) on relie le dispositif de mesure sonore (41) à ladite unité de traitement de données (50);
- c) on vérifie la connexion dudit dispositif de mesure sonore (41) à ladite unité de traitement de données (50) en mesurant un signal de bruit connu à partir de ladite source sonore témoin (51) avec lesdits microphones sonde (4) et témoin (44); 30
- d) on engage ledit dispositif de mesure sonore (41) dans ladite ouverture sur l'environnement (13) dudit alésage sonore (12), lesdits microphones témoin (42) et témoin (44) pour mesurer un niveau de pression sonore (P3') à l'intérieur dudit canal auditif (20) dudit individu et un niveau de pression sonore (P2') dudit environnement très près dudit dispositif à mettre dans une oreille (20), respectivement; 35
- e) on envoie un signal sonore connu depuis ladite source sonore témoin (52);
- f) on enregistre les niveaux (P3', P2') lus par lesdits microphones sonde (42) et témoin (44) correspondant audit signal connu de source sonore; 40
- g) on traite lesdits niveaux mesurés de pression sonore (P3', P2') pour alimenter ledit bloc d'ordinateur (54); et
- h) on obtient une valeur calculée de différence de niveau sonore produite par ledit dispositif à mettre dans une oreille (10). 45
13. La méthode de la revendication 12, comprenant, après l'étape a), l'étape de : 50
- a1) exécuter une calibration de ladite unité de traitement de données (50) pour vérifier la bonne connexion de ladite boîte de commande (52) audit bloc d'ordinateur (54). 55
14. La méthode de la revendication 13, dans laquelle ledit dispositif à mettre dans une oreille (10b) est expansible et comporte en plus un canal d'injection (16) ayant une extrémité ouverte (17) à l'extérieur dudit canal auditif (20) pour recevoir un dispositif d'injection (30) rempli d'un composite durcissable (C) qui s'étend tout au long dudit dispositif, et une extrémité fermée (18) à l'intérieur dudit dispositif à mettre dans une oreille (10b) pour y recevoir ledit composite durcissable (C) afin de permettre audit dispositif à mettre dans une oreille (10b) d'assumer convenablement ledit canal auditif (20) dudit individu, ladite méthode comprenant, après les étapes e) et h) respectivement, les étapes de : 60
- e1) amorcer une injection lente dudit composite (C) à partir dudit dispositif d'injection (30) dans ledit dispositif expansible à mettre dans une oreille (10b) via ledit canal d'injection (16); 65
- h1) répéter les étapes e) à h) pour surveiller de façon continue ladite valeur calculée dudit niveau sonore pendant qu'on continue à injecter simultanément ledit composite (C);
- h2) recommander d'arrêter ladite injection sur obtention d'une valeur calculée de différence de niveau de pression sonore dudit dispositif à mettre dans une oreille (10b) correspondant à la première fois qu'elle est substantiellement égale à une différence prédéterminée de niveau de pression sonore ou à une condition de différence de niveau sonore substantiellement stable dans le temps. 70

15. La méthode de la revendication 14, dans laquelle on détermine soit ladite différence de niveau de pression sonore prédéterminée, soit ladite différence de niveau sonore stable dans le temps sur une gamme de fréquence pré-sélectionnée, ladite méthode comprenant, après l'étape b), l'étape de :

b1) exécuter une sélection de ladite gamme de fréquence pré-sélectionnée de façon à obtenir une valeur correspondante calculée de différence de niveau de pression sonore.

16. La méthode de la revendication 15, dans laquelle ledit bloc d'ordinateur (54) inclut un organe d'affichage (56), ladite méthode comprenant, entre les étapes h) et h1), l'étape de :

h') afficher ladite valeur calculée de ladite différence de niveau sonore produite par ledit dispositif à mettre dans une oreille (10b) sur ledit organe d'affichage (56).

17. La méthode de la revendication 16, comprenant, après l'étape h2), les étapes de :

i) désengager ledit dispositif de mesure sonore (41) dudit dispositif à mettre dans une oreille (10); et
j) attendre que ledit composite durcissable (C) durcisse de façon convenable avant d'exécuter toute nouvelle étape.

18. La méthode de la revendication 12, dans laquelle ledit dispositif à mettre dans une oreille (10) comporte un second alésage sonore (60) ayant une ouverture sur l'environnement (62) et une ouverture dans l'oreille (64) à l'extérieur et à l'intérieur dudit canal auditif (20) respectivement, ladite méthode comprenant, après l'étape a), l'étape de :

a') engager un dispositif éloigné (430) comportant une fenêtre d'affichage pré-choisie dans ladite ouverture sur l'environnement (62) dudit second alésage sonore (60).

19. La méthode de la revendication 12, dans laquelle les étapes a) à

h) sont exécutées simultanément pour un second dispositif à mettre dans une oreille (10) inséré dans un second canal auditif (20) dudit individu et on utilise un second dispositif de mesure sonore correspondant (41a) pour engager de façon amovible une ouverture sur l'environnement (13) d'un alésage sonore (12) dudit dispositif à mettre dans une oreille (10).

20. La méthode de la revendication 12, dans laquelle

ledit bloc d'ordinateur (54) renferme des facteurs de corrections pré-déterminés et un coefficient de transfert, ladite méthode comprenant, après l'étape h), l'étape de :

h') estimer une valeur de perte d'insertion (IL) produite par ledit dispositif à mettre dans une oreille (10) à partir d'une valeur calculée de ladite différence de niveau sonore, lesdits facteurs pré-déterminés de correction et ledit coefficient de transfert.

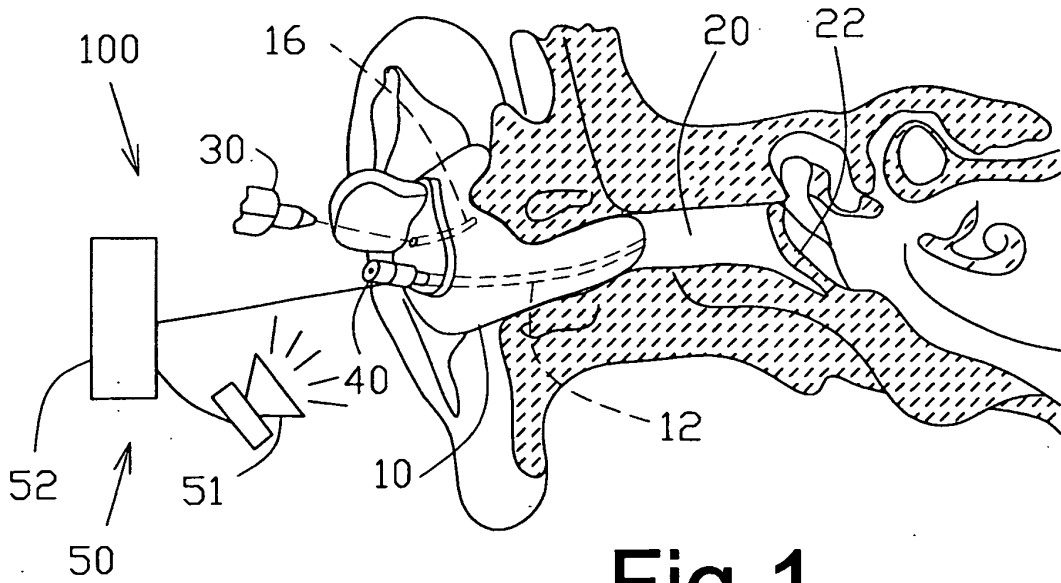


Fig. 1

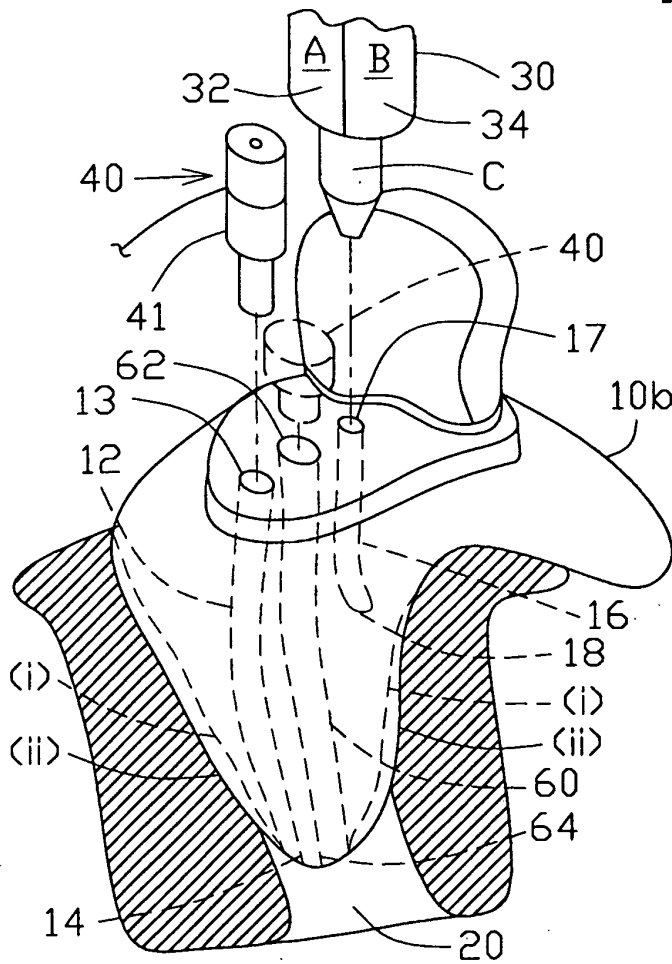


Fig. 2

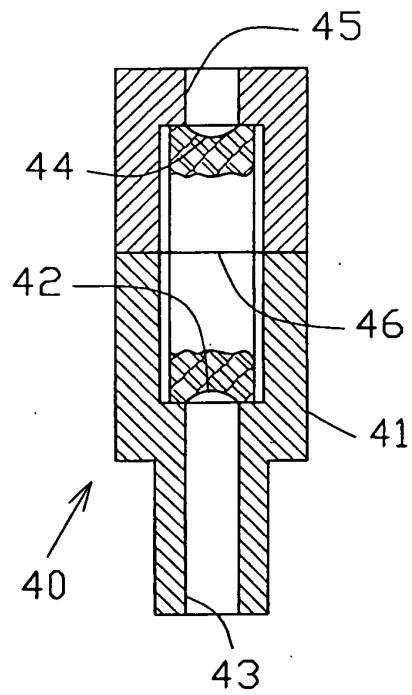


Fig. 3

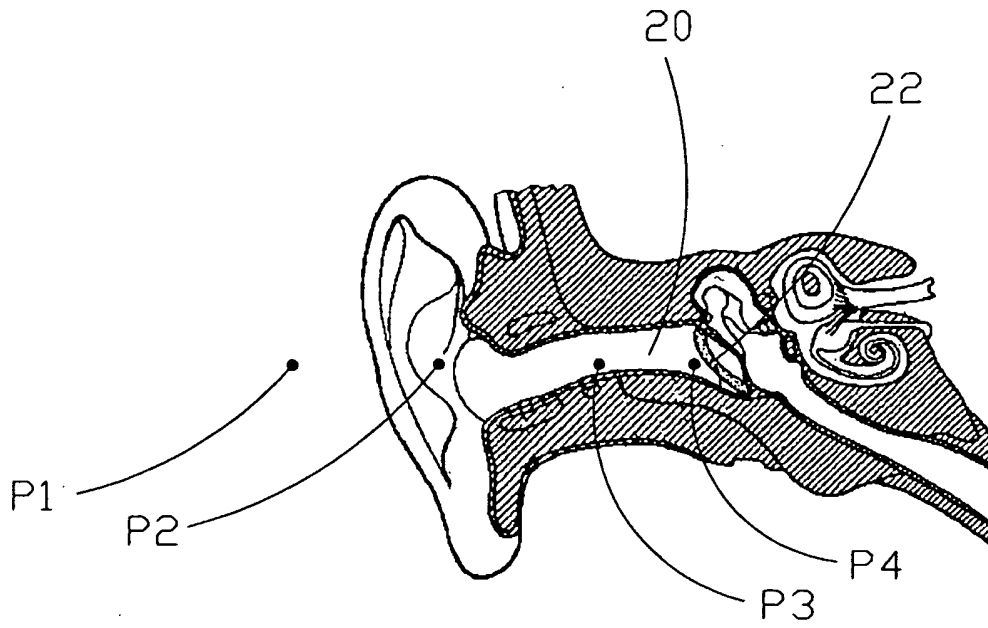


Fig.5a

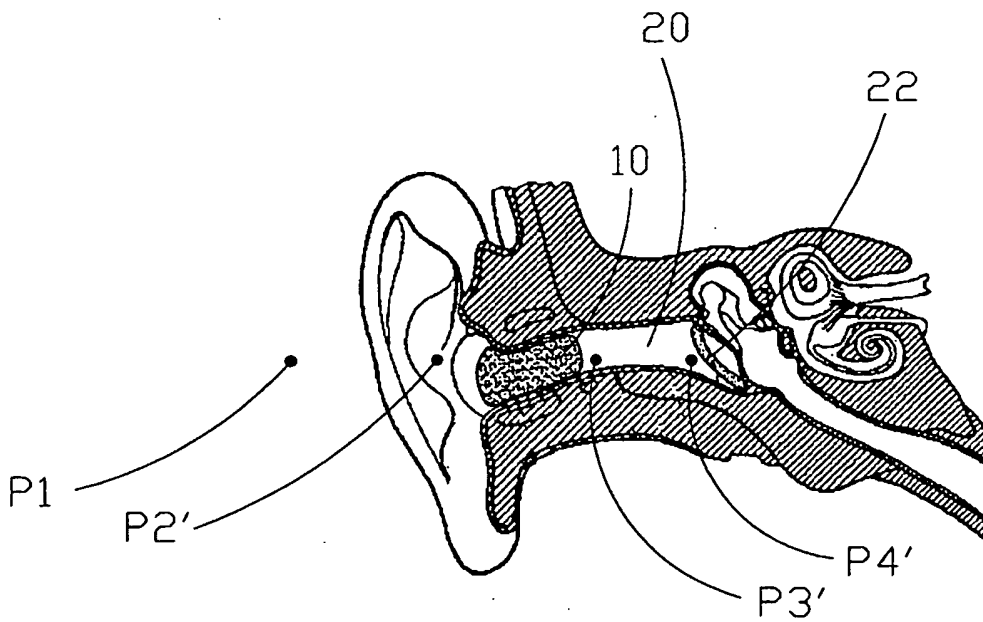


Fig.5b

专利名称(译)	用于原位确定由耳内装置提供的声学密封的方法和设备		
公开(公告)号	EP1356255B1	公开(公告)日	2006-06-28
申请号	EP2001271526	申请日	2001-11-16
[标]申请(专利权)人(译)	VOIX JEREMIE		
申请(专利权)人(译)	VOIX, 热雷米		
当前申请(专利权)人(译)	SONOMAX听力保健, INC		
[标]发明人	VOIX JEREMIE LAVILLE FREDERIC		
发明人	VOIX, JÉRÉMIE LAVILLE, FRÉDÉRIC		
IPC分类号	G01H1/00 A61B5/00 A61F11/08 H04R25/00 H04R29/00		
CPC分类号	A61F11/08 A61F2011/085 H04R25/30 H04R25/656 H04R2460/15		
优先权	09/739962 2000-12-20 US		
其他公开文献	EP1356255A2		
外部链接	Espacenet		

摘要(译)

本发明提供了一种装置 (100)，用于原位确定由插入个人耳道 (20) 中的听力保护/辅助性质的耳内装置 (10) 提供的声学密封。该装置 (10) 具有声孔 (12)，该声孔 (12) 具有环境开口 (13) 和分别在耳道 (20) 外部和内部的耳孔 (14)。装置 (100) 包括可拆卸地接合环境开口 (13) 的声音测量装置 (41)，探针麦克风 (42) 和参考麦克风 (44)，它们彼此隔离并连接到数据处理单元 (50)。具有控制盒 (52) 和扬声器 (51)。两个麦克风 (42,44) 测量内部的声压级 (P3#39; P2#39;) 所述耳道 (20) 和所述耳道 (20) 分别靠近所述装置 (10)，声压级 (P3#39;P2#39;) 对应于由扬声器 (51) 产生的已知噪声信号。数据处理单元 (50) 记录并处理声压级 (P3#39; P2#39;)，以提供由装置 (10) 提供的声压级差的相应计算值。与可扩展的耳内装置 (10b) 结合使用，装置 (100) 在装置 (10a) 的闭塞过程期间实时监测声学密封并确定何时停止该过程。本发明还涉及用于原位确定由耳内装置提供的声学密封的相应方法 (10)。

