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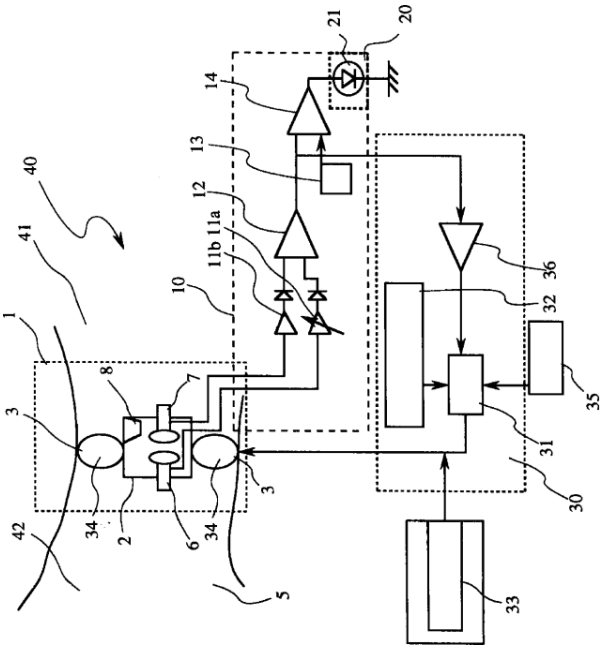
(54) [Title of Invention] LEAK TESTER OF EAR-MOUNTED EXTERNAL SOUND PROCESSING DEVICE

(57) [Abstract]
[Problem] To acquire a hearing aid-type external sound processing device having a function for objectively measuring and displaying a leakage amount of sound, and having a small size suitable for a shape of an ear of a wearer and having high soundproofing capability.
[Resolution Means] To compose of an external sound processing device provided with: an ear mounting unit provided with a housing part that houses an external microphone, an internal microphone, and a speaker, and a soundproofing part to which deformation means are connected; a signal comparison part that subtracts a signal from each microphone and compares it to a threshold set by an external setting device; a display part that displays an output signal of the signal comparison part; and deformation means for acquiring an optimum shape of the soundproofing part.



[Scope of Patent Claims]

[Claim 1] A leak tester of an ear-mounted external sound processing device, comprising: a mounting unit that houses an external microphone that opens to a free sound field and an internal microphone that opens to an inside of an ear canal when inserted into the ear canal; a signal comparison part that compares a signal input from the external microphone and a signal input from the internal microphone; and a display part that displays a comparison result of the signal comparison part.

[Claim 2] The leak tester of the ear-mounted external sound processing device according to claim 1, further comprising a speaker on a free sound field side in the mounting unit, wherein the external microphone and the internal microphone are disposed such that a phase difference between noises generated by the speaker is minimized.

[Claim 3] The leak tester of the ear-mounted external sound processing device according to claim 1 or 2, wherein the mounting unit is composed of a housing part that houses a microphone, an earplug inserted into the ear canal, and a soundproofing part that soundproofs the ear canal from the free sound field, and is further provided with deformation means that deform the soundproofing part.

[Claim 4] The leak tester of the ear-mounted external sound processing device according to claim 3, wherein the deformation means maintains a deformed state of the soundproofing part.

[Claim 5] The leak tester of the ear-mounted external sound processing device according to claim 3 or claim 4, wherein the soundproofing part is ring-shaped and fitted around the earplug.

[Claim 6] The leak tester of the ear-mounted external sound processing device according to claims 1 to 5, wherein a display part displays that a sound pressure difference between a signal input from the external microphone and a signal input from the internal microphone has exceeded a predetermined threshold when such occurs.

[Claim 7] The leak tester of the ear-mounted external sound processing device according to claim 6, further comprising an external setting device that sets the threshold.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to a device that displays a leakage amount of sound of a hearing aid-type external sound processing device and forms a soundproofing part that is suitable for a shape of an ear of a user.

[0002]

[Conventional Art] A hearing aid is a device that helps the function of hearing by collecting and amplifying external sound using a microphone and increasing and reproducing sound in the ear canal. Among hearing aids, an earplug-type hearing aid has a microphone and a speaker integrally incorporated in a unit mounted on an ear of a wearer. Conventional earplug-type hearing aids are made on the basis of an average ear shape without considering the characteristics of the ear shape of each wearer, and therefore, a space for sound leakage occurs between the hearing aid and the ear canal, and a sufficient soundproofing function cannot be obtained. Further, external sound is mixed into the ear canal, and therefore, there are problems in that a shift in frequency characteristics or a temporal shift occurs between the external sound and the processed sound and a sound recognition rate is lowered or feedback occurs.

[0003]

[Problem to be Solved by the Invention] Therefore, it is conceivable to enhance soundproofing by matching the shape of the hearing aid to the shape of the ear canal of each wearer, but determining an optimal shape for each wearer is difficult because conventionally, the leakage amount cannot be objectively measured.

[0004] An object of the present invention is to provide a leak tester of an external sound processing device that can objectively measure the leakage amount of external sound.

[0005]

[Means for Solving the Problem] The present invention is provided with the following configurations for solving the problem.

(1) Characterized by being provided with: a mounting unit that houses an external microphone that opens to a free sound field and an internal microphone that opens to an inside of an ear canal when inserted into the ear canal; a signal comparison part that compares a signal input from the external microphone and a signal input from the internal microphone; and a display part that displays a comparison result of the signal comparison part. With this invention, it is possible to objectively measure a leakage amount of external sound when the mounting unit is mounted by comparing the sound in the ear canal and the sound of the free sound field collected from the external microphone and the internal microphone and displaying a sound pressure difference.

[0006] (2) Characterized by further providing a speaker on a free sound field side in the mounting unit, wherein the external microphone and the internal microphone are disposed such that a phase difference between noises generated by the speaker is minimized. With this invention, it is possible to enhance a measuring accuracy of a pressure difference of sound collected from both microphones by disposing the microphones such that the phase difference between the signal of the external microphone and the noises of the internal microphone is minimized.

[0007] (3) Characterized by the mounting unit being composed of a housing part that houses a microphone, an earplug inserted into the ear canal, and a soundproofing part that soundproofs the ear canal from the free sound field, and being further provided with deformation means that deform the soundproofing part.

(4) Characterized by the deformation means maintaining the deformed state of the soundproofing part. With the inventions of (3) and (4), it is possible to acquire a shape of the ear canal unique to the user by changing the shape of the soundproofing part until a set volume is reached and maintaining the shape when the set volume is achieved. Furthermore, it is possible to control the shape of the soundproofing part to obtain a required soundproofing amount.

[0008] (5) Characterized by the soundproofing part being ring-shaped and fitted around the earplug. With this invention, it is possible to easily remove the soundproofing part because the soundproofing part is merely fitted in a ring shape around the earplug, and it is possible to use the removed soundproofing part in an actual hearing aid, and to use the device for a large number of people. Furthermore, it is possible to simply change a configuration of the soundproofing part by replacing the soundproofing material made of silicone resin.

[0009] (6) Characterized by the display part displaying that signals of the external microphone and the internal microphone have exceeded a threshold that is a predetermined sound pressure

difference when such occurs. 3

(7) Characterized by being provided with an external setting device for setting the threshold. With the inventions of (6) and (7), it is displayed that a predetermined sound pressure difference has been reached when such occurs. Setting the shape of the soundproofing part of the mounting unit is made easy by setting the predetermined sound pressure difference to a sound pressure difference required for the hearing aid. Thus, it is possible for the wearer to acquire a small ear-mounted external sound processing device having high soundproofing capability in an optimum shape for the ear of the wearer.

[0010]

[Embodiments of the Invention] A leak tester of an embodiment of the present invention will be described with reference to FIGS. 1 and 2. FIG. 1 is a block diagram, and FIG. 2 is an enlarged diagram of when a mounting unit is inserted into an ear canal. The leak tester is composed of an ear mounting unit 1, a signal comparison part 10, a display part 20, and soundproofing part deformation means 30. Furthermore, the ear mounting unit 1 is composed of a housing part 2, a soundproofing part 3, and an earplug 4.

[0011] The housing part 2 of the ear mounting unit 1 has an external sound generating speaker 8, an internal microphone 6, and an external microphone 7, and the soundproofing part 3 is ring-shaped and is fitted and closely attached around the earplug 4. In FIG. 1, from the housing part 2, the left side is an interior of an ear canal 5, that is, a soundproofing space 42, and the right side is an external space, that is, a free sound field 41. External sound 40 generated in the free sound field 41 is collected by the external microphone 7. Furthermore, the external sound 40 is soundproofed by the soundproofing part 3 and the earplug 4, but components of the external sound 40 which are not completely soundproofed are collected in the internal microphone 6. The external sound 40 collected from each microphone is converted into an electrical signal and inputted to the signal comparison part 10.

[0012] The soundproofing part 3 is configured by, for example, a rubber or resin ring-shaped tube, and is provided with a space part in the interior, and the internal space is connected to the soundproofing part deformation means 30. The soundproofing part deformation means 30 supplies a soundproofing material 34 of silicone resin to the internal space of the soundproofing part 3. Here, the soundproofing material 34 is composed of, for example, a two-component curing silicone rubber or a UV-curing elastic resin, and is a composition in which a soundproofing agent 32 and a curing agent 33 are mixed. The mixed soundproofing material 34 is injected into the internal space of the soundproofing part 3 by the soundproofing part deformation means 30 so as to fit the shape of the ear canal 5. Because the soundproofing material 34 (soundproofing agent 32 and curing agent 33) is made to start curing after a predetermined time (for example, about 5 minutes) has elapsed after mixing, the soundproofing agent 34 is injected from the soundproofing part deformation means 30 within the predetermined time until the sound pressure difference between the ear canal 5 and the free sound field 41 reaches a predetermined value, and after achieving the sound pressure difference, injection of the soundproofing material 34 is stopped and the shape is fixed after the predetermined time elapses.

[0013] The signal comparison part 10 is composed of an amplifier 11a having a gain adjustment function, an amplifier 11b, a subtractor 12, an external setting device 13, and a comparator 14. Note that the amplifier 11a hav 4 gain adjustment function is provided with a function that may change a gain such that a target soundproofing capability may be set from the outside. The signal comparison part 10 receives as input a signal from the internal microphone 6 directed toward the space 42 of the ear canal 5 and a signal from the external microphone 7 directed toward the free space 41. The signal from the external microphone 7 is amplified by the amplifier 11b and inputted to the subtractor 12. The signal from the internal microphone 6 is also input to the subtractor 12 after an amplification degree is adjusted by the amplifier 11a having a gain adjustment function. The subtractor 12 is a differential amplifier and amplifies a potential, that is, a sound pressure difference, obtained by subtracting an input signal of the internal microphone from an input signal of the external microphone. An output signal of the subtractor 12 is compared to a reference voltage of the external setting device 13 by the comparator 14. The comparator 14 is a comparator, and outputs an output voltage for turning on an LED 21 when an input voltage exceeds a comparison voltage, and the output voltage is 0 V when the input voltage is less than the comparison voltage. The output voltage of the comparator 14 is applied as-is to the LED 21 of the display part 20. Note that the external setting device 13 is an operation part wherein the user sets a threshold corresponding to a predetermined sound pressure difference as the reference voltage.

[0014] The display part 20 is composed of the LED 21, and the LED 21 is turned on based on the input signal from the signal comparison part 10. Note that, in the present embodiment, display is performed using the LED 21, but a method may be used to notify the user of the leakage amount of the external sound by a sound, vibration, or the like.

[0015] The soundproofing part deformation means 30 is means for injecting the soundproofing material 34 (soundproofing agent 32, curing agent 33) into the soundproofing part 3 until the leak volume in the soundproofing space 42 reaches a set value as described above, and has an amplifier 36 that amplifies the sound pressure difference, a chemical infusing pump 31 that injects the soundproofing material 34 (soundproofing agent 32, curing agent 33) into the soundproofing part 3, an automatic/manual switching device 35 that switches the chemical infusing pump 31 between automatic and manual, and the like.

[0016] The soundproofing part deformation means 30 receives as inputthe sound pressure difference that is the output signal of the subtractor 12 in the signal comparison part 10, and this signal is amplified by the amplifier 36 and is made to be a drive signal of the chemical infusing pump 31. The chemical infusing pump 31 operates by the drive signal input from the amplifier 36 and injects the soundproofing material 34 into the soundproofing part 3. A degree of sealing of the soundproofing part 3 may be increased or decreased by suitably adjusting the gain of the amplifier 36. Note that by setting the setting value of the external setting device 13 as a gain setting signal of the amplifier 36, it is also possible to inject the soundproofing material 34 into the soundproofing part 3 until reaching a sound pressure difference set from the outside. The amplifier 36 may be set to perform an on/off switching operation, or may be set to perform linear operation to adjust a driving force of the pump 31. Furthermore, the chemical infusing pump 31 may be switched from automatic to manual by an instruction from the automatic/manual switching device 35, and may be switched to manual to perform fine adjustment to match a preference of the wearer after automatic injection based on input from the subtractor 12. In this situation,

the chemical infusing pump 31 may operate not only on the injection side but also on the discharge side so as to lower an injection pressure.

[0017] Note that the soundproofing agent 32 and the curing agent 33 configuring the soundproofing material 34 are made to be mixed in advance or mixed at an injection port, and the soundproofing agent 32 and the curing agent 33 are adjusted so as to start curing after a predetermined time (for example, 5 minutes) has elapsed after mixing. Note that the chemical agent used in the deformation means 30 may be substituted by air, oil, gel, or the like.

[0018] Next, a state when the device of the present embodiment is mounted on an ear will be described using FIG. 2. As illustrated in the descriptive diagram of the ear mounting unit 1 of FIG. 2, the ear canal 5 is plugged by the earplug 4 and the soundproofing part 3 to soundproof the external sound 40. When collecting the external sound 40, the internal microphone 6 collects sound in the ear canal 5 and the external microphone 7 collects sound of the free sound field 41 and these are converted into an electrical signal. A phase of the signal is different depending on a disposition of the internal microphone 6 and the external microphone 7 in the housing part 2. Therefore, after determining in advance a disposition such that the phase difference is minimized, the housing part 2 is configured. Thus, it is possible to compare the same sound without being affected by the phase difference. The same external sound 40 collected by the internal microphone and the external microphone is converted into an electrical signal and subtracted by the subtractor 12 of the signal comparison part 10. The subtracted signal is compared to the threshold set in the external setting device 13 by the comparator 14. Then, the output signal of the signal comparison part 10 becomes an input signal to the LED 21 of the display part 20. For example, when configuring such that the threshold is set to a voltage corresponding to the predetermined sound pressure difference and the LED 21 of the display part 20 is lit up when the input signal is at or above the threshold, the user of the device of the present embodiment may know the leakage amount of the sound by looking at the lighting state of the LED 21. Furthermore, when the degree of sealing of the soundproofing part 3 is evaluated, the external sound 40 or a presentation sound generated from an external sound generating speaker 8 is collected by the internal microphone 6. At this time, the sound collected by the internal microphone 6 is a sound leaked into the ear canal 5. Therefore, the degree of sealing of the soundproofing part 3 may be evaluated by changing and generating the presentation sound and monitoring the sound pressure of the leaked sound using a presentation sound pressure monitor (not illustrated).

[0019] Furthermore, with the present invention, it is possible to acquire a shape of the soundproofing part 3 such that a target soundproofing state is obtained. First, the threshold of the external setting device 13 is set to correspond to a predetermined sound pressure difference, and the presentation sound is changed and generated. The presentation sound is converted into an electrical signal by the internal microphone 6 and the external microphone 7 to become a chemical injection pump drive signal of the soundproofing part deformation means 30 via the signal comparison part 10, and the soundproofing material 34 is injected into the soundproofing part 3. This operation is continued until the sound pressure difference reaches a predetermined value, and when the predetermined value is achieved, injection of the soundproofing material 34 into the soundproofing part 3 is stopped. Note that the soundproofing material 34 may be automatically injected until the sound pressure difference reaches the threshold of the external setting device 13 by adjusting the gain of the amplifier 36 using the setting value of the external setting device 13 of the signal comparison part 10. Thus, the shape of the soundproofing part 3 may be acquired.

[0020]

[Effect of the Invention] According to this invention, a device having a function of objectively measuring and displaying a leakage amount of an external sound can be provided. Furthermore, an external sound processing device such as a hearing aid having a function for displaying the leakage amount of sound, and having a small size suitable for a shape of an ear of a user and having a high soundproofing capability can be acquired.

[Brief Description of Drawings]

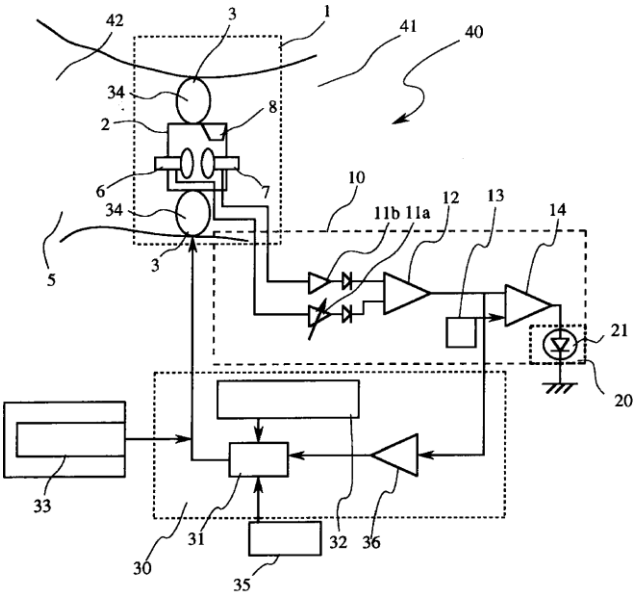
[FIG. 1] Configuration block diagram of the present embodiment

[FIG. 2] Enlarged descriptive diagram of the mounting unit of the present embodiment

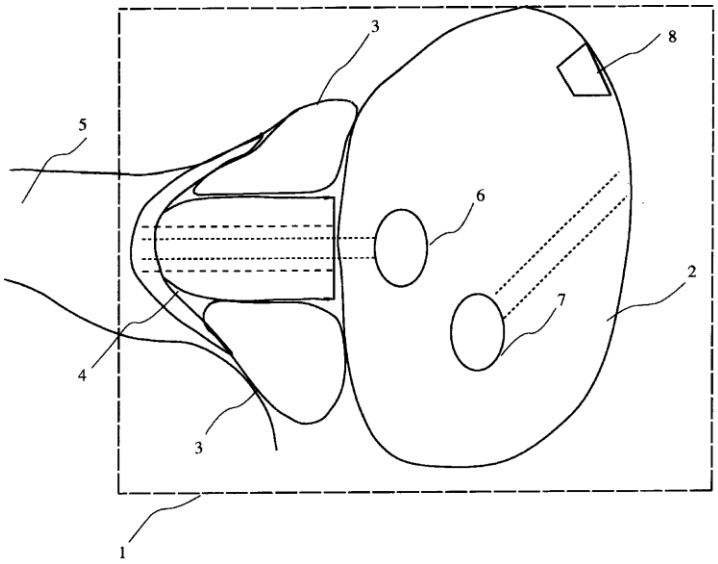
[Description of Reference Numerals]

1...Ear mounting unit, 2...Microphone housing part, 3...Soundproofing part, 4...Earplug, 5...Ear canal, 6...Internal microphone, 7...External microphone, 8...External sound generating speaker, 10...Signal comparison part, 11a...Amplifier with gain adjustment function, 11b...Amplifier, 12...Subtractor, 13...External setting device, 14...Comparator, 20...Display part, 21...LED、30...Soundproofing part deformation means, 31...Chemical infusing pump, 32...Soundproofing agent, 33...Curing agent, 34...Soundproofing material, 35...Automatic/manual switching device, 36...Amplifier, 40...External sound, 41...Free sound field, 42...Soundproofing space

[FIG. 1]



[FIG. 2]



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TRANSLATOR'S DECLARATION:

I, David Takata, hereby declare:

1. I am well versed in both the Japanese and English languages and have over 3 years of experience translating Japanese technical documents into English.

2. The following translation of the patent document JP 2002-204500 A to English is accurate and complete to the best of my knowledge.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and accurate.

Executed this 13th day of March, 2024, at St. Louis Park, MN

David Takata

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