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(54) Method for adjusting a behind-the-ear hearing device

(57) The invention relates to a method for adjusting a behind-the-ear hearing device (10) comprising an electroacoustic output transducer (18) connected to a tubing (26) extending into a user's ear canal, said method comprising: measuring the electrical impedance of the output transducer (18, 118); analyzing the measured electrical impedance of the output transducer (18, 118) in order to determine the length and/or diameter of the tubing (26); and adjusting the operation parameters of the hearing device according the determined length and/or diameter of the tubing (26) in order to optimize the acoustical performance of the hearing device..

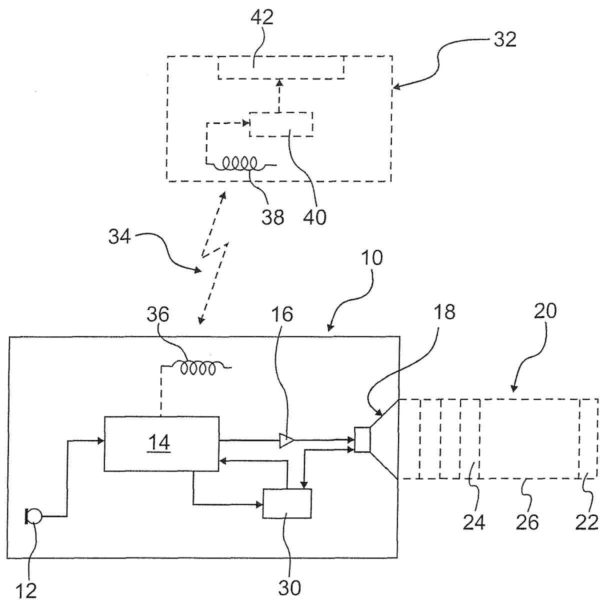


FIG. 1

EP 2 244 492 A2

Description

[0001] The invention relates to a method for adjusting a behind-the-ear hearing device and also to such an adjustable behind-the-ear hearing device.

[0002] Ear-worn hearing devices, such as hearing aids (which have an integrated microphone system) or wireless systems (which comprise a remote audio signal source, such as a remote microphone, and an ear-piece receiver) usually comprise an electro-acoustic output transducer (loudspeaker) which is located in or at least close to the ear canal. This applies particularly to in-the-ear (ITE) or completely in-the-canal (CIC) systems. However, also behind-the-ear (BTE) systems have a tubing extending from the loudspeaker (which in this case is located behind the ear) into the ear canal. A frequent problem of such ear-worn hearing devices is that the performance of the loudspeaker may be significantly deteriorated due to blocking with ear wax (cerumen) from the ear canal.

[0003] It is known to use special wax filters in order to protect the loudspeaker for preventing the loudspeaker from getting blocked by wax. However, none of these wax filters is capable of providing for a full protection from wax blocking.

[0004] If the loudspeaker performance is deteriorated by wax blocking, the user may not immediately notice this. This may be particularly true for systems used by children, since they usually have much more difficulty in noticing and communicating problems regarding the hearing device.

[0005] EP 1 276 349 B1 relates to a hearing aid with a self-test capability, wherein the hearing-aid automatically undergoes a self-test procedure for determining whether the hearing aid comprises a defect. The hearing aid is capable to indicate the presence and the type of defect to the user, for example, on the display of a programming device connected to the hearing aid for service purposes. During the self-test procedure it is checked whether each of the hearing aid microphones produces a signal. From the absence of such signal it is concluded that the input port to the respective microphone has been occluded by ear wax.

[0006] US 2004/0202333 A1 relates to a hearing device, wherein for testing of the loudspeaker a test sound is reproduced by the loudspeaker, the energy level of which test sound is measured by the hearing aid microphone and is compared to a predetermined threshold level in order to determine whether the loudspeaker and the microphone, respectively, work properly.

[0007] It is an object of the invention to provide for a method for adjusting a behind-the-ear hearing device comprising an electroacoustic output transducer connected to a tubing extending into a user's ear canal. In addition such a hearing device should be provided.

[0008] These objects are achieved by a method as defined in claim 1 and a hearing device as claimed in claim 4, respectively. The invention is beneficial in that, by measuring and analyzing the electrical impedance of the output transducer, the status of the output transducer and/or of an acoustical system cooperating with the output transducer, such as a tubing of a BTE hearing device, may be evaluated in a simple and efficient manner. Further, thereby the length and/or diameter of the tubing of a BTE hearing device can be automatically determined in a simple manner, and the thus determined length and/or diameter of the tubing can be used to optimize the operation parameters of the hearing device according the determined length and/or diameter of the tubing in order to optimize the acoustical performance of the hearing device.

[0009] Preferred embodiments of the invention are defined in the dependent claims.

[0010] In the following, examples of the invention will be illustrated by reference to the attached drawings, wherein:

Fig. 1 is a block diagram of a first embodiment of a hearing device according to the invention;

Fig. 2 is a block diagram of a second embodiment of a hearing device according to the invention;

Fig. 3 is an example of how the electrical impedance of the output transducer of a hearing device according to the invention may be measured;

Fig. 4 shows schematically the set-up for the test measurements of Figs. 5 and 6;

Fig. 5 is a plot of the voltage measured at the resistor of Fig. 4 as a function of frequency obtained in test measurements with the set-up of Fig. 4 for different obstruction levels of the loudspeaker; and

Fig. 6 is a plot of the acoustic output level curve of the loudspeaker measured with the set-up of Fig. 4 in a 1.4 cc coupler for different loudspeaker obstruction levels.

[0011] Fig. 1 is a block diagram of a first example of a hearing device for which the invention can be used, wherein the hearing device is a hearing aid 10 which comprises a microphone arrangement 12 (which may consist of two spaced-apart microphones for enabling acoustic beam forming capability), a central processing unit 14 for processing the audio signals produced by the microphone arrangement 12, a power amplifier 16 for amplifying the processed audio signals from the central processing unit 14, and a loudspeaker 18 for stimulating the user's hearing with the processed amplified audio signals from the microphone arrangement 12.

[0012] The loudspeaker 18 cooperates with an acoustical system 20 located downstream of the loudspeaker 18, which comprises, for example, a wax filter 22, acoustical filters 24 and some kind of tubing 26. Such tubing 26 has a significant length since the hearing aid 10 is of the BTE type, in which case the loudspeaker, together with the hearing aid 10, is be located behind the ear, while the tubing 26 extends into the ear canal.

[0013] Fig. 2 is a block diagram of an alternative embodiment of a hearing device, wherein the hearing device is a wireless ear-piece 110 which represents the receiver unit of a wireless audio system and which receives audio signals from a remote transmission unit 143 via a wireless audio link 145.

[0014] The transmission unit comprises a microphone arrangement 144 (which may consist of two or more spaced-apart microphones for enabling acoustic beam forming capability), an audio signal processing unit 146 for processing the audio signals from the microphone arrangement 144, a transmitter 148 and an antenna 150. Usually the audio link 145 will be an FM link. The receiver unit 110 comprises an antenna 152, a receiver 154 for recovering the audio signals from the signal received at the antenna 152, a central processing unit 114 for processing the received audio signals, a power amplifier 116 for amplifying the processed audio signals, and a loudspeaker 118. As in the example of Fig. 1, the loudspeaker 118 cooperates with an acoustical system located downstream of the loudspeaker 118, for example, a wax filter 22. As in the case of Fig. 1, the loudspeaker 118 will be located in or at the ear canal. The loudspeaker 118 may be integrated into the receiver unit 110, as shown in Fig. 2, or it may be mechanically and electrically connected thereto.

[0015] Both in the embodiment of Fig. 1 and the embodiment of Fig. 2 an analyzer unit 30 is provided which may be activated by the central processing unit 14, 114 and which serves to measure the electrical impedance as a function of frequency of the loudspeaker 18, 118 and to provide the corresponding measurement result to the central processing unit 14, 114 in order to enable the central processing 14, 114 to produce a status signal representative of the status of the loudspeaker 18, 118 and/or the acoustical system 20, 120 cooperating with the loudspeaker 18, 118. The measured electrical impedance as a function of frequency of the loudspeaker 18, 118 provided by the analyzer unit 30 is evaluated in the central processing unit 14, 114 in order to generate the respective status signal.

[0016] According to one embodiment, an acoustic alarm signal may be produced by the central processing unit 14, 114 with the help of the loudspeaker 18, 118 in order to provide the user with an acoustic alarm. Such acoustic alarm may comprise an alarm tone and/or a voice message.

[0017] According to an alternative embodiment, the status signal may be transmitted from the central processing unit 14, 114 to a remote device 32 via a wireless link 34 which possibly is an inductive link utilizing an inductive antenna 38 included in the remote device 32 and an inductive antenna 36 connected to the central processing unit 14, 114. The remote device 32 further includes a signal processing unit 40 for processing the signals received by the antenna 38 and a display 40 for displaying the alarm signal received via the inductive link 34, which in this embodiment will be an optical alarm signal rather than an acoustic alarm signal.

[0018] The remote device 32 could be used by the user of the hearing device 10, 110, or, in particular in the case of Fig. 2, it could be used by the person using the transmission unit 143, for example, the teacher in a classroom of pupils using the receiver unit 110. In this case, the remote device 32 could be functionally integrated within the transmission unit 143.

[0019] The inductive link 34 may be bidirectional link. In this case, transmission of the status signal from the hearing device 10, 110 may be initiated by receipt of a polling command at the hearing device 10, 110 transmitted from the remote device 32. Thereby, for example, the teacher in the classroom may check whether the loudspeaker 118 used by each pupil works properly. In addition, the bidirectional link 34 may serve to monitor also other components of the system, such as battery status, status of the audio link 145, etc.

[0020] According to an alternative embodiment, rather than being initiated by receipt of a polling signal, measurement of the electrical impedance of the loudspeaker 18, 118 and the subsequent analysis of the measured electrical impedance will be repeated in regular intervals.

[0021] Preferably, the measured electrical impedance as a function of frequency will be analyzed by comparing the measured electrical impedance to reference data stored in the hearing device 10, 110. Such reference data may be generated in the manufacturing process of the hearing device 10, 110. Preferably the resonance frequency and/or the quality factor of the loudspeaker 18, 118 are analyzed by measuring the electrical impedance as a function of frequency. Preferably the status signal will be provided as an alarm signal if the difference between the actually measured electrical impedance data and the stored reference data exceeds a predetermined threshold, wherein the magnitude of the difference between the measured data and the stored reference data may be taken as a measure of the degree of disturbance of the loudspeaker 18, 118, for example of the degree of the mechanical obstruction of the loudspeaker 18, 118 by ear wax.

[0022] The evaluation of the status of loudspeaker 18, 118 and/or the acoustical system 20, 120 cooperating with the loudspeaker 18, 118 may include an evaluation of whether the loudspeaker 18, 118 is working according to specification.

[0023] Preferably such evaluation will include a check of whether the loudspeaker is still working properly or whether it is out of order.

[0024] A BTE hearing aid includes a tubing 26 extending from the loudspeaker 18 into the user's ear canal. The length and/or the diameter of such tubing 26 can be selected individually by the fitter. If the length/diameter of the tubing 26 is known, the acoustical performance of the BTE hearing aid can be optimized. Due to the acoustical coupling of the tubing 26 to the loudspeaker 18 it is possible to estimate from the measured electrical impedance of the loudspeaker 18 the length/diameter of the tubing 26 used for each BTE hearing aid 10. With this knowledge, it is possible to optimize the acoustical performance of the hearing device automatically by optimizing the setting the operation parameters of the hearing aid according to the determined length/diameter of the tubing 26, eliminating therefore the need for the fitter to enter the length/diameter data into the computer (not shown) for a fine tuning procedure, thus saving time and avoiding possible errors. To this end, the central processing unit 14 of the hearing aid 10 may provide for a signal representative of the determined length/diameter of the tubing 26, which signal is supplied to the fitting computer.

[0025] In addition to evaluating the length/diameter of the tubing 26 from the measured electrical impedance of the loudspeaker 18 it is also possible to evaluate whether the end of the tubing 26 suffers from a mechanical obstruction, for example by ear wax.

[0026] An example of how the measurement of the electrical impedance of the loudspeaker 18, 118 can be done by the analyzer unit 30 as given in Fig. 3. According to Fig. 3, the voltage on a serial resistor 60 located between the ground and the loudspeaker 18 is measured by voltmeter 62. For such an arrangement the voltage curve (i.e. the voltage as a function of frequency) on the resistor 60 becomes the image of the impedance curve of the loudspeaker 18. The electric impedance - and hence the voltage measured by the voltmeter 62 - will be different depending on whether the loudspeaker is open or blocked. Even if the loudspeaker 18 is only partly blocked (resulting in a relatively small acoustic attenuation), a change in voltage will be observed.

[0027] Test measurements have been performed with the set-up of Fig. 4, wherein the resistor 60 had a resistance of 22 Ohms, the loudspeaker 18 had a resistance of 260 Ohms and the acoustic output level measurements were performed in a 1.4 cc coupler with perfect sealing.

[0028] Fig. 5 shows the voltage measured at the resistor 60 as a function of frequency for different levels of obstruction, namely for totally closed filter (close acoustic output, labeled "close"), different intermediate levels of obstruction (partly closed acoustic output, labeled "Half 1" to "Half 4", measurement without filter (open acoustic output, labeled "Nofilter") and measurement with filter (open acoustic output, labeled "Wsfilter"). The loudspeaker 18 was fluid damped.

[0029] According to Fig. 5, different voltage levels are obtained for different obstruction levels of the loudspeaker 18, 118. The voltage difference is obviously the largest at the resonance frequency of the loudspeaker 18, 118 (in the present case about 3,200 Hz). In the case of small obstruction the quality factor decreases due to the parasitic acoustical resistance. For a totally blocked filter, the air volume between the loudspeaker 18 and the "stopper" creates a compliance (acoustic capacitor) in parallel with the standard compliance of the loudspeaker diaphragm. If the acoustic resistor is replaced by a compliance, the quality factor increases, but the resonance frequency also increase to about 4,000 Hz.

[0030] Fig. 6 shows the acoustic output level of the loudspeaker 18 measured in a 1.4 cc coupler as a function of frequency for the various obstruction levels of Fig. 5.

[0031] According to one embodiment, the resonance frequency of the loudspeaker in free space is stored in the hearing device 10, 110 during the manufacturing process. Later, when the hearing device 10, 110 is operated, the analyzer unit 30 generates the stored resonance frequency and measures the voltage on the resistor 60 at this frequency. If the measurement shows too much of a difference, an alarm signal is created, as already explained above, for example, telling the user that the loudspeaker is blocked and should be cleaned.

Claims

1. A method for adjusting a behind-the-ear hearings device (10) comprising an electroacoustic output transducer (18) connected to a tubing (26) extending into a user's ear canal, said method comprising:

(a) measuring the electrical impedance of the output transducer (18, 118);
(b) analyzing the measured electrical impedance of the output transducer (18, 118) in order to determine the length and/or diameter of the tubing (26); and
(c) adjusting the operation parameters of the hearing device according the determined length and/or diameter of the tubing (26) in order to optimize the acoustical performance of the hearing device.

2. The method of claim 1, wherein in step (b) the measured electrical impedance is analyzed by comparing the measured electrical impedance to reference data stored in the hearing device (10) and wherein in step (b) the resonance frequency and/or the quality factor of the output transducer (18) are analyzed.

3. The method of one of claims 1 and 1, wherein a signal representative of the length and/or diameter of the tubing (26) is provided by the hearing device, which is used by an external fitting device communicating with the hearing device for adjusting the operation parameters of the hearing device.

4. A behind-the-ear hearing device, comprising: an electroacoustic output transducer (18) connected to a tubing (26) adapted for extending into a user's ear canal, means (60, 62) for measuring the electrical impedance of the output transducer (18), means (14) for analyzing the measured electrical impedance of the output transducer (18) in order to determine the length and/or diameter of the tubing (26); and means (14) for providing a signal representative of the determined length and/or diameter of the tubing (26) for adjusting the operation parameters of the hearing device according to the determined length and/or diameter of the tubing (26) in order to optimize the acoustical performance of the hearing device.

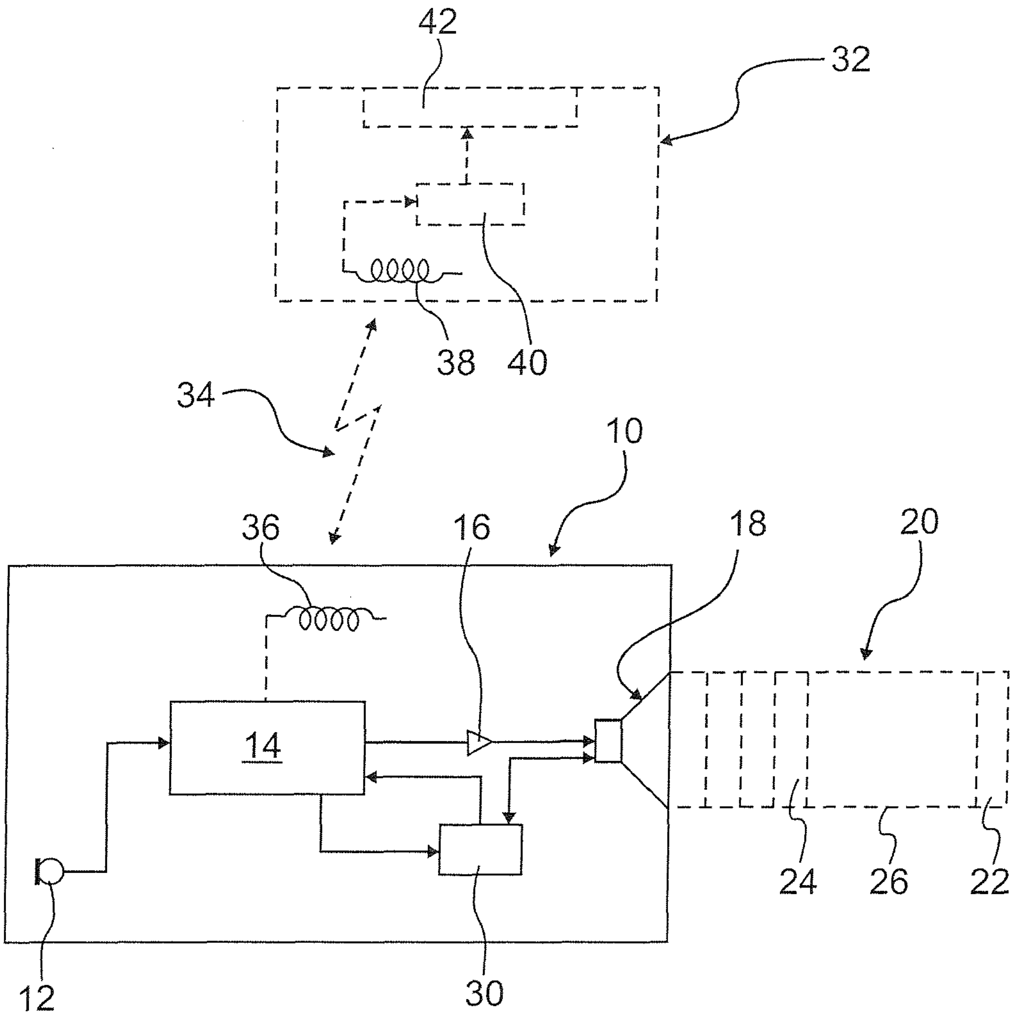
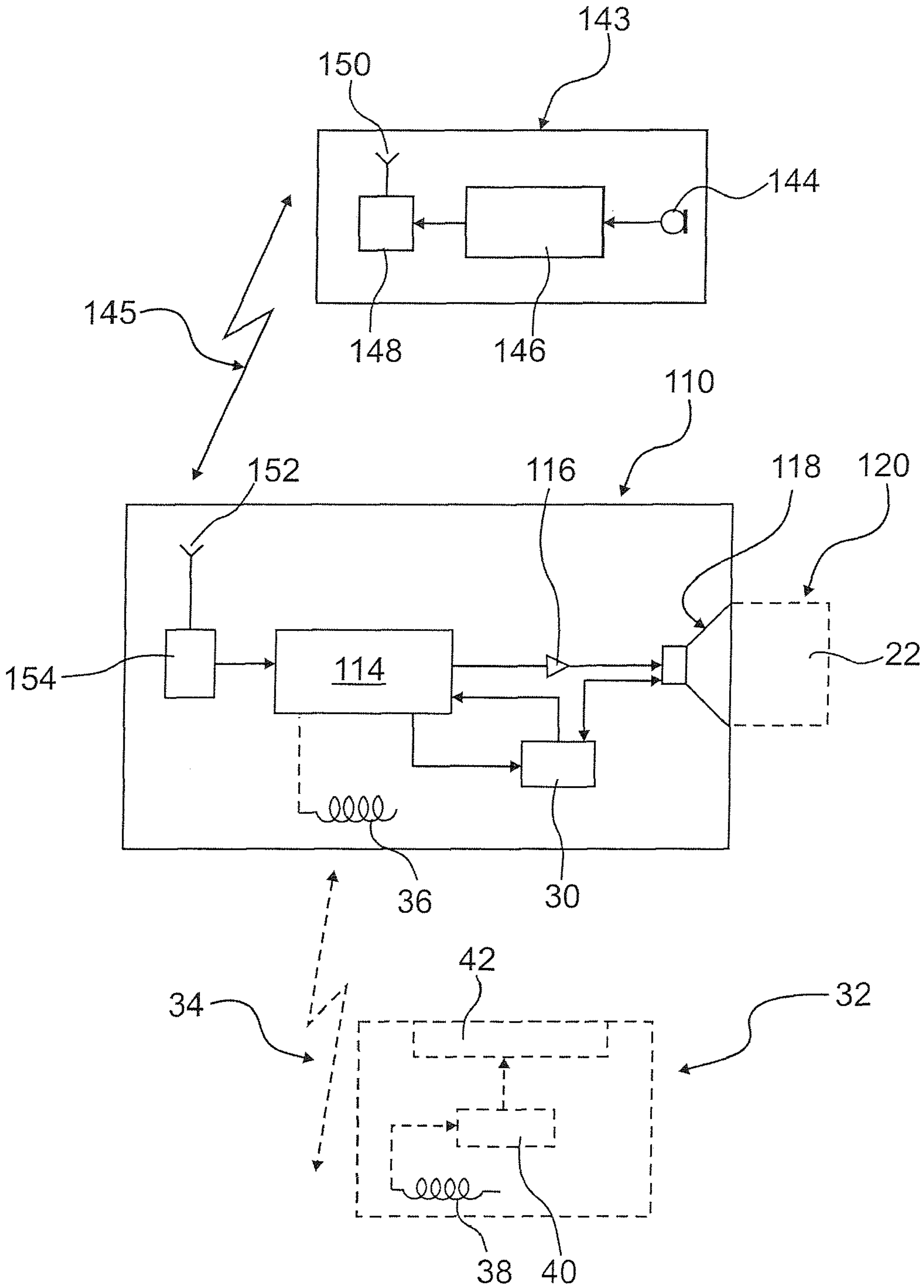


FIG. 1


143
150
144
145
148
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110
152
116
118
120
154
114
22
36
30
42
34
32
38
40

FIG. 2

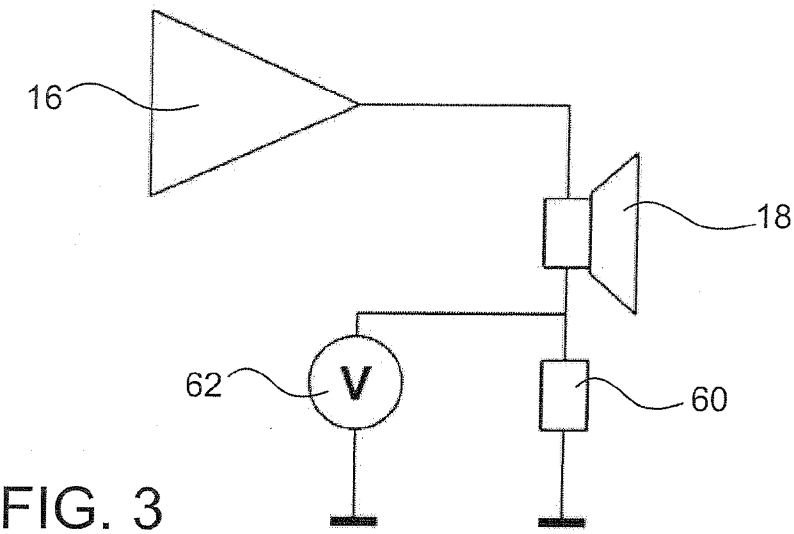

16
18
62
V
60

FIG. 3

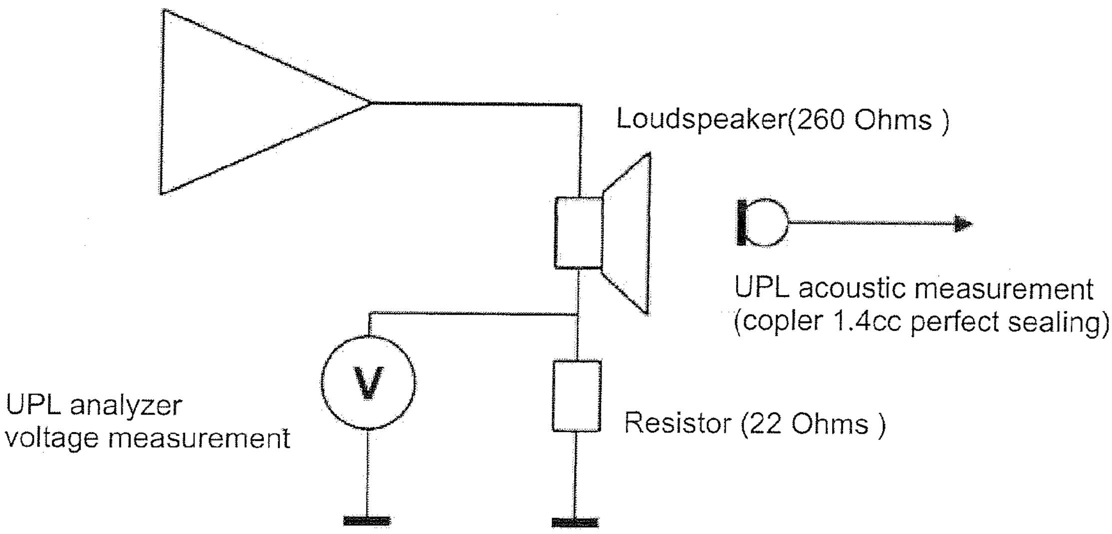

Loudspeaker(260 Ohms)
UPL acoustic measurement
(copler 1.4cc perfect sealing)
V
UPL analyzer
voltage measurement
Resistor (22 Ohms)

FIG. 4

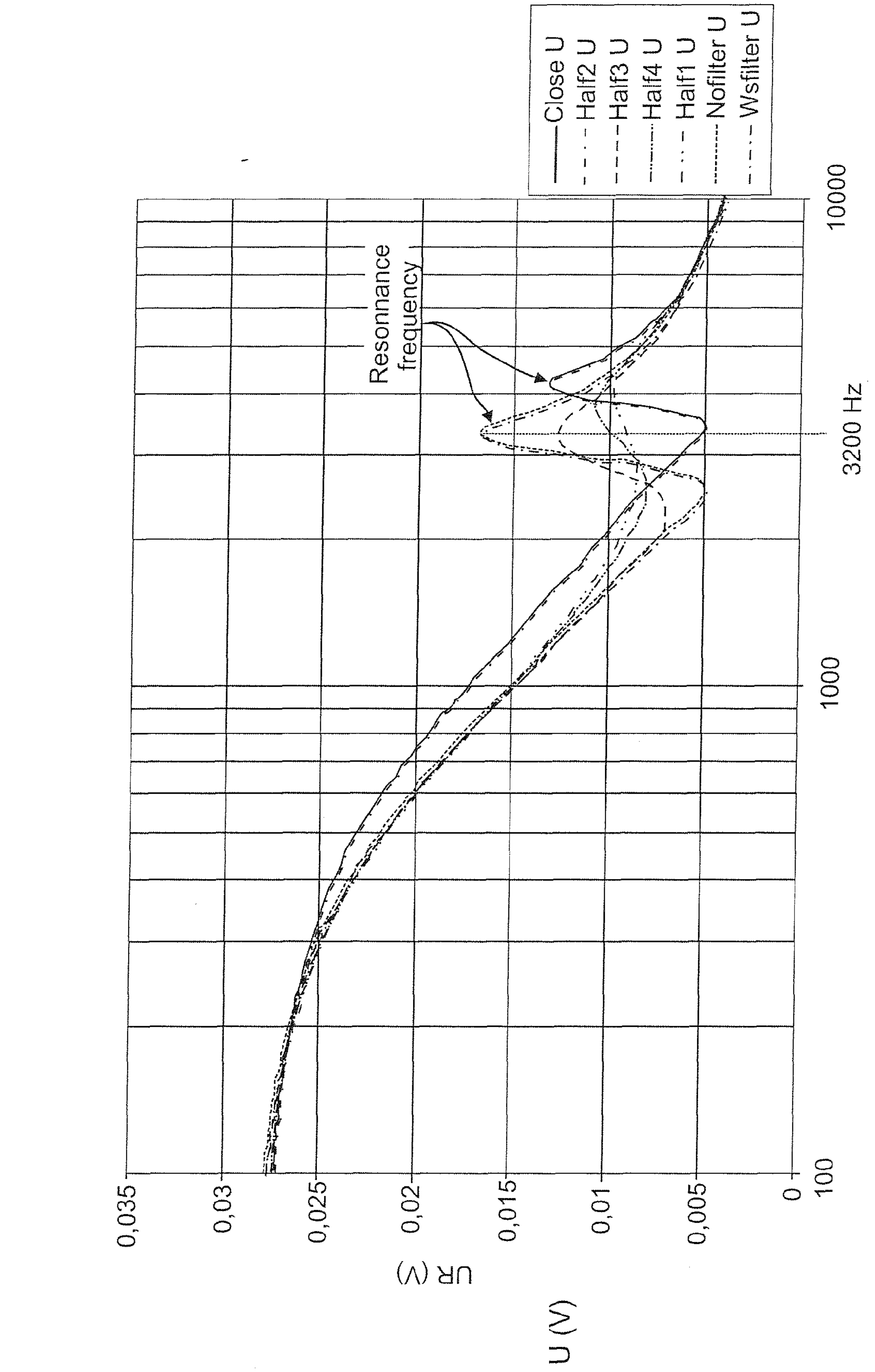
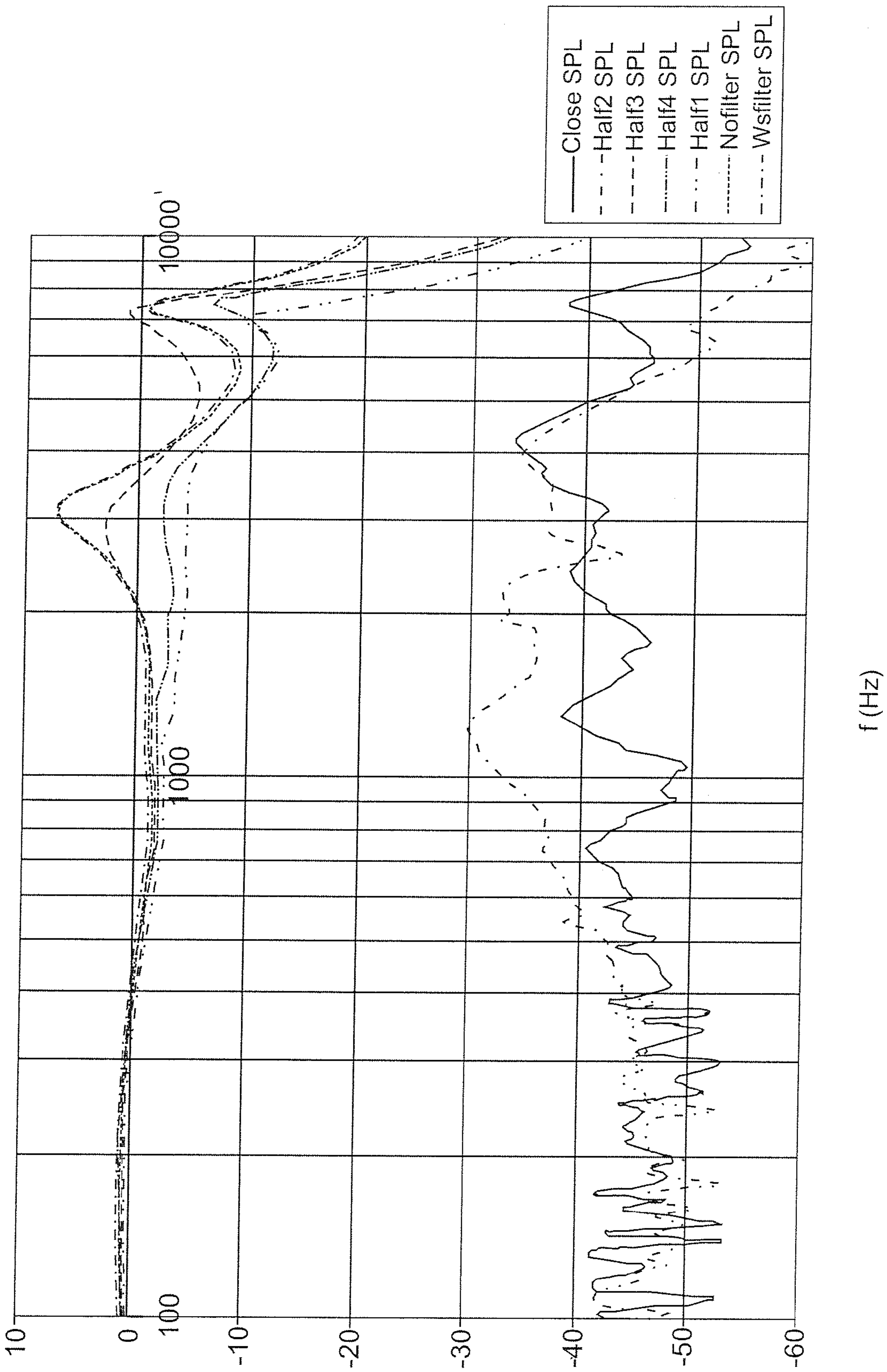

Close U
Half2 U
Half3 U
Half4 U
Half1 U
Nofilter U
Wsfilter U
Resonnance frequency
3200 Hz
U (V)
UR (V)
0,035
0,03
0,025
0,02
0,015
0,01
0,005
0
100
1000
10000
f (Hz)

FIG. 5



Close SPL
Half2 SPL
Half3 SPL
Half4 SPL
Half1 SPL
Nofilter SPL
Wsfilter SPL
10
0
-10
-20
-30
-40
-50
-60
100
1000
10000
f (Hz)

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1276349 B1 **[0005]**
- US 20040202333 A1 **[0006]**