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(54) **Method of controlling a hearing device and hearing device**

(57) The present invention relates to a method of controlling a hearing device (10) being placed at or in an ear canal (EC) of a user and defining at least partly sealed portion (B) of the ear canal (EC). The method comprises the steps of emitting predetermined sound signals (So) with different frequencies at a predetermined level, detecting the occurrence of high sound pressure levels of said predetermined sound signals indicating a resonance in said sealed portion, and providing, on the basis of said detected high sound pressure levels of the predetermined sound signals, an adjustment of the operation of said hearing device (10) to reduce the influence of said resonance. The method also comprises the steps of sensing sound signals in said sealed portion (B) of said ear canal (EC), subjecting said sensed sound signals to a predetermined processing, detecting on the basis of the processed sound signals, over a predetermined period of time, a peak value indicating a resonance, and providing on the basis of said detected peak value indicating a resonance, an adjustment of the operation of said hearing device (10) to reduce influence of said resonance.

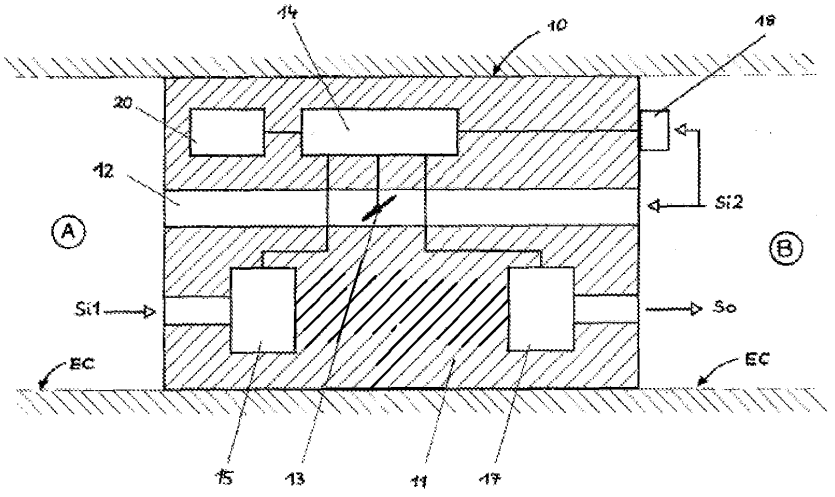

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention refers to a method of controlling a hearing device, and in particular to a method of detecting a resonance in conjunction with the hearing device, and a hearing device wherein a resonance is detected.

BACKGROUND OF THE INVENTION

[0002] A hearing device having a venting channel or a venting canal (vent) is known from reference WO 2005/107320 A1. The hearing device is preferably a CIC (completely-in-canal) hearing aid to facilitate concealment, and this hearing device does not occupy virtually all air space within the ear canal to optimize comfort. The hearing device comprises a relatively small venting channel to enable a high amplification without feedback, but with a higher possibility of providing an undesired occlusion effect. The hearing device comprises two microphones for detecting the acoustic conditions on a front side of the hearing device exposed to the outside, and on the backside of the hearing device adjacent to a speaker for outputting to the user's eardrum amplified sound signals. The second microphone is therefore exposed to the sealed (closed) segment of the ear canal enclosed by the hearing device and specifically senses the acoustic conditions in the sealed portion of the ear canal. A first signal evaluation process provides an output signal according to an input of the sound surrounding the user, and a second signal evaluation process is based on a signal from the second microphone.

[0003] Reference EP 0 124 798 A1 discloses a hearing aid with resonant peak control, wherein the hearing aid further comprises receiving means for receiving sound signals as well as an amplifying means for amplifying the sound signals picked-up by the receiving means. A resonant peak control means is arranged between the receiving means and the amplifying means and provides the resonant peak control of the hearing aid to allow the frequency response to be tailored to reduce feedback without substantial reduction in high frequency amplification by the amplifying means. The resonant peak control means is provided in the form of an RC circuit which may have a variable resistor and a capacitor.

[0004] Moreover, reference US 2005/0105741 A1 discloses a hearing aid and a method of adjusting the hearing aid, wherein the hearing aid is arranged in the ear canal of the user wearing the hearing aid. The hearing aid is provided with a sensor for detecting the acoustic conditions in the ear canal, and specifically the acoustic impedance. The acoustic impedance is estimated by measuring the input impedance of the earpiece on the hearing aid. A hearing aid module is used usually containing the adaptation software. More specifically, a mechanical resonance is determined in the signal processing device from the detected input impedance, and a shift of the mechanical resonance can be used for automatic correction of the normal frequency curve of the hearing aid.

[0005] Reference WO 2005/104610 A1 discloses a resonance frequency determining method, a resonance frequency selecting method as well as a resonance frequency determining apparatus, wherein in a portion of the ear canal sealed (closed) by a hearing aid, a microphone is arranged for sensing the acoustical conditions of this sealed portion. An amplitude and frequency characteristic is obtained and the measured signals of the microphone are evaluated for providing a setting of the hearing aid.

[0006] Reference WO 00/49837 discloses a resonant response matching circuit for a hearing aid, wherein the resonance curve of a sealed portion of the ear canal of the user is determined. The detected resonance curve is used for providing an adaptation of the hearing aid to the specific conditions of the user.

[0007] In general, as mentioned above in conjunction with the references, hearing aids or hearing devices are provided with a venting channel which is implemented as an acoustic tube connecting the portion of the ear canal of the user sealed (closed) by the hearing aid with the outside to obtain a balance of pressure. In some cases, the venting channel of hearing aid includes a valve member arranged in the venting channel and being adapted for opening or closing the venting channel in a predetermined manner, usually controlled by a control means.

[0008] Specifically in CIC/ITC/ITE hearing aids a blocking of the ear canal is possible, causing a build-up of low frequency sound pressure, resulting in the well-known occlusion effect. This phenomenon can, to a large extent, be suppressed by including the above-mentioned venting channel in the hearing aid. The inertia of the acoustic mass of such a tube-shaped venting channel can be overcome easily at low frequencies. An increase in the diameter (effective diameter, cross-sectional area) of the venting channel will reduce the possibility of occurrence of an occlusion effect, but higher frequencies of sound will be able to overcome the inertia of the acoustic mass of the venting channel. A large venting channel will allow a broader spectrum of sound to escape through it. In general, the venting channel of hearing aids of today have to compromise gain with occlusion the best way possible. This means that the cross-sectional area or effective diameter of the venting channel has the following impacts:

A large effective diameter will result in less occlusion, but reduce the amount of possible gain before feedback is introduced.

A small effective diameter will increase the amount of gain possible in the hearing aid, but occlusion becomes more and more pronounced.

[0009] Moreover, the venting channel used in hearing aids may also create acoustic resonances at higher frequencies where the length of the venting channel (which may usually be approximated as a tube) becomes of the same order of magnitude as the wave length. Such length resonances represent a problem which becomes more serious, the higher frequency the hearing aid amplifies. The influence of the resonance can either be unnaturally high sound pressure levels or unnaturally low sound pressure levels, both affecting comfort of the user. These effects occur in a limited frequency region - namely at the resonance frequency. If the resonance attenuates the sound no major problem exists, but when the resonance amplifies the sound this may be very uncomfortable to the user of the hearing aid.

[0010] Hence, in view of the resonance frequencies the problem in today's hearing aids is addressed by means of using short venting channels only, but it can be very difficult to keep the necessary dimensions of the venting channel within these restrictions.

SUMMARY OF THE INVENTION

[0011] Accordingly, it is an object of the present invention, to provide a method of controlling a hearing device, as well as a corresponding hearing device, wherein a reliable detection and control of the resonance frequency caused in the venting channel thereof is ensured.

[0012] This object is accomplished by a control method for a hearing device and by a corresponding hearing device as put forward in the appended claims.

[0013] According to a first aspect of the present invention, the method of controlling a hearing device being placed at or in an ear canal of a user and defining an at least partly sealed portion of the ear canal comprises the steps of: providing a vent channel in said hearing aid of predetermined proper-ties, emitting predetermined sound signals with different frequencies at a predetermined level, detecting the occurrence of high sound pressure levels of the predetermined sound signals indicating a resonance in the sealed portion, and providing, on the basis of the detected high sound pressure levels of the predetermined sound signals, an adjustment of the operation of the hearing device to reduce the influence of the resonance.

[0014] Hence, the operation of the hearing device and specifically the automatic performance of the testing process and the calibration or setting process to avoid the occurrence of resonances in conjunction with the sealed portion of the user's ear canal, make the use of the hearing device according to the present invention easy and comfortable for the user as the setting may be frequently repeated with the actual conditions of the hearing device in the user's ear canal without requiring any manual operation.

[0015] The predetermined sound signals may be sound signals having a predetermined frequency. Moreover, the step of providing an adjustment of the operation of the hearing device may include the step of providing an adjustment of the amplification characteristic of the hearing device to cope with the user's demand to avoid resonances when using the hearing device.

[0016] The method may further include the steps of performing a start-up sequence for initializing the hearing device, and entering into a test mode for detecting the high sound pressure levels indicating a resonance in the sealed portion. The step of emitting predetermined sound signals may be carried out in the test mode.

[0017] Alternatively according to a second aspect, the present invention refers to a method of controlling a hearing device being placed at or in the ear canal of a user and defining an at least partly sealed portion of the ear canal. The method comprises the steps of: providing a vent with predetermined properties, sensing sound signals in the sealed portion of the ear canal, subjecting the sensed sound signals to a predetermined processing, detecting on the basis of the processed sound signals, over a predetermined period of time, a peak value indicating a resonance, and providing on the basis of the detected peak value indicating a resonance, an adjustment of the operation of the hearing device to reduce influence of the resonance.

[0018] Regarding the second aspect, the operation of the hearing device and specifically the automatic performance of the testing process and the calibration or setting process to avoid the occurrence of resonances in conjunction with the sealed portion of the user's ear canal, make the use of the hearing device according to the present invention easy and comfortable for the user as the setting may be frequently repeated with the actual conditions of the hearing device in the user's ear canal without requiring any manual operation. The provision of the vent in the ITE part of the hearing aid device is required to avoid occlusion as explained above. The vent will be provided with a predetermined length and cross section and possibly with a filter or other sound regulating means.

[0019] The step of subjecting the sensed sound signals to a predetermined processing may include the step of providing a time-averaged sound pressure level of the sound signals of the sealed portion over a predetermined period of time. The step of providing an adjustment of the operation of the hearing device may include the adjustment of the amplification characteristic of the hearing device. The method may further include the steps of entering into a test mode of operating the hearing device, and performing the sensing step in the test mode.

[0020] According to a third aspect of the present invention, it is referred to a hearing device arranged at or in a user's ear canal and at least partly blocking the ear canal and defining a sealed portion of the ear canal. The hearing device comprises: a vent with predetermined properties, a sound generator adapted for generating predetermined sound signals with different frequencies at a predetermined level, and an output means for outputting the predetermined sound signals, a sensor adapt-

ed for detecting the occurrence of high sound pressure levels of the predetermined sound signals, and an adjustment means adapted for providing, on the basis of the detected high sound pressure levels of the predetermined sound signals, an adjustment of the operation of the hearing device to reduce influence of the resonance.

[0021] According to a fourth aspect of the present invention it is referred to a hearing device arranged at or in a user's ear canal and at least partly blocking said ear canal and defining a sealed portion of the ear canal and a vent with predetermined properties,. The hearing device comprises: a sensor adapted for sensing sound signals in the sealed portion of the ear canal, an evaluating mean adapted for subjecting the sensed sound signals to a predetermined processing, a detecting means adapted for detecting based on the processed sound signals a peak value indicating a resonance, and an adjustment means adapted for providing, on the basis of the detected peak value indicating a resonance, an adjustment of the operation of the hearing device to reduce influence of the resonance.

[0022] The sensor may be exposed to the sealed portion of the user's ear canal, or may be arranged with a predetermined distance to the sealed portion of the user's ear canal and connected thereto by an acoustic channel.

[0023] The present invention also refers to a computer program comprising program code means for causing a computer to carry out the steps of the methods as mentioned above when the computer program is carried out on a computer.

[0024] Accordingly, the detected resonance conditions in the venting channel of the hearing device and the at least partly sealed portion of the user's ear canal can be used for a suitable adjustment of the high frequency amplification performed in the hearing device in order to remove the influence of any resonance, and the hearing device can automatically be kept at a continuously high level of adjustment (frequency dependent amplification characteristic) to always cope with the user's requirements.

[0025] The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description in conjunction with the appended drawings referring to the embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The drawings according to the present invention show in

Fig. 1 an overall view of a hearing device according to a first embodiment of the present invention,

Fig. 2 an overall view of the hearing device according to a second embodiment of the present invention,

Fig. 3 an overall view of the hearing device according to a third embodiment of the present invention,

Fig. 4 a flowchart representing the steps of a control concept of controlling the hearing device according to the first to third embodiments of the present invention, and

Fig. 5 a flowchart representing the steps of a modified control concept of controlling the hearing device according to the first to third embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

First embodiment

[0027] The present invention is described in the following in conjunction with the schematic diagram of Fig. 1 showing an overall view of a hearing device 10 according to the first embodiment of the present invention. The hearing device 10 comprises a main body 11 wherein further means and units of the hearing device 10 are arranged or implemented.

[0028] In the main body 11 of the hearing device 10 a venting channel 12 is arranged, and the acoustical properties of the venting channel can be influenced by means of a valve element 13. The valve element 13 arranged in the venting channel 12 is connected to a central control unit (CCU) 14 which is adapted for providing a setting or controlled positioning of the valve element 13, and for controlling further means and functions of the hearing device 10 described in the following in conjunction with Fig. 1.

[0029] The central control unit 14 (which can also be referred to as a control means) may usually be based on a microprocessor or a microcomputer on a miniaturized electronic chip and including, for example, a central processing unit CPU, interface portions as well as different memory means for temporarily or continuously memorizing programs, basic data, detection data and further information generated or occurring during the operation of the hearing device 10. The components of the central control unit 14 are not shown in the Figures to facilitate the overall view of the first embodiment of the present invention. The central control unit 14 picks up information about the environmental sound conditions and provides on the basis of corresponding programs (software) for operating the central control unit 14 and the entirety of the hearing device 10 and the basic data stored in the memory means a corresponding data evaluation and control.

[0030] For picking up any information, such as sound signals or any noise signals, which are summarized in Fig. 1 as sound signals Si1, the sound and noise surrounding the user wearing the hearing device 10, the central control unit 14 is connected to an input module 15 (input means) which may usually be provided in the form of a sensing means such as a microphone. The

input module 15 picks up the acoustic signals Si1 which represents the sound pressure outside the user's ear, represented by the region A in the left portion of Fig. 1. The input module 15 accordingly detects the sound pressure of the surrounding sound signals Si1 and transmits a corresponding detection signal to the central control unit 14.

[0031] An output module 17 (output means) represents the function of an output transducer or a speaker, and is operated by and therefore connected to the central control unit 14, so that the output module 17 can provide the required electro-acoustical output after amplification. The input module 15, the output module 17 and the control unit 14 provide and represent the regular function of the hearing device, i.e. the picking-up of any surrounding sound or noise in the form of acoustic signals Si1, and the corresponding amplification of these signals in a suitable manner (according to a predetermined setting of the hearing device 10). the central control means 14, supplies the amplified signals (processed by the control means 14) to the output module 17 to output these signals as corresponding output signals So into the user's ear canal EC and towards the user's eardrum (tympanic membrane). The output signals So output by the output module 17 are provided to a portion B (see right hand side of Fig. 1) which is at least partly sealed (closed, blocked) by the hearing device 10 placed in and fitting to the ear canal EC of the user of the hearing device 10.

[0032] Accordingly, the central control unit 14 receives the sound information (acoustic sound signals Si1) representing the acoustic conditions surrounding the user and representing a sound pressure information from the outside A, and control the output module 17 to provide the regular function or performance of the hearing device 10.

[0033] As is further shown in Fig. 1, the hearing device 10 also comprises a sensing means in the form of a sensor 18 which is adapted for sensing, the acoustical conditions in the sealed or closed portion B of the user's ear canal EC. The sensor, or microphone 18 detects the acoustic conditions in the sealed portion B by sensing sound signals Si2 which basically result from the output signals (sound signals) So output by the output module 17 and being influenced and modified by the specific conditions of the hearing device 10 being placed at and fitted to the ear canal EC of the user. The acoustic conditions in the sealed portion B of the user's ear canal EC depend to a certain extent on the arrangement of the hearing device 10 in the user's ear canal and the structure of the user's ear canal EC and the distance to the user's eardrum (not shown in the Figures).

[0034] The sensor 18 is provided for picking up the acoustic signals in the user's ear canal EC, behind the hearing device 10 and in front of the eardrum of the user. The sensor 18 generates a corresponding detection signal which is fed to the central control unit 14 for further data evaluation and processing. The sensor 18 is therefore provided to have the function of a monitoring sensor for measuring the acoustic conditions.

[0035] While the sensor 18 (first sound pressure sensing means) detects the sound conditions in the closed portion B of the user's ear canal EC, the input module 15 (second sound pressure sensing means, acoustic sensing means) detects the acoustic environmental conditions surrounding the user and coming from the outside A.

[0036] According to the control concept of the present invention, the central control unit 14 receives a detection information from both the sensor 18 and the input module 15 and provides a data evaluation based on these detection signals.

[0037] In the present first embodiment the sensor 18 is located at an outer side of the main body 11 of the hearing device 10 and provides a sensing performance towards the closed portion B of the user's ear canal EC. This arrangement is shown in Fig. 1. Moreover, the hearing device 10 is powered by a battery power supply 20.

Second embodiment

[0038] A second embodiment of the arrangement of the sensor 18 is shown in Fig. 2.

[0039] The arrangement shown in Fig. 2 is basically the same as that of Fig. 1 so that for same units, means or elements of the hearing device 10 the same reference numbers are used.

[0040] The difference between the first embodiment according to Fig. 1 and the second embodiment according to Fig. 2 lies in the arrangement of the sensor 18 which is arranged inside the main body 11 of the hearing device. The sensor 18 is connected for electrical transmission of detection signals to the central control unit 14.

[0041] For detecting the acoustic conditions and in particular the sound pressure in the sealed or closed portion B of the user's ear canal EC an acoustic channel 19 is provided which serves for acoustically connecting the closed portion B of the user's ear canal EC with the sensor 18. The acoustic conditions and the sound pressure in the sealed portion B are conducted, by means of the acoustic channel 19, from the sealed portion B of the ear canal EC to the sensor 18, and the sound signals Si2, occurring in the sealed portion B of the ear canal, enter into the acoustic channel 19 and finally reach the sensor 18. The picking-up of the acoustic signals Si2 by the sensor 18 results in the generation of corresponding sensor signals (electric signals) which are fed to the central control unit 14. On the basis of this detection signals the central control unit 14 will perform the same data evaluation as in the case of the first embodiment. The further means and elements of the hearing device 10 according to the second embodiment have the same function as the corresponding means and elements of the first embodiment shown in Fig. 1. Further explanations in view of this means and elements of the hearing device 10 according to the second embodiment are therefore omitted.

[0042] According to the first and second embodiment of the present invention the detection performance of the

sensor 18 is basically the same. The arrangement of the sensor can be provided according to the type of hearing devices, such as ITC and CIC hearing devices. The hearing device 10 as such and the elements or means provided therein are powered by a general battery power supply 20 which is basically the same in both embodiments.

Third embodiment

[0043] According to a third embodiment shown in Fig. 3, the hearing device 10 may be provided as a hearing device arranged in the ear (ITE) or may be structured as a device behind the ear (BTE), wherein in both cases the circuitry is not arranged in the ear canal EC but separated from an ear mould 21 which is arranged in the ear canal EC of the user. The ear mould 21 may comprise a receiver and at least a microphone for picking up the sound level inside the ear, or both a microphone for picking up sounds in the environment and a microphone for picking up sounds inside the ear canal. As arranged in the user's ear canal, the ear mould 21 may include a venting channel 12 to reduce occlusion effect (blocking), as well as an output module 17 for outputting processed and/or amplified sound signals So to the user's ear canal EC and eardrum (not shown). The further circuitry (electronic devices, such as an input module 15, a central control unit 14 and a battery power source 20 therefore may be arranged outside the ear canal in a predetermined shell 22 in the ear or behind the ear. Moreover, the sensor such as sensor 18 shown in Figs. 1 and 2 is arranged at the ear mould 21 and exposed to the space between the ear mould 21 and the user's eardrum. In a similar manner as it is the case according to the first and second embodiments, the sensor 18 according to the third embodiment arranged on the ear mould inserted in the user's ear canal EC also detects the sound conditions in the sealed or closed space, such as the sealed space B shown in Figs. 1 and 2, this space in the user's ear canal being sealed by means of the ear mould properly fitting the user's ear canal EC.

[0044] The interaction between the particular means and elements of the hearing device 10 as well as the corresponding data evaluation which has been described in conjunction with the first and second embodiments is the same as that of the third embodiment and the advantages obtained by the third embodiment are similar to those of the first and second embodiments of the present invention according to Figs. 1 and 2 and described above. That is, the results obtained by the control concept according to the present invention which are described in the following are basically the same in all embodiments described above.

[0045] The representations in Figs. 1 to 3 do not show the real proportions of the hearing device 10 according to the present invention, but only provide schematic diagrams for supporting and facilitating understanding of the arrangement and structure of the hearing device of the present invention.

[0046] In general, the circuitry described above is powered by the battery power source 20 which is preferably provided in the form of an exchangeable or rechargeable battery. In the schematic diagrams of Figs. 1 to 3, the battery power source 20 is mainly connected to the central control unit 14. The central control unit 14 can then provide the power distribution to the other elements and circuitry connected thereto. The battery power source 20 can also be connected to each of the elements described above in addition to a connection to the central control unit 14. Moreover, in the embodiments as described above there may be arranged between the hearing device 10 and the user's eardrum (first and second embodiments), or between the mould 19 and the user's eardrum an earwax (cerumen) protection means (not shown).

Control process

[0047] In the following with reference to Fig. 4, the functioning and a control process of the control concept of the hearing device 10 according to the present invention is described.

[0048] In general, when the hearing device 10 is inserted into the ear canal EC of the user or is arranged in or at the user's ear, and when the hearing device 10 is switched on for normal operation, the regular function of the hearing device 10 is performed which results in picking up any sound or noise Si1 surrounding the user by means of the input module 15, and feeding the user's ear canal EC with an amplified sound (acoustic output signals) So to compensate for the user's hearing loss. More specifically, the amplified sound in the form of the acoustic output signals So is output by the output module 17 (output means) to the sealed (or closed) portion B of the user's ear canal EC. This represents the regular or normal function of the hearing device 10, thereby providing the user having a hearing loss with amplified sound signals based on the acoustical conditions surrounding the user.

[0049] For performing the regular or normal operation (performance) of the hearing device 10, the central control unit 14 of the hearing device 10 is operated to shift to a first operation mode which is the normal operation mode (regular or normal hearing device operation). The user switches on the hearing device 10, after correct placement thereof on and/or in the ear, and the first operation mode which is the normal operation mode of the hearing device 10 is selected and corresponding control and operation is performed. Alternatively a means for automatic activation of the hearing device without any user intervention may be applied.

[0050] The sensor 18 is provided for monitoring the acoustic conditions in the sealed portion B of the user's ear canal EC and thereby the sensor 18 provides the possibility to monitor the acoustic output signals So which are output by the output module 17 in its natural environment, i.e. the acoustic conditions in a particular ear canal

of the user in the sealed (or closed) space or portion B between the hearing device 10 and the user's eardrum. The sensor 18 can therefore monitor very precisely the sound provided to the user's eardrum, also reflecting the natural environment or natural conditions.

[0051] The sensor 18 in the sealed space of the portion B of the user's ear canal, may detect length resonance effects of the venting channel 12. In particular, resonance frequencies can be detected, i.e. the frequencies of the sound in the sealed portion B of the ear canal EC which cause or support length resonance in the venting channel 12.

[0052] The sensor 18 monitor the sound conditions (actual sound pressure) in the user's ear canal EC in conjunction with the sound signals So output by the output module 17.

[0053] When the hearing device 10 is switched on by the user for regular operation, the central control unit 14 is operated and performs the running of a predetermined software (computer program comprising program code means) implemented therein, the software representing the various operations and functions of the central control means 14 and, thus, of the entire hearing device 10.

[0054] At first, the central control unit 14 (control means) performs a start-up sequence of the hearing device including, for example, the checking of the various components of the hearing device (input module 15, output module 17, possible valve element 13 in the venting channel 12 and sensor 18, power level of the battery power source 20) and initializes several memories for temporarily storing detected information or control parameters of the hearing device 10.

[0055] For further details it is now referred to the sequence of steps (control process) shown in Fig. 4 of the present invention.

[0056] After the general starting step S401, the start-up sequence of the hearing device 10 is performed in step S402, representing the start-up sequence of all the components or elements of the complete hearing device 10.

[0057] In a subsequent step S403 the control sequence or control process of the present invention enters into a test mode for detecting resonance conditions and in particular a length resonance which may occur in the venting channel 12 and the sealed or closed portion B of the user's ear canal EC. This test mode is the second operation mode of the hearing device 10 and may form part of the start-up sequence of the hearing device or may be separated there from and be carried out on request according to an automatic procedure every (settable) predetermined period of time of using the hearing device 10 by the user, or when this test mode is desired by the user and when the central control means 14 compulsorily enters into the test mode upon manual operation of the hearing device 10 by the user on demand (manual intervention).

[0058] After the central control unit 14 and, thus, the hearing device 10 in its operation has entered into the test mode (step S403), in a next step S404 the central control unit 14 performs control to emit predetermined sound signals, and specifically high frequency sound signals at a predetermined level. Such high frequency sound signals may be emitted by means of the output module 17 upon specific driving thereof, or may be emitted by an additional sound emitting means which is for simplification of the Figures not shown. That is, the output module 17 or any sound emitting means emits the sound signals So towards the sealed portion B of the user's ear canal EC, so that such sound signals So are emitted into the space which represents a natural environment and the regular (positioning) of the hearing device in the user's ear canal EC.

[0059] For generating the plurality of predetermined sound signals So to be output by the output module 17, the central control unit 14 may include a signal generator or a sound processor which is adapted for producing such sound signals having different (various) frequencies within a predetermined frequency range (which may be appropriately set beforehand). These sound signals So can then be amplified by an amplifier included in the central control unit 14 and are then output by the output module 17 in a predetermined manner, that is, according to a predetermined timing and according to a predetermined level (volume, sound pressure).

[0060] The predetermined level at which the high frequency sound signals are emitted is a lower level (low volume or sound pressure) in order to avoid any uncomfortable feeling or unnatural impression of the user. The predetermined amplification of such high frequency sound signals So may be initially set as a basic setting of the hearing device and may be modified at a later stage or during use of the hearing device 10 by the user according to his requirements.

[0061] According to a further step S405, the high frequency sound signals emitted to and sounding in the sealed space B of the user's ear canal EC are sensed by the sensor 18, and specifically it is detected whether unnaturally high sound pressure levels (sound pressure levels) at certain frequencies occur, such high sound pressure levels indicating a resonance. Specifically, when sound signals with different high frequencies (spectrum) are emitted, a resonance at a certain frequency or plural resonances at different frequencies can occur in the sealed space B and the venting channel 12 and can be detected or monitored by the sensor 18.

[0062] For detecting the higher or lower sound pressure levels at certain frequencies based on the high frequency sound signals emitted, the versions of the arrangement of the sensor 18 as shown in Figs. 1 to 3 (first to third embodiments) can be used since basically the same detection result can be obtained.

[0063] When unnaturally high sound pressure levels of the sound pressure of the high frequency sound signals emitted occur, then according to a further step S406, adjustment of the hearing device 10 is provided. The operation or functioning of the hearing device 10 is adjusted

to remove the influence of the resonance detected in the detecting step S405. Adjustments of the functioning or operation of the hearing device 10 are made for subsequent use in the sound processing during the operation of the hearing device 10 according to the first mode (normal mode).

[0064] In step S407, the control process performed by the central control unit 14 quits the test mode and returns back to the first mode (normal mode) for normal operation of the hearing device 10 as described before.

[0065] By means of the above-described control concept and as shown in Fig. 4, the occurrence of a resonance in conjunction with the venting channel 12 and the sealed portion B of the user's ear canal EC is detected, and it is detected at which frequency or frequencies such a resonance occurs. Depending upon this detection which can be derived from the frequencies of the high frequency sound signals emitted, a further fine setting (new calibration) of the hearing device 10 can be carried out, so that any modification or deterioration in the course of the use of the hearing device can be compensated for.

[0066] The resonance of the ventilation channel 12 and of the sealed portion B of the user's ear canal EC can be used for suitably adjust the operation of the hearing device, and in particular to adjust the high frequency amplification (which can be performed by the central control unit 14) in order to effectively remove the influence of the resonance on the performance of the hearing device 10. Since entering into the test mode and the corresponding detection of any resonances and the necessary adjustment of the hearing device 10 thereafter is performed automatically during or after performing the start-up sequence (except the seldom specific case of a manual operation), the hearing device 10 can automatically be kept at a continuously high level of adjustment (frequency dependent amplification characteristic) to always cope with the user's requirements.

[0067] Only when necessary in very seldom cases, the user can initiate the calibration process (the running of the test mode including automatic calibration process) upon manual operation of the hearing device 10.

[0068] Since the resonance may depend in view of frequency and sound pressure on the exact (varying) position of the hearing device 10 inside the user's ear canal EC, the arrangement of the venting channel 12 and the sealed portion B of the ear canal EC, the control concept according to the present invention as described above is able to cope with such correspondingly varying parameters and conditions while the feature of automatic calibration should be a part of the sophisticated hearing device for frequent operation thereof, rather than being a matter of a once-and-for-all adjustment at the dispenser, i.e. when the user receives the hearing device 10 for the first time and when the hearing device 10 is initially adapted to the user's and environmental conditions.

[0069] The automatic performance of the testing process and the calibration or setting process to avoid the occurrence of resonances in conjunction with the venting channel 12 and the sealed portion B of the user's ear canal EC, make the use of the hearing device 10 according to the present invention easy and comfortable for the user as the setting is frequently repeated with the actual conditions (that is, the actual position) of the hearing device 10 in the user's ear canal EC without requiring any manual operation.

[0070] The detected resonance conditions in the venting channel 12 of the hearing device and the at least partly sealed portion B of the user's ear canal EC can be used for a suitable adjustment of the high frequency amplification performed in the hearing device 10 in order to remove the influence of any resonance in an automatic manner without the requirement of a manual operation by the user to keep the hearing device 10 appropriately set for providing maximum comfort for the user.

Modified Control process

[0071] In conjunction with Fig. 5 an alternative sequence (modified control process) in comparison to the sequence shown in Fig. 4 is described in the following.

[0072] The results obtained by the (modified) control sequence or process according to the steps of Fig. 5 is the same as that of the control process shown in Fig. 4.

[0073] Fig. 5 shows steps of a test sequence, wherein, in contrast to the control concept according to Fig. 4, step 404, the control concept does not use the step of emitting predetermined sound signals. In fig. 5, after a general starting step S501, a start-up sequence is performed according to step S502 in a manner similar to step S402 of Fig. 4. The start-up sequence also includes the initialization of the entire hearing device 10.

[0074] In a subsequent step S502, the central control unit 14 enters into a test mode for detecting length resonance in conjunction with the venting channel 12 and the sealed portion B of the user's ear canal EC.

[0075] The hearing device 10 has a first or normal mode for carrying out the regular functions of the hearing device 10. In addition thereto, the test mode, which is a second mode, is provided. The test mode may form part of the start-up sequence or may be independent there from. The test mode can therefore be carried out according to a predetermined time defined in the start-up sequence or may be carried out every predetermined period of time during the normal operation of the hearing device, or upon manual command by the user.

[0076] In a subsequent step S504 sensing of sound signals in the sealed portion B of the user's ear canal EC is performed. When the hearing device 10 is inserted in the user's ear canal EC, the regular sound conditions are monitored, i.e. the output signals So output to the sealed portion B, are sensed by the sensor 18 as new input signals Si2. The output signals So output by the output module 17 result from input sound signals Si1 picked-up by the input module 15, and the sound signals Si1 correspond to the environmental sound conditions surrounding the user. In particular, a sound pressure level

is detected.

[0077] In a next step S505 the sensed sound signals So are subjected to a predetermined processing. A time average sound pressure level over a frequency range (spectrum) in the sealed portion B of the user's ear canal EC is determined. The determination is made over a predetermined period of time. The predetermined period of time must cope with the requirement of finally providing a reliable detection result. The predetermined processing of step S505 and the time averaging process is carried out over a predetermined period of time, which may be a period of several minutes, in order to ensure a representative frequency spectrum in order to obtain a reliable basis for subsequent corrective action. The time averaging is performed in the microcomputer included in the central control unit 14, and corresponding data, such as detection values and calculated values are evaluated and temporarily stored.

[0078] Subsequently, according to further step S506 in Fig. 4, it is detected on the basis of the time average sound pressure level whether a clear level peak at certain frequencies (spectrum) occurs, such a level peak of the processed sound signals indicating a resonance in the venting channel 12 of the hearing device 10 and in the sealed or closed portion B of the user's ear canal EC. If a resonance is present the corresponding signals and control parameters derived there from are subject to a data evaluation, and the results are temporarily stored for further data evaluation and correction purposes.

[0079] According to the subsequent step S507, an adjustment of the operation of the hearing device 10 is provided. The adjustment serves to remove the influence of the resonance detected. When a resonance at a certain frequency or resonances are detected at different frequencies, the frequencies are known and a corresponding characteristic of the amplification (evaluation and calculation process in the central control unit 14) are performed to obtain the necessary adjustment of the hearing device 10.. The adjustment of the hearing device 10 depending upon the sensed or measured values, results in the adaptation of the characteristic and volume of the amplification performed in the central control unit 14 to obtain a desired driving of the output module 17 to ensure an amplification characteristic (depending on frequencies) which is able to cope with the user's requirements and the actual prevailing conditions when the hearing device 10 is positioned in the ear canal EC of the user.

[0080] After the adjustment has been performed, the control process shown in Fig. 5 now proceeds to step S508 wherein returning to the normal mode (first mode, normal operation of the hearing device) is performed.

[0081] This indicates that upon detection of the signals according to steps S504 to S506, the subsequent adjustment process of step S507, has been completed and the hearing device 10 has been set and adjusted (calibrated) to the present actual acoustical conditions of the hearing device 10 inserted in or placed at the user's ear.

[0082] In summary, both control processes as shown in Figs. 4 and 5 provide a detection of resonance conditions in the venting channel 12 and the closed space B of the user's ear canal EC and provide, on the basis of such a detection, an updated setting or new calibration of the hearing device 10, wherein the actual acoustical conditions of the hearing device 10 inserted and positioned in the user's ear canal EC are taken into account. This new setting or calibration provides a fine tuning of the hearing device in a user-dependent manner at time periods after delivery of the hearing device 10, so that the user can always rely on a comfortable setting of his hearing device 10 without manual operation.

[0083] In this connection, the steps S504 to S506 in Fig. 5 it is estimated whether during normal use of the hearing device 10 a clear peak which can be considered to indicate a resonance or resonances at predetermined frequencies is detected. The time-averaged sound pressure level (spectrum over frequency) inside the sealed portion (space) B of the user's ear canal EC in front of the eardrum contains may give this information.

[0084] When the control concepts in conjunction with Figs. 4 and 5 perform the adjustment process, the acoustic properties of the venting channel 12 and of the sealed portion B of the user's ear canal EC are considered.

[0085] The calibration or adjustment process may also consider the influence of the valve element 13 arranged at a predetermined position in the venting channel 12. The adjustment process can easily be extended to the consideration of the valve element 13 and the positioning thereof, so that the valve element 13 in addition to the amplification control can also be controlled to support a suppression of an undesired resonance in the venting channel and the sealed portion B or to favourably influence the amplification characteristic of the hearing device 10.

[0086] It is to be noted that the Figures described above do not represent real proportions but only provide a schematic view which is helpful for explanation and understanding of the subject matter of the present invention. Moreover, the present invention has been illustrated and described in detail by means of the foregoing description in conjunction with the drawings, and such illustrations and descriptions are to be considered illustrative or exemplary and not restrictive.

[0087] The subject matter of the present invention is not limited to the embodiments as described above, and even reference numbers shown in the drawings and referred to in the description and the claims do not limit the scope of the present invention. It is considered that all technical means and equivalent elements or components are included in the present invention and are considered to form part of the scope of the present invention as defined by the appended claims.

Claims

1. Method of controlling a hearing device (10) being

placed at or in an ear canal (EC) of a user and defining at least partly sealed portion (B) of the ear canal (EC), the method comprising:

providing a vent channel (12) in said hearing aid of predetermined properties,
emitting (S404) predetermined sound signals (So) with different frequencies at a predetermined level,
detecting (S405) the occurrence of high sound pressure levels of said predetermined sound signals indicating a resonance in said sealed portion, and
providing (S406), on the basis of said detected high sound pressure levels of said predetermined sound signals, an adjustment of the operation of said hearing device (10) to reduce the influence of said resonance.

2. Method according to claim 1, wherein said predetermined sound signals are sound signals having a predetermined frequency.

3. Method according to claim 1 or 2, wherein said step of providing an adjustment the operation of said hearing device (10) includes the step of providing an adjustment of the amplification characteristic of said hearing device.

4. Method according to claim 1, further comprising the steps of

performing a start-up sequence for initializing said hearing device (10), and
entering into a test mode for detecting said high intensity levels indicating a resonance in said sealed portion (B).

5. Method according to claim 4, wherein said step of emitting predetermined sound signals is carried out in said test mode.

6. Method of controlling a hearing device (10) being placed at or in the ear canal (EC) of a user and defining at least partly sealed portion (B) of the ear canal, and a vent in said device 10 with predetermined properties,
the method comprising the steps of:

sensing (S504) sound signals (So, Si2) in said sealed portion (B) of said ear canal (EC),
subjecting (S505) said sensed sound signals to a predetermined processing,
detecting (S506) on the basis of the processed sound signals, over a predetermined period of time, a peak value indicating a resonance, and
providing (S507) on the basis of said detected peak value indicating a resonance, an adjustment of the operation of said hearing device (10) to reduce influence of said resonance.

7. Method according to claim 6, wherein said step of subjecting (S505) said sensed sound signals to a predetermined processing includes the step of providing a time-averaged sound pressure level of said sound signals of said sealed portion (B) over a predetermined period of time.

8. Method according to claim 6 or 7, wherein said step of providing an adjustment (S507) of the operation of said hearing device (10) includes the adjustment of the amplification characteristic of said hearing device.

9. Method according to claim 1, further comprising the steps of

entering into a test mode of operating said hearing device (10), and
performing said sensing step (S504) in said test mode.

10. A hearing device, arranged at or in a user's ear canal (EC) and at least partly blocking said ear canal and defining a sealed portion (B) of said ear canal, and a vent with predetermined properties, comprising:

a sound generator (14, S404) adapted for generating predetermined sound signals with different frequencies at a predetermined level, and an output means (17) for outputting said predetermined sound signals,
a sensor (18, S405) adapted for detecting the occurrence of high sound pressure levels of said predetermined sound signals, and
an adjustment means (14, S406) adapted for providing, on the basis of said detected high sound pressure levels of said predetermined sound signals, an adjustment of the operation of said hearing device (10) to reduce influence of said resonance.

11. A hearing device arranged at or in a user's ear canal (EC) and at least partly blocking said ear canal and defining a sealed portion (B) of said ear canal, comprising:

a vent with predetermined properties,
a sensor (18, S504) adapted for sensing sound signals (So, Si2) in said sealed portion (B) of said ear canal (EC),
an evaluating means (14, S505) adapted for subjecting said sensed sound signals to a predetermined processing,
a detecting means (14, S506) adapted for detecting based on the processed sound signals

a peak value indicating a resonance, and
an adjustment means (14, S507) adapted for providing, on the basis of said detected peak value indicating a resonance, an adjustment of the operation of said hearing device (10) to reduce influence of said resonance.

12. Hearing device according to claim 10 or 11, wherein said sensor (18) is exposed to said sealed portion (B) of the user's ear canal (EC), or is arranged with a predetermined distance to the sealed portion (B) of the user's ear canal (EC) and connected thereto by an acoustic channel (19).

13. Computer program comprising program code means for causing a computer to carry out the steps of the method as claimed in one of claims 1 to 5 when said computer program is carried out on a computer.

14. Computer program comprising program code means for causing a computer to carry out the steps of the method as claimed in one of claims 6 to 9 when said computer program is carried out on a computer.

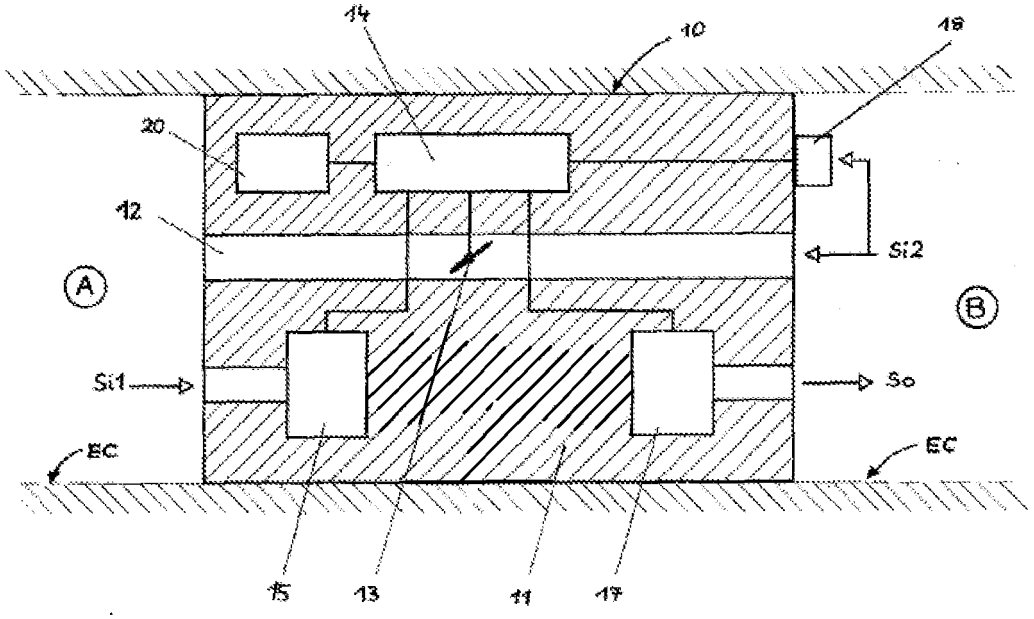

Fig. 1

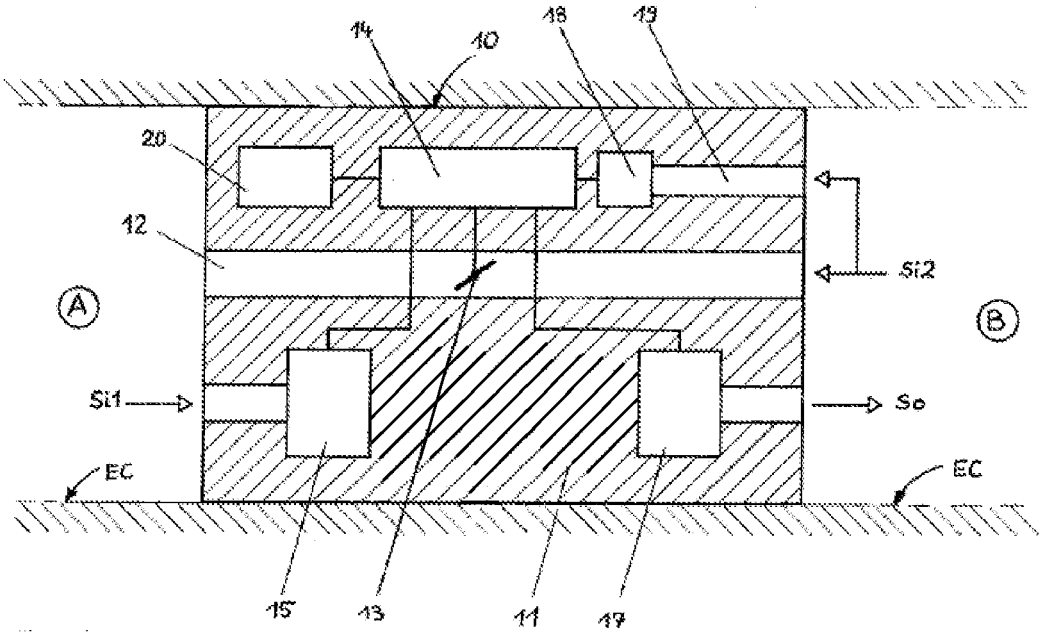

Fig. 2

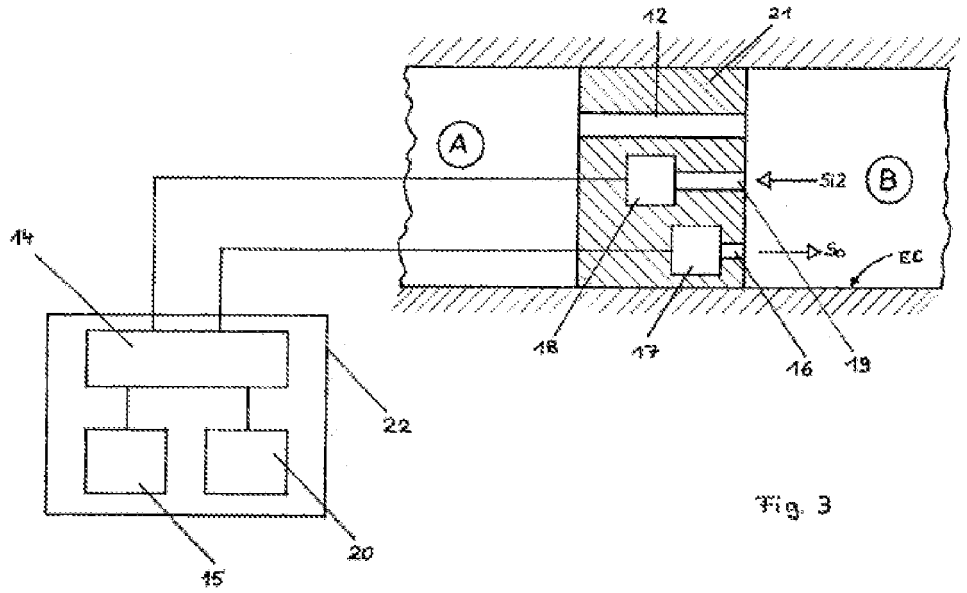

Fig. 3

Fig. 3

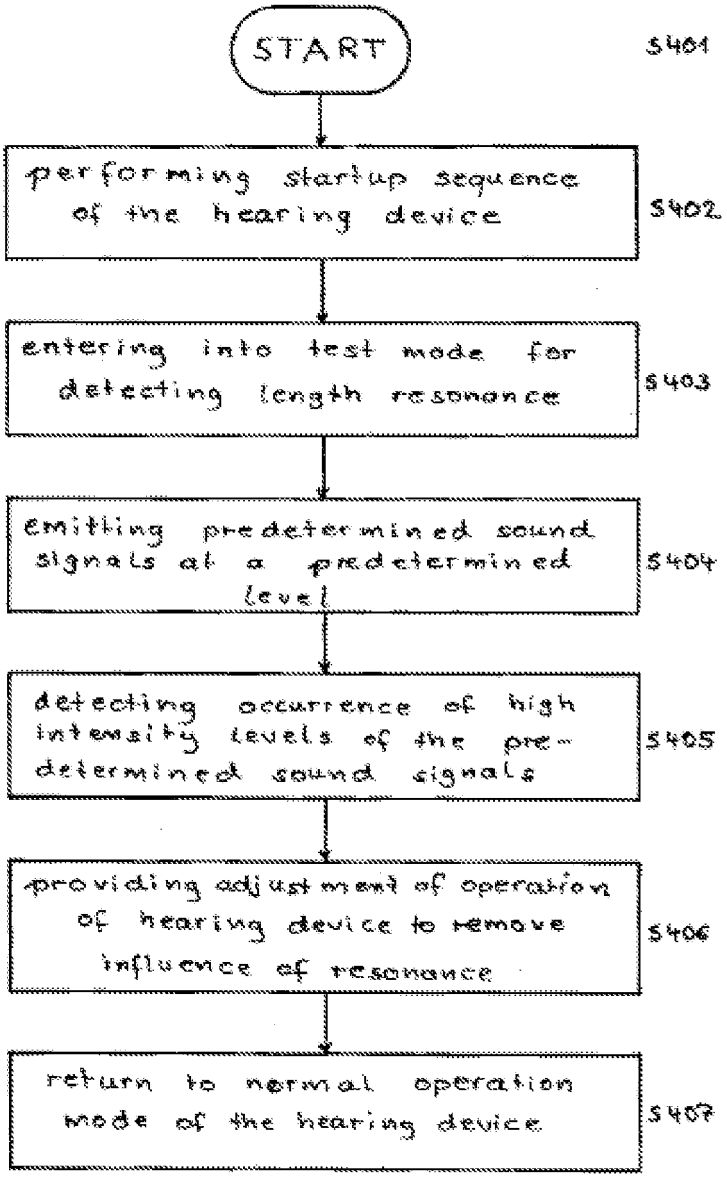
START
S401
performing startup sequence of the hearing device
S402
entering into test mode for detecting length resonance
S403
emitting predetermined sound signals at a predetermined level
S404
detecting occurrence of high intensity levels of the pre-determined sound signals
S405
providing adjustment of operation of hearing device to remove influence of resonance
S406
return to normal operation mode of the hearing device
S407

Fig. 4

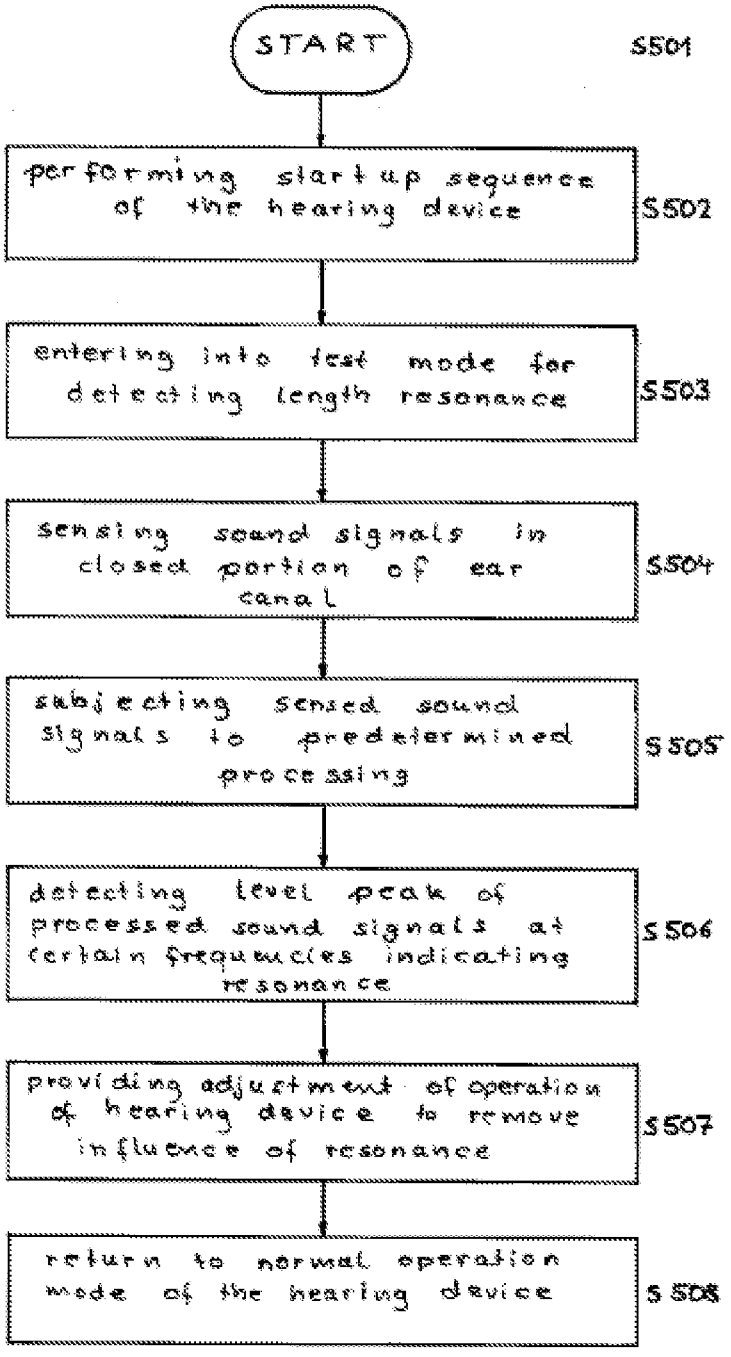
START
S501
performing start up sequence of the hearing device
S502
entering into test mode for detecting length resonance
S503
sensing sound signals in closed portion of ear canal
S504
subjecting sensed sound signals to predetermined processing
S505
detecting level peak of processed sound signals at certain frequencies indicating resonance
S506
providing adjustment of operation of hearing device to remove influence of resonance
S507
return to normal operation mode of the hearing device
S508

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 08 10 3484

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 November 2008	Timms, Olegs

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