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DESCRIPTION

[0001] The present invention relates to hearing aids. The invention, more specifically, relates to a hearing aid having means for alleviating tinnitus.

[0002] A device for treating tinnitus is known from WO-A2-2008/087157. The device comprises a generator means generating an audio signal and a transducer means for reproducing the audio signal having interposed between them a filter. The filter is matched to suppress the audio signal in an interval of frequencies around a dominant frequency of a tinnitus. WO-A2-2008/087157 also describes a method for matching the filter to enable the suppression by estimating the subjective intensity and the dominant frequency of tinnitus. The subjective intensity is estimated by means of an audiometric procedure, while the dominant frequency is estimated by means of the signal generator of the device.

[0003] This method implies that the frequencies used to estimate the subjective intensity and the frequencies identified by the estimation of the dominant frequency may differ from each other. This may result in that the peak frequency in the frequency spectrum of the estimated subjective intensity and the estimated dominant frequency differ from each other. This in turn has the implication that the matching of the filter is affected such that either an inconveniently large spectral width of the filter will be necessary or the tinnitus may not be sufficiently suppressed.

[0004] Furthermore, the known matching method is, due to its use of audiometric measurements and following dependence on extensive and complicated equipment, confined to be performed by qualified staff, thus rendering exploitation of the advantages related to the use of the matching procedure outside the laboratory rather cumbersome.

[0005] In a related method for alleviating tinnitus a patient listen, on a regular basis, to music where the music is modified to contain no energy in the frequency range surrounding the, individually determined, tinnitus frequency of the patient. According to this method the patient chooses music, which has been modified as described above. See "Listening to tailor-made notched music reduces tinnitus loudness and tinnitus-related auditory cortex activity", Proceedings of the National Academy of Sciences of the United States of America, January 19, 2010 vol. 107 no. 3, pp. 1207-1210.

[0006] This method of tinnitus alleviation is inflexible insofar as the patient, as part of the alleviation, can only listen to the music that has been modified and stored on some audio media. This may especially be problematic since the method is a long term alleviation, which is partly based on the requirement that the patient finds the music enjoyable. Another problem arises if the audio media is lost, damaged or for some reason not brought along by the patient.

[0007] In EP-A1-0820211 a programmable digital hearing device is disclosed with at least one electroacoustic input converter, a signal processing device, comprising a signal converter,

amplifier, a digital signal processor and memory means and with an electroacoustic output transducer and wherein the hearing device can function as a device for Tinnitus therapy by means of the signal processor comprising means for signal generation, the signals of which are able to be combined with the digitized user signal.

[0008] According to the invention the object is achieved by a hearing aid adapted for alleviating the tinnitus of a user of the hearing aid, the hearing aid comprising an audio input, a signal processing unit, an output transducer, a band stop filter matched to a tinnitus of a user of the hearing aid and means for selectively activating and de-activating the band stop filter according to claim 1.

[0009] Thereby a hearing aid with a band stop filter matched to a tinnitus of a user is provided which enables alleviating the tinnitus of the user. This in turn provides for improved alleviation of tinnitus in a flexible manner using equipment, which is used outside of laboratory environments during the user's everyday life.

[0010] The band stop filter is matched to the tinnitus.

[0011] Thereby a hearing aid with a band stop filter matched to a tinnitus is provided.

[0012] Further embodiments and advantages of such a hearing aid are given in the dependent claims, and in the detailed description following below.

[0013] The invention will now be described in further detail based on non-limiting exemplary embodiments, and with reference to the drawings. In the drawings.

fig. 1 is a diagram illustrating the steps of a method for matching a hearing aid band stop filter or notch filter to a tinnitus,

fig. 2 is a diagram illustrating selected steps of a rough matching procedure for determining the characteristic frequency of a tinnitus,

fig. 3 is a diagram illustrating selected steps of a fine matching procedure for determining the characteristic frequency of a tinnitus,

fig. 4 illustrates a highly schematic illustration of selected parts of a hearing aid system adapted for a free matching procedure for determining the characteristic frequency of a tinnitus.

fig. 5 is a diagram illustrating selected steps of determining a spectral width of a perceived tinnitus, and

fig. 6 illustrates a hearing aid according to the invention in association with the equipment necessary for carrying out a method according to an embodiment of the first aspect of the invention,

fig. 7 illustrates a hearing aid according to the invention.

fig. 8 illustrates highly schematically selected parts of a hearing aid according to a first embodiment of the invention,

fig. 9 illustrates highly schematically selected parts of a hearing aid according to a second embodiment of the invention,

fig. 10 illustrates highly schematically selected parts of a hearing aid according to a third embodiment of the invention, and

fig. 11 illustrates highly schematically selected parts of a hearing aid according to a fourth embodiment of the invention.

[0014] Fig. 1 illustrates a method for matching a hearing aid band stop filter to a tinnitus of a user in which the user's hearing threshold may be taken into account.

[0015] Turning to fig. 2 selected steps of a rough matching procedure for determining the characteristic frequency of the tinnitus are illustrated.

[0016] The aim of the rough matching procedure is to roughly locate the frequency of the tinnitus. This is done by presenting to the user sequences of tones with rising or falling frequencies. The user is instructed to stop the procedure when the frequency of the played tone matches the tinnitus best.

[0017] The rough matching procedure may be performed both with continuously or stepwise rising and falling sequences of tones and different start frequencies, respectively. Preferably, the start frequency for a rising sequence is 100 Hz, while the start frequency for a falling sequence is 8 kHz.

[0018] Preferably, the next frequency to be played for the user is derived as:

$$f(next) = f(previous) * (\sqrt[12]{2})^5 \quad f(next) = f(previous) * (\sqrt[12]{2})^5$$

for a rising sequence and as:

$$f(next) = f(previous) * 1/(\sqrt[12]{2})^5 \quad f(next) = f(previous) * 1/(\sqrt[12]{2})^5$$

for a falling sequence.

[0019] Thus the formula used for deriving the next frequency for the rising sequence includes multiplying the previous frequency with a constant defined as the twelfth root of two raised to the power of five. For the falling sequence the next frequency is derived by dividing the previous frequency with the constant defined as the twelfth root of two raised to the power of five.

[0020] Falling and rising sequences are repeated until a pair of frequencies, found with a falling and rising tone respectively, fall within a range of one octave.

[0021] Turning to fig. 3 selected steps of a fine matching procedure, being similar to the above described rough matching procedure are illustrated.

[0022] The aim of the fine matching procedure is to locate the characteristic frequency with a higher accuracy. Again two sequences of tones are presented to the user, one sequence with an initially falling frequency and one with an initially rising frequency. Thus the fine matching procedure can be described as comprising a falling procedure in which the sequence of tones, presented to the user, at least initially have a falling frequency, and a rising procedure in which the sequence of tones, presented to the user, at least initially have a rising frequency.

[0023] The rising procedure comprises the following steps:

Present a tone at a frequency being substantially equal to the lower edge of the frequency range found in the rough matching procedure.

[0024] Go up in frequency continuously or in intervals, preferably in intervals given as:

$$f(next) = f(previous) * 2^{(\frac{7}{39})} \quad f(next) = f(previous) * (\sqrt[20]{2})^4.$$

[0025] Go down in frequency continuously or in intervals, preferably in intervals given as:

$$f(next) = f(previous) * 1/2^{(\frac{2}{39})}.$$

[0026] Thus the formula used for deriving the next frequency for the rising sequence includes multiplying the previous frequency with a constant defined as two raised to the power of seven divided by 39 (when going up in frequency) and includes dividing the previous frequency with a constant defined as two raised to the power of two divided by 39 (when going down in frequency).

[0027] Similarly, the falling procedure comprises the following steps:

Present the tone at a frequency being substantially equal to the higher edge of the frequency range found in the rough matching procedure.

[0028] Go up in frequency continuously or in intervals, preferably in intervals given as:

$$f(next) = f(previous) * 2^{(\frac{2}{39})} \quad f(next) = f(previous) *$$

$$1/(\sqrt[20]{2}) \quad f(next) = f(previous) * 1/(\sqrt[20]{2}).$$

[0029] Go down in frequency continuously or in intervals, preferably in intervals given as:

$$f(next) = f(previous) * 1/2^{(\frac{7}{39})}.$$

[0030] Thus the formula used for deriving the next frequency for the falling sequence includes

multiplying the previous frequency with a factor defined as two raised to the power of two divided by 39 (when going up in frequency) and includes dividing the previous frequency with a factor defined as two raised to the power of seven divided by 39 (when going down in frequency). The step size, i.e. the factors

$$2^{\left(\frac{2}{39}\right)}$$

(two raised to the power of two divided by 39) and

$$2^{\left(\frac{7}{39}\right)}$$

(two raised to the power of seven divided by 39) for altering the frequencies are chosen, such that seen on a musical scale a played tone in one octave range cannot be played in the next octave range again. In other words the step sizes are chosen such that a precise doubling or halving of the tone frequencies is not possible. It is a further advantage that by going one step up or down in frequency from an initial frequency, one can not return to the initial frequency by going in the other direction.

[0031] Whenever the direction of going up or down in frequency is changed a so called "reversal point" occurs. Both the falling and the rising procedure stop when ten reversals have occurred. The frequencies found by the two procedures are then determined by averaging the frequency values of the reversal points, but disregarding the first four reversals.

[0032] Both the rising and the falling procedure are repeated until the found frequencies for both the falling and rising procedure are within at least one half an octave and preferably within one third of an octave. The characteristic tinnitus frequency is then determined by averaging the found frequencies for both the falling and rising procedure.

[0033] The step sizes for going up and going down in frequency are identical and the factor is two raised to the power of two divided by 39.

[0034] The tones are presented for the user with a duration of about three seconds.

[0035] The concept of reversal points is also used in the rough matching procedure. The rough matching starts at a frequency of 100 Hz and proceeds by going up and down in frequency dependent on the users indications of whether the frequency of the presented tone is higher than the characteristic tinnitus frequency. The procedure stops when four reversals have occurred and the fourth reversal point is used as starting point for a fine matching procedure that only includes a rising procedure. Alternatively the rough matching starts at a frequency of 8 kHz and the fine matching procedure only includes a falling procedure.

[0036] Fig. 4 shows a highly schematic illustration of selected parts of a hearing aid system adapted for finding the characteristic frequency of the tinnitus in the form of a free matching procedure. In a free matching procedure the hearing aid user is presented for a tone with a continuously or stepwise variable frequency and uses a device to freely adjust the frequency of the tone. Such a device could be the remote control of the hearing aid, a graphical user interface (GUI) on a computer or another hardware device. Where the HTL has been measured, the output level of the tone may automatically compensate for the user's HTL to

ensure audibility.

[0037] The user freely adjusts (i.e. lowers or rises) the frequency until the user thinks the frequency matches his or her tinnitus, the user registers the frequency thus found, repeats the previous steps at least once and stops when two successive frequency registrations fall within a range of one third octave or less, preferably within a range of one sixth octave or less.

[0038] Obviously, any one of the rough, fine and free matching procedures may be repeated until the frequencies found fall within a narrower octave interval than those stated above, e.g. one eighth or one twelfth octave.

[0039] Fig. 5 illustrates a procedure for determining the spectral width of the perceived tinnitus of the user.

[0040] In order to determine the spectral width of the perceived tinnitus the user is presented for multiple audio signals, preferably audio signals with different bandwidths centered on the characteristic frequency found in the matching procedure. The patient is asked to determine which audio signal matches the tinnitus best. A preferred way of realizing this is by means of a selection procedure. As illustrated in fig. 5 such a selection procedure may be a so-called ABX-procedure, in which two audio signals "A" and "B" are presented to the user, audio signal "A" having a narrower bandwidth than audio signal "B". The ABX procedure is well known in the art of detection theory, see e.g. "Detection theory: a user's guide" by Neil A. Macmillan and C. Douglas Creelman, Lawrence Erlbaum Associates, 2005.

[0041] Depending on which audio signal the user chooses to match the tinnitus best, the next iteration of the procedure comprises presenting audio signals with either narrower or wider bandwidths than the preceding audio signal. If the user chooses the audio signal "A" with the narrower bandwidth, the next iteration comprises presenting audio signals with a narrower bandwidth. If the user chooses the audio signal "B" with the wider bandwidth, the next iteration comprises presenting audio signals with a wider bandwidth.

[0042] The procedure is stopped when the bandwidth of the audio signal chosen by the user is below a given threshold.

[0043] The spectral width of the perceived tinnitus of the user is determined by a method where the start bandwidths for signal "A" and "B" are $1/4$ octave and $1/2$ octave and are narrowed or widened by $1/24$ octave in each iteration, but with a minimum signal bandwidth referring to a pure tone and a maximum signal bandwidth of $3/4$ octave. Similar to the previously described rising and falling method for the fine matching the number of reversals is counted. A reversal is again defined as a change in direction, i.e. going from wider bandwidth to a narrower bandwidth and vice versa. The procedure is finished when either of the following three criteria is fulfilled: six reversals have occurred, the patient have nine times in a row chosen the narrower bandwidth signal, resulting in the procedure presenting signal "A" with the minimum bandwidth, the patient have nine times in a row chosen the wider bandwidth signal,

resulting in the procedure presenting signal "B" with the maximum bandwidth.

[0044] In the first case the spectral width of the perceived tinnitus of the user is determined as the average of the bandwidths of signal "A" and "B" at the final six reversals. In the second case the perceived tinnitus of the user is determined as the minimum bandwidth and in the third case the spectral width of the perceived tinnitus of the user is determined as being wider than the maximum signal bandwidth.

[0045] If the found spectral width of the perceived tinnitus of the user is equal to or below $1/4$ octave, the band stop filter can be set to a bandwidth of $1/3$ octave. In case the found spectral width of the perceived tinnitus of the user is equal to or below $1/3$ octave the band stop filter can be set to a bandwidth of $1/2$ octave. In case the found spectral width of the perceived tinnitus of the user is equal to or below $1/2$ octave the band stop filter can be set to a bandwidth of one octave.

[0046] In case the found spectral width of the perceived tinnitus of the user is wider than $1/2$ octave it is recommended to consult qualified personnel since the tonal character of the tinnitus cannot be guaranteed and therefore the determined characteristic tinnitus frequency may not be the right choice as the center frequency for the band stop filter. Thus according to this embodiment the band stop filter bandwidth is set to be wider than the found spectral width of the perceived tinnitus of the user. Hereby the sensitivity to the precision of the determination of the center frequency of the band stop filter relative to the characteristic tinnitus frequency is reduced.

[0047] The spectral width of the perceived tinnitus of the user is determined by running either of the above described methods for fine matching of the characteristic tinnitus frequency at least five times and calculating the standard deviation of the ten found characteristic tinnitus frequencies (e.g. five frequencies from the rising part of the method and five frequencies from the falling part). In case the standard deviation is equal to or below $1/4$ octave the bandwidth of the band stop filter can be set to $1/3$ octave, in case the standard deviation is equal to or below $1/3$ octave the bandwidth of the band stop filter can be set to $1/2$ octave, in case the standard deviation is equal to or below $1/2$ octave the bandwidth of the band stop filter can be set to one octave and for standard deviations larger than $1/2$ octave it is recommended to consult qualified personnel since the tonal character of the tinnitus cannot be guaranteed and therefore the determined characteristic tinnitus frequency may not be the right choice as the center frequency for the band stop filter.

[0048] The tone used for determining the characteristic frequency may be an internal tone generated in the hearing aid, in which case so-called on-the-fly matching is possible, that is the hearing aid may be matched whenever needed without external devices being necessary. Hence matching after measuring a change in the tinnitus or after an adjustment of the hearing aid may be performed readily without delay.

[0049] Alternatively the tone may be an external tone generated in an external device an

transmitted to and reproduced by the hearing aid. This would enable matching performed in a user-controlled environment, e.g. as part of a so-called self-fitting procedure in which the user performs the fitting without the need of an audiologist, or as part of a fitting procedure in a so-called user environment.

[0050] A possible alternative, regardless of the source of the tone, is a remote controlled band stop filter adjustment - that is a matching procedure performed by means of a hearing aid remote control. Obviously, the matching may also be performed as an audiologist-assisted matching procedure, e.g. as part of a standard fitting procedure known *per se*.

[0051] In a further step the band stop filter may be switched into or out of the hearing aid signal path in response to detection of a trigger event. Examples on such trigger events are given in the introductory part of the description.

[0052] When the band stop filter is switched into the hearing aid signal path, audio signals filtered by means of the band stop filter and presented for the hearing aid user have been shown to be particularly efficient for alleviating tinnitus, in particular when the audio signals are music or similar relaxing sounds. Therefore it is preferred to be able to switch the band stop filter into the hearing aid signal path in response to the hearing aid detecting an audio signal comprising mainly music. The music audio signal can be received from a variety of hearing aid audio inputs such as a microphone, a telecoil, a wireless link adapted for audio streaming or internally generated fractal music. Hereby sounds for alleviating tinnitus can be provided for the hearing aid user in a simple manner that does not require synthetic generation of the sounds for the tinnitus alleviation.

[0053] It is also particularly useful to be able to switch the band stop filter out of the hearing aid signal path when the hearing aid detects a sound environment primarily being speech. Thereby it is avoided that the band stop filter compromises the hearing aid user's ability to understand the speech.

[0054] During a period of alleviating the user's tinnitus, the tinnitus parameters may change, and it may therefore be necessary to adjust the band stop filter parameters in order to continuously ensure an optimal alleviation. Such an adjustment may obviously be performed by simply repeating the matching method according to the invention at intervals without knowing on pre-hand whether the tinnitus parameters have actually changed.

[0055] It is preferred, however, to first acquire a measurement giving an indication on whether the tinnitus parameters have changed according to the user's perception of his or her tinnitus and base the adjustment of the band stop filter on this measurement. Such a measurement may be acquired by measuring the user's Auditory Steady-State Response (ASSR). Thereby an adaptive band stop filter may be obtained.

[0056] The ASSR is measured by means of electroencephalography (EEG) or magnetoencephalography (MEG) in methods being known in the art *per se*.

[0057] The EEG or MEG measurement is made by means of the hearing aid. Thereby the user's perception of his or her tinnitus, i.e. whether it is unchanged, improved or deteriorated, may be evaluated and the band stop filter parameters (center frequency, width, damping etc.) may be adjusted accordingly either manually, e.g. by the user or an audiologist, or automatically, e.g. by means of the hearing aid itself by executing a specially adapted hearing aid program.

[0058] Another particularly useful feature is to be able to log parameters regarding the method according to the invention in a memory unit, the parameters including but not being limited to parameters such as tone output level and frequency, characteristic frequency and spectral width of the perceived tinnitus, filter parameters, parameters regarding the switching on and/or off of the band stop filter, the user's hearing threshold and UCL and parameters regarding ASSR measurements.

[0059] Thereby it becomes possible to monitor both the progress of the method and, which is more essential, the progress and effects of the tinnitus alleviation by evaluating the logged data monitoring i.e. how the tinnitus develops, how, when and for how long the filter is used and so forth, and thereby to alter or adjust the alleviation in an appropriate manner. Furthermore, logging data enables the possibility of giving feedback regarding the alleviation to the user, an audiologist or another relevant person.

[0060] Fig. 6 shows the equipment necessary for carrying out a method illustrated in fig. 1 and optionally including the above described step of switching on or off the band stop filter in response to detecting a trigger event in the case where the matching procedure is carried out as part of a fitting session assisted by professional staff such as an audiologist or fitter 63.

[0061] The equipment includes a hearing aid 62 according to the invention. Such a hearing aid 62 will be described in further detail below, but generally comprises an input transducer, a signal processing unit, an output transducer and a band stop filter. The hearing aid 62 also comprises a switch and switch control means for controlling the activation and de-activation of said band stop filter.

[0062] The hearing aid 62 is in wireless or threaded communication with suitable hearing aid fitting hardware, such as a computer 61, comprising fitting software. Depending on the electronics and software present in the computer 61 and the hearing aid 62, respectively, the method may be carried out wholly or partly by the computer 61 or by the hearing aid 62.

[0063] Fig. 7 shows the equipment necessary for carrying out a method as illustrated in fig. 1, and optionally including the above described step of activating and de-activating the band stop filter, in the case where the matching procedure is carried out by the user 75 on his or her own. To this end the hearing aid 72 is supplied with an external device 74, such as a hearing aid remote control, which is operated by the user 75, adapted for wireless or threaded data communication with the hearing aid 72 and intended for carrying out a free matching

procedure as described above in connection with fig. 4.

[0064] In the following a hearing aid according to the invention will be described with reference to figs. 8, 9 and 10.

[0065] Fig. 8 shows highly schematically selected parts of a hearing aid according to a first embodiment of the invention. The hearing aid 82 comprises an audio input 83 providing an audio signal, a digital signal processing unit (DSP) 88, an output transducer shown as a speaker 80 and a band stop filter 87.

[0066] The audio signals provided by the audio input 83 may be generated internally in the hearing aid or be generated externally and transmitted to and reproduced by the hearing aid. Fractal music may be generated internally in the hearing aid or the audio signals may be transmitted from an external unit such as a computer, television or mp3 player and to the hearing aid using e.g. telecoils or wireless data links, or the hearing aid may be operated in standard mode with the microphone providing the audio signals from the surroundings. Preferably, the audio signals are normal music or fractal music, as the latter type of music may be particularly useful for alleviating tinnitus when filtered.

[0067] The hearing aid 82 further comprises a switch control 84 controlling a switch 86 arranged for switching the band stop filter into or out from the hearing aid signal path in response to detection of a trigger events. In practice the switch may be set to transmit an audio signal from the audio input 83 through the band stop filter 87 and on to the DSP 88 or alternatively directly to the DSP 88 from the audio input. The output of the DSP 88 is transmitted to the output transducer 80. The switch control 84 is in turn controlled automatically by a classifier 89 or DSP 88 or controlled manually by the user 75, additionally the control may be based on the selected type of audio input.

[0068] According to an embodiment the classifier 89 is adapted to perform speech detection and the switch control 84 is adapted to automatically switch the band stop filter 87 out from the hearing aid signal path when the classifier 89 detects speech.

[0069] Fig. 9 shows highly schematically selected parts of a hearing aid according to a second embodiment of the invention. The hearing aid 92 may in addition to the components shown in fig. 9 comprise any of the components described above in connection with fig. 8.

[0070] The hearing aid 92 further comprises a filter control means 94 for controlling an adaptation of said band stop filter in response to a registered change in the perceived strength of the tinnitus and a tinnitus monitoring means 99 for monitoring the strength of the perceived tinnitus. The filter control means 94 may comprise a classifier and it may be a part of the DSP 98.

[0071] The tinnitus monitoring means 99 registers changes in the strength of the perceived tinnitus based on measurements of an Auditory Steady-State Response (ASSR) of the user 75.

The ASSR is measured by means of EEG or MEG. The tinnitus monitoring means 99 comprises electrodes adapted for detecting brain signals, such as EEG-signals, for measuring said ASSR. Such electrodes may be placed on or imbedded in the surface of the hearing aid 92, or may be external electrodes, such as e.g. scalp electrodes of an EEG-measurement system known *per se*. Alternatively, the tinnitus monitoring means 99 may comprise means for measuring an MEG, such as a Magnetic Resonance Imaging (MRI) unit.

[0072] According to an embodiment the tinnitus monitoring means can be used to determine when the strength of the perceived tinnitus is so small that the band stop filter can be switched out from the hearing aid signal path. According to another embodiment the output from the tinnitus monitoring means is logged and stored in a data memory.

[0073] Fig. 10 shows highly schematically selected parts of a hearing aid according to a third embodiment of the second aspect of the invention. The hearing aid 102 comprises an audio input 83 providing an audio signal, a band stop filter 87, a DSP 108, a speaker 80 and a transposer 110. The audio signal is fed to the band stop filter 87 and to the input of the transposer 110. Hereby the band stop filter 87 removes a certain band of frequencies from the audio signal to create a band stop filtered audio signal and the transposer 110 transposes that same band of frequencies in the audio signal to create a frequency transposed audio signal. The band stop filtered audio signal and the frequency transposed audio signal are fed to the DSP 108, where the signals are added and further processed. Hereby it becomes possible to have the band stop filter switched into the hearing aid signal path, even in the presence of speech, without compromising speech intelligibility too much or at all.

[0074] The hearing aid 102 may in addition to the components shown in fig. 10 comprise any of the components described above in connection with figs. 8 and 9.

[0075] Fig. 11 shows highly schematically selected parts of a hearing aid according to a fourth embodiment of the second aspect of the invention. The hearing aid 112 comprises an audio input 83, a switch 86, switch control means 114, a band stop filter 87, a digital signal processor (DSP) 118 and a speaker 80. According to this embodiment the switch 116 and band stop filter 87 are positioned downstream of the digital signal processor and upstream of the speaker. Hereby the band stop filter will not have any negative impact on the various noise suppressing and speech intelligibility enhancing algorithms in the digital signal processor.

[0076] The hearing aid 112 may in addition to the components shown in fig. 11 comprise any of the components described above in connection with figs. 8, 9 and 10.

[0077] Furthermore, in a not shown embodiment, a hearing aid according to the second aspect of the invention may comprise a means for logging data, such as a memory. Such a data logging means may be a part of the DSP or be a separate component of the hearing aid. It may also be an external unit, such as e.g. a computer (cf. figs. 6 and 7). The data logging means may also be the same memory as the one described above comprising hearing aid programs.

[0078] The data logged by the means for logging data regards, but are not limited to, at least one of: the time per day in which the band stop filter has been switched into the hearing aid signal path, the switching events of the band stop filter, the time per day the means for presenting an audio signal is active, and parameters characterizing any one of the tinnitus of the user, parameters of the band stop filter and the audio signal.

[0079] Preferably the hearing aid further comprises means for providing feedback to the user based on said logged data. Such a feedback may e.g. be a speech signal providing a message, or a particular audio or alarm signal.

REFERENCES CITED IN THE DESCRIPTION

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- **NEIL A. MACMILLAN, DOUGLAS CREELMAN** *Detection theory: a user's guide* Lawrence Erlbaum Associates, 2005, [0040]

Patentkrav

1. Høreapparat indrettet til at lindre tinnitus af en bruger, idet nævnte høreapparat omfatter et lydindgangsorgan, en signalbehandlingsenhed og en udgangstransducer, idet høreapparatet yderligere omfatter et båndstopfilter
- 5 indrettet til at passe til en tinnitus af brugeren og omskifterorgan og omskifterstyringsorgan til at styre omskiftningen af nævnte båndstopfilter ind i og ud af signalstien mellem lydindgangsorganet og udgangstransduceren, som reaktion på en foruddefineret udløserhændelse, hvor nævnte lydindgangsorgan er valgt fra en gruppe omfattende en mikrofon, en teleslynge, et trådløst datalink og
- 10 en signalgenerator og **KENDETEGNET VED AT** høreapparatet yderligere omfatter: båndstopfilterstyringsorgan og tinnitusovervågningsorgan til at styre tilpasningen af båndstopfilterparametre som reaktion på en registreret ændring i den opfattede styrke af høreapparatbrugerens tinnitus, og hvor nævnte tinnitusovervågningsorgan omfatter organ til at måle elektroencefalografi-(EEG)-
- 15 signaler af nævnte bruger.
2. Høreapparat ifølge krav 1, **kendetegnet ved at** nævnte udløserhændelse omfatter, at høreapparatet detekterer, at musik tilvejebringes fra lydindgangen.
- 20 3. Høreapparat ifølge krav 2, **kendetegnet ved at** en høreapparatsklassifikator er anbragt til at detektere, hvorvidt musik tilvejebringes fra lydindgangen.
4. Høreapparat ifølge krav 1, **kendetegnet ved at** nævnte udløserhændelse initieres af høreapparatsbrugerens.
- 25 5. Høreapparat ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved at** det yderligere omfatter en frekvensomsætter indrettet til at omsætte et bånd af frekvenser, hvor båndet af frekvenser, der omsættes, svarer til båndet af frekvenser, der udfiltreres af båndstopfilteret.
- 30 6. Høreapparat ifølge et hvilket som helst af kravene 1 til 5, **kendetegnet ved at** det yderligere omfatter organ til at logge data vedrørende mindst en af følgende:
- tid pr. dag, hvor båndstopfilteret omskiftes til signalstien,
 - omskifterhændelser af båndstopfilteret,

- tid pr. dag, hvor nævnte signalgenerator er aktiv,
- parametre, der kendetegner den opfattede styrke af nævnte tinnitus af nævnte bruger, og
- parametre, der kendetegner indstillingerne af nævnte båndstopfilter.

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7. Høreapparat ifølge krav 6, **kendetegnet ved at** det yderligere omfatter organ til at tilvejebringe feedback til nævnte bruger vedrørende tinnitusen af nævnte bruger.

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8. Høreapparat ifølge et hvilket som helst af kravene 1 til 7, **kendetegnet ved at** nævnte høreapparat omfatter taledetekteringsorgan anbragt med henblik på at tilvejebringe, at båndstopfilteret omskiftes ud af signalstien, når tale detekteres.

15 **9.** Høreapparat ifølge et hvilket som helst af kravene 1 til 8 **kendetegnet ved at** det yderligere omfatter tinnitustilpasningsorgan til at tilpasse båndstopfilteret til tinnitussen af brugeren.

DRAWINGS

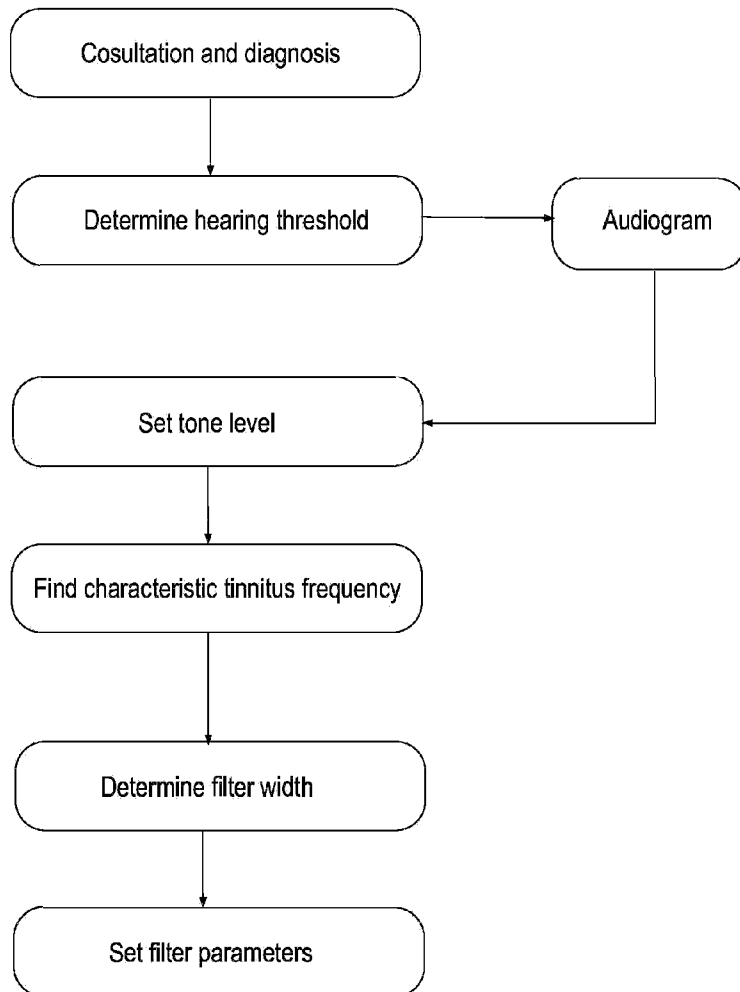
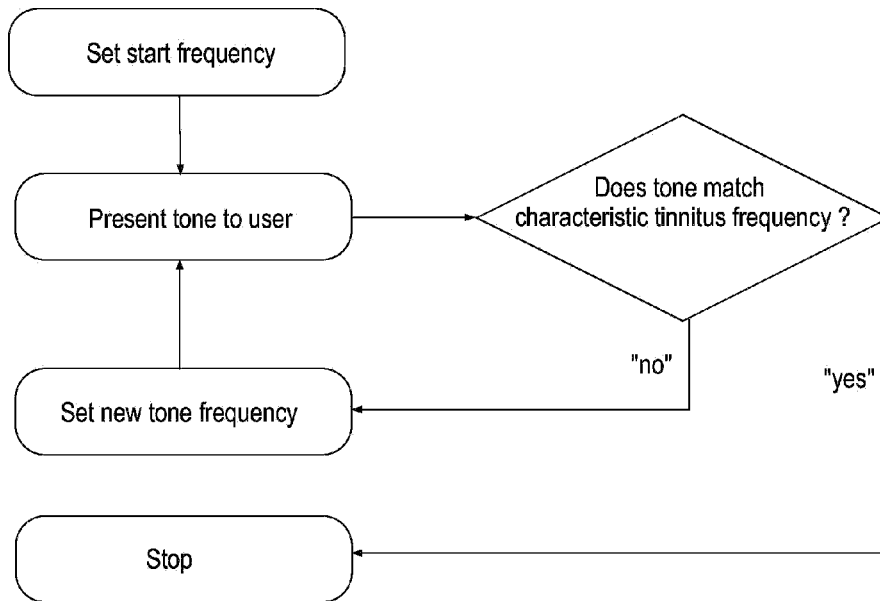
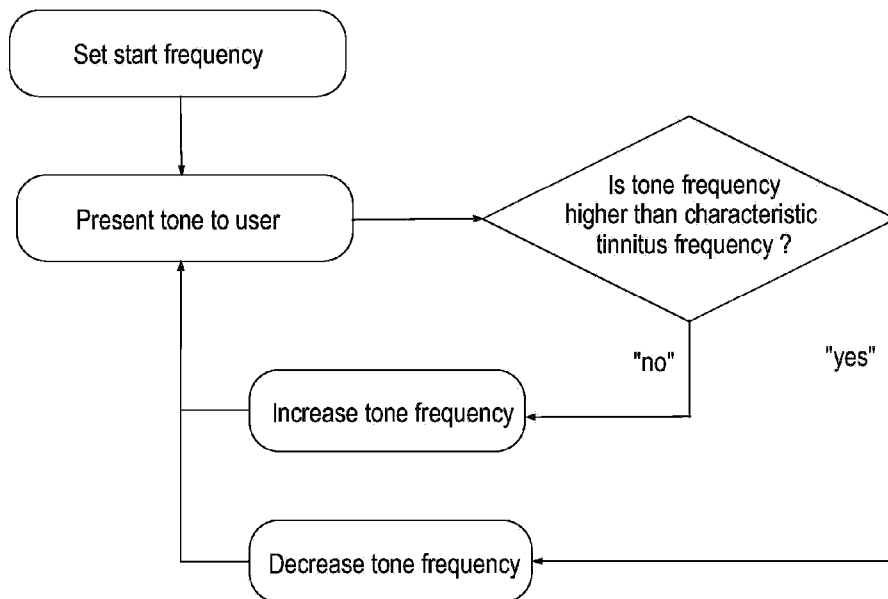
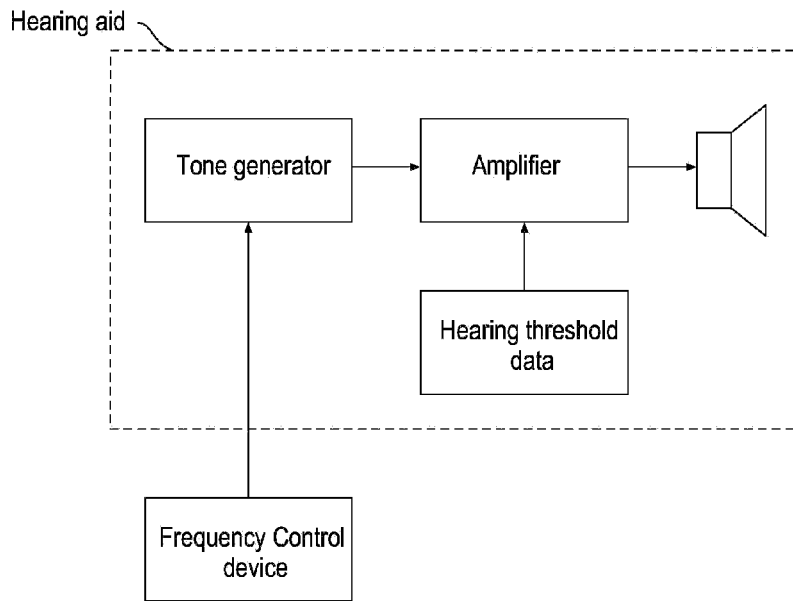
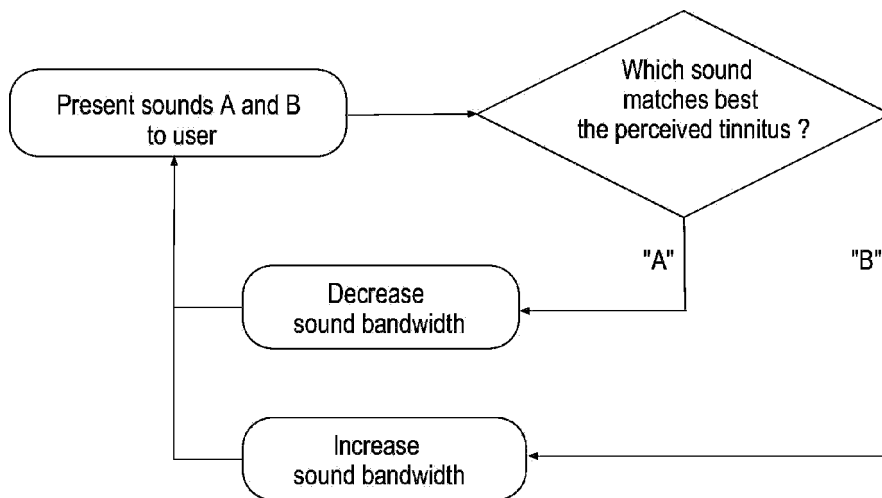
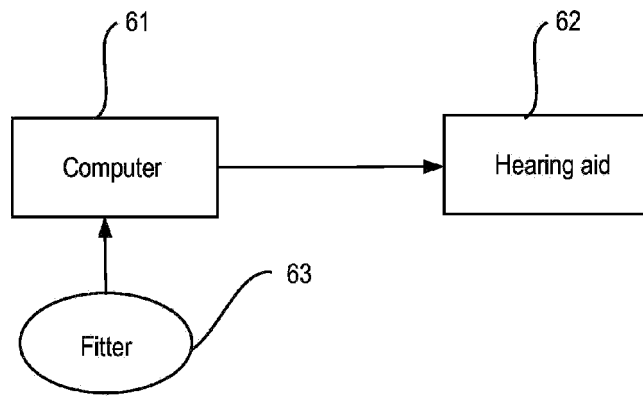
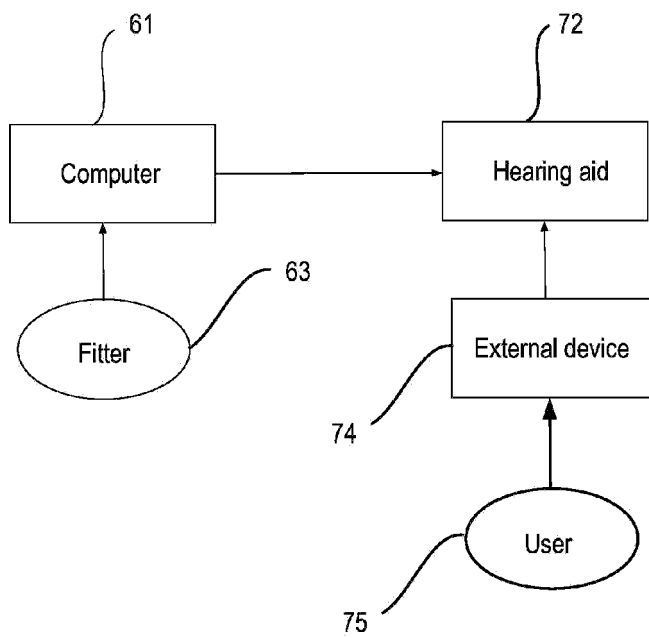
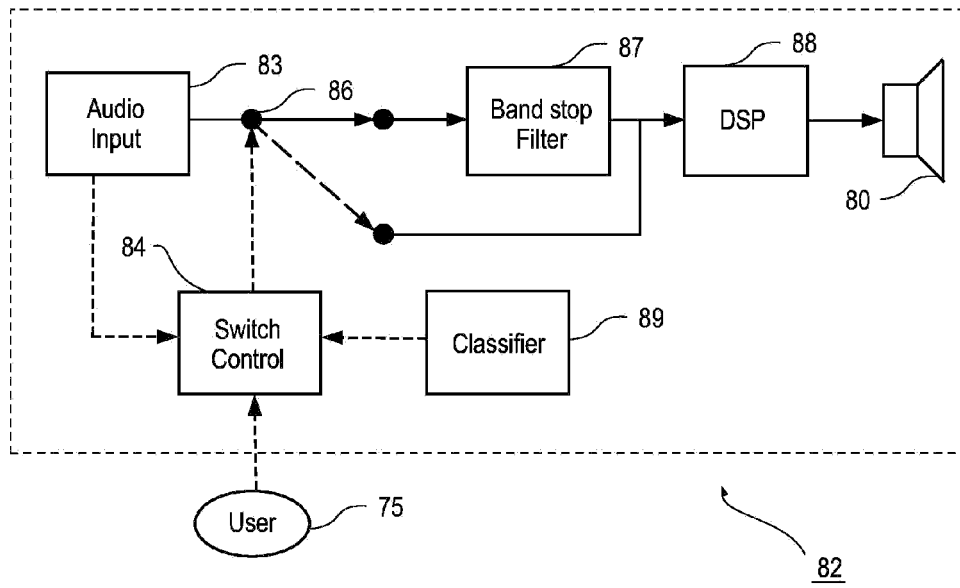
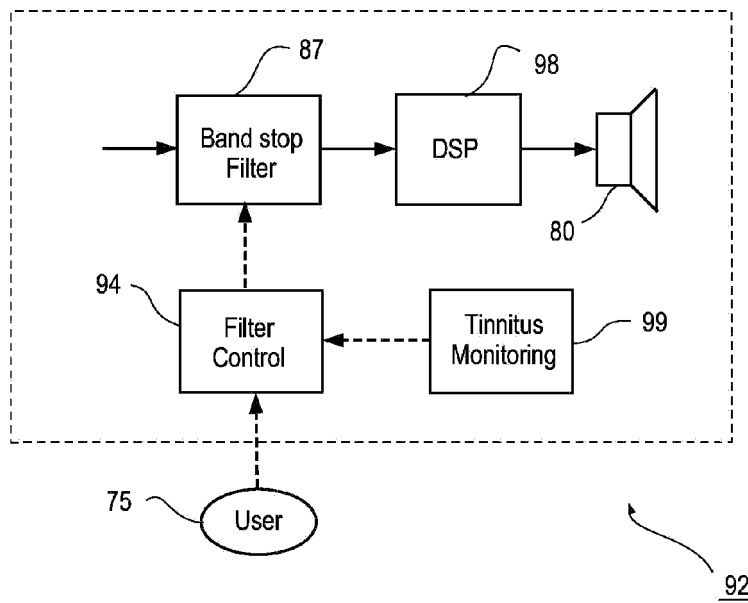


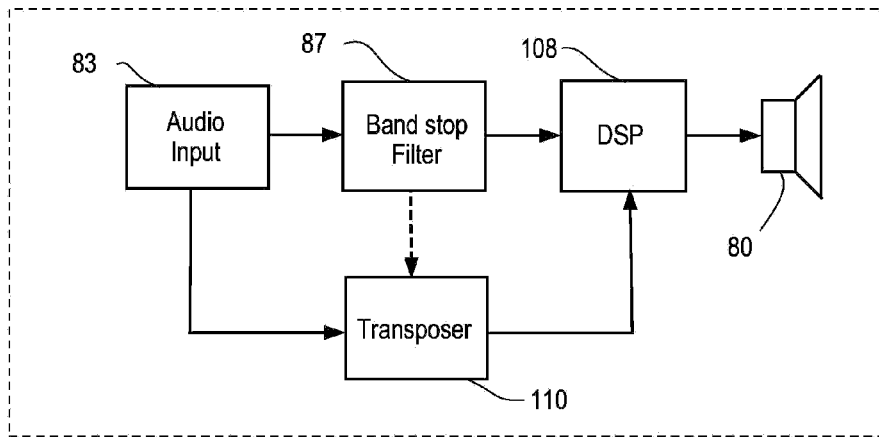
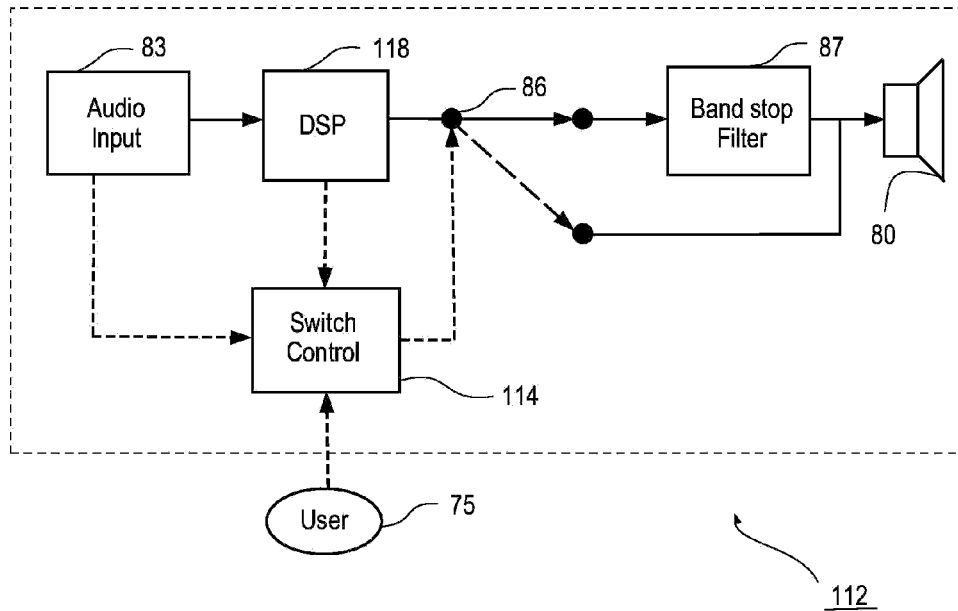
Fig. 1

**Fig. 2****Fig. 3**

**Fig. 4****Fig. 5**

**Fig. 6****Fig. 7**

**Fig. 8****Fig. 9**

102**Fig. 10**112**Fig. 11**