music that he or she finds enjoyable, and receives a recording of the 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.

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.

The present invention therefore aims at providing a method for matching a hearing aid band stop filter, or notch filter, to a tinnitus, which method provides for an improved matching of the band stop filter to the tinnitus, and which method may be performed without or with a minimum of expensive and complicated equipment. The present invention further aims at providing a hearing aid having a band stop filter, or notch filter, and control means for selectively activating the band stop filter whenever music or other types of enjoyable or relaxing sounds are detected by the hearing aid, hereby providing the patient with the possibility of modifying, as described above, all the sounds that the patient has access to from his surroundings.

Herein disclosed, in a first approach, is~~According to a first aspect of the invention this object is achieved by~~ a method for matching a hearing aid band stop filter to a tinnitus comprising the steps of providing a hearing aid comprising a band stop filter, using the hearing aid to present for the user a tone comprising a predetermined output level and frequency, using tones presented by the hearing aid to determine a characteristic frequency of the tinnitus of the user of the hearing aid, setting a center frequency of the band stop filter based on the determined characteristic frequency of the tinnitus, using sound presented by the hearing aid to determine the spectral width of the perceived tinnitus, and setting a spectral width of

the band stop filter based on the determined spectral width of the perceived tinnitus.

Thereby a method for matching a hearing aid band stop filter to a tinnitus is provided with which the whole matching procedure may be performed using the same source to present audio signals to the user for determining the relevant parameters of the tinnitus. Consequently, the spectral width of the filter may be chosen to precisely match the frequency distribution of the tinnitus, hence filtering out as few frequencies as possible, while suppressing substantially all frequencies of the tinnitus and thereby affecting the sound image perceived by the user minimally.

The method ~~according to the invention~~ to match a hearing aid band stop filter to a tinnitus may be performed solely or at least substantially solely using a hearing aid and thereby enables alleviating the tinnitus of a user by means of a hearing aid. This in turn provides for alleviating tinnitus using simple and relatively cheaper equipment, which may advantageously be used outside of laboratory environments during the user's everyday life.

In a preferred embodiment the step of determining a spectral width of the perceived tinnitus comprises the steps of presenting a first plurality of audio signals to the user and determining by selection which of the plurality of signals comprise the highest resemblance with the tinnitus. In a further preferred embodiment the step of determining a spectral width of the perceived tinnitus further comprises repeating the abovementioned steps with a second plurality of audio signals having a bandwidth being either narrower or wider than the bandwidth of the first plurality of signals. Preferably, the audio signals are narrow band noise signals.

In a preferred embodiment the method comprises the further steps of determining the users hearing threshold and setting the tone at a predetermined output level with respect to the hearing threshold. Thereby the user's hearing threshold may be taken into account ensuring that the tone is presented at an output level being audible to the user. Preferably, the predetermined output level corresponds substantially to the determined hearing threshold plus 8 to 16 dB, but not more

ments (see e.g. page 9, line 2 to page 11, line 9 and page 13, line 10 to page 14, line 20).

According to an embodiment the method comprises the further step of transposing the frequencies removed by the filter such as to provide a frequency transposed signal. Frequency transposing is well known in the art of hearing aids. Further details may be found in e.g. EP-B1-1920632.

In a preferred embodiment the method comprises the further step of logging parameters regarding the method in a memory unit, the parameters including but not being limited to parameters relating to the perceived tinnitus such as characteristic frequency and spectral width, parameters relating to the band stop filter such as center frequency and spectral width, parameters regarding the switching of the band stop filter into and out from the hearing aid signal path, parameters regarding the audio signal, the user's hearing threshold and UCL and parameters regarding ASSR measurements. Thereby it becomes possible to monitor the process of alleviating by 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.

According to one embodiment~~a second aspect~~ of 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.

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.

In a preferred embodiment the band stop filter is matched to the tinnitus by means of a method according to any one of the embodiments of the first approach mentioned above~~aspect of the invention~~.

Thereby a hearing aid with a band stop filter matched to a tinni-

tus is provided with which the advantages of the abovementioned method may be readily achieved.

According to one aspect, there is provided a hearing aid adapted for alleviating tinnitus of a user, said hearing aid comprising an audio input means, a signal processing unit and an output transducer c h a r a c t e r i z e d in that the hearing aid further comprises a band stop filter adapted to match a tinnitus of the user and in that the hearing aid further comprises switching means and switch control means for controlling the switching of said band stop filter into and out of the signal path between the audio input means and the output transducer, in response to a predefined trigger event.

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

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 an embodiment of a method according to a first aspect of the invention,

fig. 2 is a diagram illustrating selected steps of a rough matching procedure for determining the characteristic frequency of a tinnitus in a method according to an embodiment of the first aspect of the invention,

fig. 3 is a diagram illustrating selected steps of a fine matching procedure for determining the characteristic frequency of a tinnitus in a method according to an embodiment of the first aspect of the invention,

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 in a method according to an embodiment of the first aspect of the invention,

fig. 5 is a diagram illustrating selected steps of determining a spectral width of a perceived tinnitus in a method according to an embodiment of the first aspect of the invention, and

fig. 6 illustrates a hearing aid according to an embodiment of the second aspect of 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 an embodiment of the second aspect of the invention in association with the equipment necessary for enabling the user to carry out, on his or her own, a method according to an embodiment of the first aspect of the invention,

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

magnetoencephalography (MEG) signals of said user.

10. A hearing aid according to any one of claims 1 to 9, c h a r - a c t e r i z e d in that it further comprises a transposer adapted for transposing a band of frequencies, wherein the band of frequencies, that are transposed, corresponds to the band of frequencies that are filtered out by the band stop filter.

11. A hearing aid according to any one of claims 1 to 10, c h a r a c t e r i z e d in that it further comprises means for logging data regarding at least one of the following:

- time per day in which the band stop filter is switched into the signal path,
- switching events of the band stop filter,
- time per day said signal generator is active,
- parameters characterizing the perceived strength of said tinnitus of said user, and
- parameters characterizing the settings of said band stop filter.

12. A hearing aid according to claim 11, c h a r a c t e r i z e d in that it further comprises means for providing feedback to said user concerning the tinnitus of said user.

13. A hearing aid according to claim 12, wherein said feedback is based on said logged data.

14. A hearing aid according to any one of claims 1 to 13, c h a r a c t e r i z e d in that said hearing aid comprises speech detection means arranged in order to provide that the band stop filter is switched out of the signal path when speech is detected.

15. A hearing aid according to any one of claims 1 to 14 c h a r a c t e r i z e d in that it further comprises tinnitus matching means for matching the band stop filter to the tinnitus of the user.

~~16. A method for matching a hearing aid band stop filter to a~~ tinnitus of a user of said hearing aid comprising the steps of

- providing a hearing aid comprising a band stop filter,
- using the hearing aid to present for the user a tone comprising a predetermined output level and frequency,

~~using tones presented by said hearing aid to determine a~~

characteristic frequency of said tinnitus of said user of said hearing aid,

- setting a center frequency of said band stop filter based on said determined characteristic frequency of said tinnitus,

- using sound presented by said hearing aid to determine a spectral width of the perceived tinnitus of the hearing aid user, and

- setting a spectral width of said band stop filter based on said determined spectral width of the perceived tinnitus of the hearing aid user.

17. A method according to claim 16, characterized in that the step of determining a spectral width of the perceived tinnitus of the hearing aid user comprises the steps of presenting a first plurality of audio signals to said user and determining by selection which of said plurality of signals comprise the highest resemblance with said tinnitus.

18. A method according to claim 17, characterized in further comprising the step of presenting a second plurality of audio signals having a bandwidth being either narrower or wider than the bandwidth of said first plurality of signals.

19. A method according to claim 17 or 18, characterized in that said audio signals are narrow band noise signals.

20. A method according to any one of the above claims, characterized in the further steps of determining said users hearing threshold and setting said tone at a predetermined output level with respect to said hearing threshold.

21. A method according to claim 20, characterized in that said predetermined output level corresponds substantially to said determined hearing threshold plus 8 to 16 dB, but not more than between 4 and 8 dB below an uncomfortable level (UCL).

22. A method according to any one of the claims 16 to 21, where the step of determining said characteristic frequency of said tinnitus comprises the steps of performing a rough matching procedure followed by a fine matching procedure, wherein

said rough matching procedure comprises the steps of adjusting a frequency of said tone to be continuously or stepwise falling or rising, stopping said adjustment when said user indicates that said tone

matches said tinnitus, registering the frequency thus found and performing the steps at least once with the frequency falling and at least once with the frequency rising and until a pair of frequencies, found with a falling and rising tone respectively, fall within a range of about one octave, and wherein

said fine matching procedure comprises the steps of adjusting a frequency of a tone to be falling or rising, and reversing the direction of adjustment in response to a user decision, stopping the fine matching procedure when a predefined number of reversals have occurred, determining the characteristic tinnitus frequency of the hearing aid user based on a set of the reversal points and the frequencies corresponding to the reversal points.

23. A method according to any one of the claims 16 to 21, characterized in that the step of determining said characteristic frequency of said tinnitus comprises the further steps of providing said tone with a continuously or stepwise variable frequency, providing a user controlled device for adjusting said frequency until said tone matches said tinnitus, registering the frequency thus found, repeating the previous steps at least once and until two successive frequency registrations fall within a frequency range with a given bandwidth and determining the characteristic tinnitus frequency of the hearing aid user based on said frequency registrations.

24. A method according to any one of the claims 16 to 23, characterized in the further step of switching the band stop filter into or out of the hearing aid signal path in response to detection of a trigger event.

25. A method according to claim 24, characterized in that said trigger event is selected from the group comprising:

- said hearing aid detecting that the sound environment is primarily music,
- said hearing aid detecting that the sound environment is primarily speech,
- said hearing aid detecting that music is streamed directly from an external unit, and

- said hearing aid detecting that specially synthesized tones generated internally in said hearing aid (fractal music) are presented to the user.

26. A method according to any one of the claims 16 to 25, characterized in the further step of setting the attenuation of said band stop filter.

27. A method according to any one of the claims 16 to 26, characterized in the further step of regularly adjusting at least one of the band stop filter center frequency and band stop filter bandwidth based on measurements of an Auditory Steady-State Response (ASSR) of said user.

28. A method according to claim 27, characterized in that said ASSR is measured by means of electroencephalography (EEG) or magnetoencephalography (MEG).

29. A method according to any one of the claims 16 to 28, characterized in the further step of transposing a band of frequencies, wherein the band of frequencies, that are transposed, corresponds to the band of frequencies that are filtered out by the band stop filter.

30. A method according to any one of the above claims, characterized in the further step of logging parameters regarding said method in a memory unit, said parameters comprising at least one of tone output level and frequency, characteristic frequency and spectral width of the perceived tinnitus of the hearing aid user of said tinnitus, band stop filter parameters, parameters regarding the switching of the band stop filter into and out from the hearing aid signal path, said user's hearing threshold and UCL and parameters regarding ASSR measurements.