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(54) Title: METHOD FOR MONITORING A FIT OF A HEARING DEVICE AS WELL AS A HEARING DEVICE

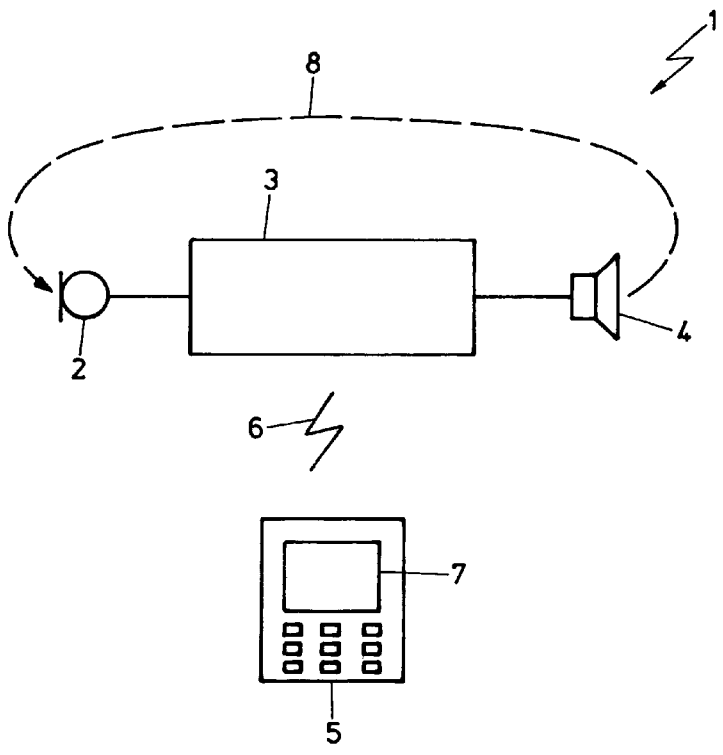

FIG.2

(57) Abstract: A method for monitoring a fit of a hearing device (1) that is at least partially inserted into an ear canal of a hearing device user is described. The method comprises the steps of estimating a feedback measure reflecting behavior between a receiver (4) and a microphone (2) of the hearing device (1) inserted into an ear, comparing the estimated feedback measure with a predetermined feedback measure, and indicating a misfit once the comparison of the estimated feedback measure with the predetermined feedback measure shows that the hearing device (1) is not properly inserted into the ear canal of the hearing device user.

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METHOD FOR MONITORING A FIT OF A HEARING DEVICE AS WELL AS A HEARING DEVICE

TECHNICAL FIELD

The present invention is related to a method for monitoring a fit of a hearing device that is at least partially inserted into an ear canal of a hearing device user as well as to a hearing device.

BACKGROUND OF THE INVENTION

A correct insertion and a good fit of a hearing device in the ear canal of the hearing device user is very important in order to obtain good and reliable, i.e. repeatable, acoustics. A bad fit of the hearing device leads to a poor acoustic coupling and will generate a lot of issues such as feedback, unreliable acoustics, i.e. wrong frequency response, which finally leads to unhappy hearing device users.

A hearing device, once inserted into the ear canal, does not remain at the same position but will move due to jawbone movements, for example. A relocation of a hearing device may even result in that the hearing device falls out of the ear canal. The hearing device user is often not aware that his hearing device has moved although the acoustics have been changed as a result of the movement of the hearing device. Even if the hearing device falls out of

the ear canal, the hearing device user does often not realize the loss of his hearing device.

Therefore, an object of the present invention is to provide a method for monitoring a fit of a hearing device in order to prevent the above-mentioned disadvantages.

The present invention is defined by the steps of claim 1. Further embodiments as well as a hearing device are defined in further claims.

SUMMARY OF THE INVENTION

A method for monitoring a fit of a hearing device, which is at least partially inserted into an ear canal of a hearing device user, is described first. The method comprises the steps of:

- estimating a feedback measure reflecting behavior between a receiver and at least one microphone of the hearing device inserted into an ear,
- comparing the estimated feedback measure with a predetermined feedback measure, and
- indicating a misfit once the comparison of the estimated feedback measure with the predetermined feedback measure shows that the hearing device is not properly inserted into the ear canal of the hearing device user.

It is pointed out that the term "hearing device" must be understood as a part that has influence on the acoustic

coupling of a device to the ear, as for example a hearing aid that is used to improve the hearing of a hearing impaired person. Furthermore, the term "hearing device" may also mean an ear mold or a slim tube. In addition, a hearing device may also be a binaural hearing aid. Finally, the term "hearing device" must be understood to comprise any communication device that is insertable into the ear, be it wired or wireless, and must also be understood to comprise hearing protection devices.

The present invention has at least one of the following advantages:

- A fit of the hearing device can be checked while wearing it.
- Elderly people that often do not realize when their hearing device do not fit properly in the ear are assisted by the hearing device.
- People taking care of an elderly person can easily check whether the hearing device properly fits in the ear.
- Parents can easily check whether the hearing device of their children properly fits in the ear.
- A loss of a hearing device can be detected very fast so that the likelihood of retrieving the lost hearing device is very high.

It is pointed out that the term "predetermined feedback measure" must be understood in various manners. For example, it may simply mean a specific predetermined

feedback threshold but it may also mean a predetermined feedback transfer function reflecting a corresponding frequency range. In addition, certain situations may be taken into account, as for example in case the hearing device user wears a hat or in case the hearing device user holds a cellular phone close to one of his ears. Such different situations may be taken into account by evaluating these situations during the fitting procedure in which situation-specific predetermined feedback measures are determined and stored in the hearing device or its accessory for later access. Therefore, such hearing devices are able to differentiate between normal feedback, feedback due to a hat or cellular or regular phone, and feedback due to a bad fit of the earmold.

In an embodiment of the present invention, the feedback measure and the corresponding predetermined feedback measure is related to one of the following:

- feedback transfer function,
- feedback threshold.

In further embodiments of the present invention, the predetermined feedback measure is equal to a feedback threshold, at which just no feedback occurs when the hearing device is properly inserted into the ear canal, and wherein a misfit is indicated as soon as an estimated feedback threshold is lower than the predetermined feedback threshold.

In further embodiments of the present invention, the predetermined feedback measure is determined during a fitting session.

In further embodiments of the present invention, the predetermined feedback measure is stored in a memory unit that is contained in the hearing device or in an accessory device being operatively connected to the hearing device.

In further embodiments of the present invention, the step of indicating a misfit is implemented by at least one of the following manner:

- generating a warning beep in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- generating a vibration in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- sending a message to an accessory device being operatively connected to the hearing device.

In further embodiments of the present invention, the method further comprises the steps of:

- providing a series of estimated feedback measures by continuously estimating feedback measure at a predetermined sampling rate,
- recording the series of estimated feedback measures in order to establish a long term development of the fit of the hearing device in the ear canal,

- deriving a point in time for exchanging an ear mold from the long term development, and
- indicating to the hearing device user as soon as the point in time is reached at which the ear mold of his hearing device must be exchanged.

In further embodiments of the present invention, the step of indicating to the hearing device user to exchange the ear mold by at least one of the following manner:

- generating a warning beep in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- generating a vibration in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- sending a message to an accessory device being operatively connected to the hearing device.

Furthermore, the present invention is also directed to a hearing device comprising:

- at least one microphone,
- a receiver,
- a signal processing unit that is operatively connected to the at least one microphone as well as to the receiver,
- means for estimating a feedback measure reflecting behavior between the receiver and the at least one microphone of the hearing device inserted into an ear,

- means for comparing the estimated feedback measure with a predetermined feedback measure, and
- means for indicating a misfit once the comparison of the estimated feedback measure with the predetermined feedback measure shows that the hearing device is not properly inserted into the ear canal of the hearing device user.

In an embodiment of the inventive hearing device, the feedback measure and the corresponding predetermined feedback measure is related to one of the following:

- feedback transfer function,
- feedback threshold.

In further embodiments of the present invention, the hearing device further comprises a memory storage unit for storing the predetermined feedback measure.

In further embodiments of the present invention, the hearing device further comprises an accessory device that is operatively connectable to the signal processing unit.

In further embodiments of the present invention, the accessory device comprises at least one of the following:

- a remote storage unit for storing the predetermined feedback measure,
- a display for displaying a misfit,
- a vibration unit for indicating a misfit,
- a loudspeaker for outputting an acoustic signal.

In further embodiments of the present invention, the hearing device further comprises:

- means for providing a series of estimated feedback measures by continuously estimating feedback measure at a predetermined sampling rate,
- means for recording the series of estimated feedback measures in order to establish a long term development of the fit of the hearing device in the ear canal,
- means for deriving a point in time for exchanging an ear mold from the long term development, and
- means for indicating to the hearing device user as soon as the point in time is reached at which the ear mold of his hearing device must be exchanged.

In further embodiments of the present invention, the means for indicating to the hearing device user to exchange the ear mold at least comprise one of the following:

- a loudspeaker, in particular for generating a warning beep,
- a vibration unit,
- a transmitting unit for sending a message to an accessory device.

It is pointed out that the present invention is directed to every possible combination of the above-mentioned embodiments. Only those combinations are excluded which would result in a contradiction.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further described in the following by referring to drawings showing exemplified embodiments of the present invention.

Fig. 1 shows a flow chart in which the main steps of the method according to the present invention are depicted, and

Fig. 2 shows a simplified block diagram of a hearing device according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows a flow chart in which the main steps of the method according to the present invention are depicted. In a first step, a feedback measure is estimated, the feedback measure being indicative of circumstances in relation to a fit of the hearing device housing in the ear canal. For example, a bad fit of the hearing device housing in the ear canal will result in a lower feedback level which means that the hearing device user may be exposed to a loud whistle sound. In this case the hearing device is useless to its user.

A misfit of the hearing device housing is detected as soon as a predetermined feedback measure, which can be seen, for example, as a threshold below or above which a misfit can be assumed, is lower or higher, respectively, than the

estimated feedback measure presently determined. As long as no misfit has been detected, the step of estimating the feedback measure is repeated.

In case a misfit has been detected by the step of comparing the estimated feedback measure with the predetermined feedback measure, the misfit is indicated to the hearing device user in order that the hearing device user can take an appropriate action, for example, by reinserting the hearing device into the correct position. Due to the ongoing estimation of the feedback measure, a good fit is resulting in that the indication is turned off. Therewith, the hearing device user has an immediate confirmation regarding the fit of the hearing device in the ear canal.

As has already been pointed out, the feedback measure and the corresponding predetermined feedback measure are, for example, related to a feedback transfer function or a feedback threshold. Since the feedback transfer function reflects the transfer function from the receiver (reference sign 4 in Fig. 2) of the hearing device to the microphone (reference sign 2 in Fig. 2) of the hearing device, the frequency response derived from the feedback transfer function directly gives an indication whether a misfit occurs. Because the feedback transfer function changes in dependence on whether there exists a good fit of the hearing device in the ear canal, the feedback transfer function is a good feedback measure to be used in connection with the present invention.

Instead of using the feedback transfer function, a feedback threshold can also very well be used as a feedback measure. The feedback threshold can also be seen as a maximum gain at which just no feedback occurs. The feedback threshold is also dependent on the fit of a hearing device in the ear canal, i.e. a bad fit results in a lower feedback threshold while a good fit results in a much higher feedback threshold. Accordingly, a feedback threshold can be determined - for example during a fitting session performed by an audiologist - when the hearing device is perfectly inserted into the ear canal of the hearing device user. The obtained feedback threshold can then be set to the predetermined feedback threshold, which is stored, for example, in a storage unit in the hearing device itself or in an accessory device, which is yet to be described. As soon as the estimated feedback threshold decreases - during regular operation - below the predetermined feedback threshold as a result of a shift of the hearing device to a less favorable position in the ear canal, an indication to the hearing device user can be triggered. Thereby, the hearing device user can take an appropriate action, namely to reposition the hearing device in his ear canal, for example.

The method according to the present invention also has the advantage that a loss of a hearing device can be prevented since a falling-out of a hearing device off the ear also results in a great reduction of the estimated feedback threshold. Therefore, the hearing device user can immediately be informed of the loss of his hearing device.

In turn, this increases the likelihood that the fallen-out hearing device can be found again.

The step of indicating a misfit to the hearing device user can be performed in many different ways. For example, the step of indicating can be implemented in at least one of the following manner:

- generating a warning beep in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- generating a vibration in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- sending a message to an accessory device being operatively connected to the hearing device.

In a further embodiment of the present invention, it is proposed to obtain a series of estimated feedback measures by continuously estimating feedback measures at a predetermined sampling rate, and recording the series of estimated feedback measures in order to establish a long term development of the fit of the hearing device in the ear canal. The long term development allows deriving a point in time, at which an ear mold, for example, must be exchanged in order to have sufficient acoustic results with the hearing device.

The indication to the hearing device user regarding the point in time at which the ear mold of the hearing device must be exchanged can be done in a similar manner as

presented above in connection with the misfit indication, namely by:

- generating a warning beep in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- generating a vibration in at least one of the hearing device and an accessory device being operatively connected to the hearing device,
- sending a message to an accessory device being operatively connected to the hearing device.

Of course, a different manner for indicating must be used if two or more instances must be distinguished by the hearing device user.

A block diagram is depicted in Fig. 2 showing a simplified hearing device 1 comprising a microphone 2, a signal processing unit 3 and a loudspeaker 4, which is also called receiver 4 in the hearing device industry. The microphone 2 is used to pick up sound that is processed in the signal processing unit 3 according to a processing scheme depending on a hearing loss of the hearing device user. The sound processed in the signal processing unit 3 is then fed to the receiver 4 which in turn outputs the processed sound into the ear canal of the hearing device user.

While the hearing device 1 is inserted into the ear of the hearing device user, the receiver 4 is positioned in a closed or almost closed volume before the ear drum. Therefore, a feedback signal via a feedback path 8 from the

receiver 4 to the microphone 2 - as it is indicated by a dashed line in Fig. 2 - is strongly attenuated. This allows applying a rather high gain to the sound signal picked-up by the microphone 2 before it is fed into the ear canal via the receiver 4.

In case that the hearing device 1 is shifted in the ear canal, e.g. as a result of jawbone movements, the attenuation is reduced. In turn, a feedback signal (loud whistle) may occur that discomforts the hearing device user to a large extent.

Even if no feedback signal is observed, a misfit of the hearing device in the ear canal of the hearing device user results in at least a reduced acoustic coupling of the hearing device to the ear. A misfit can therefore be detected by analyzing the feedback transfer function describing the feedback path 8.

A further embodiment of the present invention further comprises an accessory device 5 that is operationally connected to the hearing device 1 via a wired or wireless link 6. The accessory device 7 contains a display 7 and an input section, for example. The display is used to indicate to the hearing device user that a misfit occurred and that the hearing device 1 is not properly inserted into the ear canal of the hearing device user. Alternatively, the indication to the hearing device user may also be implemented by an acoustic signal that is generated by a loudspeaker (not shown in Fig. 2) comprised in the

accessory device. Of course, a combination of an acoustic and a visional indication may also be implemented. Furthermore, the accessory device 5 may also contain a vibration unit for indicating a misfit of the hearing device.

As has already been pointed out while describing the method according to the present invention, the hearing device comprises a memory storage unit for storing the predetermined feedback measure. When using an accessory device 5, the memory storage unit may also be implemented in the accessory device 5.

CLAIMS

1. A method for monitoring a fit of a hearing device (1) that is at least partially inserted into an ear canal of a hearing device user, the method comprising the steps of:

- estimating a feedback measure reflecting behavior between a receiver (4) and at least one microphone (2) of the hearing device (1) inserted into an ear,
- comparing the estimated feedback measure with at least one predetermined feedback measure, and
- indicating a misfit once the comparison of the estimated feedback measure with the at least one predetermined feedback measure shows that the hearing device (1) is not properly inserted into the ear canal of the hearing device user.

2. The method of claim 1, wherein the feedback measure and the corresponding at least one predetermined feedback measure is related to one of the following:

- feedback transfer function,
- feedback threshold.

3. The method of claim 1, wherein the at least one predetermined feedback measure is equal to a feedback threshold, at which just no feedback occurs when the hearing device (1) is properly inserted into the ear canal, and wherein a misfit is indicated as soon as an estimated

feedback threshold is lower than the at least one predetermined feedback threshold.

4. The method of one of the claims 1 to 3, wherein the at least one predetermined feedback measure is determined during a fitting session.

5. The method of one of the claims 1 to 4, wherein the at least one predetermined feedback measure is stored in a memory unit that is contained in the hearing device (1) or in an accessory device (5) being operatively connected to the hearing device (1).

6. The method of one of the claims 1 to 5, further comprising the step of determining a predetermined feedback measure while at least one of the following situation occurs:

- a mobile phone is close to an ear of the hearing device user;
- the hearing device user wears a hat;
- the hearing device user wears a scarf.

7. The method of one of the claims 1 to 6, wherein the step of indicating a misfit is implemented by at least one of the following manner:

- generating a warning beep in at least one of the hearing device (1) and an accessory device (5) being operatively connected to the hearing device (1),

- generating a vibration in at least one of the hearing device (1) and an accessory device (5) being operatively connected to the hearing device (1),
- sending a message to an accessory device (5) being operatively connected to the hearing device (1).

8. The method of one of the claims 1 to 7, further comprising the steps of:

- providing a series of estimated feedback measures by continuously estimating feedback measure at a predetermined sampling rate,
- recording the series of estimated feedback measures in order to establish a long term development of the fit of the hearing device (1) in the ear canal,
- deriving a point in time for exchanging an ear mold from the long term development, and
- indicating to the hearing device user as soon as the point in time is reached at which the ear mold of his hearing device (1) must be exchanged.

9. The method of claim 8, wherein the step of indicating to the hearing device user to exchange the ear mold by at least one of the following manner:

- generating a warning beep in at least one of the hearing device (1) and an accessory device (5) being operatively connected to the hearing device (1),
- generating a vibration in at least one of the hearing device (1) and an accessory device (5) being operatively connected to the hearing device (1),

- sending a message to an accessory device (5) being operatively connected to the hearing device (1).

10. A hearing device (1) comprising:

- at least one microphone (2),
- a receiver (4),
- a signal processing unit (3) that is operatively connected to the at least one microphone (2) as well as to the receiver (4),
- means for estimating a feedback measure reflecting behavior between the receiver (4) and the at least one microphone (2) of the hearing device (1) inserted into an ear,
- means for comparing the estimated feedback measure with at least one predetermined feedback measure, and
- means for indicating a misfit once the comparison of the estimated feedback measure with the at least one predetermined feedback measure shows that the hearing device (1) is not properly inserted into the ear canal of the hearing device user.

11. The hearing device of claim 10, wherein the feedback measure and the corresponding at least one predetermined feedback measure is related to one of the following:

- feedback transfer function,
- feedback threshold.

12. The hearing device of claim 10 or 11, further comprising a memory storage unit for storing the at least one predetermined feedback measure.

13. The hearing device of one of the claims 10 to 12, further comprising an accessory device (5) that is operatively connectable to the signal processing unit (3).

14. The hearing device of claim 13, wherein the accessory device (5) comprises at least one of the following:

- a remote storage unit for storing the at least one predetermined feedback measure,
- a display (7) for displaying a misfit,
- a vibration unit for indicating a misfit,
- a loudspeaker for outputting an acoustic signal.

15. The hearing device of one of the claims 10 to 14, further comprising:

- means for providing a series of estimated feedback measures by continuously estimating feedback measure at a predetermined sampling rate,
- means for recording the series of estimated feedback measures in order to establish a long term development of the fit of the hearing device (1) in the ear canal,
- means for deriving a point in time for exchanging an ear mold from the long term development, and
- means for indicating to the hearing device user as soon as the point in time is reached at which the ear mold of his hearing device (1) must be exchanged.

16. The hearing device of claim 15, wherein the means for indicating to the hearing device user to exchange the ear mold at least comprise one of the following:

- a loudspeaker, in particular for generating a warning beep,
- a vibration unit,
- a transmitting unit for sending a message to an accessory device (5).

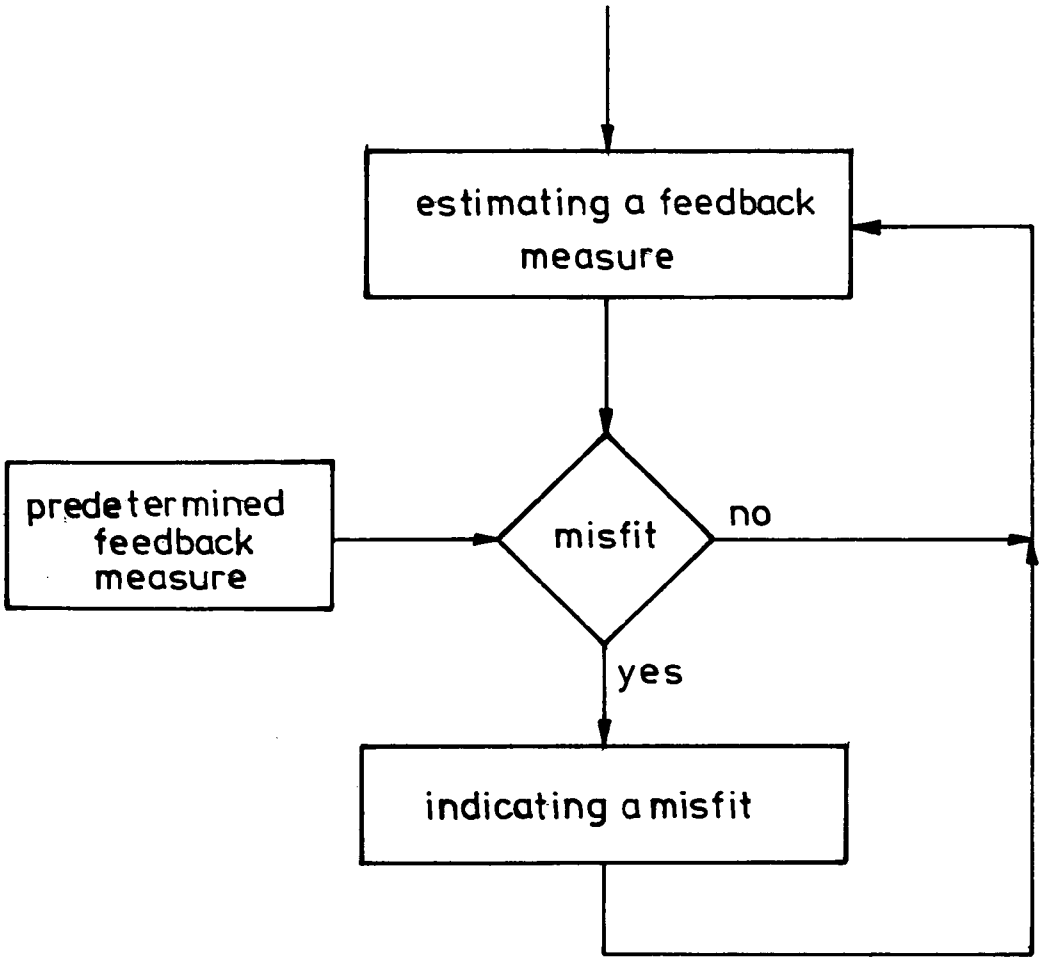
estimating a feedback measure
predetermined feedback measure
misfit
no
yes
indicating a misfit

FIG.1

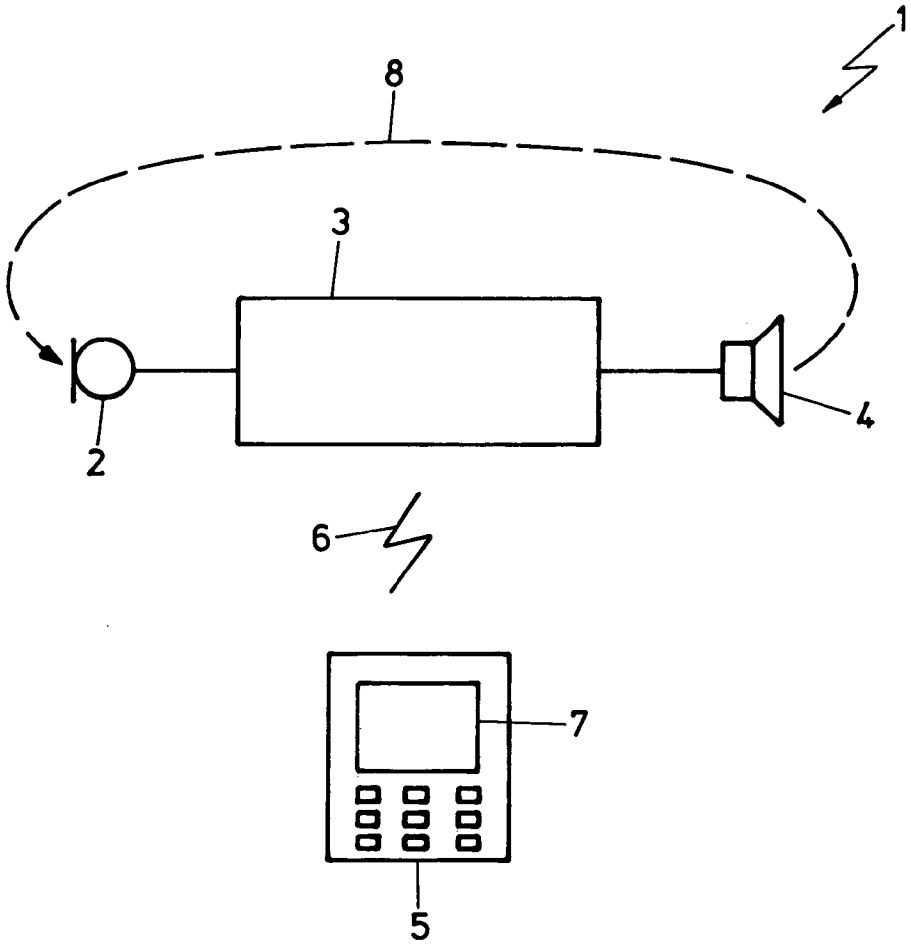

FIG.2