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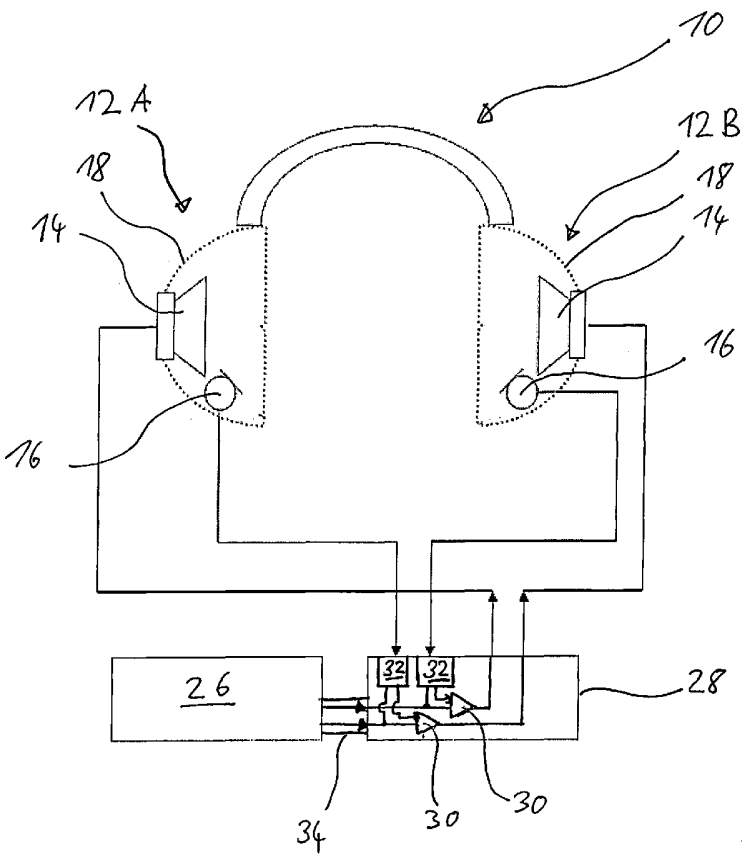
(54) Title: HEARING DEVICE AND METHOD FOR SUPPLYING AUDIO SIGNALS TO A USER WEARING SUCH HEARING DEVICE



(57) Abstract: The invention relates to a hearing system comprising: a hearing device to be worn at or in a user's ear (24) for supplying audio signals to said user and comprising a sound attenuation portion (18, 40) for attenuating ambient sound before reaching the user's ear (24), means (26, 28) for producing audio signals at a controlled level, a loudspeaker (14) which is included in the attenuation portion and which is oriented towards the user's ear canal (22) for providing sound corresponding to the audio signal produced by the audio signal producing means (26, 28) to the user's ear canal (22), a microphone (16) which is included in the attenuation portion (18, 40) and which is oriented towards the user's ear canal (22) for capturing audio signals from the sound provided by the loudspeaker (14) to the user's ear canal (22), and a level control unit (28, 30, 32) adapted to control the level of the audio signals produced by the audio signal producing means (26, 28) according to the audio signals captured by the microphone (16).

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Hearing device and method for supplying audio signals to a user wearing such hearing device

The invention relates to a method for supplying audio signals to a user wearing a hearing device at or in his ear, which comprises a sound attenuation portion for attenuating ambient sound before reaching the user's ear drum, with the sound attenuation portion comprising a loudspeaker which is oriented towards the user's ear canal.

Such a hearing device may be a headphone or an earphone which is used for listening, for example, to music from a portable audio source, such as an MP3 player or a CD player. Usually such audio devices have a manual volume control which is operated by the user of the device according to the desired sound pressure level. One problem encountered with such devices is that the users of such portable audio devices, especially if young people, are tending to use the device at sound pressure levels which may create a hearing damage.

Active hearing protection devices comprise an active communication unit consisting of a microphone for capturing ambient sound, an audio signal processing unit and a loudspeaker for reproducing the sound captured by the microphone to the user's ear according to audio signal processing in the processing unit. Such active hearing protection devices, and also hearing aids, usually comprise some kind of level limitation which is based on the level of the input audio signals to the signal processing unit as provided by the microphone in order to limit the sound pressure level created by the loudspeaker to values which are not dangerous for the user's hearing.

US 6,567,524 B1 relates to an earplug comprising a loudspeaker oriented towards the user's ear canal and a microphone connected to the user's ear canal via a sound passage in order to capture sound in the user's ear canal. According to one embodiment, the earplug may be used as a headphone coupled to a CD player in order to monitor the noise dose submitted from the headphones to the ear over time or in peaks. To this end, the earplug is provided with a signal processing unit.

DE 101 12 305 A1 relates to a hearing protection device comprising an earplug including a microphone oriented towards the user's ear canal for capturing sound in the ear canal and optionally a loudspeaker for providing audio signals to the user. The microphone is connected to a signal processing unit in order to measure in-situ the sound pressure level acting on the user's ear protected by the earplug. If the sound pressure level is found to be too high the

device may take corresponding counter-measures in order to protect the user's hearing from damages. An example of such a counter measure is to act on the machine creating the noise.

It is also known to provide a hearing protection device, such as a headphone or an earplug, with a microphone oriented towards the user's ear canal for picking up sound in the ear canal, an audio signal processing unit and a loudspeaker oriented towards the user's ear canal for performing active noise reduction (ANR) wherein the loudspeaker is used for creating a phase-shifted anti-noise signal. Examples for such ANR hearing protection devices are given in WO 2005/046543 A1, US 6,741,707 B2 and DE 101 17 705 A1.

US 6,689,377 B2 relates to a method for measuring the acoustic attenuation provided by a customized earplug, wherein the earplug is provided with a sound bore extending from the outer side of the earplug to the inner end of the earplug, wherein a remote device is inserted into the outer end of the sound bore, which remote device comprises a first microphone oriented towards the sound bore and a second microphone oriented towards ambience, and wherein test sound is provided by an external loudspeaker. Both the loudspeaker and the remote device are connected to a computer unit on which a measurement program is run. The acoustic attenuation provided by the earplug is calculated from the sound level difference between the first microphone and the second microphone.

US 5,577,511 relates to a method for measuring in-situ the acoustic attenuation provided by an earplug, wherein a probe tube extends through the earplug into the ear canal and wherein the outer end of the probe tube is connected to a first microphone, while a second microphone is provided at the ear for measuring sound pressure levels exterior to the ear canal as a reference microphone. The acoustic attenuation provided by the earplug is calculated from the difference of the sound levels measured by the first and the second microphone. The test sound for the measurement is the user's voice.

It is an object of the invention to provide for a method for supplying audio signals to a user by an ear-worn hearing device comprising a sound attenuation portion with a loudspeaker, wherein the user's ear should be protected from damages. It is a further object to provide for a corresponding hearing system.

According to the invention these objects are achieved by a method as defined in claim 1 and a hearing system as defined in claim 8, respectively.

The invention is beneficial in that, by capturing audio signals by a microphone which is included in the attenuation portion of the hearing device and which is oriented towards the user's ear canal from the sound provided by the loudspeaker to the user's ear canal and by controlling the level of the audio signal provided to the loudspeaker according to the audio signals captured by the microphone, the sound level in the user's ear canal generated by the loudspeaker can be accurately measured and controlled in order to avoid sound pressure levels which may damage the user's ear. Thereby an accurate and effective automatic sound pressure level control is realized.

Preferred embodiments of the invention are defined in the dependent claims.

In the following examples of the invention will be described by referenced to the attached drawings, wherein:

Fig. 1 shows schematically an example of a hearing system according to the invention;

Fig. 2 is a more detailed view of one of ear of the user when wearing a hearing device according to the invention; and

Fig. 3 is a view like Fig. 2, with an alternative embodiment of a hearing device according to the invention being shown.

In Fig. 1 an example of a hearing system according to the invention is schematically shown, which comprises as a hearing device a headphone 10 comprising a left ear cup 12A and a right ear cup 12B. Each cup 12A, 12B comprises at least one loudspeaker 14 and a microphone 16, which both are included in the cup 12A, 12B. Each cup 12A, 12B comprises a housing 18 which acts as a sound attenuation portion for attenuating ambient sound before reaching the user's ear drum 20. The at least one loudspeaker 14 is oriented towards the user's ear canal 22 when the headphone 10 is worn at the user's ears 24 in order to provide sound to the user's ear canal 22.

The microphone 16 likewise is oriented towards the user's ear canal 22 in order to pick up sound in the user's ear canal 22 and to capture a corresponding audio signal representative of the sound level in the user's ear canal 22.

According to Fig. 1, the system in addition to the headphone 10 comprises a preferably portable audio device 26 having a headphone output, such as a MP3 player or a CD player, which serves as an audio signal source. The headphone 10 is connected to the audio device 26 via an audio signal processing unit 28 which processes the audio signals received from the audio device 26 in order to be reproduced by the loudspeakers 14 of the headphone 10. The audio signal processing unit 28 may integrated into the headphone 10 or it may be worn somewhere at the user's body separate from the headphone 10 or it may be part of the audio amplifier of the audio device 26. Usually the audio signal processing unit 28 will include an interface 34, such a wire connection, for receiving audio signals from an audio signal source, such as from the audio device 26.

Usually the audio signal provided by the audio device 26 will be a stereo signal. Each of the two channels of the stereo signal will be amplified by a variable gain amplifier 30 which via a control unit 32 is controlled according to the audio signals captured by the microphones 16. To this end, the audio signals from the microphones 16 are provided to the audio signal processing unit 28. For example, the control units 32 may be programmed or designed such that a predetermined upper limit of the level of the audio signals captured by the microphones 16 is not exceeded. This upper limit not to be exceeded may be, for example, 95dB. To achieve such automatic volume control, the control unit 32 will set the gain applied by the variable gain amplifier 30 in such a manner that the sound pressure level in the ear canal 22 as measured by the microphone 16, which is primarily caused by the sound from the loudspeaker 18 does not exceed said predetermined upper limit. In other words, the level of the audio signals produced by the audio signal processing unit 28 is controlled according to the level of the audio signals captured by the microphones 16.

In addition to providing for such automatic, i.e. closed loop, volume control, the audio signal processing unit 28 also may serve to record the level of the audio signals captured by the microphones 16 as a function of time, thereby acting as a dosimeter. In this case, an alarm signal may be issued by the audio signal processing unit 28, for example as an alarm tone or an alarm message provided to the user via the loudspeakers 14, if a predetermined upper limit of the level of the audio signals captured by the microphones 16 is reached and/or if a predetermined upper limit of the time-integrated level of the audio signals captured by the microphones 16 is reached.

In the embodiment shown in Fig. 3 the headphone 10, i.e. the cups 12A, 12B of the headphone 10, may be replaced by an earphone 40 for each ear of the user, which comprises a

shell 42 having an outer shape which is appropriate for being received in the user's ear 24. In this case, the loudspeaker 14 and the microphones 16 are integrated into the shell 42 in such manner that they are both oriented towards the user's ear canal 22 when the earphone 40 is worn at the user's ear 24. Usually the user will wear another earphone 40 at the other ear in order to achieve stereo presentation of the audio signal.

The earplugs 40 will be connected to the audio signal processing unit 28 in a similar manner as shown in Fig. 1 for the headphone 10.

Claims

1. A method for supplying audio signals to a user wearing a hearing device (10, 12A, 12B, 40) at or in the user's ear (24), the hearing device (10, 12A, 12B, 40) comprising a sound attenuation portion (18, 42) for attenuating ambient sound before reaching the user's ear drum (20), the method comprising:

   producing an audio signal at a controlled level by audio signal producing means (26, 28);

   providing sound corresponding to the audio signal produced by the audio signal producing means (26, 28) to the user's ear canal (22) by a loudspeaker (14) which is included in the attenuation portion (18, 42) and which is oriented towards the user's ear canal (22);

   capturing audio signals by a microphone (16), which is included in the attenuation portion (18, 42) and which is oriented towards the user's ear canal (22), from the sound provided by the loudspeaker (14) to the user's ear canal (22);

   wherein the level of the audio signal produced by the audio signal producing means (26, 28) is controlled according to the audio signals captured by the microphone (16).

2. The method of claim 1, wherein the level of the audio signals produced by the audio signal producing means (26, 28)is controlled according to the level of the audio signals captured by the microphone (16).

3. The method of claim 2, wherein the level of the audio signals produced by the audio signal producing means (26, 28) is limited in such a manner that a predetermined upper limit of the level of the audio signals captured by the microphone (16) is not exceeded.

4. The method of claim 3, wherein the level of the audio signals captured by the microphone (16) is recorded as a function of time.

5. The method of claim 4, wherein an alarm signal is issued by the hearing device (10, 12A, 12B, 40) if a predetermined upper limit of the level of the audio signals captured by the microphone (16) is reached.

6. The method of one of claims 3 to 5, wherein the upper limit of the level of the audio signals captured by the microphone (16), which is not to be exceeded, is 95 dB.

7. The method of one of claims 2 to 6, wherein an alarm signal is issued by the hearing device (10, 12A, 12B, 40) if a predetermined upper limit of the time-integrated level of the audio signals captured by the microphone (16) is reached.

8. A hearing system comprising: a hearing device to be worn at or in a user's ear (24) for supplying audio signals to said user and comprising a sound attenuation portion (18, 40) for attenuating ambient sound before reaching the user's ear (24), means (26, 28) for producing audio signals at a controlled level, a loudspeaker (14) which is included in the attenuation portion and which is oriented towards the user's ear canal (22) for providing sound corresponding to the audio signal produced by the audio signal producing means (26, 28) to the user's ear canal (22), a microphone (16) which is included in the attenuation portion (18, 40) and which is oriented towards the user's ear canal (22) for capturing audio signals from the sound provided by the loudspeaker (14) to the user's ear canal (22), and a level control unit (28, 30, 32) adapted to control the level of the audio signals produced by the audio signal producing means (26, 28) according to the audio signals captured by the microphone (16).

9. The hearing system of claim 8, wherein the audio signal producing means (26, 28) comprise a variable gain amplifier (30).

10. The hearing system of claim 9, wherein the audio signal producing means (26, 28) comprise a control unit (32) for controlling the variable gain amplifier (30) according to the audio signals captured by the microphone (16).

11. The hearing system of one of claims 8 to 10, wherein the hearing device is one of the two cups (12A, 12B) of a headphone (10).

12. The hearing system of one of claims 8 to 10, wherein the hearing device is an earphone (40).

13. The hearing system of one of claims 8 to 12, wherein the audio signal producing means (26, 28) comprise an interface (34) for receiving audio signals from an audio signal source (26).

14. The hearing system of claim 13, wherein the audio signal source (26) is a portable music player.

15. The hearing system of claim 13, wherein the audio signal source (26) is an audio amplifier.

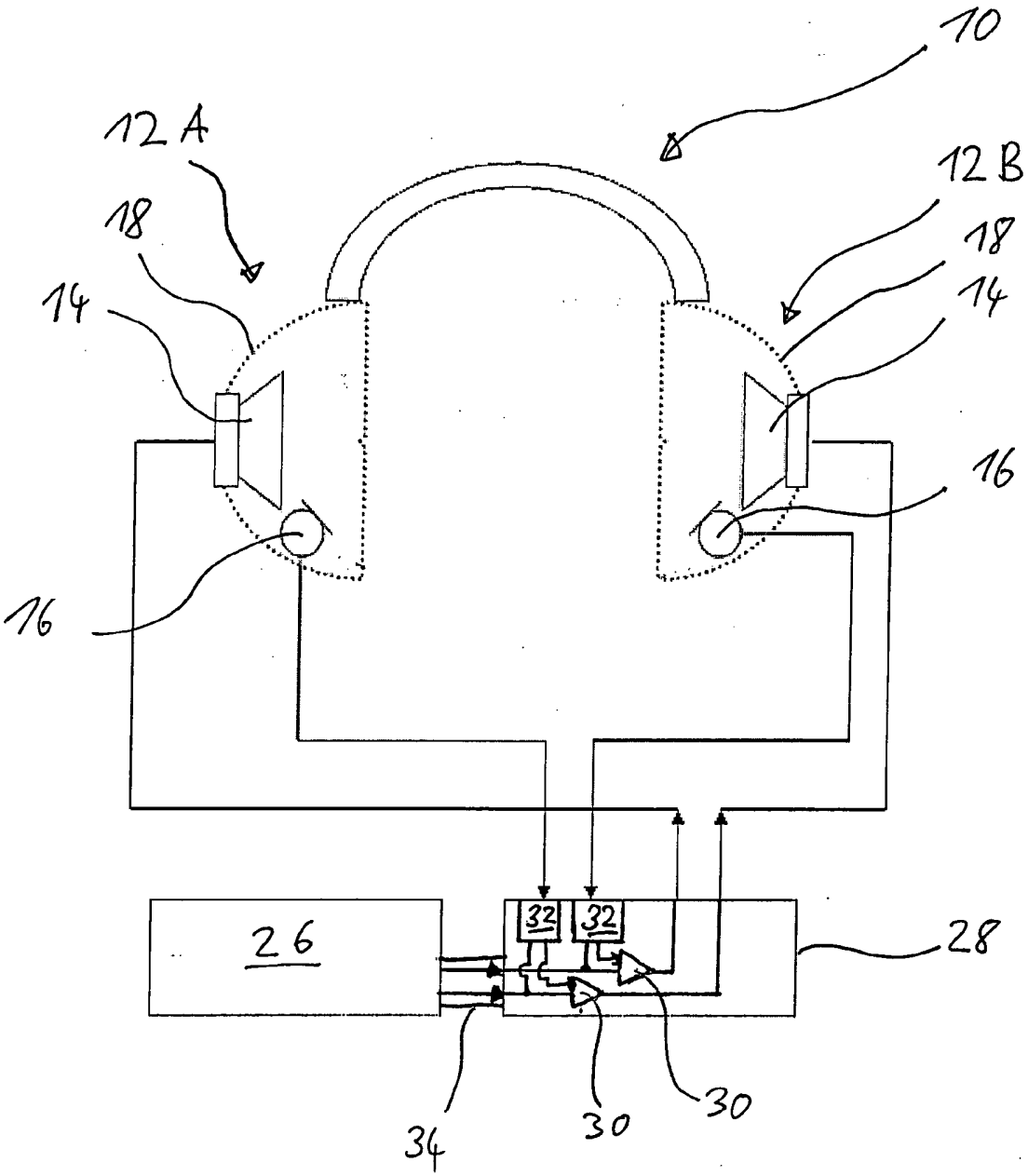

Fig. 1

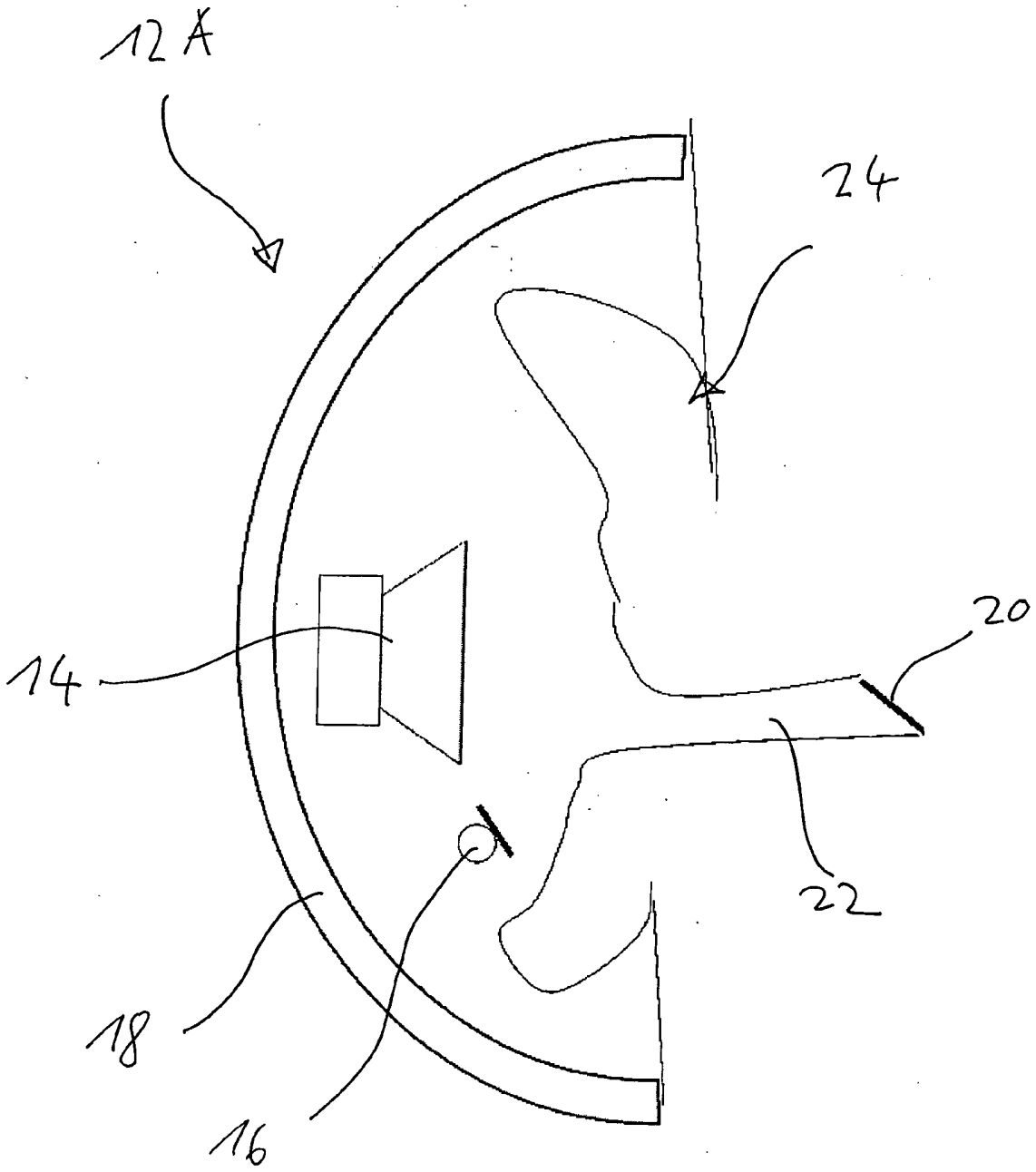

Fig. 2

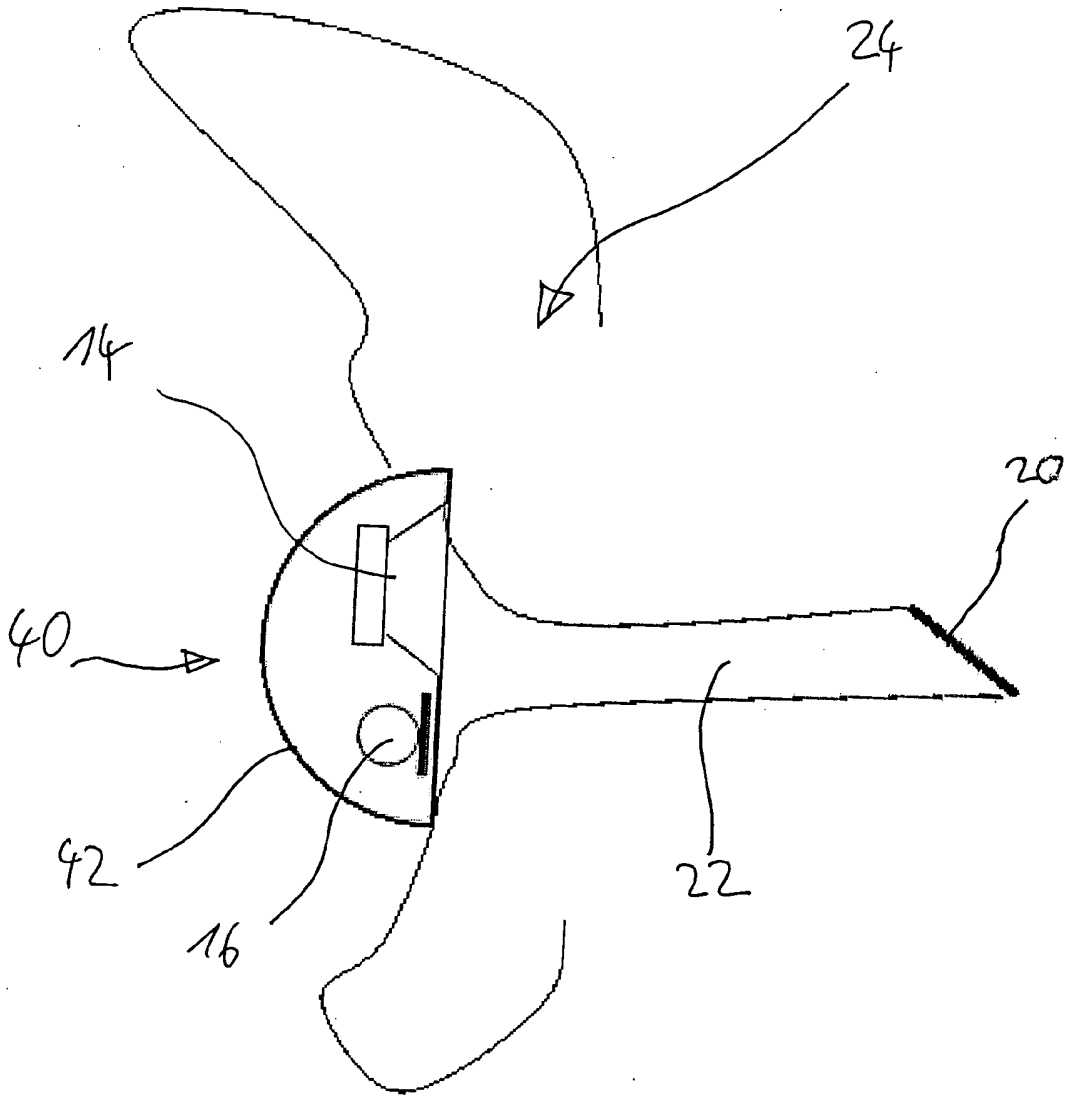

Fig. 3