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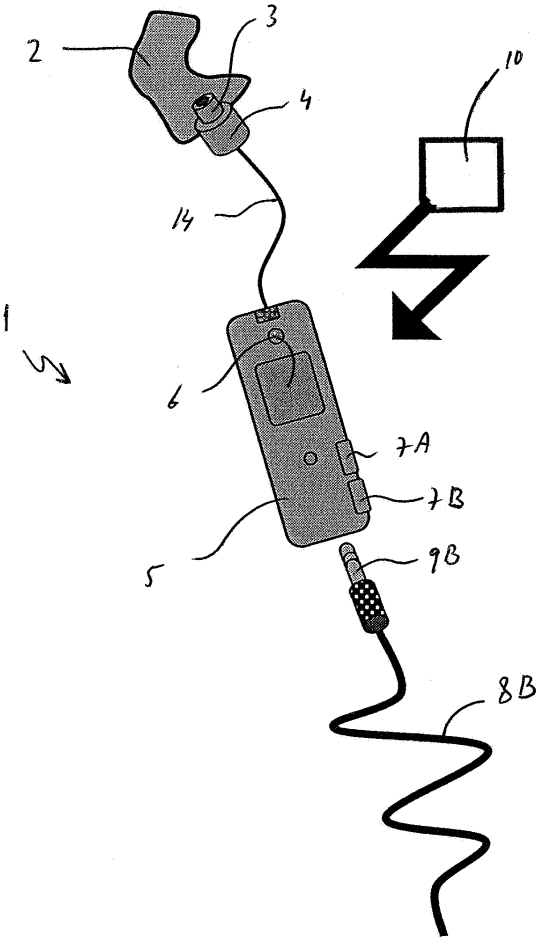
(54) **Hearing protector, transmitter, method, processor and computer program product**

(57) The invention relates to a hearing protector, comprising a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person. The hearing protector is further provided with a sound source for generating sound waves to be propagated in the auditory canal. In addition, the hearing protector comprises a control unit connectable to the sound source, which is designed for recording ambient sound. The control unit is also designed for feeding electronic signals representing the recorded ambient sound for reproduction to the sound source.




Figuur 2

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## Description

**[0001]** The invention relates to a hearing protector, comprising a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and is provided with a sound source for generating sound waves to be propagated in the auditory canal.

**[0002]** Such a hearing protector is known from, for instance, Dutch patent publication NL 1 012 664. The sealing body which is manufactured from flexible material for fittingly sealing the auditory canal of a person is generally known to the skilled person as an otoplast. Owing to the fit in the auditory canal of a specific person, the sealing body has a unique shape so that an optimal sound damping can be realized. Hearing protection is desired and/or required in spaces in which individuals are present for a period of time with harmful noise, such as in production halls.

**[0003]** Through the use of the sealing body in the auditory canal of the user, a relatively compact, lightweight and elegant, and relatively little cumbersome hearing protector is provided.

**[0004]** The hearing protector as described in NL '664 is provided with a sound source for generating sound waves which penetrate the auditory canal and reach the eardrum of the user, so that, despite the presence of the sealing body in the auditory canal, if desired, sound with a particular volume can still be observed. Connecting the sound source to a radio receiver enables users of the hearing protector to listen to a favourite radio channel or radio program, while still, hearing protection is provided for. This is noticeably beneficial to the job satisfaction of users requiring hearing protection.

**[0005]** In order to communicate with other individuals in the noisy environment, in practice, the sealing body of the hearing protector is temporarily removed from the auditory canal, in particular if other auxiliary means, such as sign language, prove to be insufficient. Although by taking out the hearing protector, individuals can understand each other better while communicating, it is clear that hearing impairment can occur. As individuals in noisy environments typically carry out relatively much manual labour, the hearing protector is often temporarily stored away or put aside, so that the period of time during which no hearing protection is provided is relatively long, which, from the viewpoint of protection of the auditory organ is, of course, undesired. The fact is that the user experiences the repeated removing and applying of the sealing body as bothersome. Furthermore, when placed in the auditory canal, the sealing body can become filthy and/or contaminated as a result of the regular placing and removing of the sealing body in a non-hygienic space. Consequently, discipline is required for reapplying the protector directly after communication has ceased. The user will sooner reapply the hearing protector after work has already resumed and/or choose to leave the protector, optionally temporarily, unused. It will be clear that such behaviour is not beneficial to the protection of the auditory organ.

**[0006]** The object of the invention is to obtain a hearing protector according to the opening paragraph, wherein the above-mentioned drawback is obviated while maintaining the advantages. In particular, the object of the invention is to obtain a hearing protector according to the opening paragraph, wherein communication with other individuals in the direct proximity is easier, while the time during which the user is exposed to ambient sound is reduced. To that end, the hearing protector further comprises a control unit connectable to the sound source, which is designed for recording ambient sound and feeding electronic signals representing the recorded ambient sound for reproduction to the sound source.

**[0007]** By recording the ambient sound with the aid of the control unit, and representing it, via the sound source, in the auditory canal of the user of the hearing protector, acoustic contact with the environment can be made in a relatively simple manner. The fact is that then, the sealing body needs not be removed from the auditory canal. Furthermore, recording ambient sound and passing it to the sound source of the protector can be stopped soon after the communication with others has ceased. As the sealing body needs not be reapplied in the auditory canal, the hearing protecting function immediately afterwards can be preserved. Thus, the time during which the user of the protector according to the invention is exposed to ambient noise is considerably reduced. Preferably, the sound is represented at a non-harmful sound level, for instance at a predetermined sound level.

**[0008]** Furthermore, in this manner, a hearing protector is obtained with which soiling of the sealing body through ambient dirt, such as dust and/or oily liquids, is less rapid, as the sealing body needs not be taken from the auditory canal for communication with others.

**[0009]** As, with the aid of the hearing protector according to the invention, the possibilities of communicating with others increase significantly, its user will make contact with others sooner than is usual so far. In addition to a further increase of job satisfaction, in this manner, mutual cooperation can improve, which can result in more efficient job behaviour. Due to increased work pressure through, for instance, computerization processes, more and more work has to be done by fewer and fewer people. In such a development, a hearing protector according to the invention can form a welcome aid in communication.

**[0010]** In addition, the control unit can be activated when the user is in a relatively risky position, for instance when lifting heavy loads. As a result, the user is more alert to potential danger manifesting itself through noise, such as shifting goods.

**[0011]** It is noted that a user of the hearing protector can activate the control unit manually, with the aid of, for instance, a button provided on the control unit. Naturally, the control unit can also be activated without deliberate intervention of the user, for instance through automatic

activation of the control unit when the user enters a low-noise space.

**[0012]** As the control unit feeds electronic signals representing the recorded ambient sound for reproduction to the sound source, the protection against noise can be interrupted, at least partly. The control unit may be designed such that the ambient sound is transmitted unattenuatedly by the sound source to the auditory canal. Naturally, it is also possible to apply an attenuation, so that there is a smaller risk of hearing impairment.

**[0013]** The sound equipment for that matter, such as a radio receiver, which transmits signals for reproduction to the sound source in the sealing body, can be temporarily disconnected upon activation of the control unit. However, the hearing protector can also be designed such that the signals, generated by the sound equipment and the control unit, are combined into a composite signal. Then, the type of sound equipment can be switched relatively simply too.

**[0014]** It is further noted that the control unit can be connectable to the sound source with the aid of a wire connection and/or wirelessly.

**[0015]** Preferably, the sound source is connectable by means of a universal connection to a multiple number of types of portable sound equipment. For instance, the equipment preferred by the user of the hearing protector can simply be connected, if possible without an adapter, to the sound source of the hearing protector. Thus, the user can individually listen to music and/or speech, as desired, while hearing protection is maintained.

**[0016]** The multiple number of types of portable sound equipment comprise, for instance, a communication unit, such as a cell phone, a portable phone, a walkie-talkie and the like. Connection to such equipment may apply to individuals employed in relatively noisy surroundings, and where relatively much communication takes place, as is the case in hotels, restaurants and cafés, with personnel of security services such as police, fire department, and/or ambulances, with pilots, motor bike riders, with employees in call centers, etc. However, it is also possible to use a different type of portable sound equipment, such as a sound reproduction unit. A sound reproduction unit is understood to include equipment suitable for generating sound for the consumer, such as a portable radio, a walkman, a portable CD player, an iPod and the like. Connection to a sound reproduction unit is appealing to individuals who are employed in, for instance, industrial environments where hearing protection is required and where there is a need for individual speech and/or music facilities for improvement of job perception.

**[0017]** In practice, there are situations in which individuals in noisy industrial environments, who are supposed to be wearing hearing protectors, refuse to do so because conventional hearing protectors are not connectable to their favourite equipment for generating, for instance, music. Instead, hearing protection is typically not used. However, often, a sound installation is activated, producing a sound level that exceeds the ambient noise, thereby increasing the risk of hearing impairment even further. Although some experience the sound produced by the sound installation as music, others employed in these spaces are annoyed by this sound, which, in practice, leads to all sorts of conflicts and delays in work. Use of a hearing protector according to the invention, while a universal connection for a multiple number of types of portable sound equipment is provided, can present an acceptable solution to the above-described situations, as everyone can listen, at will, to an individual, favourite sound fragment while protecting their hearing.

**[0018]** It is noted that use of an universal connection for connection to a multiple number of types of portable sound equipment is possible not only in combination with a hearing protector according to claim 1, but also, more generally, in combination with a hearing protector comprising a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and a sound source for generating sound waves to be propagated in the auditory canal.

**[0019]** Preferably, the sound level produced by the sound source is adjustable independently of the type of connected portable sound equipment, so that a user of the hearing protector can easily switch between different types of sound equipment without having to adjust the sound level and without running the risk of exceeding a harmful sound level.

**[0020]** By designing the control unit such that the sound produced by the sound source remains below a preset sound level, hearing impairment with the user can be prevented, the more so when the user has the tendency of setting the volume higher than what is considered safe in view of the risks of hearing impairment. Furthermore, here, standards in force with respect to the sound level to which individuals can be exposed in working conditions, for instance 82 decibels, can be taken into account.

**[0021]** As described hereinabove, the control unit of the hearing protector can be temporarily activated for, for instance, facilitating communication with other individuals. However, it is also possible to activate the control unit during use in a continuous or semi-continuous manner, so that the wearer of the hearing protector can observe ambient sounds at a non-harmful level in a virtually continuous manner.

**[0022]** Preferably, the hearing protector is provided with a filter for filtering the electronic signals that drive the sound source for generating sound waves. The filter may comprise an attenuator for attenuating the electronic signals, optionally frequency-dependently, so that ambient sound can be observed in a damped manner.

**[0023]** Most preferred, the hearing protector is further designed for applying an active, non-linear filter to the electronic signals that drive the sound source for generating sound waves. The active, non-linear filter may be designed such that the sound intensity of the sound waves produced by the sound source is actively limited

to a preset intensity level. Here, the non-linear filter attenuates the ambient sound when this exceeds the preset level, but otherwise, allows it to pass more or less unattenuatedly. Thus, a virtually environment-independent hearing protector is obtained which can be favourably used in an environment with strongly varying levels of noise, as is the case with target practices, where ambient sound can be observed well while still, good hearing protection is obtained. Preferably, such hearing protection is applied to both ears of the user, so that sound damping obtained at one auditory organ is not nullified by a less well functioning sound damping at the other auditory organ.

**[0024]** In an advantageous embodiment of the invention, the hearing protector further comprises a receiving unit for receiving an external message that is transmitted wirelessly by a transmitter, while the receiving unit is also designed for transmitting electronic signals representing the external message for reproduction to the sound source. As a result, in an advantageous manner, the user can be reached wirelessly, with auditory signals, without interrupting the protection of the hearing. Consequently, the safety in risky situations can be enhanced even further, while the auditory organ of the user is not additionally exposed to high ambient noise. Users can also be informed relatively simply about a specific situation, without additional, conspicuous optic and/or acoustic signals, which is desirable when, for instance, only a selected number of individuals are intended to be informed, or when additional, conspicuous optic and/or acoustic signals might confuse other individuals not provided with such hearing protection according to the invention.

**[0025]** It is noted that the use of a receiving unit for receiving an external message transmitted wirelessly by a transmitter is possible not only in combination with a hearing protector according to claim 1, but also, more generally, in combination with a hearing protector comprising a sealing body placeable in an auditory canal of a person, which is manufactured from a flexible material so as to fit in the auditory canal of a specific person, and is provided with a sound source for generating sound waves to be propagated in the auditory canal.

**[0026]** The invention also relates to a transmitter which is designed for wirelessly transmitting an external message to a receiving unit of a hearing protector, comprising a sealing body placeable in the auditory canal of a person, which is provided with a sound source for generating sound waves to be propagated in the auditory canal. The transmitter can, for instance, be disposed at a fixed or variable position in a space. However, it is also possible to couple the transmitter to recording means of a hearing protector, so that different users of hearing protectors can mutually communicate without removing the sealing body from the auditory canal.

**[0027]** Optionally, the external message is preprogrammed, so that the attention of users can easily be drawn to a recurring situations and/or to a risk. By connecting the transmitter to recording means for recording the external message, more specific information can be passed on to the user of the hearing protector. In some situations, it is preferred that the transmitter be positioned adjacent an entrance of a specific space so that users of a hearing protector according to the invention can be informed, in passing, about, for instance, specific details or risks of that space.

**[0028]** It is preferred that the hearing protector according to the invention further comprises a first recording unit designed for recording ambient sound and a second recording unit designed for recording a speech signal originating from a user of the hearing protector. By processing the signals generated by the two recording units in a manner such that ambient sound is suppressed in the speech signal, an improved representation of the recorded speech signal can be obtained. The improved representation of the speech signal can be transmitted for, for instance, reproduction, to a receiving unit of another hearing protector, so that an improved observation of speech is possible in situations where hearing protection is applied. The processing of signals generated by both recording units can be carried out by, for instance, a processor.

**[0029]** The above described configuration with a first and a second recording unit offers advantages over a so-called boom microphone, where a microphone is brought near the mouth with the aid of a holder. The fact is that the first and second recording unit can be integrated in the control unit so that fewer components are required, less discomfort is caused to the user and that the equipment can be provided in a simpler manner.

**[0030]** It is noted that use of the above-described first and second recording unit is possible not only in combination with a hearing protector according to claim 1, but also, more generally, with a hearing protector comprising a sealing body placeable in the auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, while it is preferred that the hearing protector further comprises a sound source for generating sound waves to be propagated in the auditory canal, so that a user of the hearing protector can also observe speech, that may or may not have been recorded and processed in the above-described manner.

**[0031]** Processing of signals generated by the two recording units is done elegantly by selecting a representation of a speech signal that is present only in the signal of the second recording unit, and by further applying a bandpass filter for allowing passage of a signal having frequency components present substantially only within a spectrum of speech. Naturally, it is also possible to apply a different type of processing, such as subtracting signals generated by the two recording units.

**[0032]** From Dutch patent publication NL 1 012 664, a hearing protector is known comprising a sealing body, while a sound filter is integrated in a canal extending between the two ends of the sealing body.

**[0033]** When a user of the hearing protector from NL

1 012 664 wants a different type of functional hearing protection, such as higher damping or damping of a specific spectrum, he/she must turn to a completely new sealing body because the sound filter is integrated in the sealing body. This is experienced as a drawback, the more so because the manufacture of a sealing body involves relatively high costs.

**[0034]** According to an aspect of the invention, a hearing protector is provided with which sound filters can be exchanged relatively easily without devaluing the quality of the hearing protection. To that end, the hearing protector according to the invention comprises a separate filter module which is connectable in a detachable and soundproof manner to a connecting part situated, during use, at the outside of the sealing body, while in the filter module, a sound filter is included.

**[0035]** Providing the hearing protector with a separate filter module with sound filter that is detachably connectable to the sealing body enables relatively simple exchange of different filter modules in which sound filters with different characteristics can be included. However, as the sealing body and filter modules link up in a soundproof manner, the quality of the sound protection is maintained.

**[0036]** It is noted that use of such a separate filter module is not limited to a hearing protector according to claim 1, but can also be used, more generally, in combination with a hearing protector comprising a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person.

**[0037]** It is preferred that the sound filter is detachably included in the separate filter module, so that, if desired, the sound filter can be replaced. However, a sound filter can also be integrated in the filter module so that the risk of damaging the module is smaller.

**[0038]** More preferably, the separate filter module is designed for receiving different types of sound filters, so that the user can use different types of sound filters at will, for instance a general sound filter for use in industrial spaces with a more or less standard noise load, or a specific sound filter suitable for use in spaces with an extremely high noise load.

**[0039]** Including the sound source in a separate connecting module for portable sound equipment which is connectable in a detachable and soundproof manner to the connecting part of the sealing body, enables the user to provide the hearing protector, at will, with a sound filter or a sound source so that a modular, flexible system is obtained with modules that are interconnectable in a relatively simple manner.

**[0040]** Although the hearing protector from NL 1 012 664 is connectable to a sound source too, in that case, a relatively complex system is required, such as a sound canal in the sealing body with a branch, and a sealing cap. In the hearing protector according to the invention, a sound canal without branches suffices, so that in an advantageous manner, a simpler geometry for the relatively expensive sealing body is obtained. Furthermore, the sealing cap is superfluous as the sealing body is sealed off by a module with, at will, a sound filter or a sound source.

**[0041]** The hearing protector can be presented to the consumer together with a separate filter module and a separate connecting module as one packet, so that the user can connect, at will, a filter module or a connecting module for portable sound equipment.

**[0042]** It is also possible to present one set with two hearing protectors, notably one protector for each ear, two filter modules and one connecting module for portable sound equipment, so that a user can apply hearing protection to both ears and can also, at will, realize a connection to portable sound equipment.

**[0043]** In addition, the invention relates to a kit.

**[0044]** The invention also relates to a transmitter.

**[0045]** The invention further relates to a method for applying an active, non-linear filter, a method for applying compression, and a method for correcting a spectrum.

**[0046]** Furthermore, the invention relates to a method for processing signals.

**[0047]** The invention also relates to a processor.

**[0048]** Finally, the invention relates to a computer program product.

**[0049]** Further advantageous embodiments of the invention are represented in the subclaims.

**[0050]** The invention will be further elucidated with reference to exemplary embodiments represented in the drawing. In the drawing:

Fig. 1 shows a schematic view of a first embodiment of a hearing protector according to the invention;
Fig. 2 shows a schematic view of a second embodiment of a hearing protector according to the invention;
Fig. 3 shows a schematic view of a third embodiment of a hearing protector according to the invention;
Fig. 4 shows a schematic view of a cross-section of a connecting module of the hearing protector according to Fig. 1;
Fig. 5 shows two schematic views of a cross-section of a filter module of the hearing protector of Fig. 1; and
Fig. 6 shows a schematic view of a set of hearing protectors according to the invention.

**[0051]** The Figures are only schematic representations of the invention and are merely given by way of non-limitative exemplary embodiments.

**[0052]** Fig. 1 shows a schematic view of a first embodiment of a hearing protector 1 according to the invention. The hearing protector 1 has a sealing body 2 also called otoplast, which is made to size so as to fit in an auditory canal of a user. In Fig. 1 a random shape of the otoplast 2 is represented. In order to obtain good, soundproof properties of the hearing protector 1, the otoplast 2 is manufactured from a flexible material. The hearing pro-

tector 1 is further provided with a sound source 3, designed as a miniature loudspeaker, which is included in a connecting module 4 for portable sound equipment as will be described in further detail with reference to Figs. 4 - 6. The user can attach the connecting module 4 to the otoplast 2 and detach it therefrom.

**[0053]** Thus, the hearing protector 1 forms a compact, lightweight system that can offer a hearing protection of relatively high quality.

**[0054]** In addition, the hearing protector 1 comprises a control unit 5 which is connected via a wire connection 14 to the loudspeaker 3. The control unit is provided with sound recording equipment for recording ambient sound. The control unit 5 then feeds electronic signals that are generated by the sound recording equipment and represent the ambient sound for reproduction to the loudspeaker 3. As a result, while protecting the auditory organ, the user can still observe ambient sound. The control unit 5 is further provided with a preferably easy to find button 6. By pushing the button 6, the user can activate the control unit 5 so that ambient sound, such as speech of a person present in the immediate proximity of the user, is actually transmitted via the loudspeaker 3. The control unit 5 also has buttons 7a, 7b for enhancing or attenuating, respectively, the sound produced by the loudspeaker 3. The sound produced by the loudspeaker 3 is passed on, via a canal in the otoplast 2, to the eardrum of the user.

**[0055]** Optionally, the control unit 5 is also designed for limiting the sound level to be produced by the loudspeaker 3 so that the hearing protector 1 can meet the sound standards in force.

**[0056]** The sound source 3 is connectable, via the control unit 5 and by means of a universal connection 8A, to a multiple number of types of portable sound equipment. Portable sound equipment is understood to mean a communication unit, such as a mobile telephone, portable telephone, walkie-talkie or the like, or a sound reproduction unit, such as a portable radio, CD player, walkman, MP3 player, iPOD and the like. Communication units can be of the simplex type or duplex type, while simultaneously, one or two channels are utilized, respectively. The universal connection 8A has a standard plug 9A so that switching between different types of sound equipment is simple. If required, an adapter plug can be used for effecting a link with a specific connection. Thus, the user can switch fairly easily between, for instance, a portable radio and a walkie-talkie. The control unit 5 is further designed for switching between connected, portable sound equipment and the sound recording equipment in the control unit 5. In this manner, a user can redirect, at will, the portable sound equipment or the sound recording equipment to the loudspeaker 3 of the hearing protector.

**[0057]** The hearing protector 1 is further designed for applying compression to sound waves to be generated by the sound source 3. This compression comprises frequency-dependent adjustment of sound levels of signals in a manner such that differences in sound intensity of frequency components of at least a part of a signal spectrum are minimized. Then, the intensity characteristic of at least a part of the signal spectrum exhibits less variation, so that the user experiences the intensity of the observed sound as more piercing, without increase of the noise load. Thus, a wish of a user is met in that the sound can be observed better without a noise standard being exceeded. Applying such a compression technique, see for instance the International patent publication W09818294, is known per se in, for instance, the field of technology of hearing aids. Naturally, the hearing protector 1 can also be designed such that no compression is applied, for instance by leaving the spectral characteristic of the sound signal substantially unchanged.

**[0058]** It is preferred that compression is applied to sound signals that originate from the portable sound equipment, such as a sound reproduction unit. However, it is also possible to apply compression to recorded ambient sound that is fed for reproduction to the sound source of the hearing protector.

**[0059]** Hence, applying compression to the sound waves to be generated by the sound source 3 is possible not only in combination with a hearing protector according to claim 1, but also in combination with a hearing protector comprising a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and a sound source for generating sound waves to be propagated in the auditory canal, wherein the sound source is connectable to portable sound equipment by means of a connection.

**[0060]** Compressing can be carried out by a specific processor, such as an ASIC processor, or with the aid of a more general processor, such as a DSP, which is provided with specific software. The processor is preferably included in the control unit 5.

**[0061]** In addition, the hearing protector is optionally designed for correcting the spectrum of sound waves to be generated by the sound source 3 for a spectral transmission characteristic of the auditory canal and/or the sound source 3 of the hearing protector 1. As a result, the sound can be transmitted to the eardrum in a less deformed fashion, so that the quality level of the observed sound increases. Naturally, the choice can also be made not to apply such a spectral correction for, for instance, reducing the cost price of the hearing protector 1.

**[0062]** The spectral correction too can be carried out by a specific processor such as an ASIC processor, or with the aid of a more general processor, such as a DSP processor which is provided with specific software. Preferably, only one processor is responsible for applying both the compression and the correction of the spectrum.

**[0063]** It is noted that correction of the spectrum of the sound waves to be generated by the sound source for a spectral transmission characteristic of the auditory canal and/or the sound source is possible not only in combination with a hearing protector according to claim 1, but also in combination with a hearing protector, comprising

a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and a sound source for generating sound waves to be propagated in the auditory canal, while the sound source is connectable to portable sound equipment by means of a connection.

**[0064]** In an alternative embodiment of the control unit 5, it is permanently or semi-permanently active, so that electronic signals that represent the recorded ambient sound are transmitted virtually continuously for reproduction to the loudspeaker 3. Here, the hearing protector is designed for applying an active non-linear filter to said electronic signals. The non-linear filter actively limits the sound waves produced by the sound source to a preset intensity level, so that the user's hearing is continuously protected, but is also able to observe ambient sound.

**[0065]** The non-linear filter can be implemented with the aid of a specific processor, such as an ASIC processor, or with the aid of a more general processor, such as a DSP, which is provided with specific software. Preferably, the hearing protector comprises only one processor for applying, at will, compression and/or correction of the spectrum and/or use of the non-linear filter.

**[0066]** Fig. 2 shows a second embodiment of a hearing protector 1 according to the invention. Here, the control unit 5 is provided with a receiver unit (not shown) for receiving an external message that is wirelessly transmitted by a transmitter 10, while the receiving unit is further designed for transmitting electronic signals representing the received external message for reproduction to the sound source 3. Further, a connection between a second universal connection 8B and the control unit 5 is effected by means of a second universal plug 9B. To that end, the control unit 5 of the second embodiment is provided with a connecting option for connection to a second universal plug 9B, so that a different type of portable sound equipment can be connected to the control unit 5 than is involved with the control unit 5 of the first embodiment. Naturally, it is also possible to effect different variations thereon. A control unit may be provided with both a universal connection 8A according to the first embodiment, and a second universal connection 8B according to the second embodiment. Further, an even more general connecting structure can be utilized for connecting types of sound equipment connectable via the universal connection 8A and the universal plug 9A, as well as the type of sound equipment connectable via the second universal connection 8B and second universal plug 9B, for instance via an adapter plug. Thus, the connection is even more interchangeable. The connecting structure can also be specifically adjusted for connection to a special type of portable sound equipment, such as walkie-talkies.

**[0067]** The transmitter 10 is connected to recording means for recording the external message. In addition, an external message can be preprogrammed. Optionally, the transmitter is connected to a data network, so that a message can also be composed via other means, for instance via a word processing program.

**[0068]** The transmitter 10 can be placed centrally in a space, so that a relatively large area falls within its reach. However, it is also possible to position the transmitter 10 adjacent an entrance of a specific space, for instance for alerting passers by to specific information. Here, a transmitter with only a restricted range can be used, or one that transmits wireless signals in a specific zone. Transmitting messages wirelessly can be done with the aid of infrared signals, or otherwise, by, for instance, radio waves, specifically in the FM range.

**[0069]** Fig. 3 shows a third embodiment of a hearing protector 1 according to the invention. Most parts of the hearing protector 1, such as the sealing body 2, the sound source 3, the connecting module 4, the control unit 5 and the connection to portable sound equipment correspond, to a large extent, to the first and second embodiment of the hearing protector 1. A user 11 has inserted the sealing body 2 in an auditory canal in order to effect hearing protection.

**[0070]** The hearing protector 1 is further provided with a first and a second recording unit. The first recording unit is designed for recording ambient sound while the second recording unit is designed for recording a speech signal originating from the user of the hearing protector 1.

**[0071]** The second recording unit has a restricted opening angle 12 directed towards the mouth of the user, so that a relatively clear speech signal is obtained. The second recording unit however may have a larger opening angle, so that more freedom is obtained with respect to the position of the second recording unit, which position may vary. By recording a speech signal, speech information, such as commands, can be processed electronically by equipment such as machines operated by the user, and/or be sent as information to others who may also have been provided with hearing protection. To that end, the hearing protector can further be provided with a transmitter module for sending information wirelessly.

**[0072]** Preferably, the first recording unit is of the omnidirectional type, so that a balanced recording of ambient sound can be obtained. As a result, the ambient sound can be filtered better from the speech signal. However, the first recording unit can also have a different design, so that it can be directed to, for instance, a specific source of noise in the direct proximity of the user.

**[0073]** Preferably, the first recording unit is included in the control unit 5, so that no additional housing is required. More preferably, the recording equipment of the control unit which is required for recording ambient sound as part of the transmission of electronic signals to be reproduced to the miniature loudspeaker, see the description at Fig. 1, is also used as first recording unit for recording ambient sound.

**[0074]** In an advantageous embodiment, the control unit 5 is attached with the aid of a clamping construction, such as a clip, to clothing of the user 11, so that the second recording unit can be directed in a more robust manner with the opening angle 12 well towards the mouth

of the user.

**[0075]** The hearing protector 1 further comprises a processor, designed for processing signals generated by the first and second recording unit for suppressing ambient sound in the recorded speech signal, so that a speech signal with a higher sound quality is obtained. Preferably, processing the signals comprises the steps of selecting a representation of a speech signal that is present only in the signal of the second recording unit, and applying a bandpass filter for allowing passage of a speech signal having frequency components present substantially only within a spectrum of speech.

**[0076]** As noted hereinabove, it is preferred from a viewpoint of costs to utilize only one processor for carrying out the processing processes of electronic signals described in this application. Naturally, it is also possible to utilize a multiple number of processors, for instance if a processor is eminently suitable for carrying out a specific process on signals.

**[0077]** Fig. 4 shows a schematic view of a cross-section of a connecting module 13 of the hearing protector 1 of Fig. 1. In the connecting module 13, also called separate connecting module for portable sound equipment, the sound source 3 is received. The separate connecting module is further connectable in a detachable and soundproof manner to a connecting part of the sealing body 2 as is described in further detail with reference to Fig. 6.

**[0078]** The connecting module 13 has a housing 15 inside which the loudspeaker 13 is attached. The electric connection 14 is connected to the loudspeaker 3 and leaves the housing 15 via an opening 16. It is noted that the electric connection 14 is connectable to the control unit 5 or directly to portable sound equipment. The connecting module 13 further comprises a form part 17 which is connected, in use, to the connecting part of the sealing body 2.

**[0079]** The connecting part of the sealing body 2 forms an end of a canal 18, see Fig. 6, that extends in the sealing body 2 adjacent the eardrum of the user, so that the sound generated by the loudspeaker is guided via the canal to the eardrum. However, it is not necessary to form a canal in the sealing body. Also a passage for instance, filled with a material with relatively good sound conducting properties can be provided in the sealing body 2 for guiding sound waves generated by the sound source 3.

**[0080]** Fig. 5 shows two schematic views of a cross-section of a filter module of a hearing protector 1 according to the invention. Like the connecting module 13, the filter module 19, also called separate filter module, is connectable in a detachable and soundproof manner to the connecting part of the sealing part 2. The filter module 19 has a housing 20 for receiving a sound filter. Like the separate connecting module 13, the separate filter module 19 further comprises a form part 17 which is connected, in use, to the connecting part of the sealing body 2.

**[0081]** The housing 20 of the filter module 19 is designed such that sound filters can be detachably arranged therein. Furthermore, different types of sound filters can be arranged. For instance, the filter module 19 in the upper view is provided with a first sound filter 21A, and, in the lower view, with a second sound filter 21B, while the sound filters 21A, 21B have different outside dimensions.

**[0082]** Fig. 6 shows a schematic view of a set of hearing protectors according to the invention. The hearing protectors comprise an above-described hearing protector and an additional hearing protector for the left and for the right ear, respectively, of the user. Each of the sealing bodies 2 is designed such that the connecting part for the separate filter module 19 and/or the separate connecting module 13 comprises an internal form cavity 22.

**[0083]** By providing the sealing body 2 with an internal form cavity 22, accessible from the outside of the sealing body 2, and located, during use, within the auricle, for including therein, in a form-closing and detachable manner, a form part 17 of the separate filter module 19 or connecting module 13, formed substantially correspondingly to the form cavity 22 in a manner such that therewith, during use of the hearing protector 1, the form cavity 22 can be sealed off from the outside environment in a soundproof manner, a soundproof connection is advantageously effected between, on the one side, the sealing body 2, and, on the other side, the separate filter module 19 or connecting module 13.

**[0084]** Consequently, the separate filter module 19 can be exchanged relatively simply for another filter module 19 or a connecting module 13 for portable sound equipment. Preferably, the form cavity 22 is accessible from the outside of the sealing body via an access canal, so that an even better sound sealing is obtained.

**[0085]** When receiving the separate filter module 19 or connecting module 13 in the form cavity 22 of the sealing body 2, the form cavity 22 encloses a form part 17 of the filter module or connecting module 19, 13 corresponding therewith in a manner such that the form part 17 is secured against axial translation within the form cavity 22. It is noted that naturally, other connecting possibilities can be utilized too, for instance with the aid of a screw connection.

**[0086]** The form cavity 22 may be obtained through a casting process, so that relatively simply, a relatively complex shape of the form cavity 22 can be obtained. What can be achieved through the use of a specifically shaped form cavity 22 is that only a specific, corresponding filter module 19 and/or connecting module 13 is connectable to the sealing body 2. By placing the form cavity 22 in the inside of the sealing body 2, it is ensured that during use, the form cavity 22 is enclosed by sufficient material for energizing the form-closing and thus obtaining a reliable acoustic sealing. Preferably, the form cavity 22 has a slight undersize with respect to the form part 17 of the correspondingly formed part of the filter module 19 and/or connecting module 13. As a result, a slight pressed fit can be realized, ensuring an even better acoustic seal between the sealing body 2 and the filter module 19 and/or connecting module 13, respectively.

Thus, especially the durability of the connection can improve.

**[0087]** The form part 17 comprises wedge-shaped segments 23, so that the filter module 19 and the connecting module 13, by pressing them well, can link up relatively simply with the sealing body 2. For removing the filter module 19 or the connecting module 13 from the sealing body 2, due to the wedge-shaped structure, more force is required. That is why the risk is relatively small that a module 13, 19 will unexpectedly come loose from the sealing body 2, with all undesired consequences. Also, with this, the module 13, 19 can be used elegantly as handle for removing the sealing body 2 from the auditory canal.

**[0088]** A hearing protector can be marketed together with a separate filter module as a set, also called a kit. Further, a separate connecting module for portable sound equipment can be added to the set, so that the user can connect a filter module or a connecting module, at will, to the sealing body of the hearing protector, depending on whether the user wants to observe an external sound, for instance from an iPOD, or wants only hearing protection. In addition, for the purpose of ear protection of the other auditory organ, the set can be added to by an additional hearing protector and an additional filter module, while the connecting parts of the sealing body and of the additional sealing body substantially correspond, so that the connecting module can be provided at the right ear as well as at the left ear.

**[0089]** The invention is not limited to the exemplary embodiment described here. Many variants are possible.

**[0090]** For instance, the control unit can be connected with the aid of a wireless connection to the separate connecting module, this instead of an application with an electronic wire connection as described hereinabove.

**[0091]** Further hearing protectors of both ears can optionally be provided with a connecting module for portable sound equipment, so that stereo sound can be listened to.

**[0092]** Also, depending on the type of background sound and the budget, the hearing protector can be provided for several of the different options, for instance handsfree calling.

**[0093]** Such variants will be clear to the skilled person and are understood to fall within the framework of the invention as set forth in the following claims.

## Claims

1. A hearing protector, comprising a sealing body placeable in the auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and a sound source for generating sound waves to be propagated in the auditory canal, wherein the hearing protector further comprises a control unit connectable to the sound source, which is designed for recording ambient sound and feeding electronic signals representing the recorded ambient sound for reproduction to the sound source.

2. A hearing protector according to claim 1, wherein the sound source is connectable by means of a universal connection to a multiple number of types of portable sound equipment.

3. A hearing protector according to claim 1 or 2, wherein the sound level produced by the sound source is adjustable independently of the type of connected portable sound equipment.

4. A hearing protector according to any one of the preceding claims, wherein the control unit is further designed for limiting the sound level produced by the sound source.

5. A hearing protector according to any one of the preceding claims, wherein the portable sound equipment comprises a communication unit.

6. A hearing protector according to any one of the preceding claims, wherein the portable sound equipment comprises a sound reproduction unit.

7. A hearing protector according to any one of the preceding claims, wherein this is further designed for applying compression to sound waves to be generated by the sound source.

8. A hearing protector according to any one of the preceding claims, wherein this is further designed for correcting the spectrum of sound waves to be generated by the sound source for a spectral transmission characteristic of the auditory canal and/or the sound source.

9. A hearing protector according to any one of the preceding claims, wherein this is further designed for applying an active, non-linear filter to electronic signals that drive the sound source for generating sound waves.

10. A hearing protector according to claim 9, wherein the non-linear filter is designed such that the sound intensity of the sound waves produced by the sound source is actively limited to a preset intensity level.

11. A hearing protector according to any one of the preceding claims, further comprising a receiving unit for receiving an external message transmitted wirelessly by a transmitter, wherein the receiving unit is also designed for transmitting electronic signals representing the received external message to the sound source for the purpose of reproduction.

12. A hearing protector according to any one of the pre-

ceding claims, further comprising a first recording unit designed for recording ambient sound and a second recording unit designed for recording a speech signal originating from a user of the hearing protector.

**13.** A hearing protector according to claim 12, wherein the first recording unit is of the omni-directional type.

**14.** A hearing protector according to claim 12 or 13, wherein the second recording unit has a limited opening angle which is directed towards the mouth of the user.

**15.** A hearing protector according to any one of preceding claims 12 - 14, further comprising a processor unit designed for processing signals generated by the first and second recording unit for suppressing ambient sound in the speech signal recorded by the second recording unit.

**16.** A hearing protector according to any one of the preceding claims, further comprising a separate filter module connectable, in a detachable and soundproof manner, to a connecting part located, during use, at the outside of the sealing body, while in the filter module, a sound filter is included.

**17.** A hearing protector according to claim 16, wherein the sound filter is detachably included in the separate filter module.

**18.** A hearing protector according to claim 16 or 17, wherein the separate filter module is designed for including different types of sound filters.

**19.** A hearing protector according to any one of claims 16 - 18, wherein the sound source is included in a separate connecting module for portable sound equipment, which is connectable in a detachable and soundproof manner to the connecting part of the sealing body.

**20.** A hearing protector according to any one of claims 16 - 19, wherein the connecting part of the sealing body comprises an internal form cavity, accessible from the outside of the sealing body, located, during use, within the auricle, for including therein in a form-closing and detachable manner a form part of the separate filter module or the separate connecting module formed substantially correspondingly to the form cavity in a manner such that, during use of the hearing protector, the form cavity can be sealed off from the outside environment in a soundproof manner.

**21.** A kit, comprising a hearing protector which is provided with a sealing body placeable in an auditory canal of a person, which is manufactured from flexible material so as to fit in the auditory canal of a specific person, and a separate filter module which is connectable in a detachable and soundproof manner to a connecting part located, during use, at the outside of the sealing body.

**22.** A kit according to claim 21, further comprising a separate connecting module for portable sound equipment which is connectable to the connecting part of the sealing body in a detachable and soundproof manner, while in the connecting module, a sound source is included.

**23.** A kit according to claim 21 or 22, further comprising an additional hearing protector which is provided with a sealing body, placeable in the other auditory canal of the user, manufactured from flexible material so as to fit in the other auditory canal of a specific person, and an additional separate filter module which is connectable in a detachable and soundproof manner to a connecting part located, during use, at the outside of the additional sealing body, while the connecting parts of the sealing body and the additional sealing body substantially correspond.

**24.** A transmitter designed for wirelessly transmitting an external message to a receiving unit of a hearing protector, comprising a sealing body placeable in the auditory canal of a person, which is provided with a sound source for generating sound waves to be propagated in the auditory canal.

**25.** A transmitter according to claim 24, wherein the external message is preprogrammed.

**26.** A transmitter according to claim 24 or 25, which is connected to recording means for recording the external message.

**27.** A transmitter according to any one of claims 24 - 26, wherein the transmitter is positioned adjacent an entrance of a specific space.

**28.** A method for applying compression to sound waves which are generated by a sound source of a hearing protector.

**29.** A method for correcting the spectrum of sound waves to be generated by a sound source of a hearing protector for a spectral transmission characteristic of an auditory canal and/or the sound source.

**30.** A method for processing signals which have been generated by a first recording unit of a hearing protector which is designed for recording ambient sound and a second recording unit of a hearing protector which is designed for recording a speech signal orig-

inating from a user of the hearing protector for suppressing ambient sound in the speech signal recorded by the second recording unit.

**31.** A method according to claim 30, wherein processing the signals comprises the steps of selecting a representation of a speech signal that is only present in the signal of the second recording unit, and applying a bandpass filter for allowing passage of a speech signal substantially possessing only frequency components that are within a spectrum of speech.

**32.** A method for applying an active, non-linear filter to electronic signals driving a sound source of a hearing protector for generating sound waves to be propagated in the auditory canal of a user of the hearing protector.

**33.** A processor which is designed for applying compression to sound waves that are generated by a sound source of a hearing protector.

**34.** A processor which is designed for correcting the spectrum of sound waves to be generated by a sound source of a hearing protector for a spectral transmission characteristic of an auditory canal and/or the sound source.

**35.** A processor which is designed for processing signals which have been generated by a first recording unit of a hearing protector which is designed for recording ambient sound and a second recording unit of the hearing protector which is designed for recording a speech signal originating from a user of the hearing protector for suppressing ambient sound in the speech signal recorded by the second recording unit.

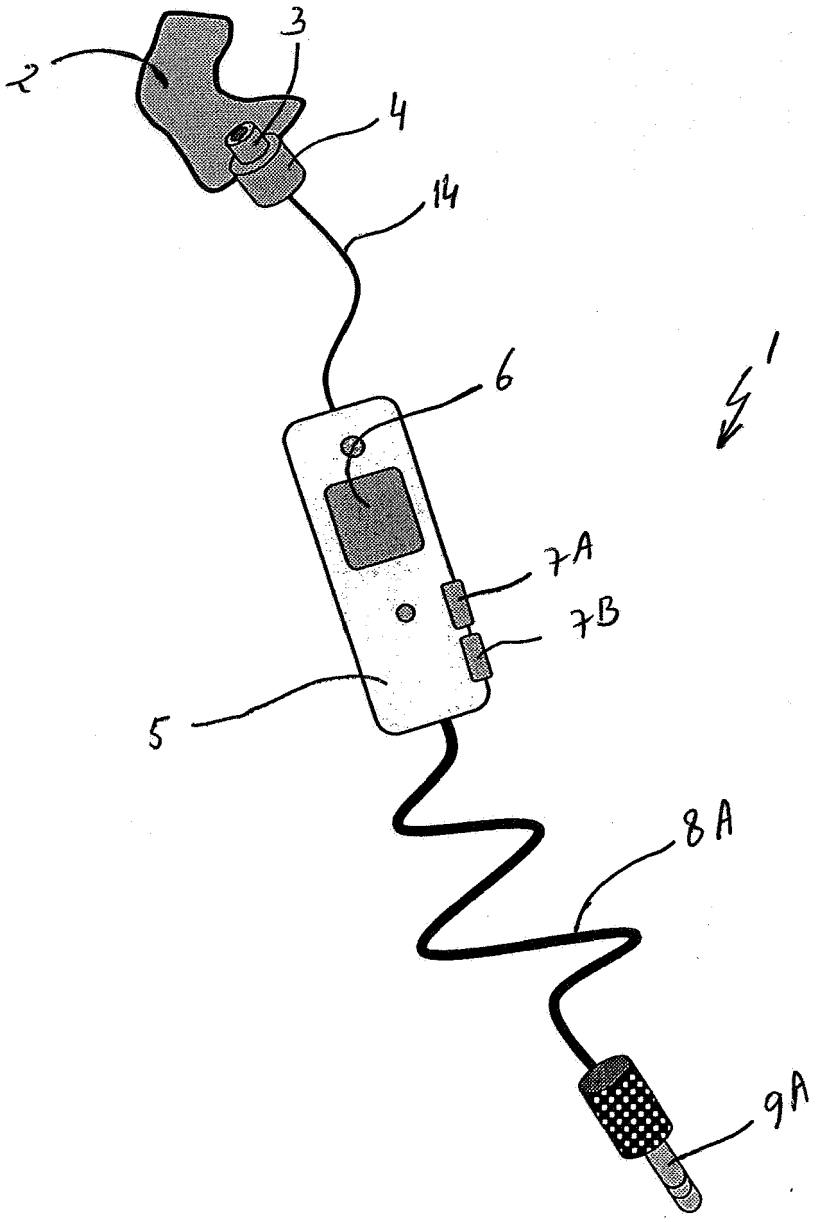
**36.** A processor which is designed for applying an active, non-linear filter to electronic signals that drive a sound source of a hearing protector for generating sound waves to be propagated in the auditory canal of a user of the hearing protector.

**37.** A computer program product comprising instructions for having a processor carry out the method of applying compression to sound waves that are generated by a sound source of a hearing protector.

**38.** A computer program product comprising instructions for having a processor carry out the method of correcting the spectrum of sound waves to be generated by a sound source of a hearing protector for a spectral transmission characteristic of an auditory canal and/or the sound source.

**39.** A computer program product comprising instructions for having a processor carry out the method of processing signals that are generated by a first recording unit of a hearing protector which is designed for recording ambient sound and a second recording unit of the hearing protector which is designed for recording a speech signal originating from a user of the hearing protector for suppressing ambient sound in the speech signal recorded by the second recording unit.

**40.** A computer program product comprising instructions for having a processor carry out the method of applying an active non-linear filter to electronic signals that drive a sound source of a hearing protector for generating sound waves to be propagated in the auditory canal of a user of the hearing protector.




Figuur 1

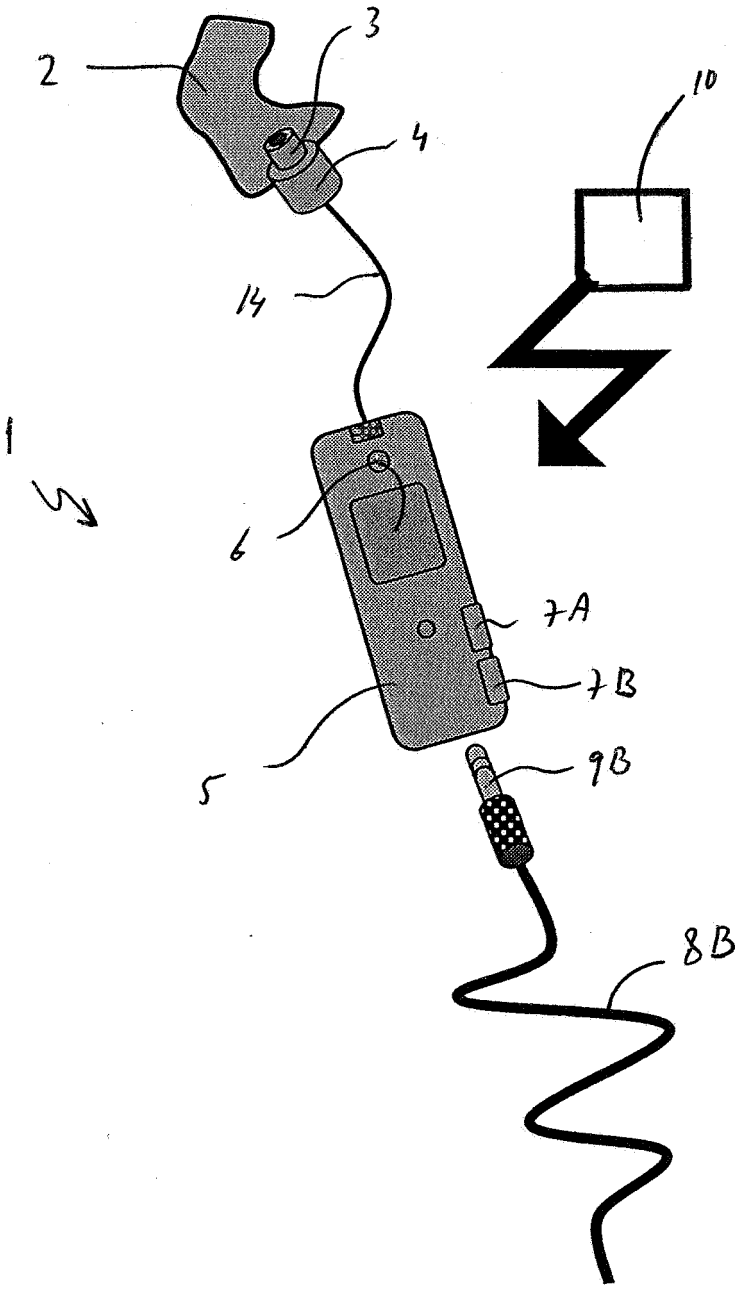
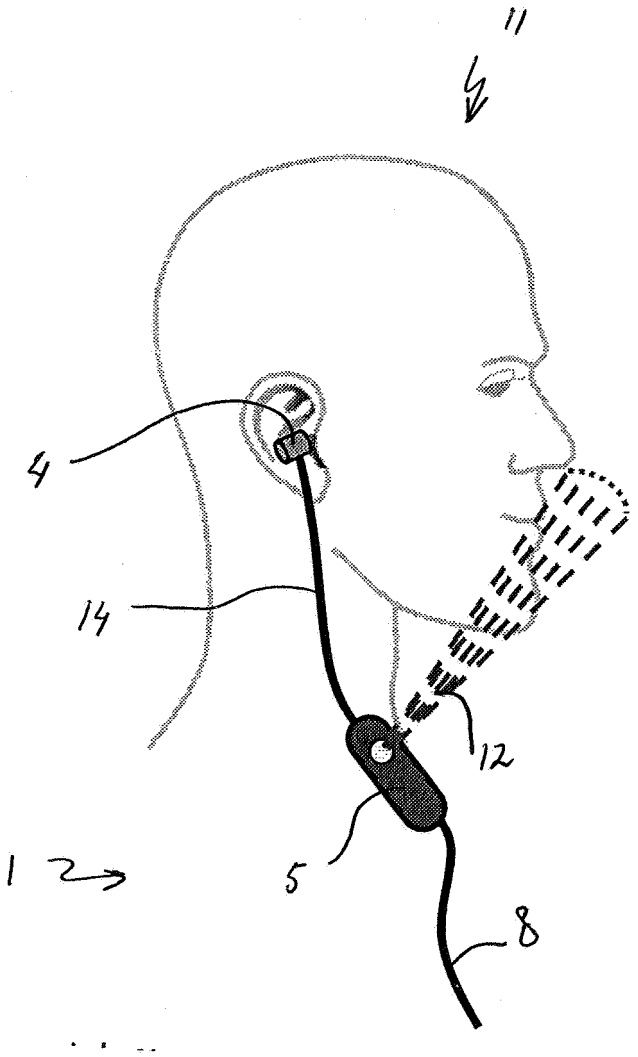



Figure 2




Figuur 3

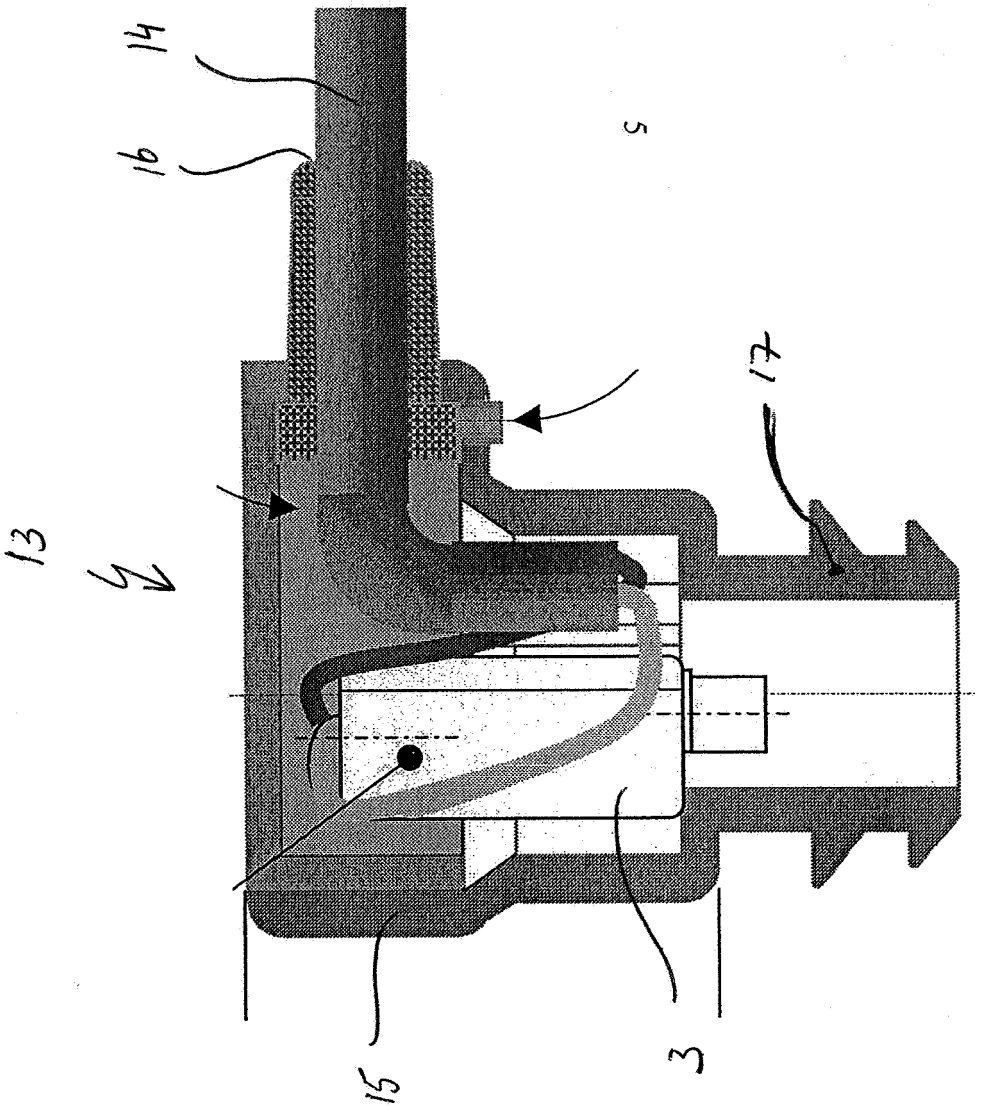
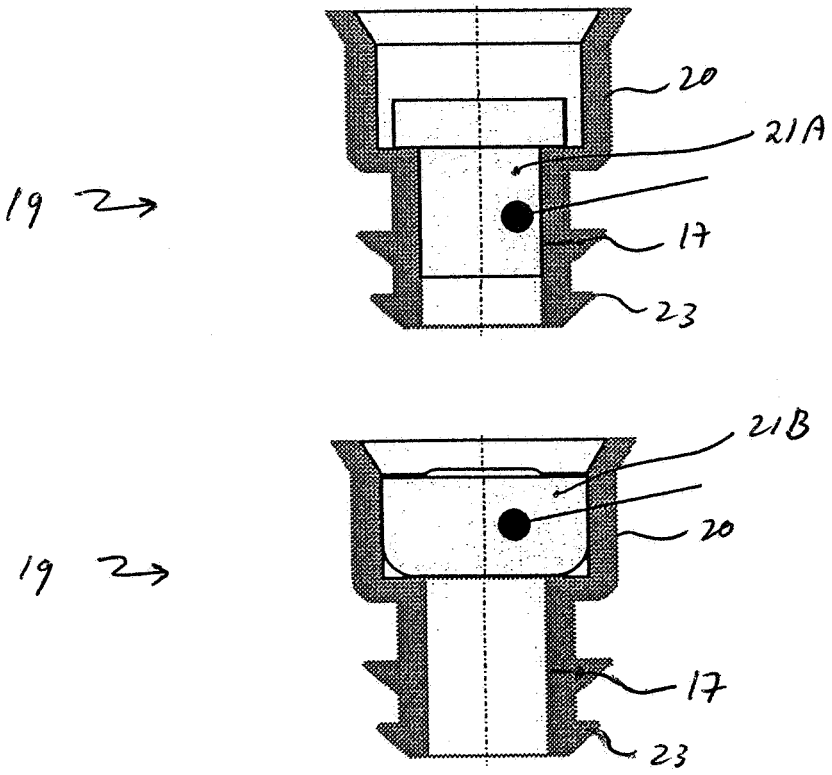



Figure 4




Figuur 5

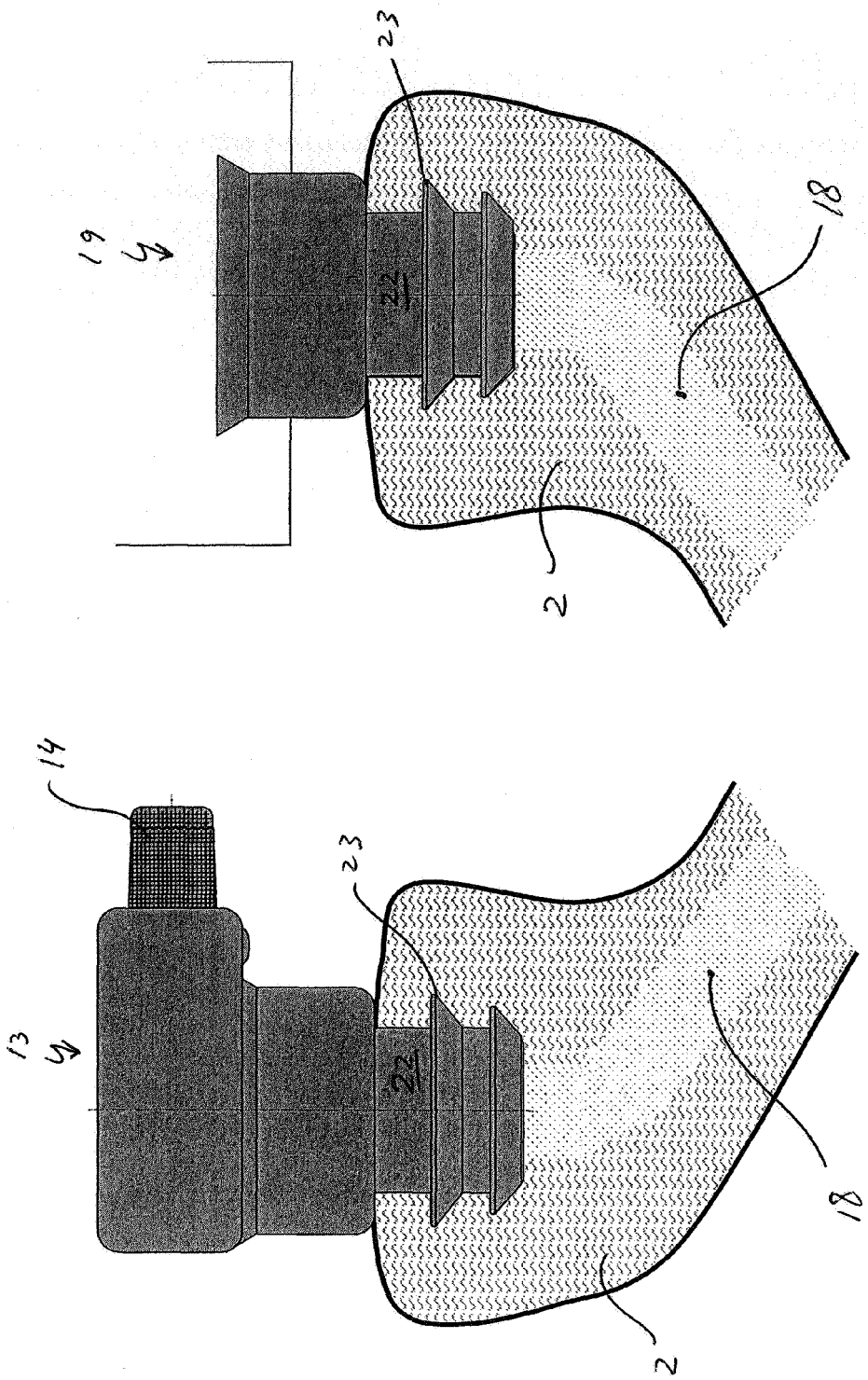



Figure 6

## REFERENCES CITED IN THE DESCRIPTION

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