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(54) Method and apparatus for protection of the hearing of telephone users

(57) A communication device for protecting the hearing of a user which comprises at least one first microphone adapted to transform an acoustic ambient signal into an input signal, a speaker adapted to transform an output signal into an acoustic sound pressure, a communication interface adapted to receive a communication signal, and a processing unit operatively connected to said first microphone and said communication interface for receiving said input signal and said communication signal, adapted to calculate a total sound exposure as the sum of the long-time sound signal exposure of said communication signal and the long-time noise signal exposure of said input signal, and further operatively connected to said speaker and adapted to generate said output signal from said communication signal, wherein the output signal level is attenuated if said total sound exposure exceeds an upper action value.

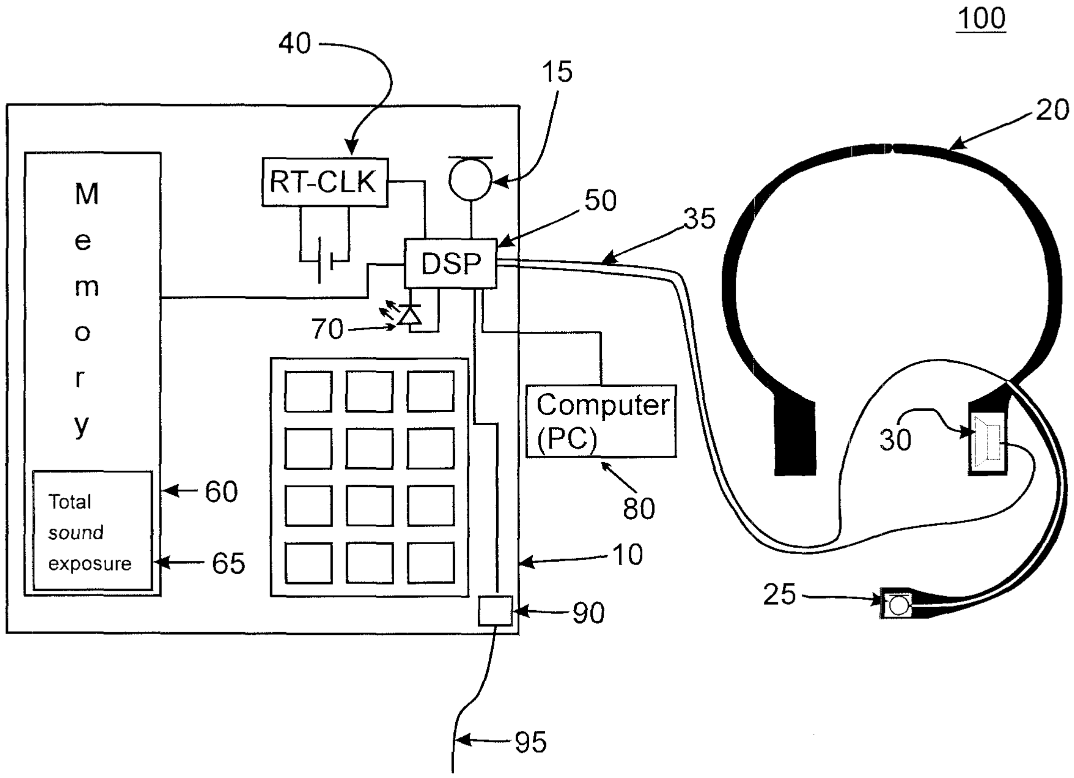

Fig. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the invention

[0001] The present invention relates to protecting the hearing of users of communication devices like a telephone and, more particularly, to methods and apparatus for monitoring and limiting the sound pressure resulting both from ambient sound and sound generated by the communication device, in particular for professional telephone users, e.g. in a call centre.

2. Description of the related art

[0002] Users of telephones for business purposes especially when use is high undergo considerable hazards of their hearing if the telephone does not provide means for hearing protection. These hazard-potentials dramatically increase, if the person wears a headset, like call centre agents usually do. Upon appearance of hazardous signals the user of a conventional telephone can remove the handset from the ear very quickly, but a headset user cannot. The headset is always tight to the ear and there is no possibility of adjusting the sound pressure exposure of the ear by simply changing the distance to the ear. Furthermore, one can assume that a headset is continuously used, while handset-use is normally intermittent. Therefore, telephones and in particular a headset telephone require means for adjusting the headset loudness over a wide range. In the business environment it will shortly become mandatory to provide the telephone with intelligence in order to protect the hearing of its user.

[0003] The sources of hazardous signals are manifold and can be divided into artificial and human-made. Artificial signals are usual tone signals. The most prominent tone hazards result from fax machines that are called by - or do call - a normal telephone, be it intentional or not. Besides fax tones there are various other tones that are liable to damage the hearing, like dial tones (DTMF) and some network control tones. Loud bangs and noise termed 'Acoustic Shocks' can also occur on the telephone network on occasions due to faults, lightning strikes and other reasons that are sufficiently loud they can cause serious hearing problems even to the extent of permanent deafness. Human-made hazards usually result from malignant users that shriek into the telephone, blow a whistle or the like, with the sole purpose of bothering the call centre agent. However, there are also unintended loud signals that can appear during normal speech, like loud smack and pop sounds that especially appear when a microphone is too close to the speaker's mouth.

[0004] But not only sudden loud signals, referred to as acoustic shocks are dangerous, also comparably quiet but permanent background noise is more than just annoying if the human ear is exposed to it for hours. Like shocks, such noise potentially has manifold sources. An omnipresent but usually uncritical source is the network background noise; however, the increasing use of IP telephony seems to considerably increase the importance of this issue. Another noise source results from the usage of hands-free telephones, especially in the car where there is permanent background noise caused by engine sound, wind, and rough surface. Hands-free telephones used in an office environment also produce more noise than a conventional telephone. Due to the greater distance between microphone and speaker's mouth, environmental noise like that of a PC fan is amplified.

[0005] Presently, there are basically two directives that have to be taken into account when designing a real-time noise-cancelling telephone. The first one is the recommendation ITU-T P.360 of the International Telecommunication Union (ITU). This directive deals with the *Efficiency of devices for preventing the occurrence of excessive acoustic pressure by telephone receivers,* i.e. it is specific for telephone-and headset design. The second one is the *Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risk arising from physical agents (noise).* This directive becomes mandatory in April 2006 and is more general about hearing protection of persons working in loud ambient conditions. Although a call centre agent usually would not be suspected of working in loud ambient conditions, all criteria of this directive apply to telephone users, with the only difference that it is primarily not only ambient noise that jeopardizes the hearing, but also noise received from the telephone.

[0006] ITU-T P.360 recommendation gives detailed rules of calculating the limits of acoustic sound pressure levels. For the reasons explained above the limits applicable to headsets are lower than those valid for handsets. The recommendation distinguishes between short disturbances (referred to as shock signals in what follows) and longer disturbances. The relevant physical measure is sound energy, i.e. if a disturbance is half as loud as another one, its signal power may be twice for to reach the same limit as the first disturbance. Longer disturbances are measured in the dBPa(A)-scale, while there is no frequency weighting for short disturbances.

[0007] In the view of Directive 2003/10/EC hearing protection denotes instruments (like ear muffs) for the physical protection of the ears against ambient sound. When applying the directive to telephony, hearing protection becomes signal processing that reduces critical sound events in order to meet the limits of the directive. The directive defines two different kinds of limits: peak level p_{peak} and daily exposure level $L_{Ex,8h}$; and three different sets of limit values for p_{peak} and $L_{Ex,8h}$: exposure limit values, upper exposure action values, lower exposure action values. The Exposure limit values of p_{peak} and $L_{Ex,8h}$ must not be exceeded. If the upper exposure action values are exceeded, one should take action in order to reduce the exposure. In view of telephony, consequently output volume of the headset or the handset of the telephone should be reduced. If one of the lower exposure action values is exceeded, the directive says that means for hearing protection shall be made available to a user. In the context of telephony one could conclude that in this case a telephone with means for hearing protection should be used. Whilst non-exceedance of the P_{peak} limits can be guaranteed quite easily by ensuring a sufficiently low volume of the telephone, $L_{EX,8h}$ monitoring is much more complex because it incorporates cumulative exposure calculations.

[0008] In regard of Directive 2003/10/EC it is worth mentioning that not only the sound pressure that is produced by the telephone itself should be taken into consideration. In the work environment there is a relevant amount of ambient noise caused by other people working in the same room. This simplest but least satisfying method would be to estimate or measure the typical ambient sound level of a work place and add it as a constant to the output sound of the telephone. However, this approach makes it impossible to take the real ambient noise into account.

[0009] The implementation of just a sound pressure limiter into the telephone may also not cope with hazardous noise exposure in all cases.

[0010] Thus, there is a need for improved techniques for providing protection of the hearing of users of communication devices.

SUMMARY OF THE INVENTION

[0011] It is therefore an object of the present invention to provide a method and a communication device for protecting the hearing of a user having improved sound or noise exposure monitoring and limiting properties.

[0012] This object is solved by a method for protecting the hearing of a user using a communication device which comprises the steps of transforming an acoustic ambient signal into an input signal, receiving a communication signal, updating a long-time noise signal exposure for said input signal, updating a long-time sound signal exposure for said communication signal, calculating a total sound exposure as the sum of said long-time sound signal exposure and said long-time noise signal exposure, generating an output signal from said communication signal, wherein the output signal level is attenuated if said total sound exposure exceeds an upper action value, and transforming said output signal into an acoustic sound signal.

[0013] The present invention further provides a communication device for protecting the hearing of a user which comprises at least one first microphone adapted to transform an acoustic ambient signal into an input signal, a speaker adapted to transform an output signal into an acoustic sound pressure, a communication interface adapted to receive a communication signal, and a processing unit operatively connected to said first microphone and said communication interface for receiving said input signal and said communication signal, adapted to calculate a total sound exposure as the sum of the long-time sound signal exposure of said communication signal and the long-time noise signal exposure of said input signal, and further operatively connected to said speaker and adapted to generate said output signal from said communication signal, wherein the output signal level is attenuated if said total sound exposure exceeds an upper action value.

[0014] With the method and communication device according to the present invention it is possible to monitor and eventually reduce the output sound pressure and thus the output volume in case there is a danger for the hearing of the user according to the total sound exposure to the user taking both the long-time noise signal exposure of ambient signals from the environment of the user as well as the long-time sound signal exposure of the communication signal like a telephone signal received over a telephone network from a remote terminal into account.

[0015] Taking said directive 2003/10/EC into account, according to the present invention, also the ambient noise level is monitored and added to the sound pressure produced by the telephone headset/handset for calculating exposure action or limiting values. According to the present invention, a kind of a measuring microphone, or at least a setup option of the telephone defining a typical ambient noise exposure is provided.

[0016] An advantage with respect to prior art technique may be seen by the fact that the communication device may not only perform Noise-, Tone- and Shock-Elimination, but also sound pressure monitoring, i.e. the telephone should calculate the $L_{Ex,8h}$ during usage, and eventually reduce the output volume in case there is the danger of exceeding the limit value of $L_{EX,8h}$. Since different headphones produce different sound pressure out of the same voltage level, the user should not be totally free to use any headset he likes. Headsets should be approved by the telephone manufacturer. According to an aspect of the present invention, a calibration of the headphone volume of approved headsets is provided, since otherwise compliance with the regulations cannot be guaranteed. For the same reason it is according to the present invention mandatory to integrate the monitor into the communication device like a telephone, the headset or a processing unit like a PC operatively linked to the telephone and not into a black box between line and telephone. In the latter approach besides the headset there is also the unknown telephone that would make it very difficult to get reliable measures. Otherwise, to be safe, such a black box approach would have to align with the loudest possible telephone and headset, with the consequence that if equipment with lower volume is used the sound pressure measure might be dramatically overestimated and the system would reduce the volume far too early resulting in an unusable configuration.

[0017] According to further aspects of the present invention, there are also provided noise reduction, shock and tone elimination from the received communication signal implemented by respective method steps as defined by dependent claims 4 and 5 or respective signal processing components of said communication device.

[0018] According to another aspect of the present invention, a warning indicator is provided which is activated when said total sound exposure exceeds a lower action value which is lower than the upper action value. The warning indicator may be implemented in the telephone itself or as a software tool providing respective display messages like "Attention: Sound or Noise Exposure!" on a computer (PC) of the user when activated. In case the total sound exposure exceeds a limit value which is higher than the upper action value, the transforming step or the speaker will be disabled.

[0019] The invention, according to further aspects, provides a computer program and a computer program product as recited in claims 9 and 10.

[0020] The invention, in yet another aspect, provides a system for processing sound and/or ambient noise signals as recited in claim 11.

[0021] Further specific variations of the invention are defined by the further dependent claims.

[0022] Other aspects and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

Figure 1 is a block diagram of a communication device according to an embodiment of the present invention.

Figure 2 is a flow diagram of a method according to an embodiment of the present invention.

Figure 3 is a more detailed flow diagram of a part of the method as illustrated in Fig. 2.

Figure 4 is a flow diagram of a method for calculating long-time exposure according to an embodiment of the present invention.

Figure 5 is a flow diagram of a method for calculating long-time exposure according to another embodiment of the present invention.

Figure 6 is a flow diagram of a method for exposure monitoring and attenuating according to an embodiment of the present invention.

Figure 7 is a combined block and flow diagram illustrating ambient sound signal measure according to an embodiment of the present invention.

Figure 8 is a flow diagram of a method for ambient sound signal estimation according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] The present invention relates to improved approaches to monitor and, if necessary, attenuate or disable output signals of communication devices like telephones. In the following telephones are described that are equipped with a headset worn by the user. However, is it also within the scope of the present invention when the telephone is equipped with a handset or itself functions as a handset like a mobile terminal or a mobile phone.

[0025] Fig. 1 shows a block diagram of a first embodiment of a communication device according to the present invention. According to Fig. 1, the communication device is a telephone 100 comprising the telephone terminal 10 and a headset 20 connected to the telephone apparatus 10 via a cable 35. The Headset to be used by the user comprises a headset microphone 25 and earphone or speaker 30 for outputting the output signal by means of an acoustic sound pressure to the ear of the user. The telephone terminal comprises, according to an embodiment, a microphone 15 for transforming the acoustic ambient signals into input signals, a preferably battery powered real-time clock 40, a memory 60, a light emitting diode (LED) 70 as warning indicator and a communication interface 90 all operatively connected to a processing unit 50 implemented by a digital signal processor (DSP) 50.The communication interface 90 may be implemented as a simple plug or socket for the telephone line 95 connected to the telephone network, a radio interface of a mobile network or the like.

[0026] The hearing protection functionality of the communication device 100 will now be described with reference to Fig. 2 illustrating a flow diagram of a method according to embodiments of the present invention. In step 210, the communication signal which is the receive signal from the telephone line is received over communication interface 90 by the telephone 10. According embodiments, noise reduction as well as tone and shock elimination techniques are applied in steps 220 and 230 to the communication signal as will be described in more detail with reference to Fig. 3. At the same time when using the communication device by the user the acoustic ambient signal which is also referred to as ambient noise signal is recorded and transformed into the input signal by microphone 15 (also called measuring microphone) in step 250. For each the input and the communication signal there is updated a long-time signal exposure in steps 240 and 260 over a certain time window (long-time noise signal exposure for the input signals and long-time sound signal exposure for the communication signal) and preferably stored in a memory 60. These long-time signal exposures are then summed in step 270 to a total sound exposure representing the total sound exposure acting on the user's ear over the working hours using the real-time clock 40 of the telephone. The total sound exposure is stored in the memory 60 as indicated by reference sign 65 and monitored by the DSP 50. The DSP 50 also generates the output signal from the communication signal which is then transmitted to the earphone 30 for transforming into an acoustic sound signal. If the DSP 50 detects that the total sound exposure exceeds an upper action value, the level of the output signal is attenuated in order to keep the total sound exposure possibly low and thus protecting the hearing of the user.

[0027] Since most modern telephone workplaces are equipped with computers (PCs), according to an embodiment of the present invention, an 8-hour total sound exposure is monitored by a PC 80 that is linked to the telephone 10 e.g. via USB. In such an embodiment, the telephone would need neither permanent power supply nor an own internal real-time clock. Calculations are done on the PC, and naturally the PC offers good display options (not shown), e.g., for displaying a sound pressure profile corresponding to the long-time sound ands noise exposures. According to an embodiment, the PC also works as the warning indicator and detailed warnings are issued by the PC either as sound warnings or as visual warnings displayed on the screen of the PC before the system is forced to reduce the output volume.

[0028] According to embodiments as now described with reference to Fig. 3, the communication signal will be further subject to noise reduction (step 220 in Fig. 2; not shown in Fig. 3) and tone and shock elimination (step 230 in Fig. 2) prior to the long-term sound pressure monitoring.

[0029] The goal of shock elimination is the reduction of (sudden) loud signals in order to prevent events that exceed the limit value and also the upper action value of p_{peak}. The simplest way of avoiding too loud signals is to physically limit the maximum sound pressure output of a telephone handset and headset. In digital signal processing, this is naturally the case, because the maximum voltage output level is restricted by the properties of D/A-converters. Thus, one can easily guarantee that the limit value of p_{peak} is never exceeded as the relation between voltage level produced by the D/A-converter and corresponding sound pressure level in the used headset or headset is known an which is a general requirement also for following discussions. Although such a simple method may produce unwanted nonlinear effects (known as clipping) when the output limit of the D/A-converter is reached, this is the easiest and safest way of assuring compliance with the limit value p_{peak}. Making clipping "smoother" by means of a characteristic curve ("soft clipping") is sometimes suggested as improvement in order to make clipping less annoying; however, in practice the cost-value ratio of this method is poor. A shock-eliminator according to the present invention is adapted to detect (step 330) and attenuate (step 340) sudden loud acoustic events below the limit, i.e. signals that exceed the upper or even the lower action value of p_{peak}. The shock eliminator does not require spectral domain processing and could, if there is no need for other additional algorithmic components, run on a standard microcontroller; or on the DSP 50 needed, for example, for the more complex noise reduction.

[0030] With respect to tone elimination, tones like fax or DTMF tones are perhaps the most annoying disturbances that appear in telephony, and since they are usually quite loud they easily exceed the p_{peak} limits and thus could be seen as special sort of shock signal (although tones usually are not short). However, from an algorithmic perspective they should be treated separately from other shock signals because of their special properties. According to the present invention, the approach of removing tones is spectral-domain processing, which is more flexible and more tolerant compared to, for example, a time-domain approach using notch filters, but naturally requires a Fourier-Transformation. This allocates considerable resources of the processor and introduces a delay into the signal processing. Such a delay may be handled by delaying the signal output itself by the time it takes to detect the tone with the drawback is the additional latency. However, a latency of 10 ms is usually acceptable, but longer delays cause problems, especially with side tone perception. If the latency is 20 ms or more the side tone appears echoic, which is unacceptable. In spite of the latency effect the spectral domain processing is favourable because it allows rather versatile handling of tones: if a tone with certain frequency is detected (step 310), attenuation (step 320) is applied as long as the tone is present. The attenuation value can be tone specific, if required, and frequency tolerances can be easily taken into account. In case the signal contains simultaneous speech, this will be attenuated, too. This fact can be seen as a drawback, but as stated earlier speech and tones rarely appear simultaneously in normal telephony. And since attenuation is only applied to the signal if a tone is present, the signal is not modified at all during the absence of tones, because nothing influences the frequency characteristic like notch filters do.

[0031] With respect to noise reduction, although also shock signals and tones can be seen as noise, too, in the context of noise reduction one usually refers to noise as constant and slowly varying background sound. The reduction of such background noise is more than a convenience issue: Being continuously present even at low volumes background noise considerably contributes to daily sound exposure $L_{Ex,8h}$, so its reduction is as important as the elimination of tones and shocks. According to embodiments, there is provided noise reduction techniques to the communication signal comprising an internal representation of the present noise by, e.g., some kind of noise estimation. If the noise level is high (signal-to-noise ratio near 0 dB) and noise reduction is set to be rather aggressive (e.g. 20 dB attenuation of white noise), artefacts in the signal become unavoidable. There are two typical effects: strange whistling sound appears (sometimes called "musical tones"), and the speech signal itself degrades, the voice sounds "hollow" or "robotic". In a noise suppressor implemented for example as software code portion executable by the DSP 50, both effects can be kept at a low level and if there is no or only low noise, the speech signal should remain completely unaltered. Examples for a suitable noise suppressor can be found in European patent No. 1091349 of the applicant which is hereby incorporated by reference. Noise reduction methods require spectral domain processing and show the latency effects discussed earlier. Since Noise Reduction is not only a simple attenuation of the signal but a sort of subtraction of noise from speech, there is always some latency in the processed signal. The latency of high quality noise reduction needs to be as low as 10 ms for the reasons stated above, and there should be an integrated approach of noise reduction with tone-elimination (and also shock-elimination), in order not to add the latencies of the single algorithms, but to build a software tool with overall latency not more than 10 ms. Since noise reduction requires spectral domain processing anyway, it is self-evident that also tone-elimination operates in the spectral domain and share resources (like Fourier Transforms) in an integrated approach.

[0032] According to an embodiment of the present invention, a telephone protecting the users hearing by means of noise, tone and shock elimination as described herein even if it works as a stand-alone telephone by using internal processing capabilities but without an internal battery powered real-time clock is regarded as a good compromise. If it is necessary to monitor 8 hour sound exposure (leading to a reduction of output volume, if necessary), in this concept a link to a PC is required. The PC 80 linked to the telephone 10 is a protection tool for the telephone user that can be used or not. However, in the responsibility of the employee usage of the protection tool is mandatory, and the PC demonstrates both to the telephone user and management that compliance with the Noise Directive is being achieved. However, such an approach cannot ensure compliance with the 8-hour exposure limit, because the communication device is able to operate without the PC connected to the communication device.

[0033] Therefore, according to an embodiment, a real-time clock 40 is integrated into the telephone 10. The real-time clock 40 and the DSP 50 are then adapted to perform the total sound exposure calculations, update and monitor the exposure(s) and if necessary adjust the level of the output acoustic sound signal by attenuating the output signal in order to ensure the limits defined in the EU-Directive are not exceeded.

[0034] The calculation of the long-time sound and noise exposures will now be described in more detail with reference to Figs. 4 and 5. Fig. 4 illustrates a method according to an embodiment without the use of a PC 80. In this embodiment, the calculation is preferably carried out by the DSP 50 of the telephone. First, the previous exposure value is fetched from memory 60 in step 410 and the present time information is determined in step 420 from real-time clock 40 in step 420. In step 430, the present signal energy is calculated, each from the input signal to calculate the present noise signal exposure value and from the communication signal to calculate the present sound signal exposure value by using respective calibration data in step 440. Each of the long-term signal exposure values are then updated by adding the respective previous and present exposure values and storing the updated exposure value back in the memory.

[0035] Fig. 5 illustrates a method according to another embodiment calculating the long-term signal exposure values by means of a PC linked to the telephone. The present signal energy for both the input and the communication signal is calculated by the DSP 50 of the telephone and submitted to the PC 80 in step 510. The present noise signal exposure value is then calculated by the processing unit of the PC from the input signal energy and the present sound signal exposure value from the communication signal energy by using respective calibration data in step 520. Similar to step 450, each of the exposure values for noise and sound are then updated in step 530 and added to get an updated total sound exposure value. This updated total sound exposure value is then submitted back to the telephone in step 540 and preferably stored in memory 60 as indicated by reference sign 65.

[0036] The flow diagram as depicted in Fig. 6 illustrates a method according to the present invention of how the sound exposure is monitored, displayed and attenuated either by means of a PC or without PC. At first, it is determined in step 610 whether there is a PC operatively connected to the telephone and prepared to carry out the monitoring or not. Of course this option can also simply be disabled on the telephone so that monitoring is always done by the telephone. However, according to a preferred embodiment, as a default setup monitoring is done by the telephone and if it is detected by the telephone that a PC is present and prepared to monitor the sound exposure monitoring is taken over by the PC. If monitoring is done by the PC, the method branches to step 630 and the updated values for the long-time sound signal exposure and the long-time noise signal exposure as well as the total sound exposure are displayed on the screen of the PC. It is further preferred to display these values together with respective limits, e.g. according to the EU Directive.

[0037] If the monitoring is done by the telephone itself, the method branches to step 620 and if a lower action value is exceeded the LED 70 as warning indicator is activated by, e.g., flashing of the LED. Of course any other appropriate warning indicator may be used instead of the LED.

[0038] In both scenarios with or without a PC, the telephone itself or the PC will attenuate the output signal if a upper action value is exceeded in step 640 in order to lower the sound pressure of the acoustic output signal produced by the earphone 30. The upper action value is preferably a preset value that is selected to ensure that the maximum allowable sound exposure over e.g. the 8 hour working time will expect-edly not be reached. As a next step 650, the speaker or earphone will be disabled if despite the attenuation is step 640 a limit value is reached or even exceeded. Of course, for future processing the upper action value should then be lowered in order to avoid the action in step 650 interrupting or even ending the use of the telephone at the current working time. The disabling can be implemented by simply disabling the step of generating the output signal or switching of the earphone itself.

[0039] Since it is not only the sound output of the earphone 30 into the user's ear that contributes to the total 8-hour sound exposure, but also the ambient noise; it is desirable to integrate this sound component into the monitoring.

[0040] According to an embodiment, an additional microphone 15 (also called ambient noise measurement microphone) is integrated into the telephone that permanently measures the ambient noise. According to this embodiment, the ambient sound level can be measured directly, if one assumes that the ambient noise is a diffuse sound field. This assumption is not completely correct, since at least one component of ambient sound is not diffuse, but produced by a single distant but nearby source: the users own voice. It comes close to a philosophical discussion whether or not the user's voice should count as contribution to ambient sound exposure, so we will neglect this effect for the sake of pragmatism. Under said assumption of background noise being a diffuse sound field a calibration is required giving the relation between the signal level of the measuring microphone and the sound pressure level caused by background noise being measured in the users ear that is covered by a headset earphone. The difference between various headsets in regard of the shielding effect against background noise is also an issue that should be taken into account. In Fig. 7, the ambient noise signal measurement by means of the microphone 15 is illustrated. A schematic circuit diagram 700 shows microphone 15 coupled to the DSP 50 over an analogue-digital converter (ADC) 750. The ambient noise microphone signal is transformed into the input signal and measured by the ADC 750 as voltage U_N in step 710. The DSP 50 then calculates a resulting sound level for the input signal produced by the earphone 30 using calibration data in step 720.

[0041] According to another embodiment, instead of integrating a dedicated measuring microphone into the telephone, one could use the microphone of the headset (headset microphone) 25 itself for the measurement of the ambient noise. This approach has the advantage that no additional ambient noise measurement microphone is needed. However, it then has to be taken into account that the microphone gain of the used headset is not a priori know, resulting in a calibration need for the microphone gain of the approved headsets (in addition to the independent calibration of the earphone volume calibration discussed above). This approach further requires distinction between speech signals and background noise, because the speaker's mouth is so close to the microphone that the user's speech would otherwise be dramatically overestimated in its contribution to the total ambient sound exposure. Said distinction is made by means of an approach according to an embodiment as illustrated in the flow diagram of Fig. 8. In step 810 first the headset microphone signal is used as input signal. Human speech is not completely continuous; there are short breaks where only background sound is present, so the minima of the microphone signal is tracked being a good estimate of the background sound (or ambient noise signal) level in step 820. In contrast to the alternative approach of integrating a measurement microphone into the telephone, according to this embodiment, the method would define the user's own voice not to be a contribution to ambient noise exposure. As stated before, whether to do so or not is not really relevant; none of the regulations attribute any importance to this detail. In step 830 again it is then calculated the resulting sound level for the input signal produced by the earphone 30 using calibration data.

[0042] According to preferred embodiments of the present invention, methods, systems and hearing aid devices described herein are implemented in a telephone or on any other signal processing devices suitable for the same, such as, e.g., digital signal processors, analogue/digital signal processing systems including field programmable gate arrays (FPGA), standard processors, or application specific signal processors (ASSP or ASIC).

[0043] According to a further embodiment, the invention is implemented in a computer program containing executable program code. The program code may be stored in a memory of a telephone or any other telecommunication terminal or a computer memory of a PC operatively connected to a telephone and executed by the telephone itself or any processing unit like the CPU of the PC or by any other suitable processor, DSP or computing element executing a method according to the described embodiments. The computer program may be embodied by a computer program product like a floppy disk, a CD-ROM, a memory stick or any other suitable memory medium for storing program code.

[0044] All appropriate combinations of features described above are to be considered as belonging to the invention, even if they have not been explicitly described in their combination.

[0045] Having described and illustrated their principles of the present invention in embodiments thereof, it should be apparent to those skilled in the art that the present invention may be modified in arrangement and detail without departing from such principles. Changes and modifications within the scope of the present invention may be made without departing from the spirit thereof, and the present invention includes all such changes and modifications.

Claims

1. A method for protecting the hearing of a user using a communication device, comprising the steps of:

   - transforming an acoustic ambient signal into an input signal;
   - receiving a communication signal;
   - updating a long-time noise signal exposure for said input signal;
   - updating a long-time sound signal exposure for said communication signal;
   - calculating a total sound exposure as the sum of said long-time sound signal exposure and said long-time noise signal exposure;
   - generating an output signal from said communication signal, wherein the output signal level is attenuated if said total sound exposure exceeds an upper action value; and
   - transforming said output signal into an acoustic sound signal.

2. The method according to claim 1, further comprising the step of:

   - activating a warning indicator when said total sound exposure exceeds a lower action value which is lower than said upper action value.

3. The method according to claim 1 or 2, further comprising the step of:

   - disabling said transforming step when said total sound exposure exceeds a limit value which is higher than said upper action value.

4. The method according to one of the preceding claims, further comprising the step of applying noise reduction to said communication signal prior to said updating of said long-time sound signal exposure.

5. The method according to one of the preceding claims, further comprising the step of applying tone or shock elimination to said communication signal prior to said updating of said long-time sound signal exposure.

6. The method according to one of the proceeding claims, wherein said updating steps of said long-time signal exposures each comprising:

   - providing said long-time signal exposure as a previous exposure value;
   - determining a present time information;
   - calculating a present signal energy from said present time information and a respective signal level of said input or communication signal;
   - calculating a present exposure value from said present signal energy by using calibration data;
   - updating said respective long-time signal exposure by summing said respective present and previous exposure values.

7. The method according to one of the preceding claims, wherein said communication device is a telephone comprising a headset worn by said user and wherein said input signal is transformed by a headset microphone and said acoustic sound pressure is transformed by an earphone of said headset, and wherein said step of updating said long-time noise signal exposure further comprises tracking minima of said input signal as ambient noise signal and calculating said long-time noise exposure by calculating an input signal level based on said ambient noise signal and calibration data.

8. The method according to one of claims 1 to 6, wherein said communication device is a telephone comprising a headset worn by said user, and wherein said input signal is transformed by a microphone disposed at a distance from a headset microphone and said acoustic sound pressure is transformed by an earphone of said headset, and wherein said step of updating said long-time noise signal exposure further comprises calculating said long-time noise exposure by calculating an input signal level based on said input signal and calibration data.

9. Computer program containing executable program code which, when executed on a computer, executes a method according to any one of Claims 1 to 8.

10. Computer program product, containing executable program code which, when executed on a computer, executes a method according to any one of Claims 1 to 8.

11. A system for processing sound or ambient noise signals comprising means configured to carry out a method according to one of Claims 1 to 8.

12. A communication device for protecting the hearing of a user, comprising:

    - at least one first microphone adapted to transform an acoustic ambient signal into an input signal;
    - a speaker adapted to transform an output signal into an acoustic sound pressure;
    - a communication interface adapted to receive

a communication signal;
- a processing unit operatively connected to said first microphone and said communication interface for receiving said input signal and said communication signal, adapted to calculate a total sound exposure as the sum of the long-time sound signal exposure of said communication signal and the long-time noise signal exposure of said input signal, and further operatively connected to said speaker and adapted to generate said output signal from said communication signal, wherein the output signal level is attenuated if said total sound exposure exceeds an upper action value.

13. The communication device according to claim 12, further comprising a clock unit which is adapted to measure a use time of said communication device by said user, and wherein said total sound exposure is calculated over said use time.

14. The communication device according to claim 12 or 13, further comprising a memory unit operatively connected to said processing device, and wherein said memory unit is further adapted to store said total sound exposure for every user over said use time.

15. The communication device according to any of claims 12 to 14, further comprising a warning indicator operatively connected to said processing unit or said memory unit, and wherein said warning indicator is activated when said total sound exposure exceeds a lower action value which is lower than said upper action value.

16. The communication device according to any of claims 12 to 15,wherein said processing unit is further adapted to disable said speaker when said total sound exposure exceeds a limit value which is higher than said upper action value.

17. The communication device according to any of claims 12 to 16, wherein said communication device is a telephone comprising a headset worn by said user and wherein said first microphone is a headset microphone and said speaker is a earphone of said headset, and wherein said processing unit is further adapted to calculate said long-time noise signal exposure of said input signal by tracking minima of said input signal as ambient noise signal and calculating said long-time noise exposure by calculating an input signal level based on said ambient noise signal and calibration data.

18. The communication device according to any of claims 12 to 16, wherein said communication device is a telephone comprising a headset worn by said user, wherein a headset microphone is a second microphone, said first microphone is disposed at a distance from said second microphone and said speaker is an earphone of said headset and wherein said processing unit is further adapted to calculate said long-time noise signal exposure by calculating an input signal level based on said input signal and calibration data.

19. A communication system comprising said communication device according claims 12 to 18 and a computer connectable to said communication device via a data interface, wherein said communication device is further adapted to calculate a signal energy from said input signal and said communication signal and to transmit said signal energy to said computer, and wherein said computer is adapted to calculate and monitor said total sound exposure from said signal energy by using calibration data and to transmit an updated total sound exposure to said communication device.

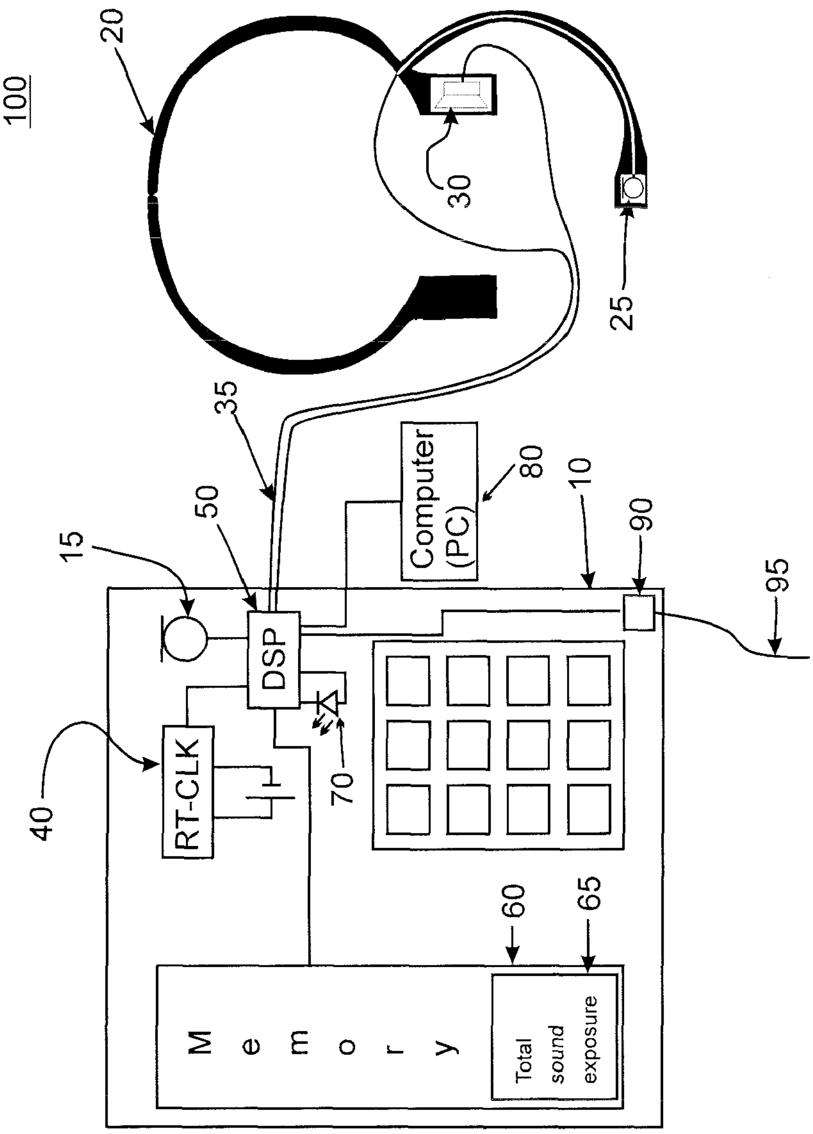
100
20
30
25
35
Computer (PC)
80
10
90
95
15
50
DSP
40
RT-CLK
70
60
65
Memory
Total sound exposure

Fig. 1

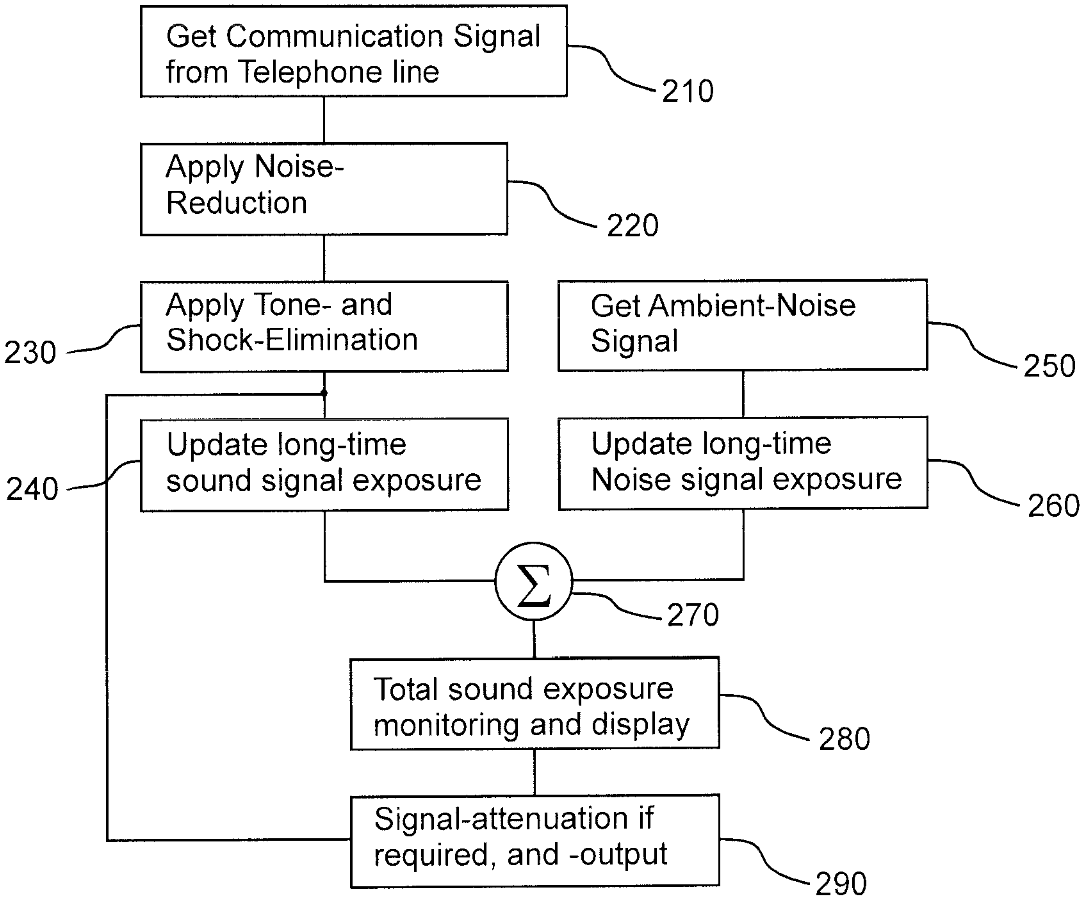
Get Communication Signal from Telephone line
210
Apply Noise-Reduction
220
Apply Tone- and Shock-Elimination
230
Get Ambient-Noise Signal
250
Update long-time sound signal exposure
240
Update long-time Noise signal exposure
260
Σ
270
Total sound exposure monitoring and display
280
Signal-attenuation if required, and -output
290

Fig. 2

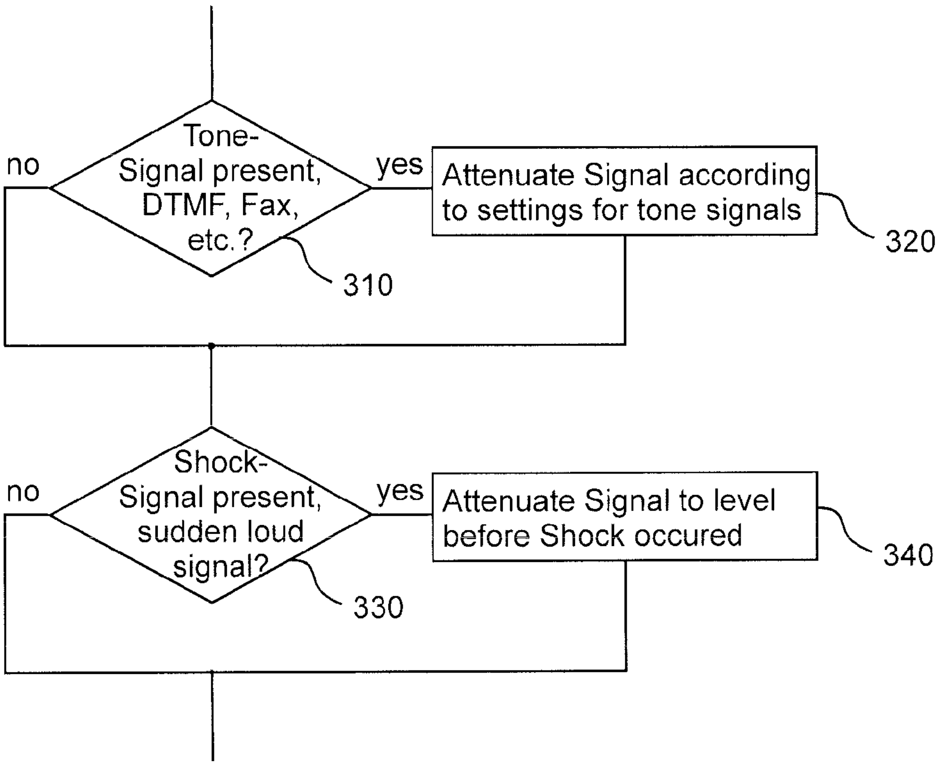
Tone-
Signal present,
DTMF, Fax,
etc.?
no
yes
Attenuate Signal according
to settings for tone signals
310
320
Shock-
Signal present,
sudden loud
signal?
no
yes
Attenuate Signal to level
before Shock occured
330
340

Fig. 3

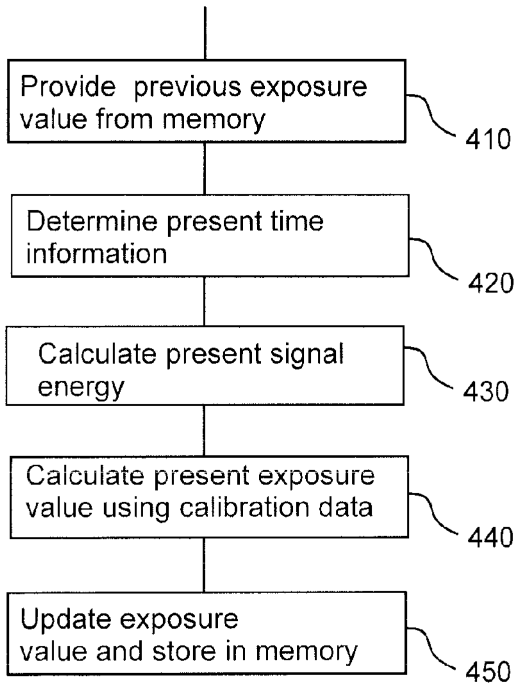

Fig. 4

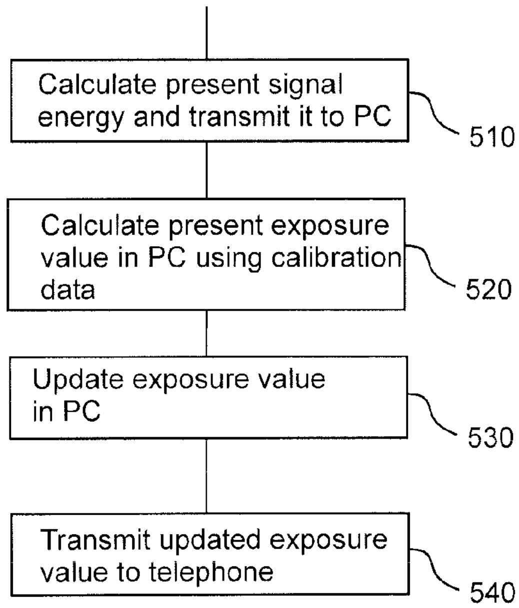

Fig. 5

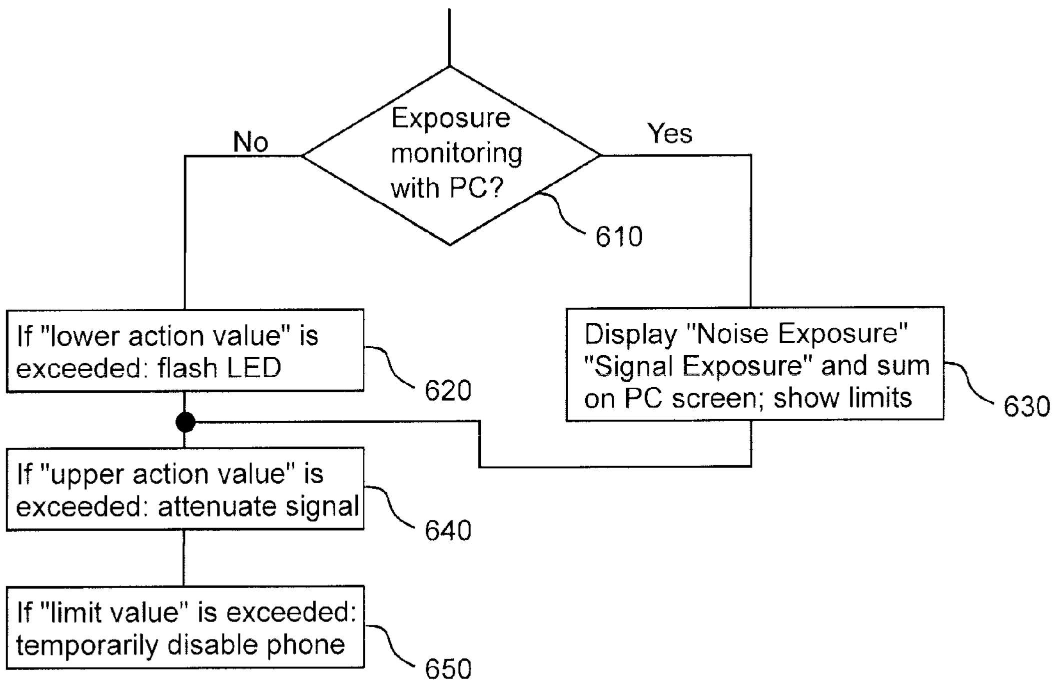

Fig. 6

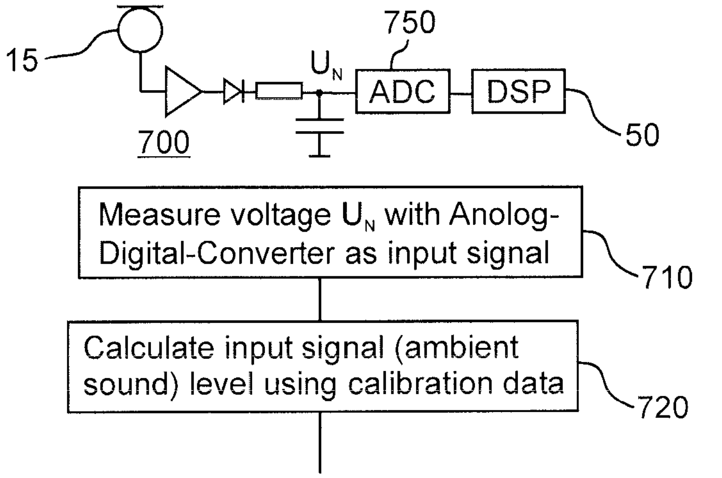
15
750
U_N
ADC
DSP
50
700
Measure voltage U_N with Anolog-Digital-Converter as input signal
710
Calculate input signal (ambient sound) level using calibration data
720

Fig. 7

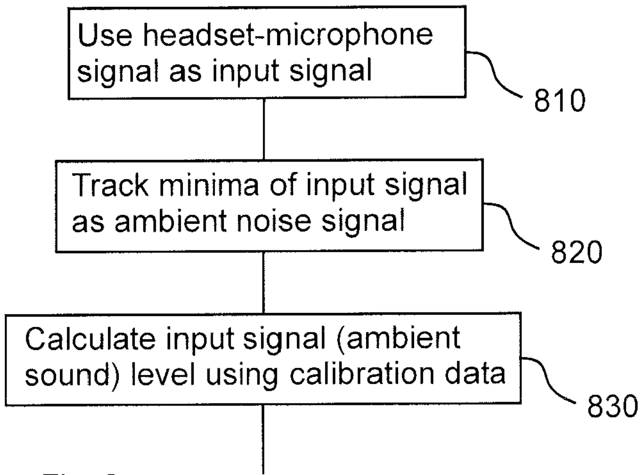
Use headset-microphone signal as input signal
810
Track minima of input signal as ambient noise signal
820
Calculate input signal (ambient sound) level using calibration data
830

Fig. 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 10 1148

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2004 016184 A1 (BEYER DYNAMIC GMBH & CO) 3 November 2005 (2005-11-03) * paragraphs [0006], [0009], [0010], [0012] - [0015], [0017] - [0020], [0026], [0027], [0029] - [0039]; figures *	1,11,12	INV. H04R3/00 G01H3/14
A	US 2003/191609 A1 (BERNARDI ROBERT J ET AL) 9 October 2003 (2003-10-09) * paragraphs [0009] - [0013], [0018] - [0022], [0025] - [0034], [0036], [0038], [0042], [0043], [0045], [0057], [0059], [0060]; figures *	1,11,12	
A	WO 02/17836 A (SINTEF TELE OG DATA; SVEAN, JARLE; SOERSDAL, SVEIN; PETTERSEN, ODD, KR) 7 March 2002 (2002-03-07) * page 4, lines 1-7 * * page 6, lines 20-25 * * page 7, lines 8-11 * * page 8, lines 12-16 * * page 17, line 17 - page 19, line 25; figures 1,2,7 *	1,11,12	TECHNICAL FIELDS SEARCHED (IPC) H04R G01H A61F
A	US 2003/035551 A1 (LIGHT JOHN J ET AL) 20 February 2003 (2003-02-20) * paragraphs [0011], [0012], [0015], [0016], [0018], [0023]; figures 1-5 *	1,11,12	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	8 August 2006	Fobel, O

CATEGORY OF CITED DOCUMENTS

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08-08-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102004016184 A1	03-11-2005	WO 2005094743 A1	13-10-2005
US 2003191609 A1	09-10-2003	AU 2003207778 A1	02-09-2003
		GB 2399639 A	22-09-2004
		HK 1065589 A1	22-07-2005
		WO 03067202 A2	14-08-2003
WO 0217836 A	07-03-2002	AU 8454601 A	13-03-2002
		CA 2418010 A1	07-03-2002
		EP 1313417 A1	28-05-2003
		NO 20004372 A	04-03-2002
US 2003035551 A1	20-02-2003	NONE	

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Patent documents cited in the description

- EP 1091349 A **[0031]**