



(11) **EP 2 161 717 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication: **10.03.2010 Bulletin 2010/10** (51) Int Cl.: **G10K 11/178 (2006.01)**

(21) Application number: **08163841.3**

(22) Date of filing: **08.09.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

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(54) **Method for attenuating or suppressing a noise signal for a listener wearing a specific kind of headphone or earphone, the corresponding headphone or earphone, and a related loudspeaker system**

(57) Acoustic noise (EAS) can be very annoying to a listener, and many solutions have been proposed to overcome the problem of undesired noise. The most straight-forward solution is to reduce the sound radiation of the primary noise source by passive means like damping material or by using an active noise cancellation. The problem of such 'global' solutions is that it affects all listeners. However, such solution is not applicable in the inventive scenario where 'noise' sound is to be played

back to the other listeners (customers). In a first embodiment of the invention, open headphones (HPH) based on a feed-forward active noise cancellation (ANC) are used, wherein the ANC system relies on a separately received reference noise signal (NRS). In a second embodiment of the invention, closed headphones (CHPH) based on frequency-selective filtering and noise cancellation techniques are used, wherein the noise cancellation or suppression system relies on the separately received reference noise signal (NRS).

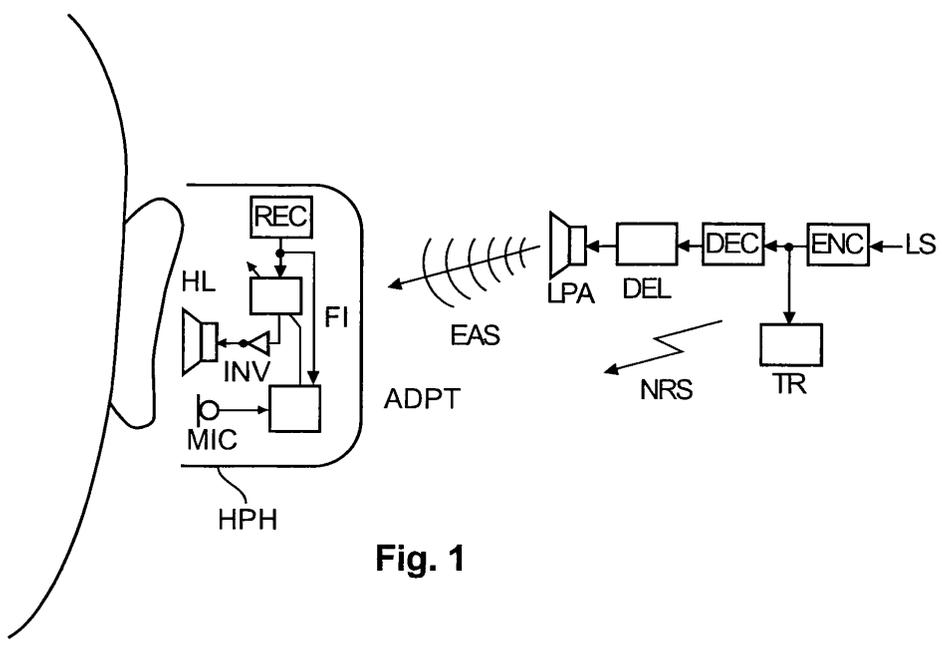


Fig. 1

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Description

[0001] The invention concerns a method for attenuating or suppressing a noise signal for a listener wearing a specific kind of headphone, and that headphone or earphone, and a related loudspeaker system.

Background

[0002] Acoustic noise can be extremely annoying to human beings. In case of extreme sound pressure levels of the noise, or with strong noise levels over a longer period of time, the human ear can become damaged. Even if the sound level of the noise is not high enough to damage the ear physiologically, the noise can still be strongly annoying to a listener. The reason for such annoyance is highly subjective: the same sound can be perceived as comfortable by one listener but as disturbing noise by another listener.

[0003] Many solutions have been proposed to overcome the problem of undesired noise. The most straightforward solution is to reduce the sound radiation of the primary noise source. This can be achieved e.g. by passive means (damping material) or by using an active noise cancellation (ANC). However, the problem of such 'global' solutions is that it more or less affects all listeners. In the inventive scenario, such solution is not applicable because the 'noise' sound is to be played back to the other listeners (customers).

Instead of using a global noise cancelling solution, a local 'silent spot' can be pursued as well by applying beam forming (or null beam forming) techniques to control the sound radiation of the primary noise source. These techniques have the disadvantage that sophisticated signal processing and loudspeaker arrangements are necessary. In addition, they cannot be applied if the location of the annoyed listener is unknown or variable.

Another approach is to use state-of-the-art hearing protection headphones or earphones. Such devices can be built using passive or active techniques. Active techniques include the well-established ANC headphones. These devices work with feed-back active noise control as described in Sen M. Kuo and Dennis R. Morgan, "Active Noise Control: A Tutorial Review", Proceedings of the IEEE, vol.87, no.6, pp.943-973, 1999. The headphone comprises a loudspeaker and a measurement microphone. In simple words, the microphone signal is fed into an electric circuit (analogue or digital) that produces a phase-inverted version of the acoustic sound to be played back via the loudspeaker. By the inversion of the phase, the loudspeaker signal and the acoustic noise cancel out each other, and the overall sound pressure level at the ears is reduced. By this approach, more or less *all* acoustic sounds are reduced at the ear, which makes it inapplicable for the scenarios targeted in this application. It is possible to inject a desired signal to be played via the loudspeaker, e.g. to listen to music with reduced background noise. To the inventors knowledge,

feed-forward ANC has never been applied for headphones before.

Another category of active hearing protection devices uses passive damping techniques ('micky mouses'). In addition, the device can have a microphone at the outside and a loudspeaker inside. In the default manner of operation, the microphone signal is fed to the loudspeaker without modification. In the case of impulse noises the transmission is attenuated. This kind of hearing protection is applied for reducing impulse noises that occur e.g. in industrial, military or hunting environments.

An extension of the above techniques applies blind noise reduction in-between the microphone and the loudspeaker. Here, the target is to reduce stationary sounds while leaving non-stationary sounds like speech unaltered. An example is the 'TalkThrough' technology applied in some Sennheiser head-sets. However, in the inventive application this blind approach cannot be used because it is not possible to separate desired speech from undesired speech.

[0004] Further prior art publications are:
EP 0737022 A2

[0005] Bernard Widrow et al., "Adaptive Noise Cancellation: Principles and Applications", Proceedings of the IEEE, vol.63, no.12, pp.1692-1716, 1975.

S.J. Elliott and P.A. Nelson, "Active Noise Control", IEEE Signal Processing Magazine, vol.10, no.4, pp.12-35, 1993. Sen M. Kuo, Sohini Mitra, Woon-Seng Gan, "Active Noise Control System for Headphone Applications", IEEE Transactions On Control Systems Technology, vol. 14, no.2, pp.331-335, 2006.

Christina Breining et al, "Acoustic Echo Control: An Application of Very-High-Order Adaptive Filters", IEEE Signal Processing Magazine, vol.16, no.4, pp.42-69, 1999.

Simon Haykin, "Adaptive Filter Theory", 4th edition, 2002, Prentice-Hall, New Jersey.

Gerald Enzner, "A Model-Based Optimum Filtering Approach to Acoustic Echo Control: Theory and Practice", Ph.D. thesis, Wissenschaftsverlag Mainz, Aachen, 2006, ISBN 3-86130-648-4.

Invention

[0006] Most, but not all embodiments in the description focus on situations where the 'noise' is produced artificially, e.g. by a playback system. For example, a target scenario is the protection of the staff of a retail store from having to listen to advertisements that are played back in the store to address the customers. The staff of a retail store cannot wear passive or active hearing protection devices because all sounds would be attenuated and therefore the communication with the customers would be impaired.

Other examples include hearing protection for people that are continuously exposed to audio signals with strong playback levels, e.g. the staff in discotheques or musicians.

[0007] A problem to be solved by the invention is to

attenuate only a specific part of the acoustic sound, but to leave the remaining sound unaltered. This problem is solved by the method disclosed in claim 1. A headphone or earphone that utilises this method is disclosed in claim 2. A related loudspeaker system is disclosed in claim 3.

[0008] According to a first embodiment of the invention, open (or closed) headphones or earphones based on a feed-forward active noise cancellation (ANC) are used, wherein the ANC system relies on a separately received reference noise signal. According to a second embodiment of the invention, closed headphones or earphones based on frequency-selective filtering and noise cancellation techniques are used, wherein the noise cancellation or suppression system relies on a separately received reference noise signal. In contrast to active noise control (ANC) techniques, the signal modification, i.e. the cancellation of the noise, does not take place in the acoustic domain but inside a signal processing device, which allows for very controlled and robust signal processing.

A pre-requisite for both embodiments of the invention is that the raw primary source signal of the undesired signal is known. The reference noise signal is transmitted, in analog or digital format, wired or (electronically or optically, i.e. non-acoustically) wireless to the headphone device, i.e. information about the original primary noise signal is transferred to a personal headphone or earphone device. In the second embodiment, instead of transmitting the reference noise signal itself, specific related parameters could be transmitted.

The term 'headphone' will include the meaning of 'earphone' in the sequel.

[0009] In the first embodiment, the headphone may be open, such that with de-activated ANC system the full acoustic sound can reach the ear without degradation. If the ANC system is activated, the system estimates the electro-acoustic transfer function from the primary source (e.g. a loudspeaker in a retail store) to the location of the ear, using a measurement microphone that is placed at the headphone, feeds the electronically or optically (i.e. non-acoustically) received version of the primary (reference) source signal into a filter using estimated filter coefficients, and emits a phase-inverted version of the resulting signal via the headphone loudspeaker. Thus, the loudspeaker signal will cancel the acoustically received undesired noise signal. Other acoustic sounds will be left unmodified because they cannot be predicted or estimated from the reference noise signal.

[0010] In the second embodiment, closed headphones based on frequency-selective filtering and noise cancellation techniques are used, i.e. headphones that feature a strong passive attenuation of surrounding acoustic sounds. A microphone is placed outside of the sound insulation and the recorded signal is played back via a loudspeaker inside the sound insulation. This embodiment relates to suppressing (frequency-selective filtering) and/or cancelling (subtraction of predicted signal) parts of the transmitted acoustic sounds that relate to a

specific noise source.

[0011] In principle, the inventive method is suited for attenuating or suppressing a noise signal for a listener wearing a specific kind of headphone or earphone, wherein said noise signal is emitted by at least one sound source - e.g. a loudspeaker- and is thus audible to other listeners not wearing said specific kind of headphone or earphone, said method including the steps:

- 10 - transferring non-acoustically a noise reference signal, which represents a source signal of the signal emitted by said at least one sound source, to said specific kind of headphone or earphone;
- 15 - in said specific kind of headphone or earphone, receiving non-acoustically said noise reference signal and receiving, using at least one microphone, said acoustical noise signal;
- 20 - in said specific kind of headphone or earphone, using said noise reference signal by performing adaptive filtering and inversion, or in case said specific kind of headphone or earphone is of closed type by performing adaptive signal processing, for attenuating or suppressing the audibility of said noise signal for said listener.

[0012] In principle the inventive headphone or earphone is suited for attenuating or suppressing a noise signal for a listener wearing said headphone or earphone, wherein said noise signal is sound source-emitted - e.g. loudspeaker-emitted - and is thus audible to other listeners not wearing said headphone or earphone, and wherein a noise reference signal that represents a source signal of said sound source-emitted signal is transferred non-acoustically to said specific kind of headphone or earphone, said headphone or earphone including:

- 35 - means being adapted for receiving non-acoustically said noise reference signal;
- 40 - at least one microphone receiving said acoustical noise signal;
- 45 - means being adapted for performing adaptive filtering and inversion using said noise reference signal, or in case said headphone or earphone is of closed type, for performing adaptive signal processing, such that the audibility of said noise signal for said listener is attenuated or suppressed.

[0013] In principle the inventive loudspeaker system emits a noise signal audible to listeners not wearing a specific kind of headphone or earphone and additionally emits non-acoustically a noise reference signal which can be used in said specific kind of headphone or earphone for attenuating or suppressing the audibility of said noise signal for a listener wearing said specific kind of headphone or earphone, said loudspeaker system including:

- an audio encoder step or stage for encoding a source

signal to be emitted acoustically and non-acoustically as said noise reference signal by said loudspeaker system;

- a corresponding audio decoder step or stage for decoding said encoded source signal;
- a delay step or stage for the output of said audio decoder;
- downstream said delay step or stage, at least one loudspeaker that emits said noise signal;
- a transmitter fed from said audio encoder step or stage for transmitting said noise reference signal.

[0014] Advantageous additional embodiments of the invention are disclosed in the respective dependent claims.

Drawings

[0015] Exemplary embodiments of the invention are described with reference to the accompanying drawings, which show in:

- Fig. 1 example of the inventive dual-transmitter system and the first-embodiment headphone;
- Fig. 2 known block diagram for feed-forward ANC processing using a filtered-X LMS algorithm;
- Fig. 3 closed ANC headphones according to the second embodiment of the invention;
- Fig. 4 exemplary primary 'noise' source;
- Fig. 5 generic signal processing for the second embodiment of the invention.

Exemplary embodiments

[0016] In the active hearing protection according to the first embodiment of the invention 'open' or 'closed' headphones are used, wherein specific undesired acoustic signals at the positions of the listener's ears are eliminated or nearly eliminated. The raw undesired signal is transferred electronically or optically (i.e. non-acoustically) to the headphone/earphone.

[0017] As an example application, the protection from a Public Address (P/A) system is described in connection with Fig. 1. The goal is to provide a public address system, but to allow for cancelling the P/A signal for certain individuals by using the depicted headphone. The P/A system is depicted at the right-hand side of Fig. 1 and the headphone at the left-hand side. In order to improve the performance of the P/A cancelling in the headphone, the known signal path (not depicted in detail) to the P/A system loudspeaker or loudspeaker array LPA is modified in that the P/A loudspeaker signal LS passes through an encoder step or stage ENC and a decoder step or stage DEC. The purpose of this feature is to guarantee that the relationship between the noise reference signal NRS as received wirelessly by the ANC headphone and the acoustic noise signal EAS is only of linear nature. Any non-linear coding noise as introduced by a mid to

low-rate encoding system would otherwise degrade the performance of the ANC headphone. Another modification of the known P/A system playback path is that a delay element DEL is inserted between the encoder ENC output and LPA, and/or between the path split to TR and the input of DEC. This delay step or stage DEL may be necessary because the wireless transmission of signal NRS introduces latencies due to forward error protection, signal processing for modulation, etc. The additional delay element DEL in front of the P/A loudspeaker LPA gives enough headroom to allow for causal ANC processing in the headphone HPH. In general, the latency of the electro-acoustic path (including the decoder DEC and the additional delay element DEL) has to be equal or greater than the latency of the wireless transmission of the noise reference signal NRS. The transmission step or stage TR for the noise reference signal NRS receives as input signal the output signal of encoder ENC and can use any wireless transmission scheme that allows a more or less error-free decoding in the corresponding receiver REC in headphone HPH, i.e. it is available bit-exactly in the ANC headphone to allow exact system identification of the electro-acoustic path. As an alternative, the noise reference signal NRS can be transferred via wire to the headphone, in which case the receiver REC may be omitted. I.e., the raw noise reference signal NRS is sent to the headphone via a separate channel.

The received noise reference signal NRS in its electronic form passes through a variable filter step or stage FI and an inverter step or stage INV to the headphone's loudspeaker HL, and is fed to an adaptation step or stage ADPT. ADPT also receives the output signal of microphone MIC, and adaptation step/stage ADPT controls the characteristic of filter FI such that its inverted output signal, when emitted from loudspeaker HL, cancels out the EAS signal as much as possible, or to a pre-determined or pre-set degree. I.e., by the sound produced by at least one loudspeaker HL, the signal derived from the received noise reference signal NRS is in the acoustic domain subtracted from the local version of the noise signal EAS.

The signal processing in REC, FI, INV, ADPT, TR, DEL, DEC and/or ENC can be analog or digital.

[0018] The ANC signal processing carried out in the headphone HPH is illustrated in Fig. 2 in more detail. With respect to Fig. 1, $x(n)$ is the noise reference signal NRS output from receiver REC, $y(n)$ is the electric signal fed into loudspeaker HL, $S(z)$ is related to the frequency response of HL (more precisely: the linear system consisting of D/A conversion, amplifier, loudspeaker, i.e. the electro-acoustic processing of the inverted noise signal), $y'(n)$ is the resulting acoustic loudspeaker signal output from HL, and $e(n)$ is the acoustic signal captured by the microphone MIC of the headphone. A filtered-X LMS algorithm (instead of a straight-forward LMS algorithm) is used for adaptation of the adaptive filter $W(z)$ (corresponding to filter FI), because the subtraction that is observed by the microphone MIC inside the headphone

takes place in the acoustic domain. The filtered-X LMS algorithm (corresponds to the function of step/stage ADPT) takes into account that the output signal of the adaptive filter $W(z)$ has to pass a linear system consisting of D/A conversion, amplifier, loudspeaker, etc., before contributing to this 'acoustic subtraction'. $P(z)$ corresponds to the 'real' acoustic path and $S(z)$ is an estimation of $S(z)$.

[0019] In the active hearing protection according to the second embodiment of the invention, 'closed' headphones or earphones are used, wherein specific undesired acoustic signals at the positions of the listener's ears are eliminated or nearly eliminated. The raw undesired signal NRS is transferred electronically or optically (i.e. non-acoustically) to the headphone.

Like in the first embodiment, in the second embodiment information on the original primary noise signal NRS is transmitted to a personal headphone device. The headphone CHPH is assumed to be closed, i.e. it provides a reasonable damping of surrounding acoustic sound by passive means. As shown in Fig. 3, examples for such headphones include in-the-ear plugs built from foam or rubber material or custom-molded plugs (right-hand side) as well as closed circum-aural headphones (left-hand side). The headphone CHPH comprises a microphone MICO outside of the sound insulation and a loudspeaker HL inside of the sound insulation. A signal processing step or stage SP is arranged between the microphone and the loudspeaker. The signal processing SP can take place in the headphone itself or in a separate break-out box. A receiver REC is used in the headphone CHPH for receiving the external noise reference signal NRS and feeding it into signal processing step/stage SP. I.e., at least one microphone MICO of the closed-type headphone or earphone receives the noise signal EAS (plus any other desired sound) outside the headphone or earphone and the adaptive signal processing SP is carried out by using the received noise reference signal NRS for electronically attenuating or suppressing the received noise signal before the resulting (desired) sound is output by at least one loudspeaker HL inside the headphone or earphone to the listener.

[0020] The noise reference signal is sent by a transmitter step or stage TR that is placed in front of, or near, the primary noise source. Example transmitters are depicted at the right-hand side of Fig. 1 and in Fig. 4.

In Fig. 4, which basically represents an alternative to Fig. 1, the transmission step or stage TR for the noise reference signal NRS receives as input signal the output signal of encoder ENC and can use any wireless transmission scheme that allows a more or less error-free decoding in the corresponding receiver REC in headphone HPH. As an alternative, the noise reference signal NRS can be transferred via wire to the headphone CHPH, in which case the receiver REC may be omitted. The encoder step/stage ENC receives as input the signal of microphone TMIC that captures the sound of the electro-acoustic path noise signal EAS, i.e. in parallel to its

acoustic presentation, the raw noise reference signal NRS is sent to the headphone via a separate channel. In other words, the trumpet 'noise' is picked up by microphone TMIC and the recorded signal is sent to the headphone.

The signal processing in REC, SP, TR and/or ENC can be analog or digital.

[0021] The signal processing device SP uses the noise reference signal NRS to suppress or cancel the noise sound that is received via the electro-acoustic path EAS. The goal is to remove all signal parts from the microphone signal that are related to the primary noise signal so that the listener has the perception that the primary noise signal NRS is not present while all other sounds are left virtually unmodified. Alternatively, it can be chosen to attenuate the parts of the acoustic sound that relate to the primary noise source merely by a specified amount. Several possibilities exist to achieve the above goal. The most generic block diagram for such processing is shown in Fig. 5. A first filter $W1$ receives the noise reference signal NRS. The output of filter $W1$ is subtracted from the microphone signal MICS, and the resulting signal SOS passes through a second filter $W2$ that outputs the loudspeaker signal LSS.

The two filters $W1$ and $W2$ have different functionalities: the first filter $W1$ operates as a predictor of the noise-related components of the microphone signal, which is adapted in order to identify the electro-acoustic system that is passed by the primary noise signal. If the overall transfer function of the electro-acoustic system is denoted by $H(z)$, then the goal of the filter adaptation is to minimise the system distance between $W1(z)$ and $H(z)$, wherein $H(z)$ denotes the electro-acoustic path from the noise source to the digital microphone signal. There exist many approaches for system identification, see e.g. the above-cited articles of Haykin or Breining et al.

In the case $W1(z) \approx H(z)$ (i.e. $W2(z)=1$), the noise reference signal NRS filtered by $W1(z)$ is virtually identical to the noise-related components within the microphone signal. Then, subtraction of the filtered noise reference signal from the microphone signal MICS leads to *cancellation* of the noise-related signal components. But in practice it is in general not possible to achieve a perfect cancellation.

[0022] The second filter $W2$ performs a frequency-selective filtering of the subtraction output signal SOS. In simple words, this filter attenuates frequency ranges in which the ratio between noise-related sound components and other sound components is high, while leaving other frequency ranges more or less unmodified. That is, $W2$ performs *suppression* of the noise-related signal components in case $W1(z) \neq H(z)$. A byproduct of the suppression is that non-noise-related sound components that coexist in the same frequency ranges as the noise-related components are suppressed as well. Therefore, in practice, a trade-off between desired suppression of the noise-related sound and undesired distortion of the non-noise-related sounds has to be found.

[0023] For the adaptation of the frequency response of filter $W2(z)$ a number of well-established algorithms can be applied. For example, the well-known Wiener criterion can be used in order to optimise the SNR at the output of the filter, see e.g. the Haykin article cited above for details and alternatives.

[0024] As described above, the two filters $W1$ and $W2$ can be applied isolated or jointly. If the electro-acoustic path is well-identifiable (reference of the raw primary noise, little variation of the electro-acoustic path, high SNR), cancellation of noise-related sounds by $W1$ may work properly, and the second filter $W2$ may be deactivated ($W2(z)=1$). If, on the other hand, the electro-acoustic path can not be identified, cancellation of the noise-related sounds may be impossible. Then, it may make sense to de-activate the cancellation filter ($W1(z)=0$) and to rely for noise suppression on filter $W2$ only. Advantageously, in combination the two filters $W1$ and $W2$ are working synergetic: if perfect cancellation by $W1$ is not possible, the residual noise-related sound components will be tackled by the subsequent frequency-selective suppression within $W2$. The best performance can be expected if the adaptation of the two filters is performed jointly, see e.g. the Enzner article cited above.

[0025] The advantage of both embodiments of the invention is that individual protection of a listener from a specific acoustic noise sound is provided while leaving other sounds unaffected. This is not possible with state-of-the-art personal hearing protection devices. Compared to ANC systems that are not headphone-based, e.g. beam-forming solutions, the invention has the advantage that less effort (in terms of loudspeaker equipment) has to be spent. Additionally, when using the invention it is guaranteed that the quality of the P/A signal as heard by the targeted customers is not impaired by any of the typical artefacts that occur with global (loudspeaker centric) solutions.

The principle of the second-embodiment processing is in particular versatile and robust. Because the cancellation (subtraction) does not take place in the acoustic domain but in a signal processing device, simpler filtering and adaptation processing can be applied, e.g. plain LMS (least mean squares) instead of filtered-X LMS. The results are more robust because variable acoustic effects of the 'secondary path' (from loudspeaker to acoustic subtraction) do not play a role. In addition, a noise suppression (by filtering) is facilitated, which is not possible with the ANC system.

[0026] In the headphone the noise reference signal can be mixed with an independent, desired signal (e.g. music) to be played back via the loudspeaker HL.

[0027] Instead of maximum attenuation of the noise-related sounds, a user-specified target attenuation of the noise-related sounds can be implemented, e.g. an attenuation by 20 dB.

[0028] The 'loudspeaker signal' can be any sound source signal or a recorded source signal, for example a musical instrument or a song.

The 'undesired signal' mentioned above can also be only an additive part of the loudspeaker or noise source signal.

5 Claims

1. Method for attenuating or suppressing a noise signal (EAS) for a listener wearing a specific kind of headphone (HPH, CHPH) or earphone, wherein said noise signal (EAS) is emitted by at least one sound source - e.g. a loudspeaker (LPA) - and is thus audible to other listeners not wearing said specific kind of headphone or earphone, **characterised by** the steps:

- transferring non-acoustically a noise reference signal (NRS), which represents a source signal of the signal emitted by said at least one sound source, to said specific kind of headphone (HPH, CHPH) or earphone;

- in said specific kind of headphone or earphone, receiving (REC) non-acoustically said noise reference signal (NRS) and receiving, using at least one microphone (MIC, MICO), said acoustical noise signal (EAS);

- in said specific kind of headphone or earphone, using said noise reference signal (NRS) by performing adaptive filtering and inversion, or in case said specific kind of headphone or earphone is of closed type by performing adaptive signal processing, for attenuating or suppressing the audibility of said noise signal (EAS) for said listener.

2. Headphone (HPH, CHPH) or earphone for attenuating or suppressing a noise signal (EAS) for a listener wearing said headphone or earphone, wherein said noise signal (EAS) is sound source-emitted - e.g. loudspeaker-emitted (LPA) - and is thus audible to other listeners not wearing said headphone or earphone, and wherein a noise reference signal (NRS) that represents a source signal of said sound source-emitted signal is transferred non-acoustically to said specific kind of headphone or earphone, said headphone or earphone including:

- means (REC) being adapted for receiving non-acoustically said noise reference signal (NRS);
- at least one microphone (MIC, MICO) receiving said acoustical noise signal (EAS);

- means (FI, INV, ADPT; SP) being adapted for performing adaptive filtering and inversion using said noise reference signal (NRS), or in case said headphone or earphone is of closed type, for performing adaptive signal processing, such that the audibility of said noise signal (EAS) for said listener is attenuated or suppressed.

3. Method according to claim 1, or headphone or earphone according to claim 2, wherein said headphone or earphone (HPH, CHPH) is of open type and said attenuating or suppressing of the audibility of said noise signal (EAS) for said listener is carried out by using a feed-forward active noise cancellation for said adaptive filtering and inversion (FI, INV, ADPT), such that by the sound produced by at least one loudspeaker (HL) downstream said inversion (INV) the signal derived from said received noise reference signal (NRS) is in the acoustic domain subtracted from the local version of said noise signal (EAS).
4. Method or apparatus according to claim 3, wherein in said adaptive filtering a filtered-X LMS processing is used.
5. Method according to claim 1, or headphone or earphone according to claim 2, wherein said headphone or earphone (HPH, CHPH) is of closed type and said at least one microphone (MICO) receives said noise signal (EAS) outside said headphone or earphone and said adaptive signal processing (SP) is carried out by using said received noise reference signal (NRS) for electronically cancelling or suppressing said received noise signal before the resulting sound is output by at least one loudspeaker (HL) inside said headphone or earphone to said listener.
6. Method or apparatus according to claim 5, wherein in said adaptive signal processing (SP) a prediction filter function (W1) is used that is applied to said received noise reference signal (NRS), and a frequency-selective filter function (W2) is used that is applied to the signal (MICS) derived from said at least one microphone (MICO) from which signal (MICS) the output signal of said prediction filter function is subtracted, and wherein said frequency-selective filter function (W2) is switched on for noise suppression and said prediction filter function (W1) is switched on for noise cancellation.
7. Method according to one of claims 1 and 3 to 6, wherein:
- an audio encoder step or stage (ENC) encodes a source signal (LS) to be emitted acoustically, and non-acoustically as said noise reference signal (NRS);
 - a corresponding audio decoder step or stage (DEC) decodes said encoded source signal (LS);
 - the output of said audio decoder (DEC) is delayed (DEL) and downstream said delay at least one loudspeaker (LPA) emits said noise signal (EAS);
 - a transmitter fed from said audio encoder step or stage (ENC) transmits said noise reference

signal (NRS).

8. Loudspeaker system that emits a noise signal (EAS) audible to listeners not wearing a specific kind of headphone (HPH, CHPH) or earphone and that additionally emits non-acoustically a noise reference signal (NRS) which can be used in said specific kind of headphone or earphone for attenuating or suppressing the audibility of said noise signal for a listener wearing said specific kind of headphone or earphone, said loudspeaker system including:

- an audio encoder step or stage (ENC) for encoding a source signal (LS) to be emitted acoustically and non-acoustically as said noise reference signal by said loudspeaker system;
- a corresponding audio decoder step or stage (DEC) for decoding said encoded source signal (LS);
- a delay step or stage (DEL) for the output of said audio decoder (DEC);
- downstream said delay step or stage (DEL), at least one loudspeaker (LPA) that emits said noise signal (EAS);
- a transmitter fed from said audio encoder step or stage (ENC) for transmitting said noise reference signal (NRS),

or said loudspeaker system including:

- an audio encoder step or stage (ENC) for encoding a delayed (DEL) source signal (LS) to be emitted acoustically and non-acoustically as said noise reference signal by said loudspeaker system;
- a corresponding audio decoder step or stage (DEC) for decoding said encoded source signal (LS);
- downstream said audio decoder step or stage (DEC), at least one loudspeaker (LPA) that emits said noise signal (EAS);
- a transmitter fed from said audio encoder step or stage (ENC) for transmitting said noise reference signal (NRS).

9. A system that emits non-acoustically a noise reference signal (NRS), related to a noise signal (EAS) that is audible to listeners not wearing a specific kind of headphone (HPH, CHPH) or earphone, which noise reference signal can be used in said specific kind of headphone or earphone for attenuating or suppressing the audibility of said noise signal for a listener wearing said specific kind of headphone or earphone, said system including:

- at least one microphone (TMIC) that receives said noise signal (EAS);
- an audio encoder step or stage (ENC) for en-

coding the output signal of said at least one microphone;

- a transmitter (TR) fed from said audio encoder step or stage (ENC) for transmitting non-acoustically said noise reference signal (NRS) that can be evaluated essentially error-free in said specific kind of headphone or earphone.

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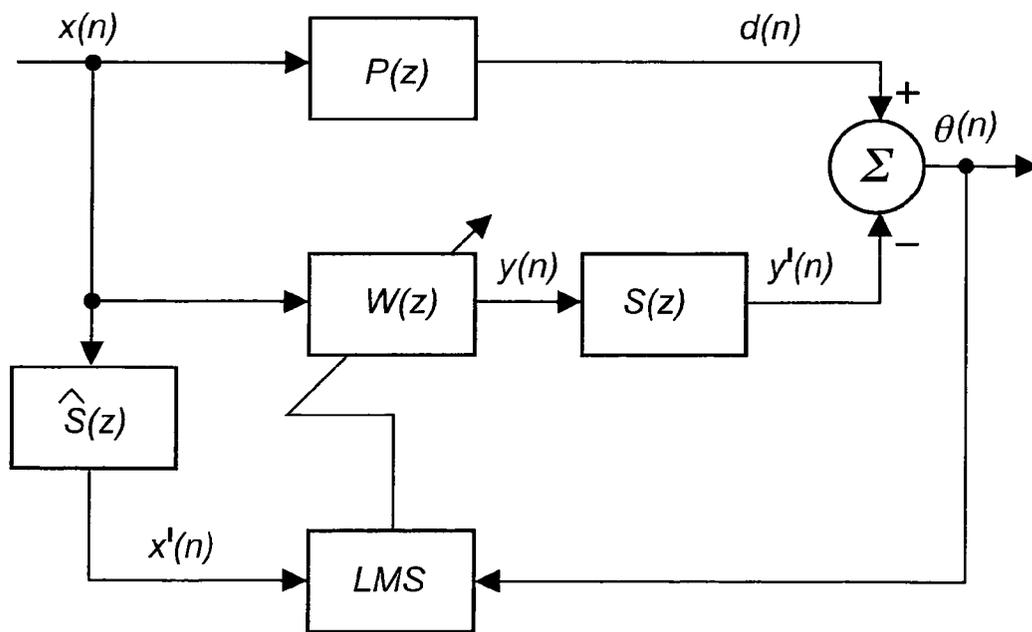
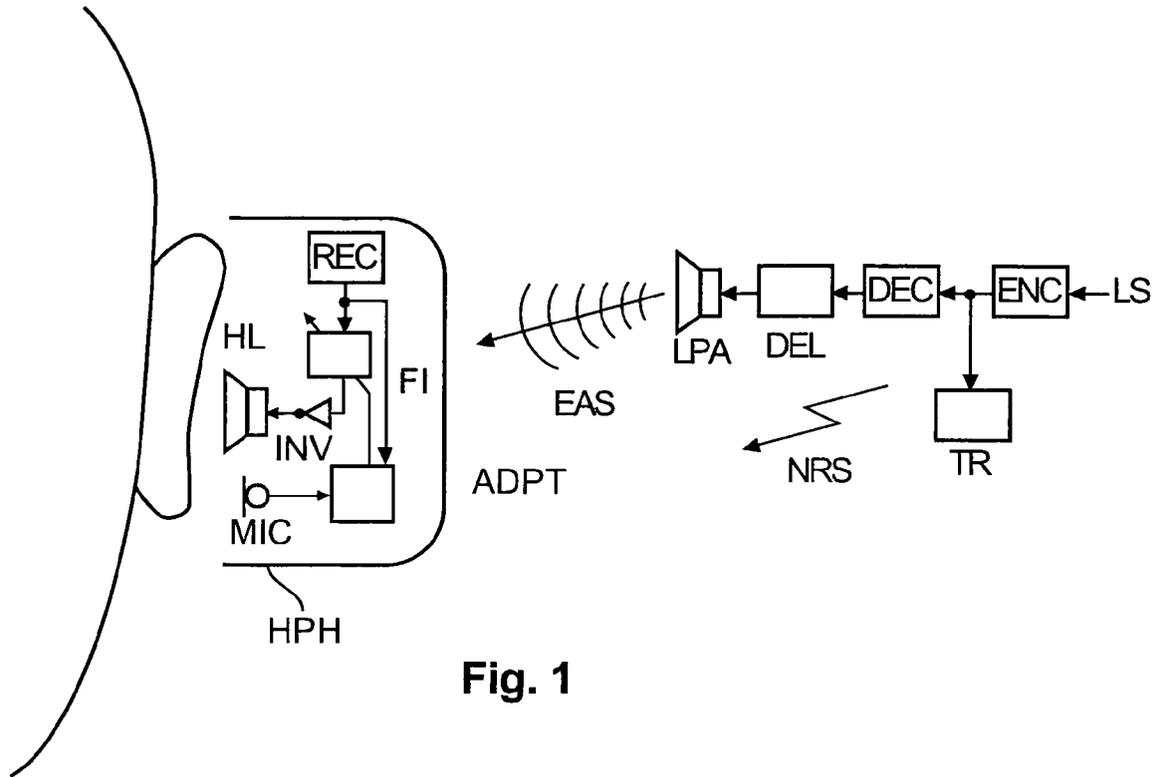
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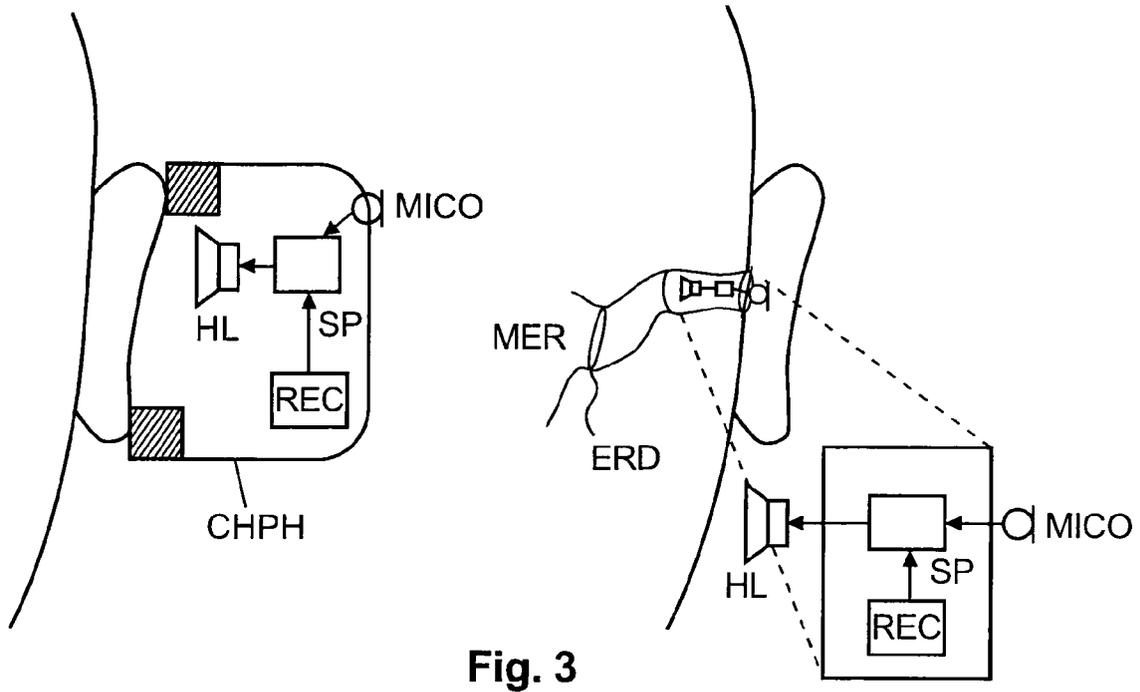


Fig. 3

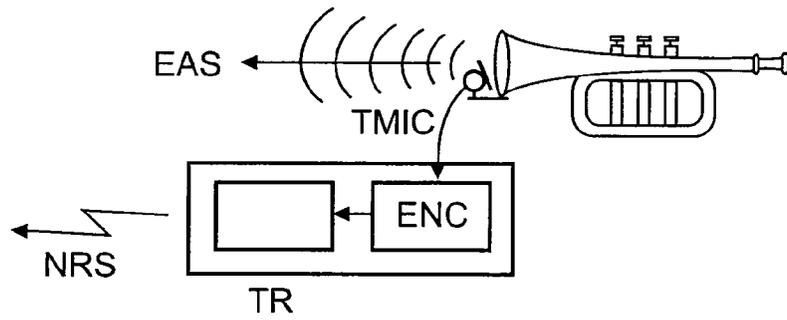


Fig. 4

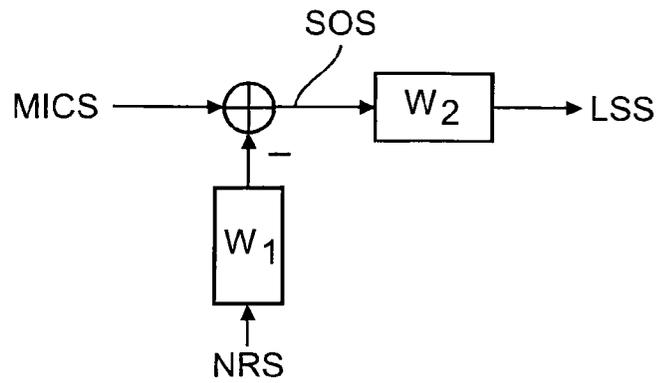


Fig. 5



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