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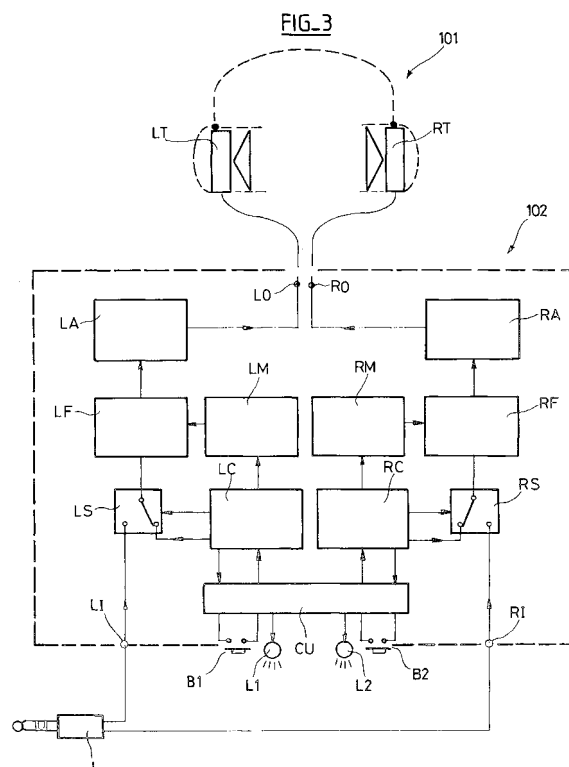
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(54) **Correction device for an audio reproducing device**

(57) A correction device for an audio reproducing device, comprising:

- means (B1,LC) for generating a series of test signals, at different frequencies and different amplitudes,
- switching means (LS) for alternately transmitting, to an input of adjustable filtering means (LF),
- a test signal, during a calibration phase,
- and an electrical audio signal during a reproduction phase following the calibration phase,
- means (B2,LC,LS) for receiving an indication from a user listening to a test signal via said transducer, when the user actually perceives this test signal, during the calibration phase,
- means (LC) for respectively storing the values of the lowest amplitudes where the user actually perceives test signals, for the respective frequencies of the series of test signals, during the calibration phase,
- means (LC) for controlling means (LM) for adjusting the frequency response curve of the filtering means, at the end of the calibration phase, so that the user's perception would correspond to a predetermined frequency response curve in a predetermined bandwidth.



Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to a correction device for an audio reproducing device. It enables to shape the frequency response curve of an audio reproducing device such as a pair of headphones, an electronic stethoscope, etc, in order to get a predetermined response of the system constituted by the reproducing device and the ears of a user, in a predetermined bandwidth. It can be built as a stand alone device, or can be embedded into a reproducing device (HiFi headphones, electronic stethoscope, etc), or can be embedded in an audio signal source to which a reproduction device can be connected (MP3 player, high fidelity amplifier, etc).

Description of the prior art

[0002] The frequency response curve of an audio reproducing device is not perfectly flat in the audio bandwidth, 16Hz to 20,000 Hz. The frequency response curve of the human ears is not flat neither, and varies with the sound level. In addition, the hearing of each individual declines with aging. In particular the sensitivity to the higher frequencies declines. Audio signal sources generally comprise manual settings for adjusting volume, bass, and treble, in order to provide a pleasant listening. Some audio sources comprise an equalizer that enables to alter the response of the device at many frequencies, for a finer adjustment. However it is not easy to adjust such settings to quickly obtain a satisfactory overall response curve for the reproduction device and the user's ears. It implies several trials, and it is not accurate. Existing devices provide a correction that is used identically both for the right and the left channels. A balance setting enables to modify the ratio of the left channel volume and the right channel volume, without altering their frequency responses. This is a severe limitation, since the characteristics of both ears are not necessarily the same.

[0003] Stethoscopes are currently used for diagnosing lung and heart pathologies. The diagnostic is based on doctors' experience, i. e. on the audio memory of the doctors. But the more a doctor gets experienced, the more he/she becomes older, with an increasing hearing loss. So it is peculiarly important to correct the frequency response curve of an electronic stethoscope, in such a way as to compensate for the doctor's hearing loss. In addition, each type of electronic stethoscope has some specific unevenness in its response curve. The best response curve for the doctor's ears would be the typical response of the ears of an average young person (in the pertinent frequency band 20 Hz to 4000Hz for auscultation sounds, and above for other applications). The best response curve for an electronic stethoscope would be even in this band, in order to hear an auscultation signal

independently of the stethoscope used.

Figure 1 represents, with a continuous line, the typical frequency response curve of the auditory system for young persons 20 to 25 years old, in quiet environment. The dotted lines marked 10% and 90% represent the dispersion of the results.

Figure 2 represents the typical aging effect on the typical frequency response curve of human auditory system, with three curves respectively corresponding to the ages of 20, 40, and 60 years.

[0004] Thus, there is a need to provide a technical solution for easily calibrating the overall response curve of an audio reproducing device and of an user's ears, quickly and with great accuracy, in order to correct the deviation of the user's ears response with respect to the typical response of the ears of an average young person, and to correct the unevenness of the response of the audio reproducing device, in particular when it is an electronic stethoscope.

[0005] This can be solved in the correction device according to the invention.

SUMMARY OF THE INVENTION

[0006] The object of the invention is a correction device for an audio reproducing device, comprising:

- an input for receiving an electrical audio signal,
- adjustable filtering means for filtering said electrical audio signal,
- at least one transducer for converting, into an acoustic signal, an electrical audio signal supplied by the filtering means,
- means for adjusting the frequency response curve of the filtering means ,

characterized in that it further comprises a set of calibration and correction means comprising:

- means for generating a series of test signals, at different frequencies and different amplitudes,
- switching means for alternately transmitting, to an input of the adjustable filtering means,
 - a test signal supplied by the means for generating, during a calibration phase,
 - and an electrical audio signal supplied by the input of the correction device, during a reproduction phase following the calibration phase,
- means for receiving an indication from a user listening to a test signal via said transducer, when the user actually perceives this test signal, during the calibration phase,
- means for respectively storing the values of the lowest amplitudes where the user actually perceives test signals, for the respective frequencies of the series of test signals, during the calibration phase,

- means for controlling the means for adjusting the frequency response curve of the filtering means, at the end of the calibration phase, so that the user's perception would correspond to a predetermined frequency response curve in a predetermined bandwidth.

Thanks to the means for storing the values of the lowest amplitudes where the user actually perceives test signals, for the respective frequencies of the series of test signals, it is possible to automatically adapt the filtering so that it cancels the impairments of the audio reproducing device and of the user's ears altogether, during the audio reproduction phase following the calibration phase. Another object of the invention is a reproduction device comprising such a correction device. In particular, such a correction device can be advantageously embedded in an electronic stethoscope.

[0007] Other features and advantages of the present invention will become more apparent from the following detailed description of embodiments of the present invention, when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In order to illustrate in detail features and advantages of embodiments of the present invention, the following description will be with reference to the accompanying drawings. If possible, like or similar reference numerals designate the same or similar components throughout the figures thereof and description, in which:

- Fig. 1 (described above) represents the typical frequency response curve of the auditory system for young persons.
- Fig. 2 (described above) represents the typical aging effect on the typical frequency response curve of human auditory system.
- Fig. 3 represents a first embodiment of the correction device according to the invention, that is used with headphones.
- Fig. 4 represents a second embodiment of the correction device according to the invention, that is embedded into an electronic stethoscope comprising a single microphone and two headphones.
- Fig. 5 represents frequency four response curves illustrating the effect of the calibrating device embedded in this electronic stethoscope.
- Fig. 6 represents a third embodiment of the correction device according to the invention, that is embedded into an electronic stethoscope comprising a single microphone, a single loudspeaker, and outer processing means.
- Fig. 7 represents more details of the stethoscope represented on figure 6.
- Fig. 8 represents a variant of the stethoscope represented on figures 6-7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] A correction device 102 that is a first embodiment of the correction device according to the invention is represented on **Figure 3**. It is connected to a high fidelity headset 101 comprising electro-acoustic transducers LT and RT. This embodiment comprises:

- A left input LI and a right input RI, linked to a jack J for receiving respectively a 1 and a right digital audio signal, supplied by an audio signal source, for instance a MP3 decoder (not represented) decompressing a music MP3 file.
- Two switches, LS and RS, each one having two inputs and one output. A first input of switch LS is linked to the input LI. Similarly a first input of switch RS is linked to the input RI.
- A left digital filter LF and a right digital filter RF, each one having a signal input, a signal output, and a control input for receiving filtering coefficients.
- Two memories LM and RM, for storing coefficients determining the frequency response curves of the digital filters LF and RF respectively. They have outputs being respectively linked to the control inputs of the digital filters LF and RF. At every time, the memory LM supplies a set of coefficients which defines the frequency response of the filter LF, and the memory RM supplies another set of coefficients which defines the frequency response of the filter RF, independently of the other set of coefficients. The coefficients stored in these memories can be electrically updated in order to adjust the frequency response curves of the two digital filters, LF and RF. The memories LM and RM can be flash memories for instance.
- Two test units LC and RC for respectively testing a left and a right channel, each channel comprising a transducer and a human ear. Each test unit comprises an output for supplying a test signal to a single channel. These outputs are respectively linked to the second input of the switch LS, and to the second input of the switch RS. Each test unit comprises a control output for respectively controlling the status of the switch LS and the status of the switch RS.
- Two output amplifiers LA and RA, each one having an input and an output. These inputs are respectively linked to an output of the filter LF and to the output of the filter RF. These output are respectively linked to output terminals LO and RO. The transducers LT and RT of the headset 101 are respectively linked to the output terminals LO and RO.
- Two push buttons B1, B2, and two light emitting diodes (LED) L1, L2 are on a front face of the correction device 102. They are linked to a control unit CU that constitutes an interface between the correction device 102 and a user. Two outputs and two inputs of the control unit CU are respectively linked to the two

calibration units LC and RC.

[0010] A user can automatically calibrate and then correct the frequency responses of the filters LF and RF so that these filters compensate the flaws of the user's hearing and the flaws of the transducers LT and RT. The calibration is made sequentially: first the left channel and then the right channel, for instance.

The user puts the headset to his/her ears, and then pushes the push button B1 once, to start calibration of the left channel. The control unit CU puts on the LED L1 to indicate that the calibration is running for the left channel. Then the control unit CU sends a control signal to the test units LC and RC so that they respectively control the switches LS and RS:

- To disconnect the input of the filter LF from the input LI, and to connect it to the output of the test unit LC, which generates no signal at this time.
- To disconnect the input of the filter RF from the input RI, and to connect it to the output of the test unit RC, which generates no signal at this time.

[0011] Then the control unit CU controls the left test unit LC to write, into the memory LM, a set of coefficients that cancel the filtering effect, i. e. the response of the filter LF is perfectly flat in the audio band.

Then the control unit CU controls the left test unit LC to generate a first series of bips, for instance with an interval of two seconds and a uniform duration, for instance 500 ms. In other embodiments, selection means can be provided for the user selecting a duration among several values, such as 500 ms, 1000 ms, 1500 ms.

Each bip is a sinusoidal tone with a constant frequency, starting with 125 Hz for the first series, and an amplitude increasing for each bip:

- 70 dB, -60 dB, -50 dB, -40 dB, -30 dB, -20 dB, -10 dB

[0012] These values are referred to a constant arbitrary reference level.

For the lowest amplitudes, the user does not hear anything. The user waits until he/she hears a bip. When the user perceives a first bip, he/she immediately presses the button B2. The control unit CU then sends a control signal to the left test unit LC. This latter stores the amplitude value of the last generated bip, in a measurement memory (not represented) at an address corresponding to the frequency value 125 Hz.

Then it generates a second series of bips. Each bip is a sinusoidal tone with a constant frequency 250Hz, and an amplitude increasing for each bip:

-70 dB, -60 dB, -50 dB, -40 dB, -30 dB, -20 dB, -10dB

For the lowest amplitudes, the user does not hear anything. The user waits until he/she hears a bip. When the user perceives a first bip, he/she immediately presses

the button B2. Then the control unit CU sends a control signal to the left test unit LC. This latter stores the amplitude value of the last generated bip, in the measurement memory at an address corresponding to the frequency value 250 Hz.

Then it generates a third series of bips. Each bip is a sinusoidal tone with a constant frequency 500Hz, and an amplitude increasing for each bip:

-70 dB, -60 dB, -50 dB, -40 dB, -30 dB, -20 dB, -10dB

This procedure is then repeated successively for 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, for instance.

[0013] When this procedure is finished for the left channel, the control unit CU puts off the LED L1, and puts on the LED L2 to indicate that the calibration is starting for the right channel.

The calibration process for the right channel is similar, and will lead to the determination of perception threshold values that are often different from those of the left channel because the hearing impairments are usually not the same on the left and right ears.

[0014] In other embodiments, selection means can be provided for the user choosing a determination of the perception thresholds with decreasing levels of signals instead of increasing ones as described, if the user finds it more easy.

[0015] At the end of the calibration, the left test unit LC determines a set of filtering coefficients for adjusting the frequency response of the left digital filter LF so that this filter compensates for the impairments of the left channel (left transducer and left ear), at the frequencies 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, with respect to a predetermined response curve which is preferably the typical response curve of a young human ear. For instance, if the user's left perception starts with a bip at -30 dB for 500Hz, and if the typical frequency response of a young human ear is at -60 dB for 500Hz, the gain of the left filter LF is increased of +30 dB at 500 Hz, with respect to a flat reference response.

Similarly the right test unit RC determines a set of filtering coefficients for adapting the frequency response of the right filter RF so that this filter compensates for the impairments of the right channel (right transducer and right ear), at the frequencies 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz.

[0016] The computation of the filtering coefficients is made according to classical methods that are described in the following documents, incorporated herewith by reference:

- "Digital Filter Design" by T.W. Parks & C.S. Burrus, Editor John Wiley & Sons Inc. ISBN : 0-471-82896-3
- and "Digital Filters : Analysis, Design and Applications by Andreas Antoniou, Editor McGraw-Hill Inc, ISBN : 0-07-002121-X

[0017] Then the control unit CU puts off the LED L2 to

indicate the end of calibration, and sends a control signal to the test units LC and RC so that they control the switches LS and RS:

- To disconnect the input of the filter LF from the output of the test unit LC, and to connect it to the input LI of the calibrating device 102.
- To disconnect the input of the filter RF from the output of the test unit RC, and to connect it to the input RI of the calibrating device 102.

[0018] The device 102 is ready to be used for listening to audio signals fed to the inputs LI, RI via the jack J.

[0019] In another embodiment the correction device 102 is embedded in the shell containing the transducer LT or the shell containing the transducer RT, or is split in both shells.

It can also be embedded into an audio signal source to which a pair of headphones, etc, can be connected. For instance it can be embedded into a MP3 player, a high fidelity amplifier, etc.

[0020] In a preferred application, the correction device is embedded into an electronic stethoscope.

[0021] Figure 4 represents a second embodiment of the correction device according to the invention, that is embedded into an electronic stethoscope. This stethoscope comprises a chest piece 202 containing: an acoustic pavilion P, a diaphragm D, a microphone M, an amplifier A, and a correction device similar to the one described above with reference to figure 1. The components that are similar to those of the first embodiment respectively carry same references.

The microphone M is placed at the narrow end of the pavilion P that is similar to the pavilion of a classical acoustical stethoscope. The pavilion P is closed by the diaphragm D, at the bottom of the chestpiece 202. The microphone M is linked to the input of the amplifier A. The output of the amplifier A is linked to both inputs LI and RI of the correction device. The surface of the chest piece 202 carries two push buttons B1, B2, and two LED L1, L2 of the correction device. The two outputs LO, RO of the calibrating device are linked to a headset 201 comprising two headphones LH, RH integrated into a flexible part looking like the headset of a classical acoustical stethoscope.

The calibration process is the same as described above.

[0022] Fig. 5 represents frequency response curves illustrating the effect of the calibration device embedded in this electronic stethoscope.

- Curve 1 represents the frequency response of one ear of a specimen of practitioner.
- Curve 2 represents the frequency response of the electro-acoustic part of the stethoscope, for this ear.
- Curve 3 represents the normal frequency response of a human ear, i. e. the typical frequency response for a young person in quiet environment.
- Curve 4 represents the correction made by the filter

and which is equal, for each frequency, to the difference between the normal response 3 and the sum of the responses 1 and 2 (the overall response of the practitioner's ear and of the stethoscope).

[0023] Figure 6 represents a third embodiment of the correction device according to the invention, that is embedded into an electronic stethoscope comprising a classical acoustic headset 301, a chestpiece 302, and an outer processing unit PU. The acoustic headset 301 is connected to the chestpiece 302 by a flexible tube 3 guiding an auscultation sound generated by an electro-acoustical transducer placed in the chestpiece 302.

In a preferred embodiment, the outer processing unit PU is a personal digital assistant that comprises a classical Bluetooth transmitter 22 and a classical Bluetooth receiver 21. The Bluetooth transmitter 22 is associated to a Bluetooth receiver integrated into a first electronic circuit 11 located in the chestpiece 302 of the stethoscope. The Bluetooth receiver 21 is associated to a Bluetooth transmitter integrated into a second electronic circuit 13 located in the chestpiece 302 of the stethoscope.

[0024] A peculiar application software is run by the processing unit PU, which:

- enables the Bluetooth receiver 21 to receive an auscultation signal from the first electronic circuit 11,
- processes the auscultation signal received by the Bluetooth receiver 21, to improve the diagnostic value of the auscultation signal, by a peculiar filtering, and by displaying waveforms on a screen 20,
- enables the Bluetooth transmitter 22 to send the auscultation signal back, to the second electronic circuit 13, after processing,
- and enables a correction of the stethoscope.

[0025] The chestpiece 302 comprises a cup shaped cavity 16 limited by a diaphragm 2 and by a metal wall 17. An opening in the wall 17 contains a microphone 10 for converting the auscultation sound transmitted by the diaphragm 2 into an electric auscultation signal. The chestpiece 302 also comprises a second cavity 18 containing an acoustical chamber 15, a loudspeaker 14 forming a wall of this chamber 15, the two electronic circuits 11-13, a switch 12, and a battery not represented.

When the stethoscope is used for auscultation, the first electronic circuit 11 amplifies the auscultation signal supplied by the microphone 10, samples it, and digitizes it. The Bluetooth transmitter of first electronic circuit 11 sends the digitized auscultation signal to the outer processing unit PU. The processing unit PU runs a filtering software module. At least one set of filtering coefficients is stored in a coefficient memory, in the processing unit PU.

The Bluetooth receiver of second electronic circuit 13 receives a digitized signal from the outer processing unit PU. This signal is the auscultation signal that has been filtered by the processing unit PU. It is amplified and then

applied to the loudspeaker 14. The tube 3 is attached to the ribbed stem 4 that is connected to the acoustic chamber 15, in front of the loudspeaker 14. This loudspeaker 14 has preferably a broad diameter (Four centimeters for instance) in order to correctly reproduce the low frequencies.

[0026] The processing unit PU in real time processes the auscultation signal. A current personal digital assistant, or a personal computer, has a computation power appropriate for applying sophisticated filtering methods which need much computation power. Examples of such sophisticated filtering methods can be found in the followings documents:

- **Acoustic echo and noise control A practical approach**, Authors: HÄNSLER Eberhard, SCHMIDT Gerhard, WILEY Editor.
- IEEE SIGNAL PROCESSING LETTERS, VOL. 11, NO. 4, APRIL 2004, **A Fast Converging Algorithm for Network Echo Cancellation**, Mehran Nekuii, *Student Member, IEEE*, and Mojtaba Atarodi, *Member, IEEE*.

Simultaneously, the processing unit PU processes the auscultation signal for displaying a waveform on the screen 20 of the processing unit PU. A method for such processing is described in the document US 5.025.809 incorporated here by reference.

The screen 20 is a touchscreen. A stylus 23 is used to give commands, in particular to activate virtual buttons displayed on the touchscreen 20.

A graphical interface displays menus on the screen 20 in order to enable a user to select different functions.

[0027] The processing unit PU is also a calibration device for calibrating the single audio channel constituted by the electronic circuit 13, the tube 3, the headset 301, and the two ears of the user. As there is only one audio channel for both ears, the calibration and correction make a trade off between the impairments of the two ears.

[0028] During a calibration phase, the processing unit PU runs a calibration software module. The user puts the headset 301 on his/her ears, and then starts the calibration software module. The touchscreen 20 displays an area dedicated to tracing a response curve:

- an horizontal axis with a frequency scale comprising marks at:

125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz,

- a vertical axis with an attenuation scale comprising marks at:

-70 dB, -60 dB, -50 dB, -40dB, -30 dB, -20 dB, -10dB.

At the bottom, the touchscreen 20 displays a button "GO".

The user touches the button GO to start a test signal generator, integrated in the calibration software module. The processing unit PU stops transmitting the auscultation signal to the filtering module, and, is prepared to transmit a test signal instead. It supplies, to the filtering module, a set of coefficients that cancel the filtering effect, i. e. the response of the filter is perfectly flat in the audio band.

Then the user launches a series of tests for measuring the frequency response of the channel, including his/her two ears. For starting the first test of the series, the user touches a first point in the area dedicated to tracing a response curve. The location of the touch point determines the frequency and the amplitude of a first bip that is then immediately generated by the test signal generator, with a fixed duration, for instance 500 ms. In other embodiments, a selection menu can be provided for the user selecting a duration among several values, such as 500 ms, 1000 ms, 1500 ms. Preferably, the user starts by touching the point 125 Hz, -70 dB. If the user does not hear the bip, he/she touches a point corresponding to the same frequency 125 Hz, but with a higher amplitude. The user does it again, until he/she finds the lowest amplitude where he/she perceives a bip, at 125 Hz. Then the user touches a virtual button "NEXT" to indicate that the last bip corresponds the lowest amplitude which gives a perception, at 125Hz, and to let the processing unit PU proceed to a next test.

Then the user preferably touches the point 250 Hz, -70 dB. If the user does not hear the bip, he/she touches a point corresponding to the same frequency 250 Hz, but with a higher amplitude. The user does it again until he/she finds the lowest amplitude where he/she perceives a bip, at 250 Hz. Then the user touches the virtual button "NEXT" to indicate that the last bip correspond the lowest amplitude which gives a perception, at 250 Hz, and to let the processing unit PU proceed to a next test.

[0029] Then the user reiterates the same procedure for the frequencies 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, for instance. When the user has finished, he/she touches a virtual button "VALIDATE". The processing unit PU determines a set of filtering coefficients for adapting the frequency response of the filtering module so that this filtering module compensates for the impairments of the whole audio channel (including the two ears), at the frequencies 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, with respect to the typical frequency response of young ears.

[0030] In the chestpiece 302, the switch 12 enables a user to bypass the Bluetooth link to the outer processing unit PU. The switch 12 can be used either when no processing unit PU is available, or when the user wants to hear the auscultation signal directly, without any filtering by an outer processing unit, for comparing with the filtered signal provided by the processing unit PU.

[0031] Memory means and selection means can be provided so that several correction filtering coefficients

can be stored and selected, to enable several doctors to use the same stethoscope with a proper correction for each doctor.

[0032] Figure 7 shows a more detailed block diagram of the electronic circuits in the chestpiece 302. The first electronic circuit 11 comprises in series: an analogue preamplifier 30, an analogue-to-digital converter 31, and a Bluetooth radio transmitter 32. An input of the analogue preamplifier 30 is linked to the microphone 10. An output of the analogue preamplifier 30 is linked to an input of analogue-to-digital converter 31. An output of this latter is linked to an input of the Bluetooth radio transmitter 32. The output of the analogue preamplifier 30 is also linked to a first terminal of the switch 12.

The second electronic circuit 13 comprises in series: a Bluetooth radio receiver 33, a digital-to-analogue converter 34, and an output amplifier 35. The output of Bluetooth radio receiver 33 is linked to the input of the digital-to-analogue converter 34. The output of the digital-to-analogue converter 34 is linked to a first input of the output amplifier 35. This latter has: a second input linked to a second terminal of the switch 12, a first output linked to the loudspeaker 14, and a second output linked to a connector 30 where a headphone, or several headphones, can be connected.

A micro controller 44 controls the Bluetooth radio transmitter 32, the Bluetooth radio receiver 33, and the output amplifier 35. A rechargeable battery 42 supplies power to a power unit 43 regulating a DC voltage distributed to all the electronic components of the stethoscope. A charging unit 41 linked to a connector 40, at the surface of the housing, can charge the battery 42. When the stethoscope is not in use, an AC power adapter (not represented) is connected to the connector 40.

[0033] Figure 8 shows a variant of the stethoscope represented on figures 6-7. This embodiment is designed to convert a classical stethoscope into an electronic one. It comprises a housing 302' with an upper ribbed stem 4' and a lower ribbed stem 4". In this example, the classical stethoscope comprised:

- A chest piece comprising a diaphragm 54 on one side, a bell 53 on the other side, and a ribbed stem 52.
- A conventional headset 301' made up of two metal eartubes 5', 6', a tension spring 7', and two eartips 8', 9'.
- A conventional flexible tube was attached to the ribbed stem 52 of the chest piece, and to the headset 301'.

[0034] The user has converted it into an electronic stethoscope by:

- Cutting the tube into two segments 3' and 3",
- then attaching the segment 3' to the upper ribbed stem 4' of the housing 302',
- and attaching the segment 3" to the lower ribbed stem 4" of the housing 302'.

[0035] The lower ribbed stem 4" continues into the housing 302' by a first acoustical chamber 51 containing a microphone 10'. The upper ribbed stem 4' continues into the housing 302' by a second acoustical chamber 15' containing a loudspeaker 14'.

The housing 302' also contains two electronic circuits 11', 13', a switch 12', and a battery not represented. These elements have respectively the same functions as those described with reference to figures 6-7. The auscultation signal is transmitted to an outer processing unit PU' (A personal computer in this example) for filtering the auscultation signal, displaying wave forms on a screen, and is transmitted back to the housing 302' for restitution by the loudspeaker 14', coupled to the tube segment 3' by the acoustical chamber 15'.

In addition, the processing unit PU' can run a calibration software module executing a procedure similar to that described above. The stylus is replaced by a mouse MS in this example.

[0036] The upward and downward links with the outer processing unit preferably are wireless, however a wire could be used as well, for instance using the USB 2 technology (Universal Serial Bus version 2).

[0037] The wireless technology preferably is the Bluetooth technology, however it can other wireless transmission technologies as well, for instance Zigbee, WiFi, or UWB.

Two different technologies can be respectively used for the transmission from the stethoscope to the processing unit PU, and for the transmission from the processing unit PU to the stethoscope, these technologies being chosen in order to minimize the power consumption in the stethoscope, while providing bandwidths respectively adapted to the two signals to be transmitted.

Claims

1. A correction device for an audio reproducing device, comprising:

- an input (LI) for receiving an electrical audio signal,
- adjustable filtering means (LF) for filtering said electrical audio signal,
- at least one transducer (LT, RT) for converting, into an acoustic signal, an electrical audio signal supplied by the filtering means,
- means (LM) for adjusting the frequency response curve of the filtering means (LF),

characterized in that it further comprises a set of calibration and correction means comprising:

- means (B1, LC) for generating a series of test signals, at different frequencies and different amplitudes,
- switching means (LS) for alternately transmit-

ting, to an input of the adjustable filtering means (LF),

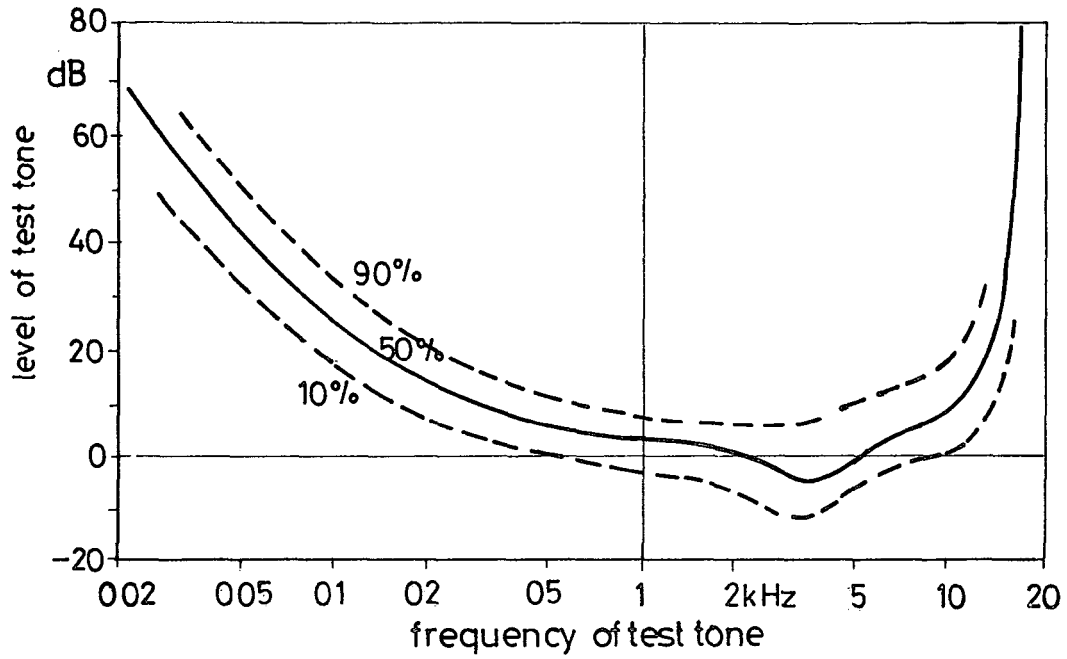
- a test signal supplied by the means (B1, LC) for generating, during a calibration phase, 5
- and an electrical audio signal supplied by the input (LI) of the correction device, during a reproduction phase following the calibration phase, 10

- means (B2, LC, LS) for receiving an indication from a user listening to a test signal via said transducer, when the user actually perceives this test signal, during the calibration phase, 15
- means (LC) for respectively storing the values of the lowest amplitudes where the user actually perceives test signals, for the respective frequencies of the series of test signals, during the calibration phase, 20
- means (LC) for controlling the means (LM) for adjusting the frequency response curve of the filtering means, at the end of the calibration phase, so that the user's perception would correspond to a predetermined frequency response curve in a predetermined bandwidth. 25

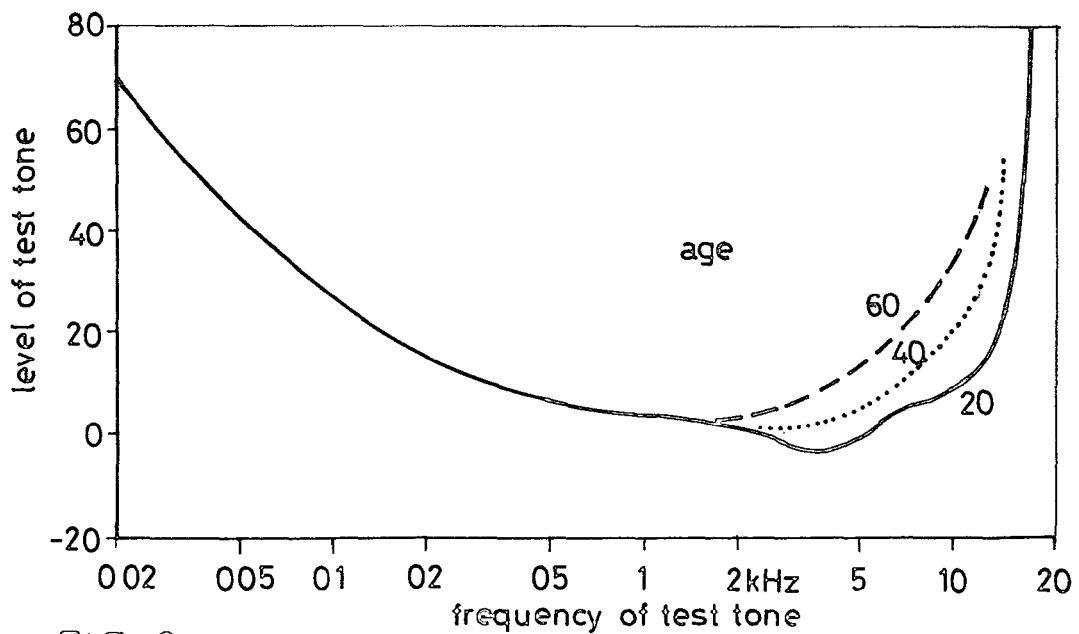
2. A correction device according to claim 1, for an audio reproducing device (101) comprising two transducers (LT, RT) adapted to be placed respectively close to the two ears of a same user, and two sets of filtering means (LF, RF) respectively dedicated to these two transducers; 30
characterized in that it comprises two independent sets of calibration and correction means (LC, RC, LM, RM, LS, RS) respectively dedicated to said two sets of filtering means. 35
3. An audio reproduction device **characterized in that** it comprises a correction device according to claim 1. 40
4. An electronic stethoscope (201, 202; 301, 302, PU) **characterized in that** it comprises a correction device according to claim 1. 45
5. A pair of headphones (101) **characterized in that** it comprises a correction device according to claim 1. 50

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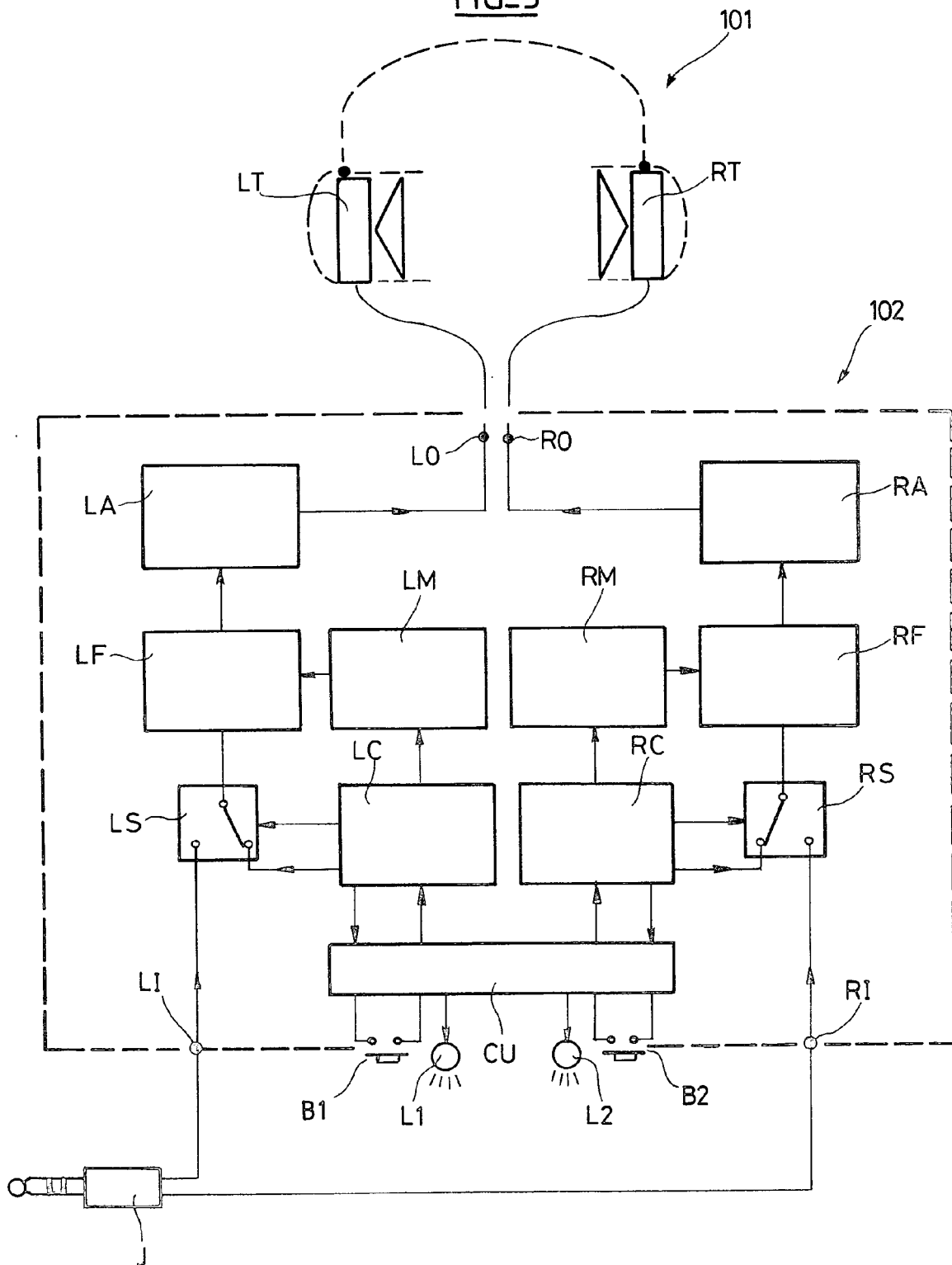


FIG_1 Statistics for threshold in quiet: 50% 90% and 10% values for threshold in quiet as a function of frequency for subjects 20 to 25 years old



FIG_2 Threshold in quiet as a function of frequency with age as a parameter

FIG_3



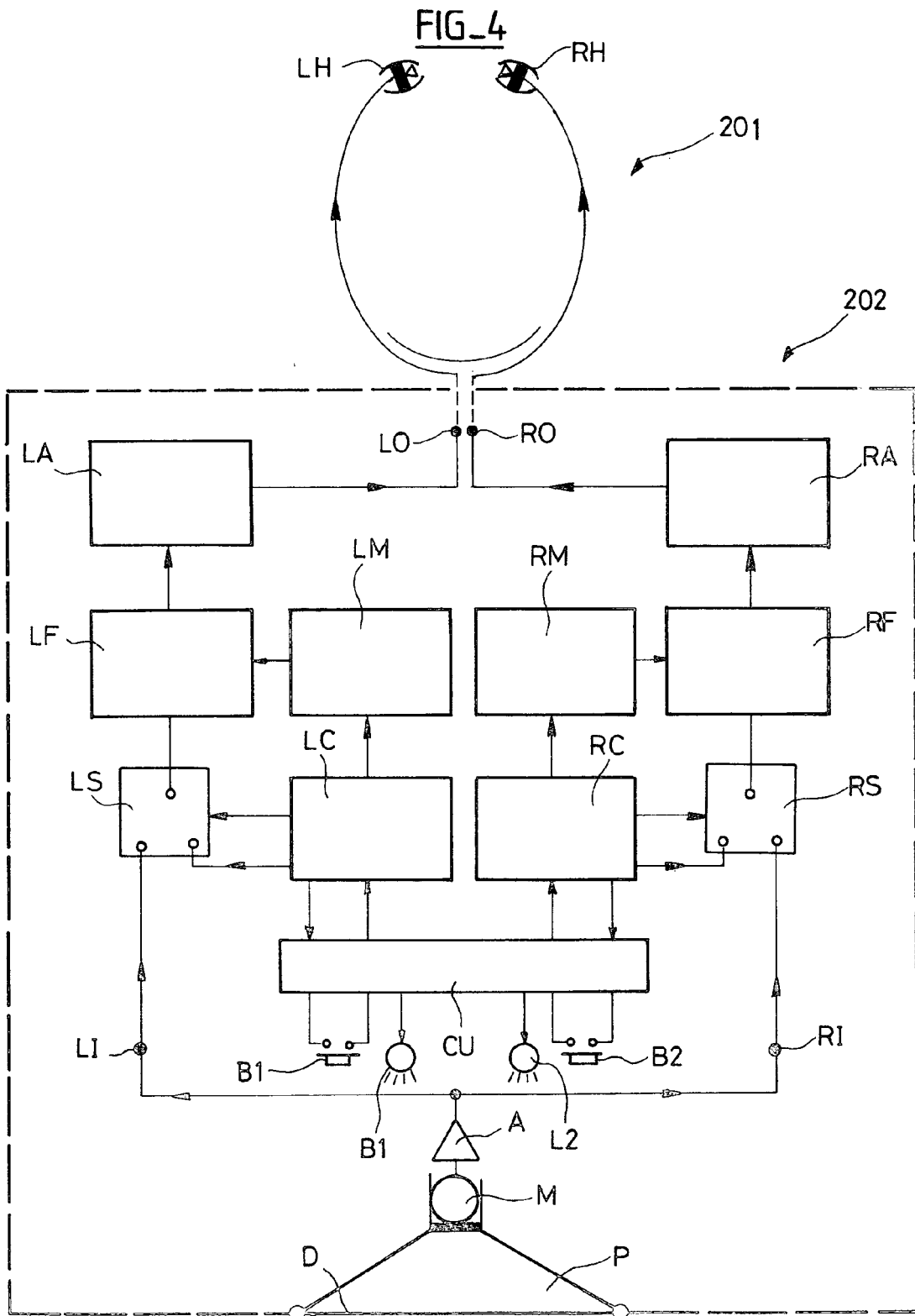
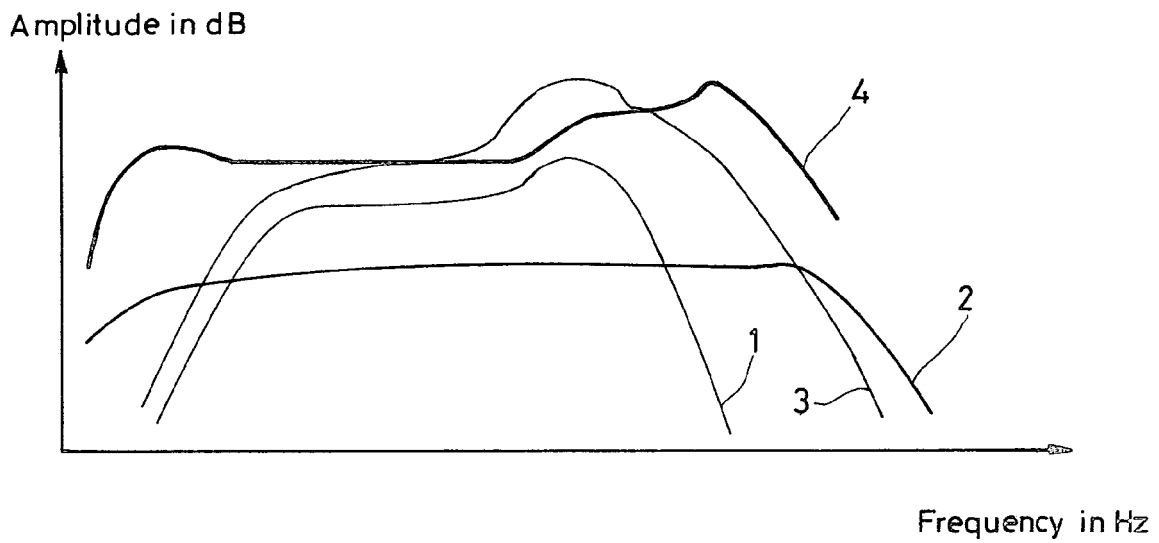


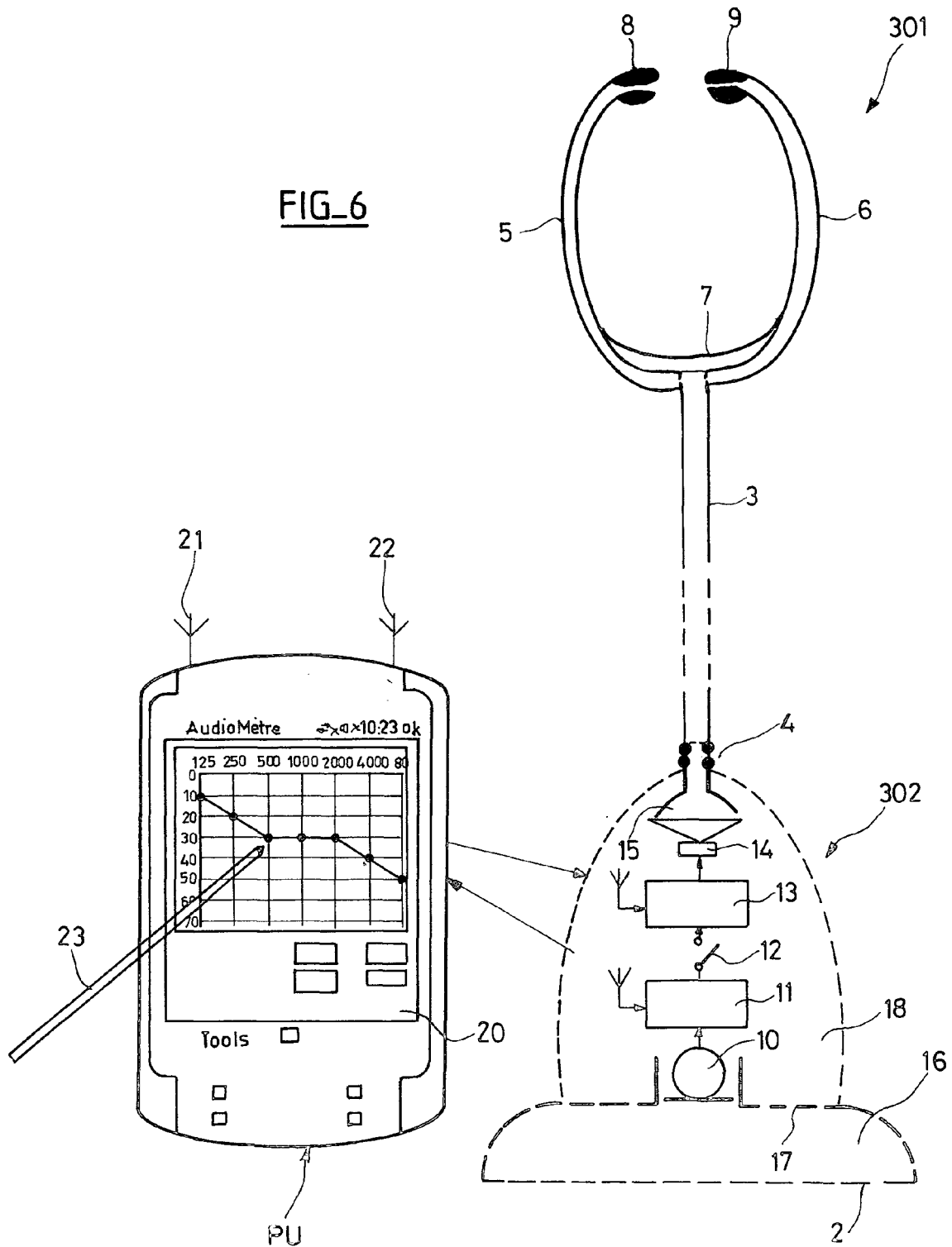
FIG-5



Legend:

- : (1) : Frequency response of one ear of the practitioner
- : (2) : Frequency response of electro acoustic part of the stethoscope
- : (3) : Normal frequency response of a human ear
- : (4) : Correction response = $(3) - (2) - (1)$

FIG_6



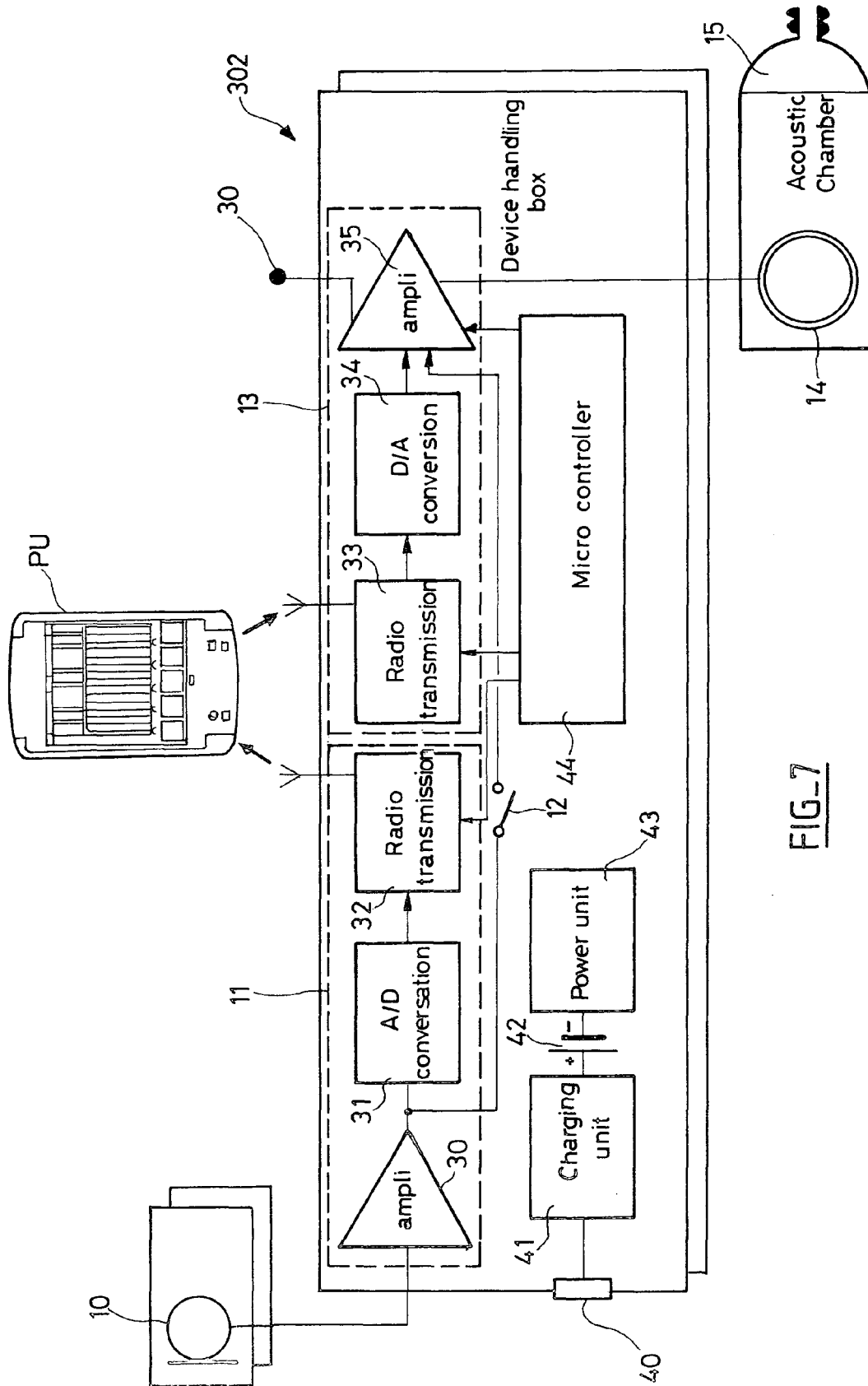
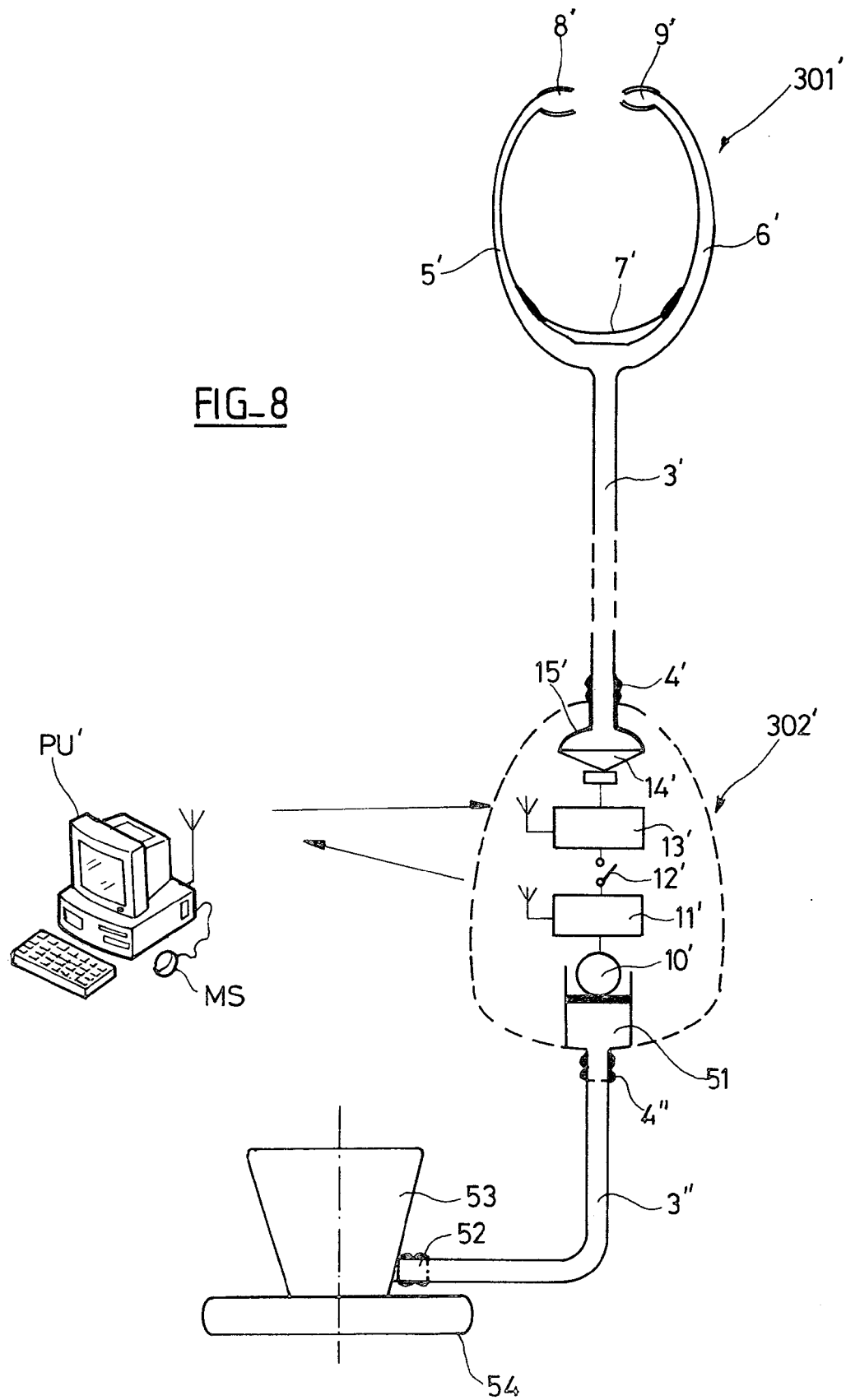


FIG. 7





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Application Number
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