The present invention relates to a pure tone audiometer, and more particularly, to a pure tone audiometer with automated masking which is capable of automatically performing air-conduction and bone-conduction hearing tests and automatically performing a masking test, if necessary, so that a person obtains an accurate pure tone hearing threshold without others' assistance. The pure tone audiometer of the present invention can accurately perform the pure tone hearing test with automated masking without assistance from a doctor or an audiologist. Thus, with the pure tone audiometer, people can easily check their hearing ability for prevention and early detection of hearing loss and take swift action to cure hearing loss.
Published:
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Description

PURE TONE AUDIOMETER WITH AUTOMATED MASKING

Technical Field
[1] The present invention relates to a pure tone audiometer, and more particularly, to a pure tone audiometer with automated masking which is capable of automatically performing air-conduction and bone-conduction hearing tests and automatically performing a masking test, if necessary, so that a person obtains an accurate pure tone hearing threshold without others' assistance.

Background Art
[2] The senses of hearing and sight are important perception means for obtaining information in modern information society. However, as industrialization has progressed, noise has increased around work places, homes, etc., and noise induced hearing loss has increased.

[3] Most hearing loss, except for some kinds of rapid hearing loss, appears slowly and unconsciously. To cure hearing loss, early detection and proper measures of hearing loss is required. Early detection may require periodic visits to a hospital to undergo hearing tests, but often people cannot afford to go to the hospital.

[4] Korean Patent No. 10-345371 describes a method to solve this problem by performing a hearing test in a web environment. This method includes only a pure tone test without noise-based masking. Accordingly, when a difference in an air-conduction hearing threshold between both ears is 35dB or more, or when a difference between an air-conduction hearing threshold of an ear with bad hearing (hereinafter referred to as a "bad ear") and a bone-conduction hearing threshold of an ear with good hearing (hereinafter referred to as a "good ear") is 15dB or more, the method cannot accurately measure hearing loss. As a result, a pure tone hearing test with masking may have to be performed again at a hospital by a well trained audiologist or doctor in order to obtain a more accurate test result. Here, masking prevents erroneous measurements that may occur when, upon measuring a hearing threshold of the bad ear, a person with a great hearing difference between his/her left and right ears first hears sound with the good ear.

[5] Hearing the sound with the other ear upon measuring one ear's hearing is called shadow hearing or cross hearing, however, a masking noise can be applied to the good ear to prevent the shadow hearing. For masking in air-conduction and bone-conduction hearing, there are a method for calculating a masking amount using a formula, and a manual method by which an audiologist or a doctor well trained for a psychoacoustic method can directly calculate a masking amount.
However, since this test method requires an audiologist or a doctor's assistance and takes a long time, taking swift action may be impossible and, since a person may visit a hospital after having suffered from severe hearing loss, early detection of hearing loss may be difficult.

Disclosure of Invention

Technical Problem

The present invention is directed to a pure tone audiometer with automated masking which is capable of easily performing an accurate pure tone hearing test without a specialist's assistance, enabling prevention and early detection of hearing loss and swift action to cure hearing loss.

Technical Solution

One aspect of the present invention provides a pure tone audiometer comprising: a display unit for displaying a use-procedure guide or a result of a pure tone hearing test; a sound generating circuit for generating and outputting an electrical signal in response to a control signal; an output unit including a headphone and a bone-conduction vibrator, and receiving the electrical signal from the sound generating circuit to generate and output a pure tone or a noise for the pure tone hearing test; an input unit for allowing a user hearing the pure tone generated by the output unit to input a response to the tone; an air-conduction hearing tester for performing the pure tone hearing test based on a pure tone propagated via an external auditory meatus by outputting a control signal to control the headphone of the output unit to generate the pure tone and by adjusting the pure tone depending on a response from the user; a bone-conduction hearing tester for performing the pure tone hearing test based on a pure tone propagated through a skull by outputting a control signal to control the bone-conduction vibrator of the output unit to generate the pure tone and by adjusting the pure tone depending on a response from the user; a masking tester for performing a hearing test by outputting a control signal to generate a masking sound to one ear having good hearing (a good ear) and the pure tone to the other ear when there is a difference of 35dB or more between both ears' hearing measured by the air-conduction hearing tester, or when there is a difference of 15dB or more between a air-conduction hearing threshold of the ear having bad hearing (a bad ear) and a bone-conduction hearing threshold of the good ear measured by the bone-conduction hearing tester; and a controller for outputting the control signal to control the sound generating circuit to generate the masking sound in response to a control signal from the air-conduction hearing tester, the bone-conduction hearing tester, and the masking tester, sending the response of the user from the input unit to the air-conduction hearing tester, the bone-conduction hearing tester, and the masking tester, and outputting a control signal to
control the display unit to display the use-procedure guide and the test result when the air-conduction hearing tester, the bone-conduction hearing tester, and the masking tester proceed to the hearing test.

Preferably, the controller comprises a storage unit for storing the result of the pure tone hearing test, such that a type and degree of hearing loss are displayed.

Preferably, the controller stores features of various types of sound generating circuits, headphones, and bone-conduction vibrators, and outputs a different electrical signal depending on used ones of the sound generating circuits, headphones, and bone-conduction vibrators.

**Advantageous Effects**

As described above, the pure tone audiometer of the present invention can accurately perform the pure tone hearing test with automated masking without assistance from a doctor or an audiologist. Thus, with the pure tone audiometer, people can easily check their hearing ability for prevention and early detection of hearing loss and take swift action to cure hearing loss.

**Brief Description of the Drawings**

FIG. 1 is a block diagram of a pure tone audiometer according to the present invention.

**Mode for the Invention**

Hereinafter, exemplary embodiments of the present invention will be described in detail. However, the present invention is not limited to the exemplary embodiments disclosed below, but can be implemented in various types. Therefore, the present exemplary embodiments are provided for complete disclosure of the present invention and to fully inform the scope of the present invention to those ordinarily skilled in the art.

Referring to FIG. 1, a pure tone audiometer of the present invention comprises a display unit 10, a sound generating circuit 20, an output unit 30, an input unit 40, an air-conduction hearing tester 50, a bone-conduction hearing tester 60, a masking tester 70, and a controller 80.

The display unit 10 displays a use-procedure guide or a test result. In an exemplary embodiment of the present invention, the display unit 10 may be a monitor for a computer. Alternatively, the display unit 10 may be a unit for printing a guide at one side of the device, turning a plurality of electric bulbs located at one side of the guide on for illuminating the guide according to a procedure, and displaying a test result on a liquid crystal display disposed at another side of the device.

When a control signal is input, the sound generating circuit 20 generates a sound in
response to the input control signal. The control signal includes an indication of the frequency and intensity of the sound to be generated and an indication of whether the sound is to be generated toward any one of left and right ears. The sound generating circuit 20 generates the sound having the required frequency and intensity, and outputs the sound as an electrical signal. In the present invention, the sound generating circuit 20 may be a commercially available sound card for a computer.

[18] The output unit 30 includes a headphone and a bone-conduction vibrator. The headphone converts the electrical signal from the sound generating circuit 20 into sound. The bone-conduction vibrator is mounted to a mastoid at a rear side of the ear, and converts the electrical signal from the sound generating circuit 20 into vibration and delivers the vibration toward the skull. The headphone and the bone-conduction vibrator vibrating and generating sound in response to the electrical signal from the sound generating circuit 20 is well known to those skilled in the art and a detailed description thereof will be omitted.

[19] The input unit 40 allows the user to indicate that he/she has heard the sound from the output unit 30. In the exemplary embodiment of the present invention, the input unit 40 is a keyboard for a computer. Alternatively, the input unit 40 may be a switch or a touch screen.

[20] The air-conduction hearing tester 50 will now be described. The air-conduction hearing tester 50 performs a hearing test in order to obtain the hearing threshold via a test to see whether the user can hear the pure tone propagated to his/her eardrum via his/her external auditory meatus by generating a pure tone to the headphone of the user. Specifically, the air-conduction hearing tester 50 generates a control signal to adjust sound pressure of the pure tone that is generated depending on a user's response input from the input unit 40. For example, the air-conduction hearing tester 50 outputs the control signal to increase the sound pressure to 45dB when the user does not hear a 40dB sound and to decrease the sound pressure to 35dB when the user hears the 40dB sound.

[21] The air-conduction hearing tester 50 performs a hearing test on the left and right ears. First, the air-conduction hearing tester 50 generates a pure tone at a pre-determined frequency. The air-conduction hearing tester 50 initially provides a pre-determined sound pressure (40dB) and increases or decreases the sound pressure at intervals of 5dB depending on response. A minimum sound pressure of a sound that the user can hear is a hearing threshold. The test is performed with several frequencies to obtain a hearing threshold corresponding to each frequency.

[22] The bone-conduction hearing tester 60 will now be described. The bone-conduction hearing tester 60 performs a hearing test on the user by using the sound propagated through the skull. The air-conduction hearing test cannot exactly perform the hearing
test when the user suffers from an external or middle ear disease, such as an external ear disease induced change or a middle ear inflammation. In this case, it is necessary to perform the hearing test based on vibration propagated via the skull. The bone-conduction hearing tester 60 sends an electrical signal to the bone-conduction vibrator rather than the headphone so that the bone-conduction vibrator generates a vibration-induced pure tone, and obtains an ear's bone-conduction hearing threshold. Since the bone-conduction hearing tester 60 performs the test in the same process as the air-conduction hearing tester 50, a detailed description of the test process of the bone-conduction hearing tester 60 will be omitted.

The masking tester 70 will now be described. The masking tester 70 performs the hearing test by generating a noise toward a headphone mounted to one ear and a pure tone to the other ear to be measured. When there is a great difference between the hearings of both ears, this hearing test is intended to prevent the sound from being delivered to the good ear via the skull instead of via an external auditory meatus. In general, the masking tester 70 is activated when there is a difference of 35dB or more between both ears in the air-conduction hearing test or when there is a difference of 15dB or more between the air-conduction hearing threshold of the bad ear and the bone-conduction hearing threshold of the good ear in the bone-conduction hearing test. When masking bone-conduction hearing, the masking tester 70 determines an ear on which the headphone will be mounted and an ear to which the bone-conduction vibrator will be attached, and outputs a control signal to display the determination result on the display unit 10. The masking tester 70 generates a control signal to increase sound pressure of the noise when the user hears the pure tone and to increase the pure tone when the user does not hear the pure tone.

The controller 80 will now be described. The controller 80 is connected to and controls the display unit 10, the sound generating circuit 20, the input unit 40, the air-conduction hearing tester 50, the bone-conduction hearing tester 60, and the masking tester 70. The controller 80 receives a control signal for the frequency and the sound pressure for testing from the air-conduction hearing tester 50, the bone-conduction hearing tester 60, and the masking tester 70, converts the control signal to be suitable for reception by the sound generating circuit 20, and sends the control signal to the sound generating circuit 20. Here, since the control signal depends on a type of commercially available sound card as the sound generating circuit 20 the controller 80 converts the control signal as mentioned above. The controller 80 controls the display unit 10 to display a guide for any procedure required to perform the hearing test. For example, in the masking test, the controller 80 controls the monitor to display on the screen an ear on which the headphone will be mounted and an ear to which the bone-conduction vibrator will be attached, such that the user correctly mounts the headphone.
and the bone-conduction vibrator. The controller 80 also receives a signal from the input unit 40 and sends the signal to the air-conduction hearing tester 50, the bone-conduction hearing tester 60, and the masking tester 70.

[25] Here, the controller 80 further includes a storage unit 82 for storing the test result so that a type and degree of hearing loss is displayed and the test result can be checked by the user at anytime.

[26] The controller 80 stores information on the sound generating circuit 20 and the headphone and the bone-conduction vibrator of the output unit 30. This is because the sound generating circuit 20, the headphone, and the bone-conduction vibrator have different features depending on make or model, and therefore, the controller 80 cannot generate an accurate sound by using the same control signal. Accordingly, it is necessary to recognize the features of the sound generating circuit 20, the headphone, and the bone-conduction vibrator by performing a test in advance. Specifically, the controller 80 measures an electrical signal, sound or vibration output while increasing or decreasing sound pressure for each frequency, determines a value to be corrected for each frequency with respect to each device, and stores the value in a database 84. The controller 80 reads a correction value for the type of corresponding device and performs correction by applying the correction value. For example, when the connected headphone generates a signal at 1000Hz to output 35dB, a non-corrected signal may be output at 30dB. In this case, the controller 80 controls the sound generating circuit to generate a 35dB signal, such that an output signal of the headphone is 35dB.

[27] Operation and effects of the pure tone audiometer according to an exemplary embodiment of the present invention will now be described in detail with reference to FIG. 1.

[28] Using the keyboard, a user inputs the type of sound generating circuit 20 mounted on the pure tone audiometer of the present invention by viewing the screen of the display unit 10. The user also inputs make and model names of the headphone and the bone-conduction vibrator connected to the sound generating circuit 20 so that the controller 80 performs the correction.

[29] When there is a request from the user for a pure tone hearing test, the controller 80 sends a control signal to control the air-conduction hearing tester 50 to perform a testing procedure. The air-conduction hearing tester 50 displays a guide to instruct the user to wear the headphone on the display unit 10 via the controller 80. When the user wears the headphone according to the guide and presses an enter key of the keyboard, an input signal from the keyboard is sent to the air-conduction hearing tester 50 via the controller 80, such that the hearing test is initiated.

[30] The air-conduction hearing tester 50 instructs the user to select an ear with good
hearing, and begins to first test the selected ear. The air-conduction hearing tester 50 generates a pure tone at 1000Hz to output 40dB, and outputs it to the selected ear. When the user hears the sound and presses a predetermined button, the air-conduction hearing tester 50 decreases the pure tone by an interval of 5dB. When the user does not hear the sound (i.e., the user does not press the button for a predetermined time), the air-conduction hearing tester 50 increases the pure tone by an interval of 5dB. The air-conduction hearing tester 50 performs this process repeatedly three times in order to obtain the threshold. When the two or more responses from the user are the same, the air-conduction hearing tester 50 determines the smallest value to be the threshold. The test is first performed at 1000Hz. The test is then performed at 2000Hz, 3000Hz, 4000Hz, and 8000Hz. A threshold at 1000Hz is obtained again. When a difference between the threshold at 1000Hz and an initial threshold is 10dB or more, the test is performed again at the higher frequencies. When the difference is less than 5dB, the test is performed at lower frequencies in the order of 500Hz, 250Hz, and 125Hz.

This process is then performed on the other ear to obtain the air-conduction hearing threshold of both ears. When a difference between both hearing thresholds is 35dB or more, the controller 80 calls the masking tester 70. The masking tester 70 sends a noise to the good ear and a pure tone to the bad ear, and increases or decreases the sound pressure of the noise or pure tone depending on a response from the user in order to test the hearing.

The pure tone audiometer then performs the bone-conduction hearing test on a user who is likely to suffer from hearing loss or is suffering from middle ear inflammation. The bone-conduction hearing test includes sending vibration via the bone-conduction vibrator attached to the rear of the ear, not via the headphone, and detecting the vibration propagated via the skull. The bone-conduction hearing test includes measuring only frequencies from 250Hz to 4000Hz. Since this testing process is the same as the process of obtaining the air-conduction hearing threshold, a detailed description thereof will be omitted.

When a difference between the air-conduction hearing threshold of the bad ear and the bone-conduction hearing threshold of the good ear, which are sequentially measured, is 15dB or more, the controller 80 calls the masking tester 70. The masking tester 70 instructs the user to attach the bone-conduction vibrator to the ear to be tested and wear the headphone on the other ear, and then sends a noise to the headphone and a pure tone to the bone-conduction vibrator for hearing testing.

The test result may be displayed on the screen of the display unit 10. The test result may be output by a printer, if necessary.

Such a test can provide accurate air-conduction and bone-conduction hearing thresholds, such that hearing loss can be prevented and early detection is possible.
without assistance from a doctor or an audiologist.

[36] While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

[37]
Claims

[1] A pure tone audiometer comprising:
a display unit for displaying a use-procedure guide or a result of a pure tone
hearing test;
a sound generating circuit for generating and outputting an electrical signal in
response to a control signal;
an output unit including a headphone and a bone-conduction vibrator, and
receiving the electrical signal from the sound generating circuit to generate and
output a pure tone or a noise for the pure tone hearing test;
an input unit for allowing a user hearing the pure tone generated by the output
unit to input a response to the tone;
an air-conduction hearing tester for performing the pure tone hearing test based
on a pure tone propagated via an external auditory meatus by outputting a control
signal to control the headphone of the output unit to generate the pure tone and
by adjusting the pure tone depending on a response from the user;
a bone-conduction hearing tester for performing the pure tone hearing test based
on a pure tone propagated through a skull by outputting a control signal to
control the bone-conduction vibrator of the output unit to generate the pure tone
and by adjusting the pure tone depending on a response from the user;
a masking tester for performing a hearing test by outputting a control signal to
generate a masking sound to one ear having good hearing (a good ear) and the
pure tone to the other ear when there is a difference of 35dB or more between
both ears' hearing measured by the air-conduction hearing tester, or when there
is a difference of 15dB or more between a air-conduction hearing threshold of
the ear having bad hearing (a bad ear) and a bone-conduction hearing threshold
of the good ear measured by the bone-conduction hearing tester; and
a controller for outputting the control signal to control the sound generating
circuit to generate the masking sound in response to a control signal from the air-
conduction hearing tester, the bone-conduction hearing tester, and the masking
tester, sending the response of the user from the input unit to the air-conduction
hearing tester, the bone-conduction hearing tester, and the masking tester, and
outputting a control signal to control the display unit to display the use-procedure
guide and the test result when the air-conduction hearing tester, the bone-
conduction hearing tester, and the masking tester proceed to the hearing test.

[2] The pure tone audiometer of claim 1, wherein the controller comprises a storage
unit for storing the result of the pure tone hearing test, such that the type and
degree of hearing loss are displayed.
The pure tone audiometer of claim 1, wherein the controller stores features of various types of sound generating circuits, headphones, and bone-conduction vibrators, and outputs a different electrical signal depending on used ones of the sound generating circuits, headphones, and bone-conduction vibrators.
INTERNATIONAL SEARCH REPORT
PCT/ISA/210 (second sheet) (April 2007)

A. CLASSIFICATION OF SUBJECT MATTER
A61B 5/12(2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 8 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
eKIPASS (KIPO internal) "hearing", "test"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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* Special categories of cited documents
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
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Date of mailing of the international search report
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Republic of Korea
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Authorized officer
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Telephone No 82-42-481-8458

Form PCT/ISA/210 (second sheet) (April 2007)
The present invention relates to a pure tone audiometer with automated masking and, in particular to a pure tone audiometer that carries out the air-conducting and the bone-conducting hearing test while making automatic masking test. The pure tone audiometer includes a display, a sound generating circuit; an output section; an input section; a air-conduction hearing test section, a bone-conduction hearing test section, a control section, and a masking test section that performs either of the bone or the air-conduction hearing test for one ear while masked is the other ear to which a masking sound is applied to block the interference between both ears in the hearing test.
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Form PCT/ISA/210 (patent family annex) (April 2007)