

[54] **HEADPHONE** 3,098,307 7/1963 Caldwell 179/156 R X
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[51] **Int. Cl.** **H04m 1/05; H04r 1/10**
[58] **Field of Search** 179/156 R, 182 R

[56] **References Cited**
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[57] **ABSTRACT**
A headphone set held over the ears by a band worn on the head of a user comprises a sound box surrounding each ear and mounting in its front, an electro-acoustic transducer. This electro-acoustic transducer has its axis inclined by a small angle from the vertical to a line connecting each ear.

3 Claims, 4 Drawing Figures

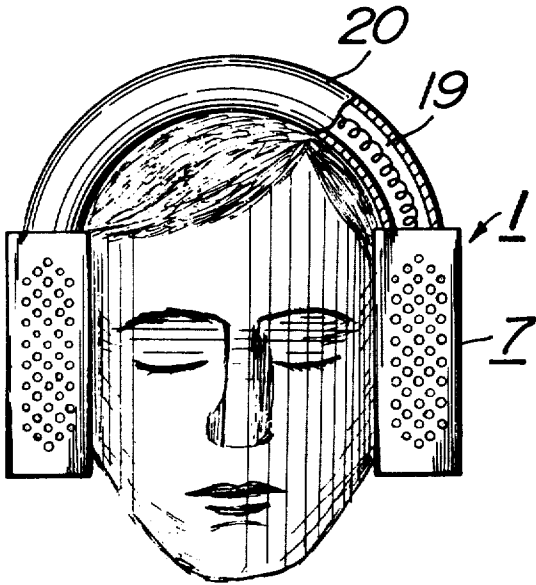


FIG. 1

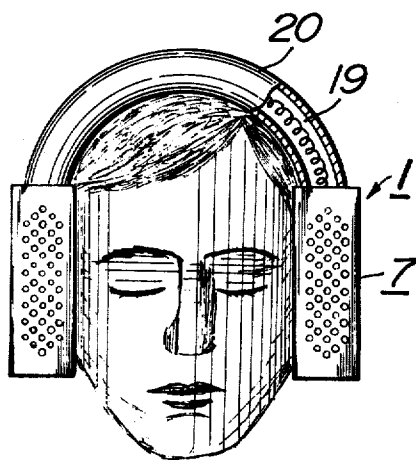


FIG. 2

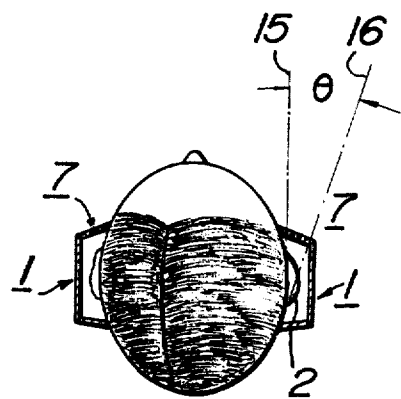


FIG. 3

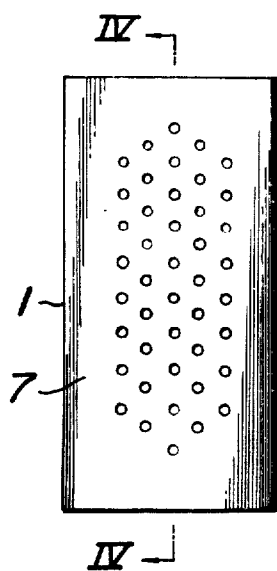
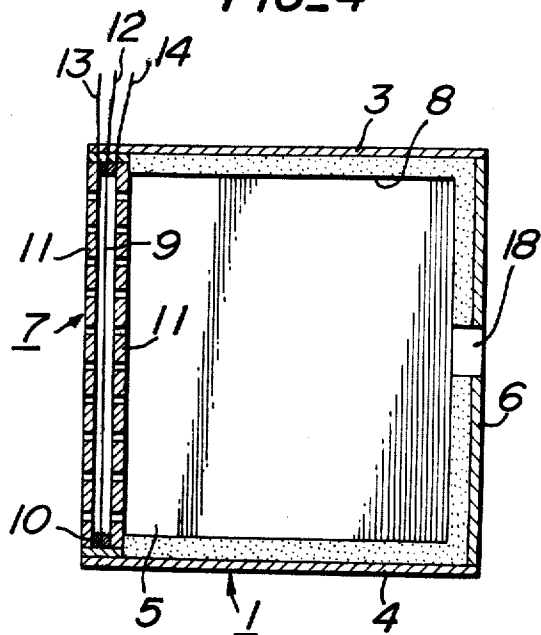


FIG. 4



HEADPHONE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a headphone set held over the ears by a band worn on the head of a user, comprising a sound box surrounding each ear and an electro-acoustic transducer mounted near each ear.

2. Description of the Prior Art

Headphone sets can be used to listen to high-fidelity recordings in a relatively easy manner irrespective of a listener's position and attitude. As a result, various improvements have been proposed to such headphones for hearing stereo recordings. However, a bare headphone is merely a kind of electro-acoustic transducer which can transmit communication signals, so that it is basically unsuitable for hearing stereo or binaural music.

Heretofore it has been proposed to modify a headphone for the purpose of hearing stereo or binaural music. For example, the headphone has been screened from outside noises with the aid of a sound box and so constructed that the sound produced by the electro-acoustic transducer is not leaked out of the box. In addition, it has been proposed to provide openings in the sound box to cause the outside sound and the sound produced in the headphone to pass through these openings to some extent.

Such an open type headphone has the advantage that outside sound can enter into the headphone or the sound reproduced can be leaked out to a certain degree, and as a result, natural and excellent high-fidelity sound can be reproduced and heard compared to a closed type headphone.

Conventional closed and open type headphones, however, have the disadvantages that since the electro-acoustic transducers are held over the ears on a line connecting each ear the sound waves issued from the left and right channels are directly transmitted to the ear-drums from the left and right on a line connecting each ear, that both a plug type earphone adapted to be inserted into the ear and a large type headphone surrounding the ear are closely fitted into and surround the external ear path and hence a sound pressure is subjected to the ear, that the headphone covers the ear in quite unnatural manner, and that the stereo signals reproduced by headphones are basically different from those transmitted from speakers and the natural sound to be heard by each ear per se.

SUMMARY OF THE INVENTION

The inventor has found out that in case of hearing a musical performance, for example, the music is picked up by a set of microphones arranged at the left and right sides of a listener and transmitted through left and right channels to electro-acoustic transducers by which the music is reproduced. In hearing such music with both ears at once, it is best to locate the speakers on lines met at the position of the listener and making an angle of about 60°. The invention is based on such recognition.

A feature of the invention is the provision of a headphone held over the ear by a band worn on the head of a user comprising a sound box open at its front and surrounding each ear, and an electro-acoustic transducer set into the open front of the sound box, the axis of the

electro-acoustic transducer being inclined outwardly by a small angle from the vertical to a line connecting each ear.

Such an such improved headphone has a number of advantages. First, it is easy to catch almost all of the sound waves produced by the electro-acoustic transducer located in front of the ear and to transmit these sound waves through the external ear-path to the eardrum. Secondly, the axial direction of the external ear-path is approximately perpendicular to the incident direction of the sound waves so that the listener can catch the sound waves transmitted from the front. Third, the frequency characteristics, phase characteristics, etc. of the sound wave can be perceived by the ear in response to the complex configuration of the ear, and as a result, the listener can hear the sound in an extremely natural aural sense from acoustic, physiological and psychological points of view. Finally, an ideal stereo sound can be heard without the disadvantage that the sound passes through a line connecting each ear.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawing:

FIG. 1 is a front view showing a headphone held over the ear by a band worn on the head of a user according to the invention, partly in section;

FIG. 2 is a plan view of FIG. 1, partly in section;

FIG. 3 is a front view showing a sound box of the headphone according to the invention in an enlarged scale; and

FIG. 4 is a section along line IV—IV in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the embodiment shown in the drawings, a sound box 1 has such dimensions that it can surround each ear 2 with spaces remaining around the ear 2 so as not to deform the ear. The sound box 1 is comprised of upper and lower walls 3, 4, a side wall 5 and a rear wall 6. The opposite side of the side wall 5 is opened so as to insert the ear 2 into the sound box 1 and make the end edges of the respective walls contact the head and cheek of a user. As a result, the user's ears are not subjected to any disagreeable sound pressure. In addition, the front side which is in opposition to the rear wall 6 is opened, and to this open front is secured an electro-acoustic transducer 7. If the box 1 is constructed as described above, some sound can leak out of the box with the frequency characteristics of the electro-acoustic transducer 7 well matched to the incident signal, and the low frequency band is adjustable. The box 1 is provided with a lining 8 made of some suitable sound absorbing material to prevent the high frequency band from being irregularly reflected.

The present invention makes use of some suitable electro-acoustic transducer 7. In the embodiment shown in the drawings, the electro-acoustic transducer 7 is comprised of an electrostatic type flat plate shaped electro-acoustic transducer comprising a diaphragm 9 and fixed electrodes 11 arranged at each side of the diaphragm 9 and spaced apart by means of spacers 10. Reference numbers 12, 13 and 14 designate lead wires connected to the diaphragm 9 and fixed electrodes 11, respectively. The electro-acoustic transducer 7 is so dimensioned that a plane sound wave can arrive at the ears 2 as a whole from the front.

The electro-acoustic transducer 7 is not limited to the above described electrostatic type, but an electro-magnetic type can also be used. In this case, it is preferable to use a velocity type, for example, an elliptic dynamic speaker.

In the present invention, the electro-acoustic transducer 7 is set into the front of the sound box 1 such that the axis of the electro-acoustic transducer 7 is inclined by a relatively small angle θ , for example, 20° to 30° from the vertical line 15 against a line connecting each ear 2 as shown in FIG. 2. This is because of the fact that if one wishes to hear the stereo-performance through two speakers, these speakers are located on lines met at the listener and symmetrically inclined by about 30° from the center line of the speakers such that the sound wave arrives from the front at each ear of the listener. The invention is based on such a stereo listening principle and the transducers 7 are set into the sound box 1 so that the transducer 7 is placed in front and inclined by about 20° to 30° from the vertical line 15 against the line connecting each ear 2 as shown in FIG. 2.

The rear wall 6 and its lining 8 may be provided with an aperture 18 for passing waves sound wave produced by the transducer 7. The provision of the aperture 18 results in an increase of the loss in the low frequency band, however, it prevents the sound from being confined in the box 1. If the frequency characteristics of the transducer 7 were flat in the open field, the sound box 1 would not be required. But, the amplitude of the sound wave is liable to become constant at a frequency lower than about 100 Hz. As a result, in order to correct for such low frequency characteristics, a totally enclosed type headphone is preferable. But, the use of such a transducer makes it difficult to eliminate the reaction of the sound pressure since the low frequency band causes resonance in the sound box cavity. As a result, it is necessary to provide a number of small holes in the box 1 or to provide the aperture 18 in the rear wall so that very low frequency sound waves leak out and any resonance is dampened.

In the present invention, it is possible to connect the inside of each sound box with a sound path 19. In this case, the sound path 19 can be provided along or inside of a head band 20. The coupling of the boxes through the sound path 19 enables the obtention of a time dif-

ference and sound pressure difference simultaneously in each box, thereby improving the stereo performance of the headphone. If it is desired to listen to a binaural performance, the sound path 19 must be closed.

Since directivity characteristics are broader at the medium and low frequency bands, the headphone according to the invention may be formed in a conventional manner so as to damp the high frequency band. A portion of the lining 8 which is near the transducer 7 can then be removed and a tweeter element, that is, a small loudspeaker responsive only to the higher frequency band, may be set there so as to secure almost the same effect by adjusting the sound pressure.

A transducer 7 can also be set into the rear wall 6 so as to provide a four channel headphone.

What is claimed is:

1. A headphone set including a pair of headphones adapted to fit over the ears of a user and connected by a head band, each headphone comprising:

a sound box having a front wall defining an opening therein, upper and lower walls, an outer side wall, and a rear wall, the sound box being adapted to fit over the ear of a user such that the inner peripheral edges of the front wall, the rear wall, and the upper and lower walls make intimate contact with the head and cheek of a user, and

a generally planar electro-acoustic transducer mounted within the front wall opening and having a perforated exterior face,

said electro-acoustic transducer having an axis generally perpendicular to the plane of the transducer inclined outwardly from the front-rear axis of the users head at an angle of between 20° to 30° .

2. A headphone set as defined in claim 1 wherein the transducer comprises a central, planar, vibratory membrane spaced from and disposed between a pair of planar, perforated electrodes, one of said electrodes constituting said exterior face of the transducer.

3. A headphone set as defined in claim 2 further comprising a layer of acoustically absorbent material covering the inner surfaces of the upper, lower, outer, and rear walls, and an aperture defined in the rear wall and extending through the layer of material.

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