

15

HEADPHONES

This invention relates to headphones.

A previously proposed headphone, shown in Figures 1 and 2 of the accompanying drawings, comprises a housing 1 which incorporates therein a speaker unit 2. The housing 1 is of a substantially circular truncated conical shape. A protector member 3 is disposed at a position opposed to a diaphragm 2a of the speaker unit 2. A large number of apertures are bored or otherwise formed through the protector member 3 to allow sound emanating from the speaker unit 2 to pass through the protector member 3. The illustrated headphone also comprises a cord supporting member 4 and a cord 5.

The above-described headphone is inserted into an auricle A and held or secured therein as shown in Figure 2. The auricle A of a human ear commonly is so shaped as to have a recess of substantially circular truncated conical form, referred to as the cavum concha C, at a side surface of which is positioned the entrance of the external auditory meatus B. At the lower side of the cavum concha C, a so-called tragus D and an anti-tragus E protrude towards the upper side of the cavum concha C from opposite sides thereof to form between them a substantially U-shaped gap known as the inter-tragus notch F. The housing 1 of the headphone is positioned within the cavum concha C and held between the tragus D and the anti-tragus E with the cord supporting member 4 disposed in the notch F.

The headphone shown in Figures 1 and 2 is inserted into the auricle A and secured therein by utilising the shape of the auricle A common to the human ear. However, the auricles of different human ears are different in size and, therefore, the headphone may be either too large to too small for a particular user. Thus, intended users of the headphone frequently find it too uncomfortable or painful to use.

Further, since the external auditory meatus B protrudes obliquely forwardly relative to the cavum concha C, the positioning of the headphone within the cavum concha C inevitably causes the diaphragm 2a of the

speaker unit 2 to be inclined relative to the external auditory meatus B. Also, the shapes of the external auditory meatus B and the periphery of its entrance differ as between different users. As a result, when the headphone is inserted into the auricle A with the diaphragm 2a oriented slantwise relative to the external auditory meatus B, the sound radiated from the diaphragm 2a is reflected by the external auditory meatus B, around the entrance of the external auditory meatus B, and then reaches the eardrum or tympanum. Thus, since the external auditory meatus B differs in shape between different ears, the sound reflected by the external auditory meatus B around the entrance of the external auditory meatus B will vary in tone quality between different individuals.

According to the present invention there is provided a headphone comprising:

a first housing member including a speaker unit with a diaphragm for radiating audible sound, and a front protective member for passing forward the radiated audible sound; and

a supporting member for supporting said housing member; said housing member being sized to provide at least a portion thereof to extend transversely into the cavum concha of a listener's ear, said front protective member of said housing member being larger in area than the entrance of the auditory meatus of the listener's ear, and said supporting member in use supporting said housing member so that said front protective member faces towards the front of the listener's ear inside said cavum concha.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which like references designate like elements and parts throughout, and in which:

Figure 1 is a side view of a previously proposed headphone having a housing with a speaker unit incorporated therein;

Figure 2 shows the headphone of Figure 1 inserted into an auricle for use;

Figure 3 is a front view of a headphone embodying the present invention;

Figure 4 is a rear view of the headphone shown in Figure 3;

Figures 5 and 6 are diagrams showing part of the headphone shown in Figure 3;

Figure 7 is a diagram useful for explaining the use of the headphone shown in Figure 3;

Figure 8 is a graph comparing the frequency responses of the headphones shown in Figures 1 and 3;

5 Figure 9 is a front view of another headphone embodying the present invention;

Figure 10 is a schematic view for explaining the use of the headphone shown in Figure 9; and

10 Figure 11 is a graph comparing the frequency responses of the headphones shown in Figures 3 to 6 and in Figure 9.

A headphone or earphone embodying the present invention will now be described with reference to Figures 3 to 7. Throughout Figures 3 to 7, parts corresponding to like parts in Figures 1 and 2 are designated by the same references and will not be described again in detail.

15 In this embodiment of the invention, as shown in Figures 3 and 4, a pair of housings 1a and 1b (each of which is substantially the same as the housing 1 in Figure 1) are attached by respective housing holders 8a and 8b to end portions of hangers 7a and 7b which are positioned at respective ends of a horseshoe-shape headband 6 and which hold the headband 6 therein. The housings 1a and 1b are attached to the respective hangers 7a and 7b in such a fashion that, when the headband 6 is stretched over a user's head, the diaphragm 2a of the speaker unit 2 is oriented in the same plane as that of the user's face or is parallel to the plane including the headband 6 and the hangers 7a and 7b. As shown in Figures 5 and 6, the housing holders 8a and 8b couple the housings 1a and 1b to the hangers 7a and 7b, respectively, through universal joints so that they are rotatable.

25 The housing holders 8a and 8b will now be described in more detail with reference to Figures 5 and 6. Figures 5 and 6 show a stopper ball of a spherical shape fixed through a plate-shaped connector 10 to the hanger 7a or 7b. The stopper ball 9 is engaged with spherical concave portions formed within the housing holder 8a or 8b so that the housing 8a or 8b is rotatable relative to the stopper ball 9. A joint cover 11 is disposed between the hanger 7a or 7b and the housing holder 8a or 8b to cover the connector 10. The joint cover 11 is resiliently deformed in accordance with rotation of the housing holder 8a or 8b. A so-called acoustic pipe or sound duct 12 serves to communicate the rear side of the speaker unit 2 with the outside or exterior

30

35

over a predetermined length. If the predetermined length of the sound duct 12 is suitably selected, the bass resonance frequency can be made lower than that of the speaker unit 2 itself.

5 Figures 3 and 4 show a plug 13 connected to a cord 5. The speaker unit 2 may otherwise be constructed to be the same as the previously proposed headphone shown in Figures 1 and 2.

10 In use, the headphone described with reference to Figures 3 to 6 is positioned as shown in Figure 7. The headband 6 is stretched over a user's head H and the housings 1a and 1b are inserted into the user's left and right auricles A, respectively, in such a fashion that the diaphragm 2a of each speaker unit 2 is opposed to the entrance of the external auditory meatus B of the associated ear, substantially half of each of the housings 1a and 1b being inserted into the cavum concha C of the associated ear so that the diaphragm 2a is opposed to or faces the tragus D. Thus, regardless of the size of the cavum concha C, tragus D, anti-tragus E and the like of the auricle A, most users can use this headphone satisfactorily. The diaphragm 2a of the speaker unit 2 is opposed through the external auditory meatus B to the tympanum G, so that most of the sound emanating from the diaphragm 2a is transmitted directly to the tympanum G and relatively little sound is reflected from the external auditory meatus B around the entrance thereof. As a result, the sound emanating from the diaphragm 2a of the speaker unit 2 is not influenced so much by the shape of the external auditory meatus B and the shape of the entrance of the external auditory meatus B, which are both peculiar to each user, thus providing excellent and consistent tone quality.

25 As set forth above, the headphone of Figures 3 to 6 comprises a supporting means or member, formed of the headband 6, the hangers 7a, 7b and the like, for the speaker unit 2. This supporting means or member enables the diaphragm 2a of the speaker unit 2 to be opposed to the entrance of the external auditory meatus B. Thus, substantially half of each of the housings 1a and 1b is inserted into the cavum concha C so that the diaphragm 2a of the speaker unit 2 is opposed to the tragus D. Therefore, regardless of different sizes of the cavum concha C, tragus D, anti-tragus E and the like of the auricle A, the headphone can satisfactorily be fitted to almost all users. Moreover, since the diaphragm 2a of the speaker unit 2 is opposed through the external auditory meatus B to the tympanum G, most of

the sound emanating from the diaphragm 2a of the speaker unit 2 is transmitted directly to the tympanum G and relatively little sound is reflected from the external auditory meatus B and from the entrance of the external auditory meatus B. Accordingly, without being influenced by different shapes of the external auditory meatus B and of the entrance of the external auditory meatus B, it is possible to produce excellent sound quality.

In Figure 8, a solid line indicates the frequency response characteristic (dB/Hz) of the headphone of Figures 3 to 6, while a chain-dotted line indicates the frequency characteristic of the headphone of Figures 1 and 2. As will be clear from the graph of Figure 8, the headphone of Figures 3 to 6 can produce sound of high quality which, as compared to that produced by the headphone of Figures 1 and 2, is less concave and convex (fluctuates less) over a wide frequency range, is expanded in the high frequency range and is more balanced.

Figures 9 and 10 show another headphone embodying the present invention. In Figures 9 and 10, parts corresponding to like parts of Figures 3 to 7 are designated by the same references and will not be described again in detail.

According to this embodiment, as shown in Figure 9, semi-circular shield plates 14a and 14b are attached to the insides of the protector members 3a and 3b. The shield plates 14a and 14b are used to lower the sound transmission coefficient of the sound emanating from the diaphragms 2a of the speaker units 2. As shown in Figure 10, the shield plate 14a on the side corresponding to the left ear is arranged to shield the left-hand half of the diaphragm 2a of the speaker unit 2, while (though not shown in Figure 10) the shield plate 14b on the side corresponding to the right ear is arranged to shield the right-hand half of the diaphragm 2a of the speaker unit 2. The other elements are formed to be same as those of the first embodiment shown in Figures 3 to 7.

If the headphone shown in Figures 9 and 10 is used such that the diaphragm 2a of the speaker unit 2 is opposed to the entrance of the external auditory meatus B as shown in Figure 7, viewed from the front of the user's face, substantially the inside half of each of the protector members 3a and 3b is covered by the tragus D and the like as shown in Figure 9, while the remaining substantially half portion, namely the portion



shielded by the shield plate 14a or 14b, is exposed. The sound emanating from the diaphragm 2a of the speaker unit 2 is radiated from the portion thereof which is not shielded by the shield plate 14a or 14b, so that only a little leakage of the sound takes place and the efficiency of sound transmission is thus made excellent. A high frequency component of the sound with strong directivity emanating from the portion of the diaphragm 2a opposed to the shield plate 14a or 14b is shielded by the shield plate while a low frequency component of weak directivity is diffracted from the shield plate 14a or 14b and then is transmitted through the external auditory meatus B to the tympanum G. Thus, even in a speaker unit with a relatively small aperture whose low frequency component is apt to be insufficient, the low frequency component can be increased in auditory sense and excellent tone quality can be obtained.

In Figure 11, a solid line indicates the frequency characteristic of the headphone according to the second embodiment of the present invention (Figures 9 and 10), while a chain-dotted line indicates the frequency characteristic of the headphone according to the first embodiment of the present invention (Figures 3 to 7). As will be clear from the graph of Figure 11, according to the headphone of Figures 9 and 10 the low frequency component which is apt to be lost in the speaker unit 2 with a small aperture can be increased and excellent tone quality can be produced. This second embodiment can achieve the same action and effect as those in the above first embodiment.

The invention can of course be embodied in other ways than those described above. For example, while in the above embodiments of the invention a supporting member formed of the headband 6, the hangers 7a, 7b and the like is used as a supporting member to support the speaker unit 2, the same action and effect can be achieved if the headphone 2 is supported between the head H and the base of the auricle A. Further, it is to be noted that a headphone embodying the invention may comprise only one speaker unit (for one ear).

Since the above-described embodiments of the present invention comprise a supporting member that holds or supports the speaker such that the diaphragm of the speaker unit is opposed to or faces the entrance of the external auditory meatus, most of the sound emanating from the diaphragm of the speaker unit is transmitted directly to the tympanum. As a result,

21

without being affected by the external auditory meatus and by the entrance of the external auditory meatus, whose shapes are different as between different users, the headphone can produce sound with excellent tone quality and can satisfactorily be used without being influenced by different sizes of auricle.

CLAIMS

1. A headphone comprising:
a first housing member including a speaker unit with a diaphragm for radiating audible sound, and a front protective member for passing forward the radiated audible sound; and
a supporting member for supporting said housing member;
said housing member being sized to provide at least a portion thereof to extend transversely into the cavum concha of a listener's ear, said front protective member of said housing member being larger in area than the entrance of the auditory meatus of the listener's ear, and said supporting member in use supporting said housing member so that said front protective member faces towards the front of the listener's ear inside said cavum concha.
2. A headphone according to claim 1 further including a second housing member including a further speaker unit with a diaphragm for radiating audible sound, and a front member for passing forward the radiated audible sound, and being connected to said first housing member through said supporting member for association with the listener's other ear.
3. A headphone according to claim 2 wherein each of said housing members is connected to said supporting member by a respective flexible joint.
4. A headphone according to claim 2 or claim 3 wherein each of said housing members is connected to said supporting member with the sound radiating direction of said diaphragm transverse to the plane defined by said supporting member.
5. A headphone according to claim 4 wherein the plane defined by said diaphragm and the plane defined by said supporting member are substantially parallel to one another.



6. A headphone according to claim 1 wherein said housing member has a sound duct for passing the backward sound radiation of said diaphragm to the outside of said housing at the other side of said housing from said diaphragm.
- 5 7. A headphone according to claim 1 wherein said housing member has a partial shield plate between said front protective member and said diaphragm for preventing sound radiated from said diaphragm from passing from the portion of said front protective member which extends outwardly beyond the ear.
- 10 8. A headphone substantially as herein described with reference to Figures 3 to 7 of the accompanying drawings.
9. A headphone substantially as herein described with reference to Figures 9 and 10 of the accompanying drawings.
-

