

EARPHONE

The present invention relates generally to an earphone, and more particularly, to an earphone for use with audio reproduction devices.

5 Various types of earphones have been used in conjunction with audio reproduction apparatus in the past. The earphones are worn in the human ear to allow private sound reproduction.

Prior to explaining the structure and operation of the earphones, the structure of the human ear will be
10 briefly described with reference to FIGURES 1(a) and 1(b). FIGURES 1(a) and 1(b) are front view and section of the leftside human ear. The rightside human ear is not shown, but has the similar structure symmetrical to the drawings. As shown in FIGURES 1(a) and 1(b), the human ear includes
15 the auricle 10, the external ear 12 and the internal ear (not shown). The auricle 10 includes the tragus 14 and the antitragus 16 on both sides of the lower portion of the auricle 10. The tragus 14 and the antitragus 16 define the fossa 18 between them. The external ear 12 includes the
20 concha cavity 20 and the external auditory meatus 22. An outer end of the concha cavity 20 is defined by the tragus 14 and the antitragus 16 and is connected to the fossa 18. An inner end of the concha cavity 20 is connected to the external auditory meatus 22. However, the external auditory meatus 22 is offset in the concha cavity 20 to the position
25 near the tragus 14. The external auditory meatus 22 is terminated at the eardrum (not shown).

Referring now to FIGURES 2, 3 and 4, some typical

examples of prior known earphones will be described.

FIGURE 2 shows a first example of a prior known earphone. As shown in FIGURE 2(a), the earphone has a housing 30 for housing therein an audio transducer (not shown). The housing 30 may be shaped similarly to a marble.

5 The marble-shape housing 30 has a size to be retained in the concha cavity 20 of the human ear, as shown in FIGURE 2(b).

The housing 30 is comprised of a front housing 32 for radiating sounds of the audio transducer and a rear housing 34. A hollow rod portion 36 is elongated from the rear housing 34. A signal cord 38 is connected to the audio transducer through the hollow rod portion 36. The hollow rod portion, i.e., the elongated portion 36 is positioned in the fossa 18 between the tragus 14 and the antitragus 16, when the earphone is worn in the ear. Then, the front housing 32 faces the external auditory meatus 22 of the ear.

15 The first conventional earphone of FIGURE 1, however, has a drawback. That is, it is difficult to stably maintain the housing 30 in an accurate direction toward the external auditory meatus 22. This is because the external auditory meatus 22 is offset in the concha cavity 20, as described above. Further, the housing 30 easily fluctuates in the concha cavity 20. As a result, the sound level reproduced by the earphone and applied to the ear through the external auditory meatus 22 is reduced or the sound level easily fluctuates.

25 Furthermore, as the housing 30 does not fit in the concha cavity 20, a relatively large gap arises between the housing 30 and the concha cavity 20. The gap reduces a

matching of the acoustic impedances between the earphone and the concha cavity 20 so that the frequency characteristic of the reproduced sound, particularly the characteristic in the low frequency range, is deteriorated.

5 FIGURE 3 shows a second example of a prior known earphone. As shown in FIGURE 3(a), the earphone has a housing 30 for housing therein an audio transducer (not shown). The housing 30 is shaped for example like a thick disc. The disc-shape housing 30 has a size a little larger than the concha cavity 20 of the human ear. Then, the housing 30 is worn in the ear by being engaged with the
10 outside of the tragus 14 and the inside of the antitragus 16, as shown in FIGURE 3(b).

 The housing 30 is comprised of a front housing 32 for radiating sounds of the audio transducer and a rear housing 34. A signal cord 38 is connected to the audio transducer
15 through the rear housing 34. Further, the earphone has a tubular sound guide member 40. The tubular sound guide member 40 protrudes from the front housing 32 at the right axis of the housing 30. The tubular sound guide member 40 of the earphone is pushed into the external auditory meatus
20 22 of the ear so that the earphone is suspended on the ear by being engaged to the antitragus 16 and the external auditory meatus 22. In order to stably fit the earphone to the ear, the tubular sound guide member 40 has a relatively long length.

 The second known earphone illustrated in FIGURE
25 3 also has a drawback. That is, a user feels an unpleasant pressure sensation or a pain. This is because the earphone is worn in the ear with a relatively strong

pressure fit. Particularly the housing 30 is strongly pressed against the tragus 14 and the antitragus 16 for positioning the tubular sound guide member 40 in the external auditory meatus 22 which is offset in the concha cavity 20.

5 FIGURE 4 shows a third example of a prior known earphone. As shown in FIGURE 4(a), the earphone has a housing 30 for housing therein an audio transducer (not shown). The housing 30 is shaped to, e.g., like a thick disc. The disc-shape housing 30 has a size to be retained
10 in the concha cavity 20 of the human ear, as shown in FIGURE 4(b).

 The third known earphone also has a housing 30, an audio transducer (not shown) mounted in the housing and a signal cord 38 connected to the audio transducer without passing through an elongated portion, as shown in
15 FIGURE 4(a). The housing 30 is shaped as a thick disc, similar to the second earphone described above. However, the housing 30 has a size smaller than that of the second earphone so that the housing 30 entirely fits in the concha cavity 20 of the ear. Further, the earphone has a small tubular sound guide member 40. The small tubular sound guide member 40 is
20 mounted to the front housing 30 at a position offset from the axis of the housing 30. Further the small tubular sound guide member 40 protrudes from the housing 30 at a slant direction to the axis of the housing 30.

 The housing 30 fits in the concha cavity 20 of the ear
25 so that the small tubular sound guide member 40 is loosely fitted into the external auditory meatus 22, as shown in FIGURE 4(b). On the other hand, the signal cord 11 is

positioned above the tragus 14, as shown in FIGURE 4(c).

5 The third known earphone of FIGURE 4, however, has a drawback. That is, it is difficult stably to wear the earphone in the ear. When an external force is applied to the earphone, the earphone can no longer be retained at a suitable position in the ear. Otherwise, the earphone falls from the ear. When the earphone is designed so as to fit stably in the ear, the housing 30 and the tubular sound guide member 40 must have a relatively large size. This, however, causes the same drawback as the earphone of FIGURE 2. Thus, a user feels an unpleasant pressure sensation or a pain.

10 In addition, all the conventional earphones are not proper in shape for using in a stereo earphone set. That is, a user finds it difficult in selecting the difference between the right and left earphones.

15 The present invention therefore seeks to provide an earphone which is retained stably in the concha cavity of the human ear.

The present invention also seeks to provide an earphone which gives a good matching of acoustic impedances between the earphone and the concha cavity of the human ear.

20 The present invention also seeks to provide an earphone set suitable for use with stereo reproduction equipment.

25 An earphone according to one aspect of the present invention includes a housing, shaped to be retained in the concha cavity of the human ear, having an elongated portion shaped to fit between the tragus and antitragus of the ear, an audio transducer contained within the housing, a device

for providing an electric signal to the audio transducer and a hollow tubular guide member attached to the housing such that when the elongated portion of the housing is inserted between the tragus and the antitragus of the human ear, the hollow tubular guide member extends into the external
5 auditory meatus of the ear.

Additional objects and advantages of the present invention will be apparent to persons skilled in the art from a study of the following description and the accompanying drawings, which are hereby incorporated in and constitute a part of this specification.

10 A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

15 FIGURES 1(a) and 1(b) are front view and section of the human ear;

FIGURES 2(a) and 2(b) are explanatory drawings showing a first known earphone;

FIGURES 3(a) and 3(b) are explanatory drawings showing a second known earphone;

20 FIGURES 4(a), 4(b) and 4(c) are explanatory drawings showing a third known earphone;

FIGURES 5(a) through FIGURE 5(d) are a front view, a side view, a section and a top view respectively of one embodiment of the present invention;

25 FIGURES 6(a) and 6(b) are drawings showing examples of use of the earphone of Figures 5(a) to 5(d);

FIGURE 7 is an electrical equivalent circuit

representing the acoustic system including the earphone and the ear;

FIGURE 8 is a graph showing the frequency characteristics of the acoustic system; and

5 FIGURE 9 is a front view showing an embodiment of the earphone according to the present invention for use in the right ear.

The present invention will be described in detail with reference to the FIGURES 5 through 9. Throughout the drawings, reference numerals or letters used in FIGURES 1, 2, 3 and 4 will be used to designate like or equivalent elements for simplicity of explanation.

10 Referring now to FIGURE 5, a first embodiment of the earphone according to the present invention will be described in detail. FIGURE 5(a) shows a front view of the earphone for the left ear. FIGURE 5(b) shows a side view of the earphone. FIGURE 5(c) shows a section of the earphone. FIGURE 5(d) shows a top view of the earphone.

15 As shown in FIGURES 5(a) through 5(d), the embodiment of the earphone has a housing 30 for housing therein an audio transducer 42. The housing 30 is shaped, e.g., like a button. The button-shaped housing 30 has a size to be retained in the concha cavity 20 of the human ear, as shown in FIGURES 6(a) and 6(b), which show the earphone in use.

20 The housing 30 is comprised of a front housing 32 and a rear housing 34. A hollow rod portion 36 is elongated from the rear housing 34. The hollow rod portion, i.e., the elongated portion 36 is connected to the rear housing 34 through a crank section 44. Therefore, the axis of the elongated portion 36 is offset from the housing 30 by a predetermined distance X, as shown in FIGURE 5(b). The

elongated portion 36 is positioned in the fossa 18 between the tragus 14 and the antitragus 16, when the housing 30 is retained in concha cavity 20. A signal cord 38 is connected to the audio transducer 42 through the elongated portion 36.

5 Further, the earphone has a small tubular sound guide member 40. The tubular sound guide member 40 protrudes from the front housing 32, at a position offset to the right from the vertical center line Y passing through the elongated portion 36 of the housing 30, as shown in FIGURE 5(a). The
10 rightward offset position is such that the tubular sound guide member 40 just opposes the external auditory meatus 22 of the left ear. This is because the external auditory meatus 22 of the left ear is offset to the left of center in the concha cavity 20. Thus, the tubular sound guide member
15 40 may be smoothly inserted into the external auditory meatus 22 of the left ear, when the housing 30 is retained in the concha cavity 20.

FIGURE 5(c) shows a cross-sectional view of the earphone. As shown in the drawing, the audio transducer 42
20 is directed to the tubular sound guide member 40. This construction provides a good transmission of the sound reproduced by the the audio transducer 42 to the external auditory meatus 22 of the ear.

According to the embodiment of the earphone according
25 to the present invention, the position of the earphone is stabilized by placing the elongated portion 36 in the fossa 18 between the tragus 14 and the antitragus 16 when the earphone is inserted into the ear, as shown in FIGURE 6(b). Then, the housing 30 and the tubular sound guide member 40 are comfortably seated in the concha cavity 20 and the

external auditory meatus 22, respectively, as shown in
FIGURE 6(b).

Since the housing 30 and the tubular sound guide member
40 are well seated in their places, their sizes are set to
5 the sizes of the concha cavity 20 and the external auditory
meatus 22, respectively, for less discomfort to the wearer.

FIGURE 7 shows an electrical equivalent circuit
presenting the acoustic system including the earphone and
the ear, as shown in FIGURE 6(c).

10 In the equivalent circuit of FIGURE 7, an inductance
 M_d , a capacitance C_d and a resistance R_d correspond to the
mass, the compliance and the mechanical resistance of a
diaphragm (not shown) of the audio transducer 42. A voltage
source V_s corresponds to the signal voltage supplied to the
15 audio transducer 42. A block Z_{ear} is the acoustic impedance
of the ear viewed from the audio transducer 42. The
acoustic impedance Z_{ear} comprises an inductance M_{ear} and a
resistance R_{ear} corresponding respectively to the inertance
and the acoustic resistance of the space left between the
20 earphone and the ear. Further, a capacitance C_{ear} is the
acoustic capacitance in the ear viewed from the audio
transducer 42. Resistances R_1 and R_2 are the acoustic
resistances of the housing 30 and the tubular sound guide
member 40. A capacitance C_1 is the acoustic capacitance of
25 the space in the housing 30.

According to the disclosed embodiment, the acoustic
impedance of the external auditory meatus 22 viewed from the
audio transducer 42 increases when compared with

known earphones. This makes the voltage E across the
the resistance R_2 in the equivalent circuit of FIGURE 7

become high. This is because the space between the housing 30 and the concha cavity 20 is reduced so that leakage of the sound outside the ear is reduced.

FIGURE 8 shows a graph of frequency characteristics of the acoustic system. In the graph, each graph line shows a sound level responsive to the frequency of the sound radiated from the earphone, in tests carried out for test samples of earphones according to the present invention and the conventional earphones. The graph line rises as the space left between the earphone and the concha cavity is reduced. The samples of the present invention produced the upper three graph lines, while the samples of the known earphones produced the lower three graph lines.

As shown by the test, an earphone according to the present invention has good sound level characteristics in comparison with known earphones. Particularly, the improved earphone is superior to the prior art earphones in the low frequency range.

The above explanation is made for an earphone designed for use in the left ear. However, the present invention can be applied to the earphone for use to the right ear in a similar manner, as shown in FIGURE 9. FIGURE 9 shows the front view of the earphone for the right ear. The tubular sound guide member 40 of the earphone for the left ear is provided at a position offset rightward in the drawing from the vertical center line Y passing through the elongated portion 36 of the housing 30 (see FIGURE 5(a)). On the other hand, the tubular sound guide member 40 of the earphone for the right ear is provided at a position

offset leftwards in the drawing from the vertical center line Y passing through the elongated portion 36 of the housing 30 (see FIGURE 9). Thus, the leftward offset position just opposes the external auditory meatus 22 of the right ear.

5 In other words, the tubular sound guide members 40 are symmetrically provided by offsetting rightward and leftward from the vertical center line Y passing through the elongated portion 36 of the housing 30 for the leftside and the rightside ears.

10 The present invention is also useful for a stereo earphone set. For example, if the user puts the earphone for use in the left ear into the right ear, the earphone does not comfortably match to the ear. Therefore, the user can easily find that the wrong earphone has been inserted
15 into the ear.

While there have been illustrated and described what are at present considered to be preferred embodiments of the present invention, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof
20 without departing from the true scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the present invention without departing from the central
25 scope thereof. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out the present invention, but that the present invention includes all embodiments falling within the scope of the appended claims.

CLAIMS

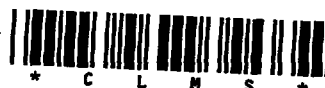
1. An earphone for use with audio reproduction devices comprising a housing shaped to be retained in the concha cavity of the human ear and having an elongated portion shaped to fit between the tragus and antitragus of the ear, an audio transducer contained within the housing, means for providing an electric signal to the audio transducer and a hollow tubular guide member attached to the housing, the hollow tubular guide member being located on the housing such that the hollow tubular guide member extends into the external auditory meatus of the ear when the elongated portion of the housing is inserted between the tragus and the antitragus of the ear.

2. An earphone according to claim 1, wherein the audio transducer is positioned opposite the hollow tubular guide member.

3. An earphone according to claim 1 or 2, wherein the hollow tubular guide member is offset from the vertical center line (Y) passing through the elongated portion of the housing.

4. An earphone set for use with audio reproduction devices comprising first and second earphones according to any one of claims 1 to 3 the earphones being shaped to fit left and right ears respectively.

5. An earphone for use with audio reproduction devices comprising a housing shaped to be retained in the concha cavity of the human ear and having an elongated portion shaped to fit between the tragus and antitragus of the ear, an audio transducer contained within the housing, means for providing an electric signal to the audio transducer and a hollow tubular guide member attached to the housing, the hollow tubular guide member being located on the housing in a position offset from the vertical center line (Y)



passing through the elongated portion of the housing.

6. An earphone according to claim 5, wherein the audio transducer is positioned opposite the hollow tubular guide member.

5 7. An earphone set for use with audio reproduction devices comprising first and second earphones according to claim 5 or 6, the earphones being shaped to fit left and right ears respectively.

10 8. An earphone substantially as hereinbefore described with reference to Figures 5 to 8 and/or 9 of the accompanying drawings.

