Fig. 1

Fig. 2

Fig. 3

Fig. 4

INVENTOR.

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This invention relates to wearable hearing aids, and more particularly to the cases in which the microphones are mounted.

One of the objections that hard-of-hearing people have to using a hearing aid is the undesirable noise it produces in the ear along with the sounds they want to hear. The two most annoying sources of noise are frictional noises caused by clothing rubbing against the case, especially near the grille in front of the microphone, and air borne noises in the vicinity of the user of the hearing aid. The air borne noises come from all around the user, from his sides as well as from the direction of the sounds to which he desires to listen.

It is among the objects of this invention to provide a hearing aid which greatly reduces the annoyance from both types of noises mentioned above, which makes a hearing aid easier and more pleasant to use, which permits the hearing aid case to be worn in a pocket without closing the openings to the microphone, which makes the microphone directional so that the user may be able to determinate the directions from which familiar sounds come, and which provides all of these features in a simple and inexpensive manner.

In accordance with this invention the hearing aid case, which contains the microphone and generally the amplifying system, is provided with a pair of sound entrance openings that lie in substantially parallel vertically disposed planes separated by a solid front wall. These openings face in opposite directions and are spaced apart a mean distance equal to a half wavelength of sound having a frequency near the upper end of the frequency range amplified, or desired to be amplified, by the hearing aid. By spacing the openings apart in this manner, high frequency sounds or noises coming from either side of the case enter the opposite openings as sound waves that are out of phase and that thereby cancel each other to a substantial degree which attenuates the high frequency sounds. The low frequency sounds are not affected, and neither are the sounds coming from directly in front of the case. The solid front wall of the case avoids grille openings across the edges of which clothing may rub, and the side openings are so positioned that they will not be closed by the clothing.

The preferred embodiment of the invention is illustrated in the accompanying drawings in which Fig. 1 is a front view of the hearing aid case; Fig. 2 is a side view; Fig. 3 is a plan view; and Fig. 4 is an enlarged horizontal section taken on the line IV-IV of Fig. 1.

Referring to the drawings, the hearing aid shown is the type in which the battery pack (not shown) is separate and is connected by an electric cord 1 to the hearing aid case 2, which is the case that contains the microphone 3 and the amplifying unit 4 behind and below it. However, this invention is just as applicable to a longer case provided with a compartment containing the batteries. The case has a recessed back section 5 by which the amplifying unit is supported, and a removable deep cover 6 that contains the microphone and conceals the amplifier. The microphone is spaced from the front wall of the case, and is electrically connected to the amplifying unit in the usual way. An electric cord 8 extends from the amplifier through the side of the case and is connected to a receiver 9, such as an air receiver that is worn in the ear, or a bone conduction receiver. The amount of amplification desired is controlled by the volume control wheel 11 projecting through the top of the case. Mounted on the back of the case is a spring clip 12 for attaching the clip to the clothing, but, if desired, the case may simply be inserted in a pocket. The hearing aid disclosed thus far is more or less conventional and includes, in addition to the elements shown in detail, the usual transformers, vacuum tubes, condensers, and other elements which make up the amplifier and corrective network in such a hearing aid.

The front or cover of the case, however, is not conventional, but has been altered to improve it over those known heretofore by making the front face solid without the usual grille slots for sound. Near the top of the case the opposite sides of the front wall are offset rearwardly relative to the central portion 15 of that wall between them, and vertically extending sound admission slots 16 are formed between the offset sides and central portion 15. These slots lie in approximately (not necessarily exactly) parallel planes which, preferably, are substantially perpendicular to the front plane of the case. The slots are covered by suitable screens 14 that keep out dust and other foreign matter, but that do not interfere with acoustic transmission through the slots. Inside the cover, between the slots, there is a resonance cavity 17 (Fig. 4) into which the microphone projects. The back of the cavity is sealed by the microphone and a thin, flexible, rubber sealing gasket 18 that supports the microphone from the inner surface of cover 1 to which it is cemented all around the cavity. This resilient...
mounting of the microphone greatly reduces vibration that otherwise would be transmitted directly from the case to the microphone. The new location of the slots prevents them from being covered by clothing, and thereby eliminates the noises that used to occur due to clothing rubbing across and closing grille slots in the front face of the case. As the solid front wall of the case presents a smooth surface to the clothing, and as all exposed corners and edges of the case are rounded and curved, friction between the clothing and case is negligible. When the case is carried in a pocket, the material of the pocket does not scrape across or close the side slots because the slots are set back in the offsets and face laterally. The pocket, being open at the top and down beside the side slots, allows sound to enter the slots freely. Therefore, one of the principal sources of annoying noises in a hearing aid is reduced to a minimum by my improved case.

The reduction or substantial elimination of high frequency noises coming from the sides of the hearing aid is accomplished by spacing apart the sound admission slots a mean distance D (Fig. 1) equal to a half wavelength of sound of a frequency not, even slightly above, the upper limit of the frequency range desired to be amplified, which usually is the same as the range amplified by the hearing aid. The attenuation of high frequencies from the side occurs because of the phase difference in the sound pressures reaching slots 16. For sound directly in front of the case there is no phase difference, but if it comes from the side the length of its paths to the two slots is different. If this difference is equal to half of the wavelength of the sound in question, the phase of the sound waves at the two slots will be opposite for the frequency of that sound and thereby the out-of-phase sound waves will cancel each other to a material extent.

As high frequency noises are the most objectional, the distance between the sound entrance slots is made equal to a half wavelength of a high frequency sound. With such a situation, the attenuating effect will diminish the farther down the frequency scale one goes, because the sound waves will be less and less out of phase and the wavelengths become longer. It is undesirable to have much attenuation in the lower frequencies, so the frequency of which a half wavelength is taken for determining the distance between slots 16 should be high enough that the attenuating effect will be negligible for the lower frequencies. Therefore, desirable spacing for the slots should be derived from a frequency in the upper portion of the frequency range amplified by the hearing aid, or even somewhat above the upper limit of the frequency range it is desired to amplify, so that the lower speech frequencies will not be affected. The amount of attenuation in the middle and high frequency portions of the frequency range can be controlled by the choice of the cancellation frequency. A mean distance of one and one-half inches between the sound entrance slots corresponds to a half wavelength of 4,500 cycles, which is a frequency in the upper portion of the frequency range desired to be amplified. This spacing fits in particularly well with the usual frequency range and microphone size of a hearing aid. However, the spacing can be based on other frequencies, such as any frequency above about 2,000 cycles, but preferably below 6,000 cycles.

In general, most of the important hearing done by a hard-of-hearing person is in the 90° horizontal angle directly in front of him. In this region my improved case has substantially no effect as far as air born noises are concerned, but this is desirable because there may be many high frequency sounds that he wants to hear. At the sides, however, the high frequencies are greatly attenuated and thus undesirable noises are reduced materially. As this attenuation occurs on both sides of the case, it serves to lower the total ambient noises heard by the user to a very marked extent. A hearing aid so constructed gives the wearer a feeling of "quiet" performance as compared to the usual hearing aid. However, the user's ability to pick up speech sounds at any angle around him is not impaired greatly because, as explained above, attenuation is not great at the lower speech frequencies.

After a person becomes used to this hearing aid he will be able to determine the directions from which familiar sounds come. This is because he will learn that the frequency response of the hearing aid is different for sounds coming from the sides of the instrument as compared to those approaching from the front. In other words, the high frequencies will be suppressed in the sounds coming from the sides, and therefore the general tone of those sounds will be lower than the same sounds coming from the front.

A hearing aid constructed in accordance with this invention not only is more comfortable and pleasant to use than those known heretofore, but also it has the advantage of being "directional."

This application is a continuation of my co-pending patent application for wearable hearing aid, Serial Number 750,480 filed May 28, 1947.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a pair of sound entrance openings leading into said cavity and lying in substantially parallel vertically disposed planes and separated by a solid front wall of the upright case, said sound entrance openings facing in opposite directions and spaced apart a distance equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be transmitted.

2. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a front wall provided with a forwardly offset solid central portion having between its upright side edges and the rearwardly disposed portions of said wall laterally facing vertically disposed sound entrance openings leading into said cavity, the width of said offset portion of the wall being equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be transmitted.

3. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a front wall provided with a forwardly offset solid central portion having between its upright side edges and the rearwardly disposed portions of said wall laterally facing vertically disposed sound en-
trance slots leading into said cavity and lying in substantially parallel planes, said offset portion of the wall having a smooth front surface with transversely rounded side edges connecting it to said slots, the width of said offset portion being equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be transmitted.

4. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a pair of sound entrance openings leading into said cavity and lying in substantially parallel vertically disposed planes and separated by a solid front wall of the upright case, said sound entrance openings facing in opposite directions and spaced apart a distance equal to a half wavelength of sound having a frequency between 1,000 and 6,000 cycles.

5. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a pair of sound entrance openings leading into said cavity and lying in substantially parallel vertically disposed planes and separated by a solid front wall of the upright case, said sound entrance openings facing in opposite directions and spaced apart a distance equal to a half wavelength of sound having a frequency of about 4,500 cycles.

6. A normally upright hearing aid case provided with a cavity having a rear opening adapted to receive a microphone, said case having a pair of sound entrance openings leading into said cavity and lying in substantially parallel vertically disposed planes and separated by a solid front wall of the upright case, said sound entrance openings facing in opposite directions and spaced apart approximately one and one-half inches.

7. A normally upright hearing aid case comprising a back section and a front section, the inside of the upright front section being provided with a forwardly extending resonant cavity having a solid front wall and sound admission openings in only its side walls, a microphone disposed at the back of said cavity, and a flexible gasket supporting the microphone and sealing the back of the cavity, said openings being spaced apart a distance equal to a half wavelength of sound having frequency near the upper end of the frequency range desired to be transmitted.

8. In a wearable hearing aid, a case adapted to be worn in upright position by a hard-of-hearing person, the front of the upright case being solid except for laterally facing sound admission openings lying in substantially parallel vertically disposed planes spaced apart a distance equal to a half wavelength of sound having a frequency near the upper end of the frequency range transmitted by the hearing aid, and a microphone mounted in the front section of the case behind and between said openings.

9. A hearing aid case designed to be worn in upright position and provided with a cavity having a rear opening adapted to receive a microphone, said upright case having sound entrance openings leading only into opposite sides of said cavity and separated by a solid front wall having a smooth front surface and rounded corners and edges, said sound entrance openings lying in substantially parallel vertically disposed planes when the case is in said upright wearing position, and said openings facing in opposite directions and being spaced apart a distance equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be transmitted.

10. A hearing aid case designed to be worn in upright position and provided with a cavity having a rear opening adapted to receive a microphone, said case having sound admission slots leading only into opposite sides of said cavity and extending vertically in substantially parallel planes when the case is in said upright wearing position, said slots facing away from each other with a solid front wall connecting their outer edges, the width of said wall being equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be transmitted.

11. A hearing aid case designed to be worn in upright position and provided with a cavity having a rear opening adapted to receive a microphone, said case having sound entrance openings leading only into opposite sides of said cavity and separated by a solid front wall, said sound entrance openings lying in substantially parallel vertically disposed planes when the case is in said upright wearing position, and said openings facing in opposite directions and spaced apart a distance equal to a half wavelength of sound having a frequency near the upper end of the frequency range desired to be amplified but below 6,000 cycles.

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