This invention relates to hearing aids and more particularly to hearing aids which are enclosed in very small cases suitable for being contained in an earpiece of a pair of eyeglasses.

In a hearing aid of such small size, the microphone is sometimes housed in an acoustic resonance chamber. Such a chamber is a closed, acoustically sealed, chamber in which the microphone is resiliently mounted. An opening in one of the chamber walls communicates directly with the microphone to provide a path for sound to reach the microphone directly.

It is a known fact that the hearing loss of hard of hearing people is not uniform over the entire audio frequency range, but is pronounced in certain loss regions. For instance, some hard of hearing people experience a high frequency loss, while others experience a low frequency loss, and still others experience a pronounced loss of sensitivity for intermediate frequencies. In the past, electronic means have been devised which aim to match the acoustic performance of hearing aids to such individual conditions, but these electronic means are complicated and costly, and not especially effective in their acoustic end result.

Accordingly, it is an object of the present invention to provide means for selectively changing the frequency response characteristic of a hearing aid by entirely mechanical means.

Other objects and advantages of the present invention will be apparent upon reference to the accompanying drawings, in which:

FIG. 1 is a view, partly in section, of a hearing aid instrument in place in one-half of its cover;

FIG. 2 is a graph showing four response characteristics, one of which may be selected by the operation of the present invention;

FIG. 3 is a sectional view of a portion of the structure shown in FIG. 1, without the microphone, taken at section 3-3; and

FIG. 4 is an illustration of a “tree” bearing a number of closure plugs which may be used in the operation of the present invention.

The present invention provides a resonance chamber having a pair of openings, each of which openings may be selectively plugged, or left open to communicate with the atmosphere, to provide four different frequency response characteristics for the microphone-chamber combination. One response characteristic is provided for each of the four possible conditions in which one, or both, or none of the openings is plugged. One of the openings is in the form of a tube which may be closed at different positions along its length to provide a further variation in the frequency response characteristic of the microphone-chamber combination.

In FIG. 1, there is shown a casing section 10 in which the hearing aid instrument is disposed. The casing section 10 cooperates with a similar casing section (not shown) to surround the instrument and protect it from dust and other foreign matter. When the two casing sections are assembled together, the closed case is in the form of, and the size of, an ear piece of a pair of eyeglasses. The casing is adapted to be connected to the remainder of such eyeglasses by means of a screw connector 12 projecting beyond the end of the casing section 10 and rigidly connected thereto.

The casing section 10 is provided with an upstanding ridge 14 set back from the outside surface of the casing section 10. The ridge 14 cooperates with a corresponding groove in another casing section (not shown) to provide an acoustic seal around a resonance chamber 16 at the lower end of the casing, and a dust seal surrounding the remainder of the instrument. The two casing sections are held together by a bolt extending through aperture 11 in casing section 10, and another bolt extending through aperture 13 in casing section 10.

Near the center of the hearing aid case, there is disposed an amplifier on a chassis shown generally as 18 having a control 20 suitable for varying the amplification of the amplifier. The amplified output of the amplifier is connected from the chassis 18 to a receiver or transducer 22, by which the electrical signals received from the chassis are transformed into sound. The sound passes out through tube 24 and through a bore in the screw 12 to an earpiece which is worn in the user's ear.

Directly below the portion of the hearing aid instrument in which the amplifier chassis 18 is located is a battery compartment 26, which is adapted to releasably hold batteries for the operation of the electronic circuitry of the chassis. Near the battery compartment is disposed a switch 28 having an operating arm 32 projecting through an aperture 34 in the casing section 10. Switch 28 is operated by depressing the operating arm 32 to turn the instrument on and off.

An interior wall 35 separates the battery compartment 26 from the resonance chamber 16. A microphone 36 is disposed in the resonance chamber 16 at the lower portion of the hearing aid instrument and is supported therein by resilient pads 38, 40 and 41. A pair of wires 42 leading from the microphone 36 pass through the interior wall 35 and communicate with the amplifier chassis 18 through an opening which is sealed against the wall, so as not to break the acoustic seal of the resonance chamber.

The resilient pads 40 and 41 are provided with centrally disposed apertures aligned with the sound entrance opening of the microphone 36 and also with an aperture 44 in the casing section 10. This aperture is the primary entrance of sound into the diaphragm or other motor device (not shown), which may be of any suitable known type, of microphone 36 and the resonance chamber 16. An opening (not shown) is provided in the wall of the microphone which connects the chamber 16 of the opposite side of the diaphragm or other motor device, from the aperture 44. Thus, the front or bottom side as oriented in FIG. 1 of the microphone diaphragm, not shown, opens through opening 44 to the atmosphere and its opposite, or top side as oriented in FIG. 1 opens through the opening, not shown, to the chamber 16.

Two other apertures are provided in the resonance chamber 16, leading to the atmosphere outside the casing section 10. The aperture 46 is located on the wall of the casing section 10 which is located away from the head of the user when the instrument is in operation, while the second aperture 48 is formed in the interior wall 35. Tightly fitting in aperture 48 is a tube 50. An acoustic seal is formed between the wall 35 and tube 50 by virtue of the fit of the tube 50 therein.

The tube 50 extends into the battery compartment 26, and then bends and extends out through a further aperture 52 in the outside wall of the casing section 10. The aperture 52 is in the same wall as is aperture 46.

The primary aperture 44 communicating directly with the sound entrance opening of the microphone is always open. However, the aperture 46 and/or the tube 50 may be plugged to provide a number of different frequency response characteristics for the instrument. Four such frequency response characteristics are shown in FIG. 2. Each of the characteristics of FIG. 2 corresponds to
a unique configuration of the aperture 46 and tube 50, according to the following table:

<table>
<thead>
<tr>
<th>Curve</th>
<th>Tube 50</th>
<th>Aperture 46</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Open</td>
<td>Closed</td>
</tr>
<tr>
<td>53</td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>55</td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>57</td>
<td>Closed</td>
<td>Closed</td>
</tr>
</tbody>
</table>

It can be seen that the response characteristic curve 51 having the greatest response for low frequencies is obtained when the aperture 46 is closed and the tube 50 is permitted to remain open. The response curve 57 having the next greatest amount of low frequency response is obtained when both the apertures 46 and the tube 50 are closed.

When both the aperture 46 and the tube 50 are permitted to remain open, the curve 55 is obtained, in which the low frequency response is at a minimum, while a medium response curve 53 is obtained when the aperture 46 remains open while the tube 50 is closed. The high frequency response is also changed somewhat, as shown.

The physical mechanism by which this particular response characteristics is obtained has to do with the change in the natural resonance frequency of the chamber 16 resulting from opening or closing either the aperture 46 or the tube 50. Since, as noted above, the chamber 16 is associated with the opposite side of the microphone diaphragm, it will affect the movement of the diaphragm in accordance with the relative phase and amplitude of sound pressures applied to the two sides of the microphone.

The tube 50 is preferably made of silver, and is about .250 inch long with an inside diameter of about .055 inch. Both the tube 50 and aperture 46 are closed by inserting a closure plug 54 into the aperture or tube, respectively, and when the tube 50 is closed, varying the position of the plug within the tube will affect the low frequency portion of the response characteristic, without significantly altering the high frequency response. This is quite satisfactory however, since the most important aspect of hearing correction for most persons, is the shape of the low frequency portion of the response characteristic.

A plurality of closure plugs 54 are shown in FIG. 4 in a "tree" which is composed entirely of molded plastic. Each of the plugs 54 has a head having a diameter such that it will fit tightly into the interior of tube 50 or aperture 46, thereby to form an acoustic seal. Each of the plugs also has a tail 56 which may be broken off from the main stem of the tree and employed to insert the head of the plug 54 as far as desirable into the tube 50.

When a suitable position within the tube 50 has been found, any excess portion of the tail 56 can be clipped off and the head of the plug 54 will remain stationary within the tube 50 by frictional contact with the inside walls of the tube 50. A number of the different combinations in the above table may be tried, with the user determining which of the combinations is the most suitable for his particular hearing loss. The plugs 54 are then inserted where required by that combination and remain in place thereafter.

Variations in the acoustical response of the chamber may be made by varying the length of tube 50 or by varying the inside diameter of the tube 50. In the latter case, of course, closure plugs having different head diameters are required if the tube is to be closed. It has been found, generally, that increasing the length of the tube tends to attenuate the intermediate frequencies while decreasing the diameter of the tube tends to attenuate the lower frequencies. Still other variations may be made by inserting an additional tube in the aperture 46.

Having thus described an exemplary embodiment of my invention, it will be apparent to those skilled in the art that certain minor variations may be made in the device disclosed without departing from the spirit of my invention, which I desire to be limited only by the appended claims.

I claim:

1. An acoustic resonance chamber for mounting a hearing aid microphone, said chamber including a casing and an interior wall, said casing and wall having a plurality of openings connecting the interior of said chamber to the atmosphere, at least one of said openings comprising a tubular member, said tubular member being mounted to have one end thereof affixed to said casing and the other end affixed to said interior wall to open into said chamber, and the portion of said tubular member between said ends being free whereby said chamber and tubular member provide a distinct frequency response which response may be conveniently varied by changing the length and the inside diameter of said tubular member.

2. An acoustic resonance chamber for mounting a hearing aid microphone, said chamber including a cup shaped casing and an interior wall, said casing having a main opening therein adjacent said microphone for communicating sound to one side of the motor element of said microphone, a plurality of other openings in said casing and said wall for communicating sound through said chamber to the opposite side of said motor element, at least one of said other openings comprising a tubular member, said tubular member being mounted to have one end affixed to said casing and to open into the atmosphere and the other end affixed to said wall and opening into said chamber, and the portion of said tubular member between said ends being free whereby said chamber and tubular member provide a distinct frequency response which response may be conveniently varied by changing the length and the inside diameter of said tubular member.

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