The disclosure is directed to an improvement in a microphone used primarily in head-worn hearing aids in which the microphone achieves a directional characteristic. The chamber and aperture in front of the diaphragm or other speech-responsive member is constructed in the normal manner while the chamber to the rear of the diaphragm or other speech-responsive member has a plurality of hollow elongated members secured within the walls of the microphone housing. The elongated members may be formed from sintered porous material such as metal, glass, or plastic, and may be arranged side-by-side or in a honeycomb arrangement. The elongated members attenuate the propagation of the sound waves, the attenuation being approximately 20 decibels lower than that reaching the other side of the diaphragm or other speech-responsive member without materially changing the inherent response characteristic of the microphone.

9 Claims, 2 Drawing Figures
FIG 1

FIG 2

INVENTOR

OTTO HASSLER

BY JOHANNES WITTKOWSKI

& Ryan ATTORNEYS
DIRECTIONAL MICROPHONE FOR HEARING AID

This application is a continuation of Ser. No. 682,346, filed Nov. 13, 1967, and now abandoned.

This invention relates to a microphone for hearing aids and, in particular, to a small and miniature microphone for use on head-worn hearing aids, such as the spectacle type or the type worn behind the ear.

Numerous attempts have been made in devising microphones for use with hearing aids in which a sense of direction is achieved which identifies the sound-emitting source. Generally such constructions are somewhat bulky and cumbersome, generally consisting of using two microphones in a back-to-back relationship. One such construction is that in a co-pending application, filed Dec. 6, 1966, Ser. No. 599,505, now U.S. Pat. No. 3,458,668 entitled "Transducer For Head Worn Hearing Aid" and assigned to the same assignee. Another variation shown in the co-pending application makes use of a pair of diaphragms for imparting movement to the sound-responsive member within the microphone.

In contrast thereto, the present invention makes use of a microphone in which a plurality of propagation-retarding acoustic elements are formed in a chamber to the rear of the diaphragm of the microphone and in a general direction facing away from the direction of observation of the hearing aid wearer. The propagation-retarding acoustic resistances are provided in elements forming a plurality of narrow passages within the chamber adjacent the diaphragm. A preferred form of the embodiment for the propagation-retarding acoustic resistance elements is achieved by arranging a plurality of capillary tubes which are generally assembled into a block, the block being situated in the chamber at the rear of the diaphragm. Another embodiment of the invention is achieved by providing a plurality of fine hairs, such as that of a rabbit, within the confines of the chamber to the rear of the diaphragm, the fine hairs creating the plurality of substantially narrow and parallel passages. To achieve an optimum directional effect with the microphone, the dimensions of the propagation wave-retarding resistances are chosen so that upon the pressure of the sound impinging upon the diaphragm from the preferred direction reaching a maximum sound level, the sound pressure acting upon the rear of the diaphragm at the same time is at a minimum level, providing a ratio of the front pressure to the back pressure with a maximum value. It has been found that in forming the propagation wave-retarding resistances, the best results are achieved by the use of a "block" formed from a plurality of capillary tubes in which the ratio of their length to their cross section is made very large and the overall or passage cross section of the tubes correspond approximately to the effective area of the diaphragm. While this condition may be somewhat difficult to achieve without enlarging the cross section of the microphone by the use of capillary tubes, considering even a minimum wall thickness, it has been found that glass, metal, or certain synthetic plastics are quite acceptable and when sintered form a block of the appropriate dimensions as just mentioned. It has been found that a honeycomb-type arrangement of the capillary tubes produces a very favorable ratio of the free sound-admitting cross section to the total cross section. It has also been found that the certain corrugated foils of metal or synthetic plastic materials may be rolled or folded to form a pack of block of capillary tubes such as just described. It will also be found that the invention can be used with electro-magnetic type transducers or a piezo-electric transducer used as the element for changing the sound to an electrical signal within the microphone.

It is another object of this invention to provide in a microphone for use with a head-worn hearing aid, an acoustic resistance mechanism having a cross-sectional area which corresponds to the effective area of the sound pressure responsive member.

It is another object of this invention to provide a directional microphone for use with a head-worn hearing aid in which the sound reaching a responsive member facing away from the desired direction is approximately 20 decibels lower than the sound reaching the other side of the sound-responsive member.

These and other objects and advantages of the invention will more fully appear from the following description, made in connection with the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is a diagrammatic longitudinal section of a typical microphone; and

FIG. 2 is a diagrammatic illustration of a frequency-response curve showing the operational effect of the microphone.

As found in FIG. 1, a microphone housing 11, has enclosed therein, a transducer or converter system 12, which as mentioned previously, may be of the electro-magnetic or piezo-electric type. Transducer 12 is connected through a coupling pin 13 to a diaphragm 14, which is secured in the normal manner to the outer edges of housing 11. Diaphragm 14 is secured at a spatially disposed position from the end wall of housing 11 so that a chamber 15 is formed therein and an aperture 16 is formed in the end of the housing to admit the sound waves to impinge upon diaphragm 13.

Another chamber 17 is formed to the rear of diaphragm 14 by the use of a block of propagation-retarding acoustic resistance material 18 which may be of one of the forms previously described. The entire rearwardly facing end of housing 11 is open to create another aperture 19. Thus sound waves entering through aperture 19 pass through the block of propagation-retarding acoustic resistance material in order to reach chamber 17 and thus provide an actuating motion to diaphragm 14.

FIG. 2 shows a frequency-response curve for sound waves detected by the microphone emanating from a preferred direction for detection by the microphone. Curve 20 is a frequency-response curve for a microphone of normal construction receiving the sound propagated waves from the preferred direction. Curve 21 corresponds to the frequency response of the present invention for sound received from the preferred direction through aperture 16. Curve 22 is the frequency-response curve for sound propagated waves arriving at the aperture 19 of the structure as seen in FIG. 1 when directed from a direction opposite to the preferred direction.

It will be observed that the decibel difference between curves 21 and 22 exhibits the ratio of the gain of the microphone between the two directions of sound reception. It will be seen that a mean value of approximately 20 decibels is achieved throughout the predominance of the audio range which insures that the user of such a microphone will be assured of directional hearing.

It will be observed that the effective area of diaphragm 14 is approximated by the cross-sectional area of housing 11 and aperture 19, the compartment being enclosed with the block of extremely fine capillary tubes or other appropriate material as set forth herein. It will also be observed that the microphone has achieved a directional characteristic which is somewhat kidney shaped with the mouth worn upon the head as opposed to the general microphone pickup characteristics which are generally spherical in nature.

What is claimed is:
1. An improved miniature microphone constructed and arranged to be used in a hearing aid housing to be worn on the head of the wearer wherein the improvement comprises:
   a. a miniature elongated microphone housing having a substantially enclosed end and an open end, said enclosed end having a sound admitting aperture formed therein which is considerably smaller than said open end, a sound pressure-responsive member secured to said housing and disposed between said ends to define first and second chambers therebetween, said pressure-responsive member adapted to be coupled to a transducer for movement by sound waves;
   b. a transducer for producing electrical signals representative of sound waves operably connected to said sound pressure-responsive member and secured within said second chamber in said housing; and
   c. a propagation-retarding acoustic resistance mechanism disposed within and obstructing said open end of the housing, said mechanism forming a plurality of narrow elongated passages, each having substantially the same length to admit the sound waves to said sound pressure-responsive member, said mechanism containing a plurality of elongated elements in juxtaposition arrangement forming a plurality of parallel elongated passages and extending between the open end of said housing and said transducer in said second chamber, said transducer producing electrical signals from sound waves received through said acoustic resistance mechanism which has a frequency response having a profile substantially the same as that produced by said transducer from sound waves received from said aperture.

2. The invention set forth in claim 1 wherein said open end of the housing having said propagation-retarding acoustic resistance mechanism disposed therein has a cross-sectional area substantially equal to the effective area of said sound pressure-responsive member.

3. The invention set forth in claim 1 wherein said propagation-retarding acoustic resistance mechanism produces an acoustic attenuation having a mean value of substantially 20 decibels higher than that for sound waves entering the aperture of the substantially enclosed end of the housing.

4. A microphone for a hearing aid to be worn on a person's head for detecting a sound and discriminating the direction of the source of the sound, comprising:
   a. a sound pressure-responsive diaphragm having opposite sides,
   b. an electric signal-generating transducer connected to the diaphragm and producing such signals in response to diaphragm movement;
   c. a housing confining and mounting the diaphragm and defining open and substantially enclosed chambers respectively disposed at the opposite sides of the diaphragm, the housing having a sound admitting aperture communicating with the substantially enclosed chamber, the open chamber being disposed to the rear of the diaphragm and having an open end to face away from the source of sound, the housing defining unobstructed space adjacent the transducer to freely transmit sound past the transducer and to the diaphragm,
   d. a sound wave propagation-retarding acoustic resistance mechanism obstructing the open rear end of the open chamber, said mechanism including a plurality of elongate and substantially parallel capillaries, the individual capillaries having a size of opening of the order of the size of passages existing between confined camel hairs, and said capillaries being assembled into a block and confined in the elongate open chamber of the housing, the capillaries in the block extending generally longitudinally of the chamber and toward the open end thereof, the open ends of the capillaries confronting the open end of the chamber to face the direction opposite the source of sound, the sound waves creating maximum and minimum pressures impinging the diaphragm and producing movement thereof, the sound wave propagation being retarded by the resistance mechanism to the extent that at the time the sound waves impinge the front side of the diaphragm with a maximum pressure, the sound waves impinge the back side of the diaphragm with less than maximum pressure, whereby to achieve directional effect with the microphone.

5. The invention according to claim 4 and the overall open cross section of the capillaries corresponding approximately to the effective area of the diaphragm.

6. The invention according to claim 4 and the overall open cross section of the capillaries being approximately the same as the effective area of the open end of the open chamber.

7. The invention according to claim 4 and the dimensions of the propagation wave-retarding resistance mechanism including the capillaries being dimensioned to maximize the ratio of the sound wave pressures applied against the front of the diaphragm in relation to such pressures applied to the back of the diaphragm.

8. A microphone for a hearing aid to be worn on a person's head for detecting a sound and discriminating the direction of the sound, comprising,
   a. a sound pressure-responsive diaphragm having front and back sides,
   b. an electric signal-generating transducer connected to the diaphragm and producing such signals in response to diaphragm movement;
   c. a housing confining and mounting the diaphragm and defining open and substantially enclosed chambers respectively disposed at the back and front sides of the diaphragm, the housing having a sound-admitting aperture communicating with the substantially enclosed chamber, the open chamber being elongate and disposed at the rear of the housing and having an open rear end to face away from the source of the sound and for admitting sound for propagation to the back side of the diaphragm.

9. A directional microphone for use in a hearing aid to be worn on a person's head, comprising:
   a. a diaphragm sensitive to sound pressure;
   b. a diaphragm-operated transducer generating electric signals related to the sound pressures sensed by the diaphragm;
   c. a microphone housing enclosing the diaphragm and defining front and rear chambers at opposite sides of the diaphragm, the housing having a sound opening communicating with the front chamber and freely admitting sound pressures to impinge upon the diaphragm; and
   d. means defining clear passages into the rear chamber of the housing at a location remote from the sound opening said passages having a size admisive to sound pressures and also resistive to transmission of such sound pressures to retard impingement of the sound pressures against the diaphragm, the retardation effected by the clear passages...
causing sound pressure from the preferred direction acting upon the rear of the diaphragm being at a minimum level while sound pressure admitted through the sound opening at the rear of the diaphragm reaches a maximum level.

* * * * *
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,662,124 Dated May 9, 1972

Inventor(s) Otto Hassler; Johannes Wittkowski

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

[73] Assignee: Change "Appgratebau" to --Apparatebau--.

In claim 3, column 3, line 40, please change "means" to --mean--.

Signed and sealed this 12th day of September 1972.

(SEAL)
Attest:
EDWARD M. FLETCHER, JR. ROBERT GOTTSCALK
Attesting Officer Commissioner of Patents