May 12, 1953 R. W. CARLISLE 2,638,508

VENTED CASING AND VAPORPROOF ENCLOSURE FOR SOUND TRANSDUCERS

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FIG. 1

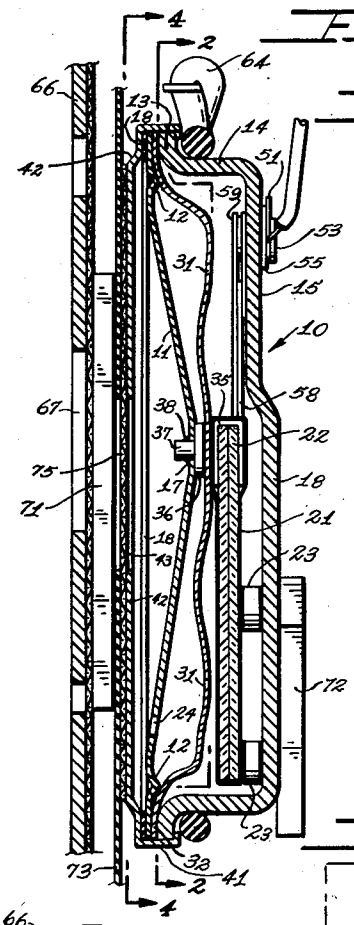


FIG. 3

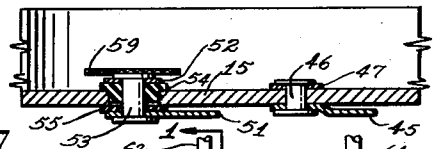


FIG. 2

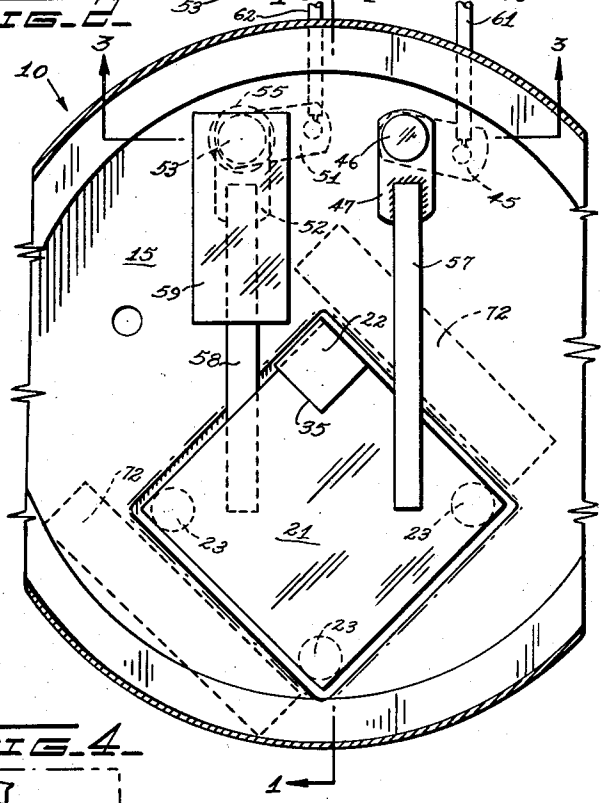


FIG. 4

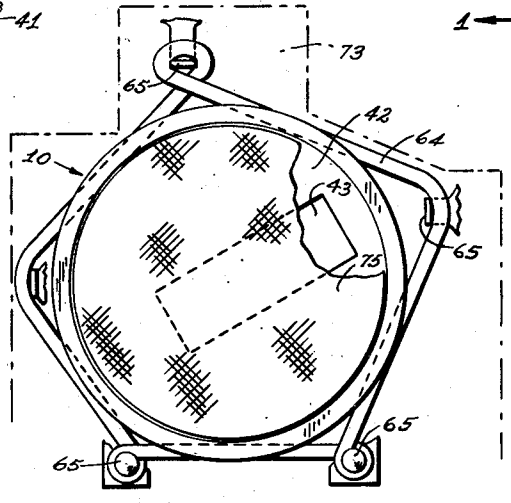


FIG. 5

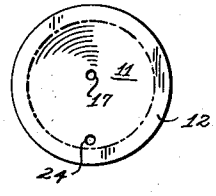
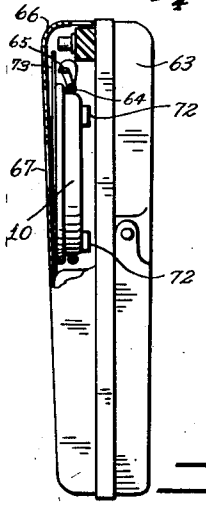


FIG. 1A



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FIG. 7

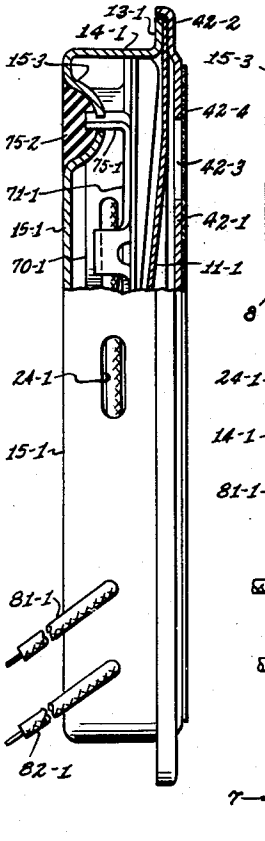


FIG. 6

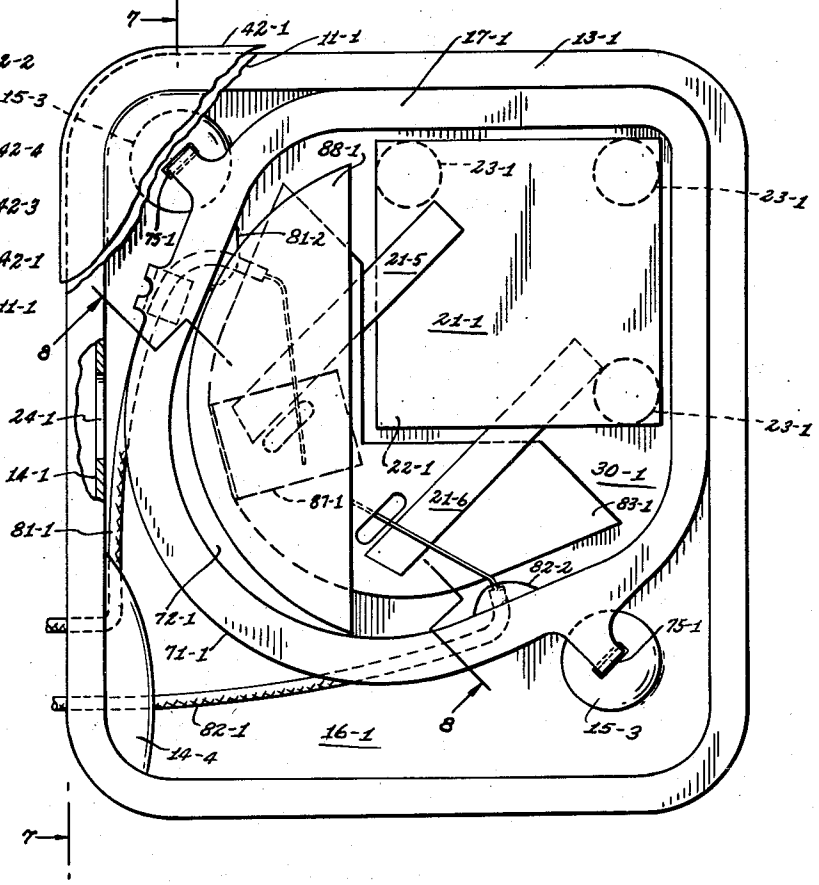
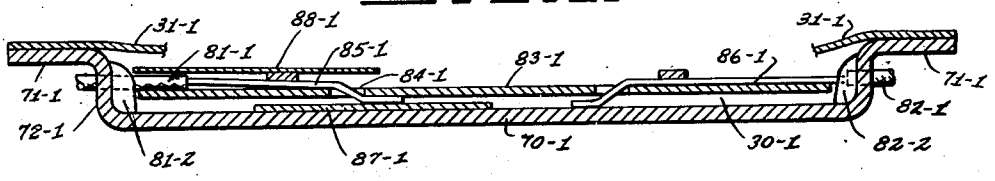


FIG. 8



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FIG. 10

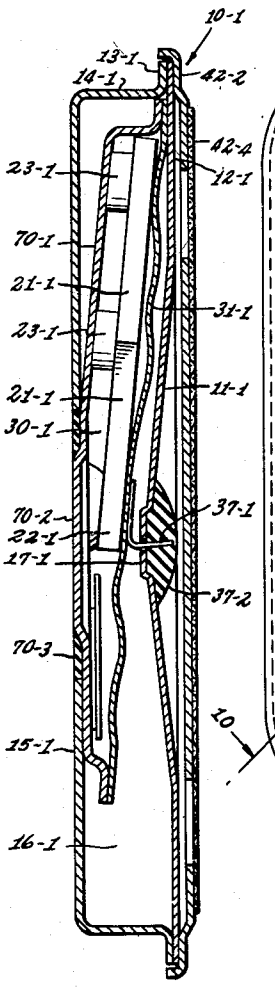
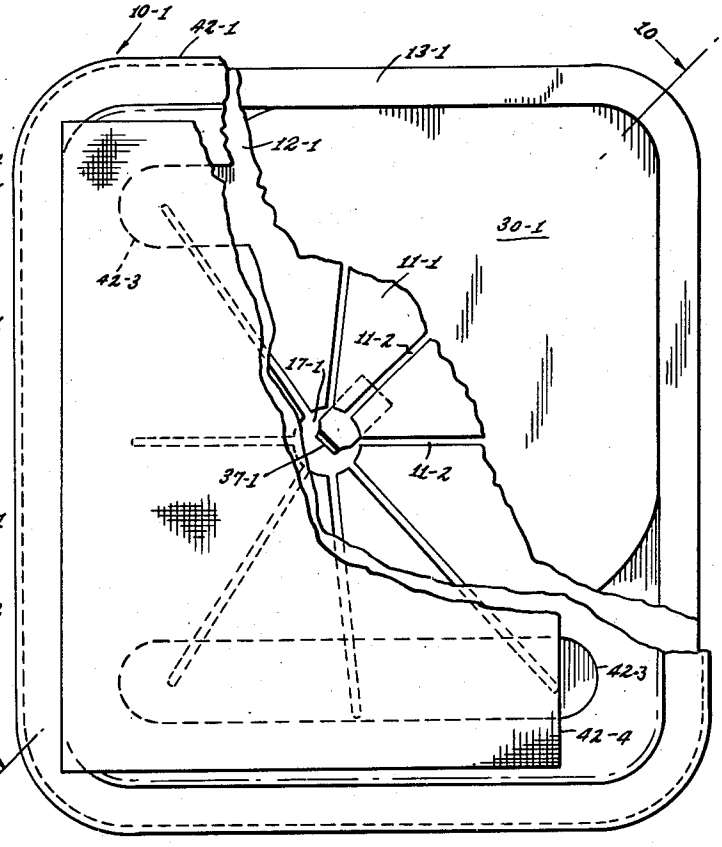


FIG. 9



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VENTED CASING AND VAPORPROOF ENCLOSURE FOR SOUND TRANSDUCERS

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Application August 31, 1950, Serial No. 182,490

2 Claims. (Cl. 179—110)

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This invention relates to sound transducing devices such as microphones used as part of a compact small hearing aid amplifier worn on the body of the user, although the general principles of the invention are also applicable to other sound transducing devices such as commercial microphones or telephones. More specifically, the invention is directed to such sound transducing devices in which a vibratory diaphragm is connected to a vibro-electric transducing element such as a piezo-electric crystal transducer element which transduces electric potentials into mechanical forces or mechanical forces into electric potentials.

Among the objects of the invention is a sound transducing device of the foregoing type in which the vibratory diaphragm forms part of an extremely flat microphone cavity enclosure within which the vibro-electric transducer element is mounted, and in which the cavity enclosure is provided with vent opening portions which reduce the great stiffness of the body of air confined in the cavity enclosure and secure the desired microphone sensitivity in the low frequency range, while also providing a protectively sealed vapor-proof enclosure for the humidity sensitive vibro-electric element.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein:

Fig. 1 is a greatly enlarged sectional view, along lines of 1—1 of Fig. 2, of one form of a hearing aid microphone exemplifying the principles of the invention;

Fig. 1-A is an elevational view of the narrow side of a hearing aid amplifier, shown in actual size, with parts of the housing in cross-section, to expose a microphone held back of the sound pervious front-wall portion of the amplifier housing;

Fig. 2 is a cross-sectional view of the microphone along lines 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view along lines 3—3 of Fig. 2;

Fig. 4 is a cross-sectional view along lines 4—4 of Fig. 1;

Fig. 5 is a front view of the vibratory diaphragm of the microphone;

Fig. 6 is a front view generally similar to that of Figure 2 of another form of a microphone of the invention, the front wall and the major part of the diaphragm and diaphragm barrier removed to expose the interior of the microphone

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cavity enclosure with the elements mounted thereon;

Fig. 7 is a side view of the microphone shown in Fig. 6 with the upper portion in cross-section along lines 7—7 of Fig. 6;

Fig. 8 is a cross-sectional enlarged detailed view of a part of the microphone shown in Fig. 6 along lines 8—8 thereof;

Fig. 9 is a front view of the microphone similar to Fig. 6 with only a portion of the front cover and the vibratory diaphragm removed; and

Fig. 10 is a cross-sectional view of the microphone of Figures 6 to 9 along lines 10—10 of Figure 9.

Hearing aid microphones which are used as a part of a high-gain amplifier hearing aid have to operate under conditions utterly different from those encountered in other microphone applications. This is due to the fact that the amplifier housing in which the microphone is housed has to be worn more or less hidden under the clothing of the user where it is exposed to humidity which greatly affects its performance, particularly if the microphone transducer element is formed of piezo-electric Rochelle salt crystal parts or similar transducer crystal parts the operation of which suffers greatly when they are exposed to humidity.

Furthermore, the amplifier housing within which the microphone is positioned, must also house the amplifier tubes and all other amplifier components including the switches and rheostats as well as the batteries which supply cathode heating current and space current to the amplifier tubes. This makes it essential to keep the space occupied by the microphone to a minimum, while at the same time designing in such a way as to cause it to operate with a desired high sensitivity over the principal part of the audio frequency range essential for the intelligible reproduction of speech.

These requirements impose very strict limitations on the construction of such hearing aid microphone, since in order to obtain high sensitivity the vibro-electric transducer element must be driven by a relatively large vibratory diaphragm exposed to sound propagated in the surrounding air.

If an attempt is made to provide a flat microphone casing having such vibratory diaphragm with a microphone cavity sealed against entry of humid air, there is encountered the problem of assuring that the diaphragm shall be able to withstand the high forces, of about 2 to 5 pounds, caused by normal variations in the at-

mospheric pressure to which it is exposed. This makes it necessary to provide a very strong and stiff diaphragm structure which, for its small size, is inherently insensitive to sound propagated in the surrounding atmosphere. As a result, such microphones would have to operate with the greatly reduced sensitivity in the frequency range below about 1000 cycles per second, thereby greatly detracting from its usefulness as a hearing aid microphone.

In accordance with the invention these limitations are overcome by providing microphone cavity enclosure formed by the vibratory diaphragm and the associated small compact microphone casing with vent opening portions which equalize the air pressure on both sides of the vibratory diaphragm for maintaining it in the desired vibratory position and securing the desired transducing sensitivity of the microphone in the lower part of the speech frequency range, and interposing between the vibratory diaphragm and the cavity portion within which the piezo-electric crystal transducer element is held a limp barrier diaphragm which is hermetically joined to the rear wall of the microphone casing to form therewith a sealed vapor and humidity-proof enclosure around the transducer element without materially detracting from the desired over-all sensitivity and frequency response of the microphone. What was said above about the harmful effect of humidity on piezo-electric crystal transducer elements applies also to vibro-electric electret elements which may be used in their stead.

The sound transducing microphone, generally designated 10, comprises a generally conical outwardly tapering diaphragm 11, having a circular peripheral portion 12, the edge of which is sealed and held affixed to the flange 13, of the circular rim 14 of a flat casing wall 15 of the microphone so as to form with the diaphragm 11 a flat microphone cavity 16. The diaphragm 11 is light, and its outwardly tapering conical shape gives it the desired stiffness so that substantially its entire exposed area will vibrate when excited by sound propagated in the air space in front of the conical diaphragm 11.

The conical diaphragm 11 is shallow, and its conical center portion 17 is connected to a vibratory portion 22 of a vibro-electric transducer element 21 shown in the form of a piezo-electrical crystal bimorph of generally rectangular, flat shape, and extending immediately above the inner surface of outwardly offset wall portions 18 of the casing wall 15. In the particular offset form of the microphone of the invention shown, the transducer element 21 is a conventional twister-type bimorph of Rochelle salt crystal having the usual surface electrodes. Three corners of the piezo-electric transducer are connected through elastomer pads 23 to the inner surface of the casing wall portion 17. The fourth corner portion 22 of the piezo-electric crystal transducer 21 has a driving connection 37 to the generally central drive portion 17 of the conical diaphragm 11. As an alternative an electret-type condenser structure may be mounted within the cavity and connected to the diaphragm for actuation thereby.

In order to reduce the overall thickness of the microphone 10 to a minimum, the thickness of the microphone cavity 16 is kept down to provide just enough space for housing therein the conical vibratory diaphragm 11 and the transducer element 21. As a result, the thin body or layer of air confined in the cavity 16 of the microphone casing has high stiffness which cuts down the microphone sensitivity in the low-frequency part of the principal audio-frequency range important for the intelligible reproduction of speech, and particularly in the range of about 1,000 cycles and below. To overcome this difficulty it is essential to provide a vent opening from the microphone cavity to the air in the outer space. On the other hand, it is essential that the humidity sensitive transducer element of the microphone, which in most cases is made of Rochelle salt crystal or a similar humidity-sensitive piezo-electric crystal substance, be enclosed within an enclosure which prevents humid air from reaching it.

In the microphone of the invention, its sensitivity in the low-frequency part of the audio-frequency range, is raised by providing the vibratory diaphragm 11 with vent opening portions in the form of a small hole 24 which equalizes the air pressure in the cavity 16 with the outer atmosphere and maintains the vibratory diaphragm in the desired vibratory condition irrespective of variations of the outer air pressure. Such vent opening portion 24 raises the sensitivity of the microphone in the low frequency range between about 300 to 1000 cycles per second, so that notwithstanding the small thickness of the acoustic air cavity 16 of the microphone structure, its sensitivity is as high as that obtainable with bulkier microphone structures.

In accordance with the invention, the cavity part housing the transducer element 21 is sealed against entrance of humid air by interposing between it and the inner side of the vibratory diaphragm 11 a limp vapor-proof barrier diaphragm 31 having a circular peripheral portion 32 sealed in a vapor-proof hermetic manner to the circular casing wall flange 13 to which the periphery of the vibratory diaphragm 11 is secured. The portion of the barrier diaphragm 31 extending between the drive portion 22 of the piezo-electric crystal transducer element 21 and the central drive portion 17 of the diaphragm 11, provides a motion-transmitting connection therebetween, being united thereto as by cement.

Without thereby limiting the scope of the invention, there will now be described one specific manner for providing a driving connection between the driving portion 22 of the vibratory diaphragm 11 across the portion of the barrier diaphragm 31 extending therebetween then forming part of the driving connection. A rectangular strip 35 of fibrous material such as resin-impregnated paper, is cemented over the corner drive portion 22 of the transducer crystal element 21, shellac being a good cement for this purpose. The outer surface of the cover strip 35 underlying the drive portion 17 of the vibratory diaphragm 11 has secured thereto a facing portion of the barrier diaphragm 31, likewise by a good, strong cement, so that the central portion of the barrier diaphragm 31 overlying the corner drive portion 22 of the transducer element 21 forms a substantially rigid part thereof.

As seen in Figs. 1, 2 and 5, the apex portion 17 of the conical vibratory diaphragm 11, which is connected to the drive portion 22 of the transducer structure 21, is slightly eccentric relatively to the periphery of the diaphragm, to enable the use of a larger, more compliant crystal transducer structure 21 which matches better the low mechanical impedance of the small cone, and increases the sensitivity of such small hearing-aid microphone.

To the outer side of the barrier diaphragm

portion 31 secured to the drive portion 22 of the transducer element 21, there is secured the enlarged head 36 of a short rivet-like rod 37 fitting into an opening formed in the central drive portion 17 of the conical vibratory diaphragm 11, the rod head 36 being secured to the underlying driving portion of the barrier diaphragm 31 and to the transducer element 21 by a strong and stable, commercially available cement. After securing the drive rod 37 to the drive portion 22 of the transducer element and the overlying small portion of the barrier diaphragm 31 previously secured thereto, the vibratory diaphragm 11 is placed with the hole of its central drive portion 17 over the drive rod 37, so as to surround the same. Thereupon the periphery 12 of the vibratory diaphragm 11 is cemented to the periphery of the barrier diaphragm 31 overlying the flange 13 of the microphone casing wall 15 to which the periphery of the barrier diaphragm 31 was previously united by a strong, stable cement, similar to that used for cementing the periphery 12 of the vibratory diaphragm 11 thereto.

After the periphery of the vibratory diaphragm has been thus united by cementing to the flange 13 of the microphone casing wall 15, the central drive portion 17 of the diaphragm surrounding the drive rod 37 is united thereto by applying a quantity of cement 38 thereto, so that it fills the space between the opening of the drive portion 17 of the vibratory diaphragm and the drive rod surrounded thereby, and rigidly unites the same to provide a rigid, stable driving connection between the drive portion 22 of the transducer element and the drive portion 17 of the vibratory diaphragm across the portion of the barrier diaphragm 31 united to them.

As explained above, the barrier diaphragm 31 is sufficiently limp and loose and has such high flexibility that it moves freely when the drive portion 22 of the crystal vibrates with the vibratory diaphragm 11, without substantially impeding their vibrations. In the practical construction of microphones, it was found that thin aluminum foil may be effectively used both for the vibratory diaphragm 11 and for the limp, loose, barrier diaphragm 31.

To protect the hermetic cement seal between diaphragm 31, and the circular flange 13 of the relatively rigid microphone casing 15, there is placed over the several cemented peripheral edges of the same, a channel-like member 41, which is crimped and clamped over the peripheral border portion of the circular peripheries of the diaphragms 11 and 31, and the casing wall flange 13. In the form shown, the channel-member 41 forms the circular peripheral flange portion of a sound-pervious grille wall 42 placed over the outer side of the vibratory diaphragm 11, so as to protect its fragile foil structure against mechanical contact. The grille 42 has a relatively large opening 43 through which the vibratory diaphragm 11 is acoustically coupled to the air space in front of it, to provide for sound transmission therethrough.

As shown in Fig. 1, an additional washer 18 of a yieldable material such as fibre-impregnated resinous sheet material or tough rubber-like material, is placed against the outer peripheral surface region 12 of the vibratory diaphragm 11, so that it is yieldably clamped by the facing peripheral portion of the grille wall 42 when its flange 41 is clampingly crimped over the peripheral circular edge regions of the vibratory diaphragm 11, the barrier diaphragm 31, and the flange 31, of the microphone casing wall 15.

In a practical form of microphone of the invention, the casing wall 15 of the microphone, as well as the grille 42, are made of sheet aluminum shaped by conventional cutting and forming operations. The grille with its channel-member 41 is placed over the periphery of the vibratory diaphragm 11, and the underlying periphery of the barrier diaphragm 31, both of which have been previously secured by cementing in an hermetically sealed manner to the casing wall flange 13, whereupon the rear edge of the cylindrical channel flange 41 of the grille is crimped over the rear surface of the casing wall flange, to provide a protective channel-like seal around the peripheries of the diaphragms 11 and 31 and the casing wall flange 13, and assure a positive and stable hermetic seal therebetween.

To provide electric terminal connections to the vibro-electric transducer element 21 of the microphone, the casing wall has secured to opposite sides of a portion thereof, two sheet metal terminal tabs 45, 47, as by a rivet 46 extending through the casing wall, to provide an intimate hermetic seal therebetween. In addition, two other metal terminal tabs 51, 52 are secured to another portion of the casing wall 15 by a rivet 53 passing through a hole of the wall, insulating washers and spacers 54, 55 insulating the two tabs 51, 52 and the rivet 53 from the metallic casing wall 15. The insulating spacers 54, 55 may be made of resin-impregnated fibrous material, and they are so secured within the hole of the casing by the rivet heads clamped thereover and the overlying portions of the two terminal tabs 51, 52, as to provide an hermetic seal for the portion of the wall through which the rivet 53 passes.

In addition, sealing wax cement of a type which provides a stable hermetic seal, is placed over the rivets and the tabs 45, 47, 51, 52, and the insulating spacers, to assure that under all conditions the holes through which the terminal rivets 46 and 53 pass, are at all times hermetically sealed to prevent entrance of moisture into the cavity part within which the humidity-sensitive transducer element is operatively mounted.

To the inward terminal tabs 47, 52 are secured, as by soldering, terminal elements 57, 58 of aluminum foil, for instance, secured to the usual opposite external surface electrodes of the vibro-electric transducer element 21.

Furthermore, strips of insulating material 59, such as resin-impregnated insulating material, are placed against the opposite surfaces of the terminal lead 58 and the terminal tab 52, connecting the insulatingly supported surface electrode of the transducer element 21 to the insulated terminal rivet 53 through which an insulated external terminal connection is provided to the insulated transducer electrode of the transducer element 21. The external terminal tabs 45, 51, may thus be used to provide terminal connections to leads such as leads 61, 62, through which the transducer element 21 is connected to the amplifier circuit of the amplifier elements, including tubes mounted within the hearing aid amplifier-microphone assembly housed in a flat casing 63, as shown in Fig. 1-A.

As indicated in Figs. 1, 1-A and 4, the microphone unit 10 is held suspended on a vibration-damping, flexible support 64 shown in the form of a loop formed of hollow tubing of rubber-like, elastomer material strung around a plurality of

supporting lugs or pins 65 extending from the frame structure of the hearing-aid amplifier mounted in the rear of the front wall 66 of the amplifier casing 63. The front wall 66 of the amplifier casing has a sound-pervious portion provided with openings 67 through which the outer air is acoustically coupled by way of the grille opening 43 to the acoustic space in front of the vibratory diaphragm 11, for assuring that the microphone diaphragm is excited by sound propagated in the outer air, and actuates the transducer element 21 to generate a corresponding electric output. To the outer surface of the front grille wall 42 of the microphone and the rear microphone wall 15, are secured spacer strips 72, 72 of a vibration-suppressing material such as sponge rubber, to suppress transmission of vibrations to the microphone 10 from the walls of the amplifier casing 63 and the amplifier structure, and other elements housed therein.

As shown in Figs. 1, 1–A and 4, an additional thin sheet 73 of plastic material is united as by cement to the front grille wall 42 of the microphone 10, the sheet member 73 extending closely adjacent the rear surface of the sound-pervious front wall 66 of the amplifier casing, to suppress propagation of sound from the space in front of the vibratory diaphragm 11 of the microphone casing 15 toward the rear space in the microphone amplifier casing. In other words, the flexible sheet member 73 extending beyond the borders of the front grille wall 42 of the microphone unit, is arranged to serve as a barrier suppressing propagation of sound from the space in front of the vibratory diaphragm 11 to the space in back of the microphone casing wall 15.

As indicated in Figs. 1 and 4, an additional sound-pervious sheet portion, for instance, of gauze 75, is secured as by cement over the opening 43 of the front grille wall 42 of the microphone, as an acoustical damping control and also to suppress entrance of dust into the space between the vibratory diaphragm 11 and the grille wall 42 of the microphone. A similar sound-pervious gauze sheet portion, which is substantially impervious to dust, is also shown cemented to the inner side of the sound-pervious casing wall 66 of the amplifier, through which sound is propagated to the space in front of the vibratory diaphragm 11.

Without in any way limiting the scope of the invention, and in order to enable those skilled in the art to more readily practice the invention, there are given below constructional data for a small, compact hearing-aid microphone with the desired sensitivity and frequency response characteristics:

The vibratory diaphragm 11 has a diameter of about 1 inch, and a cone height of about .090 to .12 inch. In general, good results are obtained with a ratio of diameter to cone height of about 10/1. The rear space of the microphone cavity extending between the rear wall 15 of the microphone and the barrier diaphragm 31, has a diameter of about 1 inch, and a height of about .070 inch. In general, good results are obtained with a ratio of the volume of the cavity part confined between the barrier diaphragm 31 and the microphone rear wall 15, to the total volume of the microphone cavity confined between the vibratory diaphragm 11 and the microphone rear wall, of between about 2.5/1 to 1.5/1.

In the microphone of the invention, the barrier diaphragm 31 which provides the hermetic seal, has an area at least as great as the entire large dimension or transverse area of the microphone cavity. In addition, the hermetically sealing barrier diaphragm 31 has to move over a very small distance to equalize variations in the atmospheric pressure of only a small percentage of the total volume of the microphone cavity, represented by the small volume of the cavity part confined between the barrier diaphragm 31 and the microphone rear wall 15. It was found that in practical microphones of the invention, the desired hermetic sealing action against moisture at all joints, such as the joints between the periphery of the barrier diaphragm and the periphery of the microphone wall 15, and the joints of the rivet terminals 46 and 53 to the microphone wall 15, readily obtained by applying to them coatings of a moisture-resistant type of wax, of the type used to provide hermetic vacuum sealing. Thus, such wax may be applied to the peripheral surfaces of the barrier diaphragm 31 and the flange 13 of the microphone wall 15, as well as to the surfaces of the rivet junctions of the terminal rivets 46, 53 to the microphone casing wall 15.

Figs. 6 to 10 show another form of the microphone transducer device 10–1 exemplifying the invention. It comprises a generally conical outwardly tapering diaphragm 11–1 having a generally rectangular peripheral border portion 12–1 which is secured to the flange 13–1 of the rectangular rim 14–1 of a flat microphone casing wall structure 15–1 which forms with the diaphragm 11–1 a flat microphone cavity 16–1. The diaphragm 11–1 is light and its outwardly tapering conical shape gives it the desired stiffness so that substantially its entire exposed area will vibrate when excited by sound propagated in the air space in front of the diaphragm 11–1.

The conical diaphragm 11–1 is shallow and its central portion 17–1 is connected to a vibratory portion 22–1 of a vibro-electric transducer element 21–1 formed of a piezo-electric crystal bimorph of a conventional generally rectangular shape extending flatwise adjacent to the inner side of the casing wall structure 15–1. Three corners of the piezo-electric transducer crystal unit 21–1 are connected by elastomer pads 23–1 to the underlying supporting wall structure and the fourth corner 22–1 is connected through a drive connection 37–1 to the central drive portion 17 of the vibratory diaphragm 11–1.

In order to reduce the overall thickness of the microphone 10–1, the thickness of the microphone cavity 16–1 is kept down to provide just enough space for housing the conical vibratory diaphragm 11–1 and the transducer element 21–1 drivingly connected thereto. Because of the special shape of the vapor-proof transducer compartment 30–1, the body of air within the microphone cavity 16–1 has a lower stiffness relatively to the vibratory diaphragm 11–1 as compared to the microphone arrangement of Figs. 1 to 5. When the cavity vent opening 24–1 is closed, the sensitivity of the microphone above 5000 cycles per second is not materially reduced. However, if the vent opening 24–1 is closed and the entire microphone cavity 16–1 is hermetically sealed, changes in the atmospheric pressure will force the conical diaphragm completely out of shape within a few hours and abruptly if it is used on an ascending or decending airplane in which it is subjected to sudden changes in the air pressure.

In the particular microphone described above in connection with Figs. 6 to 10, the vented

microphone cavity 16–1 is designed to resonate in the region of about 300 cycles per second, thereby increasing its sensitivity in that region.

The vapor-proof transducer compartment 31–1 is made as small as possible to keep down the air enclosed thereby and thus minimize the excursions of the limp barrier diaphragm 31–1 under variations of the atmospheric pressure.

In the form of the invention shown in Figs. 6 to 10 this is achieved by providing the casing wall structure 15–1 of the microphone cavity 16–1 with a vent opening 24–1 to the exterior air while separating the vented part of the microphone cavity from the cavity part housing the transducer unit 21 by an interposed limp vapor-proof barrier diaphragm 31–1. The limp barrier diaphragm 31–1 has a peripheral portion 32–1 sealed by a vaporproof sealing cement in a vapor-proof hermetic manner to compartment partition wall portions 71–1 of the microphone casing structure so as to form with the barrier diaphragm 31–1 a vaportight compartment enclosure 30–1 around the transducer unit 21–1.

The portion of the barrier diaphragm 31–1 extending between the drive portion 22–1 of the piezo-electric transducer unit 21–1 and the central drive portion 17–1 of the diaphragm 11–1 provides a motion transmitting drive connection therebetween. In the form shown, the outward surface of the drive portion 22–1 of the transducer unit 21–1 is united, as by a good insulating cement, to the adjacent overlying portion of the limp barrier diaphragm 31–1. To the outer side of the limp barrier diaphragm 31–1, which is cemented and united to the underlying drive portion 22–1 of the crystal transducer unit 21–1, is secured one arm of a strip-shaped drive rod 37–1 the other arm of which passes through a slit in the central portion 17–1 of the vibratory diaphragm 11–1 to which it is secured, as by sealing cement 37–2. This arrangement assures that the portion of the barrier diaphragm overlying the corner drive portion 22–1 of the transducer crystal unit 21 forms a substantially rigid part of the driving connection to the drive portion 17–1 of the vibratory diaphragm 11–1 of the microphone.

By making the drive rod 37–1 in the form of a strip there is provided transverse flexural compliance in the driving connection between the crystal transducer unit 21–1 and the vibratory diaphragm 11–1 in a direction transverse to the direction of the transmitted driving forces. This arrangement reduces the overall stiffness of the vibrating system and increases the efficiency and the overall sensitivity of the microphone as an acoustic transducer device.

The compartment partition wall 71–1, to which the periphery of the limp barrier diaphragm 31–1 is hermetically united, may be formed of integral portions of the microphone casing structure 15–1. In the form shown, the compartment partition wall 71–1 forms a peripheral flange of the rim 71–2 of a separate inner compartment wall 70–1 constituting with the barrier diaphragm 31–1 the vapor-proof enclosure compartment 30–1 of the transducer unit 21–1.

As in the microphone of Figs. 1 to 5, the vapor proof transducer enclosure compartment 30–1 with the associated ocmpartment wall 70–1 occupies only a small part of the volume of the microphone cavity 16–1. In the form shown, the compartment wall 70–1 is shaped to fit against the border rim of the microphone casing wall 15–1 and to support on its inner side the transducer unit 21–1 in a position in which its driving portion 22–1 is approximately adjacent to the center portion of the vibratory diaphragm. The compartment wall 70–1 is formed out of sheet metal to constitute a relatively rigid structure having a peripheral flange 71–1 to which the periphery of the limp barrier diaphragm 31 is united by a vaporproof cement to form a hermetically sealed enclosure around the transducer unit 21.

This arrangement makes it possible to first mount and assemble the transducer unit 21–1 and the associated parts in their operative positions within the compartment wall 70–1 and to thereafter seal the periphery of the limp barrier diaphragm 31–1 in a vaporproof hermetic manner to the flanged rim 72–1 of the compartment wall 70–1 and thereby form a vaporproof enclosure around the piezo-electric transducer unit 21–1. The sealed enclosure compartment casing 70–1 is suitably secured in its position within microphone cavity 16–1 to the casing wall 51–1 in the position shown in which the center portion of the vibratory diaphragm may be affixed to the drive rod 37–1 previously affixed to the barrier diaphragm portion overlying the driving portion 22–1 of the piezo-electric transducer unit 21–1 and held in vibratory position within the compartment wall 70–1.

The compartment wall 70–1 is shaped so as to provide an enclosure compartment of a minimum thickness at the region where its enclosed transducer unit 21–1 is connected through the driving rod 37–1 to the vibratory diaphragm 11–1. To achieve a minimum overall thickness, the portion of the compartment wall 70–1 underlying the drive corner 22–1 of the transducer unit 21–1 is offset at 70–2 in outward direction and is held at the same level as the main microphone casing wall 15–1 within an opening thereof (Fig. 10).

In the form shown the compartment wall 70–1 is held in position on the microphone casing wall 15–1 by two tail portions 75–1, forming integral extensions of the wall rim 70–1, and extending through slits in reentrant wall depressions 15–3 of the microphone casing wall 15–1 (Figs. 6 and 7).

The tail portions 75–1 may be affixed within the slits of the microphone casing wall portions 15–3 by twisting their outer ends and or by placing over the interfitting parts of the depressed wall portions 15–3 lumps 75–2 of sealing cement.

In addition, sealing wax cement is also applied at 70–3 to the junction region between the offset portion 70–2 of the compartment wall 70–1 and the adjoining sealing opening region of the microphone casing wall 15–1 (Fig. 10).

The microphone 10–1 shown is also provided with a novel arrangement of terminal lead connections from exterior circuits to the piezo-electric transducer unit 21–2 held enclosed within the vapor-proof enclosure compartment 30–1. In the form shown, two insulated conductor leads 81–1, 82–1 pass through small perforations of the compartment wall rim 72–1 into the interior cavity space 30–1. The rim openings through which the two insulated leads 81–1, 81–2 enter the sealed compartment interior 30–1 are hermetically sealed by applying thereto and to the adjoining lead portions an insulating sealing wax cement of a type which provides a stable hermetic vapor- and moisture-proof seal to assure that the vapor-proof enclosure provided by the compartment wall 70–1 is fully maintained.

A strip of insulating sheet material 83–1 overlying the inner surface of the compartment wall 70–1 (Figs. 6, 8) has two slits 84–1 for retaining in position the free ends 85–1, 86–1 of the two

conductor leads 81–1, 82–1 from which the insulation has been stripped. A folded tongue extension 87–1 of the insulating sheet 83–1 is folded over the end portion of conductor lead 85–1, which constitutes the high potential conductor lead, to maintain it insulated from the metallic compartment wall 70–1. The two opposite polarity terminal tail portions 87–1, 21–5, 21–6 of the transducer unit 21–1 are joined, as by soldering, to the underlying stripped conductor leads 85–1, 86–1 of the two conductor leads 81–1, 82–1 (Figs. 6, 7). An additional insulating strip 88–1 is placed over the exposed metallic conductor terminal portions 21–5, 85–1 to maintain them insulated from the overlying barrier diaphragm 31–1.

The terminal leads 81–1, 82–1 emerging from the rim of the compartment of the enclosure compartment wall 70–1 are led in a similar manner through similarly sealed openings in the rim 14–1 of the microphone casing wall 15–1, to the exterior thereof (Figs. 6 and 7).

Without thereby limiting the scope of the invention, there will be now given further details about constructional features of the microphone invention shown in Figs. 6 to 10. The vibratory diaphragm 11–1 is formed of a thin aluminum foil which is given the required stiffness by providing its conical portion with the generally radially extending channel formations 11–2. The barrier diaphragm 31–1 is formed of similar thin aluminum foil, and made sufficiently limp and loose and of such high flexibility that it moves freely when the drive portion 22–1 of the crystal transducer 21 vibrates with the vibratory diaphragm 11–1, without substantially impeding their vibrations. A protective sound pervious grill wall 42–1 is placed over the outer side of the vibratory diaphragm 11–1 to protect it against exterior forces. The grill wall 42–1 is secured along its periphery 42–2 to the flange 71–1 of the microphone casing wall 15–1 over the periphery of the vibratory diaphragm cemented thereto. Openings 42–3 in the grill wall 42–1 permit free propagation of sound from and to the vibratory diaphragm and a gauze layer 42–4 cemented over the openings 42–3 suppresses entrance of dust and foreign matter into the interior. The periphery of the grill wall 42–1 is affixed to the the periphery 71–1 of the casing wall 15–1 by a sealing cement without any additional crimping junction, or with a crimping junction such as shown at 41 (Fig. 1) for the microphone of Figs. 1 to 5.

Without thereby limiting the scope of the invention and in order to enable those skilled in the art to more readily practice the same there are given below constructional data of a small compact hearing aid microphone of the form shown in Figs. 6 to 10, having the required sensitivity and frequency response characteristics:

The microphone cavity 16–1 had lateral dimensions 1 x $\frac{15}{16}$ inch and a depth of $\frac{1}{8}$ inch. The vibratory diaphragm 11–1 had a cone height of about .065 inch. The crystal transducer unit was $\frac{7}{16}$ x $\frac{1}{2}$ x $\frac{1}{32}$ inch in size. The other dimensions are apparent from the drawings, Figs. 6 to 10.

Various other modifications of the invention will suggest themselves to those skilled in the art. It is accordingly desired that in construing the breadth of the appended claims, they shall not be limited to the specific details shown and described in connection with the exemplifications of the invention.

I claim:

1. In a sound-transducing device such as a microphone for a hearing air small enough to inconspicious wear on the body of the user: a generally flat relatively-rigid cavity wall structure; a vibratory diaphragm having a periphery joined to said wall structure to form therewith an acoustic cavity; a generally flat vibro-electric transducer element held within said cavity and having a portion mechanically connected to a vibratory portion of said diaphragm to form therewith a transducing system which transduces vibratory forces imparted to said diaphragm into electric output or vice versa; a light, substantially limp metal barrier diaphragm interposed within said cavity between said vibratory diaphragm and said transducer element; said wall structure having a continuous wall region surrounding said transducer element; said barrier diaphragm having a continuous metallic peripheral region hermetically joined to said continuous wall region of said wall structure and forming therewith a substantially vapor-proof hermetically sealed transducer compartment within which said transducing element is held; the cavity part of said cavity extending outside said transducer compartment having vent opening portions for equalizing the air pressure in the cavity relatively to the outer atmosphere and securing the desired sensitivity of said transducing system.

2. In a sound-transducing device as claimed in claim 1, said wall structure having a wall member separable from other parts of said cavity wall structure and having said continuous wall region hermetically joined to the periphery of said barrier diaphragm to form therewith said vapor-proof transducer compartment.

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