Oct. 22, 1963 M. SCHINDLER 3,108,162

CAPACITOR ACOUSTO-ELECTRIC TRANSDUCER AND METHOD OF MAKING THE SAME

Filed April 11, 1960

FIG. 1.

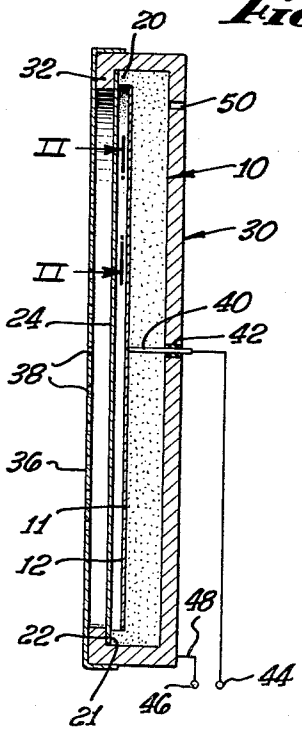


FIG. 2.

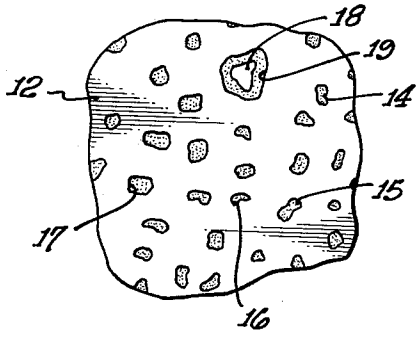


FIG. 3.

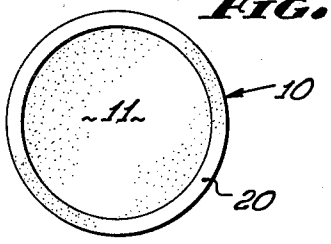


FIG. 4.

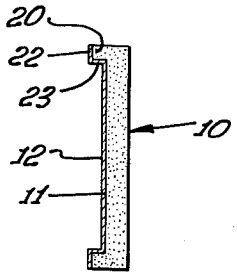


FIG. 5.

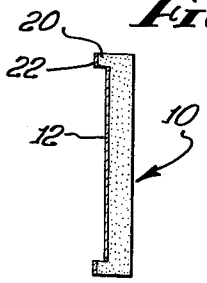
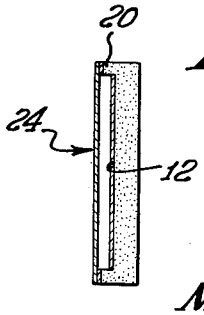


FIG. 6.



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CAPACITOR ACOUSTO-ELECTRIC TRANSDUCER AND METHOD OF MAKING THE SAME

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The present invention is directed to an acousto-electric transducer or capacitor microphone and to a method for making such a transducer involving the use of a rigid dielectric porous body as a support means for one plate of the transducer whereby to make a compact, rigid construction.

The invention contemplates the use of a body of rigid dielectric porous material such as sintered glass, ceramic or the like preferably generally cylindrical in shape. On one end of the body there is provided as by grinding or a similar process a planar face, such face being interrupted by a multiplicity of small holes or openings because of the nature of the porous body. For best results the openings should aggregate not more than about ten percent of the area of the face. A thin electrically conductive layer or coating constituting the back electrode is now deposited upon the face by suitable means such as evaporation, sputtering, painting or a plating technique. The layer is desirably a metal having good resistance to corrosion and, if the transducer is to be used in a hot environment, to thermal deterioration as well. Titanium is preferred. When the metal is applied by evaporation or sputtering, the source should be of appreciable area, or a point source should be moved about during the depositing process so that as much as possible of the metal on the planar face will be in electrical contact with all other metal deposited upon the planar portions of the face. Thus such contact may be provided by portions of metal which find their way into the openings in the face and serve to bridge between metal layers on planar portions one or more of which might be electrically isolated in the absence of such internal bridging. At the same time care must be taken to minimize the possible filling or plugging of the openings which would impede acoustic access to the interior of the body, and the metal may thus be said to constitute an interrupted layer. The porosity of the body should be such that the holes have transverse dimensions of no more than about one-tenth of the inter-electrode spacing. Thus the spacing may typically be one mil or less and the holes about one-tenth mil across.

Means are provided for mounting a flexible metallic diaphragm constituting the front electrode in spaced parallel relation with the back electrode or metallic layer on the planar face. Preferably such mounting is accomplished by grinding or otherwise forming a rim or lip disposed peripherally around the planar face, the lip terminating forwardly in a flat peripheral face or area lying in a plane parallel to the central planar area and spaced therefrom by the desired inter-electrode distance. Metal may be deposited upon the peripheral area simultaneously with the deposit of metal on the central area, and the two areas may then be electrically separated from one another by removing, as by grinding or the like, a strip of deposited metal surrounding the central area. The diaphragm may then be soldered, brazed or otherwise fixed to the metallized peripheral area. Alternatively, the peripheral area may be shielded or otherwise protected from having metal deposited thereon and the diaphragm held in place by suitable mechanical means such as the in-turned lip of a shell or casing housing the transducer.

The construction as above set forth produces a transducer which is exceptionally rugged and economically

made. Since the back plate or electrode is physically supported by the porous body, the metal layer constituting the plate can be very thin, thus minimizing stray capacitance. Desirably the depth of the body is so chosen as to minimize acoustic interference by waves which may be reflected to the front from the back. Thus the depth is desirably not substantially greater than one-eighth the wave length of the highest working frequency to be handled; for normal audio work the depth may accordingly be no greater than about 100 mils and preferably about 70 mils. When the transducer is housed in a casing, it may be vented to atmosphere by a small port in the rear casing wall. However the vent will of course be omitted when the transducer is used not as a microphone but as, for example, a fluid pressure measuring instrument where the absolute position or excursion of the diaphragm from a known position is measured by the capacitance of the device.

It is to be noted that the small size and rigid construction of the present invention permit a comparatively high resonant frequency in the microphone.

An object of the invention is accordingly to provide a capacitor transducer wherein one plate consists of a metallic layer on a porous dielectric body. Other objects are to provide such a device of improved strength and economy of construction as compared with prior capacitor transducers; to disclose a capacitor construction particularly well adapted for very small transducers and providing a high resonant frequency whereby to minimize distortion in the selected frequency range; to disclose a construction of a capacitor which is advantageous in use either as a microphone or as a pressure measuring instrument; and for other and additional purposes as will be understood from a study of the following description of exemplary embodiments of the invention taken in connection with the accompanying drawing in which:

FIG. 1 is a sectional view taken along a diameter of a capacitor transducer embodying the present invention.

FIG. 2 is a fragmentary view on a greatly enlarged scale of the porous body of the transducer taken as indicated by the arrows II—II of FIG. 1.

FIG. 3 is a plan view of a porous body of dielectric material constituting a blank for the production of a transducer in accordance with the present invention.

FIG. 4 is a sectional view along a diameter of the dielectric porous body of FIG. 3 with a coating of conductive material such as metal deposited on the central face and on the peripheral face of the body.

FIG. 5 is a sectional view similar to FIG. 4 except showing the metallic coating removed from around the central flat surface whereby to electrically insulate the peripheral metallic coating from the central metallic coating.

FIG. 6 is a sectional view of the device of FIGS. 3, 4 and 5 with the diaphragm or front electrode added to the transducer.

Referring now in detail to the drawing there is shown in FIG. 1 a sectional view of a transducer in accordance with the present invention. The transducer includes a body indicated generally at **10** and constituting a porous mass of dielectric material such as sintered glass, ceramic or the like which may desirably be generally cylindrical in shape. The left surface **11** of the body **10** as seen in FIG. 1 is made planar as by grinding. On this surface there is deposited by suitable means a thin coating or layer **12** of electrically conductive material preferably a metal such as titanium. As appears in the enlarged view of FIG. 2, the porous body **10** is made up of a large number of openings or holes with the body portion of the material between the openings or holes ground to be planar, the planar parts being of somewhat irregular

shape. Thus the planar areas having metallic coating 12 are interrupted by a number of openings or holes giving acoustic access to the interior of the body, some of the openings being indicated at 14, 15, 16 and 17.

Here and there there may occur a small planar island such as 18, but the porosity characteristics of the body are chosen to minimize such occurrences. In general it is desirable that the openings such as 14, 15, 16 and 17 constitute only a small proportion—preferably of the order of ten percent—of the total central planar area 11 having the metallic layer 12 deposited thereon. It is to be noted that even an island such as 18 may be in electrical contact with the major conductive layer 12 by reason of metal as indicated for example at 19 which finds its way into the interior of the porous body and is deposited therein. It is however important to minimize the filling up or plugging of the openings in the body, so that at least some acoustic access is available into the body.

The metallic or other electrically conductive coating on the planar surface 12 constitutes the fixed or back electrode of the present transducer. Means are provided in the device of FIG. 1 for facilitating the mounting of the second electrode or front electrode of the device. Thus there is provided an annular rim or lip 20 surrounding the central planar area 11 and having a peripheral planar surface 21 lying in a plane parallel to and spaced from the plane of the central area 11, the spacing being equal to the inter-electrode spacing of the transducer as determined by design considerations and the like. It is to be understood that such spacing as is shown in FIG. 1 has been exaggerated for clarity of presentation and is not necessarily intended to be to scale relative to the remainder of the device as there shown. The peripheral planar area 21 on lip 20 may be covered with a metallic layer 22 similarly to the central area. A flexible diaphragm indicated generally at 24 constitutes the front electrode and is mounted upon the peripheral planar surface 21 of the annular rim 20 and fixed to layer 22 thereon by suitable means such as brazing, welding or the like. Desirably the entire structure is housed within a suitable shell or casing indicated generally at 30 and desirably made of electrically conductive material such as metal so that it can be electrically grounded in whatever circuit it may be used. In the present instance the housing 30 may include a front inturned annular lip 32 which when formed as shown in FIG. 1 serves to retain the entire structure in assembled relation. In accordance with conventional microphone construction there may also be provided a protective guard or grill indicated generally at 36 and mounted upon the shell 30 by suitable means, the guard including a plurality of openings 38 therethrough. The back or fixed electrode consisting of the central metallic layer 12 is connected to an external circuit by a lead 40 extending through the porous body and through the rear wall of the casing 30, being insulated from the latter by suitable conventional means 42. Lead 40 may extend to one of a pair of terminals 44 and 46, the latter terminal being connected to the body or shell 30 by a lead 48. It will be understood that the terminals 44 and 46 are adapted to be connected to an external circuit of known arrangement, the details of which form no part of the present invention. Means may be provided for venting the interior of the shell to atmosphere, such means being here shown as including a vent 50 extending through the rear wall of the shell 30. Since the present device exhibits a changed capacitance upon movement of diaphragm 24, it may be used to measure fluid pressure or other phenomenon causing such movement. In this case the vent 50 is omitted so that the absolute position of the diaphragm can be a measure of the external fluid pressure.

The device in accordance with the present invention may be conveniently and efficiently made as illustrated in FIGS. 3, 4, 5 and 6. In FIG. 3 is shown the body of porous dielectric material 10 having a generally circular

central area 11 surrounded by the annular peripheral lip 20. The central area and lip are ground or otherwise machined to make them parallel to one another. A metallic electrically conductive layer is formed or produced upon the central flat area 11 of the body 10 and, desirably, also upon the peripheral area of the lip 20, a sectional view of the body as thus coated being shown in FIG. 4. As there shown the electrically conductive layer 22 on the peripheral area 21 of lip 20 and the similar layer 12 on the central planar area 11 of the body are joined by a metallic layer 23 on the inner surface of the lip 20 surrounding central area 12. In FIG. 5 this electrically conductive layer 23 has been removed as by grinding or the like so that the layer 22 and layer 12 are now electrically separated as described in connection with FIG. 1. In FIG. 6 the front electrode or flexible diaphragm 24 is fixed in place, being soldered, brazed or otherwise fixed to the electrically conductive layer 22 on the peripheral lip 20, the diaphragm 24 being spaced from the metallic layer 12 in the central area by the desired inter-electrode spacing.

It will be understood that modifications and changes from the specific forms of the invention hereinabove described and illustrated will occur to those skilled in the art. All such changes not departing from the spirit of the invention are intended to be embraced within the scope of the appended claims.

I claim:

1. In a capacitor transducer having a fixed plate and a diaphragm, in combination:
   a porous body of rigid dielectric material having a flat surface bearing thereon a layer of electrically conductive material constituting the fixed plate;
   an electrically conductive diaphragm;
   and means mounting said diaphragm in spaced parallel relation with the layer on said surface.

2. The invention as stated in claim 1 including a rigid housing receiving said body therein and in continuous sealing contact with the diaphragm periphery.

3. The invention as stated in claim 2 wherein said housing is electrically conductive.

4. The invention as stated in claim 1 wherein said body is generally cylindrical in shape, said flat surface is circular and the body includes an annular lip surrounding the flat surface and projecting therefrom and forming the mounting means for said diaphragm.

5. In a capacitor transducer having a fixed electrically conductive plate and an acoustically movable electrically conductive diaphragm in spaced parallel relation with the plate, the provision of a porous body of rigid dielectric material bearing thereon an apertured layer of electrically conductive material constituting said fixed plate.

6. In a method of making a capacitor transducer having a generally cylindrical rigid body of porous dielectric material the steps of: forming on one end of said body a virtually planar front face and a rim surrounding said face and in a plane parallel thereto and spaced forwardly therefrom; depositing a layer of electrically conductive material on said face and rim; removing a continuous portion of said layer inwardly of the rim whereby to electrically isolate the rim and face layers; and fixing to said rim a metallic diaphragm extending parallel to the face and spaced therefrom.

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