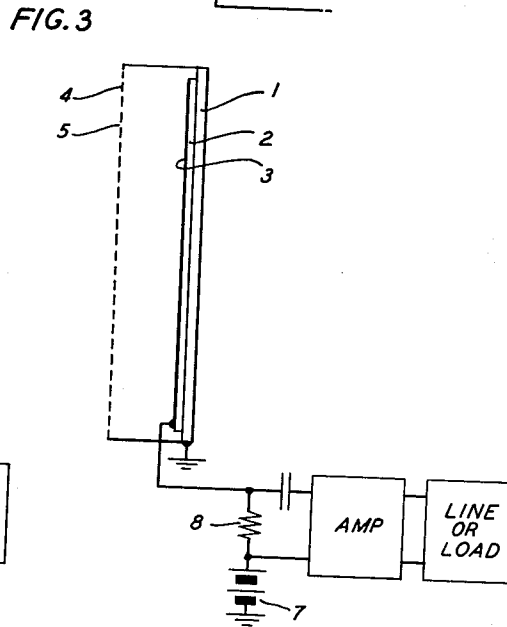
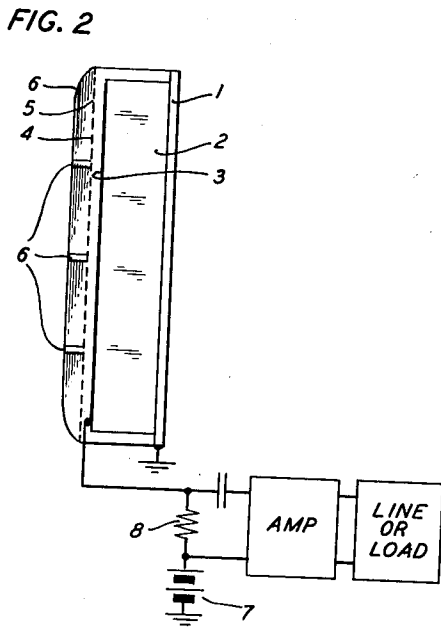
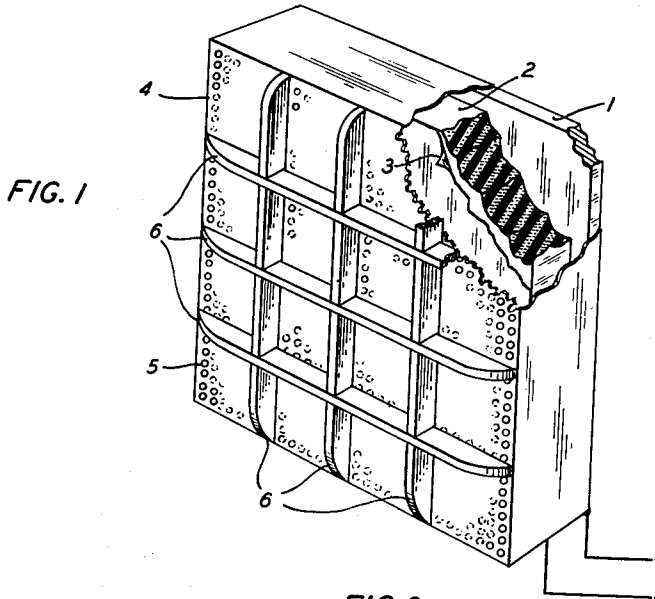


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DIRECTIONAL TRANSDUCER
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DIRECTIONAL TRANSDUCER

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6 Claims. (Cl. 179-111)

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This invention relates to electroacoustical transducers and has for its principal object to provide a transducer of improved sensitivity and high directional characteristic.

Of the many known types of microphones, the condenser microphone is generally accepted as being the freest from distortion. A condenser microphone normally comprises a rigid metal back plate and a flexible metal diaphragm stretched or mounted by its edge in a plane parallel to the face of the back plate and closely spaced and insulated therefrom. When sound waves impinge on the diaphragm it moves toward or away from the back plate, thus changing the capacitance provided therebetween. When this capacitance is charged electrically, alteration of the capacitance manifests itself as an alteration in the potential difference between the back plate and the diaphragm and this potential difference is normally applied by way of an amplifier to utilization apparatus of any desired variety.

As a practical matter the high quality of the reproduction obtainable with a condenser microphone of conventional construction is largely offset by its low sensitivity. This low sensitivity is due to the fact that allowance must be made in its construction for a maximum amount of bowing of the diaphragm without its touching the back plate. Such bowing exists statically due to the electric attraction between the back plate and the diaphragm under the influence of the polarizing charge, and it is increased dynamically under the influence of impinging sound waves. This construction also limits the microphone to comparatively small dimensions since, for a given sound pressure and therefore a given amount of bowing, the safe static separation between diaphragm and back plate increases with the linear dimensions. In turn, the restriction to dimensions which are small compared with the sound wavelength at ordinary voice frequencies prevents the conventional condenser microphone from having a directional characteristic. It is, therefore, generally employed as a non-directional device.

As compared with such condenser microphones of the prior art, the present invention furnishes a condenser microphone of simplified construction which, while it is mechanically rugged, may be of practically unlimited linear dimensions with consequent proportional increase in sensitivity and almost proportional increase in directivity. The microphone of the invention comprises a rigid back plate, preferably of metal, on which is fixedly mounted a sheet of compliant dielectric material such as foam rubber, while a sheet of metal foil is mounted on the opposite face of the rubber sheet. The foil is not otherwise supported. In particular it is not in any way supported at its periphery or edge. The rubber being uniform in thickness and compliance, the peripheral parts of it move with the

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same amplitude as the central parts; i. e., there is no bowing, either static or dynamic. Therefore, no bowing need be allowed for in the construction of the unit and its linear dimensions may be as large as desired; for example, they may be comparable with the wavelength at voice frequencies. This large size makes for high sensitivity and for directivity.

The unit is preferably protected from the influence of stray electric fields by the provision of a perforated metal shield which may be connected to the rigid back plate and to a point of fixed potential such as ground.

When sound waves impinge on the unit they pass through the perforations in the screen electrode to exert varying pressures on the metal foil. The latter therefore move inwardly toward the back plate and away from the perforated screen or vice versa, thus altering both the capacitance which obtains between the foil and the back plate by way of the dielectric foam rubber and, at the same time the capacitance which obtains between the foil and the perforated shield by way of the air between them. These two capacitance variations take place in opposite phase and it is therefore important that one of them, connected to a utilization circuit, be made large as compared with the other. In a transducer which forms the subject matter of a co-pending application of W. E. Kock, Serial No. 261,222, filed December 12, 1951, the rubber sheet is thin, e. g., about one-sixteenth inch in thickness while the air space between the foil and the perforated screen is much thicker, e. g. about one inch. In this transducer the capacitance variation of interest is between the foil and the back plate. Both because of the spacing ratio and because the dielectric constant of the rubber exceeds that of air, this capacitance variation greatly exceeds the undesired one between the foil and the perforated shield and it is applied by way of suitable connections to a utilization circuit.

In a preferred modification, the rubber is made much thicker, e. g., about one inch in thickness. It is thus more accurately described as a slab. Furthermore it is preferably of a dielectric constant not differing greatly from that of air. A perforated shield, which may be stiffened by ribs or fillets, is spaced very closely from the foil electrode. In this modification the capacitance variation between the foil electrode and the screen greatly exceeds that through the foam rubber slab, and it is this one which is applied to the utilization circuit. This preferred modification offers the advantage that the mechanical impedance of the thick rubber slab may be made so low as closely to match the impedance of air.

The invention will be fully apprehended from the following detailed description of a preferred embodiment thereof, taken in connection with the appended drawings, in which:

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Fig. 1 is a perspective diagram showing in section a microphone constructed in accordance with the invention;

Fig. 2 is a circuit diagram showing the microphone of Fig. 1 in section and circuit connections for energizing it and utilizing its output; and

Fig. 3 is a similar diagram showing a modification of the microphone of Figs. 1 and 2.

Referring now to the drawings, Figs. 1 and 2 show a rigid back plate 1 which is preferably of metal, for example, sheet steel about one-quarter inch in thickness. It may be in the form of a rectangle, for example three feet wide and two feet high. Mounted on one face of this back plate is a slab 2 of foam rubber of about one inch thickness extending throughout all of its area, except for a small margin of one inch or so at each of its edges. The rubber slab should be as uniform as possible in thickness, in its mechanical properties, and in its electrical properties, particularly its dielectric constant.

Mounted on the opposite face of this rubber slab is a sheet 3 of light metal foil, for example aluminum foil of two to five ten-thousandth inch thickness. It is supported by cementing to the outer face of the rubber sheet and in no other way. If preferred, the metal foil may be formed in place simply by spraying the face of the rubber sheet with metallic paint.

To prevent absorption of moisture in the foam rubber, which might promote electrical leakage between the metal foil electrode and the back plate, the back plate is first covered with a coat of a non-hygroscopic material of high dielectric strength such as enamel and the edges of the rubber sheet may be sealed against absorption of moisture, for example with beeswax. A front electrode 4 in the form of a stiff sheet of metal of one-sixteenth inch thickness or so and preferably stiffened by fillets 6, is mounted close to and parallel with the foil electrode 3 in its rest position. It is generously perforated with holes 5 to permit impinging sound waves to pass through it and actuate the foil electrodes. This perforated electrode is preferably connected electrically to the rigid back plate. Thus the front electrode 4 and the back plate 1 act together to shield the foil electrode 3 from the action of stray electric fields.

A potential of 300 volts or so, derived from a source 7 and positive or negative as may be convenient, is applied by way of a high resistor 8 to the foil electrode 3, the back plate 1 and the screen 4 being connected to a point of fixed potential such as ground. In operation, when voice waves impinge on the unit the resulting pressure variations cause minute movements of the foil electrode 3 toward and away from the screen electrode 4, thus altering the capacitance which obtains therebetween by way of the air between them. In consequence voice frequency voltage variations appear across the high resistor 8 and these may be amplified and utilized in the conventional fashion.

Fig. 3 shows the transducer of the aforementioned application of W. E. Kock. Here the thick foam rubber slab of Fig. 1 is replaced by a thin sheet of about one-sixteenth inch thickness; i. e., its thickness is small compared with the thickness of the air space between the metal foil electrode and the perforated front electrode. The larger of the two capacitances is now that between the foil electrode and the perforated front electrode, and, because the separation of these

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electrodes is much greater than the separation, through the rubber sheet, between the foil electrode and the back plate, the variations of the latter capacitance are likewise much greater. They are applied by way of an external circuit, which may be identical with that described above in connection with Figs. 1 and 2 to a utilization circuit of any desired variety. This form of the invention offers the added advantage that the dielectric constant of foam rubber is greater than that of air, so that a sheet of foam rubber whose thickness is about one-sixteenth inch furnishes a larger capacity and so a more sensitive microphone, than does a like thickness of air.

In view of the principle of reciprocity it is obvious that the transducer of the invention may also be employed as a sound reproducer to convert received electric energy in the form of voltage variations across the dielectric foam rubber, or across the air space which separates the foil electrode from the perforated shield, into minute movements of the foil electrode which thus generate sound pressure waves. The term "transducer" is for this reason employed in the appended claims to designate the unit structurally independently of whether it effects a conversion from acoustic energy into electric energy or vice versa.

What is claimed is:

30 1. An electroacoustical transducer which comprises a rigid back plate, a slab of compliant insulating material fixed to said plate, said slab being under uniform lateral tension throughout its extent and being supported solely and throughout its extent by the said rigid back plate, a limp, unstretched sheet electrode fixed to said compliant slab, said sheet electrode being supported solely by said slab, a rigid perforated sheet of conductive material mounted coplanarly with and close to said sheet electrode and insulated therefrom, said slab having a thickness at least twenty times the spacing between said sheet electrode and said rigid perforated sheet, the material and thickness of said compliant slab being proportioned to adjust the mechanical impedance of said slab to a value approximating that of said acoustic wave-supporting medium, whereby acoustic waves in an acoustic wave-supporting medium may pass through the perforations of said conductive sheet to cause movements of said electrode against the restoring force of said compliant slab, thereby to alter the separation of said electrode from said perforated sheet, and so the capacitance therebetween.

55 2. Apparatus as defined in claim 1 wherein said rigid back plate is of metal.

3. Apparatus as defined in claim 1 wherein said sheet electrode is of metal foil.

60 4. Apparatus as defined in claim 1 wherein said sheet electrode comprises a solid residue of metallic particles applied to the compliant slab in liquid form by a spraying process.

5. Apparatus as defined in claim 1 wherein said compliant slab is of foam rubber.

65 6. Apparatus as defined in claim 1 wherein said back plate, said compliant slab and said sheet electrode are substantially coextensive in area.

70 References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,777,170	Kyle	Sept. 30, 1930
2,284,039	Bruno	May 26, 1942