

June 18, 1957

W. E. KOCK

2,796,467

DIRECTIONAL TRANSDUCER

Filed Dec. 12, 1951

FIG. 1

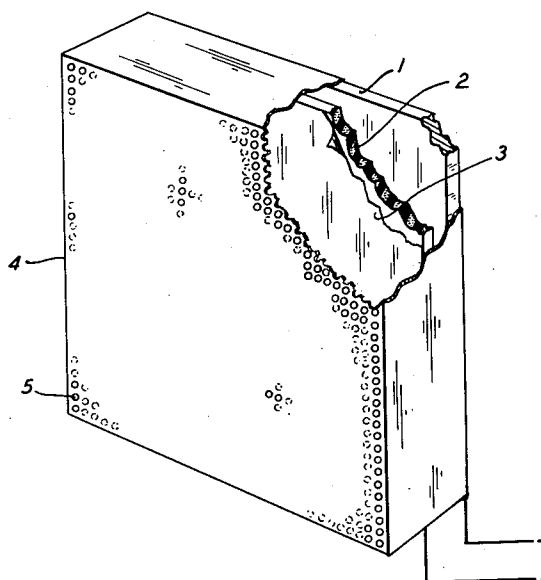


FIG. 2

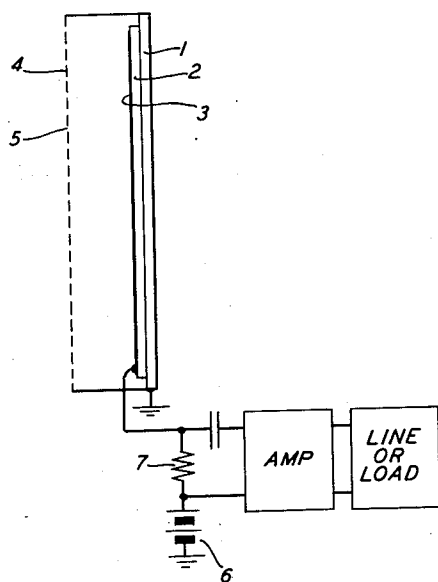
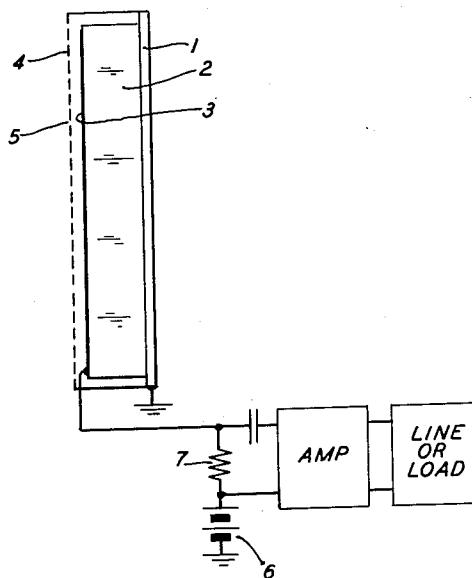


FIG. 3



INVENTOR
W. E. KOCK
BY *Harry C. Hart*
ATTORNEY

1

2,796,467

DIRECTIONAL TRANSDUCER

Winston E. Kock, Basking Ridge, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 12, 1951, Serial No. 261,222

1 Claim. (Cl. 179—111)

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

Of the many known types of microphone, the condenser microphone is generally regarded as 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 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

2

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 moves 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 preferred modification 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 modification 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 modification of the invention which is claimed in a copending application of T. Aamodt, Serial No. 261,286, filed December 12, 1951, the rubber sheet is replaced by a slab, e. g., about one inch in thickness and preferably of a dielectric constant not differing greatly from that of air. A perforated shield is spaced very closely from the foil electrode. In that 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. While this modification draws no advantage from the dielectric constant of the rubber, this disadvantage tends to be offset by the fact that, with a foam rubber slab of about one inch thickness, its mechanical impedance 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:

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 sheet 2 of foam rubber extending throughout all of its area, except for a small margin of one inch or so at each of its edges. The rubber sheet 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 sheet is a sheet 3 of light metal foil, for example aluminum foil one one-thousandth inch in thickness. It is supported

3

as 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-hydroscopic 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.

To prevent the unit from being influenced by stray electric fields the foil electrode may be shielded as by a metal screen 4 in the form of a sheet of metal of one-sixteenth inch thickness or so, generously perforated with holes 5 to permit impinging sound waves to pass through the screen and actuate the foil electrodes. This shield or screen is mounted on and connected to the rigid back plate 1.

A potential of 300 volts or so, derived from a source 6, and positive or negative as may be convenient, is applied by way of a high resistor 7 to the foil electrode, 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 3 toward and away from the back plate 1 thus altering the capacitance which obtains therebetween by way of the dielectric rubber sheet 2. In consequence voice frequency voltage variations appear across the high resistor and these may be amplified and utilized in the conventional fashion.

Fig. 3 shows a modification of the invention which is the subject of the copending application of T. Aamodt, above referred to. In this modification the thin foam rubber sheet 2 has been replaced by a slab whose thickness is large compared with the thickness of the air space between the metal foil electrode and the perforated shield. The larger of the two capacitances is now that between the foil electrode and the shield and, because the separation of its electrodes is much less than the separation, through the rubber sheet, between the foil electrode and the back plate, the variations with capacitance are likewise much greater. They are applied by way of an external circuit which may be identical with those 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 mechanical impedance of a sheet of foam rubber whose thickness is about one inch approximately matches that of the air through which the impinging sound waves reach the unit.

4

In view of the principle of reciprocity it is obvious that the novel transducer 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:

An effective directional electroacoustic transducer operable at frequencies of the speech frequency range comprising a plane flat sheet of resilient, spongy, dielectric material of homogeneous texture and having two like major parallel surfaces, a rigid backing plate having a plane flat surface, means for fixedly mounting on said plane flat surface one major surface of said dielectric sheet in such a manner that substantially no stresses are created in said sheet, the junction between said plate and said sheet surfaces constituting the sole mechanical support of said sheet, a thin flexible coating of conductive material, means for firmly securing by adhesion said coating and the other major surface of said sheet throughout the entire area of contact therebetween in such a manner that said flexible coating is supported solely by said other major surface and substantially no stresses are created in either said dielectric sheet or said coating, and means for connecting electrically to said coating and said backing plate, whereby each point of said coating is free from transverse stresses and can move freely in a direction normal to said other major surface in response to electrical energy applied to said electrical connecting means or to speech frequency acoustic wave energy impinging upon said coating.

References Cited in the file of this patent

UNITED STATES PATENTS

1,584,613	Comstock	May 11, 1926
1,644,387	Kyle	Oct. 4, 1927
1,777,170	Kyle	Sept. 20, 1930
2,130,946	Bruno	Sept. 20, 1938
2,231,159	Gerlach	Feb. 11, 1941
2,284,039	Bruno	May 26, 1942
2,509,310	Moreland	May 10, 1950
2,567,407	Slaymaker	Sept. 11, 1951