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[54] **ELECTROSTATIC TRANSDUCER**

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[21] Appl. No.: **337,843**

Related U.S. Application Data

[63] Continuation of Ser. No. 95,856, Dec. 7, 1970, abandoned.

[30] **Foreign Application Priority Data**

Dec. 11, 1969 Japan 44-99939

[52] **U.S. Cl.** .... **29/594,** 29/592, 179/100.41 B, 179/111 E, 307/88 ET, 317/262 A

[51] **Int. Cl.** **H04r 31/00**

[58] **Field of Search** .... 29/592, 594; 317/262; 307/88 ET; 179/111 E, 100.4 B, DIG. 10

[56] **References Cited**

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3,705,312	12/1972	Sessler et al.	307/88 ET

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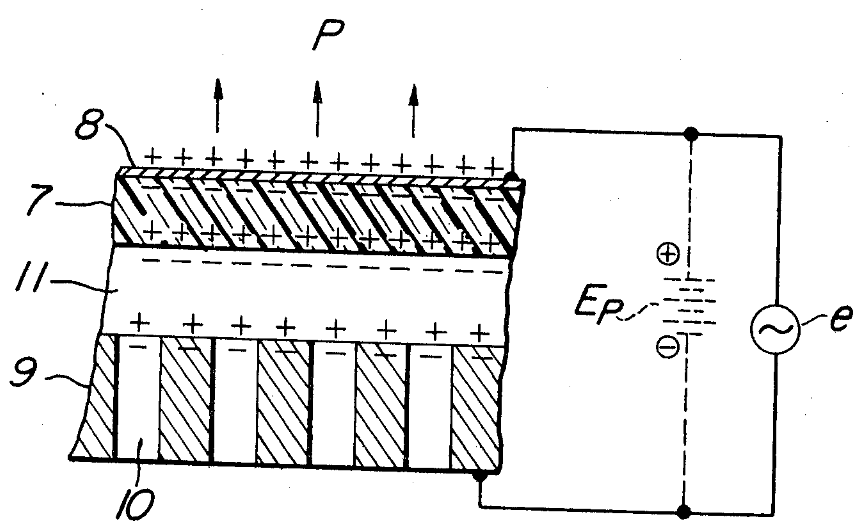
[57] **ABSTRACT**

A method of permanently polarizing a vibratile film of an electrostatic transducer wherein an unpolarized film having a vibratile electrode on one side is disposed in a housing opposite a stationary electrode. A saturation polarizing voltage is applied across the vibratile and stationary electrodes to cause a ferroelectric phenomenon due to absorbed surface charges to occur in the vibratile film thereby permanently polarizing the vibratile film.

3 Claims, 3 Drawing Figures



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2 Sheets-Sheet 1

FIG. 1

PRIOR ART

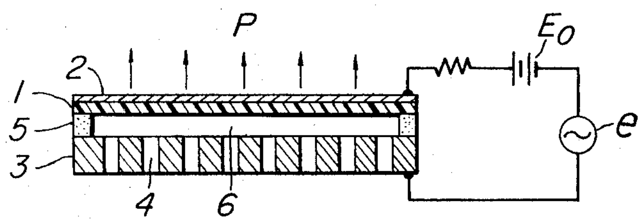

FIG. 2

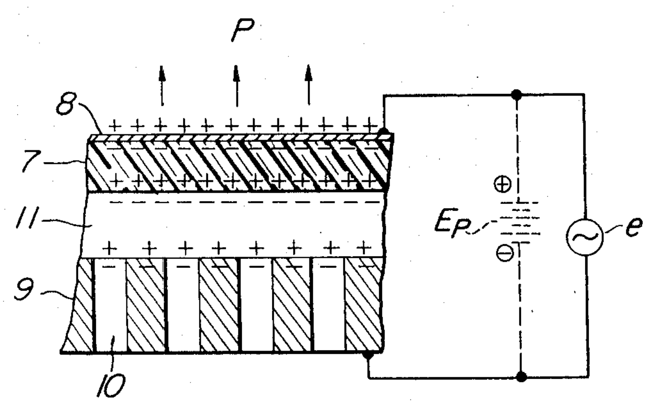

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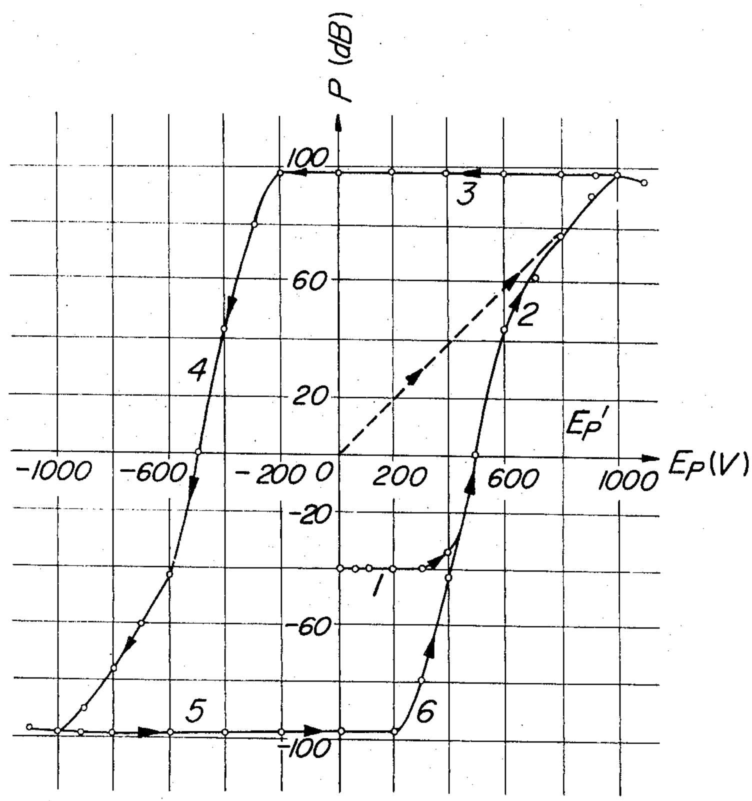
FIG. 3



ELECTROSTATIC TRANSDUCER

This is a continuation of application Ser. No. 95,856, filed Dec. 7, 1970.

This invention relates to electrostatic type transducers and particularly to a method of polarizing vibratile films of electrostatic type transducers, the vibratile films being permanently polarized after assembly into housings of the transducers.

The electrostatic type speaker, which is a typical example of the electrostatic type transducer, is usually of a construction as shown in FIG. 1 of the accompanying drawing. It comprises a vibratile film **1** of a dielectric material, a vibratile electrode **2** formed by depositing or applying a thin film of such material as aluminum and silver on one surface of the dielectric film **1** and vibrating therewith, and a stationary electrode **3** of a punched or perforate metal plate extending parallel to the vibratile film **1** to form a capacitor therewith. The stationary electrode **3** and vibrating film **1** are spaced apart a certain distance conforming to the required acoustic characteristics of the speaker by a spacer **5** defining an air layer **6** between them.

In the speaker of the above construction, when a-c signal e is superimposed upon a high d-c bias voltage E_0 between both the electrodes **2** and **3**, the vibratile film **1** is vibrated to produce sound pressure.

Since the prior-art transducer of the above type requires a high d-c bias voltage E_0 for its operation, the speaker unit should include a high voltage generator and an amplifier as well as requiring a signal input terminal and a bias voltage terminal, which imposes restriction on the speaker design and leads to increased manufacturing cost. Besides, the high d-c bias voltage will cause ionization of the air layer between the electrodes, thus rendering the speaker sensitivity unstable resulting in various practical problems. Further, the use of high d-c voltage is quite hazardous to the user.

To overcome the above drawbacks inherent in the electrostatic type transducer requiring a high d-c bias voltage, it has been proposed to use the "Electret" film of a plastic material, which is pre-polarized and carries a permanent electostatic charge, as the vibratile film of the transducer. To pre-polarize the plastic film, however, it is usually necessary to heat the film by placing it in a strong d-c electric field up to its softening point, maintaining it at this temperature for a certain period of time and then cooling it down to room temperature in a certain period of time, thereby to freeze or thermoset its polarization. However, this requires not only special equipment but also complicated manufacturing steps, and a long time (1 to 0.5 hours) so that the productivity is inferior and the manufacturing cost is high.

Accordingly, an object of the invention is to provide an electrostatic type transducer, which is free from the drawbacks inherent in the conventional transducers of these types and can be readily manufactured.

Another object of the invention is to provide an electro-static transducer for use in speakers, microphones, pickups and the like, which uses a vibratile film of a dielectric material such as a plastic film capable of readily undergoing permanent polarization by the forced induction and charge attraction phenomena therein and does not require any d-c bias voltage for operation.

According to the invention, a permanent electrostatic charge can be built up on the vibratile film by applying a saturation polarizing voltage thereto for several seconds, so that it is possible to manufacture an electrostatic transducer without requiring any d-c bias voltage for its operation. Thus, it is possible to provide an electrostatic transducer requiring no high voltage generator nor any bias voltage terminal. Also, the ionization of the air layer between the electrodes can be eliminated to greatly improve the sensitivity and other characteristics of the transducer.

Further, the saturation polarizing voltage may be applied after the vibrating film is assembled into a housing of the transducer such as a speaker, microphone and the like. By so doing, the initially built-up charge may be prevented from being otherwise neutralized during the assemblage.

The above and other objects, features and advantages of the invention will become more apparent from the following description with reference to the accompanying drawing, in which;

FIG. **1** is a schematic representation of a prior-art electrostatic transducer;

FIG. **2** is a schematic representation of the principles underlying the invention; and

FIG. **3** is a graph representing a hysteresis characteristic showing the relationship between the polarizing voltage E_p applied on the vibrating film and the residual sound pressure after the removal of the polarizing voltage E_p, which is obtained when the vibratile film according to the invention is applied to a speaker.

Aluminum was deposited on one surface of an unpolarized film of polyethylene terephthalate known commercially by the trademark "Tetron" and assembled, as a vibratile film, into a housing of an electrostatic speaker, opposite to a stationary electrode and spaced therefrom so as to define an air layer. It was found that a capacitor consisting of the deposited aluminum layer, Tetron film, air layer and the stationary electrode exhibits a hysteresis phenomenon due to absorbed surface charges. This phenomenon is thought to correspond to a ferroelectric phenomenon of a ferroelectric substance and is called a hysteresis of the condenser speaker with absorbed surface charges.

Referring now to FIG. **2**, which shows the principles underlying the invention, reference numeral **7** designates a vibratile dielectric thin film made of such plastic material as "Tetron" and "Mylar" trademarks for polyethylene terephthalate, polymide or a fluorine compound resin, for instance ethylene tetrafluoride or polyvinylidene fluoride, capable of readily undergoing permanent polarization. It should be noted that the vibratile film initially undergoes no polarization. The vibratile film is provided on one side with a vibratile electrode **8** as in the conventional transducer. It faces a stationary electrode **9** formed with a plurality of small pores **10.** The stationary electrode **9** and the vibrating film **7** define an air layer **11** therebetween. Thus, a capacitor consisting of the electrodes **8** and **9** in between which the vibratile film **7** and the air layer **11** are sandwiched is formed.

With the above construction, a saturation polarizing voltage E_p is applied between the electrodes **8** and **9** such that the residual charge on the vibratile film **7** is maximum, thereby causing the ferroelectric phenomenon in the vibratile film **7** due to absorbed surface charges and thereby polarizing permanently the vibratile film **7.** The direction of polarization when the polarizing voltage E_p is applied between the electrodes **8** and **9** is shown in FIG. **2.** Even when the polarizing voltage E_p is removed, the vibratile film **7** still remains polarized. This is thought to be due to spontaneous polarization for permanent superficial charge attraction. That is, spontaneous polarization is induced in the vibratile film **7** and permanent superficial charge attraction consequently occurs in opposite surfaces of the vibratile film **7.**

FIG. **3** shows a hysteresis of the output residual sound pressure p, which is obtained by using a "Tetron" film **15** microns thick as the vibratile film **7** and applying input signal e after the application of polarizing voltage E_p for several seconds without heating the vibratile film **7.**

If the plastic film is absolutely non-polarized, the sound pressure would follow the dashed plot in FIG. **3.** Actually, the plastic film usually bears a slight negative charge. Due to the natural charging of the film and the application of the polarizing voltage, the output sound pressure will start to follow segment **1** of the plot and then follow through segments **2, 3, 4, 5** and **6** of the hysteresis curve in the mentioned order back to segment **2** as the polarizing voltage on the non-polarized film is increased in small steps to a positive maximum, then reduced to a negative maximum and back to the positive maximum.

When the transducer according to the invention is applied to a speaker, the saturation polarizing voltage E_p', which may be applied for several seconds, is determined by the speaker construction, the thickness of the air layer **11** and the material of the vibratile film **7.** After removal of the saturation polarizing voltage a residual sound pressure of about 98 db may be obtained, so that the bias voltage becomes unnecessary.

What is claimed is:

1. A method of polarizing a vibratile film of an electrostatic transducer, the vibratile film being permanently polarized after assembly into a housing of the transducer, comprising the steps of:

preparing an unpolarized vibratile film of a plastic material capable of readily undergoing permanent polarization,

depositing a vibratile electrode of metal on one surface of said vibratile film, said vibratile electrode being vibratile with said vibratile film,

assembling into a housing of the transducer said vibratile film on which said vibratile electrode is deposited,

disposing in said housing a stationary electrode of metal opposite to said vibratile film and spaced therefrom so as to define an air layer, and

then applying across said vibratile and stationary electrodes a saturation polarizing voltage without heating said vibratile film, said saturation polarizing voltage causing ferroelectric phenomena in said vibratile film due to absorbed surface changes to maximize the residual charge on said vibratile film after the removal of said saturation polarizing voltage, thereby polarizing permanently said vibratile film.

2. A method according to claim **1,** wherein the plastic material is selected from a group consisting of polyethylene terephthalate, a polyimide resin and fluorine compound resin.

3. A method according to claim **1,** wherein the saturation polarizing voltage is applied for several seconds.

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