Jan. 6, 1953 H. C. PAGE 2,624,853

FLEXURE-SENSITIVE ELECTROMECHANICAL TRANSDUCER DEVICE

Filed Dec. 28, 1948

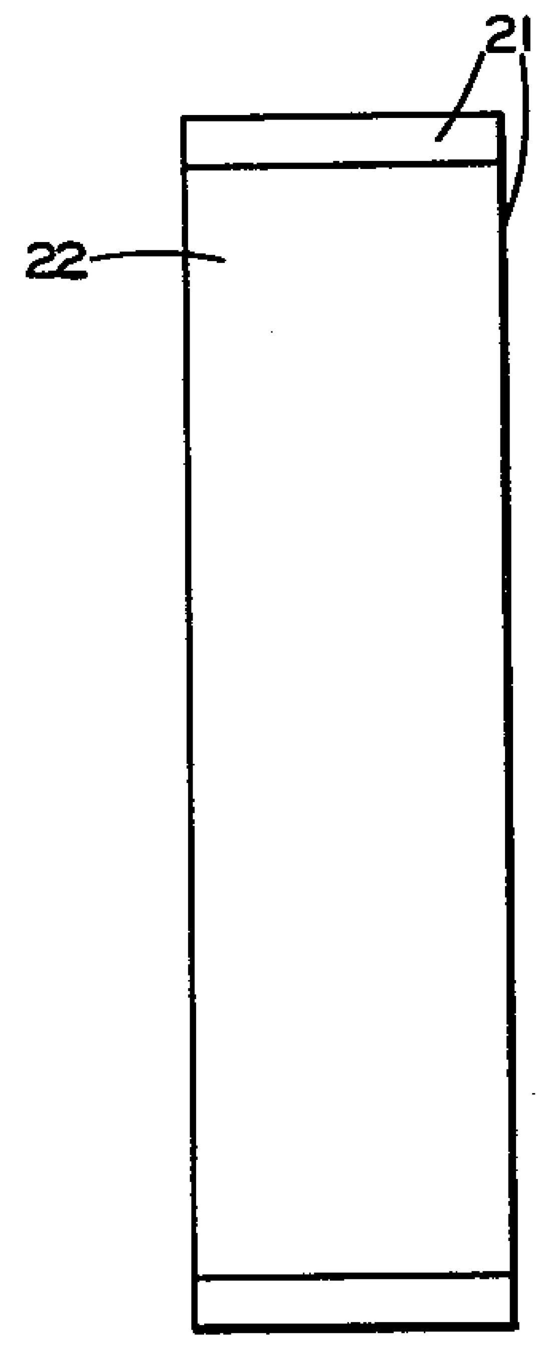

FIG. 1

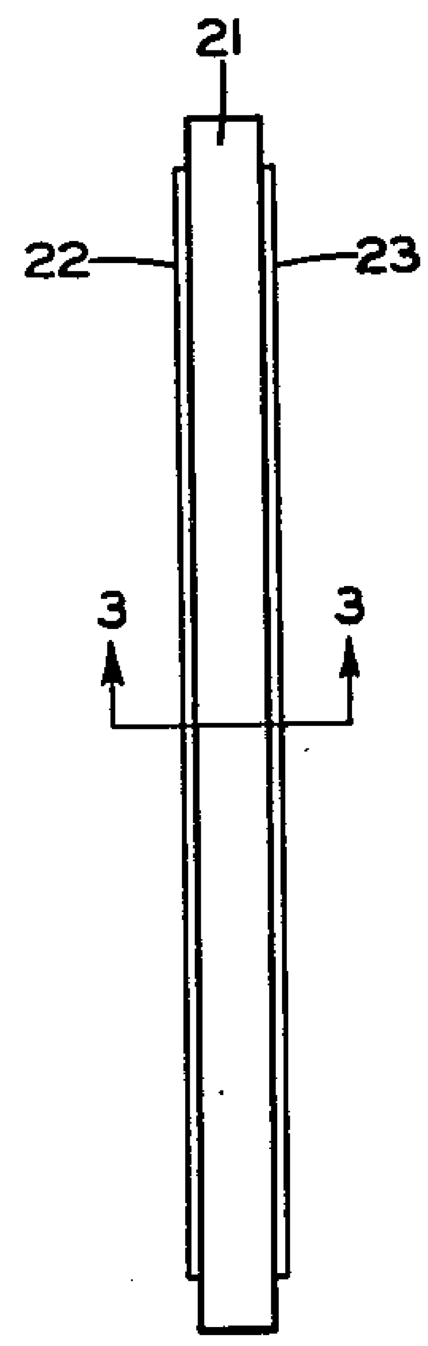

FIG. 2

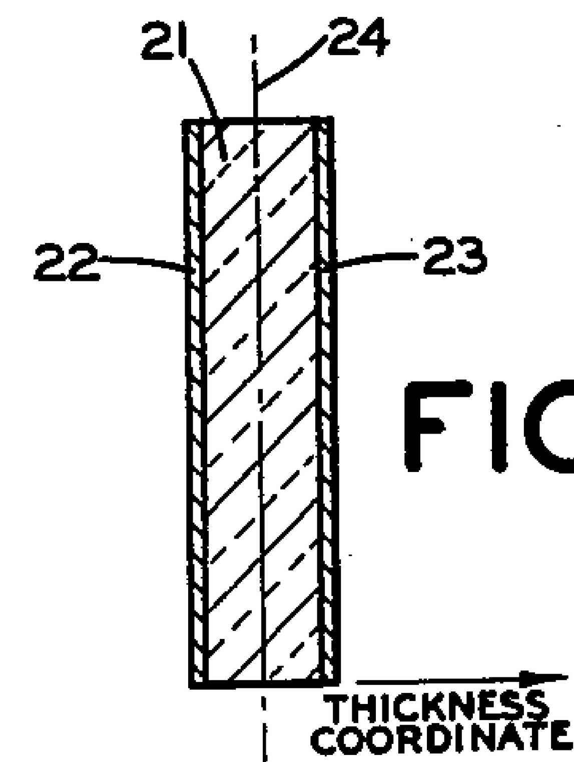

FIG. 3

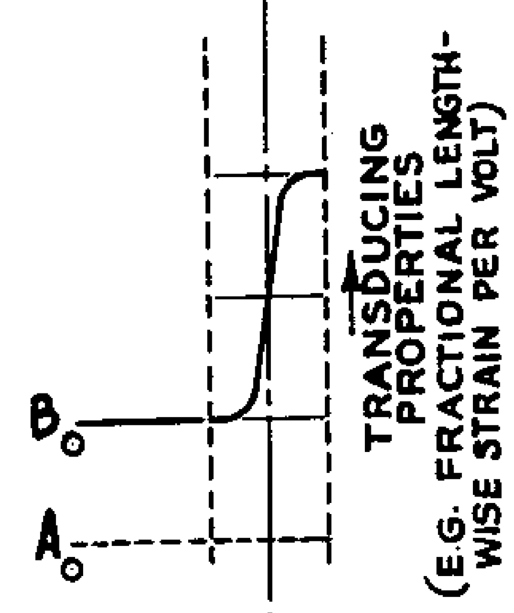

FIG. 4

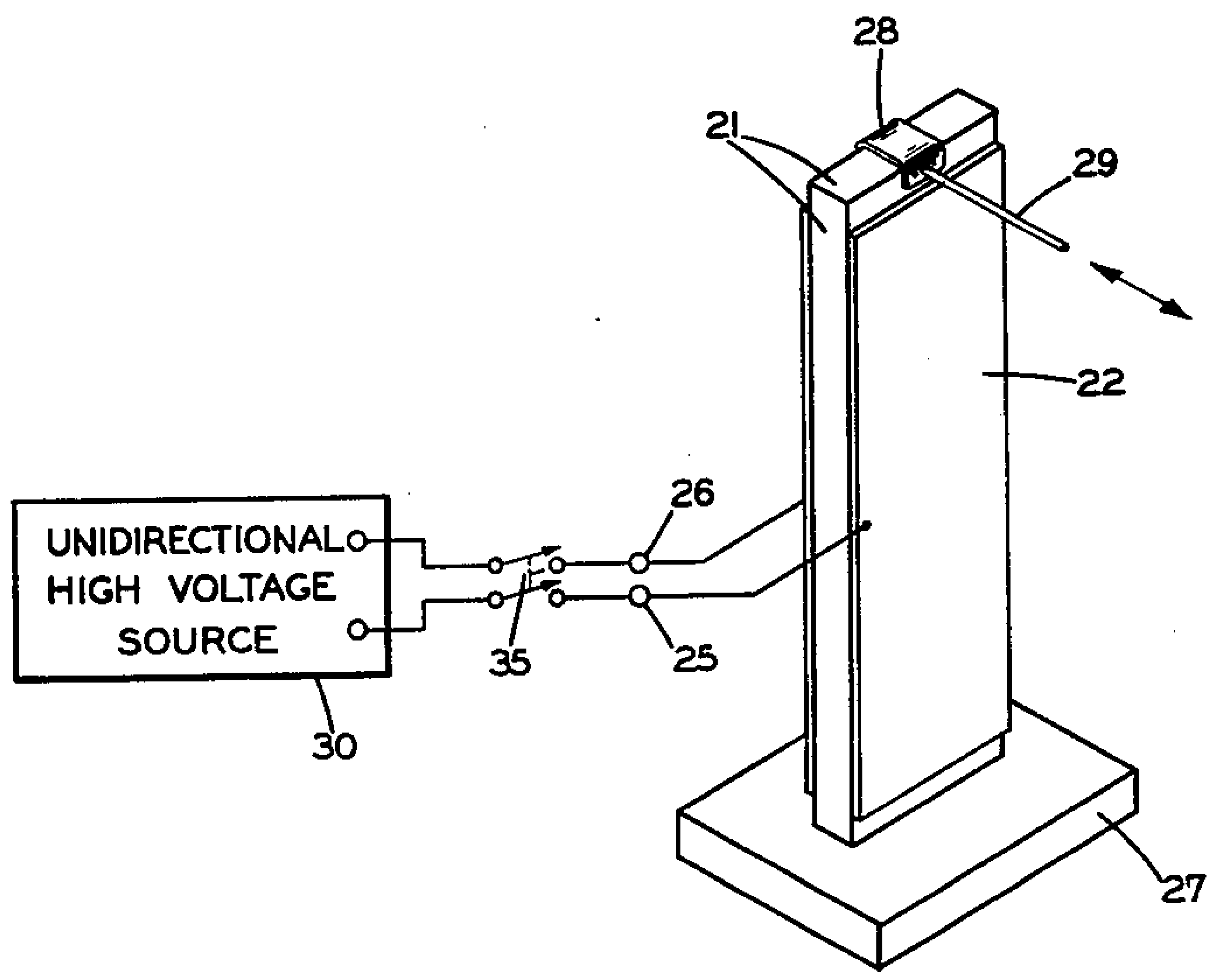

FIG. 5

INVENTOR.
HARRY C. PAGE
BY
Harris A. Mumma Jr.
ATTORNEY

Patented Jan. 6, 1953 2,624,853

UNITED STATES PATENT OFFICE

2,624,853

FLEXURE-SENSITIVE ELECTROMECHANICAL TRANSDUCER DEVICE

Harry C. Page, Cleveland Heights, Ohio, assignor to The Brush Development Company, Cleveland, Ohio, a corporation of Ohio

Application December 28, 1948, Serial No. 67,741

11 Claims. (Cl. 310—8.5)

1

This invention relates to a transducer device electromechanically sensitive to flexure of an electromechanically responsive element of the device. More particularly, this invention relates to a bending-sensitive or twisting-sensitive electromechanical transducer device in which such flexure is associated with mechanical reaction between portions of the device containing material having electromechanical properties such that the individual portions tend to deform to different extents during transducing from electrostatic-field energy to mechanical energy.

In an application for Letters Patent of the United States, Ser. No. 67,645, filed concurrently herewith in the name of Hans G. Baerwald and assigned to the same assignee as the present invention, there is disclosed and claimed, inter alia, a flexure-sensitive transducer device comprising a substantially homogeneous body having a substantial variation with location through the body of local electromechanical transducing properties. One portion of the body is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic. In accordance with one arrangement disclosed and claimed in the aforementioned application, the homogeneous body is made up of permanently polarizable polycrystalline dielectric material, such as barium titanate material, which has been conditioned by polarization with a unidirectional potential but a portion of which has been at least partially depolarized by localized heating. The depolarized portion exhibits practically no electromechanical response. This portion may occupy, say, about half of the thickness of a plate-shaped or bar-shaped body. When the body is subjected to an incremental electric potential, the portion which remains polarized tends to expand or contract. Mechanical reaction of this electromechanically responsive portion with the relatively unresponsive half of the body produces a flexure, specifically, a bending of lines extending lengthwise in the body, as upon the application of a signal potential across the bar. Conversely, subjecting the bar to a bending displacement results in the appearance of a signal potential across the bar.

The transducer device just described is very simple structurally and exhibits several advantages over the composite bender devices of the prior art, which comprise two or more electroded plates or bars cemented together along major surfaces thereof. Nevertheless, a transducer device utilizing such a homogeneous polycrystalline body requires careful treatment to produce different electromechanical transducing-response characteristics in different portions of the body. When the variation of the local electromechanical transducing properties within the body is achieved by electrostatic prepolarization and subsequent localized heating, only a repetition of this type of careful treatment, utilizing special equipment, can reinstate the device to a useful condition if the polarization subsequently should be disturbed, for example by inadvertent heating or by the application of an unusually high signal potential to the body.

2

Accordingly, it is an object of the present invention to provide a new and improved transducer device electromechanically sensitive to flexure which substantially avoids some or all of the limitations and disadvantages of devices hitherto proposed.

It is another object of the invention to provide a new and improved transducer device electromechanically sensitive to flexure and of simpler construction than composite bender and twister devices.

It is a further object of the invention to provide a new and improved flexure-sensitive transducer device which may be made to exhibit a reasonably high efficiency of transducing after a simple electrical treatment.

It is a still further object of the invention to provide a novel, inexpensive, and easily manufactured flexure-sensitive transducer device.

In accordance with the invention, a transducer device electromechanically sensitive to flexure comprises a body substantially free of structural discontinuities, having one substantial portion of a dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a dielectric material of different composition which upon the application of said unidirectional potential has a transducing-response characteristic as between the aforementioned signal energies substantially different from the first-mentioned transducing-response characteristic. The transducer device also comprises means including electrodes adjacent to the body for translating currents associated with the electrostatic-field signal energy transduced in the body, and mechanical means for translating the motion associated with the flexure during transducing, this flexure being associated with mechanical reaction between the one portion of the body having the aforesaid substantial transducing-response characteristic and the other portion of the body. As will appear hereinbelow, the last-mentioned portion of the transducer body, which is of different composition from that of, and has a different transducing-response characteristic from that of, the first-mentioned portion, may have a substantially zero-valued transducing-response characteristic and thus may exhibit no appreciable electromechanical response except by mechanical reaction with the first-mentioned responsive portion.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, Figs. 1 and 2 are front and side elevations respectively of an electroded body useful in devices embodying the present invention; Fig. 3 is an enlarged sectional plan view of this body taken in the direction indicated **3, 3** on Fig. 2; Fig. 4 is a representative rough plot of the variation of the transducing properties of the body illustrated in section in Fig. 3 as a function of the thickness of the body as viewed in Fig. 3; and Fig. 5 is a perspective view of a transducer device in accordance with the present invention, this device comprising the body illustrated in Figs. 1–3 and being shown in association with apparatus, illustrated schematically, for use in a preliminary electrical conditioning of that body.

Referring now to Figs. 1 and 2 of the drawing, there is illustrated a thin body **21** substantially free of structural discontinuities, having one substantial portion, more specifically a thickness portion underlying and near the right hand major surface of the body, of a dielectric material, and having another substantial portion, more specifically a thickness portion underlying and near the left hand major surface, of a material of different composition. The body **21** may be designated as noncomposite, since it is not made up of two or more structurally distinct parts. A composite structure, on the other hand, is one made up of two or more distinct parts or elements with a pronounced interface therebetween. From a mechanical point of view the body **21** is substantially free of structural discontinuities, although it is recognized that the microstructure of the body may involve numerous crystalline grains having numerous interfaces but nevertheless forming essentially one structure as regards bending or twisting forces applied to the body within the elastic limits. On the other hand, it is clear that the composite elements of the prior art, constructed by cementing together two or more plates, have macroscopic interfaces. These interfaces constitute structural discontinuities, in which, due at least in part to imperfect adhesive properties of the cement used and to the different shear moduli of elasticity of the materials in the regions of the interfaces and elsewhere in the elements, a substantial fraction of the mechanical energy available during transducing may be lost.

Generally speaking, a difference in the composition of the material in two portions of the noncomposite body **21** may be realized in either of two ways. In one, the variation in composition through the body is a gradual one. In the other, materials of substantially different composition are present in neighboring portions of the body, but the molecular or crystal grain structure of the materials is so similar that the structural properties, determined at least to a large extent by the cohesive properties of the constituent materials and by their moduli of elasticity, are substantially unbroken throughout the body. If one of the conditions just mentioned is not met, an interface usually appears within the body and the noncomposite character of the body is destroyed. However, it should be understood that local imperfections of a small and scattered nature may appear, for example in the regions of greatest variation of the composition of the material, without destroying the essentially noncomposite nature of the body.

Electrodes **22** and **23** are affixed to the body **21** in opposed positions adjacent respectively to the left hand and right hand major surfaces of the body, as viewed in Figs. 2 and 3. As illustrated, unelectroded margins are provided at the top and bottom of the body to facilitate mechanical connections to the body. The electrodes are shown with exaggerated thickness for ease of illustration. They may be made, for example, of conductive metal foil or of suitably bonded graphitic particles.

In the cross-sectional plan view of Fig. 3, the body **21** appears as a unitary member with the central plane of its thickness indicated by the center line **24**. The body **21** has the shape of a plate or bar of small thickness compared with the other dimensions thereof. The one thickness portion of the body underlying the electrode **23** and disposed generally parallel to the major surfaces of the body is of a dielectric material, preferably a polycrystalline barium titanate material, which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy. The other thickness portion of the body, underlying the electrode **22**, is disposed generally parallel to and laterally of the aforesaid one portion and is of a dielectric material, preferably a polycrystalline dielectric material such as a modified barium titanate containing strontium titanate, which upon the application of the unidirectional potential as mentioned above has a transducing-response characteristic as between the mechanical and electrostatic-field signal energies substantially different from the first-mentioned transducing-response characteristic of the one portion.

It should be noted here that the effective transducing response of a portion of the body **21** may be determined in part by the distribution in the thickness direction of the body of the signal potentials, corresponding to the electrostatic-field signal energy in the body, which appear between the opposed electrodes **22** and **23**. As a result of the differences in the composition of the materials making up the various portions of the body, this distribution may not be the same throughout the thickness of the body; in other words, the field strength may be different in different thickness portions of the body. Accordingly, for the purposes of this specification and the appended claims, it is convenient to define a transducing-response characteristic as the relationship between incremental mechanical energy per unit volume of the portion of the body under consideration and an incremental potential difference across the entire thickness of the body, the incremental potential difference being associated with an incremental electrostatic field energy per unit volume. It is assumed, as ordinarily is the case, that polarizing and signal electric fields are applied in the thickness direction of the body, but fields may be applied across a larger dimension.

In the manufacture of bodies of the type described from polycrystalline titanate materials, portions of the body may be shaped by methods known generally in the ceramic arts. Thus a thin sheet of a dielectric material containing primarily raw barium titanate may be formed by any conventional method. After eventual ceramic firing, a sheet of such a material may be conditioned to provide the desired response by the application, whenever convenient and for a predetermined period of time of the order of a minute, of a unidirectional potential. The fired material is susceptible to remanent electrical polarization, which persists after removal of the unidirectional polarizing potential. When so polarized, this material exhibits a transducing-response characteristic which not only is of a high magnitude but also is substantially linear over a reasonable amplitude range. This large linear response probably depends both on the polarization of the dielectric material by the unidirectional voltage applied thereto and on the properties of the material before polarization. Another thin sheet of a dielectric material containing primarily a raw barium-strontium titanate may be formed in like manner. The two flat sheets of unfired material are placed with a major surface of each sheet in mutual contact and subjected to a ceramic-firing operation in which the interface between the two sheets is eliminated as far as structural properties are concerned by the incipient sintering or vitrifying action which occurs during ceramic firing. After polarization in a manner described hereinbelow, the resulting noncomposite body includes corresponding portions with substantial electromechanical transducing properties in the portion containing primarily barium titanate and substantially weaker transducing properties in the other portion. However, in view of the care which must be taken to insure substantial elimination of the interface during firing, it is preferable to form a single body of raw barium titanate and treat this body chemically to modify the composition of the barium titanate material in one portion of the body.

Thus, the body may be modified near one major face only by controlled amounts of a material capable of reacting with, or forming a solid solution with, the barium titanate to form in a portion of the body a material which after ceramic firing is not susceptible to appreciable remanent electrical polarization upon the application for a predetermined period of the unidirectional polarizing potential, or which at least is susceptible to remanent electrical polarization of only a lower order of magnitude than the remanent polarization of the untreated barium titanate material in the remainder of the body at ordinary temperatures of use. The portion of the body so treated may exhibit no appreciable transducing-response characteristic, at least in the absence of a continuously applied unidirectional potential of high intensity. A material which might be used for this purpose is strontium oxide, which is best used in the form of strontium titanate. The treatment may be carried out during the ceramic-firing operation, the material being applied to the side of the body being treated in finely powdered form along with small amounts of a suitable flux. During the firing the applied material penetrates to a depth depending on the quantities of material used and the temperature cycle used in the firing. To the extent of such penetration the composition of the material is modified, forming a barium-strontium titanate. Where the ratio in moles of strontium to barium titanate exceeds about 25:75 or 30:70, the portion so modified retains practically no remanent polarization at room temperature.

Another material capable of forming a solid solution which may yield better results in a chemical treatment of the type just described is finely powdered stannic oxide, with which a flux also may be mixed. The desired modification of the barium titanate material can be achieved with penetration of less material into the titanate body than is the case with the strontium oxide material. Thus, modification of portions of the barium titanate material by incorporation therein of several percent by weight of stannic oxide greatly decreases the ability of that portion of the material to exhibit transducing-response characteristics when the fired body is conditioned by the application of a unidirectional polarizing potential. Whether the modifying material contains strontium or tin, smaller amounts of modifying material may suffice if, during or following a temporary application of a polarizing field, the temperature of the body is raised moderately to remove remanent polarization in the portion of the body whose composition has been modified as described above. If the temperature remains below about 110° or 120° C., the unmodified polarized barium titanate material retains all or most of its remanent polarization.

The noncomposite electromechanically sensitive body **21** also may be formed by dipping a backing structure successively into aqueous dispersions of barium titanate and barium-strontium titanate to form contiguous layers of the two materials. This double-dipping process is disclosed and claimed in an application for Letters Patent of the United States, Serial No. 67,695, filed concurrently herewith in the name of Charles K. Gravley and assigned to the same assignee as the present invention, which issued on September 25, 1951, as Patent No. 2,569,163. The body formed by this double-dipping operation then is subjected to ceramic-firing temperatures to establish a ceramic bond between the two layers which is substantially as strong as the bonds within the individual layers and of substantially similar elastic properties.

A plate-like body substantially free of structural discontinuities, formed by one of the methods suggested hereinabove, has portions of different compositions differing substantially in their electromechanical transducing properties. At least the portions of this body which have relatively high values of the local electromechanical transducing properties are of a dielectric material, and in the examples mentioned hereinabove all portions of the body are of dielectric materials. Transducer bodies free of structural discontinuities and containing one portion of a dielectric material and another portion of a conductive material are described and claimed in the aforementioned copending application of Hans G. Baerwald. Often it is convenient to form the portions of different compositions so that these portions have equal thicknesses. Then one portion lies generally to one side of the center line **24**, Fig. 3, while the other portion lies generally to the other side. In the region of the central plane the composition may change more or less abruptly in the thickness direction, but without any abrupt change in the structural properties of the material. However, it may be desirable to make one portion considerably thicker than the other. For example, the portion having a transducing-response characteristic of greater value may be thinner than the relatively unresponsive portion. In such a case a chemical treatment for modifying the composition of the body near one side thereof might become impractical, and it is recommended that the body be formed by the method of the aforementioned copending Gravley application. Some of the considerations which determine the optimum relative thicknesses of the two portions of the body are discussed in the aforementioned copending Baerwald application.

When the two layers of the body **21** have approximately equal thicknesses but have different transducing-response characteristics upon conditioning by a polarizing potential, the transducing properties of the body may be represented in a rough manner by the plot of Fig. 4. This plot is aligned vertically below the transverse sectional view of Fig. 3 so that the thickness coordinate of the plot coincides with the thickness direction in the body as viewed in Fig. 3. The plot of Fig. 4 may represent roughly the variation of the transducing properties through the thickness direction when the left hand portion of the body is a barium-strontium titanate material and the right hand portion is polarized barium titanate material. In this case only the right hand portion has substantial transducing-response characteristics, and the transducing properties of the regions of the body near the left hand major surface have zero values. In this connection it appears from the above that the different polarization of the left hand portion advantageously is a polarization of a lower order of magnitude than the polarization of the right hand portion, with a corresponding transducing-response characteristic of a lower order of magnitude than that of the right hand portion. In the case where the material of the left-hand portion has a lower or residual, but substantial, local response, it will appear that a transducing property represented along the vertical coordinate in the plot of Fig. 4 would have a zero value below the plotted curve, as at A_0. As a matter of fact, if the left hand portion is a barium-strontium titanate of the 70:30 mole ratio mentioned hereinabove, when a preliminary polarizing field has been applied and removed, the different polarization of the left hand portion actually is zero with a negligible transducing-response characteristic therein, since this material does not retain remanent polarization. In this case it appears that the local transducing properties in the regions near the left hand surface have zero value, as indicated at B_0 in Fig. 4. In both cases the two portions of the body just underlying its two major surfaces are of materials providing the extremes of values of transducing-response characteristics in the body, which is a condition conducive to efficient bending response of the body during transducing. The mechanism of the bending response, involving mechanical reaction between portions of the body having different values of the electromechanical transducing properties, will be explained in greater detail hereinbelow. Any of various local transducing properties might be plotted to

obtain the curve of Fig. 4. The transducing-response characteristic as defined hereinabove may be used. In this case, for example, after polarization of the body **21** by the application of a high unidirectional voltage across the electrodes in the thickness direction, the mechanical effect of the electric signal field resulting from the application of unit voltage across the electrodes is plotted for small volume portions of the body. The mechanical effect may be expressed in terms of the fractional or percentage distortion or strain in a direction lengthwise of the body, since this type of strain is associated with the desired bending response.

A complete transducer device which is electromechanically sensitive to flexure is illustrated in Fig. 5. The device includes the body **21** and its electrodes, electrical circuit terminals **25** and **26** connected to the electrodes **22** and **23** respectively, a base **27** in which the lower end of the body **21** is mounted securely, a yoke **28** secured to the top of the body **21**, and a rod **29** projecting horizontally from the yoke **28** for providing mechanical coupling to the device.

For use in the initial polarization of the body **21** a unidirectional high voltage source **30** may be connected to the terminals **25** and **26**, for example through a double pole switch **35**. This connection may be made before or after the complete transducer device represented in Fig. 5 is assembled, and the switch **35** may be closed for a short period of time to provide the transducing properties represented by the plot of Fig. 4. A polarizing potential approaching the breakdown voltage of the material may be used, although lower polarizing potentials often are entirely adequate. The polarizing connections to the terminals **25** and **26** then may be removed and used in polarizing other transducer bodies. However, if the body should lose its polarization for any reason, for example by inadvertent heating above 120° C., the polarizing arrangement easily may be employed again to restore the desired transducing properties.

In operation, the device of Fig. 5 may be used to transduce from electrical energy to mechanical energy or vice versa. In either case, suitable electrical and mechanical means, not shown, are connected to the electrical-circuit terminals **25**, **26** and to the mechanical-coupling rod **29**, respectively, to serve as source means or utilization means for the energy transduced, as the case may be. Accordingly, the device comprises means including the electrodes **22**, **23** and the terminals **25**, **26** for translating currents associated with the electrostatic-field signal energy transduced in the body. Furthermore, the yoke **28** and rod **29** constitute mechanical means for translating the motion associated with the flexure of the body **21** during transducing. Thus a bending flexure of the body is associated with mechanical reaction between the right hand portion having the substantial transducing-response characteristic and the left hand portion of the body. Application of a signal potential acros the terminals **25** and **26** causes the more responsive right hand thickness portion to expand or contract, resulting in a net bending motion by mechanical reaction with the opposed thickness portion having negligible electromechanical response. The bending motion is translated by longitudinal motion of the rod **29** in the direction of the double arrow, Fig. 5. Conversely, moving the rod **29** longitudinally causes a bending of lines extending vertically in the device, resulting in the appearance of a signal potential across the terminals.

Under some circumstances, for example for operation at high temperatures or with high electric signal potentials, it may be desirable to maintain the unidirectional voltage source of Fig. 5 connected to the transducer body during operation. With such continuous polarization the response of a barium titanate material is higher than with remanent polarization. The unresponsive portion of the body then advantageously is a barium titanate containing barium stannate, which may be introduced by treatment with stannic oxide as mentioned hereinabove. The response of the modified titanate is much less than that of the barium titanate even under a continuously applied polarizing field.

It is advantageous that the electromechanically unresponsive portion of the body 21, that is, the left hand portion as represented in Figs. 3 and 4 be of a dielectric material of a composition which has a higher dielectric constant than that of the material of the more responsive portion at predetermined operating temperatures, such as temperatures between 20° and 100° C. For example, a barium-strontium titanate may have a dielectric constant 3 or 4 times that of barium titanate, while barium titanate containing several weight percent of stannic oxide may have a dielectric constant about twice that of the unmodified barium titanate. When the electromechanically unresponsive portion has a higher dielectric constant, the several portions of the body act as a voltage divider made up of series capacitances. An electric potential appearing across the entire body then is associated with a higher field strength in the electromechanically responsive portion, increasing the transducing efficiency.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities having one substantial portion of a dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a dielectric material of different composition which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies substantially different from said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

2. A transducer device electromechanically sensitive to flexure comprising: a body of small thickness compared with the other dimensions thereof, substantially free of structural discontinuities, having one substantial thickness portion disposed generally parallel to the major surfaces of said body and of a dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial thickness portion disposed generally parallel to and laterally of said one portion and of a dielectric material of different composition which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies substantially different from said first-mentioned characteristic; means for translating currents associated with said electrostatic-field signal energy transduced in said body, including electrodes in opposed positions adjacent to said major surfaces of said body and between which signal potentials corresponding to said electrostatic-field signal energy may appear; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

3. A transducer device electromechanically sensitive to flexure comprising: a thin body substantially free of structural discontinuities, having near one of the major surfaces of said body one substantial portion of a dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having near the other major surface of said body another substantial portion of a dielectric material of different composition which upon said application of said unidirectional potential is effective to provide a transducing-response characteristic as between said signal energies substantially different from said first-mentioned characteristic, said one and said other portions being of materials providing the extremes of values of transducing-response characteristics in said body; means for translating currents associated with said electrostatic-field energy transduced in said body, including electrodes in opposed positions adjacent to said major surfaces of said body and between which signal potentials corresponding to said electrostatic-field signal energy may appear; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and other portions of said body.

4. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a polycrystalline titanate dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a dielectric material of different composition which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies sub-

stantially different from said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

5. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a polycrystalline barium titanate material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a polycrystalline dielectric material of different composition which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies substantially different from said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

6. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a polycrystalline barium titanate material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a polycrystalline titanate dielectric material of different composition which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies substantially different from said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

7. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a dielectric material which is susceptible to remanent electrical polarization to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a dielectric material of a different composition which is susceptible to remanent electrical polarization of only a lower order of magnitude than said remanent polarization of said dielectric material of said one portion to provide a transducing-response characteristic as between said signal energies lower in magnitude than said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

8. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a dielectric material which is conditioned by the application of a unidirectional electric potential to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a material of a different composition which has a higher dielectric constant than that of the material of said one portion at predetermined operating temperatures and which upon said application of said unidirectional potential has a transducing-response characteristic as between said signal energies of a lower order of magnitude than said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

9. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a dielectric material which is susceptible to remanent electrical polarization to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and having another substantial portion of a dielectric material of a different composition which has a higher dielectric constant than that of the material of said one portion at predetermined operating temperatures and which is susceptible to remanent electrical polarization of only a lower order of magnitude than said remanent polarization of said dielectric material of said one portion to provide a transducing-response characteristic as between said signal energies substantially lower in magnitude than said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

10. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities, having one substantial portion of a dielectric material containing primarily barium titanate which is susceptible to remanent electrical polarization to provide a substantial transducing-response characteristic as between mechanical signal energy and electrostatic-field signal energy, and

having another substantial portion of a dielectric material containing primarily a barium-strontium titanate not susceptible to appreciable remanent electrical polarization to provide a transducing-response characteristic as between said signal energies substantially lower in magnitude than said first-mentioned characteristic; means including electrodes adjacent to said body for translating currents associated with said electrostatic-field signal energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantial transducing-response characteristic and said other portion of said body.

11. A transducer device electromechanically sensitive to flexure comprising: a body substantially free of structural discontinuities and having polycrystalline dielectric portions of different compositions, including one portion containing primarily barium titanate with substantial electromechanical transducing properties and another portion containing primarily a barium-strontium titanate with substantially weaker electromechanical transducing properties and a higher dielectric constant than that of the material of said one portion at predetermined operating temperatures; means including electrodes adjacent to said body for translating currents associated with electrostatic energy transduced in said body; and mechanical means for translating the motion associated with said flexure during transducing, said flexure being associated with mechanical reaction between said one portion having said substantiial electromechanical transducing properties and said other portion of said body.

HARRY C. PAGE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
355,149	Dolbear	Dec. 28, 1886
1,803,274	Sawyer	Apr. 28, 1931
2,388,242	Arndt	Nov. 6, 1945
2,394,670	Detrick	Feb. 12, 1946
2,402,515	Wainer	June 18, 1946