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PIEZOELECTRIC CRYSTAL

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Fig. 1.

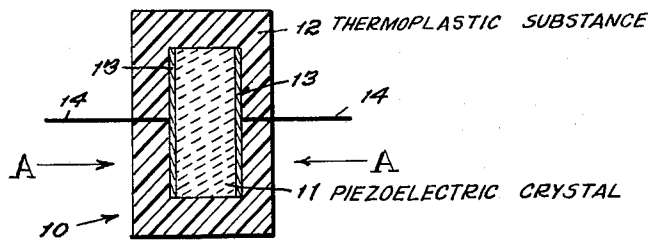
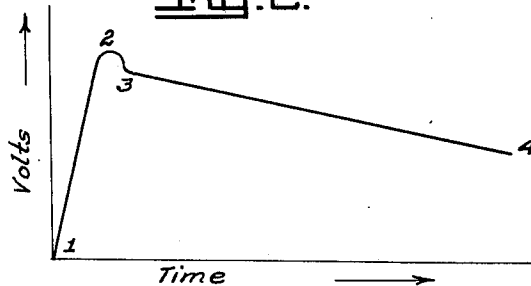


Fig. 2.



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PIEZOELECTRIC CRYSTAL

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5 Claims. (Cl. 310—8.3)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon.

The present invention relates to a device for generating electrical voltage and more particularly to a transducer having a controlled energy-release rate.

In the field of electrical generating devices of this type it has been the general practice to employ crystals or ceramics exhibiting the piezoelectric effect, e.g. barium titanate, which when acted upon by a mechanical force, generates electrical voltage of short duration. Although such devices have served the purpose, they have not proved entirely satisfactory under all conditions of service for the reason that considerable difficulty has been experienced in prolonging the effective period during which voltage is available as a result of such mechanical force.

Those concerned with the development of crystal type generating devices have long recognized the need for extending the effective time of such voltage availability. The present invention fulfills this need.

The general purpose of this invention, therefore, is to provide an electrical generating device which embraces all the advantages of similarly employed piezoelectric devices and avoids the aforesaid disadvantage. To attain this, the present invention contemplates an encapsulating sheath about a piezoelectric crystal which will determine the rate of voltage released from the crystal following the application of a compressive restraining force.

More particularly, a new and novel result is produced by combining the piezoelectric effect of crystals and ceramics with the "plastic-memory" characteristic of thermoplastic materials.

An object of the present invention is the provision of a piezoelectric device having a prolonged period of voltage availability.

Another object is to provide an electrical generating device which produces electrical energy at a particular time after the exertion of a mechanical force thereon.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the several figures and wherein:

FIGURE 1 illustrates a cross-sectional view of an encapsulated piezoelectric crystal; and

FIGURE 2 is a graph of the general voltage-time characteristics of a typical device illustrated in FIGURE 1.

Referring now more particularly to the drawings, there is shown in FIGURE 1 a conventional piezoelectric crystal 11, carrying two electrodes 13 on opposite surfaces thereof and being completely surrounded or encapsulated by a resilient thermoplastic substance 12, such as Lucite or nylon. Leads 14 are each connected to one of electrodes 13. Thermo-plastic substance 12 has "plastic-memory" characteristics, i.e., after this material is mechanically deformed at elevated temperatures, it has the

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ability to return to its original shape with the lapse of time. Rate of recovery is generally dependent on temperature, i.e., the higher the temperature (not to exceed the plastic flow limit), the faster the return to its original shape. Accordingly, when plastic encapsulated crystal 10 is deformed in compression along arrows AA at an elevated temperature and subsequently chilled to room temperature accompanied by removal of the deforming force, crystal 11 is retained under a compressive force by plastic sheath 12. Item 10 is subsequently exposed to a higher environmental temperature, plastic 12 commences to resume its original shape thereby releasing the compressive force on the crystal and generating a voltage which is picked off by leads 14. The foregoing is graphically observed by reference to FIGURE 2 where initial compression or deformation takes place along the curve from points 1-2, room temperature chilling and removal of deforming force exist from 2-3, and when exposed to elevated temperatures, resumption of original shape and generation of voltage occurs from points 3-4. It is of course to be understood that item 10 is ready for storage for a substantial period of time at point 3 on the graph to be withdrawn for use at any future convenient time. Thus it can now be seen that the rate of energy release is dependent, in part, on the particular elevated temperature chosen, i.e., the higher the temperature, the more rapid the release of energy.

It will be noted that the encapsulating plastic sheath 12 inherently protects crystal 13 against accidental breakage during handling, shipping or other. If an ordinary crystal is broken into pieces electrical current is not effectively generated or conducted therethrough. However, if crystal 11 were accidentally cracked the compressive forces on crystal 11 and electrodes 13, exerted by encapsulating plastic sheath 12, would inherently prevent separation of the pieces. Thus the pieces would remain in contact with one another and would still be capable of generating a current to some degree.

It is to be understood, of course, that the foregoing disclosure relates only to a preferred embodiment of the invention and that modifications or alterations may be resorted to without departing from the spirit of the invention and the scope of the appended claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An electrical generating device comprising the combination of a piezoelectric crystal held in a state of compression by a compressively stressed thermoplastic envelope encapsulating said crystal, the said compression being releasable upon introducing the encapsulating crystal and plastic envelope into an environment of elevated temperature not to exceed the plastic flow limit of the envelope.

2. A method of generating an electrical voltage and preserving it for controlled release at a later time, comprising the steps of encapsulating a piezoelectric crystal within a thermoplastic material so as to form an integral unit, introducing said unit into an environment of elevated temperature not to exceed the plastic flow temperature of the thermoplastic, applying a compressive deforming force to said integral unit in order to induce a compression into the stress sensitive faces of said crystal, chilling said unit to room temperature while maintaining the aforesaid compressive force thereon, removing said compressive force when said unit has reached room temperature, subjecting said unit to an elevated temperature to allow said deformed thermoplastic to assume its original shape and condition and generate a voltage.

3. A device for generating electrical energy, comprising a piezoelectric crystal, a pre-stressed thermoplastic envelope completely surrounding said crystal and in wall-to-wall relation therewith, whereby said envelope stresses

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said crystal, said device being placeable in a medium at a high temperature below that of the plastic flow limit of the envelope to release the pressure on said envelope and crystal and generate a voltage, and electrical leads from said crystal to a point of use of said voltage.

4. A method generating an electrical voltage and preserving it for controlled release at a later time comprising the steps of encapsulating a piezoelectric crystal within a thermoplastic envelope so as to form an integral unit, applying a deformative compressive stress to said unit in order to induce a compression into the stress sensitive faces of said crystal, releasing the compressive stress at a predetermined later time in order to permit said envelope to resume its original shape and condition thereby generating a voltage.

5. An apparatus for generating an electrical voltage

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comprising: a piezoelectric crystal, a compressively-stressed thermoplastic envelope encapsulating the crystal, said crystal being held in a state of compression by said compressively stressed envelope, the said compression being releasable upon introducing the encapsulated crystal and envelope into an environment of elevated temperature not to exceed the plastic flow limit of the thermoplastic envelope.

References Cited by the Examiner

UNITED STATES PATENTS

2,985,870 5/1961 Lindberg ----- 340—227

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KATHLEEN H. CLAFFY, *Examiner.*