May 26, 1953 G. N. HOWATT 2,640,165

CERAMIC TRANSDUCER ELEMENT

Filed May 29, 1948

Fig. 1.

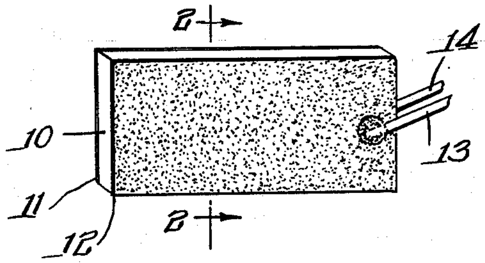


Fig. 2.

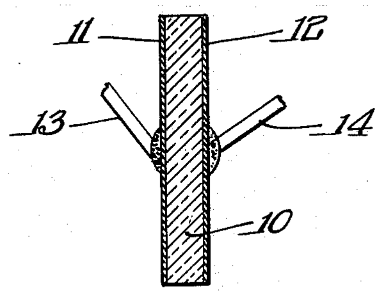


Fig. 3.

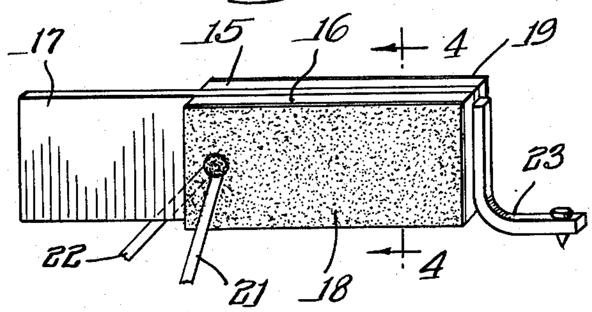


Fig. 4

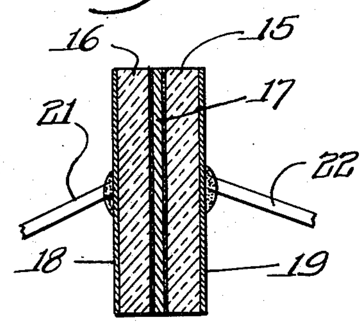


Fig. 5.

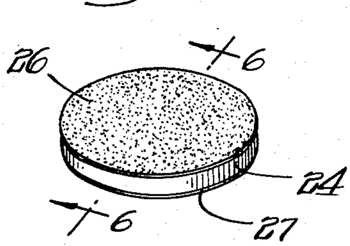
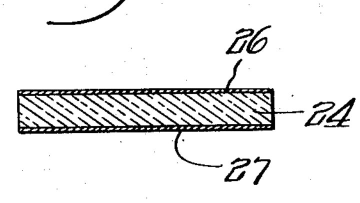


Fig. 6.



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UNITED STATES PATENT OFFICE

2,640,165

CERAMIC TRANSDUCER ELEMENT

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11 Claims. (Cl. 310—8.1)

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My invention relates to piezoelectric elements and methods of producing the same. The invention is also concerned with the production of transducer devices employing such piezoelectric elements.

Before the perfection of my invention as described hereinbelow, transducers of the type comprising phonograph pickups and hearing aid microphones have conventionally employed Rochelle salt crystals as a piezoelectric element, notwithstanding the definite limitations thereof. A Rochelle salt crystal cannot withstand a temperature much above 120 degrees F., and moisture, even as encountered in a very humid atmosphere, will dissolve the crystals sufficiently to render them useless. A great deal of the work in the design of equipment employing Rochelle salt crystals has to do with avoiding high temperatures, or humid conditions. I have discovered that titanate ceramics, particularly barium titanate, may be employed to produce piezoelectric elements and transducer devices which are free of the limitations which are incident to the use of Rochelle salt crystals.

In carrying out my invention, I first produce a thin section of ceramic, fire the same, apply silver electrodes in such a manner as to cause the same to adhere to the ceramic but produce a conducting electrode surface, and then permanently polarize or charge the ceramic by subjecting it to a direct current potential across the portion thereof between the electrodes, using a voltage somewhat below that calculated to cause break down but high enough to have a distinct polarizing action, and continue to apply the said direct current potential until the maximum piezoelectric property is developed. I have found that the element so produced and so charged is definitely permanently piezoelectric in character in that it will convert mechanical energy into electric energy or electric energy into mechanical energy in the same manner as in piezoelectric crystals heretofore known.

Other objects and detailed features of the invention will be apparent from a consideration of the following detailed description taken with the accompanying drawing wherein—

Fig. 1 is an enlarged perspective view showing a completed element;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1, Fig. 2 being enlarged with respect to Fig. 1;

Fig. 3 is an enlarged perspective view showing a completed transducer;

Fig. 4 is a sectional view on the line 4—4 of Fig. 3;

Fig. 5 is a perspective view showing a button type of element; and

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5.

Looking now first at Figs. 1 and 2, the element there shown comprises a barium titanate thin sheet ceramic 10 having electrode 11 and 12 on

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the opposite larger area flat faces thereof. The barium titanate thin sheet ceramic may be made by the methods disclosed in my copending applications, Serial No. 554,295, filed September 15, 1944, now abandoned, and Serial No. 607,241, filed July 26, 1945, now Patent No. 2,486,410. The electrodes 11 and 12 comprise, for example, powdered silver with 10–20% powdered relatively low melting point glass mixed therewith. The ceramic is first fired to a sufficiently high temperature to set the same and drive off all organic materials which may be present as binders or the like. After firing, the ceramic sheet is cooled, the silver applied in the form of a paste and the composite body then fired to a sufficiently high temperature to fuse the glass portion of the silver paste to the ceramic body. Charging leads 13 and 14 are then soldered to the electrodes and the ceramic charged to develop the piezo properties therein. Care must be taken in applying the leads and I may either apply a coating of copper to the electrodes electrolytically or apply a second layer or coating of silver to build up a sufficiently thin layer of silver that soldering is facilitated. After charging, vibration of the element will generate a voltage or signal at the leads 13 and 14. On the other hand, if alternating current is applied to the electrodes through the leads 13 and 14 the ceramic will vibrate in the manner of piezoelectric elements.

In Figs. 3 and 4, I employ a pair of ceramic bodies 15 and 16 on opposite sides of a flexible re-inforcing plate 17. The plate 17 strengthens the ceramic and also acts as a center contact for charging the ceramics, electrodes 18 and 19 also functioning as signal electrodes and having the leads 21 and 22 secured thereto. A phonograph needle 23 is secured to the unitary integral structure, so that when the element is supported by the plate 17 and the needle 23 caused to track a record, an electric signal will be generated in the leads 21 and 22 and the transducer may, therefore, comprise the active part of a phonograph pickup. In producing the device shown in Figs. 3 and 4, the ceramic is produced in the way described in connection with Figs. 1 and 2, the electrodes are applied on both opposite faces, the two ceramic strips are soldered to opposite sides of plate 17, the leads attached and needle attached, both by suitable soldering methods. The ceramics are charged with opposite polarities by using the center electrodes as one side of the charging source and connecting the opposite side of the charging source to the two signal electrodes 18 and 19.

Figs. 5 and 6 show a button type of electrode in which a ceramic 24 has electrodes 26 and 27. These electrodes may comprise both the charging and signal electrodes, and the round ceramic may be used, for example, in those types of installations in which the change in capacitance of the piezoelectric body caused by the vibration thereof is utilized as the changing or changeable factor.

In a specific example, I produced several barium titanate sheets 1" x 1" x .015" thick, fired to a temperature between 2400 and 2500 degrees F. These sheets were made by first producing a larger sheet in the manner disclosed in my copending applications and then cutting the larger sheet to the size described. I also produced round tamped buttons, 1/4" diameter and .020" thick, of the type shown in Fig. 5, and fired these at a temperature of 2400 degrees for one hour. Silver electrodes were applied to the flat surfaces of both the square and round sheets and the elements then fired at 1200 degrees F. until the glass portion of the silver fused to the flat exterior surface of the thin ceramic sheets. The resulting sheets were then charged at 1000 volts for several minutes and when then subjected to alternating current were found to vibrate audibly. Further tests showed the pieces to be piezoelectric in character in all respects.

I have determined that the piezoelectric elements may take various shapes and that a suitable charging voltage is of the order of 50 volts per mil thickness continued for 15 minutes to 30 minutes. Higher voltages, in general, require less charging time than lower voltages but relatively low direct current voltages may be employed satisfactorily if continued long enough.

What I claim as new and desire to protect by Letters Patent of the United States is:

1. A piezoelectric element comprising a permanently charged titanate ceramic having electrodes on opposite faces thereof.

2. A piezoelectric element comprising a titanate ceramic having electrodes on oppositely disposed surfaces thereof, the ceramic being permanently polarized by the application of a direct current potential thereto between the electrodes.

3. A transducer element comprising at least one permanently charged ceramic body, electrodes at opposite faces thereof, and means for supporting said ceramic body to cause the same to vibrate and generate a signal in said electrodes.

4. The method of producing a piezoelectric element, which comprises applying electrodes to opposite sides of a titanate ceramic, and applying a direct current voltage between the electrodes permanently to charge the ceramic.

5. A piezoelectric element comprising a titanate ceramic member having metallic electrodes fused on oppositely disposed surfaces thereof, the ceramic member being permanently polarized by the application of a direct current potential thereto between the electrodes until the maximum piezoelectric property is developed.

6. The method of producing a piezoelectric element, which comprises fusing metallic electrodes to oppositely disposed surfaces of a titanate ceramic member, and permanently polarizing the ceramic member by applying a direct current voltage thereto between the electrodes until the maximum piezoelectric property is developed.

7. A piezoelectric element comprising a thin sheet of titanate ceramic having metallic electrodes fused on the opposite flat surfaces thereof, and a flexible reinforcing plate secured to one of the metallic electrodes for strengthening and supporting the ceramic sheet, the ceramic sheet being permanently polarized by the application of a direct current potential thereto between the electrodes.

8. A piezoelectric transducer comprising a thin sheet of titanate ceramic having metallic electrodes fused on the opposite flat surfaces thereof, a flexible reinforcing plate secured to one of the metallic electrodes for strengthening and supporting the ceramic sheet, the ceramic sheet being permanently polarized by the application of a direct current potential thereto between the electrodes, and means for flexing the plate and the ceramic sheet supported thereby for generating an electric signal at the metallic electrodes.

9. A piezoelectirc element comprising a pair of thin sheets of titanate ceramic, each having metallic electrodes fused on opposite flat surfaces thereof, and a flexible metallic plate, the pair of ceramic sheets being secured to opposite sides of the plate by securing a metallic electrode of each to the metallic plate for strengthening and supporting the pair of ceramic sheets, the pair of ceramic sheets being permanently polarized by the application of a direct current potential thereto between the electrodes.

10. A piezoelectric element comprising a pair of thin sheets of titanate ceramic, each having metallic electrodes fused on opposite flat surfaces thereof, and a flexible metallic plate, the pair of ceramic sheets being secured to opposite sides of the plate by securing a metallic electrode of each to the metallic plate for strengthening and supporting the pair of ceramic sheets, the pair of ceramic sheets being permanently oppositely polarized by the application of one side of a direct current potential to the outer metallic electrodes and the other side thereof to the metallic plate.

11. A piezoelectric transducer comprising a pair of thin sheets of titanate ceramic, each having metallic electrodes fused on opposite flat surfaces thereof, a flexible metallic plate, the pair of ceramic sheets being secured to opposite sides of the plate by securing a metallic electrode of each to the metallic plate for strengthening and supporting the pair of ceramic sheets, the pair of ceramic sheets being permanently oppositely polarized by the application of one side of a direct current potential to the outer metallic electrodes and the other side thereof to the metallic plate, and means for flexing the plate and the ceramic sheets supported thereby for generating an electric signal at the outer metallic electrodes.

GLENN N. HOWATT.

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