

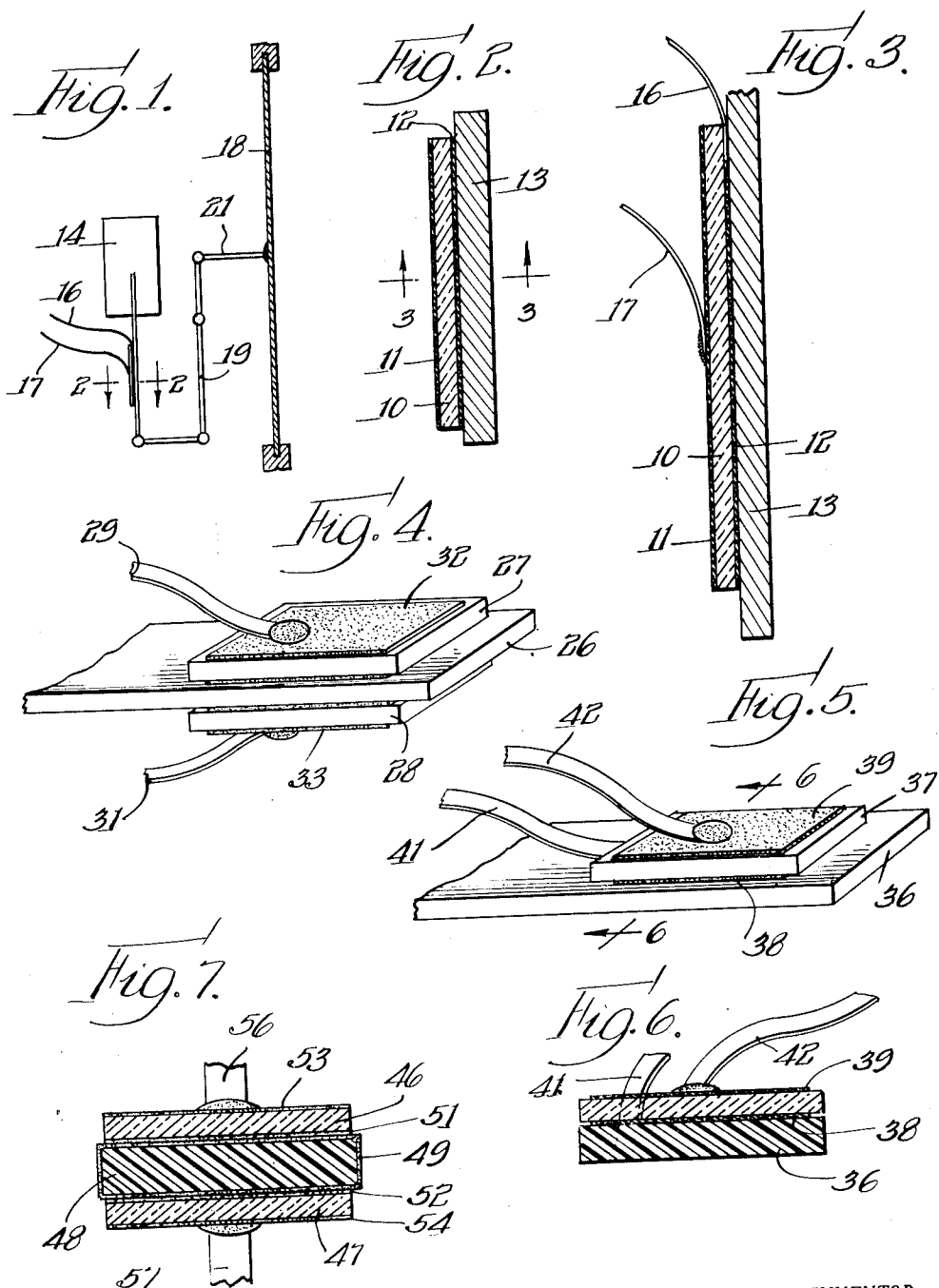
Oct. 14, 1952

G. N. HOWATT

2,614,144

TRANSDUCER ELEMENT AND METHOD OF MAKING SAME

Filed June 26, 1948



INVENTOR.
Glenn N. Howatt
 BY
McLaughlin & Wallenstein
 Attys.

UNITED STATES PATENT OFFICE

2,614,144

TRANSDUCER ELEMENT AND METHOD OF
MAKING SAMEGlenn N. Howatt, Metuchen, N. J., assignor to
Gulton Mfg. Corp., a corporation of New Jersey

Application June 26, 1948, Serial No. 35,415

12 Claims. (Cl. 171-327)

1

My invention relates to piezoelectric transducer elements and methods for making the same.

The invention has for its object an improved method of making a piezoelectric element for use in transducers and the production of an improved transducer employing such piezoelectric elements.

Piezoelectric bodies have been used extensively in the production of transducer elements of the type comprising phonograph pick-ups and microphones. A common piezoelectric material used for the purpose is a Rochelle salt crystal wherein the Rochelle salt crystal is first grown in the form of relatively large slabs having a definite crystal lattice and in which the said slab is cut according to the lattice orientation to form a piezoelectric body in which the axis of the crystal has a definite relationship to the support therefor. Transducers employing Rochelle salt crystals are used extensively to great advantage but they are incapable of successful use under certain types of conditions as those skilled in the art understand. Polygranular ceramic materials have been used successfully as a substitute for single Rochelle salt crystals and overcome many of the disadvantages of the latter. The polygranular ceramics have themselves had certain disadvantages, particularly so far as sensitivity is concerned.

The principal object of my invention is the provision of an improved transducer element.

Another object is the provision of a transducer element employing a single piece crystal body of barium titanate.

While the invention may take various forms, certain end products of the practice thereof are shown in the drawings and may be considered as illustrative. In such drawings—

Fig. 1 is an elevational view partly schematic, showing a microphone type of transducer;

Fig. 2 is a sectional view through the crystal and support taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a perspective view showing another type of transducer element in which two piezoelectric bodies are employed;

Fig. 5 is a perspective view showing still another way of producing the transducer;

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

Fig. 7 is a sectional view similar to Fig. 6, but showing the use of two piezoelectric bodies.

According to the general features of my invention, I first produce a single piece crystal body

2

of barium titanate by one of several suitable high temperature techniques. When the crystals have been cooled, instead of determining their lattice structure and orientation, I cut them at random orientation to the desired flat or parallelepiped form and size, apply electrodes thereto and subject them to relatively high temperature direct current potential until the piezoelectric axis is orientated in the direction of the external polarizing field. The piezoelectric sensitivity of the element so produced is much higher than that of any polygranular material and considerably greater than Rochelle salt, heretofore thought to be the most sensitive piezoelectric material available.

Piezoelectric single piece crystalline bodies of the character identified may be employed to produce very efficient transducer elements, particularly in those types of installations in which relatively small size and very high sensitivity, such as in small microphones, is desired. The single piece barium titanate crystal has a piezoelectric modulus of the order of 5 to 10 times that of Rochelle salt crystals. The temperature range at which this high sensitivity is maintained is very much greater than that of Rochelle salt crystals. As a practical proposition, microphones may be made in accordance with my invention which are in excess of 10 decibels more sensitive than corresponding microphones made with Rochelle salt crystals. Such a microphone also has the advantage that it is completely moisture and mildew resistant, has the wider temperature range expected because of the greater temperature range of its sensitive element and is not affected by high humidity, extreme dryness and excessive temperatures, as are piezoelectric microphones heretofore known.

In carrying out my invention, any suitable way of producing the single piece crystalline bodies may be employed. While the single piece crystalline bodies which I have employed appear to be single crystals, so called twinning can apparently take place and so far as I can determine a single piece crystalline body in which the crystals are twinned can be employed as well as the bodies in which there is only a single crystal and in which the lattice of the single crystal is orientated in only one direction.

One manner of producing the crystals is to add to a substantially pure body of granular barium titanate a relatively small amount of a fluxing material, such, for example, as 2 to 5% of borax or boric acid. After mixing, the resulting product is suitably fused, as, for example, by means

of a blow torch. The body while fused may be held in a platform crucible or suitably constructed zirconium oxide vessel. If the fused body is held at a temperature of about 2600 degrees F., crystals will begin to grow and by maintaining the temperature for one to several hours a substantial number of relatively large crystals will be formed. The fused mass is then allowed to cool and the agglomerate of crystals can be separated mechanically.

Another method of producing the crystals is to fuse two chemicals which, by chemical reaction, such as by double decomposition, will produce barium titanate. Under such circumstances, the crystals apparently grow out of a saturated solution and time and temperature are controlled, depending upon the materials employed. According to one example, which has been used successfully, a mixture of barium chloride and titanium dioxide are mixed in stoichiometric proportions and fused by means of a blow torch and the fused mass maintained at an elevated temperature until crystal growth has progressed adequately. Still another method is to drop barium titanate through an electric arc in a manner known in the art, the mass of barium titanate and the character of the arc being so maintained that fusion takes place as the barium titanate is subjected to the temperature developed at the arc. Under such conditions, crystals are formed in the resulting drops of fused barium titanate, and the crystals so formed may be collected and separated mechanically. The crystals as formed are relatively flat and generally tetragonal. While they may vary in size, when following the first described method, they will, in general, be of the order of two or three mils thick by about 100 mils square. In general, they may be used substantially as produced but should be trimmed for control purposes to a uniform size.

The single crystals are provided with suitable electrodes, such as fritted silver electrodes. The transducer element may comprise such a single crystal secured to a support or two crystals secured to a support to form a sandwich, but the support should be of such character that the neutral plane or the plane of zero extension in flexure is external to the body or bodies of the barium titanate. The crystal suitably is charged with a field strength of approximately 50 volts per mil of thickness for a period of from 5 minutes to a number of hours depending upon the purity of the barium titanate. The element so charged is disconnected from the polarizing source and will maintain its charge during its normal life. The crystals may be subjected to the direct current potential either before or after they are mounted on their supports. I have found that a practical method is to so construct the transducer element that the crystal may be subjected to the lattice orientating charge after it has been mounted in position so that the amount of charge required may be determined empirically by using an empirical test such as for output or performance.

In the drawings, I show one embodiment in Figs. 1-3, inclusive, in which the single piece crystalline body of barium titanate is the active element in a microphone. The element comprises the body 10 having electrodes 11 and 12, with the latter soldered to a metal plate support 13. The plate 13 is secured by a body of plastic 14, and signal electrodes 16 and 17 are connected to the plate 13 and electrode 11, respectively. A diaphragm 18 is suitably supported mechanically

and is so associated with the plate 13 as to impart a bending stress thereto. In the drawing, I indicate schematically a bell crank lever 19 with connecting links 21 and 22, the bell crank lever being so pivoted that movements of the diaphragm are slightly magnified mechanically.

In Fig. 4, I employ a resilient metallic mounting plate 26 and single piece crystal barium titanate bodies 27 and 28 are secured to opposite sides thereof. These bodies also have electrodes on their opposite faces and they may, therefore, be soldered to the plate 26. Signal leads 29 and 31 are secured to the oppositely placed outer electrodes 32 and 33. When the transducer is produced in this form, the piezoelectric bodies are oppositely charged as, for example, by connecting one terminal from the charging source to the plate 26 and the other terminal to the two leads 19 and 31.

In Fig. 5, I utilize a non-metallic resilient support 36 which may be, for example, a suitable plastic and which may comprise a part of a supporting body as of a transducer frame or the like. In this form of invention, the piezoelectric body 37 has the usual oppositely positioned electrodes 38 and 39 and signal leads 41 and 42, respectively, connected therewith. These signal leads may be employed also for charging, or, if preferred, the piezoelectric body may be orientated with respect to its lattice before the leads are applied and before it is secured to the support 36. Any suitable adhesive may be employed for securing the piezoelectric body in position as, for example, we have different types of plastic cements, providing, of course, the piezoelectric body is so mounted that movement of the support will have the effect of stressing the piezoelectric body and producing a signal voltage therein. It will be understood, of course, that an actuating element such as a phonograph needle, a microphone or the like member is suitably functionally associated with the free end of the supporting plate.

In Fig. 7, I employ the same structure as in Figs. 5 and 6 except instead of a single piezoelectric body I employ two such bodies 46 and 47 mounted on opposite sides of a non-metallic resilient support 48. A bridging electrical connection 49 extends around a portion only of the support 48 to interconnect the proximal electrodes 51 and 52. The outer electrodes 53 and 54 have signal leads 56 and 57 soldered or otherwise suitably secured thereto. A charging lead 58 is connected to the bridging electric connection 49. In this form of the invention, the two piezoelectric bodies are separately charged as in the case of the transducer shown in Fig. 4.

The scope of my invention is defined in the claims.

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

1. A transducer element comprising a single crystal of barium titanate having electrodes on opposite faces thereof, signal leads secured to said electrodes, and means for mounting the said crystal to cause stress therein.

2. A transducer element comprising a single crystal of barium titanate having electrodes on opposite faces thereof, signal leads secured to said electrodes, and means for mounting the said crystal to cause stress therein, said means comprising an elastic supporting structure to which an actuating element is secured.

3. A transducer element comprising a single crystal of barium titanate having electrodes on

5

opposite faces thereof, signal leads secured to said electrodes, a relatively thin metallic strip to which one of the electrodes of the crystal is secured, and actuating means connected to said metallic strip.

4. The method of producing a piezoelectric body which comprises growing a crystal from barium titanate, shaping the crystal to a desired form without regard to lattice orientation, and subjecting the shaped crystal to a relatively high direct current potential until the lattice is oriented.

5. A transducer element comprising a single crystal of barium titanate having electrodes on opposite faces thereof, signal leads secured to said electrodes, a resilient non-metallic support, and means for securing the crystal to the support in a manner to be stressed by movement of such support.

6. A transducer comprising a non-metallic resilient support, two single crystals of barium titanate having electrodes on opposite faces, said electrodes secured to opposite sides of said support, a bridging electrical connection between proximal electrodes of the two crystals, and signal leads secured to the outermost of the said electrodes.

7. The method of producing an improved transducer element which comprises growing a single crystal from barium titanate, shaping the crystal to a desired form without regard to lattice orientation, applying electrodes to opposite faces of the shaped crystal, mounting said shaped crystal on a relatively thin metallic strip, and subjecting the shaped crystal to a relatively high direct current potential until the lattice is oriented.

8. A piezoelectric body comprising a single crystal of barium titanate of parallelepiped shape and originally of random lattice orientation with respect to the said parallelepiped body, a pair of electrodes secured to opposite faces of the said parallelepiped body, the said crystalline parallelepiped body being electrically charged and electrically oriented,

6

9. A piezoelectric body comprising a flat piece of single crystal barium titanate originally randomly oriented and having electrodes on opposite faces thereof and being electrically charged and electrically oriented.

10. A transducer element comprising a piezoelectric body consisting of a flat piece of single crystal barium titanate originally randomly oriented and having electrodes on opposite faces thereof and being electrically charged and electrically oriented, and an elastic supporting member secured to one of the faces of the piezoelectric body.

11. A transducer element comprising a flat elastic supporting strip, and a pair of piezoelectric bodies, each consisting of a flat piece of single crystal barium titanate originally randomly oriented and having electrodes on opposite faces thereof and being electrically charged and electrically oriented, said pair of piezoelectric bodies being secured to opposite sides of said elastic supporting strip.

12. A transducer comprising a relatively thin metallic supporting strip, a single flat crystal of barium titanate secured on each side of the supporting strip, electrodes on the exposed faces of said crystals, and signal leads secured to said electrodes.

GLENN N. HOWATT.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,803,274	Sawyer	Apr. 28, 1931
1,886,234	Meissner	Nov. 1, 1932
1,997,263	Meissner	Apr. 9, 1935
2,373,445	Baerwald	Apr. 10, 1945
2,434,079	Nutting	Jan. 6, 1948
2,436,840	Wainer	Mar. 2, 1948
2,438,761	Martin	Mar. 30, 1948
2,486,560	Gray	Nov. 1, 1949