

March 12, 1957

E. A. WOOD

2,785,322

STABLE LIQUID ELECTRODES

Filed Aug. 4, 1953

FIG. 1

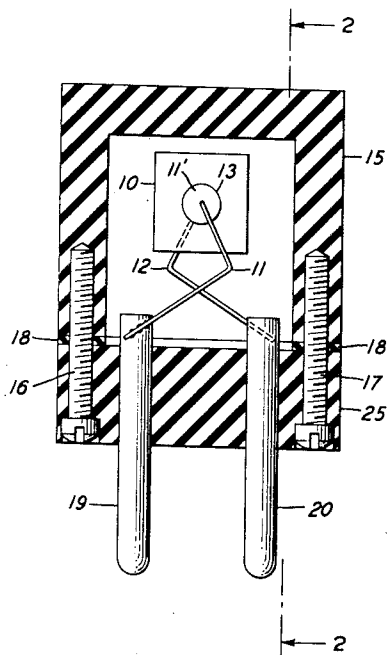
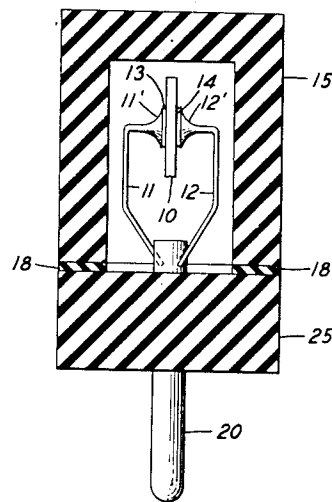


FIG. 2



INVENTOR
E. A. WOOD
BY
H. O. Wright
ATTORNEY

1

2,785,322

STABLE LIQUID ELECTRODES

Elizabeth A. Wood, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 4, 1953, Serial No. 372,288

5 Claims. (Cl. 310—9.7)

This invention relates in general to electrode contacts and to liquid electrode contacts as applied to electrical devices and, more particularly, to piezoelectric and/or ferroelectric crystal elements.

The hysteresis property of ferroelectric crystals has recently assumed considerable importance as applied to memory circuits and calculating devices. This property depends on the rapidity and regularity with which small electrically polarized units or "domains" shift within the crystal structure when an electrical field is applied. It has been found that when the electrical field is applied through conventional metallic electrodes substantial distortions are introduced into the hysteresis pattern, and the response times for applied fields are objectionably long. Possible explanations for this are mechanical clamping of the crystal surface by the metal electrode, and the presence of a layer of lower conductivity between the electrode and the crystal. The use of liquid electrodes for this purpose has greatly reduced or eliminated such distortion by eliminating the clamping, and making possible more direct contact between the electrode and the crystal surface. However, certain further problems are presented. For example, certain of the electrolytes used as liquid electrodes were found to gradually etch the surfaces of the crystal to which they were applied. Moreover, experiments with prior art liquid electrodes have necessarily been short-lived because of the rapid evaporation of the liquid drops.

Accordingly, a primary object of the present invention is the substantial elimination of volume and concentration variations of liquid electrodes.

A further primary object of the present invention is the substantial elimination of disintegrating chemical reactions between the liquid electrodes and the crystal surfaces and metallic terminals with which the electrodes make contact.

Another more specific object of the invention is to improve the shapes of the hysteresis curves in ferroelectric crystal units.

In accordance with the present invention, the aforesaid objects are attained in an electrode comprising a fine wire, headed contact separated from the crystal surface with which it is conductively associated by a drop of hygroscopic electrolyte. In a specific example of the invention described in detail hereinafter, lithium chloride is utilized as the hygroscopic electrolyte.

For the purposes of the present disclosure and the appended claims, a hygroscopic salt is defined as any salt which will absorb enough water from the atmosphere in which the electrode unit is assembled to form a conducting solution.

A particular advantage of the present invention is that the hysteresis loops, which are characteristic of ferroelectric crystals using the disclosed hygroscopic liquid electrodes, maintain their optimum shapes for long periods of time, and the response to applied fields is substantially faster.

Other objects, features, and advantages of the present

2

invention will be understood from a study of a typical embodiment, as described in detail hereinafter with reference to the drawing, in which Fig. 1 shows a side section of said embodiment and Fig. 2 shows an end section along the line 2—2 of Fig. 1.

Figs. 1 and 2 show in detail an assembly including a crystal element having attached to its opposing surfaces a pair of hygroscopic liquid electrodes in accordance with the present invention. The crystal may be any conventional piezoelectric or ferroelectric element, and may comprise either a ceramic or single crystal. Assume, for example, that the ferroelectric element 10 comprises a wafer 1.5 millimeters square and .05 millimeter thick, cut from a barium titanate single crystal. The aforesaid wafer is supported between a pair of terminal wires of platinum 11, 12, with respective heads 11', 12', which make electrical (but not mechanical) contact with its opposing major faces through drops of lithium chloride solution 13, 14. These drops cover an area of the central portions of each of the faces of the wafer, without creeping over the wafer edges. The surface tension of the lithium chloride drops functions to hold the unit, including the wafer 10 and the wire heads 11' and 12', together, as well as to restrain the drops from creeping over the edges of wafer 10.

The electrolytic solution from which the drops 13, 14 are derived, is prepared by allowing lithium chloride in dry powdered form to remain in an open dish for a few hours until it absorbs sufficient moisture to form a conducting solution which is in equilibrium with the ambient atmosphere. Electrode drops of this solution will not change in concentration or volume as long as they are kept in an atmosphere of the same humidity.

For increased mechanical stability, and as an added protection against extreme changes in the ambient atmosphere, the assembled unit including the crystal 10, the liquid electrodes 13 and 14, and the contacting headed wires 11 and 12, may be enclosed in a hollow, substantially moisture-proof, two-piece hard rubber or plastic housing 15, 25, which is held together by means of screws 16 and 17, the joint between the housing portions 15 and 25 being sealed by a gasket 18. The wires 11 and 12 are secured to separate binding posts 19 and 20, embedded in housing portion 25, so that the crystal assemblage may be readily plugged into an external circuit.

Advantages to be derived from use of the hygroscopic liquid electrodes in accordance with the present invention are that the polarizations of the units remain constant for extended periods, inasmuch as the areas covered by the electrodes do not change substantially. Moreover, the forms of the rectangular hysteresis loops are improved by the use of hygroscopic electrodes, and the response times to applied fields for units using such electrodes are substantially decreased.

Although lithium chloride has been disclosed as a specific example of a salt suitable for the practice of the present invention, other hygroscopic substances which are electrolytic in aqueous solution, and which do not chemically attack the crystal or the electrode wires, are also suitable. These include such salts as calcium and magnesium chloride which are highly hygroscopic at humidities ordinarily encountered. However, it will be apparent to those skilled in the art that under conditions of extremely high or extremely low humidity, materials with different moisture-absorbing characteristics than those herein disclosed would be suitable for the purposes of the present invention.

What is claimed is:

1. Electrical contact means for a ferroelectric crystal element comprising in combination a pair of conducting wires the terminals of which are spaced apart from opposing major surfaces of said element, and drops of an

3

electrolyte comprising an aqueous solution of a hygroscopic salt in moisture exchange equilibrium with the ambient atmosphere, said drops being interposed in electrical conducting relation between each of said wire terminals and a respective one of said surfaces, wherein said electrolyte has substantially no chemical affinity for said crystal element and said wire terminals.

2. Electrical contact means for a ferroelectric crystal element comprising a drop of an aqueous solution of a chloride of a metal selected from the group consisting of lithium, calcium, and magnesium.

3. Electrical contact means for a piezoelectric crystal wafer comprising in combination a pair of conducting wires having terminals respectively adjacent the opposing major surfaces of said wafer, and drops of electrolyte each comprising an aqueous solution of a hygroscopic salt respectively interposed between said terminals and said surfaces, said wafer being suspended in spaced mechanical relation between said terminals by the surface tension of said drops, and making intimate electrical contact with said terminals by virtue of the conductivity of said drops.

4

4. Electrical contact means for a piezoelectric crystal element comprising in combination a conducting wire the terminal of which is spaced apart from a major surface of said element, and a drop of an electrolyte comprising an aqueous solution of a hygroscopic salt in moisture exchange equilibrium with the ambient atmosphere, said drop being interposed in electrical conducting relation between said wire terminal and said surface, wherein said drop has an extent which is substantially less than the extent of the surface on which it rests.

5. A combination in accordance with claim 4 in which said salt is a chloride of a metal selected from the group consisting of lithium, calcium, and magnesium.

References Cited in the file of this patent

UNITED STATES PATENTS

2,287,950	Tibbetts	June 30, 1942
2,411,298	Shore	Nov. 19, 1946
2,661,388	Warner	Dec. 1, 1953
2,666,801	Victoreen	Jan. 19, 1954