Aug. 21, 1956 R. H. STURM 2,759,241

PIEZO-ELECTRIC DEVICES

Filed Oct. 14, 1952

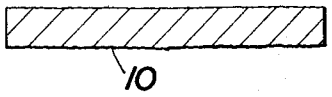


FIG. 1.

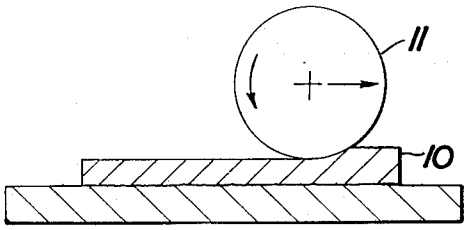


FIG. 2.

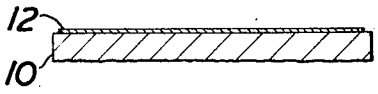


FIG. 3.

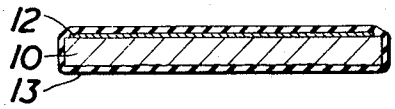


FIG. 4.

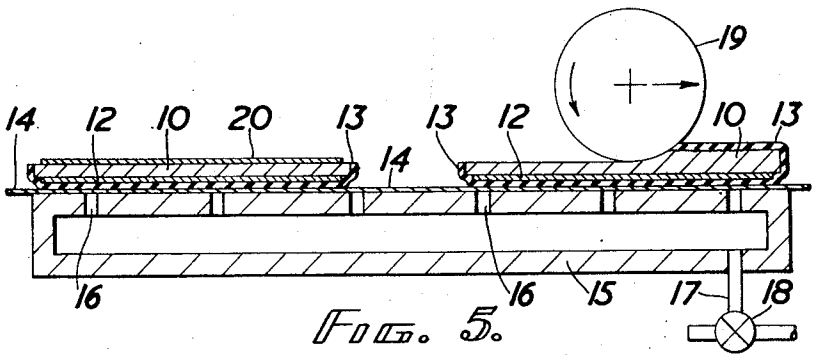


FIG. 5.

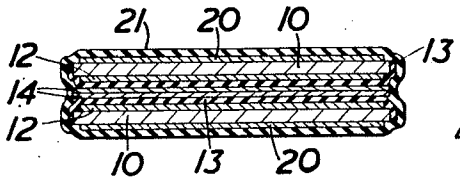


FIG. 6.

Inventor

Robert Heinrich Sturm,

By Pierce, Scheffler & Parker

his Attorneys

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PIEZO-ELECTRIC DEVICES

Robert Heinrich Sturm, Enfield, England

Application October 14, 1952, Serial No. 314,615

Claims priority, application Great Britain October 17, 1951

2 Claims. (Cl. 29—25.35)

This invention relates to piezo-electric devices of the type employing two or more layers of material which are secured together.

A well known piezo-electric assembly, widely used in transducers such as microphones, gramophone pickups, sound reproducers and like, is a "bimorph" construction in which two plates of a piezo-electric substance, having electrodes on their surfaces, are cemented together. More complicated constructions using three or more piezo-electric elements secured together are also known; for the purpose of this present specification the term "bimorph" is to be taken as including not only the two element assembly, but also the more complicated ones.

The crystal plates which are used in bimorphs are often very thin: commonly they are of the order of 25 to 30 mils thick. Since these plates have to be ground or machined to this thickness, care must be exercised to avoid undue losses due to breakage of the plates during machining.

The present invention has for its object to provide an improved method of machining or grinding the plates of bimorphs, and in accordance with the invention one side of a crystal element is ground and the member is then stuck by this face to a thin sheet; whilst held by this sheet upon a support surface the opposite side of the element is ground or machined. The supporting sheet permits the crystal element to be held by vacuum pressure upon the support.

In the specification of my co-pending application Serial No. 314,563 filed October 13, 1952 we have described a method of moisture-proofing bimorphs, which involves the steps of first preparing one surface of each crystal element, providing an electrode means on that surface and then applying a moisture-proof coating to the surface; thereafter two crystal elements prepared in this way are cemented together. The cementing can be effected by means of a sheet or layer of material chemically affine to the material of the coating, used as an interlaminate between the two plates to be secured together. The present invention can be used with advantage with such a method.

Other features and advantages of the invention will appear from the following description of one embodiment thereof as applied to the manufacture of bimorphs suitable for use in a transducer such as a microphone, gramophone pickup, sound reproducer or the like.

In this process sheets of Rochelle salt are cut from a crystal slab in known manner, for example by means of a band saw. These plates are as thin as may be produced in this way without undue loss due to breakages; a thickness of about 0.1 of an inch is obtainable in practice.

The sheets are then cut in rectangular plates having a predetermined orientation with respect to the electrical axes of the crystal, the rectangles being slightly larger than the desired final size of the plate.

The edges of the plates are lightly ground to finish them to the desired size, and one of the major surfaces of each plate is then machined flat (assuming, as is almost invariably the case, the bimorph is flat). This machining

can be carried out safely with a crystal plate of the thickness mentioned; the plate can be temporarily attached to a work support by a viscous material, and the surface trued by grinding, milling or turning.

The plates are next cleaned; it is important that the machined surfaces should be free not only of ordinary foreign matter, but also any minute crystal of the Rochelle salt itself, since these react more quickly to atmospheric moisture than the monocrystalline plate, due to their small size and proportionally large surface. These small particles therefore increase the possibility of deterioration of the finished bimorph due to the ingress of moisture, if these are permitted to remain on the crystal.

The trued major surface of the crystal is next provided with an electrode; various methods of providing electrodes can be used including vacuum evaporation, electroplating or the application of a metal foil, but we prefer to make use of a metallic coating material consisting of extremely fine metallic silver particles, of 750 mesh size, suspended in a solution of preferably synthetic resin, such as for example an acrylic resin in a volatile solvent such as toluene, xylene or the like. This is brushed onto the surface, a foil strip terminal being attached, and is allowed to dry. There results an extremely closely adherent conductive layer of material consisting of about 95% metallic silver. The very close adherence is of importance inasmuch as it ensures a high capacitance for the finished bimorph.

When the electrode is dry the plate is coated with a high dielectric material having low moisture absorption; this material is of the type disclosed in the copending application referred to, namely, fully or partly polymerised polyester resins such as diallyl phthalate, polystyrene resins, polyvinyl resins, polyvinyl copolymer resins, polyaryl ethylene oxide resins, polyacrylic resins, chlorinated diphenyl resins alone, or a mixture of a coplymerisation product of such resins with or without the addition of modifying agents such as plasticizers like dibutyl or di-octyl phthalate, tri-cresyl phosphate or dibutyl sebacate, tackifying resins such as ester gums, polyisobutylene resins, abietic acid esters, fillers and pigments such as talc, silica or titanium dioxide, and catalysts such as benzoyl peroxide, tertiary butyl hydroperoxide, pentaethylene diamine.

The coating may be limited to the machined surfaces of the plates, but it is easier to give a complete coating. The coating is of the order of half a mil in thickness. The plates are coated and dried at a temperature of about 20° to 22° C., at a relative humidity of 40 to 50%.

The plates are then stuck to a thin sheet of a material which is chemically affine to the coating material, or it may be of the same material as the coating. The sheet or the coatings can be wetted with a suitable solvent or the corresponding monomer. The nature of the sheet material used will depend upon the coating, and two examples will be given of suitable materials. The proportions are parts by weight.

In the first example, the coating material used is that given as "Example 1" in my aforesaid Application No. 314,563, and is as follows:

Example 1

Copolymer resin of 70% styrene and 30% butyl acrylate	16.40
Chlorinated diphenyl specific gravity 1.530 to 1.630	1.60
Xylene	40.00
Butyl acetate	34.00
Ethyl lactate	2.00
Titanium dioxide	3.50
Colloidal silica	2.50
	100.00

The single crystal elements with the electrode applied firmly to the surface thereof are individually dip coated with the solution, which on evaporation of the solvents, will provide a film round the element. The required thickness of the coating which should be at least 0.0005 inch is achieved from the dipping solution and by adjusting the viscosity and the temperature of said solution.

The sheet material used in this example is a polystyrene sheet, of about .0015 inch thick. The coated crystal plate is wetted with a styrene monomer on that side of the crystal which has been electroded, and is pressed against the sheet. A second, and further, crystals are applied to the same sheet in the same way.

In a second example an acrylic resin is used for coating and cementing the crystals. The coating composition is that given in Example 3 of Specification No. 23965/51, and is as follows:

Example 2

Copolymer resin of 50% butyl methacrylate and 50% methyl methacrylate	12.00
Chlorinated rubber	2.00
Chlorinated diphenyl specific gravity 1.530	1.50
Methyl ethyl ketone	65.00
Diacetone alcohol	16.00
Titanium dioxide	1.50
Talc	2.00
	100.00

With this coating composition, the sheet material used can be of polymethyl methacrylate, the engaging surfaces being wetted with the corresponding monomer or with a low boiling point solvent such as methylene chloride.

The sheet, with the plates secured thereto, can now be handled conveniently as a unit and can be placed on the surface of a work holder and there held by vacuum pressure, suitable holes being formed for this purpose in the surface.

The plates, whilst being held in this way can be safely machined since the adherence to the suport surface is good; the plates are therefore worked to the desired thickness. During this process it will be seen that the sides of the plates are protected by the coating against the deposit of crystal dust upon them.

When the surface has been machined to the desired thickness the surface is cleaned and provided with an electrode as above. Thereafter, the plates are separated by cutting the supporting sheet around each plate and plates having suitable orientation are then cemented together by wetting the sections of the supporting sheet adhering to each plate. The surplus sheet material is trimmed off, and the pairs of plates are coated with a coating of the type disclosed in my copending application Serial No. 219,756 filed April 6, 1951.

It will be understood that the customary connecting

leads will be made to the electrodes, and that these leads will be connected together as necessary. For example, the leads to the main electrodes can be joined together, and those to the outer electrodes joined together to form a suitable transducer element.

The accompanying drawing shows diagrammatically the various steps in preparing a bimorph as in the method described above. The drawings are not to scale.

Figure 1 shows in section a crystal plate **10**, as it is after rough cutting, by means of a saw, from the crystal block,

Figure 2 shows the plate **10**, in the process of being cut by a miller or grinder **11**, to prepare one surface of the plate,

Figure 3 shows the plate **10** with electrode **12** applied to the worked surface of the crystal,

Figure 4 shows the plate, with the one electrode thereon, after the initial moisture-proofing coating **13** has been applied thereto, and

Figure 5 shows two plates, prepared up to the stage of Figure 4, secured to a supporting sheet **14**. The sheet is supported upon the surface of a work table **15**, which is provided with holes **16** leading to a closed space beneath the work table. This communicates through a conduit **17** to a source of vacuum pressure; a control and release valve **18** is included. On the work table the second surface of the members are finished with miller or grinder **19**, and the second electrode **20** is thereafter applied. The plate **10** on the right in Fig. 5 is in the process of being ground and the plate **10** on the left has been ground and the electrode **20** applied.

Figure 6 shows the pairs of crystals cemented together and given a final moisture-proof coating **21**.

I claim:

1. A method of making a piezo-electric assembly which comprises working a surface of each of at least two piezo-electric members, applying an electrode to each of said worked surfaces, applying to each said member at least over said electrode a coating material, securing each said coated member permanently to a supporting sheet of flexible material holding said sheet flat against displacement, working the opposite surface of each of said members while secured to said supporting sheet, separating the plates by cutting the sheet around the same, and thereafter securing together the sheet material secured to said members to form said assembly.

2. A method in accordance with claim 1, wherein a further and moisture-proof coating is applied to said assembly.

References Cited in the file of this patent

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