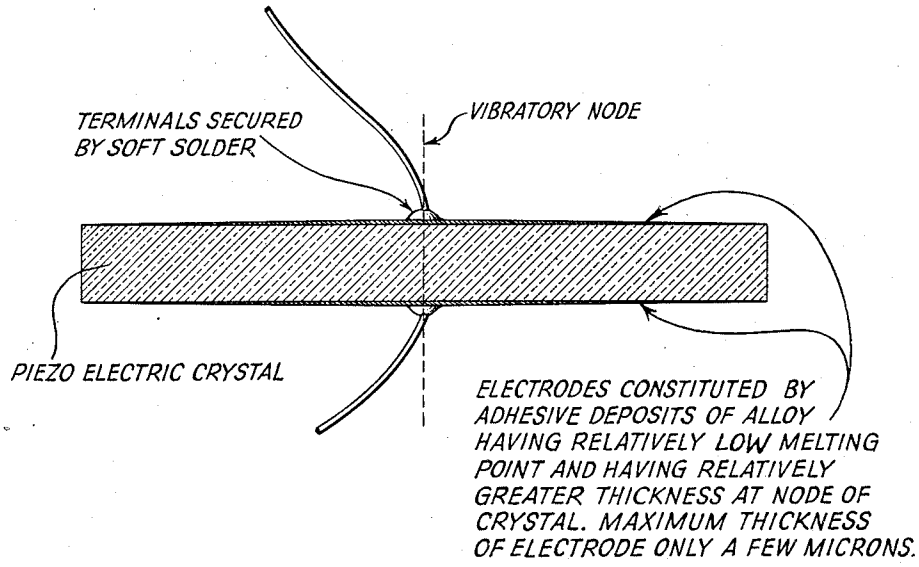
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PIEZOELECTRIC CRYSTAL ELECTRODE AND METHOD OF FORMING THE SAME

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PIEZOELECTRIC CRYSTAL ELECTRODE AND METHOD OF FORMING THE SAME

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This invention relates to electrodes for piezo-electric crystals and methods of forming the same. Metallic plates or coatings as applied to opposite surfaces of a piezo-electric crystal have heretofore been formed in a great variety of ways. For example, the metallic layers have been produced by chemical precipitation of solutions, also by a ceramic decoration method, and again by a method whereby the metal is burnt on from a suspension in oil at a suitable temperature. Another proposed method was to apply the metallic layer by cathodic atomization, and still another method was by a spraying process under suitable hydraulic pressure.

Among the difficulties heretofore encountered in the application of metallic coatings to the crystal element itself may be mentioned the fact that thin layers of metal do not always adhere as satisfactorily as is desired. In many instances rare metals have been used, including metals having a high melting point and metals that are heat and rust resisting. Chromium has been used with some success. The difficulties, nevertheless, are primarily due to the fact that in making a connection between the metallic layer of the electrode and a conductor, it was considered necessary to use soft solder. Where the soldered joint is made the metallic coating frequently becomes loosened because non-adhesive alloys of the rare metal and the soft metal are formed.

The weaknesses of a soldered connection between the conductive lead and the rare metal of the electrode layer are not always manifest when the soldered joint is first made. It appears that there is a phenomenon of equilibrium, so to speak, which must be exhibited in the molecular structure of the alloy at the joint in order to render this joint permanent. Such equilibrium may be delayed and when it does take place, even at room temperature, it causes a rupture of the adhesive characteristics as between the layer and the quartz crystal.

In order to overcome the difficulties aforementioned, I have found that very satisfactory electrodes can be formed on the faces of a quartz or tourmaline crystal if soft metals and those having a relatively low melting point are used. Among the metals that may be chosen for this purpose are lead, tin, cadmium, bismuth, antimony, zinc and their alloys. Surprising as it seems, a very good and well adhering layer of the above metals may be made. Thus, I am able to form a satisfactory electrode for the piezo-electric crystal, where the adhesive characteristics are relatively permanent.

My invention will be hereinafter described in greater detail, reference being made to the accompanying drawing in which the sole figure thereof shows in cross section a typical piezo-electric element having electrodes adheringly deposited thereon.

After adopting a metal for the electrode itself, which is more or less of the type used as soft solder, it becomes a simple matter to make the necessary connection between the conductor wire and the electrode. To do this I prefer to employ solder which has a lower melting point than that of the electrode material.

It should be here stated that all apprehension as to possible difficulties with respect to the lower electric conductance of the layers may at once be dispelled. It is true that the layers if sprayed on should be very thin in order that there may not be an excess of surface strain between the layer itself and the crystal when the crystal is caused to vibrate, otherwise the vibratory characteristics of the crystal would be attenuated. Where the thickness of the layer is from one to only a few microns no noticeable attenuation of the vibration amplitude takes place. Material of such a thickness as ordinary tinfoil, however, would be unsatisfactory. Considering the electric conductance of the layer it may be said, nevertheless, that for the very small currents which are generally used in connection with a piezo-electric device and considering the area of the electrode, there is no serious disadvantage in using soft metals with a lead, tin, cadmium or bismuth base.

Among the methods of applying the metallic coating, which I have found to be most satisfactory, "spraying" or "sputtering" may be mentioned. This is sometimes known as the Schoop method. It consists in atomizing the metal and applying it in an atmosphere of very much reduced gas pressure so as to prevent oxidizing the metal even at high temperatures.

When alloys of lead and tin are to be used, according to the methods of my invention, I have found that the tin content may be as much as 65%. If a lead-cadmium alloy is used the cadmium content may be up to 50%.

In order to insure against attenuation of the crystal vibratory characteristics it has been found that the spraying on of the metallic layer may best be done in the following manner:

The layer can be made very thin near the edges, but it is increased in thickness at a nodal

point where an additional mass will not influence the oscillating action. It is at this nodal point that the conductive lead should preferably be soldered. The manner of tapering the metallic layer from a maximum thickness near the center to a minimum thickness at the edges is illustrated in the drawing. The drawing also illustrates how the terminals may be secured by soft solder at points adjacent a vibratory nodal point of the crystal.

Another method which may be adopted satisfactorily is to apply the soft metal coating to a small zone in the vicinity of the nodal point and then to metallize the other portions of the crystal surface by the application of the usual rare metals. Where this method is adopted the application of the rare metals must be performed by some cold process, for instance, by cathode atomization or evaporation. This is necessary in order to prevent the formation of an alloy between the rare metals and the lead-tin or lead-cadmium alloy.

Although I have described my invention as it relates to improvements in the process of forming electrodes for piezo-electric crystal devices, and have given examples of suitable metals that may be used in this connection, it will be understood by those skilled in the art that various modifications of the article and of the process may be adopted without departing from the spirit and scope of the invention itself.

I claim:

1. A piezo-electric crystal electrode adheringly deposited upon the piezo-electric element and composed of an alloy including at least two of the following metals: lead, tin, cadmium, antimony, and zinc, said electrode having a thickness which is tapered from a maximum at the center to a minimum at the edges.

2. An electrode for a piezo-electric crystal having its greatest thickness disposed in the zone of a node on the surface of the crystal when the crystal vibrates, and having a conductor soldered to said electrode at the thickest part thereof.

3. A piezo-electric crystal electrode adheringly affixed to the crystal element and composed mainly of an alloy of tin and lead, the tin content being of any value up to 65 percent of the total weight, and means including a relatively heavy deposit of metal at the center of the electrode for affixing a conductor thereto.

4. An electrode for a piezo-electric crystal comprising a thin adhering coat thereon, said coat being composed of a lead-cadmium alloy where the cadmium content is of any value up to 50 percent of the total weight.

5. The method of forming a metallic deposit upon a piezo-electric crystal and permanently connecting a conductor to said deposit which comprises spraying the crystal while in an atmosphere of reduced gas pressure with a soft metal selected from a group consisting of lead, tin, cadmium, antimony, zinc, and any alloy consisting of a plurality of these metals, building up a greater thickness of such deposit at a nodal point of the crystal, and soldering said conductor to the crystal electrode at the nodal point with metal having a lower melting point than the metal of said crystal electrode.

6. A piezo-electric device having a crystal and electrodes therefor composed of soft solder metal selected from a group consisting of lead, tin, cadmium, antimony and zinc, said metal being adheringly deposited upon the crystal and each electrode having a maximum thickness adjacent a nodal point of the crystal and a minimum thickness at the edges of the metallic deposit.

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