Aug. 24, 1943. H. M. BACH 2,327,487

PIEZOELECTRIC DEVICE

Filed Sept. 27, 1941 2 Sheets-Sheet 1

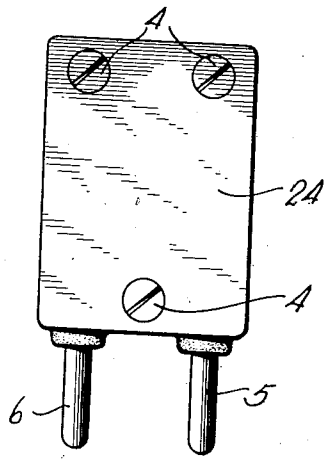


Fig. 1.

Fig. 2.

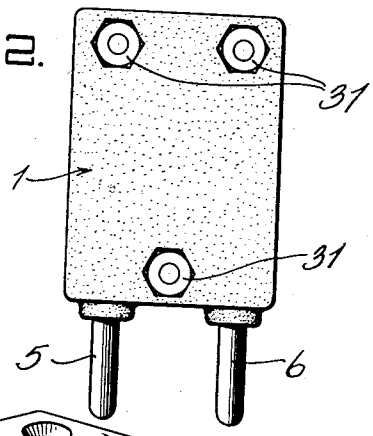
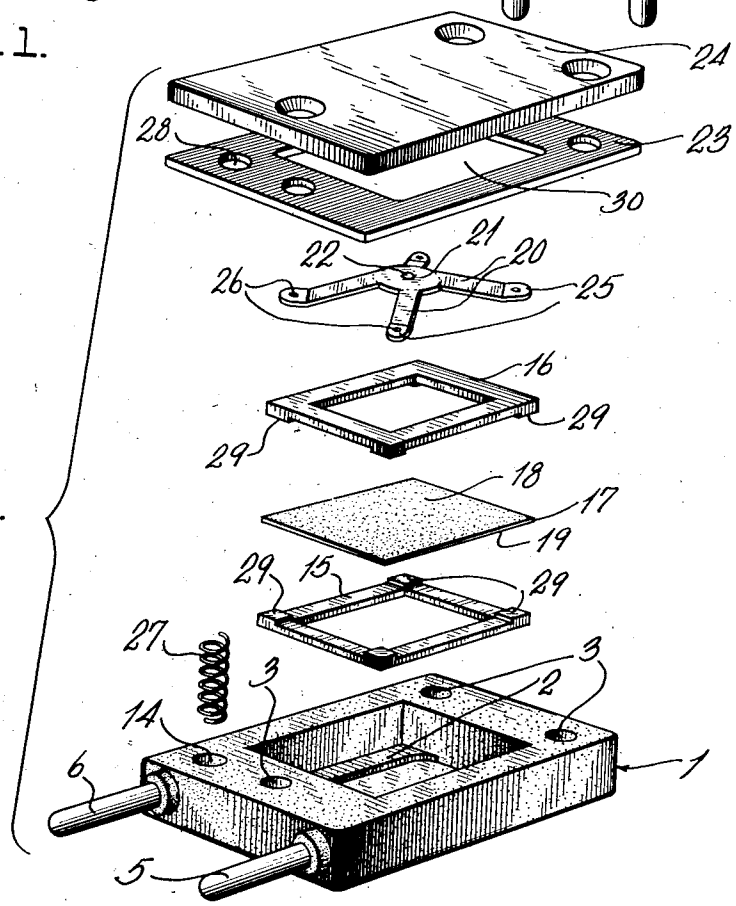


Fig. 3.



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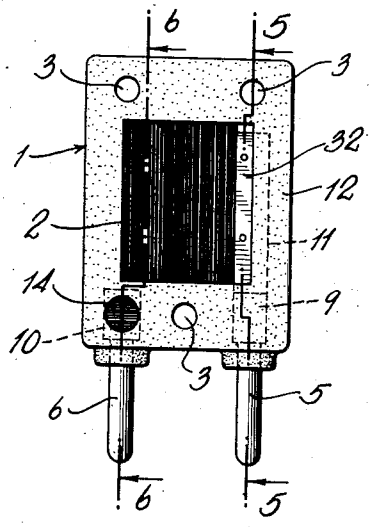


Fig. 4.

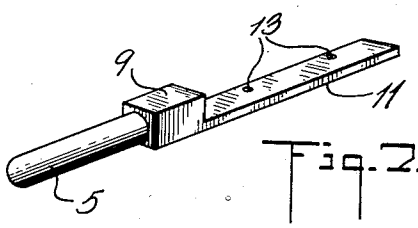


Fig. 7.

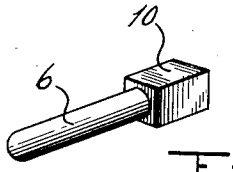


Fig. 8.

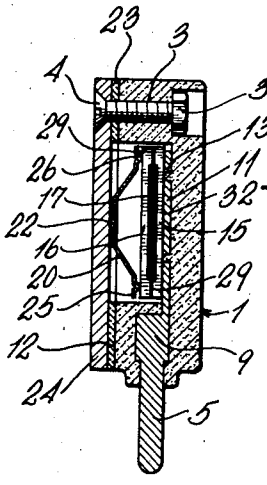


Fig. 5

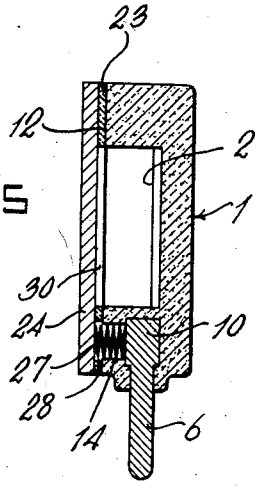
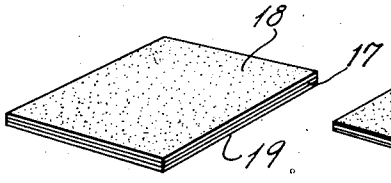


Fig. 6.

Fig. 10.



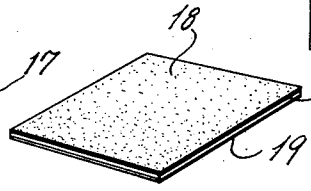


Fig. 9.

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PIEZOELECTRIC DEVICE

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Application September 27, 1941, Serial No. 412,553

11 Claims. (Cl. 171—327)

This invention relates to piezo-electric devices and more particularly to improved holders and contacting arrangements for such devices.

A principal object is to provide a small, compact holder for piezo crystals wherein the frequency adjustment is maintained even though the unit is subjected to strong shocks or vibrations such as are encountered when the unit is used aboard a mobile vehicle or the like.

Another object is to provide an improved moistureproof and airtight crystal holder, wherein the assembly of the parts within the holder can be effected rapidly and without employing any soldered or similar permanent connections to and from the crystal electrodes or other movable parts. As a result the necessity of flexible or relatively long wire connections with their consequent liability of sagging or shifting and causing short circuits, are avoided.

A further object is to provide an improved form of plug-in crystal holder.

A further object is to provide an improved method of fabricating and frequency adjustment of piezo crystals.

A feature of the invention relates to a piezo crystal of the clamped type having the electrodes in the utmost intimate and permanent contact with the crystal faces, by providing these electrodes in the form of metallic or other conductive coatings applied to the crystal by plating, sputtering, spraying, dipping, brushing or the like.

A further feature relates to a plug-in holder for piezo crystals wherein soldered or similar permanently connected lead-in members are avoided between the contact prongs and the crystal electrodes.

A further feature relates to a plug-in crystal holder wherein one of the contact prongs extends inwardly into the housing proper and is provided with a flattened portion to receive and support a crystal clamping frame while at the same time making electrical contact therewith.

A further feature relates to a novel manner of making contact between the crystal electrodes and the external plug-in prongs.

A further feature relates to a novel set of clamping frames and spring-pressure member for piezo-crystal holders of the clamped crystal type.

A still further feature relates to the novel organization, arrangement and relative location and interconnection of parts whereby a stable, sensitive and durable crystal unit is obtained.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawings which represent one preferred form of the invention,

Fig. 1 is a top-plan view of a plated unit embodying features of the invention.

Fig. 2 is a bottom plan view of Fig. 1.

Fig. 3 is an exploded perspective view showing the manner of assembly of the several constituents of Figs. 1 and 2.

Fig. 4 is a view of Fig. 1 with the metal cover plate removed.

Fig. 5 is a sectional view of Fig. 4 taken along the line 5—5 thereof and viewed in the direction of the arrows.

Fig. 6 is a sectional view of Fig. 4 taken along the line 6—6 thereof and viewed in the direction of the arrows.

Fig. 7 is a detailed perspective view of one of the contact prongs.

Fig. 8 is a detailed perspective of the other contact prong.

Figs. 9 and 10 are perspective explanatory views of the manner of adjusting the crystal unit for frequency.

Because of the stress of present day requirements, particularly military requirements, most piezo-crystal devices are not always suited for use under severe service conditions such as on mobile vehicles where they are subject to strong vibrations and jars. Furthermore, the requirements of compactness and light weight restrict the usefulness of the conventional type of crystal holder and especially where such holder must be airtight and moistureproof. In accordance with the present invention, there is provided a crystal holder which meets all the above requirements and which nevertheless is cheap to manufacture and is easily assembled and adjustable by relatively unskilled artisans. In accordance with one phase of the invention, there is provided a method of adjusting the frequency of a crystal unit which does not require any specialized knowledge of crystal cutting, grinding or the like. Furthermore, the crystal unit per se can be tested and adjusted as to frequency while outside the holder, with the assurance that it will have the same frequency response within very narrow limits when it is finally assembled within the holder.

Heretofore, in plug-in type crystal holders, it has been the conventional practice to employ contact prongs which are fastened into the housing by nuts or by staking or the like. With such constructions, it has been necessary to provide separate lead-ins or connector wires between the

prongs and the crystal electrodes. This has usually been accomplished by inserting each relatively thin lead-in conductor into the shank of the hollow contact prong and soldering the conductor to the prong. This requires a difficult "threading" of the lead-in wire into the prong and increases materially the cost of manufacture. Furthermore, if the soldering is done at the external tip of the prong, it may require an additional trimming operation, and a plating operation to protect the solder from corrosion. Such plating must be effected after the prongs are molded into the Bakelite and the cost of plating the prongs without destroying the properties of the Bakelite would become prohibitive. Added to this is the fact that with prior soldered lead-ins, unless the soldering is done very effectively, there is always the danger of a high resistance contact developing between the lead-in conductor and the prong. In accordance with the present invention, no separate soldered lead-in wires are required, the prongs being prefabricated and molded directly and rigidly into the wall of the crystal housing. One of these molded-in prongs is so designed that it acts not only directly as a connector to one of the electrodes of the crystal, but also acts as a level support for the crystal assembly.

Referring to Figs. 1 to 3, the unit comprises a box-like housing 1 of insulation material preferably of a molded phenolic condensation product such as "Bakelite." The bottom of housing 1 is formed with an integral narrow flat-faced ledge 2, and the wall of the housing is provided with a series of perforations 3 to receive suitable fastening screws. Also rigidly molded into one end wall of the housing are two external plug-in contactor prongs 5, 6. As shown more clearly in Figs. 7 and 8, each prong has an integral block portion 9, 10, to provide a more efficient anchoring of the prongs in the Bakelite during the molding-in operation. Prong 5 is also formed with an elongated flat extension 11 of approximately twice the width as the width of ledge 2 and of such a length that it extends nearly the full length of ledge 2.

As shown more clearly in Fig. 4, the prong 5 is molded into the housing 1 in such a position that approximately half the width of the flat portion 11 is exposed, the other half being imbedded in the side wall 12. The flat portion 11 may have a pair of small perforations 13 to allow the molded Bakelite to flow therein during the molding process to insure a further anchoring of the flat portion 11, and also to serve as locators for the prong during molding. The portion 11 has exactly the same thickness as the ledge 2 and forms with the ledge a perfectly flat support for the elements of the crystal assembly. The other prong 6 is likewise molded into the housing 1 and the said housing is formed with a transverse perforation 14 in alignment with the block portion 10 of prong 6. The crystal assembly likewise comprises a lower clamping plate 15 and an upper clamping plate 16 between which the crystal 17 and its integral electrodes 18 and 19 are clamped. The clamping is effected by means of a four-armed spider spring 20. The spider spring has its hub 21 provided with a central raised boss 22 and the dimensions of the spring are such that when it rests on the member 16 without pressure, the projection 22 is above the plane of the sealing gasket 23. Thus when the metal cover plate 24 is fastened in place by the screws 4, the projection 22 is engaged by plate 24 and forces the arms of the spider 20 resiliently against the corresponding corners of plate 16. In accordance with one feature of the invention, each of the arms of the spider spring is formed at its end with a substantially horizontal foot portion 25 and each foot is formed with a localized rounded projection 26 so as to restrict the area of contact between the spider spring and the member 16. The projections 26 may be formed by embossing or punching the metal strip of the spring and if desired each projection 26 can be plated so as to insure a lower resistance contact to member 16.

A coil spring 27 is inserted into perforation 14 and at one end this spring engages the exposed face of the block portion 10 of prong 6. The upper end of spring 27 normally projects through the corresponding opening 28 in gasket 23 so as to be engaged by the cover plate 24. The gasket 23 is of a moisture-proof resilient material such as "neoprene" so that when the cover plate is tightly fastened in place by screws 4, a moisture-proof and airtight seal is provided for the housing contents.

As shown clearly in Fig. 3, each of the clamping frames 15, 16, is formed with integral raised flat surfaced corners 29. These corners may be formed by cutting or milling, stamping each flat side of the frame between corners to the required depth. Since the members 2 and 11 are of the same thickness, they provide a uniform space between the crystal and the bottom of the housing and the frame 15 is supported uniformly at its four corners. If desired, the frames 15 and 16 may be of molded material such as Bakelite, ceramic or the like insulating material conductively coated as by spraying, dipping, etc.

Frames 15 and 16 have lateral dimensions corresponding to those of crystal 17 which dimensions are just slightly less than the corresponding inside lateral dimensions of the cavity in housing 1. Thus the crystal is clamped uniformly and only at its corner portions by the cooperating opposed corners of members 15 and 16. Likewise the window 30 in gasket 23 is about the same size and shape as the upper rim of member 1 thus providing a sealed air chamber above the electrode 18.

After the crystal has been adjusted as to frequency in the manner described hereinbelow, the assembly of the parts is as follows. The frame 15 is dropped into the housing 1 with its corners 29 uppermost so that the side legs of frame 15 rest respectively on ledge 2 and the exposed section 32 of prong extension 11. The crystal 17 with its coated electrodes 18 and 19 is then dropped into the housing with the corners resting on corners 29. Frame 16 is then dropped into the housing with its corners 29 downward, whereupon the spider spring 20 is dropped into place and then the gasket 23 is placed on the upper rim of housing 1 with opening 28 in alignment with opening 14. Spring 27 is then inserted into opening 14 and cover plate 24 is applied and fastened by means of screws 4 and cooperating nuts 31.

Electrical contact is therefore made with crystal electrode 18 through frame 16, spider spring 20 and its contacts 26 and 22, cover plate 24 and spring 27 to prong 6. Electrical contact is also made from electrode 19 through frame 15 directly to prong 5 by engagement with the prong extension 11. Frame 15 is insulated from the other contact prong since it rests upon the insulating ledge 2, and the inner end of block

portion 10 is not exposed within the housing cavity. This arrangement avoids entirely the use of separate soldered lead-in conductors between the prongs and the electrodes; and connection between the prongs and electrodes is automatically effected by the mechanical assembly of the parts. Furthermore, the prongs can, if desired, be of hollow stock rather than solid metal.

In accordance with another aspect of the invention, the crystal proper is provided on opposite faces with layers or coatings 18, 19, of a suitable conductive material such as aluminum. These coatings can be applied in any suitable manner as by painting, spraying, brushing, dipping, sputtering, plating or the like. It will be understood of course that the coatings are applied only to the opposite flat faces of the crystal and if any coating material is deposited on the edges, it is appropriately removed. In accordance with the invention, the coatings 18 and 19 constituting the electrodes are initially applied with such a thickness that the overall frequency response of the crystal is lower than that for which it is intended to be used. The frequency is then adjusted by uniformly removing minute layers of one or both coatings until the desired frequency response is obtained. I have discovered that in order to effect this result properly, it is necessary to remove the coating substantially uniformly over its entire area or at least to remove it without exposing any of the crystal. While the frequency characteristics can be adjusted by entirely removing a localized strip or small part of each coating, this will also change the sensitivity of the crystal since it would reduce the effective electrode area acting on the crystal. By uniformly thinning one or both coatings, the frequency can be adjusted without affecting the sensitivity. While the coating may be thinned in any known way, I prefer to remove it by immersing or uniformly wiping the surface of the coatings with a suitable chemical which dissolves the coating material. The duration or concentration of this solution can be regulated in a predetermined manner so as to control accurately the quantity of metal removed. This coating may also be removed by using the coated crystal as one electrode in an electrolytic bath which acts to remove the coating to any desired extent. Merely as an example the coatings 18 and 19 may be of aluminum and they may be thinned by wiping or dissolving with a caustic solution such as lye or the like. If accidentally too much coating is removed thereby raising the frequency of the crystal, it is a relatively simple matter to apply additional coating material so as to restore the crystal to its desired frequency.

It will be understood of course that the contents of the crystal housing 1 may be evacuated prior to sealing or the housing may be provided with an inert gas or mixture of inert gases under atmospheric or other pressure. One of the outstanding advantages of the present invention is that it enables higher frequency crystals to be used in housings of a type which are subject to powdering or wear. Thus in the Bakelite housing shown, if an ordinary crystal with separate metal electrodes were employed, the vibration of the crystal in the housing due to mechanical shocks and the like, might over a period of time, result in the production of powder from the various surfaces within the housing. Some of this power would eventually get between the crystal and the crystal electrodes and at higher frequencies the presence of this powder in some cases results in the cracking of the crystal. In accordance with the present invention, by providing the crystal with integrally bonded electrodes in the form of plated coatings, higher frequency crystals may be used and enclosed within a housing of Bakelite or similar material which is subjected to powdering, flaking or the like.

Various changes and modifications may be made in this disclosed embodiment without departing from the spirit and scope of the invention.

What I claim is:

1. A piezo-crystal device comprising a box-like housing of insulation having a removable cover plate, a pair of spacer members at the bottom interior of said member, one of said spacers being of insulation and the other of metal, a crystal assembly including a crystal and a pair of opposed electrodes resting on said spacer members, one of said electrodes being in electrical connection with said metal spacer, and a pair of plug-in prongs fastened into said housing, one of said prongs being directly connected to said metal spacer member.

2. A piezo-crystal device comprising a box-like housing of insulation, a metal member embedded in said housing and having a portion exposed within the housing cavity, a crystal assembly including a crystal with a pair of electrodes, said assembly resting on the exposed portion of said metal member to form an electrical connection between said metal member and only one of said electrodes, a pair of external plug-in prongs rigidly fastened into said housing, one of said prongs being in substantially direct electrical connection with said metal member, and an electrical connection between the other prong and the other electrode.

3. A piezo-crystal device comprising a box-like housing of insulation, a pair of rigid plug-in contactor prongs molded into a wall of said housing, one of said prongs having an integral elongation extending into said housing, and a crystal assembly including a piezo crystal and its co-operating electrodes mounted within said housing and resting in part on said elongation, said elongation being in substantial direct electrical connection with the crystal assembly.

4. A piezo crystal comprising a housing of insulation enclosing a crystal with its pair of electrodes, a metal cover plate for said housing, a pair of rigid contactor prongs molded into a wall of said housing, and means to connect said prongs respectively to the corresponding crystal electrodes, the last-mentioned means including an integral elongation on one prong extending inwardly of the housing, and electrically connected to one of the electrodes, a spring having one end in engagement with the other prong and having its opposite end in contact with said metal cover plate, said metal cover plate being electrically connected to said other electrode.

5. A piezo-crystal device comprising a housing having a plurality of rigid contactor prongs molded therein, one of said prongs having an integral extension projecting into the housing cavity, a piezo crystal having a pair of electrodes carried thereby on opposite faces, a pair of metal frame members between which the crystal and its electrodes are sandwiched, each of said frame members engaging the corresponding electrode

only at opposed localized areas adjacent the periphery thereof, the lower frame member resting directly on said projection, a spring having a plurality of arms resiliently engaging the localized areas of the upper frame member, and a metal cover plate for said housing in direct electrical connection with said spring.

6. A piezo-crystal device comprising a box-like housing having a pair of plug-in prongs molded therein, a metal member forming an elongation of one of said prongs, and having an exposed section within said housing, a piezo crystal assembly including a metal frame support for the crystal and a crystal electrode between said frame and the crystal, said assembly resting on said metal member whereby substantial direct electrical connection is made between said frame and said one of the prongs, and a metal cover plate for closing said housing and for completing an electrical connection between the other electrode and the other prong.

7. A housing for a piezo-electric crystal assembly comprising a box-like member of insulation having a plurality of rigid contactor prongs molded into a wall thereof, one of said prongs having an integral elongated extension projecting into the housing cavity and serving as a level support for the crystal assembly within the housing, in which said extension is flat and has a section of its length embedded in a side wall of the housing and the remaining section of its length exposed within the housing cavity.

8. In a piezo-crystal assembly, a crystal having a pair of electrode coatings on opposite faces thereof, a pair of metal clamping frames between which the crystal is clamped, each of said frames having a plurality of localized projections to engage corresponding localized areas adjacent the periphery of the crystal, said frames being assembled so that the corresponding projections are in opposed aligned relation, and a spider spring for resiliently pressing against only the localized areas of one of said frames which localized areas are in alignment with the corresponding raised portions of the frame member.

9. A piezo-crystal device comprising a housing, a plate-like piezo crystal within said housing, at least one electrode directly plated on to the surface of said crystal, and means to clamp said electrode at four spaced points around its margin, said means being in direct electrical contact with said electrode.

10. A piezo-crystal device comprising a housing, a rectangular piezo crystal within said housing, electrodes directly plated on opposite surfaces of said crystal, and means to clamp said crystal only at the four corner regions thereof, said means being in direct electrical contact with said electrodes.

11. A piezo-crystal device according to claim 10, in which the clamping means includes a pair of rectangular frames disposed at opposite sides of the crystal with raised conductive corner portions in electrical contact with the plated coatings.

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