Nov. 8, 1949 A. E. MILLER 2,487,165

CRYSTAL ELECTRODE

Filed Oct. 10, 1946

Fig. 1

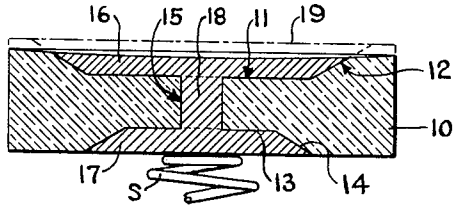


Fig. 2

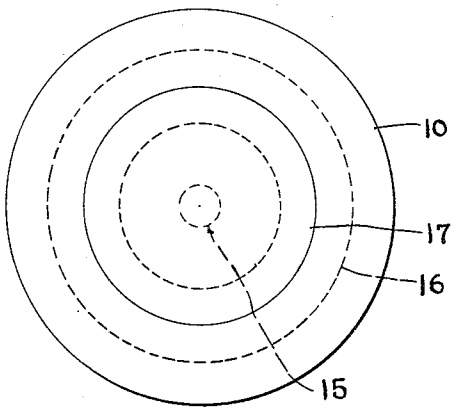


Fig. 3

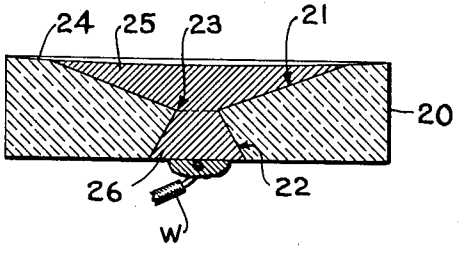
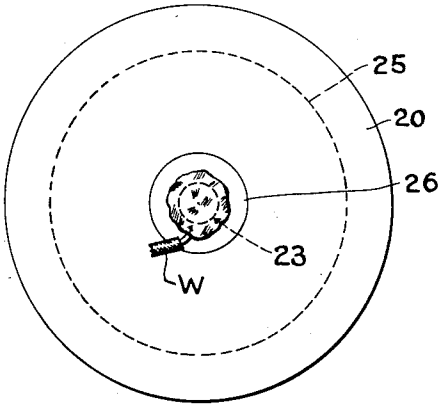


Fig. 4



INVENTOR

AUGUST E. MILLER

BY

Bohlber, Jaosett & Montstream

ATTORNEYS

Patented Nov. 8, 1949

2,487,165

UNITED STATES PATENT OFFICE

2,487,165

CRYSTAL ELECTRODE

August E. Miller, Cliffside Park, N. J.

Application October 10, 1946, Serial No. 702,411

16 Claims. (Cl. 171—327)

1

The invention relates to an electrode to be used with a piezoelectric crystal device as used particularly with high frequency oscillating circuits. Two electrodes are used with each crystal one being placed upon each side thereof. The crystal and the two electrodes are customarily held in a case or housing of any suitable sort for assembly or mounting into an electric circuit.

There are several factors which enter into the stability with which the crystal oscillates in the circuit at the desired frequency. Two of these factors are the dimensions of the surface of the conductor carried by the electrode as well as its spacing from the crystal. The spacing of the surface of the conductor from the crystal at very high frequencies is of the order of microns. Dimensions of this order heretofore have been obtained by separately vaporizing thin layers of metal upon the faces of an insulator or by electronic deposition. These metallic layers frequently peel off, are extremely difficult to control as to their thickness in order to obtain proper spacing between the conductor surface and the crystal, the conducting surfaces or layers on opposite faces are difficult to connect electrically, and exhibit other disadvantages.

It is an object of the invention to construct a crystal electrode in which the conducting material has integral flanges by which it is locked to an insulator body.

Another object of the invention is to construct a crystal electrode in which the dimensions of the surface of the metal may be selected as desired.

Another object of the invention is to construct a crystal electrode in which either face of the electrode may be utilized as the conducting face which is mounted adjacent to the crystal depending upon the dimension of the conducting surface which may be desired.

A further object is to construct an electrode which is more easily manufactured.

A still further object is to provide a new and novel method of making a crystal electrode.

Other objects of the invention are more apparent from the following description when taken with the accompanying drawings illustrating different embodiments thereof in which:

Figure 1 is a cross section through an enlarged crystal electrode.

Figure 2 is a plan view of the electrode of Figure 1.

Figure 3 is a cross section through an enlarged crystal electrode of another form.

2

Figure 4 is a plan view of the crystal of Figure 3.

The crystal electrode includes an insulating body 10 of any suitable insulating material, a ceramic being preferred because this material stands up under relatively high temperatures. The body has two opposite flat faces one of which carries a recess 11. Preferably some portion of or all of the side edge or edges 12 of the recess are inclined outwardly. Since the electrode particularly shown is circular, the entire circumference of the edge is shown inclined. It is clear, however, that the entire edge need not be inclined and with a rectangular or square form of metallic or conducting surface, for example, one or more of the edges may be inclined outwardly. The opposite face of the insulating body 10 preferably carries a recess 13 and the edge or edges 14 thereof also may be inclined outwardly if it is desired to utilize this face as a conducting or metallic surface to be positioned adjacent to a crystal as will appear more fully hereinafter. The recesses shown are flat-bottomed and are relatively thin in order to conserve metal. An opening or hole 15 extends through the body 10 which hole has a dimension less than that of the recesses and connects the recess in one face of the body with the opposite face of the body or with the opposite recess if one is provided.

The recesses and hole are filled with an electrically conductive material in plastic form. The conducting material may be any metal such as silver, copper, aluminum and the like or any alloy, amalgam or composition which is electrically conducting. The metal is in powdered or comminuted form and is mixed with about 10% of powdered borosilicate glass or other suitable binder which will harden or can be hardened after it is applied. Preferably the binder is heat fusible, such as powdered borosilicate glass, at a temperature lower than that at which the body becomes plastic or is destroyed. A liquid binder is also mixed into the dry composition or mixture so that the mass has a pasty consistency and adheres together. Such compositions or mixtures are known. The electrode body with the paste conductor material filling the recesses and the hole, is heated such as in an oven to drive off the liquid binder and to fuse the borosilicate glass thereby binding together the metallic powder and attaching the fused material to the body. A hardened metallic conductor results from the powdered metallic material held together by the binder which conductor has flanges 16 and 17 on

each side of the body connected by a center plug 18 to form an integral whole. The conducting material or metal is therefore locked or firmly anchored to the body by the flanges.

One of the faces of the electrode is then dished such as cylindrically concave or spherically concave. Grinding of the face or faces of the electrode may be utilized for this purpose so that points at the edge of the body are above or higher than the face of the metallic conductor. The grinding may be controlled so that the highest point of the surface of the conductor is one or more microns below the higher points at the edge of the electrode or the body. Optical grinding permits the concavity to be acurately controlled and thereby enables the spacing of the conducting surface below the high points at the outer edge of electrode to be of the order of microns. With a circular electrode which has been spherically ground, the entire peripheral edge of the electrode or body is higher than the surface of the conductor.

With an electrode in which the recess has an inclined edge or edges 12, the metallic conducting flange fused within the recess also has an inclined edge or edges. This enables the electrode to be ground with an electrically conducting surface adjacent to the crystal of any desired dimension. In other words the face of the electrode may be initially at 19 and ground flat until the outside dimension of the conducting surface is slightly larger than the desired dimension. Upon grinding the face concave, the dimension is reduced slightly more. The initial grinding of the face of the electrode would be to an extent sufficiently to give the approximate desired dimension and the concave grinding reduces the surface to the desired dimension. A single concave grinding operation may be used the extent of which is determined by the surface dimension desired. It is this dished or concave face that is placed against the crystal with the higher edges of the body engaging the crystal. The degree or radius of concavity with which the face of the electrode is ground determines the spacing of the conducting surface from the crystal.

The recess 13 as previously mentioned may also have its edge or edges 14 inclined outwardly. The outer or maximum dimension of this recess may be approximately the minimum dimension of the recess 11 so that this face of the electrode may be ground and placed adjacent to the crystal in the event that a smaller surface area is desired. This face also may be initially ground to an approximate dimension and the concave or dished grinding giving a surface for the conductor of any desired dimension. With an electrode so constructed an increased range of dimensions for the surface adjacent to the crystal may be achieved.

The electrode shown in Figure 3 includes a body 20 of insulating material having a recess 21 in one face thereof and a recess 22 in the other face thereof. These recesses have inclined edges which merge to form a connecting opening 23. The angle of inclination of the edges may be the same or different as desired. These recesses are filled with the hardening or fusible plastic conducting material and allowed to harden or is fused. This electrode also may be ground initially upon one face until the surface of the conducting material is approximately of the desired dimension after which it is ground with a concave or dished face 24. The conducting material forms flanges 25 and 26 on opposite faces of the electrode or body which are integrally connected with each other through the opening 23 and hence lock or anchor the same to the body. A spring contact S or a wire W may be soldered to the opposite conducting face of each electrode in order to establish electrical connection therewith.

Although in the preferred forms recesses are provided in the opposite face of the body from the face which is concaved and placed adjacent to the crystal, the integral flange construction can be secured without this recess in each face merely by filling the recess provided in one face of the body and the hole through the body with the fusible plastic conducting composition and spreading the composition over the other face of the electrode. When fused or hardened the hardened conductor or metallic composition has flanges on opposite sides of the body which are integrally connected by the plug of material in the hole and thereby anchor the conductor to the body.

So far as the method of obtaining a metallic electrode surface of the desired surface area or dimension and desired spacing of the surface from the surrounding edge or edges are concerned, the central metallic conducting material 16 and 25 may be secured to the ceramic body in any way desired although the fusing method particularly described is preferred.

This invention is presented to fill a need for improvements in electrode for piezo crystal. It is understood that various modifications in structure, as well as changes in mode of operation, assembly, and manner of use, may and often do occur to those skilled in the art, especially after benefiting from the teachings of an invention. Hence, it will be understood that this disclosure is illustrative of preferred means of embodying the invention in useful form by explaining the construction, operation and advantages thereof.

What is claimed is:

1. An electrode for a piezo electric crystal device comprising a body of insulating material having opposite faces; a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body, and the body having an opening therethrough of a lesser dimension than the recess to connect the latter with the other face of the body; an electrical conducting material filling the recess and the connecting opening and extending over the opposite face of the body to form an integral whole with connected flanges which is locked to the body by the flanges, and the recessed face of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

2. An electrode for a piezo electric crystal device comprising a body of insulating material having opposite faces, a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body, and the body having an opening therethrough of a lesser dimension than the recess to connect the latter with the other face of the body, a heat fusible electrical conducting material filling the recess, the connecting opening and extending over at least a portion of the opposite face of the body to form an integral whole with connected flanges which is locked to the body by the flanges, and the recessed face of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

3. An electrode for a piezo electric crystal de-

vice comprising a body of insulating material, a cavity in the body including a recess in each face thereof of a lesser dimension than the outer dimension of the body, and the body having an opening connecting the recesses through the body at a lesser dimension than the recesses, an electrical conducting material in both recesses and the connecting opening to form an integral whole with connected flanges which is locked to the body by the flanges, and one of the faces of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

4. An electrode for a piezo electric crystal device comprising a body of insulating material; a cavity in the body including a recess in each face thereof of a lesser dimension than the outer dimension of the body and having a flat bottom, and the body having a hole extending between the recesses and through the body at a lesser dimension than the recesses; an electrical conducting material in both recesses and the hole to form an integral whole with connected flanges which is locked to the body by the flanges, and one face of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

5. An electrode for a piezo electric crystal device comprising a body of insulating material; a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body, the side edge of the recess inclining outwardly, and the body having an opening through the body at a lesser dimension than the recesses to connect the recess with the other side of the body; an electrical conducting material filling the recess with the inclined side and the connecting opening and extending around the opening on the other side of the body to form an integral whole with connected flanges which is locked to the body by the flanges, and the face of the electrode having the recess with an inclined side edge being dished to space the surface of the electrically conducting material below the outer edge of the body and provide a conductor surface of a desired dimension.

6. An electrode for a piezo electric crystal device comprising a body of insulating material; a cavity in the body including a recess in each face thereof of a lesser dimension than the outer dimension of the body, the side edge of at least one recess being inclined outwardly, and the body having an opening connecting the recesses through the body and having a lesser dimension than the recesses; an electrical conducting material in both recesses and the connecting opening to form an integral whole with connected flanges which is locked to the body by the flanges, and the face of the electrode having the recess with an inclined edge being dished to space the surface of the electrically conducting material below the outer edge of the body and to provide a conducting surface of a desired dimension.

7. An electrode for a piezo electric crystal device comprising a body of insulating material, a cavity in the body including a recess in each face thereof of a lesser dimension than the outer dimension of the body, each recess having an edge inclined outwardly, and the body having an opening through the body of a lesser dimension than the recesses and connecting the same; an electrical conducting material filling both recesses and the connecting opening to form an integral whole with connected flanges which is locked to the body by the flanges, and at least one of the faces of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body and provide a conducting surface of a desired dimension.

8. An electrode for a piezo electric crystal device comprising a body of insulating material, a cavity in the body including a recess in each face thereof of a lesser dimension than the outer dimension of the body and having a flat bottom, each recess having an edge inclining outwardly, the maximum dimension of one recess being approximately the same as the lesser dimension of the other recess, and the body having a hole through the body of a lesser dimension than the recesses to connect the same; an electrical conducting material filling both recesses and the connecting opening to form an integral whole with connected flanges which is locked to the body by the flanges, and at least one of the faces of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

9. A method of making an electrode for a piezo electric crystal device having a body of insulating material and a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body and having an edge inclining outwardly, and an opening through the body of a lesser dimension than the recess material comprising filling the recess and the connecting opening and spreading over the opposite face of the body with an initially plastic electrical conducting material to form connected flanges, hardening the conducting material to form an integral whole which is locked to the body by the flanges, and grinding concave the face of the electrode having the recess to space the surface of the electrically conducting material below the outer edge of the body.

10. A method of making an electrode for a piezo electric crystal device having a body of insulating material and a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body and an opening through the body of a lesser dimension than the recess material comprising filling the recess and the connecting opening with and spreading over the opposite face of the body an initially plastic and fusible electrical conducting material to form connected flanges, fusing the conducting material with heat at a temperature high enough to fuse the conducting material but insufficient to affect the body to form an integral whole which is locked to the body by the flanges, and grinding concave the face of the electrode having the recess to space the surface of the electrically conducting material below the outer edge of the body.

11. A method of making an electrode for a piezo electric crystal device having a body of insulating material and a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body and having an edge inclining outwardly, and an opening through the body of a lesser dimension than the recess material comprising filling the recess and the connecting opening and spreading over the opposite face of the body with an initially plastic electrical conducting material to form connected flanges, hardening the conducting material to form an integral whole which is locked to the body by the flanges, grinding the face of the electrode having the recess with the inclined edge until the conducting ma-

terial is of approximately the desired dimension, and grinding concave this face of the electrode to space the surface of the electrically conducting material below the outer edge of the body.

12. A method of making an electrode for a piezo electric crystal device having a body of insulating material and a cavity in the body including a recess in at least one face thereof of a lesser dimension than the outer dimension of the body and having an edge inclining outwardly, and an opening through the body of a lesser dimension than the recess material comprising filling the recess and the connecting opening and spreading over the opposite face of the body with an initially plastic and heat fusible electrical conducting material to form connected flanges, fusing the conducting material at a temperature high enough to fuse the conducting material but insufficient to affect the body to form an integral whole which is locked to the body by the flanges, grinding the face of the electrode having the recess with the inclined edge until the conducting material is of approximate'y the desired dimension, and grinding concave this face of the electrode to space the surface of the electrically conducting material below the outer edge of the body.

13. An electrode for a piezo electric crystal device comprising a body of insulating material having opposite faces; the body having an opening therethrough at least one edge thereof of a lesser dimension than the outer dimension of the body, the opening having an inclined edge providing different sectional areas parallel with a face of the body, an electrical conducting material filling the opening, and the face of the electrode having the edge of the opening spaced from the outer dimension of the body being dished to a dimension greater than the face of the conducting material and to a depth with respect to the outer edge of the electrode corresponding with the desired spacing of the surface of the electrically conducting material from the crystal.

14. An electrode for a piezo electric crystal device comprising a body of insulating material having opposite faces, a cavity extending through the body and between the faces, at least one face of the cavity having a lesser dimension than the outer dimension of the body, and the cavity having at least one sectional area spaced from the face of the body of a lesser dimension than another sectional area; an electrical conducting material filling the cavity to form an integral whole which is locked to the body, and the recessed face of the electrode being dished to space the surface of the electrically conducting material below the outer edge of the body.

15. A piezo crystal combination comprising a piezo crystal having flat faces, an electrode engaging each face of the crystal at its outer edges; at least one electrode including a body of insulating material having opposite faces, the body having an opening therethrough at least one edge thereof of a lesser dimension than the outer dimension of the body, an electrical conducting material filling the opening and extending over the face of the body to form an integral whole with connected flanges which is locked to the body by the flanges, and a face of the electrode, having the edge of the opening spaced from the outer dimension of the body, being dished to a diameter greater than the face of the conducting material and to a depth with respect to the outer edge of the body corresponding with the desired spacing of the surface of the electrically conducting material from the crystal.

16. A piezo crystal combination comprising a piezo crystal having flat faces, an electrode engaging each face of the crystal at its outer edges; at least one electrode including a body of insulating material having opposite faces, the body having an opening therethrough at least one edge thereof of a lesser dimension than the outer dimension of the body, the opening having an inclined edge providing different sectional areas parallel with the face of the body, an electrical conducting material filling the opening, and a face of the electrode having the edge of the opening spaced from the outer dimension of the body being dished to a diameter greater than the face of the conducting material and to a depth with respect to the outer edge of the body corresponding with the desired spacing of the surface of the electrically conducting material from the crystal.

AUGUST E. MILLER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,783,014	Hansell	Nov. 25, 1930
2,076,060	Bechmann et al.	Apr. 6, 1937
2,146,994	Schroter et al.	Feb. 14, 1939
2,252,277	Tate et al.	Aug. 12, 1941
2,255,184	Osenberg	Sept. 9, 1941
2,366,274	Suth	Jan. 2, 1945