

June 22, 1948.

F. F. SYLVESTER ET AL
ELECTRICAL COMPONENTS

2,443,700

Filed Aug. 14, 1946

2 Sheets-Sheet 1

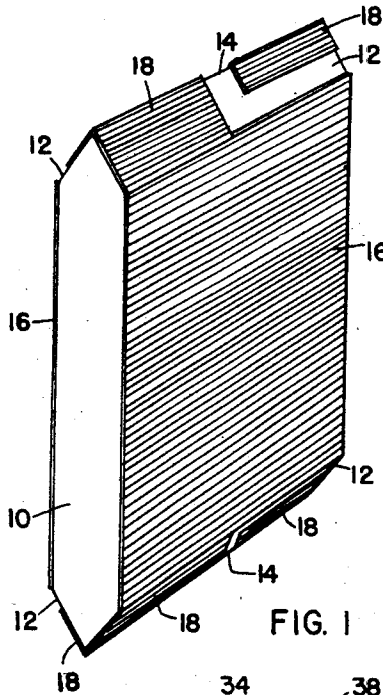


FIG. 1

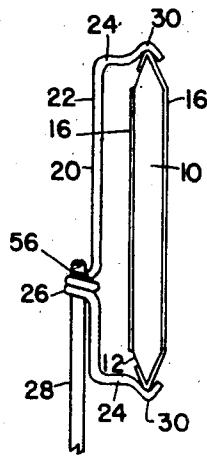


FIG. 2

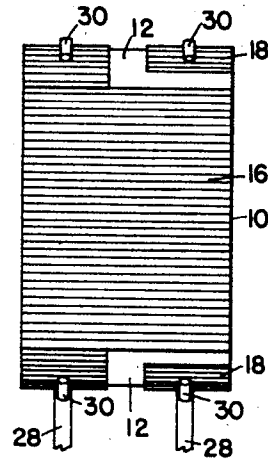


FIG. 3

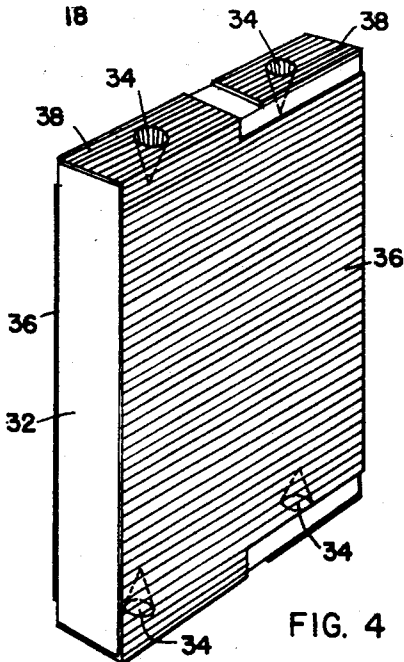


FIG. 4

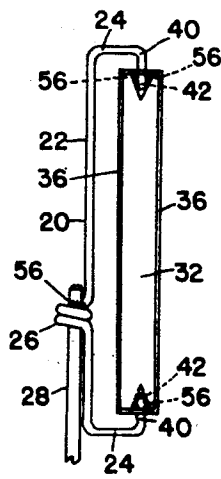


FIG. 5

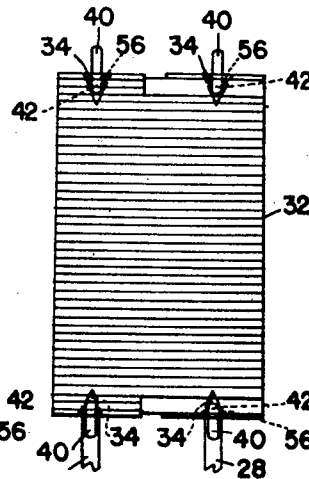


FIG. 6

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2 Sheets-Sheet 2

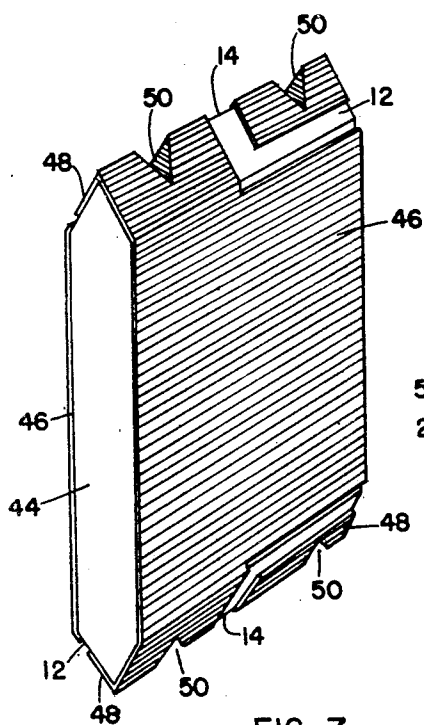


FIG. 7

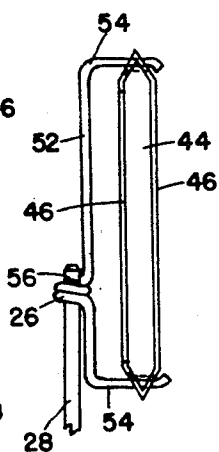


FIG. 8

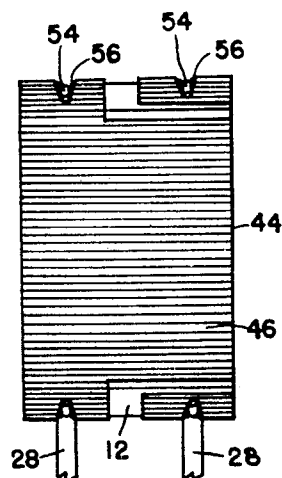


FIG. 9

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2,443,700

ELECTRICAL COMPONENTS

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Application August 14, 1946, Serial No. 690,462

14 Claims. (Cl. 171-327)

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This invention relates to shear mode oscillators and to means for mounting the same.

The principal modes of vibration occurring in conjunction with piezoelectric crystals are discussed at some length in an article entitled "Modes of motion in quartz crystals, the effects of coupling and methods of design," by R. A. Sykes, starting on page 52 of the Bell System Technical Journal, volume 23, No. 1, January 1944, published by the American Telephone and Telegraph Company. As set forth in this article, the three types of motion most commonly considered are flexural, extensional and shear. Whereas these types of motion can be isolated for purposes of discussion, practically, they occur in the form of complex vibrations requiring consideration in the design and production of piezoelectric bodies. The coupling of these various modes of vibration persists despite the care exercised in selecting specific cuts from the raw material and the care exercised in accurately dimensioning the finished bodies.

Accordingly, while this invention is directed to piezoelectric bodies of the type known as shear mode oscillators, the preferred manner of mounting them necessarily takes into consideration the flexural and extensional modes of vibration as well.

Many proposals have been made in the past for mounting piezoelectric bodies with a view towards reducing damping as much as possible. It has been proposed for example to employ supports having substantially point contact with such bodies. Various arrangements of grooving and drilling crystals for cooperation with supporting elements have been attempted. But nowhere among the prior art patents has there been disclosed a piezoelectric body and mount therefor possessing the simplicity of design, inexpensive production possibilities and reliability of performance of the arrangement described in copending application Serial Number 658,618, filed April 1, 1946, of which this application may be considered to be a continuation in part.

This invention contemplates the use of piezoelectric bodies for low frequency operation smaller in size for a given frequency than has been deemed possible heretofore. The design of the body and the manner of mounting it jointly contribute to this new and unexpected result.

In accordance with the present invention a shear mode oscillator plate is provided with mounting portions lying substantially in a nodal plane of shear mode oscillation of the plate. Such mounting portions may be in the form of substantially linear edges which may be the trans-

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verse and/or the longitudinal linear edges of the plate. These edges will preferably occur at the intersection of a nodal plane of shear mode oscillation and a nodal line of flexural oscillation of the plate, which may be the nodal line of longitudinal flexural oscillation or of transverse flexural oscillation, depending upon the characteristics desired. In most cases the nodal plane of shear mode oscillation involved will be that of the fundamental. In the case of the nodal line of flexural oscillation however, it may be a harmonic and/or a fundamental oscillation which is primarily involved. It is further contemplated that suitable mounting means for such a shear mode oscillator plate will engage the plate substantially solely at the intersection of a nodal plane of shear mode oscillation, a nodal line of longitudinal flexural oscillation, and/or a nodal line of transverse flexural oscillation.

The major surfaces of the plate are preferably provided with spaced electrodes extending over one or more prescribed edges thereof for cooperation with conducting terminals which serve the further function of physically supporting the plate with a minimum of damping. The mounting and/or terminal means may be of a resilient nature, to thus lend further advantages which will be recognized by those skilled in the art.

In some cases substantially point support of such bodies is contemplated, a condition which may be accomplished by locating conical recesses at prescribed portions of the body to produce minimum damping and introducing supporting elements into such recesses to produce a minimum area of contact with the body consistent with proper physical support and electrical conductivity with respect to the body electrodes.

Where recesses or grooves are provided in the body for the reception of mounting elements they may be coated to afford dependable electrical joints with such elements, and in any case the supporting elements may be retained in their optimum positions with respect to a body by friction, cement or solder.

A more complete understanding of the invention will follow from a more detailed description based upon the accompanying drawings wherein:

Fig. 1 is a perspective of a form of piezoelectric body contemplated herein;

Fig. 2 is an elevation of a body like that of Fig. 1 assembled in a mount;

Fig. 3 is an elevation of the right side of the assembly shown in Fig. 2;

Fig. 4 is a perspective of a modified form of

piezoelectric body contemplated by the present invention;

Fig. 5 is an elevation of a body like that of Fig. 4 assembled in a mount;

Fig. 6 is an elevation of the right end of Fig. 5;

Fig. 7 is a perspective of another modification of a piezoelectric body;

Fig. 8 is an elevation of the body of Fig. 7 assembled in a mount; and

Fig. 9 is an elevation of the right face of Fig. 8.

With reference to Figs. 1, 2 and 3 of the drawings, the shear mode oscillator in the form of a plate or body 10 is provided with bevels 12 at its opposed edges, terminating in substantially linear edges 14 lying substantially in a nodal plane of shear mode oscillation of the plate. As depicted, these are the transverse edges of the plate, but it will be understood that the longitudinal edges could be similarly ground or otherwise formed. These substantially linear edges lie not only in a nodal plane of shear mode oscillation, but preferably substantially at the intersection of a nodal plane of shear mode oscillation and a nodal line of flexural oscillation of the plate, and more specifically in the case illustrated, a nodal line of longitudinal flexural oscillation.

The opposed major surfaces of the plate 10 are provided with conductive electrodes 16 which are extended over one or more of the bevelled edges to form conductive tabs 18 spaced from one another to avoid mutual contact. These electrodes and their tabs may be applied by evaporating metals, such as silver, and maintained in the necessary spaced relationship by the use of suitable masking procedures. In the form of the invention depicted in Figs. 1, 2 and 3, either bevelled edge of the plate may remain uncoated where desired.

Mounting clips 20, formed from resilient wire or strip material, assume a somewhat channel shape having a web 22, a pair of opposed reentrant flanges 24 and a loop 26 bent or twisted from the plane of the web to form a suitable number of turns for embracing the upper portions of the terminal pins 28 to which they may be bonded electrically and mechanically by welding or soldering. The flanges 24 of the clips terminate in substantially V-shaped plate engaging elements 30, the legs of which are preferably more widely divergent than are the bevel forming faces of the plate. In this manner, the clips will engage the opposed substantially linear edges of the plate with a minimum of contact area and are preferably so spaced as to engage the plate substantially along lines of transverse flexural oscillation, by virtue of which, in conjunction with the design of the plate itself, damping will be maintained at a minimum. It will be understood that the outer ends of the clips may be conductively connected with the respective electrodes by means of friction, cement or solder, for completion of the desired electrical circuits through the terminal pins 28.

The piezoelectric body or plate 32 depicted in Figs. 4, 5 and 6 is also of predetermined shape and dimensions to produce a desired oscillating frequency, and is primarily a shear mode oscillator plate as well. In this case, the ends of the plate are formed with conical openings or recesses 34 having apices which lie substantially at the intersection of: a nodal plane of shear mode oscillation; a nodal line of longitudinal flexural oscillation; and a nodal line of transverse flexural oscillation of the plate. This intersection is preferably that of the fundamental

oscillations respectively so that the engagement of suitable mounting means substantially at these apices with a minimum practicable contact area will reduce damping to a minimum.

The opposed major surfaces of the plate are provided with electrodes 36 applied in any suitable manner as by the evaporation of metal. These electrodes are shown as extending over the edges of the plate to form tabs 38 which are maintained in suitably spaced relationship to avoid mutual conduction. The conical recesses formed in the edges over which the tabs are applied may be coated initially with a suitable conducting composition so that when the plate has been formed with its electrodes extending into contact with such composition, the supporting elements employed for mounting the plate will make electrical contact with the respective electrodes through the metallic composition received in these recesses. A suitable conducting composition may comprise polished silver particles admixed with a low sintering ceramic frit, known in the trade as "liquid silver." This material may be dispersed in a suitable vehicle to facilitate coating, and then dried at a relatively low temperature, 160° C. for example, and then fired at a temperature sufficiently low as to have no adverse affect upon the piezoelectric properties of the body, such a temperature preferably not exceeding 1000° F. After maintaining the firing temperature for approximately 20 minutes, atmospheric conditions are then slowly restored and the surface may be burnished. The coating may be very thin of the order of .001 of an inch for satisfactory results.

The mounting clips 20 in this case are also somewhat channel shaped in elevation, defining a web 22 and opposed flanges 24. In this case however, the opposed flanges terminate in substantially right angularly bent tips 40 which converge to form ball points 42 whose convergence defines an angle slightly smaller than that defined by the elements of the conical recesses. In this manner, the resilient wire or strip material from which the clips are formed make possible a relatively small area of contact with the plate at positions where mechanical motion of the plate is at a minimum. The clips may be retained in position and electrically bonded to the coating of the recesses by the use of solder 56, or if desired, friction or cement may be relied upon.

The modified form of piezoelectric body or plate 44 shown in Figs. 7, 8 and 9 is particularly well adapted for installations which are apt to be subjected to rough usage of the type encountered, for example, by the military services. Here again, the body is primarily a shear mode oscillator proportioned to operate at a desired frequency. The transverse edges are provided with bevels 12 as in the modification shown in Fig. 1, the bevels intersecting in substantially linear edges 14 lying substantially in a nodal plane of shear mode oscillation and in the vicinity of a nodal line of longitudinal flexural oscillation.

The opposed major surfaces of the plate are provided with conductive electrodes 46 which are extended over either or both of the upper and lower bevelled edges 12, terminating in conductive tabs 48, the conductive material extending down into notches 50 of which two are provided in each of the transverse edges 14. These notches are formed along lines corresponding to transverse nodal lines of flexural oscillation and preferably have a width at their apices not ex-

ceeding 30% of the thickness of the plate or body. These apices will be located preferably in the vicinity of a nodal line of longitudinal flexural oscillation also.

Conductive material similar to that employed in connection with the conical recesses of Fig. 4 may be applied to the surfaces of the notches 50 for a similar purpose.

The mounting clips 52 for this form of the invention have been depicted in Figs. 8 and 9 as formed from resilient wire or strip material to produce a channel like configuration having flanges 54 whose forwardly directed portions are received in the notches 50 to the coatings of which they are connected by solder 56 or other suitable means to assure proper physical and electrical joints. As in the case of the preceding figures, the web of the channel may be provided with a loop 26 to embrace a terminal pin 28, and may be secured by solder 56.

Where solder is employed to secure the mounting clips to the coating on the body, or in its recesses or notches, it may be of a silver bearing type, containing for example 1 to 5% silver and a high proportion of tin, ranging for example between 57 and 60%. Other types of high conductive solder may be employed satisfactorily however so long as they prevent scavenging of the silver.

The foregoing illustrations constitute but three examples of the manner in which the present invention can be practiced, which are not to be construed as limiting beyond the scope of the appended claims.

We claim:

1. A shear mode oscillator body having opposed substantially linear edges lying substantially in a nodal plane of shear mode oscillation of the body.

2. A shear mode oscillator body having opposed substantially linear edges lying substantially at the intersection of a nodal plane of shear mode oscillation and a nodal line of flexural oscillation of the body.

3. A shear mode oscillator body having opposed substantially linear edges lying substantially at the intersection of a nodal plane of shear mode oscillation and a nodal line of longitudinal flexural oscillation of the body.

4. A shear mode oscillator body having opposed substantially linear edges lying substantially at the intersection of a nodal plane of shear mode oscillation and a nodal line of fundamental flexural oscillation of the body.

5. A shear mode oscillator body having opposed substantially linear edges lying substantially in a nodal plane of shear mode oscillation of the body and mounting means engaging said edges.

6. A shear mode oscillator body having opposed substantially linear edges lying substantially at the intersection of a nodal plane of shear

mode oscillation and a nodal line of flexural oscillation of the body, and mounting means engaging said edges.

7. A shear mode oscillator body and mounting means therefor, said mounting means engaging said body substantially solely at the intersection of a nodal plane of shear mode oscillation and a nodal line of flexural oscillation of the body.

8. A shear mode oscillator body and mounting means therefor, said mounting means engaging said body, substantially solely at the intersection of a nodal plane of shear mode oscillation, a nodal line of longitudinal flexural oscillation, and a nodal line of transverse flexural oscillation.

9. A shear mode oscillator body having opposed substantially linear edges lying substantially in a nodal plane of shear mode oscillation of the body, spaced electrodes extending over said edges respectively, and conducting terminals engaging said edges to physically support said body.

10. A shear mode oscillator body having mounting portions lying substantially in a nodal plane of shear mode oscillation of the body and resilient mounting means engaging said portions.

11. A shear mode oscillator body carrying electrodes and having mounting portions lying substantially in a nodal plane of shear mode oscillation of the body and mounting means engaging said portions and electrically connected with certain of said electrodes.

12. A shear mode oscillator body having electrodes, said body having opposed edges provided with notches and mounting means received by said notches in conductive relationship with said electrodes.

13. A shear mode oscillator body having electrodes, said body having transverse edges provided with notches, said notches having conductive surfaces electrically connected with said electrodes, and mounting means received in said notches physically and electrically cooperating with said body.

14. A shear mode oscillator body having electrodes, said body having transverse edges provided with notches whose apices have an extent not exceeding 30% of the thickness of the body, and mounting means secured in said notches in conductive relationship with said electrodes.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,343,059	Hight	Feb. 29, 1944