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2,543,500

MEANS FOR SUPPRESSING TRANSVERSE MODES OF OSCILLATION IN A PIEZOELECTRIC CRYSTAL

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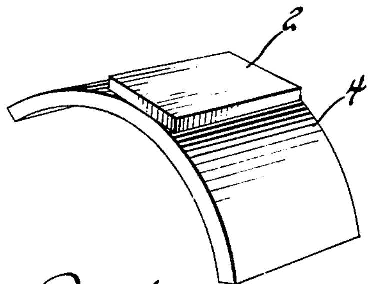

Fig. 1

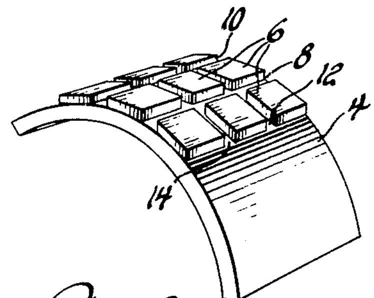

Fig. 2

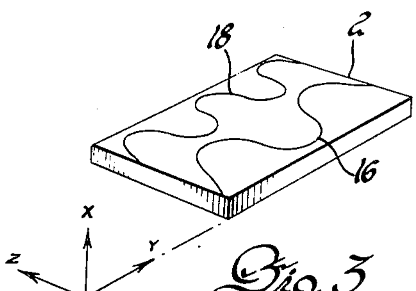

Fig. 3

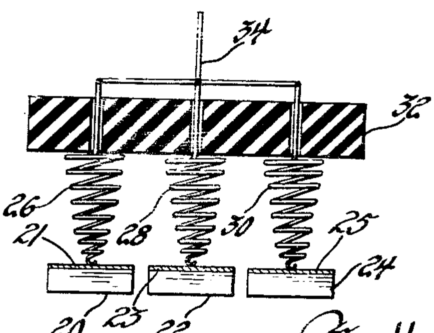

Fig. 4

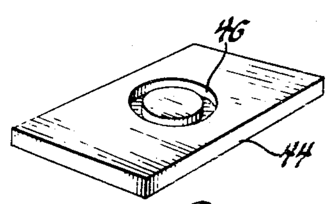

Fig. 6

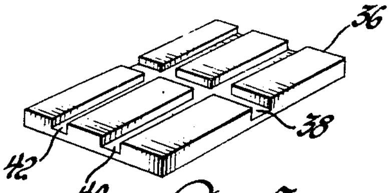

Fig. 5

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MEANS FOR SUPPRESSING TRANSVERSE MODES OF OSCILLATION IN A PIEZO-ELECTRIC CRYSTAL

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5 Claims. (Cl. 171—327)

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This invention relates to transducers and more specifically to piezoelectric crystals and the method of mounting same.

One of the main uses for these crystals is to control an electronic oscillator by vibrating the crystal at its natural or resonant frequency. There are, however, uses for these crystals in which the same are vibrated at frequencies off resonance to impart mechanical vibration to another structure. An example of this latter use is set forth in Patent No. 2,431,233, granted November 18, 1947, entitled "Supersonic Measuring Means" filed April 21, 1944, in the name of Wesley S. Erwin and assigned to a common assignee. In that instance a crystal is vibrated or set into motion by an oscillator, tunable over a predetermined frequency range, and thus driven mechanically at a number of different frequencies. The mechanical vibration of the crystal is transmitted to the mass to be tested by contact pressure to determine certain physical or structural characteristics of the mass. In such use it is desired to drive the crystal off resonance and transmit various known frequencies to the load. Therefore, spurious vibration of the crystal, which may be caused by various harmonic modes of oscillation within the crystal itself, may result in acquiring inaccurate and undependable results. A mechanical device such as a crystal having regular configuration may easily set itself into modes of oscillation in any of its three axes. It is desired, therefore, to design a crystal to minimize these objectionable modes of oscillation. One means of obtaining this result is described in copending Application 575,387, filed January 31, 1945, now U. S. Patent No. 2,485,722, dated October 25, 1949, under the name of Wesley S. Erwin and assigned to a common assignee.

It is therefore an object of our present invention to provide a piezoelectric crystal having no resonant frequency within the range of operation.

It is a further object of our invention to provide a means of transforming electrical energy into mechanical energy and transferring this mechanical energy to a body at maximum efficiency.

It is a still further object of our invention to provide a piezoelectric crystal having grooves therein to attenuate modes of oscillation in the Y and Z axis of the crystal.

It is a still further object of our invention to provide a transducer having a plurality of piezoelectric crystals so supported and arranged to simultaneously impart in phase, vibration to a common body.

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With these and other objects in view it becomes apparent as the specification proceeds that our invention will be best understood with reference to the following specification and claims and the illustration in the accompanying drawings in which:

Fig. 1 shows a usual crystal in contact with the body to be vibrated.

Fig. 2 shows a multiplicity of crystals in contact with a common body.

Fig. 3 shows modes of oscillation of the usual piezoelectric crystal.

Fig. 4 shows one means for mounting a plurality of crystals.

Figs. 5 and 6 show the use of grooves to attenuate undesired modes of oscillation.

Referring more particularly to Figs. 1, 2 and 3, Fig. 1 shows a usual crystal 2 in contact with the body to be vibrated 4. Fig. 2 shows a multiplicity of crystals 6 having the same overall volume as crystal 2 in Fig. 1 but having approximately three times the area of contact with the body to be vibrated 4. Separations 8 and 10 of the crystals prevent objectionable modes of vibration in the Z axis while the separations 12 and 14 prevent objectionable harmonics in the Y axis. These harmonics or modes of oscillation are shown in Fig. 3 in which 16 is a third harmonic and 18 is a fifth harmonic in the Y axis. This crystal, of course, would have the same type of harmonic oscillation in the Z axis.

Fig. 4 illustrates means of mechanically supporting and electrically connecting a plurality of crystals so as to get maximum contact and transfer of energy to the work with a minimum objectionable harmonic and modes of oscillation in the Y and Z axes. In this figure, 20, 22 and 24 are piezoelectric crystals with electrodes 21, 23 and 25 on their upper surfaces which are firmly mechanically and electrically connected to the spring conductors 26, 28 and 30. These spring conductors are supported on the backing plate 32, said backing plate being made of a rigid insulating material. The conductors 26, 28 and 30 extend through openings in the backing plate 32 and are electrically connected to a common conductor 34 to receive electrical energy.

Referring to Fig. 5, 36 is a piezoelectric crystal having a groove 38 to attenuate undesirable modes of oscillation in the Y axis and grooves 40 and 42 to attenuate undesirable modes of oscillation in the Z axis. As illustrative of groove depths it has been found that satisfactory operation is obtained if the grooves extend at least one-third through the crystal.

Referring to Fig. 6, the piezoelectric crystal **44** has a toroidal groove **46** cut therein. This groove is shown as being circular in cross-section but a groove of any other configuration will give satisfactory results if of sufficient depth and extends sufficiently across the face of the crystal.

In the modification of our invention shown in Figures 2 and 4, the frequencies of the Y and Z modes of oscillation are increased by a factor which is the reciprocal of the dimension factor of the crystal in the axis under consideration.

In the modification of our invention shown in Figure 5, the ordinary Y and Z modes of oscillation are eliminated by the grooves which change the part modulus of the crystal in these directions. The modes remaining in the crystals shown in Figs. 2, 4 and 5 are of such high frequency or are so small as to be unobjectionable in the contemplated applications of this device.

Fig. 6 eliminates the objectionable modes of oscillation by attenuating and dispersing the wave front when it strikes the curved portion of the groove.

It is to be understood also that although the invention has been described with specific reference to a particular embodiment thereof, it is not to be so limited, since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

We claim:

1. A piezoelectric crystal to impart mechanical vibration to a load, said crystal having a dimension in the direction of vibration transmission such as to place all its resonant frequency modes in this direction outside the range of operating frequencies and having a dimension normal to the direction of vibration transmission such as may place one or more resonant frequency modes in this direction within the range of operating frequencies, said crystal having a groove cut in one side of the crystal which lies in a plane normal to the direction of vibration transmission to alter the formation of modes of vibration in the dimension transverse to the groove.

2. A piezoelectric crystal to impart mechanical vibration to a load, said crystal having a dimension in the direction of vibration transmission of

magnitude less than one wave length in the crystal material of the highest operating frequency of vibration and a dimension transverse the direction of vibration transmission equal to one or more wave lengths of a frequency within said range of operating frequencies, said crystal having a plurality of transverse grooves in one face of the crystal lying in a plane transverse the direction of vibration transmission to suppress resonant modes of vibration in the axes along said face.

3. A piezoelectric crystal to impart mechanical vibration to a load, said crystal having a dimention in the direction of vibration transmission of magnitude less than one wave length in the crystal material of the highest operating frequency of vibration and a dimension transverse the direction of vibration transmission equal to one or more wave lengths of a frequency within said range of operating frequencies, said crystal having a toroidal shaped groove in the face of the crystal lying in a plane transverse the direction of vibration transmission to suppress resonant modes of vibration in axes along said face.

4. A piezoelectric crystal as claimed in claim 3 in which the depth of the groove is between one-quarter and three-quarters of the thickness of the crystal.

5. A piezoelectric crystal as claimed in claim 3 in which both the depth and the width of the groove is between one-quarter and three-quarters of the crystal's thickness.

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WESLEY S. ERWIN.

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