

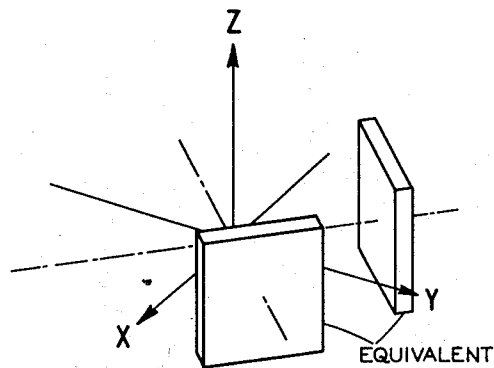
Oct. 18, 1949.

H. G. BAERWALD

2,485,131

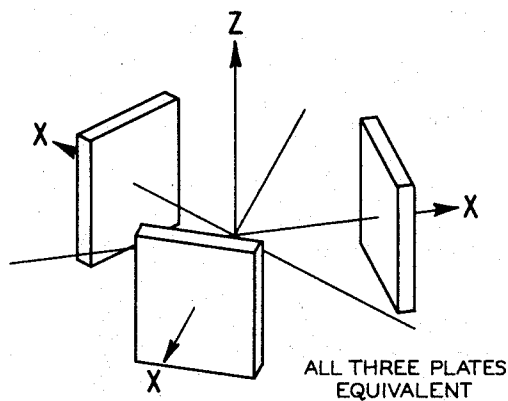
PIEZOELECTRIC CRYSTAL PLATE

Original Filed March 19, 1945



$$I_{4v} = V_d$$

FIG. 1



$$I_{6v} (=D_{3h})$$

FIG. 2

INVENTOR.

HANS G. BAERWALD

BY

Eber J. Hyde

ATTORNEY

UNITED STATES PATENT OFFICE

2,485,131

PIEZOELECTRIC CRYSTAL PLATE

Hans G. Baerwald, Cleveland Heights, Ohio, assignor to The Brush Development Company, Cleveland, Ohio, a corporation of Ohio

Original application March 19, 1945, Serial No. 583,477. Divided and this application April 10, 1948, Serial No. 20,174

3 Claims. (Cl. 171-327)

1

This application is a division of my application Serial Number 583,477, filed March 19, 1945, for Piezoelectric crystal plates, to which reference may be made for a complete discussion of the invention with respect to all crystal classes to which the invention is applicable.

This invention relates to cuts of piezoelectric crystals and more particularly to thickness-controlled shear crystal plates for frequency control or as filter elements in the upper radio and ultra-high frequency range.

The fundamental object of this invention is to provide from crystal classes I_{4v} and I_{6v} , and the cuts or orientations therein possible by virtue of the laws of phenomenological crystal physics, plates with the following three fundamental properties:

1. They are excitable in simple-mode thickness-controlled elastic shear vibrations by longitudinal electric fields and/or dielectric displacements;

2. No elastic and dielectric interaction of these shear modes with any other modes of vibration exists;

3. These orientations are independent of the physical constants of any particular material belonging to one of the specified classes of crystallographic symmetry as well as of extraneous physical conditions such as temperature.

For the purpose of this description, cuts with these three properties are called piezoelectric unconditionally pure thickness-controlled shear cuts.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In accordance with a feature of the invention there is provided a piezoelectric thickness-controlled shear crystal plate cut from crystalline piezoelectric material having a crystallographic plane of symmetry containing an inversion-rotation axis. The plate which is cut from the above described crystalline material has a pair of plane parallel major faces which are substantially parallel to a crystallographic plane of symmetry.

With respect to the drawings, Fig. 1 shows the orientation of piezoelectrically active crystal plates having thickness-controlled uncondition-

2

ally pure shear modes of vibration for a material of the class $I_{4v}=(V_d)$ and Fig. 2 illustrates the corresponding conditions for the class I_{6v} .

From the arguments advanced in the description in the parent application it follows that of all unconditionally pure shear waves possible under the crystallographic symmetry of classes I_{4v} and I_{6v} , only one is piezoelectrically excitable by longitudinal fields. These fields are perpendicular to the many of the equivalent crystallographic planes of symmetry and the direction of motion associated with the shear vibration is parallel to the Z axis in case of I_{4v} and parallel to a Y axis in case of I_{6v} , the X axis in the latter case being defined by the usual convention as being perpendicular to the mirror plane. Therefore, in both classes, the desired plates lie parallel to the crystallographic planes of symmetry, of which there are two equivalent ones in class I_{4v} and three in class I_{6v} .

These are all of the piezoelectric classes having a crystallographic plane of symmetry containing an inversion-rotation axis of an order higher than two.

As in the angular neighborhood of any pure shear cut undesired elastic interactions are proportion to the square of an angular deviation only and, therefore, are practically eliminated throughout that neighborhood, moderate angular deviations cannot only be tolerated but may even be desirable if they lead to a slight improvement in the temperature coefficients.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a piezoelectric thickness-controlled shear crystal plate: a plate cut from crystalline piezoelectric material having a crystallographic plane of symmetry containing an inversion-rotation axis, said plate having a pair of plane parallel major faces which are substantially parallel to said crystallographic plane of symmetry.

2. In a piezoelectric thickness-controlled shear

3

crystal plate: a plate cut from crystalline piezo-electric material of the class I_v, said plate having a pair of plane parallel major faces which are substantially parallel to a crystallographic plane of symmetry of said material.

3. In a piezoelectric thickness-controlled shear crystal plate: a plate cut from crystalline piezo-electric material of the class I_v, said plate having a pair of plane parallel major faces which are substantially parallel to a crystallographic plane of symmetry of said material.

HANS G. BAERWALD.

4

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,303,375	Mason	Dec. 1, 1942
2,306,555	Mueller	Dec. 29, 1942

OTHER REFERENCES

Cady, W. G. "Piezoelectricity," McGraw-Hill, N. W. 1946, pages 19 and 20.