

X 89 599

(H)

Aug. 13, 1929.

A. H. TAYLOR ET AL

1,724,232

PIEZO ELECTRIC CRYSTAL

Filed Oct. 14, 1925

Fig. 1.

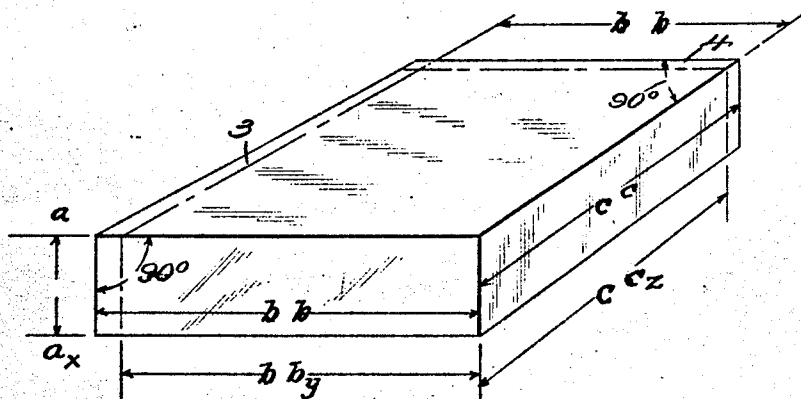
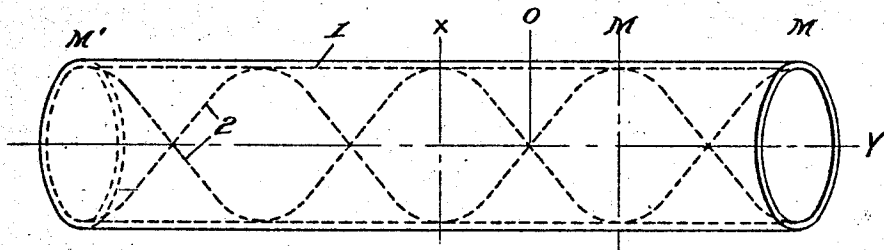


Fig. 2.



Inventor
 Albert H. Taylor and Alfred Crossley.

By Robert A. Lanender,
 Attorney

Patented Aug. 13, 1929.

1,724,232

UNITED STATES PATENT OFFICE.

ALBERT H. TAYLOR AND ALFRED CROSSLEY, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNORS TO WIRED RADIO, INC., OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

PIEZO ELECTRIC CRYSTAL.

Application filed October 14, 1925. Serial No. 62,472.

Our invention relates broadly to piezo electric crystals and more particularly to a construction of piezo electric crystal which may be produced at relatively small cost having maximum power output.

One of the objects of our invention is to provide a system for grinding piezo electric crystals according to a definite law, by which a piezo electric crystal having maximum piezo electric effect may be produced.

Another object of our invention is to provide a construction of piezo electric crystal wherein the crystal is cut with one of its geometrical axes at a zero angle to the optical axis of a natural crystalline body and then the faces perpendicular to the geometrical axes of the crystal are ground to mathematical ratio with respect to each other equal to a whole number for producing a crystal in the shape of a right angular parallelopiped having maximum piezo electric effect.

We have set forth our invention in detail in the following specification with reference to the accompanying drawings, in which:

Figure 1 represents a piezo electric crystal in the process of preparation in accordance with the principles of our invention; and Fig. 2 is a view showing the theoretical principles involved in our invention.

Our invention resides in the cutting of piezo electric crystals with one of the geometrical axes thereof at a zero angle to the optical axis of the natural crystalline body from which the crystals are produced. The individual crystals are cut from the original crystal in such manner that the optical axis is exactly parallel to a plane which contains either side of the crystal along one dimension, as shown in Fig. 1 at $c c$. In Fig. 1, I have represented the three geometrical axes of the crystal that is the optical axis $c c$ and the axes $a a$ and $b b$ which are the two electrical axes along which piezo electric properties are exhibited. In zero angle crystals the $b b$ axis is at right angles to the axis $c c$ and the axis $a a$ is perpendicular to the plane of the faces of the crystal.

Having cut the crystal along the optical axis in such manner that one side is disposed parallel to the optical axis, we have discovered that the maximum radio frequency oscillatory output or piezo electric effect of the crystal can be obtained from the

crystal when two of the geometrical axes are ground to dimensions which bear a mathematical ratio to each other equal to a whole number. That is to say $a a$ dimension should be ground to be an integral part of $b b$ dimension or vice versa, for maximum output from the crystal. An example of this case may be given as follows: a crystal having dimension of five millimeters along the $a a$ axis, dimension of twenty-two millimeters along the $b b$ axis, and a dimension of twenty-five millimeters along the $c c$ axis, is ground on the $b b$ axis until the $b b$ axis is reduced to twenty millimeters at which dimension maximum output or greatest piezo electric effect will be obtained from the crystal. It can be noted in this case that the dimension of the $b b$ axis is exactly four times the dimension of the $a a$ axis when maximum output is obtained. The dimension along the $b b$ axis could also be reduced to ten or fifteen millimeters, and at each of these dimensions the maximum output relationship is noted when a mathematical ratio of $\frac{b b}{a a}$ equal to a whole number is obtained.

It is also necessary at times to grind the crystal down on the $c c$ axis to increase output and to correct for single frequency, that is to say to secure a crystal which is capable of oscillating freely at one and only one frequency, and in some cases to make the $c c$ axis also equal to an integral times the $a a$ axis dimension, that is, by grinding the $c c$ dimension to a value equal to $c c_2$.

In Fig. 1 of the drawings we have shown the piezo electric crystal ground along the $b b$ axis from an original $b b$ dimension to a $b b_1$ dimension, in order to secure a whole number relationship between $b b_1$ and the thickness dimension $a a$.

Reference is made to Fig. 2 in order to explain the reasons for the desirable integral relationship of the dimensions $a a$ and $b b$ for securing the increased output from the crystal. The crystal may be likened to an open and organ pipe, indicated by reference character 1, which has been so built as to be resonant to a definite sound wave. In this pipe a standing sound wave, indicated by reference character 2, may be produced.

In the drawing the heavy lines represent the sides and the ends of the pipe, while the

dotted lines 2 represent the standing wave form present in the pipe for the resonant sound wave. At position O the pressure is greatest, which position corresponds to a nodal point, while at M an anti-node exists which represents a condition of maximum amplitude. Therefore, we have a condition where there is maximum amplitude at each end of the pipe which produces the greatest volume of sound.

The relationship of the diameter and length of the pipe 1 may be likened to the $a a$ and $b b$ axes of a piezo electric crystal. In the organ pipe theory there is an integral relationship between the amplitude or $a a$ dimension and the length of $b b$ dimension is a whole number relationship.

From this discussion we may consider that the integral relationship between $a a$ and $b b$ dimension has a reinforcing effect on the sound wave which causes a condition of maximum sound vibration. Any decrease or increase in length along the $b b$ dimension will change the reinforcing effect until another integral dimension is again obtained.

The same conditions stated with reference to the organ pipe are also met with in the crystals and it appears that the crystal pressure vibration conditions are identical to that of the organ pipe. Therefore, for maximum output from crystals it is imperative that the dimensions along the $a a$ and $b b$ axes should be integrally related to each other.

In the drawings we have shown the amount of material 3 which is removed from the $b b$ dimension of the crystal and the amount of material 4 which may be removed from the $c c$ dimension of the crystal in greatly exaggerated size and it will be realized that the actual amount removed from the crystal may be infinitesimal along the $c c$ axis after the $b b$ and $a a$ dimensions have been fixed by grinding the faces of the crystals parallel to their geometrical axis to a mathematical ratio equal to a whole number.

In the construction of piezo electric crystals according to our invention, the length of the lateral dimension or width of the crystal is an integral multiple of the length of the vertical dimension or thickness of the crystal or briefly the width divided by the thickness gives an integer.

In the claims we have designated the direction along the lateral dimension or width of the crystal as the "lateral axis" and the direction along the vertical dimension or thickness of the crystal as the "vertical axis."

While we have described the invention in certain specific embodiments we desire that

it be understood that modifications may be made within the scope of the appended claims, without departing from the spirit of our invention.

What we claim and desire to secure by Letters Patent of the United States is as follows:

1. A piezo electric quartz crystal having three sides disposed at right angles to each other, in which the axes are proportioned to each other in a ratio which is equal to a whole number for securing maximum piezo electric effect from said crystal.

2. A piezo electric quartz crystal in the form of a parallelopiped having a plurality of sides, in which the dimensions of two adjacent sides bear a whole number relationship to each other for securing the maximum piezo electric effect from said crystal.

3. A piezo electric quartz crystal having a plurality of sides extending at right angles to each other with a pair of said sides extending in a direction coincident with the optical axis of said crystal, said crystal having different dimensions along each of said sides, with one dimension smaller than the other two, and having the smaller dimension mathematically related to one of the other two dimensions in a ratio equal to an integer for securing maximum piezo electric effect from the crystal.

4. A piezo electric quartz crystal having three geometrical axes disposed at right angles to each other, in which the expression $\frac{b b}{a a}$, where $b b$ represents the dimension along the lateral axis, and $a a$ represents the dimension along the vertical axis is equal to an integer.

5. A piezo electric quartz crystal, comprising a crystal having three sides disposed at right angles with respect to each other, with one of said sides positioned at a zero angle with respect to the optical axis of the crystalline body from which the crystal is cut, and the dimensions of the other sides having a mathematical ratio equal to a whole number.

6. A piezo electric quartz crystal in the form of a parallelopiped having a pair of faces substantially parallel to the optic axis and two other pairs of faces perpendicular to the first pair, said last mentioned pairs of faces having dimensions which are divisible one by the other to give a resultant equal to a whole number.

ALBERT H. TAYLOR.
ALFRED CROSSLEY.