May 9, 1933. E. D. TILLYER 1,907,613

OSCILLATING CRYSTAL

Filed Jan. 12, 1927

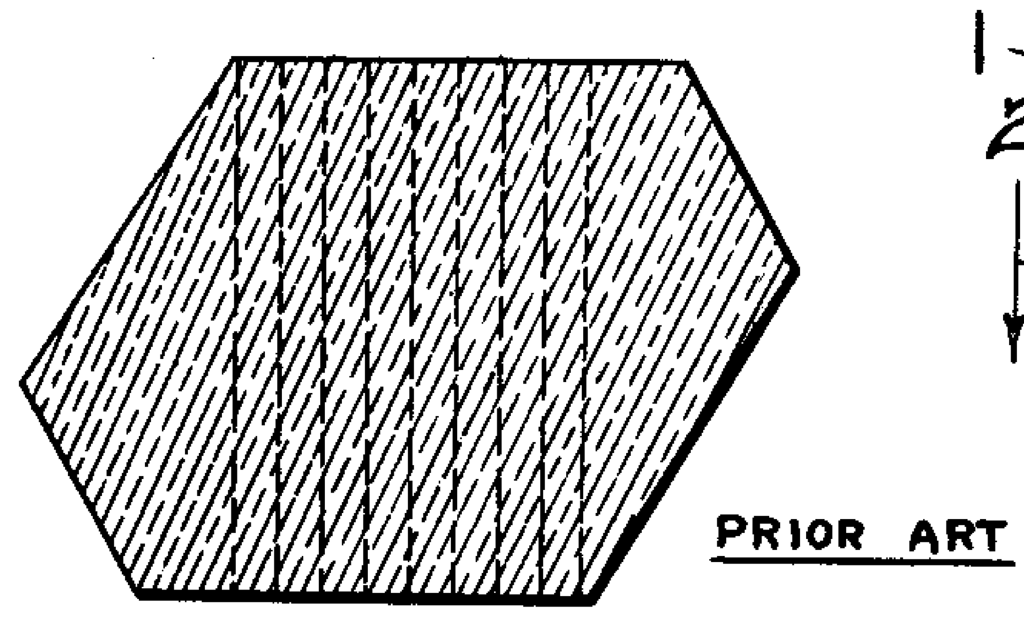

Fig.2.

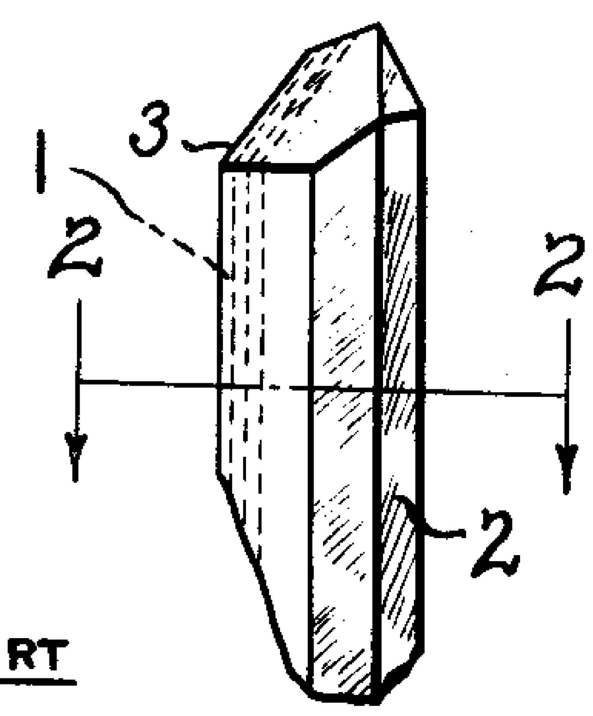

Fig.1.

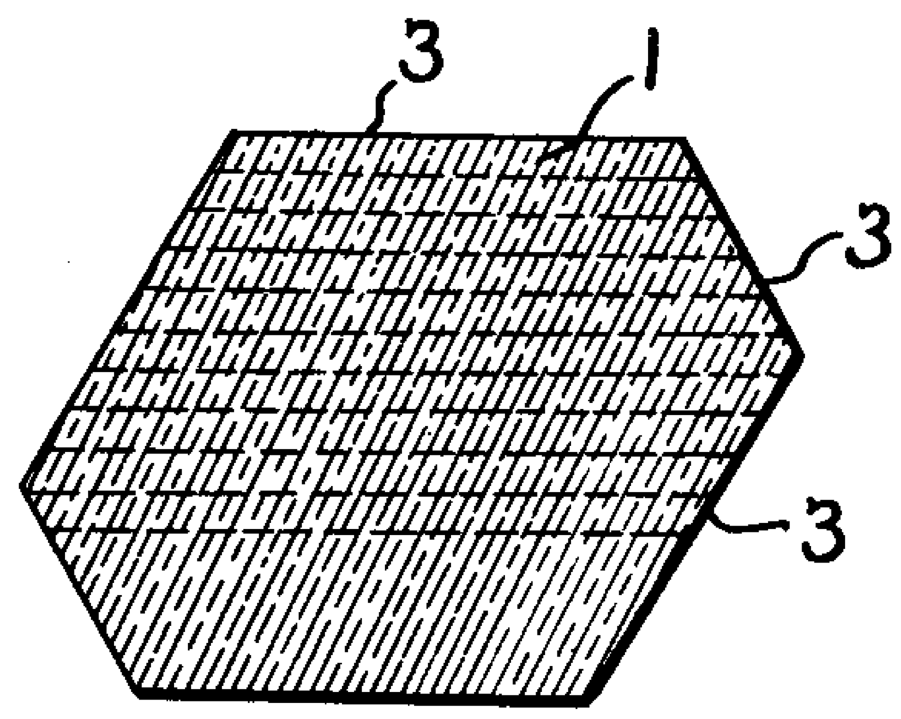

Fig.3.

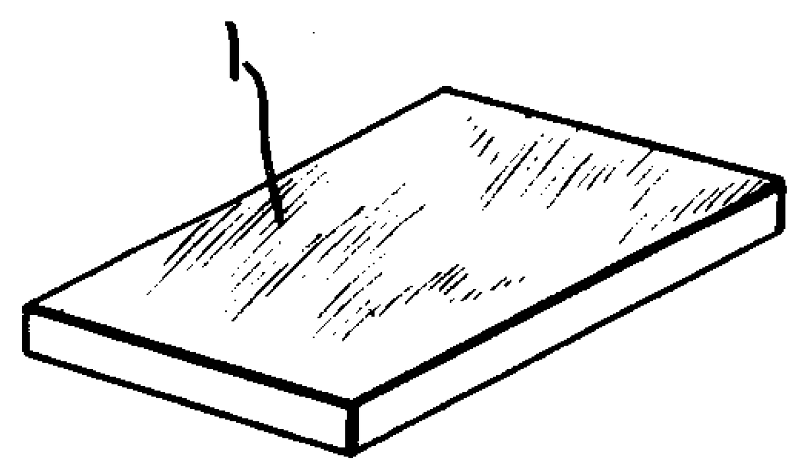

Fig.4.

Inventor

Edgar D. Tillyer.

By Harry H. Styll

Attorney

Patented May 9, 1933 **1,907,613**

UNITED STATES PATENT OFFICE

EDGAR D. TILLYER, OF SOUTHBRIDGE, MASSACHUSETTS, ASSIGNOR TO AMERICAN OPTICAL COMPANY, OF SOUTHBRIDGE, MASSACHUSETTS, A VOLUNTARY ASSOCIATION OF MASSACHUSETTS

OSCILLATING CRYSTAL

Application filed January 12, 1927. Serial No. 160,621.

This invention relates to oscillating crystals and more particularly to a crystal to be used in an oscillating circuit or a resonator circuit and to improved means for producing the same.

The principal object of this invention is to provide a crystal of this nature that will oscillate efficiently for short waves.

Another object of the invention is to provide a process for cutting such a crystal so that it will have high efficiency in oscillation, particularly on short wave lengths.

Another object of the invention is to provide simple, inexpensive and efficient means for producing such crystals, reducing the cost of manufacture of the same, assuring efficiency and particularly reducing wastage by eliminating the production of non-usuable crystals, as has occurred hitherto.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawing and it will be understood that many changes may be made in the exact details of construction and the steps of cutting the crystals without departing from the spirit of the invention as expressed in the accompanying claims. I, therefore, do not wish to be limited to the exact details and arrangements of parts and steps of the process shown, the preferred forms only having been shown by way of illustration.

Referring to the drawing,

Figure 1 indicates a portion of a quartz crystal from which I preferably manufacture my oscillating crystals;

Figure 2 shows a cross section on line 2—2 of Figure 1 showing how the prior art crystals were cut and indicating the direction in which the oscillating crystals are cut from the main crystal;

Figure 3 indicates a cross section on line 2—2 of Figure 1 wherein the direction in which I cut my oscillating crystals is indicated in dotted lines;

Figure 4 indicates the completed oscillating crystal as cut from the whole crystal as indicated in Figure 3.

Prior to my invention it has been usual to cut oscillating crystals as indicated in dotted lines in Fig. 2, that is, the sides of the oscillating crystals as cut are not parallel with any of the faces of the original crystal. It has been found that in crystals cut in this way a large percentage of them, say from seventy to eighty per cent. will not oscillate on the short wave lengths and have to be discarded. I have found, however, that if I cut my oscillating crystals with one face parallel to a face of the mother crystal, as indicated in dotted lines in Fig. 2, about ninety per cent. of these crystals will give good results in those cases where the prior art crystals failed, and that the crystals so cut are particularly efficient on the short wave lengths.

Referring to the drawing in which similar reference characters indicate corresponding parts throughout, I cut my oscillating crystals 1 preferably from a quartz crystal 2 with the face of the oscillating crystal 1 parallel with a face 3 of the mother crystal. In the quartz mother crystal the broad or longitudinal faces of the crystal are parallel to the optic axis of the crystal. This condition probably exists in the case of all piezo electric crystals, but the effect of the relationship of the longitudinal face of the crystal to the optic axis is not clearly known and understood. I have, however, found from experience with a thousand or more of these oscillating crystals that if the longitudinal faces of the oscillating crystal are parallel to the longitudinal faces of the mother crystal, improved results are obtained. These crystals are cut and finished in the same way as are the prior art crystals, the difference being that they are cut in a different direction and consequently their faces which are placed between the electrodes of the circuit have a different relation to the faces and optical axis of the mother crystal than those of the prior art. I have found from experience that in crystals cut as in the prior art their greatest vibration appears to be in their length, width or thickness, but that when cut with one side parallel to a face 3 such as I have cut them their greatest vibration appears to be sidewise or nearly so, that is, nearly in the direction of their thickness which is the direction in which they are used and inserted in the circuit. The wave length in meters per millimeter of thickness of my crystal is roughly 150, while cut in the method of the prior art it is about 110, indicating that there is a difference in the mode of vibration between the oscillating crystals cut in the two ways, but what this difference is is not known or understood. This figure of 150 depends somewhat on other dimensions than thickness. I have found from experimentation with many of the crystals cut in my way that the range of this constant is lowest 145 and the highest 158, although these limits may possibly be exceeded, so that if it is desired to make a crystal which will oscillate at 400 meters there is a probability that the thickness of the oscillating crystal will be three millimeters or slightly more, possibly a trifle less, depending on the above value of the constant. The other dimensions of this crystal are more or less immaterial, making a slight effect on the wave length. There are indications that the vibration of my crystal is not in the direction of the length, width or thickness but has an eskew effect, that is to say, somewhat similar to the movement of the front and back covers of a book if pushed in a direction parallel to the covers of the book, that is, one surface would tend to move in one direction and the opposite surface in the opposite direction, but this is not definitely known and makes no difference in the operation of the crystal except that experience has shown that crystals cut in this manner vibrate differently from those cut in the prior art manner and with much greater freedom and produce much better practical results. With crystals cut as in the prior art vibrations are found in three dimensions, length, width and thickness, whereas in my crystals it appears to be only in one direction, as explained above. There are occasional nondescript modes of vibration in these crystals as well as in other crystals. These crystals are to provide a constant radio frequency or to act as a standard of radio frequency in either oscillating or in resonator circuits. I have found from experience (a great number of these crystals having gone into use) that they give decidedly good results for the short wave lengths and that by cutting the crystals in this way I eliminate a great wastage as crystals cut in the prior art way, as above stated, have failed in from seventy to eighty per cent., wheras in my crystals I get an efficiency of over 90 per cent.

The oscillating crystals 1 may be cut from the mother crystal with a diamond saw, with a revolving piece of sheet metal the edge of which is charged with carborundum, or other abrasive, and in other similar ways. It is not necessary that the direction of cut be determined with any great precision, simple methods for approximating the same being sufficient since small deviations from parallelism with a face of the crystal, optical axes, etc., do not materially affect the useful qualities and characteristics of the crystals thereby obtained.

The faces of the oscillating crystal cut from the mother crystal which face the electrodes of the circuit when placed between said electrodes I term the electrode faces. One electrode face is indicated at 1, Fig. 4; the other is on the opposite side of the oscillating crystal from the face indicated at 1, Fig. 4.

From the foregoing it will be seen that I have provided a simple, efficient and inexpensive method of producing a very efficient crystal oscillator for the purposes required and have perfected a method of producing this crystal oscillator that eliminates a great percentage of the wastage hitherto found in the production of such crystals, it being pointed out that crystals of this kind are very expensive. It is a difficult artirle to produce so that any savings in the production of this article is of great advantage and a step forward in the art.

Statements herein regarding the direction or plane of cut of crystals made in accordance with the invention with reference to the faces of the mother crystal, are to be understood as applying to crystals of typical shape; and where the optical or Z axes, or the crystallographic or Y axes, are referred to herein, these terms are to be understood as used in their ordinary scientific meanings. The electrical or X axes as referred to herein, are to be understood as defined by lines extending respectively between the opposite apices of the angles formed by the sides of a typical prismatic mother crystal of approximately regular hexagonal cross section.

Having described my invention, I claim:

1. A piezo-electric element having its electrode faces substantially parallel to the optic axis and substantially parallel to one of the lateral faces of the mother crystal.

2. A quartz piezo-electric element having its electrode faces substantially parallel to the optic axis and substantially parallel to one of the lateral faces of the mother crystal.

3. A piezo electric device comprising a crystal plate having electrode faces thereof cut parallel to one of the electrical axes of the natural crystal from which the plate is cut.

4. A piezo electric plate cut from a quartz crystal having two substantially parallel electrode faces, the planes of said electrode faces being substantially parallel to the Z axis and to an X axis thereof.

5. In combination, a piezo-electric crystal section so cut from a mother-crystal that the largest surfaces of said section are substan-

tially parallel to the optic axis thereof and are approximately perpendicular to an axis which, in the mother crystal, was approximately parallel to one of the principal crystallographic axes thereof, and a plurality of electrodes associated therewith to constitute an oscillation-controlling device having an oscillation constant of the order of 130 to 160 meters per millimeter of thickness along the axis to which said surfaces are perpendicular.

6. A piezo electric element cut from a mother crystal of the class described and having its thickness dimension substantially along an axis of crystallization of such mother crystal.

7. A piezo electric element cut from a mother crystal of the class described and having its electrode faces substantially parallel with an electrical axis of such mother crystal.

EDGAR D. TILLYER.