April 3, 1962 W. A. MERKL ETAL 3,027,689

DEVICE FOR TREATING PIEZOELECTRIC CRYSTALS

Filed Oct. 5, 1960

FIG. 1

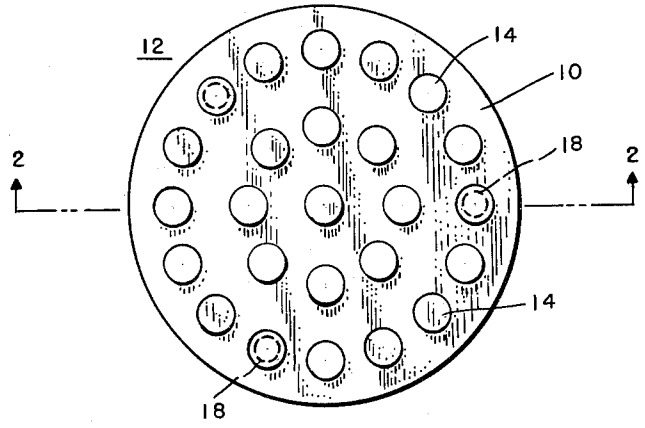


FIG. 2

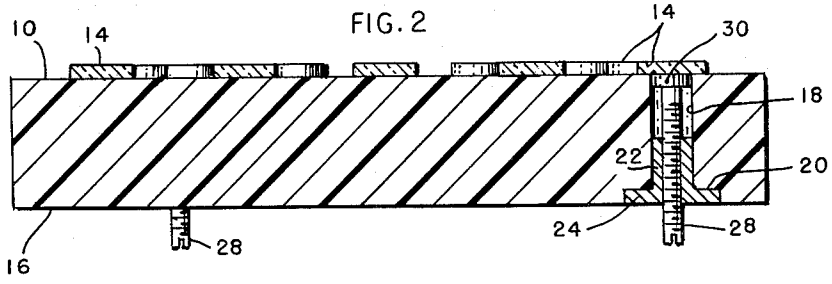


FIG. 3

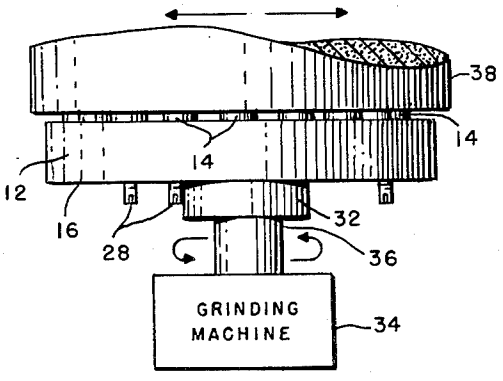
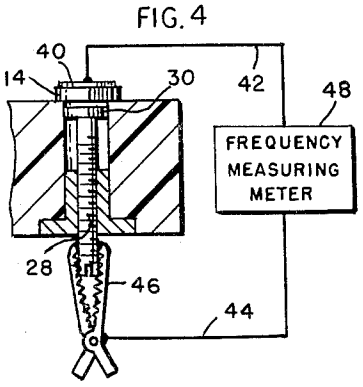


FIG. 4



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DEVICE FOR TREATING PIEZOELECTRIC CRYSTALS

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(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to crystal frequency stabilization devices. More particularly, it relates to a device for mass producing piezoelectric crystals which are used in electronic apparatus to provide a frequency source of high stability.

Quartz crystals vibrating in their thickness shear mode are presently in wide use for the control of high frequencies. Since the frequency of quartz crystals is inversely proportional to the thickness, the crystals become extremely thin at the higher end of the frequency range to be used. It is conventional practice to accomplish this reduction of thickness by grinding, polishing or otherwise treating the crystals. One device in use, for finishing crystals to a predetermined high frequency with a corresponding thinness, includes an optical flat for mounting a plurality of crystals. However, the use of such conventional optical flats is not only complicated and expensive but introduces difficulties in maintaining uniformity of the desired frequency when the crystals are fabricated on a mass production basis. At least one crystal has to be removed from this conventional flat, at intervals, to be checked for frequency. Because of the number of crystals involved, errors or miscalculations, in the frequent testing of the crystals during the grinding process, are costly mistakes.

Bearing the foregoing in mind, it is the object of the present invention to provide a grinding device capable of testing the frequency of ground crystals directly, during the grinding process, to ascertain whether the desired frequency has been reached.

Another object of the present invention is to provide a device for treating crystals wherein they may be ground to operate at high frequencies and be economically produced on a mass production basis.

For a more detailed description of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, in which similar nuerals designate similar elements and wherein:

FIG. 1 is a top plan view of an optical flat according to the invention;

FIG. 2 is a sectional view on an enlarged scale, taken along line 2—2 of FIG. 1;

FIG. 3 is an elevational side view of the optical flat illustrating the grinding of the crystals mounted thereon to increase their natural frequency; and

FIG. 4 is a fragmentary view similar to FIG. 2 of the drawing, illustrating a way of utilizing one of the built-in electrodes to test the frequency of the crystals directly on the optical flat.

In the drawing and referring to FIGS. 1 and 2, there is shown at 12 an optical flat or holder made of insulating material such as crystalline or fused quartz, and having top and bottom parallel surfaces 10 and 16, respectively. Optical flat 12 preferably is of a circular shape and has a plurality of spaced circular piezoelectric crystals 14, such as natural or synthetic quartz, secured to surface 10 in a symmetrical series of circles. A practical method of mounting crystals 14 on flat 12 is by the conventional

wringing-in process whereby one face of each of the crystals are pressed down on surface 10 with a pointed wooden stick. Beeswax or paraffin is then poured around the edges of crystals 14 to prevent moisture entering between the crystals and surface 10. The crystals 14, whose co-efficient of expansion is substantially the same as flat 12, have been cut and may have been only slightly ground to remove any irregularities. Their thickness is, therefore, many times that desired. As an example, their natural frequency may be anywhere from 50 kilocycles per second to a few megacycles per second.

In FIG. 2 there is shown a bore 18 extending transversely through flat 12 from surface 16 to surface 10. Bore 18 is provided with a hollowed out wider base portion adjacent surface 16 to form a shoulder 20. Extending upwardly part way into bore 18, from surface 16, is a metal sleeve 22 which is permanently mounted therein and is provided with a flange 24 which rests against shoulder 20. Sleeve 22 is internally threaded to engage a threaded shank 28 which is terminated adjacent surface 10 by an electrode 30. By such an arrangement, electrode 30 may be movably positioned within bore 18. The periphery of bore 18, at surface 10, is slightly smaller than the circumference of each crystal 14, such that when a crystal is positioned over the bore, the bore will be substantially covered by the crystal.

Again referring to FIG. 1, three bores 18 are indicated within the peripheries of three of the crystals 14. Each of the bores 18 are identical to the bore described in FIG. 2, and each incloses a shank 28 and an electrode 30. In the specific embodiment illustrated, three such randomly disposed bores 18 are provided in flat 12, but it is understood any appropriate number of bores may be employed in any suitable arrangement.

A flat metal plate 32 is fastened to the central portion of surface 16, as shown in FIG. 3, and this assembly is then mounted on shaft 36 which is driven by the grinding machine 34, the essential action of which is well known in the art. Briefly, the optical flat 12 is located centrally in respect to the shaft 36 of the grinding machine 34, and the rotation of the shaft 36 causes the flat 12 to revolve in respect thereto. Simultaneously, the grinding member 38 reciprocates back and forth so that continuously varying surfaces of the exposed faces of crystals 14 are subjected to its action. A suitable grinding paste is applied between the crystals 14 and the grinding member 38 in the conventional manner.

At this point, if the conventional optical flats, had been employed, the operator would now be confronted with the expensive and time-consuming problem of removing a crystal from the flat and mounting it in a crystal holder so that it could be tested to determine its frequency. However, with the improved optical flat 12 of this invention, three randomly placed crystals 14, over the built-in electrodes 30, are tested at intervals directly on the optical flat 12, during the grinding operation.

FIG. 4, wherein one of the three electrodes 30 are illustrated, shows a means for testing the frequency of the crystals. Grinding machine 34 is stopped, and electrode 30 is reset to avoid contact with crystal 14, and to create a small air gap therebetween. A second electrode 40, made of suitable metal, is placed on the exposed side of crystal 14. A conductor 42, soldered to electrode 40, is connected to a frequency measuring meter 48, and another wire connector 44, attached to electrode 28 by a clip 46, is likewise connected to the meter. Each of the three crystals 14 are tested one at a time to determine their progress toward the frequency desired. Statistically, it has been shown that if three crystals randomly placed on the optical flat have the same frequency, the probability is sufficiently high to insure the uniformity in frequency and the parallelism of the remaining crys-

tals. It has been determined empirically that the number of randomly placed bores can be between 2 to 3 percent of the total number of crystals on said flat. The grinding action now continues until the crystals have been ground to the desired frequency.

It can be seen that with the optical flat 12 described herein, the frequency of the crystals can be tested directly on the optical flat without removal therefrom. It has been found, that it is thus possible to mass-produce piezoelectric crystals to a thinness having a corresponding prescribed uniform fundamental frequency up to 60 megacycles per second with AT-cut crystals.

While there has been described what is at present a preferred embodiment of the 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.

What is claimed is:

1. A device for grinding and polishing a plurality of high frequency piezoelectric crystals having a pair of faces to a prescribed uniform frequency comprising a disc-like optical flat of insulating material having top and bottom parallel surfaces, said flat being rotatably mounted on a shaft, one face of each of said crystals being secured to the top surface of said flat, a grinding member movable back and forth across the exposed faces of said crystals for grinding said crystals to a thickness corresponding to said prescribed frequency, said flat being provided with a plurality of randomly disposed cylindrical bores extending transversely therethrough, each of said bores being of smaller diameter than a respective crystal mounted thereover and secured to the top surface of said flat, an adjustable metal electrode within each of said bores, each of said adjustable electrodes being initially positioned in contact with said secured surface of its respective crystal, means affixed to each of said adjustable electrodes for spacing said electrodes from its initial position, whereby the frequency of each of said crystals covering each respective electrode is measurable without removing said crystals from said flat.

2. A device as set forth in claim 1, wherein said optical flat is of fused quartz and has substantially the same coefficient of expansion as said crystals.

3. A device as set forth in claim 1, wherein said adjustable metal electrodes are spaced from their respective crystals when the frequency thereof is measured.

4. A device as set forth in claim 1, wherein the number of randomly disposed cylindrical bores in said flat is about 3 percent of the total number of crystals thereon.

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