Nov. 17, 1942. F. A. GOSS, JR 2,302,024

METHOD OF CUTTING

Filed May 23, 1941 2 Sheets-Sheet 1

FIG. 1

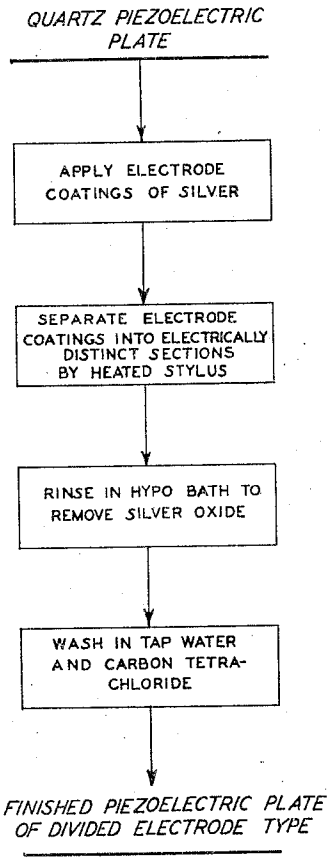


FIG. 3

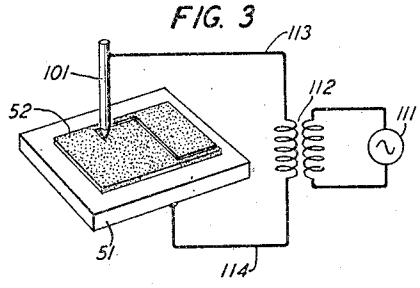
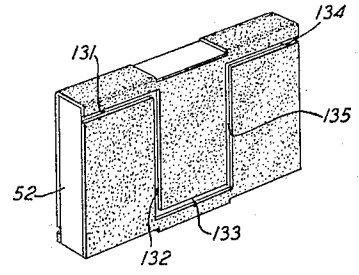


FIG. 4



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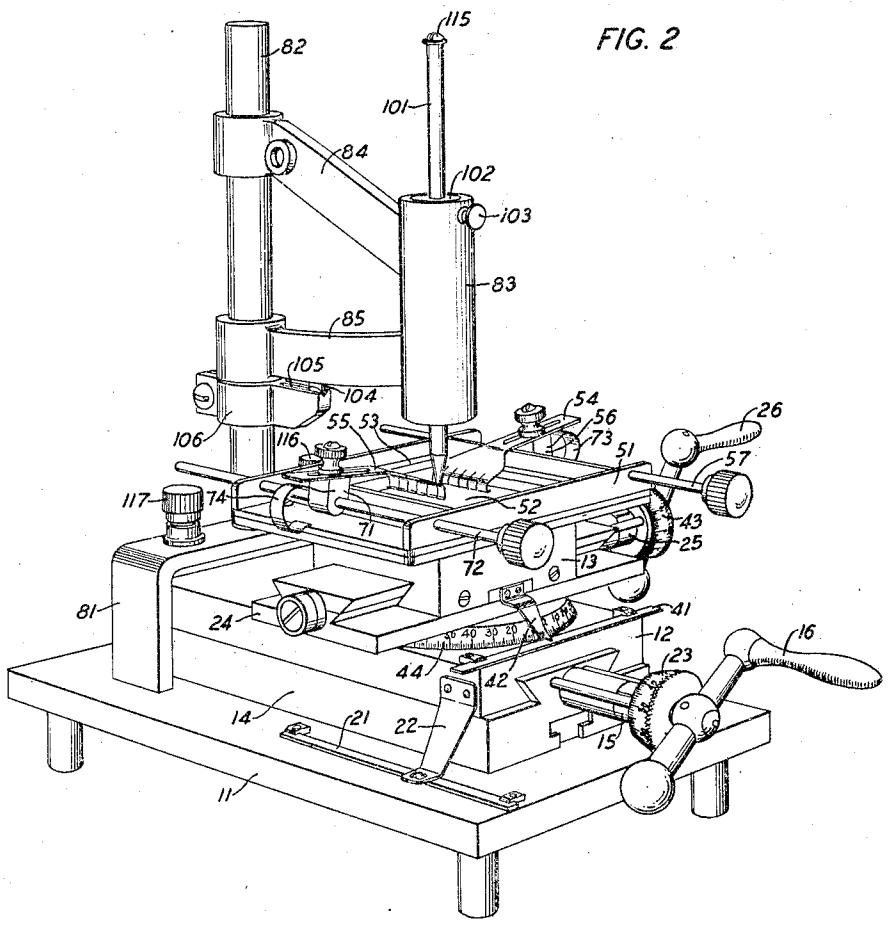
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FIG. 2



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UNITED STATES PATENT OFFICE

2,302,024

METHOD OF CUTTING

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Application May 23, 1941, Serial No. 394,780

6 Claims. (Cl. 171—327)

This invention relates to a method of cutting and particularly to a method of cutting and removing predetermined portions of the metallic coatings of objects such, for example, as the electrode coatings of silver applied to quartz piezoelectric crystal plates.

An object of the invention is to facilitate the removal of predetermined portions of the metallic coatings of objects.

Another object of the invention is to facilitate the production of piezoelectric plates.

A more specific object of the invention is to remove predetermined, narrowly defined portions of the silver electrode coating of a quartz piezoelectric crystal plate and to remove at the same time any silver oxide formed during the process.

To facilitate the use of piezoelectric crystals in electrical circuits, it is common practice, as is well known, to provide a coating of suitable conductive material on one or more of the electrode surfaces of the crystal plate, the necessary circuit lead wires then being electrically connected to the coating by a suitable method. It has been proposed, for example, to provide a quartz piezoelectric crystal plate with electrode coatings of silver and to attach the lead wires directly to the electrode coatings by soldering; the present invention is particularly applicable to such a crystal plate.

In connection with the preparation of certain types of piezoelectric crystal plates, for example the so-called "harmonic crystals" described in Patent 2,185,599 issued January 2, 1940, to W. P. Mason, it is desirable to divide the metallic coatings into a plurality of electrically distinct portions or patches. It has been proposed heretofore to divide the metallic coatings by means of an electrically energized stylus, the point of which is moved over the electrode coating along a predetermined path. A device of this nature is described in Patent 2,248,057 issued July 8, 1941, to W. L. Bond, entitled "Electrical cutting device."

Use of a movable stylus arrangement of the nature referred to above offers many worthwhile advantages over other available methods of dividing the electrode coatings such as the acid etching method or the use of abrasive wheels. It has been found, however, that when electrode coatings of silver are subjected to the electrically energized stylus, silver oxide is formed in the cut which establishes an undesirable low resistance connection between the "divided" areas.

A feature of the present invention is a method of removing silver oxide films formed during the division of silver electrode coatings by the electrically energized stylus method.

In accordance with a specific embodiment of the invention, the quartz piezoelectric plate, after the silver electrode coatings thereof have been divided by the electrically energized stylus method, is rinsed in a bath of photographer's hypo (sodium thiosulphate) in order to remove the silver oxide formed during the dividing process.

A complete understanding of the method contemplated by the invention as well as appreciation of the various valuable features thereof may be had by consideration of the subsequent detailed description in connection with the drawings, in which:

Fig. 1 is an operational diagram of one form of the method contemplated by the invention;

Fig. 2 is a perspective view of a suitable device for removing predetermined portions of the metallic electrode coatings;

Fig. 3 is a schematic of the electrical circuit involved in the device of Fig. 2; and

Fig. 4 is a perspective, enlarged view of a third harmonic crystal, the coating of which has been divided into electrically distinct portions by the method contemplated by the present invention.

One method in accordance with the present invention whereby a piezoelectric plate of the divided electrode type is produced is outlined in four steps in Fig. 1. As a first step, electrode coatings of silver are applied to the quartz piezoelectric plate by suitable means, for example, the coatings may be applied by means of evaporation apparatus similar to that disclosed in Patent 2,241,228 issued May 6, 1941, to H. W. Weinhart, entitled "Coating machine."

As a second step, the electrode coatings are separated into the desired electrically distinct sections by suitable dividing apparatus such as, for example, the device illustrated in Fig. 2 which is generally similar to that disclosed in the W. L. Bond patent referred to above.

As a third step, the plate is immersed for a period of not less than one minute in a solution of photographer's hypo preferably made up by dissolving one pound of plain hypo crystals (sodium thiosulphate) in two quarts of distilled water. Applicant has discovered that the hypo is effective in completely dissolving the silver oxide found in the dividing tracks but that it has no deleterious effect on the silver electrode coatings. Applicant has observed that it is particularly important that the hypo solution used in the above process be free from contamination.

As a fourth and final step the plate is thoroughly washed, first in tap water and then in carbon tetrachloride.

It may occasionally happen that, during testing of the finished crystal plates, oxides may be formed in the dividing paths by the high testing voltages; in such event steps three and four of the above process may be repeated in order to dissolve and remove all traces of oxide.

It has been found that a process of the nature outlined above is particularly effective in dividing silver electrode coatings of quartz piezoelectric plates; the process is an economical one and entails no perplexing or uncertain operations and the resulting product is entirely satisfactory both electrically and mechanically.

Referring now to Fig. 2, there is illustrated a device which may be used advantageously in connection with step 2 of the process referred to above, i. e., the step of separating the electrode coatings into electrically distinct sections. The device illustrated comprises a rectangular base 11 upon which are mounted two carriages 12 and 13, these carriages being movable with respect to the base and to each other.

Carriage 12 is movable along slide 14 in a direction parallel to the longer axis of base 11; feed screw 15 when rotated by crank 16 causes movement of this carriage backward or forward depending upon the direction of rotation of the crank. Graduated scale 21 and index 22 serve to gauge movement of carriage 12 while rotation of crank 16 may be gauged by friction micrometer dial 23.

Carriage 13 is movable along slide 24 in a direction generally at right angles to the direction of movement of carriage 12. Feed screw 25 when rotated by crank 26 causes movement of this carriage backward or forward depending upon the direction of rotation of crank 26. Graduated scale 41 and index 42 serve to gauge movement of carriage 13 while rotation of crank 26 may be gauged by friction micrometer dial 43.

Slide 24 is rotatable, within limits, with respect to base 11 and slide 14 thereby varying somewhat the right angular relationship between the movements of the two carriages. Scale 44 serves to gauge this rotational movement of slide 24; the slide after angular adjustment may be rigidly clamped in position by means of a suitable binding lever (not shown).

Work table 51 is supported upon carriage 13. A piezoelectric plate 52, the electrode coating of which is to be divided, is shown on the work table being positioned within tray 53 which is mounted thereon. The plate is held in position on the work table by spring fingers 54 and 55; these fingers, as will be described subsequently, serve also as electrically contacting members and are specially designed both to hold the crystal firmly in place and to provide wide electrically contacting surfaces on the coating of the crystal plate. Spring finger 54 is mounted on block 56 which in turn is supported on rod 57; similarly, spring finger 55 is mounted on block 71 which in turn is supported on rod 72. Springs 73 and 74, acting respectively through blocks 56 and 71, supply a proper bias to spring fingers 54 and 55. Blocks 56 and 71 may be moved laterally along their supporting rods thereby adjusting the position of the respective spring fingers. Rod 57 may be rotated in a clockwise direction against the bias of spring 73 in order to raise the spring finger 54 from its contacting position on plate 52; similarly rod 72 may be rotated in a counter-clockwise direction in order to raise spring finger 55 from its contacting position.

An inverted U-shaped member 81 is mounted on base 11 and supports upright shaft member 82. Stylus supporting block 83 is, in turn, supported by upright member 82 through angular arms 84 and 85.

Stylus 101 of suitable hard material, for example a tungsten-carbon-cobalt alloy is positioned within a cylindrical sleeve 102 of suitable insulating material which sleeve, in turn, is positioned within stylus supporting block 83 being held therein by screw 103.

The stylus supporting assembly is normally held in the position illustrated through engagement of projecting tab 104 with grooves 105 which is provided on the upper surface of stop 106. Upon occasion, however, for example when a plate is being positioned on the work table, angle arms 84 and 85 may be raised slightly on upright shaft 82 in order to free tab 104 from groove 105 after which the stylus assembly may be rotated to a position away from work table 51.

The electrical circuit involved is indicated schematically in Fig. 3 to which figure we will now refer for the moment. A suitable power source 111, preferably a source of 60 volts alternating current, is connected through a suitable transformer 112 to leads 113 and 114. Applicant has observed that it is preferable to energize stylus 101 with voltage of a value that is as low as is consistent with a complete removal of silver in the division area. Use of voltage of a value higher than this "ideal" value has been found to result in a rough edged division. For the thickness of silver electrode coatings normally specified at present for quartz piezoelectric plates, applicant has found that 2.5 volts is the ideal value. We will asume, therefore, that transformer 112 is designed to deliver 2.5 volts across the secondary winding and that the transformer is capable of delivering at least 10 amperes when connected to a 0.2 ohm load. The circuit across the secondary of transformer 112 may be traced through lead 113 to conductive stylus 101, through the stylus to the conductive coating of silver on quartz plate 52, through this silver coating to work table 51 of the divider mechanism and to lead 114.

Referring again now to Fig. 2, one external lead (113 of Fig. 3) may be connected directly to stylus 101 by screw 115 or it may be connected to binding post 116, which is "floating," i. e., insulated from member 81 and the rest of the machine, in which event a suitable local conductor would be run from binding post 116 to screw 115. The other external lead (114 of Fig. 3) is connected to binding post 117 which is electrically connected to support 81. It might be pointed out here that all metal portions of the machine are bonded together electrically with the exception of stylus 101 which, it will be recalled, is insulated electrically from the rest of the machine by insulating sleeve 102. We have, therefore, (as indicated schematically in Fig. 3) one side of the circuit brought through stylus 101 to the silver coatings of plate 52, through the coatings to spring fingers 54 and 55 which are in contact with said coatings, and through the spring fingers and other metal parts of the machine to binding post 117 and the other side of the circuit.

In order to further describe the machine of Fig. 2 let us assume that it is to be used to divide the silver coating of quartz piezoelectric plate

52 in the manner illustrated by Fig. 4. As shown in Fig. 4 the silver coating on the front surface of the plate has been divided into two electrically distinct sections by cutting a thin line across the coating, this line comprising three straight portions, 131, 133 and 134 extending in one direction joined by straight portions 132 and 135 which extend in a direction at right angles thereto. Referring again to Fig. 2, we will see just how such a line is cut.

Work table 51, upon which plate 52 is carried, is first positioned so that the point of stylus 101 contacts the coating of the plate at the exact point where section 131 of the cut is to be started. The electrical circuit is completed and crank 16 is rotated in the proper direction to cause forward horizontal motion of carriage 12 and the assembly, including work table 51, which moves therewith. As plate 52 is moved along under the point of stylus 101, the electrode coating is burned away in the form of a thin, distinct line. Upon completion of section 131, rotation of crank 16 is stopped and crank 26 is rotated in order to cause the transverse movement of carriage 13 and the work table necessary to produce section 132. Upon completion of section 132, crank 16 is again rotated in the first direction to produce section 133 and so on.

It will be understood that in an instance such as described above where the two directions of the line sections to be cut are at right angles to each other, the angular adjustment of slide 24 with respect to slide 14 is such that their longer axes are at right angles.

In the process described above care should be exercised to insure that the work table is in motion when the electrical circuit is completed in order to prevent the formation of silver "islands" at the point of contact of stylus and coating. The piezo electric plate should be moved at a rate of approximately ¼" per second and a continuous pressure of the order of one pound should be applied to the stylus. The width of the "cut" may well be regulated by varying the dimension of the point of the stylus which should be ground to a small flat circular surface perpendicular to the longer axis of the stylus. As an illustration, applicant has observed the following relationships between the dimension of the stylus tip and the width of the cut:

Diameter of stylus tip:	Width of cut, millimeters
.204 mm	.32 to .35
.127 mm	.22 to .25
.089 mm	.12 to .15

After division of the electrode coatings as described above, plate 52 is then subjected to steps 3 and 4 of the process in order to remove any traces of silver oxide that may have been formed in the cuts and to thoroughly clean the plate.

While a specific embodiment of the invention has been described and illustrated, the invention is not, of course, limited in its application to such specific embodiment. The embodiment described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. The method of producing a piezoelectric plate of the divided electrode type which comprises the steps of forming an electrode coating of conducting material on a quartz plate, dividing the electrode coating into electrically distinct sections by removal of certain predetermined portions of the conducting coating by means of an electrically energized stylus, and dissolving the oxides of the conducting material formed during the removal process.

2. The method of producing a piezoelectric plate of the divided electrode type which comprises the steps of forming an electrode coating of silver on a quartz plate, dividing the electrode coating into electrically distinct sections by removal of certain predetermined portions of the silver coating by means of an electrically energized stylus, and dissolving the silver oxide formed during the removal process.

3. In a method of producing a quartz piezoelectric plate of the divided electrode type which is productive of undesired silver oxide, the method of removing the silver oxide which comprises the steps of rinsing the plate after division of the electrode in a solution containing sodium thiosulphate and thereafter washing the plate with water and carbon tetrachloride.

4. The method of producing a piezoelectric plate of the divided electrode type which comprises the steps of forming an electrode coating of silver on a quartz plate, dividing the electrode coating into a plurality of electrically distinct sections by removal of certain predetermined portions of the silver coating by means of an electrically energized stylus, rinsing the plate in a solution of sodium thiosulphate and water and washing the plate in water and carbon tetrachloride.

5. In a method of producing a quartz piezoelectric plate of the type provided with divided electrode coatings of silver which is productive of undesired silver oxide, the method of removing the silver oxide without disturbing the required silver electrode coating which comprises the steps of rinsing the plate after division of the electrode in a material which is effective to dissolve silver oxide but which has no deleterious effect on substantially pure silver and thereafter washing the plate in water and carbon tetrachloride.

6. In a method of producing a piezoelectric plate of the type provided with divided electrode coatings of a conductive metal which is productive of undesired oxides of said metal, the method of removing the oxides without disturbing the required electrode coatings which comprises the steps of rinsing the plate after division of the electrode coatings in a material which is effective to dissolve said undesired oxides but which has no deleterious effect on said conductive metal in a substantially pure form and thereafter washing the plate to remove any contaminating substance.

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