

UNITED STATES PATENT OFFICE

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HEAT TREATMENT OF PIEZO-ELECTRIC-CRYSTAL SECTIONS

No Drawing.

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My invention relates to frequency-control devices and it has particular relation to the manufacture of piezo-electric crystal sections.

5 Quartz, by reason of its mechanical strength, is the crystalline substance that is, most generally, used for controlling, through its piezo-electric characteristics, the frequency of oscillation generators comprising thermionic tubes. The thickness of a quartz plate determines the oscillation frequency thereof; the thinner the plate the higher the frequency. A plate having a thickness of substantially three inches will oscillate at the rate of 10 about 30,000 cycles per second; a plate .5 millimeter in thickness will oscillate at a frequency of about 3,500,000 cycles per second.

In making quartz-crystal plates for the control of oscillation generators at high frequencies, great difficulty has, heretofore, been experienced in obtaining plates that would resonate at substantially a single frequency. The phenomenon of plural-resonance appears to be caused by lack of absolute parallelism 20 between the crystal-section faces that lie perpendicular to the dimension which determines the oscillation frequency.

The percentage of deviation from parallelism, in thin plates is, obviously, much greater than in thick plates, provided that equal care is used in the manufacture of both; or, in other words, in a thick plate, the number of deviations from a plane surface, as compared with the mass of the plate, is vastly less than when a thin plate is considered.

35 It is highly probable that quartz crystals, as found in nature, have grown by the apposition of an infinite number of microscopic crystals of different sizes. The ratio of the total volume of the microscopic crystals to the total of the inter-crystal spaces is not known to me, at this time, but it seems reasonably certain that a quartz crystal has, actually, a very "loose" or lattice-like structure and that the constituent microscopic crystals have a certain freedom of motion.

It is, accordingly, reasonable to assume that the ratio of the mass involved in the deviations from a plane surface to the mass of the entire crystal plate can be changed by

changing the temperature of the plate. Or, to state the matter somewhat differently, heating causes such molecular change, or movement, within the crystal that the deviations are accentuated.

Irrespective of the correctness of the foregoing theory, however, it is an experimental fact that, when thin quartz plates are heated to about 50° centigrade the oscillations thereof are materially damped, with the consequent production of harmonic frequencies and other frequencies that are undesirable. Thick plates, however, are not greatly affected by heating to the same temperature, probably because the percentage of deviations to mass is so much lower than in thin crystals.

It is, accordingly, an object of my invention to provide, as an article of manufacture, a quartz plate that shall be uni-resonant, as distinguished from plural-resonant plates of the prior art.

Another object of my invention is to provide a manufacturing method for quartz-crystal plates that shall ensure the production of plates which are not detrimentally affected by being operated at temperatures of the order of 50° centigrade.

A still further object of my invention is to provide a manufacturing method for quartz-crystal plates that shall ensure the production of plates which resonate at substantially a single frequency.

In practicing my invention, I first cause a crystal section to be cut from a mother-crystal, preferably in the manner disclosed in the copending application of D. G. Little, Serial Number 187,125, filed April 28, 1927 and assigned to the Westinghouse Electric and Manufacturing Company. The exact manner of cutting the section from the crystal is not determinative, however, since my invention may, with equally as good results, be practiced in connection with crystals cut in any of the well-known ways.

I next give the crystal section a preliminary rough grinding to bring it to approximately the size that experience has shown is correct for the frequency desired. A final grinding and polishing is then given, with

frequent comparisons with a standard oscillator, until the section resonates at a frequency only slightly lower than that desired.

The crystal is then placed in a sand-bath, and the temperature is gradually raised to between 300 and 1000° Fahrenheit and maintained thereat for a period of from 3 to 5 hours. The table below gives the approximate temperatures and treatment periods for crystals of different thickness and is indicative of the proper procedure to follow:

Thickness	Frequency	Temperature	Duration of heat
2 m. m.	1,000 K. C.	500° F.	5 hrs.
1.30 m. m.	1,500 K. C.	500° F.	5 hrs.
1 m. m.	2,000 K. C.	500° F.	5 hrs.

The crystal, after the heating has been maintained for the necessary period, is next allowed to cool slowly, in the sand-bath, until it reaches room temperature and may be safely handled. Sudden cooling should be avoided because the crystal, if very thin, is liable to breakage thereby.

A final polishing is then given the section, with frequent tests, until sufficient material has been removed to cause it to resonate, within the permissible degree of error, to the predetermined frequency.

It will be seen, from a consideration of the foregoing description of my method of crystal-treatment, that it is somewhat analogous to the annealing of metal. It is my present belief that the heat treatment either removes internal strains in the crystal or else causes the molecular structure to so change that subsequent heating, during operation, does not cause an accentuation of the percentage of deviation from parallelism of the faces. The matter of theory, however, is relatively unimportant since, regardless of the type of change caused by the heat treatment, it is found that crystals so treated are definitely uni-resonant and are not detrimentally damped by molecular changes during use at temperatures higher than room temperature.

A crystal section made according to my improved method is, also, less liable to breakage during use than untreated sections, thus further justifying the time and expense involved in the treatment.

Although I have explained my invention in connection with a specific method of heat-treatment many modifications thereof will be apparent to those skilled in the art. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. As an article of manufacture, a quartz-crystal section that has been annealed at a temperature between 300° and 1000° Fahrenheit.

2. As an article of manufacture, a quartz-

crystal section devoid of internal molecular strains.

3. The method of manufacturing a quartz-crystal section which comprises shaping the section to approximately correct dimensions and thereafter maintaining it at an elevated temperature for a sufficient length of time to relieve any internal stresses that may exist in it.

4. The method of manufacturing a quartz-crystal section which comprises shaping the section to approximately correct dimensions and thereafter raising its temperature to between 300° and 1000° Fahrenheit and maintaining it at the raised temperature a sufficient length of time to cause a readjustment of the molecular structure thereof.

In testimony whereof I have hereunto subscribed my name this thirtieth day of November, 1929.

J. AIMÉ LAVALLEE.