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METHOD TO DIMINISH DAMPING OF CRYSTALS

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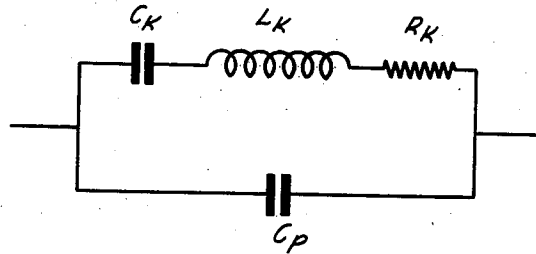


Fig. 1

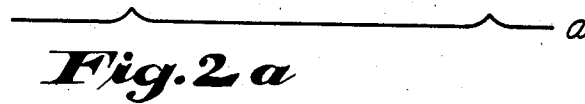
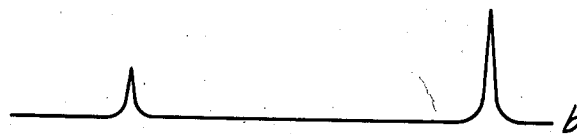


Fig. 2b

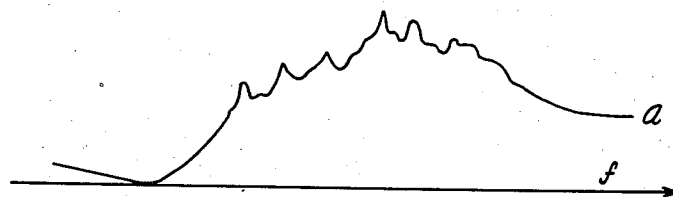


Fig. 3a

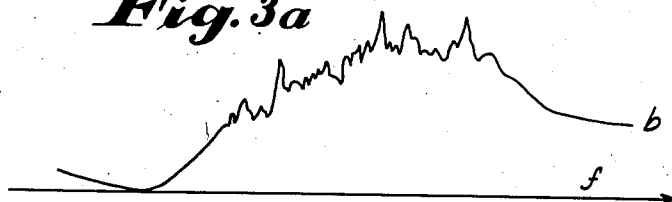


Fig. 3b

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METHOD TO DIMINISH DAMPING OF CRYSTALS

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2 Claims. (Cl. 171—327)

This invention relates to a new and novel method to diminish damping of crystals, especially smoky crystals.

This invention will best be understood by referring to the accompanying drawing, in which:

Fig. 1 is a diagram of resonance elements to illustrate the invention;

Fig. 2a is a resonance curve of a crystal before heating;

Fig. 2b is a resonance curve of a crystal after heating;

Fig. 3a is a resonance curve of a crystal exhibiting multi-wave characteristics before heating; and

Fig. 3b is a resonance curve of a crystal exhibiting multi-wave characteristics after heating.

The use of crystal oscillators in electrical circuit organization is essentially governed by two viewpoints, namely, to secure maximum frequency stability in an oscillator and to obtain maximum selection in a resonator. However, both these demands presuppose minimum damping of the resonance element represented in the equivalent scheme shown in Fig. 1 for a quartz oscillator. Referring to Fig. 1, R_k denotes the so-called quartz crystal resistance, L_k and C_k the inductance and the capacity of the crystal, and C_p finally the parallel capacitance of the crystal. Denoting by ω its natural period, then δk which hereinafter for short shall be called the crystal damping is expressible as follows:

$$\delta k = \frac{R_k}{\omega L_k}$$

The said crystal damping or the crystal resistance R_k must be minimized. The vibrating crystal insures mechanical damping as a result of its mechanical vibrations which manifest themselves electrically in the resistance R_k . A certain increase in damping is occasioned by the mounting of the crystal. Often also the form of the crystal is decisive so far as the damping is concerned, but these last two influences and factors shall be here excluded in these considerations as unessential. They are eliminated by the use of two crystals being alike both in mounting and form so that they must also exhibit the same crystal resistance seeing that they consist of the same material being formed by crystallization. Now, it has been ascertained that this is not always the case, in fact, that rather appreciable discrepancies in the resistance values may arise in perfectly identical crystals.

Nothing has been found so far to account for the cause of this discovery.

Now, the idea underlying the present invention is that it is contaminations and impurities of various kinds included in finely divided state in the quartz crystal materials that are responsible for the said finding. The difference in the damping is due to different quantities of impurities. The influence of the impurities is best examined in quartz crystals which even to the naked eye evidence the presence of extraneous substances. As a typical example will be taken here the so-called smoky crystal which is widely occurring in native state and which is of brown transparency. In this crystal, the damping is so high that it will not start to oscillate at all so that it is not possible to use it as an oscillator. Very bright varieties of smoky crystal can be excited, though they inhere by far too high a damping as compared with pure quartz crystals. It is here provable quite clearly that the damping is a function of the amount of admixtures of other substances. The lowest damping means the lowest degree or amount of contamination.

Now, according to the invention, it is suggested to expel the contaminations by heating. These impurities may be regarded as molecules or molecule complexes or aggregations of widely varying substances which may be expelled by the heat stream caused by loosening up of the crystal texture upon strong heating. This fact is most conspicuous and clearly visible in the case of the smoky crystal. If a mother crystal of smoky quartz or a plate cut therefrom is heated, the admixtures escape to the surface in the form of tiny beads or droplets and the smoky crystal slowly is rid of its turbidity or cloudy state until when heated up to around 400–500 degrees it assumes a clear and transparent appearance like that of an ordinary crystal, and this modified crystal, contradistinct to its previous state, is excitable to vibrations and has low damping. However, also a crystal variety which judging by its looks is pure and white is improvable by a treatment as before indicated insofar as its damping is concerned, the necessary degree of the heating being a function of the nature of the impurities. Crystals which in comparison to others being perfectly similar may show high resistance and are thus entirely unserviceable in many cases can be made usable by decreasing the resistance by ways and means as before disclosed.

In certain types of impurities and admixtures the purifying treatment before outlined can be

assisted by the application of a higher direct current voltage which is impressed upon the piece of crystal while it is heated, and then the degree of heating may be made more moderate.

The procedure to be followed in purifying crystals according to the invention shall be discussed by reference to a simple arrangement. The quartz crystal plate to be examined after being cut from the mother crystal as known in the art is connected in a circuit so as to act as a coupling element between plate and grid of two tubes. If, then, an alternating potential is impressed upon this circuit arrangement which acts like a filter and the frequency is varied, it is possible to record the resonance curve of the crystal as it is being heat treated by the aid of an ink recorder. The cut crystal may be further improved by impressing a high direct current potential upon the crystal during the heating.

Referring to the curves shown by Figs. 2a and 2b, there will first be described the resonant curve of a smoky crystal before and after the thermal and high potential treatment of this invention is impressed on the crystal. It will be noted that in Fig. 2a, the resonant peaks prior to heating are very small in amplitude. However, when the crystal is treated as mentioned above, the resonant peaks will then become much taller in amplitude, as shown by the curve, Fig. 2b, or in other words, there will be a marked

reduction in the crystal damping. Figs. 3a and 3b are a second group of curves resulting from the examining of a quartz crystal exhibiting marked multi-wave characteristics, Fig. 3a being a curve of a quartz crystal prior to the thermal and high potential treatment. The curve shown by Fig. 3b is the result of thermal and high potential treatment of this invention. It will be noted in comparing the curves of Figs. 3a and 3b that a great many new peaks have been added at points where before they had been suppressed because the damping was unduly high.

What is claimed is:

1. The method of improving the operating characteristics by diminishing the electrical damping of a piezo-electric crystal which includes the steps of cutting the crystal to a desired shape, heating the cut crystal up to 600 degrees, and impressing a high potential upon said crystal during said heating.

2. The method of improving the operating characteristics by diminishing the electrical damping of a piezo-electric crystal of the smoky variety which includes the steps of cutting the crystal to a desired shape, heating the cut crystal up to 600 degrees, and impressing a high direct current potential upon said crystal during said heating.

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