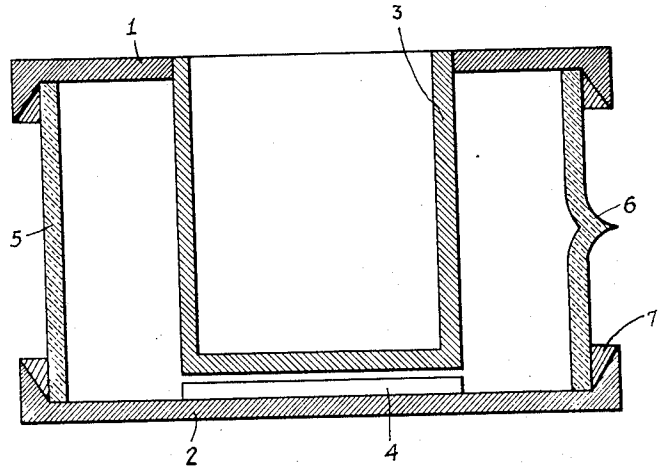
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PIEZO ELECTRIC CRYSTAL APPARATUS

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PIEZO-ELECTRIC CRYSTAL APPARATUS

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8 Claims. (Cl. 171—327)

The invention has the object of making the natural period of a piezo-electric crystal set into suitable holder means independent of the temperature.

This end is attained:

1. By a construction of the crystal holder means in such a way that the distance between the crystal and the electrode increases with the temperature, and

2. By that the crystal, as well known in the prior art, is confined inside a space being as completely as feasible freed from air and gas.

The action and operation of the arrangement may be explained as follows:

It is a known fact that the natural frequency of a crystal decreases with growth in temperature, while it increases with decrease in temperature. Now, if the assumption be made that the temperature of the crystal ambient and thus that of the crystal itself has increased, the natural frequency thereof as a result will fall off. By such growth of temperature, however, as above pointed out under condition 1, the distance between electrode and crystal grows, and this is known to result in an increase in the natural period of the crystal. By suitable selection of the material and the dimensions of the different parts of the crystal holder means, as will thus be seen, it is fundamentally feasible to cause both effects of temperature increase to counteract each other.

In the case of ordinary crystal holders in which air or gas is contained between the electrode and the crystal, the construction with spontaneously variable electrode distance is practically not utilizable, seeing that in crystal holders of this kind, because of the damping occasioned by the air, the performance of the crystal is greatly dependent upon the distance between crystal and electrode (see, for instance, Telefunken-Zeitung, No. 44, 8th year, article by Dr. K. Hegener on "Measurements with piezo-electric crystals", pp. 60 et seq.) so that, if the power is to be adequate the distance between crystal and electrode must have a very definite value; in other words, in the ordinary crystal holder the optimum distance between crystal and electrode, once it has been chosen, should not be changed. Hence, the arrangement for which the condition mentioned in 1 is fulfilled cannot be employed in connection with the ordinary kind of crystal holder. However, this arrangement becomes very effective and advantageous if the surroundings of the crystal are wholly or partially evacuated, for in the case of evacuated crystal holders the influence produced by the air is absent so that the distance between the crystal and the electrode can be varied within comparatively rather wide limits without rendering the device ineffective.

One embodiment is shown by way of example in the drawing wherein a crystal holder is shown, of the same general type described in copending application Serial No. 589,442 filed January 28, 1932. 1 is a metal flange, 2 a metal electrode serving as a support for the crystal, 3 is an electrode disposed above the crystal consisting of conducting material possessing a very low heat expansion coefficient such as a nickel-steel alloy, 4 a quartz crystal, 5 a glass body, 6 a pump stem, and 7 cementing mass.

As can be seen from the drawing, the distance between the top electrode and the crystal as a result of a temperature increase and the consequent expansion of the glass cylinder 5 is augmented, but by virtue of the expansion of the nickel-steel cylinder it is diminished. Suppose that the thermal coefficient of expansion of the grade of glass and the ferro-nickel alloy used is $10^{-6} \cdot 8.97$ and $10^{-6} \cdot 0.88$ (see Deutscher Kalender fuer Elektrotechniker, 1922, page 92). Inasmuch as the lengths of the bodies 3 and 5, judging from the drawing, are approximately alike, it can be said that the increase Δa of the distance between electrode and crystal per degree C. of temperature increase is expressible by the formula:

$$\Delta a = h(10^{-6} \cdot 8.97 - 10^{-6} \cdot 0.88) = 10^{-6} \cdot 8.1h$$

where h the length of body 5.

By suitable selection of the distance between crystal and electrode at the initial temperature and the length h it is easily feasible to make conditions so that the frequency increase due to change in distance Δa becomes equal to the frequency decrease due to the temperature increase.

In order to preclude all chances of hysterisis losses due to the high permeability of ferro-nickel cylinder 3 the same may be provided with a thin coat of copper. The material to be used for the said cylinder may consist of any alloy possessing a minimum heat expansion coefficient. For instance, the nickel-steel alloy known as invar having a heat expansion coefficient near zero is readily useful for this purpose.

Under certain circumstances it may be recommendable for increasing the expansion of body 5 to make the same, for instance, of brass; but in that case the flange 1 must consist of an insulator. The cylinder 5 could also be made partly of brass and partly of glass.

It will be understood that the embodiment of a crystal holder as hereinbefore disclosed could be modified in different ways. When used in the reversed position than here shown the electrode 3 would be the support for the crystal, and the electrode 2 would be the top electrode. Electrode 2 could be made cylindrical in a similar manner as electrode 3.

What is claimed is:

1. A piezo-electric crystal holder adapted to control frequency variation of a crystal by compensating for temperature changes comprising a plurality of metallic electrodes spaced apart by an outer insulating wall, one of said electrodes consisting of a cup-shaped cylindrical member of a ferro-nickel alloy concentric with and supported by said outer insulating wall and constituting the upper electrode, said inner and outer members constituting walls of an enclosed chamber which is evacuated, the length of said cup-shaped cylindrical member being so chosen that any tendency toward frequency increase of the crystal due to change in distance between said electrodes is compensated for by the decrease in frequency of said crystal due to increase in temperature.

2. A holder of the type disclosed in claim 1, characterized in this, that said ferro-nickel cup-shaped cylindrical member is provided with a thin coat of copper.

3. A piezo-electric crystal holder adapted to control frequency variation of a crystal by compensation for temperature changes comprising an outer insulating wall, a plurality of metallic electrodes spaced by said outer insulating wall, a piezo-electric crystal interposed between said electrodes and an air gap between one of said electrodes and the crystal, one of said electrodes being in the form of a cup-shaped cylinder concentric with and supported by said outer insulating wall and constituting walls of a closed chamber which is evacuated, the length of the walls of said chamber and said cylinder being substantially equal in length so that a temperature change will cause substantially equal expansion, thereby maintaining a uniform air gap between the electrode and the crystal.

4. A piezo-electric crystal adapted to control frequency variation of a crystal by compensation for temperature changes comprising an outer insulating wall, a plurality of end electrode members spaced by said outer insulating wall, a piezo-electric crystal interposed between said electrodes forming an air gap between one of said end members and the crystal, one of said end electrode members being in the form of a concentric cup-shaped cylinder located within the outer insulating wall, means for joining said end electrode members with said insulating wall so as to form a closed chamber which is evacuated, the length of the insulating walls of said chamber and said concentric cup-shaped cylinder being substantially equal in length so that a temperature change will cause substantially equal expansion, thereby maintaining a uniform air gap between the bottom of said concentric cup-shaped cylinder and the top of the crystal.

5. A piezo-electric crystal holder comprising a flat base member constituting a lower electrode, a substantially cylindrical insulating wall mounted on said flat base member, a cup-shaped cylindrical member concentric with and supported by said first named cylindrical member and constituting an upper electrode, said inner and outer cylindrical members constituting walls of a closed chamber which is evacuated.

6. A piezo-electric crystal holder comprising a flat base member constituting a lower electrode, a substantially cylindrical insulating wall mounted on said flat base member, a cup-shaped cylindrical member concentric with and supported by said first named cylindrical member and constituting an upper electrode so as to provide a space in which a piezo-electric crystal is interposed between the upper and lower electrodes, said inner and outer cylindrical members constituting walls of a closed chamber which is evacuated.

7. A piezo-electric crystal holder comprising a flat base member constituting a lower electrode, a substantially cylindrical insulating wall mounted on said flat base member, a cup-shaped cylindrical member concentric with and supported by said first named cylindrical member and constituting an upper electrode so as to provide a space in which a piezo-electric crystal is interposed by said electrodes, the length of said cylindrical member being at least ten times greater than the thickness of the said crystal, said inner and outer cylindrical members constituting walls of a closed chamber which is evacuated.

8. A piezo-electric crystal holder comprising a flat base member constituting a lower electrode, a substantially cylindrical glass wall mounted on said flat base member, a cup-shaped cylindrical member of a nickel steel alloy concentric with and supported by said first named cylindrical member and constituting an upper electrode so as to provide a space in which a piezo-electric crystal is interposed between the upper and lower electrodes, said inner and outer cylindrical members constituting walls of a closed chamber which is evacuated.

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