May 9, 1933. D. G. LITTLE 1,907,986

FREQUENCY CONTROL DEVICE

Filed July 15, 1927

Fig. 1.

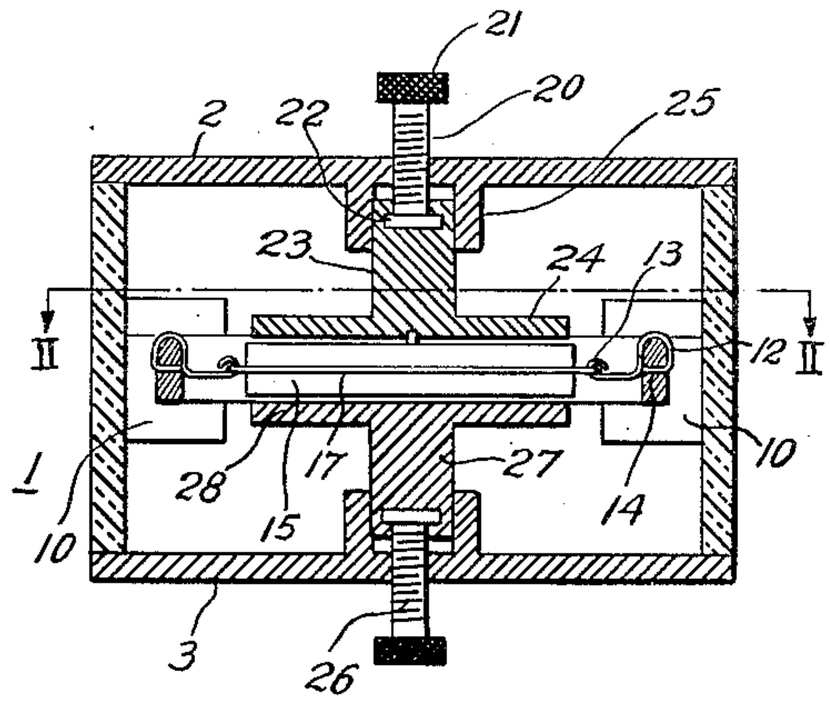


Fig. 4.

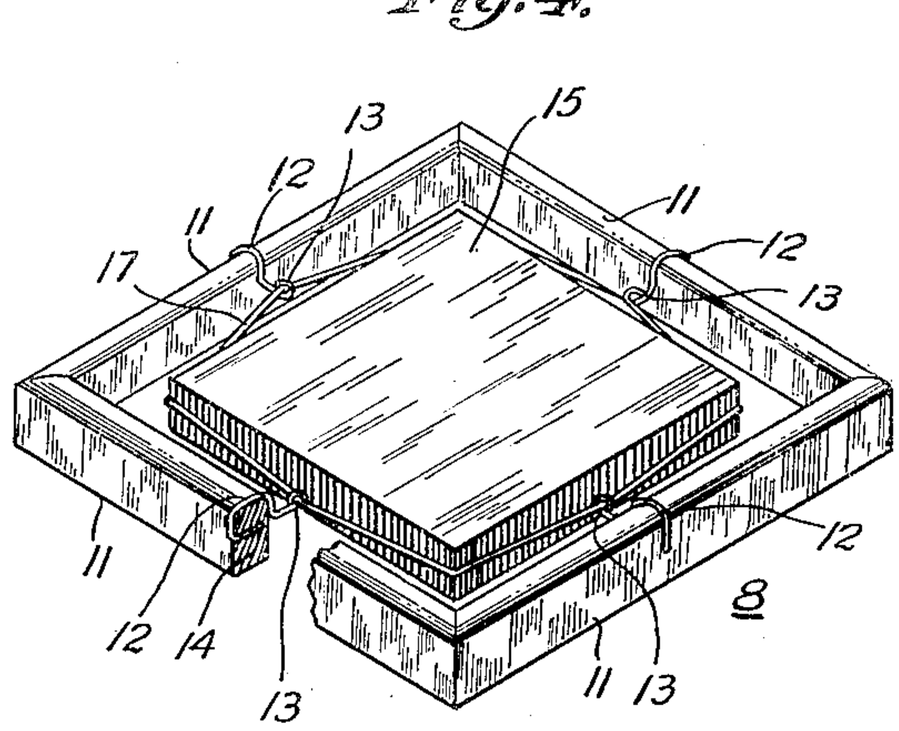


Fig. 2.

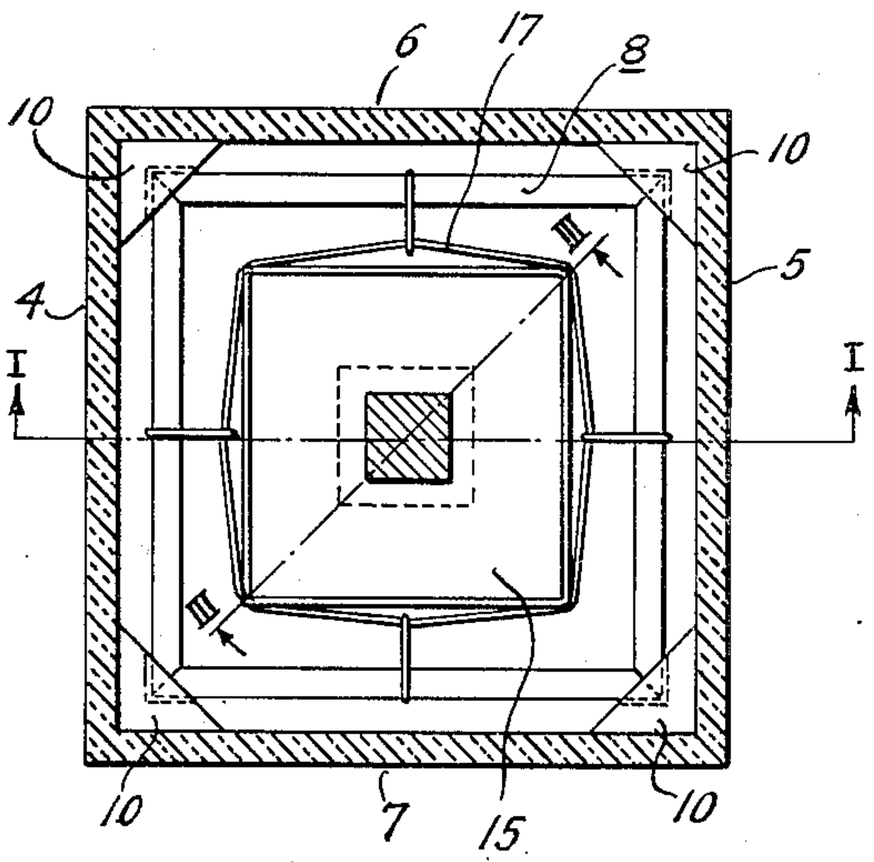
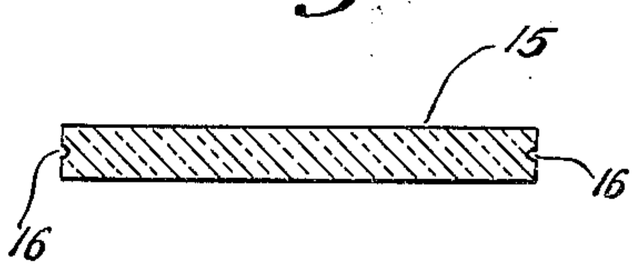


Fig. 3.



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UNITED STATES PATENT OFFICE

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FREQUENCY CONTROL DEVICE

Application filed July 15, 1927. Serial No. 205,839.

My invention relates to frequency-control devices, and it has particular relation to devices comprising piezo-electric crystals.

One object of my invention is to provide a piezo-electric-crystal-holding device wherein the undesirable effects of the electrodes on the free vibration period of the crystal are entirely obviated.

Another object of my invention is to provide a piezo-electric-crystal-holding device wherein the crystal is not subject to wear when in use.

Another object of my invention is to provide a piezo-electric-crystal-holding device wherein the crystal may be utilized for any period desired with full assurance that the original calibration of the crystal will not change.

It has been found by experience that piezo-electric-crystal sections, when utilized for frequency-control of a thermionic-tube oscillation generator, are subject to a detrimental amount of wear by reason of their contact with the supporting electrodes. The crystal-section vibrates violently, when electrostatic fields of the proper period are impressed thereacross, and tends to so move about on the lower electrode that the surface of the crystal in contact therewith is being constantly abraded to a more or less extent. In the case of large crystal sections utilized to control oscillations at relatively low frequencies, the wear is not particularly disadvantageous, since the percentage change in the oscillation frequency of the crystal caused thereby is relatively small.

The situation is different, however, when the crystal-sections are utilized to control the generation of extremely high frequencies. The vibration period of a piezo-electric crystal, such as a disc of quartz, is principally determined by its physical dimensions, as is well known in the art. For extremely high frequencies, the thickness of the crystal, measured in a direction perpendicular to the face thereof in contact with the supporting electrode, may be of the order of only a few millimeters. In such event, even the slightest wear will cause a relatively large percentage change in the oscillation frequency of the crystal and, consequently, a relatively large shift in the frequency of the oscillations generated by the thermionic-tube device associated therewith.

In accordance with the present invention, I dispense entirely with the physical contact between the crystal and the lower supporting electrode that has been deemed necessary, according to the teachings of the prior art, and suspend the crystal section by filamentary means in the space above such electrode.

An important feature of my invention lies in the choice of that portion of the piezo-electric oscillator with which the filamentary supporting means makes contact. In general, it may be stated that crystal sections, of the types commercially utilized for frequency control of thermionic-tube oscillation generators, are so arranged that they oscillate symmetrically about a plane that is parallel to one of the cooperating electrode faces. The regions of the crystal defined by the intersection of such plane with the faces thereof are consequently nodal points, and, by so arranging the supporting means that it contacts such nodal points only, wear on both crystal and supporting means is minimized.

Among the features that I consider characteristic of my invention are those set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description, taken in connection with the accompanying drawing, in which:

Figure 1 is a view, partly in elevation and partly in section, illustrating a preferred embodiment of my invention.

Fig. 2 is a sectional view taken along a line corresponding to the line II—II of Fig. 1.

Fig. 3 is a sectional view of a piezo-electric oscillator taken along a line corresponding to the line III—III of the Fig. 2.

Fig. 4 is a view, in perspective, of the piezo-electric crystal and a supporting frame therefor.

As shown in Figs. 1 and 2, a box-like, rec-

tangular container 1, preferably made of bakelite, hard rubber, or other insulating material, comprising a top 2, a bottom 3, and a plurality of sides 4, 5, 6 and 7, carries a frame-device 8 centrally positioned in the interior thereof. The frame 8, which is shown in detail in Fig. 4, may be supported by a plurality of brackets 10 arranged diagonally of the corners of the container, or may be supported in any other appropriate manner.

The frame 8 preferably comprises a plurality of sides 11 and is preferably cut or molded from a single piece of insulating material.

A hook 12, provided at one end with an eyelet 13, is mounted on each side 11 of the frame, the eyelets extending toward the center of the space enclosed by the frame and being arranged to lie in a plane parallel to the plane defined by the under surfaces of the frame-members 11. The opposite ends of the hooks may be anchored in small holes 14 drilled in the frame-members, as shown in Fig. 4.

A piezo-electric-crystal section 15, substantially a rectangular parallelopiped in shape, has small notches 16 cut into certain of the corners thereof, as shown in Fig. 3. A cord 17, preferably of silk or other good insulating material, encircles the crystal section and is retained in position by the said notches. The cord 17, intermediate the points where it lies in the notches, extends through and is held by the eyelet portions 13 of the hook devices 12, thus supporting the crystal section with its upper and lower faces parallel to the plane defined by the under surface of the frame members.

The top 2 of the container has a threaded opening extending therethrough, and, in this opening is mounted a metallic adjusting screw 20 having a knurled head 21. The lower end of the adjusting screw is provided with an enlarged circular portion 22 that is rotatably mounted in a recess in the upper end of a metallic rectangular stem-element 23 which carries an electrode 24. A rectangular guide 25 is affixed to the inner surface of the top of the container and surrounds the stem 23 to prevent rotation thereof while permitting the said stem to move toward and from the top, under the influence of the adjusting screw.

The bottom 3 of the container is provided with an adjusting screw 26 which actuates a stem 27 carrying an electrode 28 analogous to the upper electrode 24.

Suitable electrical connections (not shown) are provided for the electrodes 24 and 28, whereby they may be conductively, or otherwise, associated with a thermionic device.

The opposing surfaces of the electrodes are parallel to each other and are also parallel to the lower surfaces of the frame members. The crystal is so supported in the frame that its faces are parallel to the lower surface of the frame members and, consequently, the said faces are parallel to the electrode surfaces.

The crystal, when subjected to an electrostatic field, at its natural frequency, tends to vibrate symmetrically with respect to a plane which is parallel to the faces thereof and which is substantially midway between the said faces. The notches which engage the supporting string or thread are so placed that they will be in the said plane. The crystal, therefore, when vibrating does not tend to exert any wear upon the said supporting means, inasmuch as the points in which the supporting means touch the crystal are nodal points and move to only an inappreciable extent when the crystal is vibrating.

The spacing between the crystal and the two electrodes may be made as small as desirable by moving the said electrode in and out. Preferably, the distance between a face of the crystal and the electrode associated therewith should be an odd number of wave lengths, in air, of the crystal frequency.

When in operation, the physical vibration of the crystal is in no way interfered with by the electrodes, and, by reason of the fact that the crystal is supported only at nodal points, it is free to vibrate with respect to such points with maximum amplitude.

In addition, there is, of course, no wear upon the crystal, since vibrating portions thereof do not make contact with electrode surfaces, as is the case in devices constructed according to the teachings of the prior art.

I have found that the frequency of a crystal, when mounted according to my invention, is absolutely constant, provided the surrounding atmosphere is kept at a constant temperature, and the likelihood of crystal breakage is minimized.

Although I have illustrated and described only a single specific form of my invention modifications thereof will be apparent to those skilled in the art. My invention therefore is not to be limited except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In combination, a frame provided with attaching devices, a piezo-electric-crystal oscillator, means for supporting said oscillator from said devices out of contact with said frame, a supporting structure carrying a plurality of electrodes, and means whereby said frame may be so carried by said structure that the said oscillator is suspended between and out of contact with said electrodes.

2. In combination, a frame provided with attaching devices, a piezo-electric-crystal oscillator, means for supporting said oscillator from said devices out of contact with said frame, a supporting structure carrying a plurality of relatively adjustable electrodes,

and means whereby said frame may be so carried by said structure that the said oscillator is suspended between and out of contact with said electrodes.

In testimony whereof, I have hereunto subscribed my name this 11th day of July, 1927.

DONALD G. LITTLE.