

Oct. 11, 1949.

M. L. SMITH

2,484,428

PIEZOELECTRIC CRYSTAL MOUNTING

Filed July 15, 1947

2 Sheets-Sheet 1

Fig. 1.

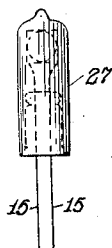


Fig. 2.

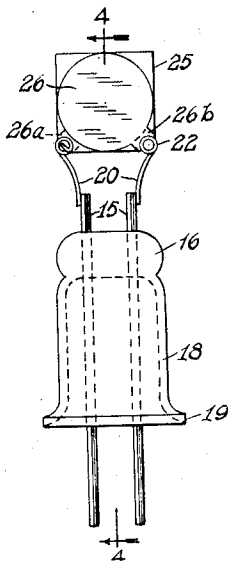


Fig. 3.

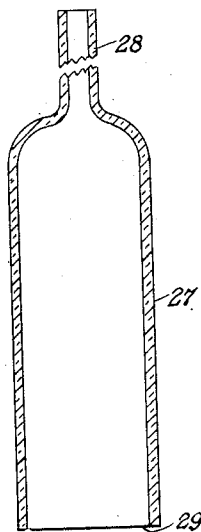


Fig. 4.

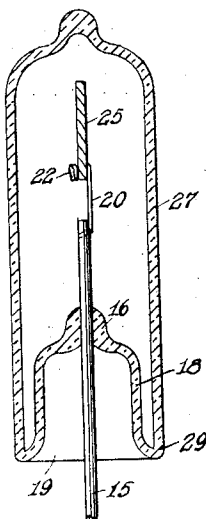


Fig. 5.

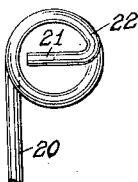


Fig. 6.



Fig. 7.

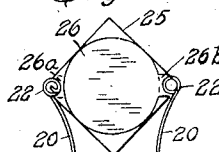


Fig. 8.

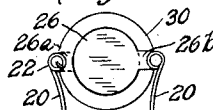
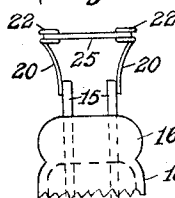


Fig. 9.



INVENTOR.

MELVIN L. SMITH

BY

Williams, Rich & Moore

ATTORNEYS

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M. L. SMITH

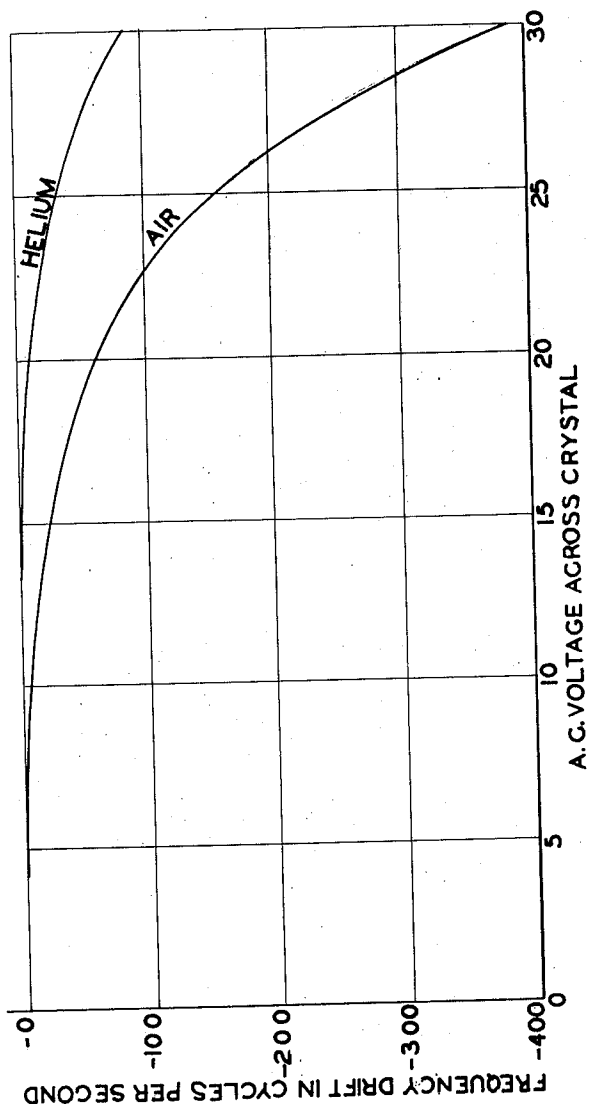
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PIEZOELECTRIC CRYSTAL MOUNTING

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Fig. 10.



CRYSTAL FREQUENCY 5992.000
AMBIENT TEMPERATURE 23 C
1/4" BT. CUT CRYSTAL PLATED

INVENTOR.
MELVIN L. SMITH

BY
William R. Moore

ATTORNEYS

UNITED STATES PATENT OFFICE

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PIEZOELECTRIC CRYSTAL MOUNTING

Melvin L. Smith, Kane, Pa.

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3 Claims. (Cl. 171-327)

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This invention relates to piezoelectric elements and more particularly to mountings therefor.

The principal object of the invention is to provide an improved hermetically sealed mounting for quartz and other piezoelectric crystals. Especially is the invention concerned with a practical and efficient mounting for quartz crystals of small size, such for example, as flat crystals having dimensions of the order of quarter inch to half inch squares.

An object of the invention is to produce a mounted crystal having a maximum quality to size ratio, that is having optimum electrical qualities in relation to physical envelope size, particularly the lowest possible values of capacitance and effective resistance and maximum crystal activity.

Another object is to provide a mounting adapted to reduce the frequency drift of the crystal during use, which is due to heating, by providing a mounting having improved heat dissipation.

Another object is to provide improved means of attaching the crystal itself to supports.

A further object is to provide a mounting of simple, rugged construction which is capable of being easily and economically assembled on a volume production basis.

Other objects and advantages will hereinafter appear.

The invention will best be understood from the following detailed description of the present preferred embodiment of the invention, taken in conjunction with the drawings in which:

Fig. 1 shows a mounted crystal, the size of the mounting in the original drawing being substantially full scale for a crystal one-quarter inch square;

Fig. 2 shows, on an enlarged scale, a crystal mounted on the conductors which are carried by the press, prior to its assembly with the envelope;

Fig. 3 is a longitudinal section of the envelope on the same scale as Fig. 2;

Fig. 4 is a longitudinal section through a completed unit, parts thereof being shown in section, taken on the line 4-4 of Fig. 2 and also on the scale of Fig. 2;

Figs. 5 and 6 are greatly enlarged detailed views, taken at right angles to each other, of the coiled end of a support wire;

Fig. 7 shows a modified mounting of a crystal which is supported at opposite corners instead of at adjacent corners as shown in Fig. 2;

Fig. 8 shows the mounting of a circular crystal;

Fig. 9 shows a modified form of mounting in which either a rectangular or round crystal is

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supported in a horizontal instead of a vertical position as shown in the other figures; and

Fig. 10 is a graph showing curves comparing the frequency drift with change in applied voltage of a crystal mounted in an envelope filled with air with the drift of the same crystal in the same envelope filled with helium.

The construction of the crystal mounting and the steps in forming it will be described together.

Referring to Fig. 2, a pair of conductors 15 of a suitable material are sealed in a glass press 16 which has a depending skirt portion 18 terminating in a circular flared sealing edge 19. The skirt portion is of a substantial length so as to space the press 16 from the sealing edge 19. The skirt may, for example, have a length of approximately one third the over-all length of the finished mounting.

Supporting wires 20 of resilient material such as, for example, tungsten wire having a diameter of .006" are provided with coiled ends having the configuration shown in Figs. 5 and 6. These coils comprise a cross-bar 21 formed from the end of the wire and a plurality of turns 22 in the form of a closely coiled spring. Materials other than tungsten may be used, for example hard nickel.

The crystal 25 is provided on opposite faces with conductive coatings which may be applied thereto in various well known ways, for example by the evaporation process. In Fig. 2 the coating is shown at 26 as circular in outline except for a tab portion 26a which extends to one corner of the crystal. The opposite side of the crystal is provided with a similar coating having a tab portion 26b extending to an adjacent corner.

After the crystal has been thus coated and otherwise prepared for mounting, it is fixed in its support by forcing its coated corner portions between the coils 22 of the support wires 20. In order to make the electrical bond between the support wires and the coatings 26 more perfect, a small quantity of a suitable conductive paste is applied which bridges the support wire and the conductive coating. Many such pastes are known, including those having a volatile base which may be set to solid form by evaporation, and those which are fused by the application of heat. The use of the right type of paste is important and it has been found that one composed of finely divided silver in an organic base, designed to be fused at a temperature of from 900 to 1000° F., is suitable. The high fusion point assures its stability during the subsequent sealing of the glass elements. Such a paste is available from Hanovia Chemical and Manufacturing

Co. under the designation "122B." The amount of such paste is kept to a minimum in order to avoid reduction of the crystal activity, and to this end a small quantity of the conductive paste is placed within the coils 22 in contact with the cross-bars 21. The unit is then passed through an oven providing a temperature adequate to fuse the paste and adequate air circulation to remove volatile material.

When the unit has been thus far assembled, the crystal may be given such electrical tests as may be desired and its frequency brought to the desired value in known manner while it is still accessible.

When the crystal has been adequately adjusted and tested, the press upon which it is supported is inserted in a tubular glass envelope 27, such as that shown in Fig. 3, equipped with an evacuation tube 28 and having an open bottom 29. The bottom 29 is of a size to fit the sealing edge 19 and, in a suitable sealing machine, these two parts are fused together into the form shown in Fig. 4. It will be observed that the crystal 25 is supported at a point as far removed from the point of sealing as possible, considering the size of the envelope 27 so that the temperature rise of the crystal during sealing is kept to a minimum.

After the crystal assembly and envelope have been formed into an integral unit, the envelope is evacuated through tube 28 and filled with helium, preferably at a pressure slightly below atmospheric pressure so as to facilitate sealing off of the tube 28. The degree of partial vacuum may be varied and it has been found that a reduction in pressure below atmospheric corresponding to between 2" and 8" of mercury is satisfactory. The filling of the envelope with helium is an important aspect of the invention as it has been discovered that when the crystal is surrounded by an atmosphere of helium the heat, which is generated in the crystal during use, is conducted away from it with much greater rapidity than would be the case were the envelope filled with air and therefore frequency drift of the crystal is substantially reduced and one is enabled to operate the crystal at much higher voltages without undue change in frequency. This phenomenon is illustrated in Fig. 10 where frequency drift is plotted against the voltage applied to the crystal. In the specific test illustrated by the chart, a crystal having a normal frequency of 5992 kc. at an ambient temperature of 23° C. suffered a drop in frequency at an applied voltage of 30 volts of nearly 400 cycles per second when contained in an air-filled envelope. The same crystal mounted in the same envelope when filled with helium suffered a drop in frequency at the same voltage of only about 80 cycles per second. It has been determined that this difference is due to the lower operating temperature of the crystal in the helium-filled envelope, due to the fact that the helium more rapidly conducts heat away from the crystal.

While the conductive coating 26 applied to the crystal 25 may be of various materials, it is preferred to use a coating of aluminum applied by the evaporation method. It has surprisingly been discovered that when aluminum is used, no fre-

quency change in the crystals occurs during the heating of the elements of the unit during fusion of the glass parts and the annealing thereof. Coatings of silver and copper have been found to cause undesirable changes in frequency, probably due to oxidation, and while gold is reasonably satisfactory from this standpoint, it is lacking in abrasion resistance due to its softness, some abrasion occurring at the point where the crystal is forced into the coils of the supporting wires. The aluminum coating has very good abrasion resistance.

Fig. 7 shows a mounting similar to that shown in Fig. 2 except that the portions 26a and 26b of the conductive coatings 26 are positioned over diametrically opposite corners of the crystal instead of over adjacent corners.

Fig. 8 illustrates the mounting of a circular crystal 30 which is clamped at any suitably spaced points on its periphery by the coils 22 of the support wires 20.

Fig. 9 is a mount formed in the same manner as the others except that the crystal is turned to a position at right angles to the longitudinal axis of the mounting, permitting the use of a somewhat shorter envelope.

While various specific embodiments of the invention have been described above, it is to be understood that they are merely illustrative of the invention which is to be construed broadly within the purview of the claims.

What is claimed is:

1. A piezoelectric crystal holder comprising a hermetically sealed tube, and means for supporting the crystal in the tube, the space within the tube being filled with helium at a pressure reduced below atmospheric pressure by an amount corresponding to not over eight inches of mercury.

2. A piezoelectric crystal holder comprising a hermetically sealed tube, and means for supporting the crystal in the tube, the space within the tube being filled substantially exclusively with helium at a pressure corresponding to between 2 inches and 8 inches of mercury.

3. A piezoelectric crystal holder comprising a hermetically sealed tube, and means for supporting the crystal in the tube, the space within the tube being filled substantially exclusively with helium at a pressure reduced below atmospheric pressure by an amount which is no more than sufficient to seal off the evacuating tube when the latter is softened by heating.

MELVIN L. SMITH.

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