

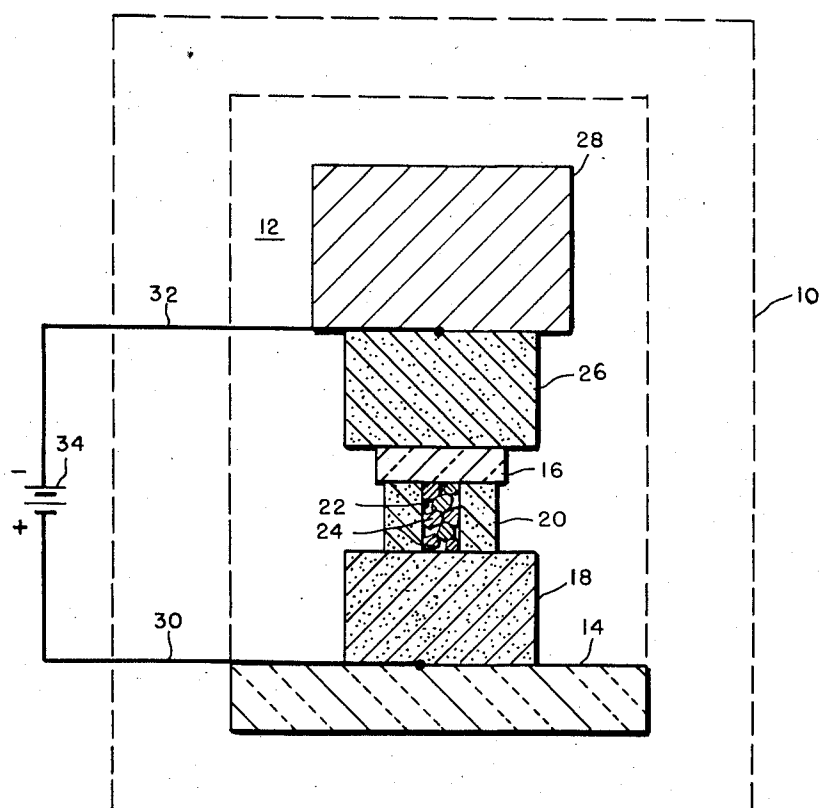
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METHOD OF CHANGING THE RESONANT FREQUENCY OF A QUARTZ CRYSTAL

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METHOD OF CHANGING THE RESONANT FREQUENCY OF A QUARTZ CRYSTAL

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This invention relates to quartz crystal resonators and particularly to methods of and means for adjusting the resonant frequency thereof to closer tolerances.

Prior to the present invention, in the manufacture of BT quartz oscillator plates, the final finishing of the plates to their desired oscillating frequency required hand lapping or acid etching. In a plate desired to have a final frequency of, say 6,000 kc., the pre-hand-finishing treatment is stopped when the plate is roughly a few hundred cycles up to a few kilocycles under the final desired frequency. To increase the frequency of the plate to a desired frequency by these conventional lapping or etching techniques is a slow, tedious and costly operation at best and leaves much to be desired.

According to the present invention, the difficulties experienced with the prior art have been overcome by subjecting the quartz oscillator plates to the action of heat and an applied electric field to diffuse therein ions of a salt or oxide of an alkali metal or an alkaline earth metal into the plates in an amount sufficient to change their frequency of oscillation.

The change in frequency produced in oscillator plates by ion diffusion treatment is downwards from the original value by as much as four kilocycles when the plates are treated with ions of metals such as beryllium, magnesium, sodium or calcium. On the other hand, the oscillator plates may be shifted upward in frequency as much as twelve kilocycles by diffusion into them of alien ions of metals, such as barium, cesium, lithium or strontium. The downward or upward change in frequency of oscillation of the plates appears to depend primarily on the material used for the source of ions.

For a more detailed description of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the single figure of the accompanying drawing, which is a vertical cross-sectional view of the apparatus embodying the invention.

The apparatus shown comprises a conventional muffle furnace 10 in which are mounted the various elements of the quartz oscillator plate holder 12, appropriately insulated from the furnace 10 and connected through insulated connections 30 and 32 to a source of direct current voltage 34.

Inside of the furnace 10 is positioned a ceramic plate 14 which isolates the entire holder 12 from the furnace lining to prevent shunt paths around the oscillator plate 16. A graphite cylinder 18 is mounted on the ceramic plate 14. Mounted on the graphite cylinder 18 is a graphite block 20 substantially narrower than the diameter of cylinder 18. Block 20 has a central bore 22 which serves as well in which the material 24 used as a source of ions is packed. The material 24 preferably consists of a salt or an oxide of an alkali metal or an alkaline earth metal. Specific materials include beryllium sulphate, magnesium chloride, calcium fluoride, sodium chloride, calcium chloride, barium chloride, stron-

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tium fluoride, lithium chloride, cesium chloride, magnesium oxide, strontium oxide and calcium oxide.

Quartz oscillator plate 16, larger in diameter than block 20, is mounted on block 20 and centered over the bore 22 so that it is in contact with material 24. Another graphite cylinder 26 identical to the lower cylinder 18 is mounted on quartz plate 16. On top of cylinder 26 a heavy cylinder 28 of stainless steel is placed and serves as a weight to hold the above elements of the holder under compression. The ends of a pair of platinum wires 30 and 32 are suitably secured to make electrical contact to graphite cylinders 18 and 26, respectively.

In operation, the furnace 10 is heated to its operating temperature and the direct current voltage is applied to the graphite cylinders 18 and 26. When plate 16 acquires the desired oscillating frequency value or range, furnace 10 is turned off and the connection to voltage source 34 is opened.

In accordance with the invention, quartz oscillator plates were treated for periods up to 12 hours, at approximately 300 volts D.C. potential with furnace temperatures ranging between 475° to 485° centigrade. The oscillator plates decreased in frequency in the case of diffusion with ions of metals such as beryllium, magnesium, sodium or calcium. When barium, cesium, lithium or strontium were used as ion source material, the frequency of oscillation increased.

In one experiment a BT-cut quartz oscillator plate was treated with barium chloride at 475° C. and 300 volts D.C. After 12 hours the frequency of the plate was found to have increased from 5925.1 kc. to 5937.1 kc., showing an increase of 12 kc. In another experiment a BT-cut quartz oscillator plate was treated with sodium chloride at 485° C. and 325 volts D.C. After 12 hours it was found that the oscillating frequency of the plate was decreased from 6573.6 kc. to 6569.2 kc., showing a decrease in frequency of oscillation of 4.4 kc. Similar results of varying degree were obtained with the other materials, and by variation of the amount and potential and the time of exposure thereof.

While there has been described what is at present considered a preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of adjusting the resonant frequency of a quartz crystal comprising placing said crystal in contact with a compound selected from the group consisting of the inorganic salts and oxides of beryllium, magnesium, calcium, strontium, barium, lithium, sodium and cesium, maintaining said crystal and said compound at a predetermined temperature, and applying a direct current potential across said crystal and said compound for a predetermined period of time.

2. The method of changing the resonant frequency of a quartz crystal comprising placing said crystal in contact with a compound selected from the group consisting of the inorganic salts of beryllium, magnesium, calcium, strontium, barium, lithium, sodium and cesium, maintaining said crystal and said compound at a predetermined temperature, and applying a direct current potential across said crystal and said compound for a predetermined period of time.

3. The method of increasing the oscillating frequency of a quartz oscillator plate comprising placing said plate in contact with an inorganic salt selected from the group consisting of barium, cesium, lithium and strontium, main-

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taining said plate and said salt at a predetermined temperature, and applying a direct current potential across said plate and said salt for a period of time to permit ions of said salt to diffuse into said plate until a desired increase in oscillating frequency of said plate is effected. 5

4. The method of decreasing the oscillating frequency of a quartz oscillator plate comprising placing said plate in contact with an inorganic salt selected from the group consisting of beryllium, magnesium, sodium and calcium, maintaining said plate and said salt at a predetermined temperature, and applying a direct current potential across said plate and said salt for a period of time to permit ions of said salt to diffuse into said plate until a desired decrease in oscillating frequency of said plate is effected. 10

5. The method of increasing the resonant frequency of a quartz crystal comprising placing said crystal in contact with an inorganic salt of barium, maintaining said crystal and said salt at a predetermined temperature, and applying a direct current potential across said crystal and said salt for a predetermined time. 15

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6. The method as set forth in claim 5, wherein said inorganic salt of barium is barium chloride, said temperature is 475° C., and said time is 12 hours, and said potential is 300 volts.

7. The method of decreasing the resonant frequency of a quartz crystal comprising placing said crystal in contact with an inorganic salt of sodium, maintaining said crystal and said salt at a predetermined temperature, and applying a direct current potential across said crystal and said salt for a predetermined time.

8. The method as set forth in claim 7, wherein said inorganic salt of sodium is sodium chloride, said temperature is 485° C., and said time is 12 hours, and said potential is 325 volts.

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