

Oct. 31, 1961

J. F. SILVER

3,006,711

CRYSTAL ASSEMBLY

Filed May 13, 1959

Fig. 1.

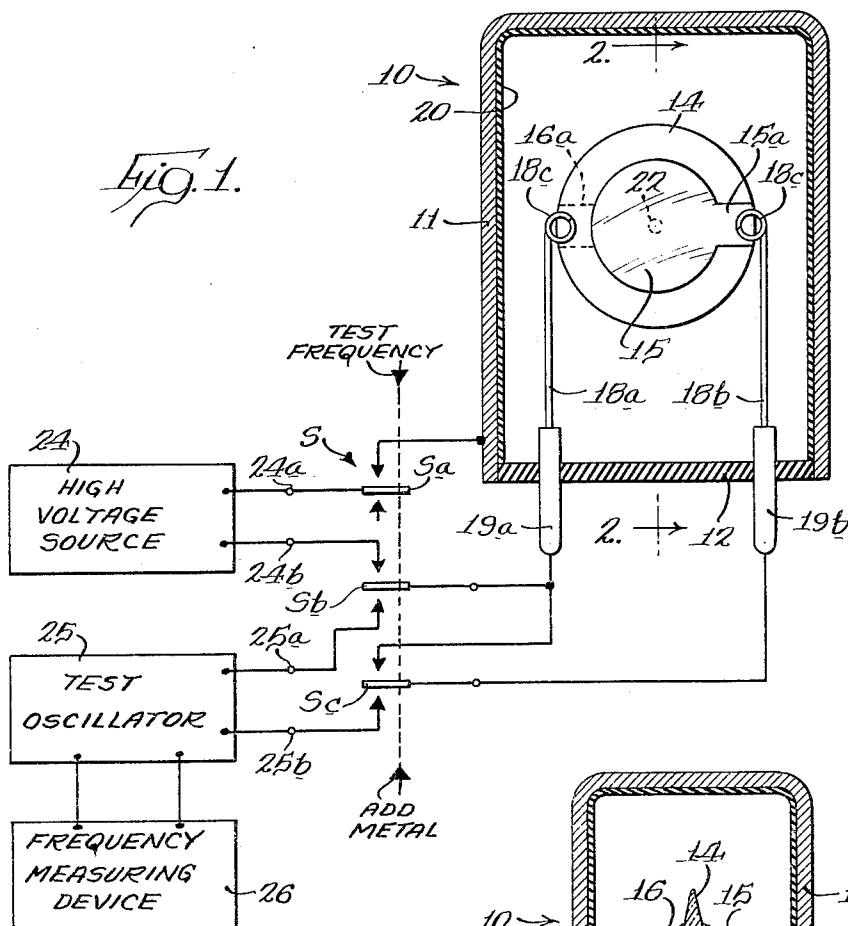


Fig. 2.

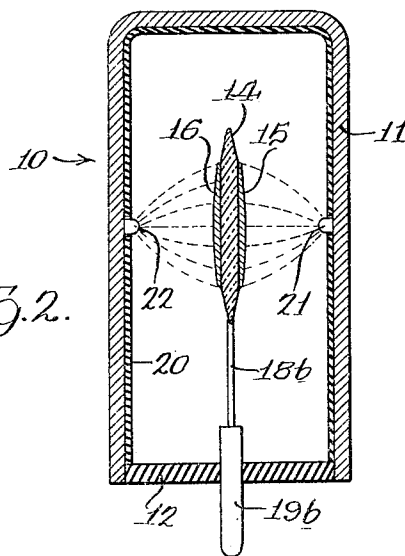
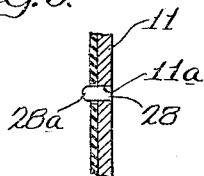


Fig. 3.



INVENTOR.

John F. Silver

BY

Wolfe, Hubbard, Voit & Osann

Attys.

1

3,006,711

CRYSTAL ASSEMBLY

John F. Silver, Park Ridge, Ill., assignor, by mesne assignments, to The James Knights Company, Sandwich, Ill., a corporation of Delaware

Filed May 13, 1959, Ser. No. 812,975

5 Claims. (Cl. 310—8.1)

The present invention relates in general to piezoelectric crystals, and more particularly to assemblies in which precisely calibrated crystals are contained within hermetically sealed envelopes.

The principal object of the invention is to provide a simple, compact, and inexpensive crystal assembly which affords calibrating reductions in the operating frequency of the crystal after the latter has been sealed in a metal envelope.

Another object of the invention is to achieve reductions in the frequency of a crystal, after the latter has been sealed in a metal envelope, by an arrangement which does not require special physical components of appreciable size within the envelope, and which does not require that the envelope be made larger than it otherwise would be.

It is a further object of the invention to provide such a crystal assembly in which the "sputtering" transfer of metal to decrease the crystal frequency may be effected by using either an alternating or direct voltage source.

Still another object is to provide such a crystal assembly in which no special lead or pin need extend through an envelope to afford electrical connection to sputtering material. On the contrary, the invention in its preferred form affords "sputtering on" to increase the crystal frequency simply by the connection of a voltage source between the metal envelope and the external crystal leads.

Other objects and advantages will become apparent as the following description proceeds, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view of an exemplary crystal assembly embodying the features of the invention, and associated with diagrammatically illustrated means for effecting adjustments in the crystal frequency;

FIG. 2 is a cross section taken substantially along the lines of 2—2 in FIG. 1; and

FIG. 3 is a fragmentary detail view illustrating a modified construction.

While the invention has been shown and will be described in some detail with reference to particular embodiments thereof, there is no intention that it thus be limited to such detail. On the contrary, it is intended here to cover all alternatives, modifications, and equivalents falling within the spirit and scope of the invention as defined by the appended claims.

Turning now to the drawings, a crystal assembly 10 illustrated in FIGS. 1 and 2 comprises a metal envelope including a relatively thin sheet metal bonnet 11 which is closed and hermetically sealed at its lower end by a base or disc 12 formed of suitable insulating material. A crystal 14, which may be of any well known type such as an accurately cut wafer of natural or synthetic quartz, is disposed within the envelope and provided with metallic coatings 15 and 16 on the opposite faces thereof.

As is well known, a piezoelectric quartz crystal when excited by an alternating electric field exhibits physical dimensional changes which tend to have a characteristic or operating resonant frequency. The size of the crystal, the manner in which it is cut relative to its crystalline structure, and extent and thickness of the metal coatings 15, 16 all combine to determine the natural or operating frequency of the crystal. When connected in an oscilla-

2

tor or filter circuit, the crystal establishes the frequency at which such circuits operate. The metal coatings 15, 16 not only serve conveniently to afford the application of electric potentials to the body of the crystal, but also serve as means for effecting changes in the natural frequency of the crystal. If metal is added to the coatings to increase their thickness and the mechanical loading effect which they have upon crystal vibrations, then the operating frequency of the crystal will be decreased. Conversely, if metal is removed from these coatings, making them thinner and reducing their physical loading effect, the operating frequency of the crystal is increased.

For supporting the crystal 14 within the envelope 11, 12 and spaced from the interior surfaces thereof, a pair of wires or leads 18a, 18b project upwardly from stems or connectors 19a, 19b extending in sealed relation through the base 12. The leads 18a, 18b are preferably formed of semi-resilient wires formed with tight spirals 18c at their upper ends. These spirals are clipped over diametrically opposite edge portions of the crystal thus supporting the latter and making electrical contact with the coatings 15, 16 through engagement with radial extensions or "flags" 15a and 16a forming a part of the coatings. Thus, the leads 18a, 18b and the stems 19a, 19b not only serve physically to support the crystal 14 within the envelope 11, 12 but also provide for external electrical connection to the coatings 15 and 16 on the opposite faces of the crystal.

After the crystal has been mounted in the envelope, the latter is evacuated prior to closing off and hermetically sealing. It has been a familiar practice to mount piezoelectric crystals in sealed and evacuated envelopes in order to exclude dirt and foreign matter from the crystal surfaces, and substantially to eliminate the spurious effects of changing pressure, humidity and temperature on the crystal's operating frequency. While, as noted above, the natural frequency of the crystal may be determined by carefully determining its size and the thickness of the metal coatings during manufacture, some slight change of this natural frequency inevitably occurs as an incident to mounting the crystal in the leads 18a 18b exhausting the envelope, and sealing the latter. Therefore, it is desirable to provide some means for precisely adjusting the natural frequency of the crystal to the exact value desired after the envelope 11, 12 has been evacuated and sealed. The frequency of a crystal may be increased, after it has been sealed in an envelope, in the manner disclosed and claimed in Berge Patent No. 2,877,338. Also the frequency of a crystal may be decreased, after it has been sealed in an envelope, in the manner disclosed and claimed in Berge Patent No. 2,816,239. It is to an improvement in sealed crystal assemblies which afford decreases in crystal operating frequency, particularly where metal envelopes are employed to house the crystal, that the present invention is directed.

In accordance with the present invention, provision is made to add metal to the coatings 15, 16 of the crystal 14 in order to reduce the operating frequency of the latter after it has been sealed in the metal envelope 11, 12. This is here accomplished by providing a thin layer or covering 20 of a suitable insulating material on all of the exposed interior metallic surfaces of the envelope. This covering may be of a variety of materials, such as the well known "Teflon" insulation, or a glass or porcelain substance. In addition to the coating 20, small globules or spots of metal 21, 22 are supported by the envelope bonnet 11 so that they project through small openings in the insulating covering 20. Preferably, the metallic spots 21 and 22 are disposed opposite the coatings 15 and 16 on the faces of the crystal, such spots being bonded or soldered directly to the interior surface of the metallic

bonnet 11. These metal globules or spots 21, 22 are preferably made of the same material as the metal coatings 15, 16 although this is not vitally necessary. Gold or silver is most often applied for the coatings 15, 16 and so the small metallic spots 21, 22 may likewise be made of gold or silver.

With the metal spots 21, 22 bonded or soldered to the inner surface of the metal bonnet 11, and the insulating coating 20 applied to that inner surface so as to leave the spots exposed, it is but a simple matter to effect calibrating reductions in the operating frequency of the crystal 14 after the envelope 11, 12 has been evacuated and sealed. It is only necessary to apply a suitable electric potential between the metal spots 21, 22 and the crystal coatings 15, 16 in order to effect an electrical discharge which transfers metal from the spots to the coatings by "sputtering" action. For this purpose, a suitable voltage source may be connected directly between the leads or stems 19a, 19b and the metal bonnet 11, thereby setting up an electrical field and discharge between the metal spots 21, 22 and the coatings 15, 16. Either direct or alternating voltage may be so applied, although if a direct voltage is employed, the polarity should be such as to make the coatings 15 and 16 positive with respect to the spots 21, 22.

An alternating voltage has been found to work successfully and, in fact, is preferred since it results in an intermittent discharging action which avoids the formation of a localized discharge beam. An alternating voltage source is believed to be successful since, as shown, the exposed area of the metal spots 21, 22 is relatively small compared to the area of the metal coatings 15, 16 on the crystal. Because of this difference in relative areas, more metal is transferred from the spots 21, 22 to the coatings 15, 16 on half cycles of the alternating voltage which make the coatings positive relative to the spots than is transferred in the opposite direction on half cycles which make the spots 21, 22 positive with respect to the coatings 15, 16. This net transfer of metal, which has been observed in successful tests with A.C. voltages, is believed to result from a "point rectification" phenomenon, i.e., there is a heavier discharge carrying more metal from the spots 21, 22 to the coatings 15, 16 than from the coatings to the spots because the electrical field is more concentrated at the small-area spots.

The insulating coating 20, which preferably has a high dielectric constant, masks the inner surface of the metal bonnet 11 and makes an electric field (indicated by dashed lines in FIG. 2) be effectively concentrated between the spots 21, 22 and the crystal coating. Except for the presence of this insulating covering 20, there would be a tendency for metal to be removed from the crystal coatings and transferred to the interior surface of the metal bonnet. The combination of the insulating covering with the relatively small-area metal spots 21, 22 projecting therethrough thus makes it possible to obtain a net transfer of metal from the spots to the crystal coatings and without transferring metal to the envelope itself. The insulating covering 20 provides the additional benefit of inhibiting the release of occluded gases in the metal bonnet 11, and this reduces contamination of the vacuum within the envelope.

FIGURE 1 illustrates in diagrammatic form exemplary apparatus which may be employed to reduce the operating frequency of the crystal 14 precisely to a desired value after the latter has been mounted and sealed in the evacuated envelope 11, 12. Assume that the crystal frequency is higher than desired after the envelope is sealed. The stems 19a, 19b and the metal bonnet 11 may be selectively connected through a three pole double throw switch S to an appropriate high voltage source 24 or to a test oscillator 25. To add metal to the crystal coatings and reduce the crystal frequency, the switch S is shifted to and held in its upper position for a few seconds. Thus, the switch blade S_a connects one output terminal 24a of

the source 24 to the metal bonnet 11 which is electrically united with the metal spots 21, 22. The switch blade S_b connects the other terminal 24b of the source 24 to the stem 19a, and to the switch blade S_c which leads to the stem 19b. The voltage of the source 24, whether it be alternating or direct, is therefore applied between the metal spots 21, 22 and the two crystal coatings 15, 16, so that a "sputtering" discharge will occur to transfer metal from those spots to the coatings.

After the switch S has been held in its upper position for a few seconds, it is depressed to its lower position. The switch blade S_a isolates the source 24 from the bonnet 11, the switch blade S_b connects the stem 19a and the crystal coating 16 to a first terminal 25a of a test oscillator 25, and the switch blade S_c connects the second terminal 25b of the oscillator to the stem 19b and coating 15. With this, the crystal 14 is connected in frequency-controlling relation with the oscillator 25, and the latter operates at a frequency determined by the natural frequency of the crystal. The oscillator frequency may be observed from a suitable frequency-measuring and indicating device 26 connected thereto.

If the crystal's frequency is still above the value desired, the switch S is again shifted to its upper position for a few seconds to cause additional transfer of metal from the spots 21, 22 to the coatings 15, 16. The switch is then reversed to measure the crystal's frequency a second time. This procedure may be repeated until the natural frequency of the crystal is decreased precisely to the value desired. The entire adjustment procedure may be accomplished in a very short time.

In FIG. 2 the metal spots 20, 21 have been shown simply as small drops or globules of metal which are bonded by soldering or the like directly to the interior surface of the bonnet 11. FIG. 3, however, illustrates a modified arrangement in which small holes 11a are initially drilled in the metal bonnet 11, and then filled with a molten drop or slug of metal 28, the inner end 28a of such metal forming a spot from which discharge and transfer of metal to the crystal coatings can occur. The metal drop 28 is disposed in hermetically sealed relation within the hole 11a.

Because the metal spots 21, 22 occupy almost no space within the envelope, the latter do not require that the envelope be especially constructed or made larger to accommodate a source of metal for sputtering onto the crystal coatings. The insulating covering 20 may be easily applied to the inner surface of the metal envelope without appreciable additional expense. Moreover, it is not necessary in the preferred construction of FIG. 2 to have any lead wire or support extend through and be hermetically sealed to the envelope, since the metal spots 21 and 22 are entirely carried by the inner surface of the envelope. Finally, it is extremely convenient and quick to establish the necessary connections to the crystal assembly in order to produce the transfer of metal to the coatings 15, 16, it being required only that one terminal of an appropriate voltage source be connected to the metallic envelope, and the other terminal of that source, connected to the leads which extend from the crystal coatings to the exterior of the envelope. A very simple, compact, and inexpensive assembly is thus achieved which makes it possible to precisely decrease the operating frequency of the crystal after it has been mounted in a metal envelope and the latter evacuated and completely sealed.

I claim as my invention:

1. In a crystal assembly, the combination comprising an evacuated, hermetically sealed metal envelope, a crystal mounted in said envelope and having a metal coating on the surface thereof electrically connected with a lead extending through and insulated from said envelope, a layer of electrically insulating material on the interior metallic surfaces of said envelope, and a spot of metal projecting through said layer and located sub-

5

stantially opposite said metal coating, whereby application of a voltage between said lead and said spot may sputter metal from the latter to the metal coating to decrease the operating frequency of the crystal.

2. In a crystal assembly including an hermetically sealed, evacuated metal envelope, a crystal mounted within said envelope and having a metal coating on its surface, and a lead electrically connected with said coating and extending through and insulated from said envelope, that improvement which comprises a layer of insulating material on the inner surface of said envelope, and a spot of metal disposed within and united with said envelope and projecting through said layer substantially opposite said metal coating.

3. In a crystal assembly, the combination comprising an hermetically sealed, evacuated metal envelope, a crystal and means supporting the same within said envelope, a metal coating on the surface of said crystal and a lead electrically connected to said coating and extending through and insulated from said envelope, a covering of insulating material on the interior metal surface of said envelope, a spot of metal similar to the metal of said coating and supported by the envelope on the interior thereof in a position opposite said coating, said metal spot projecting through said covering and having an exposed area which is small relative to the area of said coating, so that sputtering of metal from said spot to said coating is produced by connection of a voltage source between said spot and said lead.

4. In a crystal assembly, the combination comprising an hermetically sealed, evacuated metal envelope, a crystal disposed within said envelope, a metal coating on the surface of said crystal and a lead electrically con-

6

nected to said crystal and extending through and insulated from said envelope, a covering of insulating material on the interior metal surface of said envelope, an insert of metal located substantially opposite said coating and similar in character to the metal of said coating projecting through said envelope and covering and sealed to the former, so that the crystal frequency may be increased by momentarily applying a voltage between said insert and said lead.

5. In a crystal assembly, the combination comprising an hermetically sealed evacuated metal envelope, a crystal disposed within said envelope and having metal coatings on the opposite faces thereof, leads electrically connected with said coatings and extending in insulated relation through said envelope, a covering of insulating material on all exposed interior metal surfaces of said envelope, a pair of metal spots disposed on the interior of said envelope and electrically united therewith, said spots being located respectively opposite said coatings and having areas projecting through said covering which are small in relation to the areas of said coatings.

References Cited in the file of this patent

UNITED STATES PATENTS

2,505,370	Sykes	Apr. 25, 1950
2,699,508	Fastenan	Jan. 11, 1955
2,808,523	Holmbeck	Oct. 1, 1957
2,816,239	Berge	Dec. 10, 1957

FOREIGN PATENTS

746,971	Great Britain	Mar. 21, 1956
---------	---------------	---------------