United States Patent [19]

Assmus et al.

[11] **3,805,509**

[45] **Apr. 23, 1974**

[54] **CRYSTAL VIBRATOR AS A TIME KEEPING VIBRATOR FOR A TIMEPIECE**

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[22] Filed: **Nov. 8, 1972**

[21] Appl. No.: **304,593**

[30] **Foreign Application Priority Data**

Nov. 15, 1971 Germany 2156691

[52] **U.S. Cl.** ..... **58/23 V,** 310/9.1, 331/158

[51] **Int. Cl.** **G04c 3/00**

[58] **Field of Search** ..... 58/23 AO, 23 TF, 23 V, 58/23 D; 310/8.9, 9.1; 331/154–156, 158, 187

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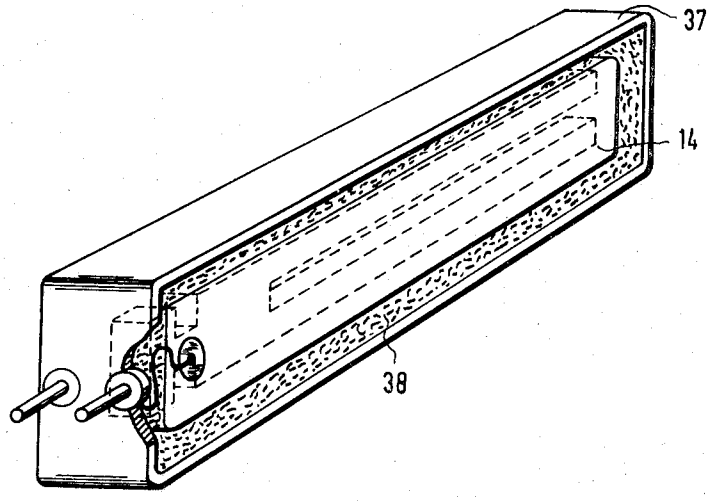
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Assistant Examiner—Edith Simmons Jackmon
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

A crystal vibrator for a timepiece in which a crystal tuning fork is mounted within an evacuated housing and the evacuated housing in turn resiliently supported from a support. Stops are provided to limit the movement of the evacuated housing relative to the support.

13 Claims, 9 Drawing Figures



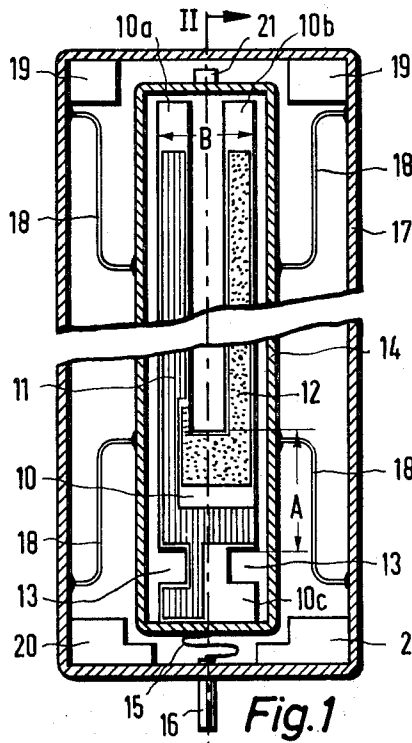


Fig.1

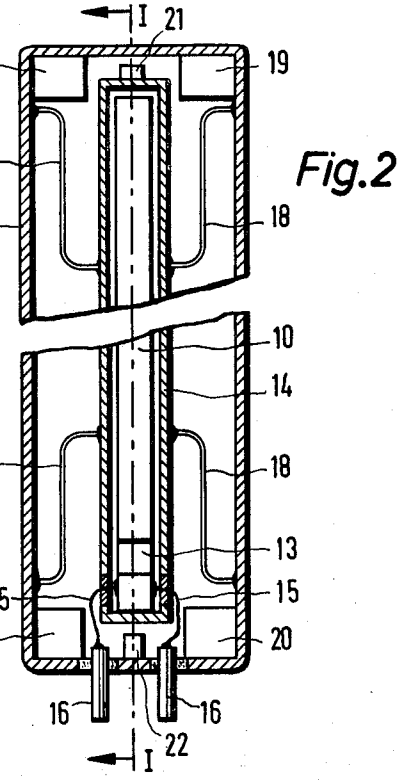


Fig.2

Fig.3

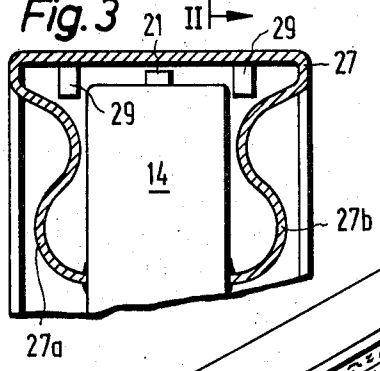


Fig.5

Fig.4

Fig. 6A

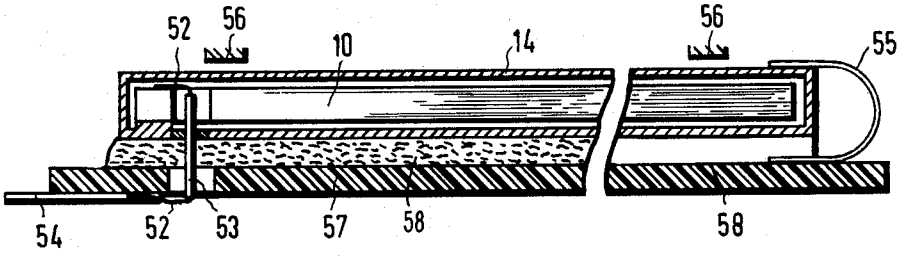


Fig. 6B

Fig.7

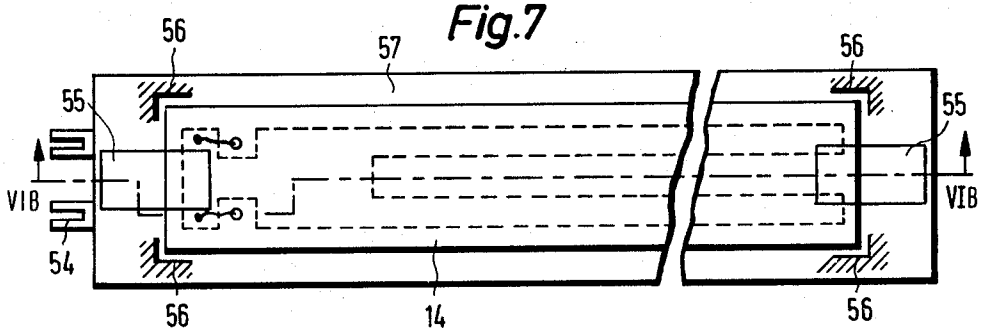
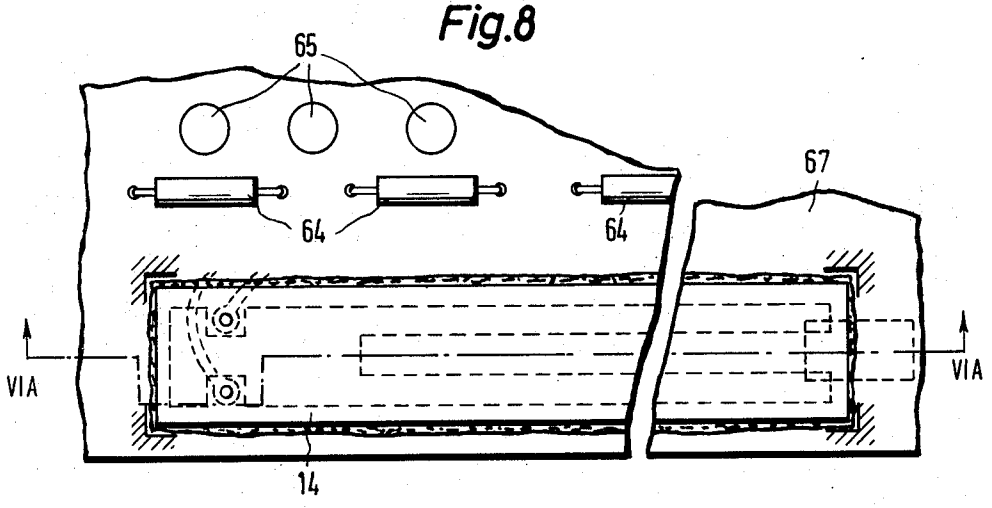


Fig.8



CRYSTAL VIBRATOR AS A TIME KEEPING VIBRATOR FOR A TIMEPIECE

BACKGROUND OF THE INVENTION

The invention relates to a crystal vibrator, e.g., of quartz and preferably in the shape of a tuning fork disposed in an evacuated housing and suspended by means of one or several elastic elements, as a time keeping vibrator for a timepiece.

In the case of the use of crystal vibrators of relatively low frequency, e.g., tuning forks of quartz, as time keeping vibrators for timepieces and especially for wristwatches, the influence of shocks and vibrations present very difficult problems which can assume quite considerable proportions. Customarily permissible values of acceleration are at 50g to 300g for a few milliseconds and/or 5g vibration load within certain frequency ranges. The influences of vibration are especially difficult to control.

Crystal vibrators, are generally disposed in an evacuated housing and are held therein with the help of either supporting springs in the form of wires or with the help of a silicone rubber mass. In these known vibrators there is a danger that in the case of shocks, the crystal vibrator will strike against the housing resulting in destruction of the vibrator. In addition, it is a disadvantage that the elastic elements holding the crystal vibrator are no longer accessible after insertion of the vibrator in the housing, so that a subsequent alignment or realignment is not possible.

The invention has for its objective to provide a novel crystal vibrator of the type described herebefore which can endure a high degree of strain from shock, e.g., 3,000g or more.

It is another object to provide a novel crystal vibrator in which the elastic suspension elements are accessible at any time.

According to the invention, these objects are achieved by rigidly connecting the vibrator at one end to the evacuated housing and by mounting the housing on a solid support by at least one elastic element. As a result, the vibrator can move only insignificantly inside of the evacuated housing so that a striking against the housing wall, even in the case of small dimensions of the housing, can be avoided. Moreover, a change of position of the vibrator in the evacuated housing is not possible and the elastic elements holding the evacuated housing are accessible at any time. Because of the possible small dimensions, the evacuated housing cannot be developed with a small mass relative to the vibrator.

The support for the evacuated housing can be an additional housing incorporating the evacuated housing. It is also possible to develop the support as a frame surrounding the evacuated housing. The support, however, can also be a plate of insulating material.

The one or more elastic elements can be elastic metal elements. For example, the elastic elements can be lamellae stamped out of the support. Special mass elements can be assigned effectively to the elastic elements, which are attached to said elastic elements in such a way that they form limiting stops for the evacuated housing. The elastic element may also comprise a resilient plastic mass, such as silicone rubber.

When using a crystal tuning fork, such as a quartz tuning fork, the foot of said tuning fork for practical purposes is glued to the evacuated housing. The tuning fork is preferably dimensioned such that the width thereof is smaller than the height of the foot of the tuning fork.

Preferably, the evacuated housing is dimensioned such that its mass is small as compared to the mass of the tuning fork.

As a result of the present invention, not only will the danger of breaking the crystal vibrator be decreased, but an uncoupling between the crystal vibrator and the support will also be achieved. As a result of the rigid attachment of the vibrator to the evacuated housing, it will also be possible to use very thin leads for the electrodes disposed on the vibrator as a result of which the soldering points on the electrodes can be kept small.

These and other objects and advantages of the present invention will be apparent from the claims and from the following detailed description when read in conjunction with the appended drawings.

THE DRAWINGS

FIG. 1 is a top plan view of a section of a first embodiment following line I—I in FIG. 2;

FIG. 2 is a section through lines II—II of the embodiment of FIG. 1;

FIG. 3 is a partial presentation of a second embodiment in partial section;

FIG. 4 is a partial presentation of a third embodiment in partial section;

FIG. 5 is a perspective view of a fourth embodiment;

FIGS. 6A and 6B are sections in elevation of two other embodiments of the invention as taken through lines IVA—IVA and IVB—IVB in FIG. 7 and 8, respectively;

FIG. 7 is a top plan view of the embodiment of FIG. 6B; and,

FIG. 8 is a partial presentation of a modified embodiment of that illustrated in FIG. 6A.

THE DETAILED DESCRIPTION

In FIGS. 1 and 2, a crystal 10, preferably a quartz crystal, is in the form of a tuning fork having prongs 10*a* and 10*b* provided with electrodes 11 and 12. The foot of the tuning fork 10 has recesses 13, which bring about an uncoupling of the real tuning fork from the surrounding housing 14. The foot 10*c* of the tuning fork 10 is connected rigidly with the housing 14, preferably by gluing.

As a result of the rigid connection between tuning fork 10 and housing 14, only a slight movement of the tuning fork 10 in relation to the housing 14 is possible, and consequently, the housing can be produced with comparatively small dimensions. As a result it is also possible to keep the mass of the housing 14 small in comparison to the mass of the tuning fork 10.

The housing 14 is evacuated after insertion of the tuning fork 10, so that the tuning fork can vibrate as freely as possible. The electrodes 11 and 12 are provided with insulated leads 15 guided out of the housing 14.

The housing 14 is attached to a support by means of elastic electrodes 18, said support being another housing 17 surrounding the evacuated housing 14. Mechanical stops 19 and 20 are provided in the housing 17. These stops may be a somewhat elastic material, e.g., a suitable plastic, to prevent a deflection of the evacuated housing 14 in the case of extremely hard shocks,

and to thereby prevent a permanent deformation of the elastic elements **18.**

The slits **13** in the foot **10***c* of the tuning fork **10** are effectively disposed in such a way that the height A of the foot **10***c* is more than the overall width B of the body of the tuning fork. As a result of these dimensions, any influencing of the frequency of the tuning fork by the recesses **13** is avoided for all practical purposes.

The elastic elements **18** can be, for example, elastic metal bands attached at one end to the support housing **17** and at the other end to the evacuated housing **14.**

The electric leads **15** are conducted to contact pins **16** which are insulated where they penetrate the housing **17.**

As becomes clear from FIG. **3,** the elastic elements holding the evacuated housing **14** can be made simply by stamping out lamellae **27***a* and **27***b* from the support housing **27.** In the case of the embodiment according to FIG. **3,** stops **21** and **29** may be provided to limit the movement of the housing **14** in the case of extremely hard blows.

In the case of the embodiment according to FIG. **4,** the evacuated housing **14** containing the crystal vibrator is held by metal bands **48** which carry mass elements **49** disposed on nodal points of the elastic elements **48** for additional uncoupling. These mass elements **49,** as shown in FIG. **4,** can be arranged such that they serve at the same time as stops which bring about a limitation of the movement of the housing **14** in relation to the housing **47.**

In the case of the embodiment according to FIG. **5,** the support for the evacuated housing **14** containing the tuning fork, is developed as a frame **37** which surrounds the housing **14.** In this case, an elastic mass **38** is provided as an elastic element such as silicone rubber between the housing **14** and the frame **27.**

The **6A** show a further embodiment which can be produced with comparatively small dimensions as a built-in unit. In this case, the housing **14** is attached by means of an elastic element in the shape of an elastic mass **58** to a plate **57** made from insulating material and provides support for the evacuated housing **14** containing the vibrator **10.** Instead of the elastic mass **58,** elastic bands **55** can also be provided here, as shown in FIG. **6B.**

Plug pins **54** are attached to the insulating plate **57** and are connected via electrically conductive pins **53** as well as flexible leads **52** to the vibrator electrodes. Stops **56** are provided to limit the movement of the housing **14** in the case of severe blows.

The embodiment according to FIG. **6A** can be modified for example, according to FIG. **8** in such a way that the insulating plate **67** serving as support is made at an enlarged scale and incorporates switching elements **64** and **65** for a driving circuit. The plate of insulating material can support, for example, a printed circuit to which the switching elements are attached. The circuit can also be made in an integrated construction if desired.

The embodiments shown by way of example represent crystal vibrators in the form of two pole tuning forks. Naturally, the arrangement according to the invention can also be used for multiple pole crystal tuning forks. The tuning forks can be made of a quartz crystal or else of some other piezoelectric crystal. It is also possible to use some other flexural vibrators instead of tuning forks.

As a result of the present invention, a crystal vibrator is provided which on the one hand is largely uncoupled in relation to the support holding it, and which on the other hand is in a position to receive shock loads amounting to 3,000g and more without damage to the crystal vibrator or without the occurrence of a significant frequency change. In addition, the resonance points lie at least above 5,000 Hz as a result of which the quartz, for practical purposes, becomes insensitive to vibrations resulting from lawn mowers, compressed air hammers, etc.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A crystal vibrator for a timepiece comprising:
a support;
an evacuated housing;
means for elastically supporting said evacuated housing on said support; and,
a crystal vibrating element rigidly connected at one end thereof to said evacuated housing internally thereof.

2. The crystal vibrator of claim **1** wherein said support comprises an additional housing externally surrounding said evacuated housing.

3. The crystal vibrator of claim **1** wherein said support comprises a frame substantially surrounding said evacuated housing.

4. The crystal vibrator of claim **1** wherein said support is substantially planar and comprised of insulating material.

5. The crystal vibrator of claim **1** wherein said supporting means comprises a plurality of elastic metal elements.

6. The crystal vibrator of claim **5** wherein said elastic elements each comprise lamella formed integrally with said support.

7. The crystal vibrator of claim **6** including a mass element carried by each of said elastic elements.

8. The crystal vibrator of claim **7** wherein the mass element includes means for limiting movement of the evacuated housing relative to said support.

9. The crystal vibrator of claim **1** wherein said supporting means comprises an elastic plastic mass.

10. The crystal vibrator of claim **9** wherein said plastic mass comprises silicone rubber.

11. The crystal vibrator of claim **1** wherein said crystal vibrating element is a tuning fork fixed to said evacuated housing by means of an adhesive material.

12. The crystal vibrator of claim **1** wherein said crystal vibrating element is a tuning fork having prongs and a foot portion and dimensioned such that the overall width thereof is not greater than the height of the foot portion.

13. The crystal vibrator of claim **1** wherein the mass of said evacuated housing is small relative to the mass of said crystal vibrating element.

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