

SPECIFICATION

Method of making a plurality of oscillator assemblies

- 5 This invention concerns a method of making a plurality of oscillator assemblies and, although the invention is not so restricted, it is more particularly concerned with a method of making a plurality of quartz crystal oscillator assemblies for use in an electronic watch.
- 10 Fashion dictates that a quartz crystal electronic watch should be as thin as possible, and this in turn means that it is desirable to make its oscillator assembly as thin as possible, while ensuring that the assembly is both of low price and high reliability. Conventional quartz crystal oscillators, however do not enable the watches in which they are used to be especially thin, since they usually have a thickness of 20 2 to 3mm. In fact, it is, inter alia, because of the thickness of such assemblies that the quartz crystal electronic watches which use them are thicker than comparable conventional mechanical watches.
- Accordingly therefore to the present invention there is provided a method of making a plurality of oscillator assemblies comprising etching a strip of piezo-electric crystalline material to form a plurality of oscillators interconnected by strip material; etching a strip of piezo-electric crystalline material to form a plurality of first housing parts interconnected by strip material; etching a strip of piezo-electric crystalline or other material to form a plurality of second housing parts interconnected by strip material; securing each oscillator to a respective first housing part and thereafter removing the strip material interconnecting the oscillators; securing each second housing part to a respective first housing part to form a plurality of interconnected hermetically sealed assemblies in each of which there is disposed a respective oscillator; and removing the strip material between the assemblies so as to separate the latter from each other.
- Since both the oscillator and the said first housing part of each assembly on which the oscillator is mounted are made of piezo-electric crystalline material, differences in the thermal expansion coefficients of these parts will be reduced, and therefore the degree of distortion which occurs when these parts are secured together is correspondingly reduced, while the formation of the assemblies from strip material provides a large area of support for the oscillators. This makes it simpler to ensure that the oscillators can be mounted in the correct plane, and therefore reduces the amount of space which has to be provided within each housing. As a result, the invention makes it simpler to provide thin oscillator assemblies of low cost and high reliability. Moreover, this formation of the assemblies by etching further reduces the cost of manufacture and permits the production of thin parts.
- Preferably, each first housing part has a recess into which the respective oscillator can oscillate. Each first housing part and the respective oscillator are preferably made of the same material, e.g. quartz crystal material.

Each oscillator is preferably mounted on two spaced apart electrically conductive films which are provided on the respective first housing part.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1A is a plan view of a lower part of a known quartz crystal oscillator assembly,

Figure 1B is a vertical sectional view of a known oscillator assembly provided with the lower part shown in *Figure 1A*,

Figures 2A and *2B* are respectively a horizontal sectional view and a vertical sectional view of a known quartz crystal oscillator assembly provided with a cylindrical metallic case,

Figures 3A and *3B* are respectively a horizontal sectional view and a vertical sectional view of another known quartz crystal oscillator employing three ceramic plates and a glass plate, and

Figures 4A, 4B and *4C* are respectively perspective views of interconnected upper housing parts, interconnected quartz crystal oscillators, and interconnected lower housing parts of an embodiment of an oscillator assembly which may be produced by the method according to the present invention.

Terms such as "upper" and "lower" as used in the description below, are to be understood to refer to directions as seen in the accompanying drawings.

In *Figure 1* there is shown a known quartz crystal oscillator assembly comprising a quartz crystal oscillator 1 produced by a photo-etching process. The oscillator 1, which is shaped as a tuning fork, is disposed within an hermetically sealed housing comprising an upper housing part 3 and a lower housing part 2 each of which is constituted by a metallic member. The metallic housing parts 2, 3 are hermetically sealed in each other by methods such as cold pressure bonding or welding. The oscillator 1 is mounted on lead wires 4, 5 which are respectively electrically connected to two electrodes (not shown) of the oscillator 1. The lead wires 4, 5, extend through and are hermetically sealed in a glass member 7 of a bush 6, the glass member 7 also serving to provide electrical insulation between the lead wires 4, 5. The bush 6 is itself mounted in and is hermetically sealed (e.g. by brazing) in an aperture in the lower housing part 2.

The oscillator assembly shown in *Figure 1* has the following disadvantages:-

1. In order to ensure that the bush 6 is hermetically sealed in the lower housing part 2, it is necessary to provide a bush 6 of considerable axial length and this makes it difficult to make the oscillator assembly thin.

2. The oscillator 1 is connected to the lead wires 4, 5, only over very small areas so that it can easily happen that the oscillator 1 is not mounted in the correct plane and extends towards one or other of the housing parts 2, 3. This in turn means that it is necessary to provide a large housing to prevent accidental contact between a housing part and the oscillator 1, and this is another reason why the assembly of *Figure 1* cannot be made thin.

3. When the oscillator 1 is fixed to the lead wires 4, 5, distortion arises by reason of the difference in the thermal expansion coefficients of the parts, and

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this renders the assembly very liable to a shift in its frequency if it is subjected to external shock, e.g. as a result of a fall.

4. The number of parts of the assembly shown in Figure 1 is rather large, and its manufacturing cost is therefore high.

Another known quartz crystal oscillator assembly is shown in Figure 2 and in this case an oscillator 1a is disposed within a metallic cylindrical housing 8 having an integral closed end 8a. The oscillator 1a is mounted on lead wires 9, 10 which are respectively connected to two electrodes (not shown) of the oscillator 1a and which extend through a glass member 12. The glass member 12 is hermetically sealed within a bush 11, the bush 11 itself being hermetically sealed within the end of the housing 8 remote from the end 8a. The glass member 12 serves to insulate the lead wires 9, 10 from each other and to hermetically seal them within the bush 11. The hermetic sealing of the bush 11 and cylinder 8 may be effected by means of press-fitting, welding and other techniques.

The oscillator assembly shown in Figure 2 has the following disadvantages:-

1. If the external diameter of the metallic housing 8 were to be reduced, this would in turn require the thickness of the oscillator 1a to be reduced. It is not however practical to reduce the thickness of the oscillator 1a since this would lower its performance.

2. When the oscillator 1a is secured to the lead wires 9, 10, there is a considerable risk that the oscillator 1a will be secured to the lead wires in a position in which the oscillator 1a is not disposed perfectly axially of the housing 8. If this occurs, there is a severe risk that the ends of the tines of the oscillator 1a will contact the housing 8 and, in order to prevent this, it is necessary to make the latter large.

3. When the oscillator 1a is secured to the lead wires 9, 10, there is distortion due to the difference between the thermal expansion coefficients of these parts, thus rendering the assembly liable to a change of frequency if subjected to external shock.

In Figure 3 there is shown yet another known oscillator assembly having a quartz crystal oscillator 1b which is disposed within a hermetically sealed housing. The said housing comprises a lower housing part 13 constituted by a plate of ceramic material, an upper housing part 18 constituted by a glass plate, and intermediate housing parts 14, 15 each of which is constituted by a ceramic plate, the intermediate housing member 15 being hermetically sealed to the upper housing part 18 by a layer 15a of hermetic adhesive material. Mounted on the intermediate housing member 14 and disposed immediately beneath the intermediate housing member 15 are two spaced apart electrode films 16, 17 each of which is formed of electrically conductive paste, the films 16, 17 being respectively connected electrically to electrodes (not shown) on the oscillator 1b.

The oscillator assembly shown in Figure 3 has the following disadvantages:-

1. Since the housing has ceramic parts, it is difficult to secure the parts hermetically together if the assembly is made a thin one.

2. When the oscillator 1b is mounted on the films 16, 17, contact can occur between the oscillator 1b and the intermediate housing part 15, and the latter will not prevent the possibility of contact between the oscillator 1b and either the ceramic housing part 13 or the glass housing part 18. Consequently considerable space needs to be provided within the housing, and this prevents the latter from being made thin.

3. Because of the distortion which arises from the different thermal expansion coefficients of the quartz crystal oscillator 1b and the ceramic intermediate housing part 14, the frequency of the assembly is liable to shift if the assembly is subjected to an external shock, e.g. by reason of being dropped.

Figure 4 illustrates an embodiment of the present invention in which a plurality of oscillator assemblies are formed, each oscillator assembly comprising a quartz crystal oscillator 23, a plate-shaped quartz crystal lower housing part 24, and a plate-shaped upper housing part 25 which may be formed either of quartz or other piezo-electric crystalline material or may be formed of glass or metal. Each oscillator assembly has a recess 42 into which the respective oscillator 23 can oscillate. Each oscillator 23 is mounted on two spaced apart electrically conductive films 43, 44 which are provided on the respective lower housing part 24.

The oscillator assembly shown in Figure 5 may be made by photo-etching a strip of quartz crystal material to form a plurality of oscillators 23 which are interconnected by strip material 26. A strip of quartz crystal material is also photo-etched to form a plurality of lower housing parts 24 which are interconnected by strip material 27, the spacing of the lower housing parts 24 from each other corresponding to the spacing of the oscillator 23 from each other.

A strip of quartz crystal material (or if desired, metallic or glass material), is photo-etched to form a plurality of upper housing parts 25 interconnected by strip material 28, the spacing between adjacent upper housing parts 25 corresponding to that between lower housing parts 24.

The interconnected oscillators 23 are then placed above the interconnected lower housing parts 24, each oscillator 23 being mounted on a planar support portion 24a of a respective lower housing part 24. The oscillators 23 are then secured to the lower housing parts 24 by means of conductive adhesive material (not shown), the various oscillators 23 being simultaneously connected to the corresponding lower housing parts 24. The strip material 26 interconnecting the oscillators 23 is then cut away and the strip of interconnected upper housing parts 25 is placed in position, each upper housing part 25 being adhered and hermetically sealed at the same time to a corresponding lower housing part 24. Thus at this stage a plurality of interconnected hermetically sealed oscillator assemblies are formed in each of which there is disposed a respective oscillator 23. Finally, the strip material 27, 28 interconnecting the various assemblies is cut away so as to enable the assemblies to be separated from each other.

As will be appreciated, the method illustrated in Figure 4 involves the use of a row of oscillators 23 and thus enables the characteristics of all the oscillators of this row to be easily examined simultaneously.

The construction shown in Figure 4 has the following advantages.

1. The housing is made of materials such as quartz crystal glass and metallic plate which can be hermetically sealed and enable the oscillator assembly to be as thin as possible.

2. The oscillator is supported on a planar support portion and therefore is stably supported over a wide area. This in turn has the result that the oscillator is less likely to be inclined towards either the upper or the lower housing part and consequently the amount of free space which needs to be provided within the housing can be reduced, thus enabling the oscillator assembly to be made thin.

3. Especially in the case in which the housing is made by etching quartz crystal, glass or metallic sheet material, it is possible to prevent the quartz crystal oscillator from being displaced either horizontally or vertically and it is also possible to make the oscillator small and thin.

4. Since the thermal expansion coefficients of the quartz crystal oscillator is the same as that of the lower housing part, little distortion occurs at the time that they are fixed together. This enables an oscillator assembly of high reliability to be produced.

5. The number of the parts is small and the manufacturing cost is low.

6. It is easy to automate the manufacturing inspection and assembly and thereby lower manufacturing costs.

CLAIMS:

1. A method of making a plurality of oscillator assemblies comprising etching a strip of piezo-electric crystalline material to form a plurality of oscillators interconnected by strip material; etching a strip of piezo-electric crystalline material to form a plurality of first housing parts interconnected by strip material; etching a strip of piezo-electric crystalline or other material to form a plurality of second housing parts interconnected by strip material; securing each oscillator to a respective first housing part and thereafter removing the strip material interconnecting the oscillators; securing each second housing part to a respective first housing part to form a plurality of interconnected hermetically sealed assemblies in each of which there is disposed a respective oscillator; and removing the strip material between the assemblies so as to separate the latter from each other.

2. A method as claimed in claim 1 in which each first housing part has a recess into which the respective oscillator can oscillate.

3. A method as claimed in claim 1 or 2 in which each first housing part and the respective oscillator are made of the same material.

4. A method as claimed in claim 3 in which the material is quartz crystal material.

5. A method as claimed in any preceding claim in

which each oscillator is mounted on two spaced apart electrically conductive films which are provided on the respective first housing part.

6. A method of making a plurality of oscillator assemblies substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

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3. Especially in the case in which the housing is made by etching quartz crystal, glass or metallic sheet material, it is possible to prevent the quartz crystal oscillator from being displaced either horizontally or vertically and it is also possible to make the oscillator small and thin.
4. Since the thermal expansion coefficients of the quartz crystal oscillator is the same as that of the lower housing part, little distortion occurs at the time that they are fixed together. This enables an oscillator assembly of high reliability to be produced.
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3. A method as claimed in claim 1 or 2 in which each first housing part and the respective oscillator are made of the same material.
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