May 25, 1965 W. G. STODDARD ETAL 3,185,870

CRYSTAL CAGE ASSEMBLY

Filed Oct. 26, 1961

FIG. 1

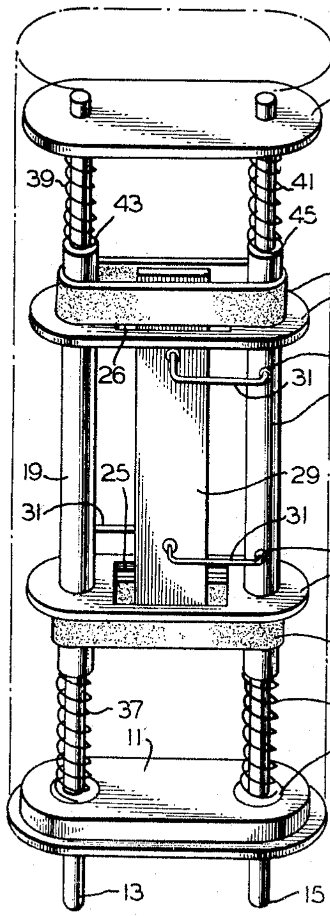


FIG. 2.

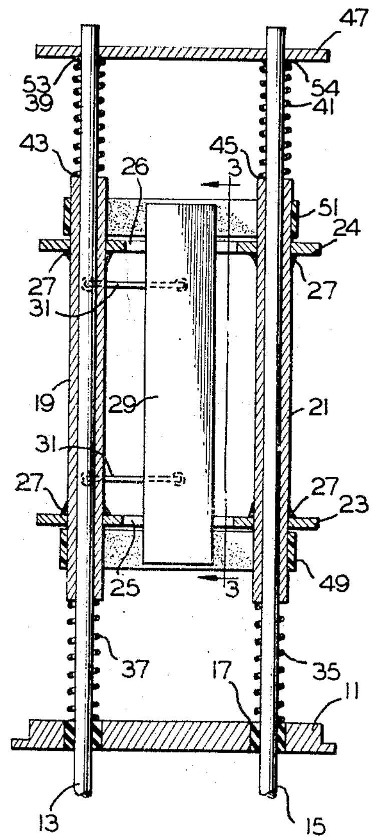
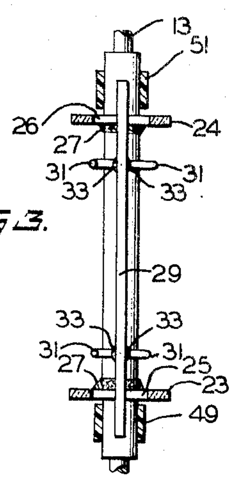


FIG. 3.



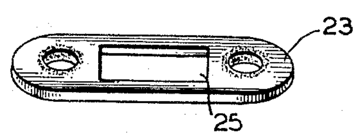


FIG. 4.

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United States Patent Office 3,185,870
Patented May 25, 1965

3,185,870
CRYSTAL CAGE ASSEMBLY
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Filed Oct. 26, 1961, Ser. No. 147,843
9 Claims. (Cl. 310—9.4)

This invention relates to mounting structures and more specifically to mounting structures for piezoelectric crystals.

Two major operational problems are encountered in the use of piezoelectric crystal units under modern conditions. Since these units are commonly used in high-speed aircraft and the like a problem always exists relative to the various shocks imposed upon the unit during such use. Additionally, high frequency vibration will also destroy the effectiveness of the crystal unit in a relatively short time. Many of the devices in use today are mounted in structures designed to eliminate one or the other of the above mentioned detriments and have proved to be effective in varying degrees. However, many of these cage assemblies are bulky, increasing the size and weight of the unit to the point where it is impractical to use, particularly if damage from both shock and vibration is to be reduced, in a single unit.

Accordingly, it is an object of this invention to provide a crystal mounting assembly which is ruggedized against the effects of shock.

A further object of this invention is to provide a crystal assembly which reduces the detrimental effects of vibration.

Another object of this invention is to provide a crystal assembly having a shock and vibration resistant mount.

Yet another object of this invention is to provide a crystal assembly which is resistant to shock and vibration and which is compact in size and relatively simple to assemble.

These and other objects of the invention will be apparent from the following description when taken in conjunction with the drawings wherein:

FIG. 1 is a perspective view of the structure embodying the principles of the present invention;

FIG. 2 is a sectional elevation view of the mounting structure of FIG. 1;

FIG. 3 is a partial sectional view taken along the lines 3—3 of FIG. 2; and

FIG. 4 is a perspective view of one of the spacer plates used in the crystal structure mounting.

Turning now more specifically to the drawings, a base unit **11**, which may consist of any rigid material, is provided with two grommets **17** of dielectric material through which the output leads **13** and **15** extend from below the base and upward therethrough. These wire leads, in effect, from dual substantially parallel posts extending upwardly to the top of the crystal mounting structure. In order to provide a floating type mount, tubes 43 and 45 are slidably positioned on the support members **13** and **15**. This tubing may be made of any good electrically conductive rigid material such as brass or the like.

Two rigid spacers **23** and **24** maintain the brass tubes in fixed positions relative to each other and give additional support to the structure as a whole. These spacers may be made of material which has a high mechanical rigidity and does not outgas such as high alumina ceramic, high beryllia ceramics or the like. The brass tubing passes through the outer portions of each of the spacers and the edges and walls of the spacer holes through which the tubing passes may be metallized by applying silver glass paste and firing at high temperature to produce the unit as shown in FIG. 4. This metallizing creates a strongly

bonded area to which solder readily adheres. This result could also be obtained by either active-metal or moly-managanese metallizing. Spacers **23** and **24** are also provided with substantially rectangular centrally located apertures **25** and **26**.

A flat piezoelectric crystal **29** such as a bimorph crystal or the like is mounted between the tubes **19** and **21** by means of flexible support wires **31** which are connected to the tubing by means of solder joint **33** or the like. The other ends of the flexible wires **31** are soldered or welded to the electrodes on either face of the crystal and support the crystal in the well-known cantilever fashion with the crystal **29** extending vertically through the apertures **25** and **26** in the spacer plates **23** and **24**.

In order to protect the crystal unit against extreme shock, thin plastic bands or belts **51** extend about the posts above the upper spacer plate **24** and below the lower spacer plate **23**. As may be seen, these belts encompass the end portions of the crystal plate and limit the movement of the crystal when the unit is subjected to shock and additionally prevent the crystal from coming into contact with the spacer plates which would change the crystal frequency and activity. The bumpers also restrict the crystal movement caused by low frequency vibration, thus preventing excess strain on the wires **31** and the soldered or welded connections **33**. Belts **51** may be made of any flexible plastic material which does not outgas in vacuum or react unfavorably in an inert gas atmosphere. One such material is the plastic material having the trade name Teflon, since this material does not outgas in a vacuum and is mechanically stable under varying temperature conditions.

The mounting structure discussed above greatly reduces the effects of shock on the crystal and also reduces low frequency high acceleration vibration damage. Test results show that the use of the plastic belt as a bumper provides cage assemblies which can stand a shock of more than 100 g's of 6 milliseconds' duration with a rejection rate of under 5%. The same tests show that standard units not using the bumper have a higher rejection rate due to the same shock testing procedures.

As mentioned above, a further detrimental effect is that which occurs due to high frequency vibrations. Vibration tests indicate that only the end vibrational plane is detrimental to the performance of this type of crystal unit. The end vibrational plane consists of vibrating the crystal in a direction parallel to the longitudinal axis of the base straights.

In order to greatly improve the resistance of the crystal to this detrimental end vibrational effect the unit is further provided with a floating action mount. To provide this floating action, a stand-off spring retainer **47** is secured between the upper ends of the posts **13** and **15** and is composed of a rigid electrically non-conductive material. Coil springs **39** and **41** are then soldered or welded at either end to the spring retainer **47** and to the tops of the brass tubing 43 and **45**. This arrangement assures positive electrical connection between the posts and the brass tube, thus eliminating microphonics during vibration. Although the upper springs **39** and **41** give the desired electrical connections and provide a good floating action for the basic crystal mount, additional spring members **35** and **37** may be placed between the lower ends of the tubing and the base member **17** to provide additional vibrational protection.

Test results have shown that this floating mount arrangement has the ability to withstand high aceleration, high frequency vibration and extreme shock with a minimum of damage. Under tests of high frequency vibration, standard units reach a resonant frequency and fail catastrophically in a few seconds. However, under similar tests the floating mount unit of the present invention may be vibrated at its resonant frequency for over 3 minutes before failure.

It is to be noted that the plastic bumpers may be used singly on any type crystal unit which is mounted on wire leads between uprights and may be used in any type of enclosure in any type of atmosphere. Likewise, if the only concern is protection of a particular unit against vibrational effects, the floating mount feature could be used singly without the plastic bumpers and is applicable to any type of crystal mount. However, when both shock and high frequency vibration are to be encountered, these two features may be used together as illustrated in the drawings.

Accordingly, the enclosed description and drawings are intended to be illustrative only and not a limitation on the scope of the invention as set forth in the following claims.

We claim:

1. A crystal cage assembly comprising a base, a plurality of substantially parallel support members extending upwardly from said base, a rigid plate secured to the free ends of said support members and extending therebetween, a sleeve on each of said support members between said base and said plate, said sleeves being slidable on said support members, a coil spring on each of said support members between said sleeves and said plate, said springs being secured at one end thereof to said plate and at the other end thereof to said sleeves, first and second substantially parallel rigid spacers mounted between said sleeves at opposite ends thereof, each of said spacers having centrally located apertures therethrough, a piezoelectric crystal element extending through said apertures, a plurality of wires each attached at their base ends to said sleeves and connected at their other ends to respective ones of spaced points on said crystal element to support it in cantilever fashion, a plurality of flexible continuous dielectric belts substantially adjacent to each of said spacers and extending between said sleeves, each of said belts encompassing a portion of said crystal element.

2. The apparatus of claim 1 further comprising a coil spring mounted on each of said support members between said base and the lower end of said sleeves.

3. A crystal cage assembly comprising a base, supporting means extending upwardly from said base, a rigid supporting structure slidably mounted on said supporting means, a piezoelectric crystal element mounted within said supporting structure, and resilient means secured between said supporting structure and said base for controlling the degree of movement of said supporting structure.

4. The apparatus of claim 3 further comprising continuous flexible dielectric means carried by said supporting structure for encompassing a portion of said crystal.

5. The apparatus of claim 3 wherein said resilient means comprises spring members secured between said base and said supporting structure wherein the degree of sliding movement of said structure along said supporting means is dependent upon the resiliency of the spring members.

6. A crystal unit comprising a rigid structure including substantially parallel tubular members, a piezoelectric crystal element supported by wire leads in cantilever fashion between said members, at least one continuous flexible belt extending between said members and encompassing a portion of said crystal element, a base, upright members extending from said base and through said tubular members, retaining means mounted on said upright members at the upper ends thereof, and resilient means for supporting said rigid structure above said base.

7. The apparatus of claim 6 wherein said resilient means comprises coil springs mounted on said upright members between said retaining means and said rigid structure.

8. A crystal unit comprising a rigid structure including substantially parallel tubular members, a piezoelectric crystal element supported by wire leads in cantilever fashion between said members, a base, upright members extending from said base and through said tubular members, retaining means mounted on said upright members at the upper end thereof and resilient means for supporting said rigid structure above said base.

9. The apparatus of claim 8 wherein said resilient means comprises coil springs mounted on said upright members between said retaining means and said rigid structure.

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