Sept. 18, 1962 W. G. SIELAFF 3,054,380

MOUNTING FOR ULTRASONIC RESONATOR ROD

Filed May 29, 1961

Fig. 1.

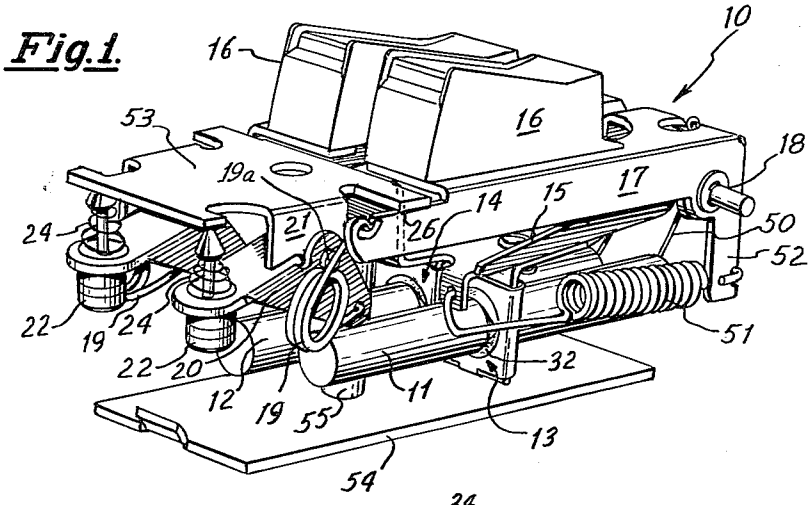
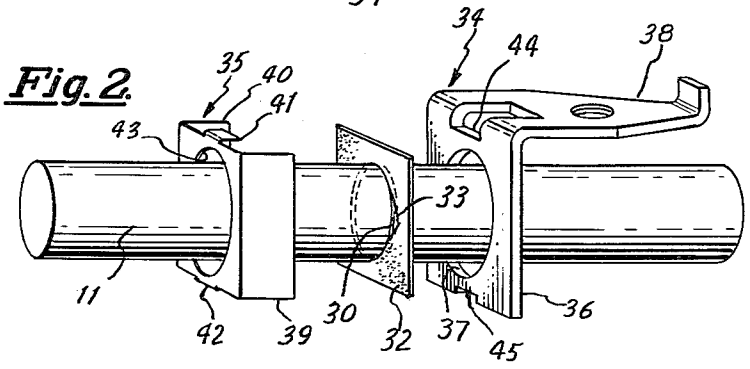


Fig. 2.



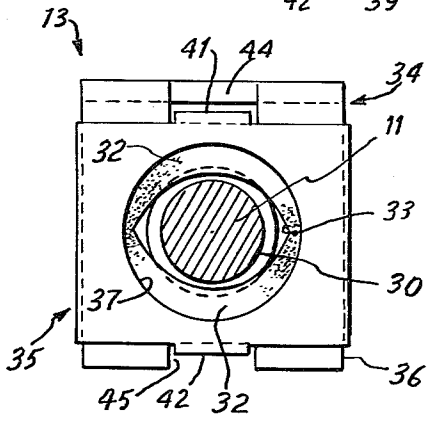


Fig. 3.

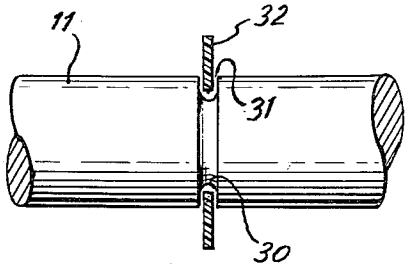


Fig. 4.

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MOUNTING FOR ULTRASONIC RESONATOR ROD

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6 Claims. (Cl. 116—137)

The present invention relates ot an ultrasonic resonator rod and a special mounting therefor.

Prior to this invention, resonator rods of the type commonly employed in signal generating units for remote control systems were generally mounted to their housings by resilient wire segments that clamped the rods at their midpoints. Two such mountings are set forth in the patent to Ole E. Wold entitled "Ultrasonic Generator," Patent No. 2,821,956, in which a similar longitudinal-mode ultrasonic resonator rod is employed.

Like Wold, the present invention employs a hammer that impinges sharply on one end of such a rod to excite the rod and generate an ultrasonic frequency wave. The frequency of the emitted wave is determined by the length of the resonator rod, the speed of sound in the resonating material, and the general physical configuration of the rod. A vibrational node appears at the center of the rod, and the oscillatory amplitudes at surfaces of the rod adjacent its center are less than elsewhere in the rod. Thus, a mounting which supports the rod at or near its longitudinal center will absorb a minimum of vibrational energy from the rod and dampen the resonant vibrations less severely than a mounting at any other position along the rod. To prevent significant translational movement of the rod following strike, the center supports of Wold and the present invention are received in grooves or notches in the rod.

In Wold and other mounts of the prior art the mounting elements resiliently clamp the rod and extract small portions of vibrational energy from the rod during each vibrational cycle. However, as will be described in greater detail, the present invention provides a mount that contacts the rod but a small proportion of the time during vibration. The rod is essentially "free-floating," and vibrational damping is considerably reduced. The signal receiving apparatus used in conjunction with the transmitting rod does not have to be designed to such great sensitivity as formerly. Signals initiated to change an operational condition in the receiving apparatus may be more reliably distinguished from extraneous noise occurring in the same frequency band.

Therefore, it is an object of this invention to provide a mounting for an ultrasonic resonator rod that will dampen vibrations within the rod to a lesser degree than prior mounts.

Another object of the present invention is to provide cooperating configurations for a resonator rod of the type herein described and its mount that will provide minimal contact between rod and mount and permit prolonged high vibrational intensity within the rod.

A further object of the present invention is to provide a durable, economical mount for a resonator rod that will insure positional stability of the rod while providing minimal damping.

An additional object of this invention is to provide resonator rod holding means which provide positive support for the rod and high resistance to shock damage from dropping or the like.

A still further object of the present invention is to provide an ultrasonic generator with a substantially "free-floating" resonator element.

Other and further advantages and objects of the present invention will become apparent from examination of the detailed disclosure and drawings and from a reading of the claims.

A preferred embodiment of this invention is illustrated by the accompanying drawings in which:

FIG. 1 is a perspective view of an ultrasonic resonator chassis incorporating the present invention.

FIG. 2 is an enlarged exploded perspective showing the elements of the rod mount in pre-assembled positions.

FIG. 3 is a further enlarged cross-section perpendicular to the rod axis at its midpoint, showing the assembled mount and rod.

FIG. 4 is a fragmentary view of the rod and adjacent portions of the mount with the mount portions shown in vertical section along the longitudinal center plane of the rod.

The structural and operational association of the components that provide the rod-striking action to be described are clearly illustrated in a copending U.S. application, Serial No. 81,382 of James E. Vistain, and will not be described in extreme detail herein, because they are not of the essence of the present invention. Although the illustrations in Serial No. 81,382 are somewhat schematic as compared with FIGURE 1 of the present application, the detailed description is in every way applicable to the physical striking apparatus disclosed in the present application.

Referring now to the drawings, in which like elements are designated by like reference numbers, an ultrasonic generator chassis **10** (FIG. 1) is provided with two longitudinal mode resonator rods **11** and **12** centrally mounted through identical mounting assemblies **13** and **14** to a common support plate **15**. A push button **16** is provided for manual operation of a first lever **17** which is pivoted at **18** on the chassis **10**. One leg **19***a* of a torison spring **19** is received in the free end of the lever **17**, and a second triangular shaped lever **20** is adapted to receive the other leg of the spring **19**. The triangular shaped lever **20** is normally urged against a flange **21** by the spring **19**, and is provided with a hammer **22** mounted thereto through a spring **24**. The levers **17** and **20** are so situated as to provide the following action as the first lever is manually depressed:

Energy is stored in the torsion spring **19** until it passes over center. Then, spring **19** acts to accelerate the second lever **20** and its hammer **22** toward the adjacent end of the rod **11**. Before the hammer **22** can strike the rod, the lever **20** strikes a flange **26**. The flange **26** extends laterally from a supporting top plate **53** to overlie the triangular shaped lever **20** and provide a terminus for the counterclockwise movement of the triangular shaped lever **20** as viewed in FIGURE 1. The hammer **22** is carried forward by its momentum against the bias of its mounting spring **24** to impinge upon the end of the rod **11**. Upon rebounding from the rod **11** the hammer **22** is held from further re-strike by the spring **24**. A compressional wave passes through the rod **11** and is reflected and re-reflected to provide a standing wave of given preselected frequency within the rod **11**. The fundamental frequency of the wave is the resonant frequency of the rod **11** as determined primarily by its length, its other physical dimensions, and the material properties of the rod. All even harmonics are quickly suppressed by the center support, and all high odd harmonics are quickly attenuated by internal damping within the rod. However, the fundamental frequency persists, minimally attenuated by the novel configuration of the mount to be described.

The rod is provided with an annular groove **31** at its center section. The annular groove **31** has a rounded root **30** and is adapted to receive a vertical diaphragm member **32** of nylon, plastic, fish paper, woven fabric, metal, or other material. Nylon or similar resilient plastic materials have been found preferable for this use. The diaphragm **32** is rectangular in shape with a symmetrical, eye-shaped hole **33** therein for receiving the rod.

The major axis of the hole **33**, as viewed in FIGURE 3, is its maximum horizontal dimension and is greater than the diameter of the rod **11**. The minor axis of the hole **33**, as viewed in FIGURE 3, is its maximum vertical dimension and is less than the diameter of the rod **11**. As best seen in FIGS. 3 and 4, the eye-shaped hole **33** is of sufficient cross-sectional dimension to provide slight clearances from the root **30** of the annular groove **31**. The thickness of the diaphragm **32** is slightly less than the width of the groove **31** in which it is disposed, thereby providing longitudinal clearance as well. The diaphragm **32** is clamped between two metal flange members **34** and **35**. The first of these flange members **34** is substantially L-shaped, having a vertical rectangular leg **36** that is provided with a circular hole **37** substantially greater in diameter than the rod **11**, and an upper, horizontal leg **38** that is secured to the support plate **15**. The second of the flange members **35** is of thin, easily bendable sheet metal. It is provided with two side flanges **39** and **40** adapted to straddle the rectangular leg **36** of the first flange member **34** and be bent therearound. Smaller top and bottom flanges **41** and **42** overlap leg **36** to retain the diaphragm vertically in position. The second flange member **35** is provided with a circular hole **43** of equal diameter and matching disposition with hole **37**.

Referring now, in particular, to FIG. 2, assembly of the mounting elements onto the rod **11** begins with the diaphragm **32**. The narrow, vertical axis of the eye-shaped hole **33** is shorter than the rod diameter, but when the flexible diaphragm **32** is vertically bowed and forced against the rod end as by urging its top and bottom edges toward one another and twisting the diaphragm against the rod, the hole **33** may be opened sufficiently to fit over the rod. The diaphragm is then slid along the rod to the center groove position where it is permitted to resiliently return to its planar configuration and engage the groove. The sturdy first clamping flange member **34** is then inserted over one end of the rod **11**, while the thin second clamping flange member **35** is inserted over the other end of rod **11**. The clamping flange members are brought together to sandwich the diaphragm **32** therebetween, and flanges **39** and **40** are tightly bent around the opposing rectangular leg **36** of the first flange members **34**. The small flanges **41** and **42** protrude into cooperating notches **44** and **45** in the vertical leg **36** to restrain the diaphragm **32** and second clamping flange member **35** against vertical displacement. Thus, the diaphragm **32** is held in position to space the rod from the metal clamping flange members.

It should be noted that the edge of the eye-shaped diaphragm hole **33** is square (see FIG. 4) and that it does not fit snugly within the curved root annular groove **31**. The amount of clearance between the diaphragm and the rod is critical. If this clearance is too small, the result will be unduly high vibrational damping, while if the clearance is too great, positional stability of the rod in its mount will be sacrificed. The clearances between the vertical surfaces of the diaphragm **32** and the adjacent vertical surfaces of the groove **31** should be greater than the peak oscillatory amplitude at these surfaces in the expansional phase of rod vibration. Likewise, the clearances between the horizontal edges of the diaphragm hole **33** and the adjacent portions of the annular groove root **30** should be greater than the peak oscillatory amplitude at these surfaces due to the Poisson ratio effect. If these clearances are not ample, vibrational energy is lost each time the oscillations reach an expansional peak of motion, or once every cycle. However, with adequate clearance, the rod is permitted to bounce or "dance" on its supports and actually be airborne or "floating" a great majority of the time. Due to the high frequency of vibration in the rod, approximately 40,000 vibrations per second, vibrational acceleration of the rod surfaces reaches values much greater than the acceleration of gravity. Thus, upon excitation of the rod by the hammer **22** and initiation of vibration therein, the rod will thrust itself upward a slight distance off of its support, drop back due to gravity, quickly rebound upwardly, and continue to bounce in this fashion so long as vibrations of sufficient energy level continue within the rod. This bounce occurs very rapidly, but nevertheless only once every several hundred vibrations. Therefore, energy is extracted from the rod by the mount during but a small fraction of the cycles of vibration. Depending on the amplitudes of vibration and physical dimensions of parts employed, the clearances referred to above may be in the nature of .001 inch to .005 inch, and considerable experimentation is required to arrive at the optimum clearances for maximum vibrational response. As can be readily seen, the configurations of mount and rod groove described above provide a minimum of surface area contact without creating any possible wedging between diaphragm and groove. It is desirable to maintain the angle of contact of diaphragm and groove near horizontal to minimize the wedging effect and the lateral bounce that would occur from the greater amplitude of the longitudinal oscillations.

In addition to providing prolonged duration of high amplitude oscillations, the mount of the present invention is durable, long-lived, and economical. The eye-shaped hole facilitates assembly, provides minimal contact area between rod and diaphragm, and functions well in any position of the hand generator.

The signal thus generated is damped when the button **16** is released by a damping wire **50** that pivots with the lever **17** out of contact with the front edge of the rod **11** during strike, but normally rests against said front end. A return spring **51** is attached to a downwardly extending portion **52** of lever **17** to return the mechanisms to their rest positions. When button **16** is released, lever **17** comes to rest against the flange **26**, toggle spring **19** is carried back over center and lever **20** comes to rest against flange **21**. The chassis **10** is adapted to be mounted in a plastic case, not shown, which is fastened by screws or other means to a top plate **53** and a bottom plate **54** which is spaced from top plate **53** by a post **55**.

The annular groove is preferred, but other shaped mounting grooves are also contemplated, such as an opposite pair of partial grooves similar to those of Wold in Patent No. 2,821,956.

Alternatively, the diaphragm may be mounted between the flanges at right angles to the position shown in the drawings, i.e. with the eye-shaped opening vertical instead of horizontal. The actuator of the present invention is designed to be effectively useable in whatever position the operating individual may choose to hold the generator. While the preferred mounting is illustrated and described in detail above, the rod will float freely, or relatively so, in any position the actuator assumes.

It is obvious that numerous other modifications and alterations not specifically mentioned in the preceding disclosure could be employed without departing from the spirit and scope of this invention, but it is not intended to limit the scope of the appended claims by the omission from this disclosure of such modifications and alterations.

Therefore, what is claimed is:

1. In combination with a longitudinal mode resonator rod adapted for vibration at a predetermined frequency responsive to impact by a hammer, said rod having a generally cylindrical shape and having an annular groove centrally disposed thereabout; a mounting for said rod comprising flexible sheet material means forming a generally elliptical opening with the major dimension of said opening being greater than the diameter of said rod and the minor dimension of said opening being smaller than the diameter of said rod; said sheet material means being deformable to allow positioning thereof in said annular groove; and means clamping said sheet material means whereby a substantially rigid support for said rod is obtained.

2. A mounting for a cylindrical resonator rod having a transversely oriented groove midway between its ends; said mounting comprising a thin sheet of flexible material forming an arcuate opening; said rod being received in said opening in the transverse plane of said groove, said opening having a minor axis which is smaller than the diameter of said rod but greater than the diameter of said rod at its grooved section; means clamping said sheet of flexible material over a substantial portion of its surface to impart rigidity thereto whereby said rod is free to move in a direction parallel to the plane of said sheet of flexible material but is restrained from substantial movement in a direction transverse to the plane of said sheet of flexible material.

3. A mounting as set forth in claim 2 wherein the thickness of said groove exceeds the thickness of said sheet of flexible material by a predetermined amount, said predetermined amount being greater than the peak oscillatory amplitude of the central portion of the rod.

4. A mounting as set forth in claim 3 wherein said sheet of flexible material comprises nylon.

5. In combination with a compressional wave generator including a longitudinal mode resonator rod having an annular groove at a predetermined nodal point, support means, a hammer for percussive engagement with one end of said rod, means mounted to said support means carrying said hammer into and out of engagement with said one end of said rod, exciter means operatively coupled to the means carrying said hammer, and means mounting said rod to said support means, said last-mentioned means including; a diaphragm of thin flexible material forming an eye shaped hole having major and minor dimensions, said major dimension being greater than the outside dimension of said rod and said minor dimension being greater than the inside dimension of said annular groove; said diaphragm being deformable to allow said rod to be slipped therethrough whereby said eye shaped hole engages said rod at said annular groove; and clamping means mounted on said support means, said clamping means clamping said diaphragm over a major portion of its surface to impart substantial rigidity to said diaphragm and consequent high resistance to translational movement of said rod.

6. In a mechanical resonator of the type for generating compressional waves of predetermined frequency including support means, a cylindrical, longitudinal mode resonator rod having an annular groove midway between its ends, mounting means mounting said resonator rod to said support means at said annular groove, and hammer means percussively engaging one end of said rod responsive to manual actuation of exciter means, the improvement in said mounting means comprising; a thin flexible diaphragm forming an aperture having two arcuately shaped portions, said diaphragm being deformable and receiving said rod in said aperture such that the edges of said arcuately shaped portions nest in said annular groove; the maximum distance between said arcuately shaped portions being less than the diameter of said rod, but greater than the diameter of said rod at its grooved section; and a pair of clamping members clamping said diaphragm therebetween over a major portion of the diaphragm surface whereby substantial rigidity is imparted to said diaphragm and said rod is restrained from substantial movement transversely of the plane of said diaphragm.

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