Dec. 25, 1956 H. SUSSMAN 2,775,749

MASS-LOADED RING VIBRATOR

Filed April 1, 1953

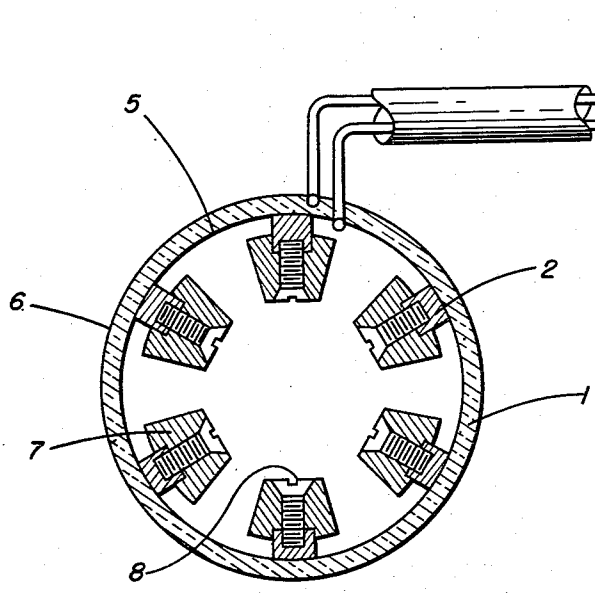


FIG. 1

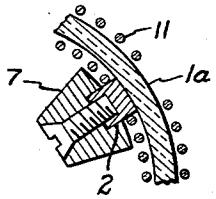


FIG. 3

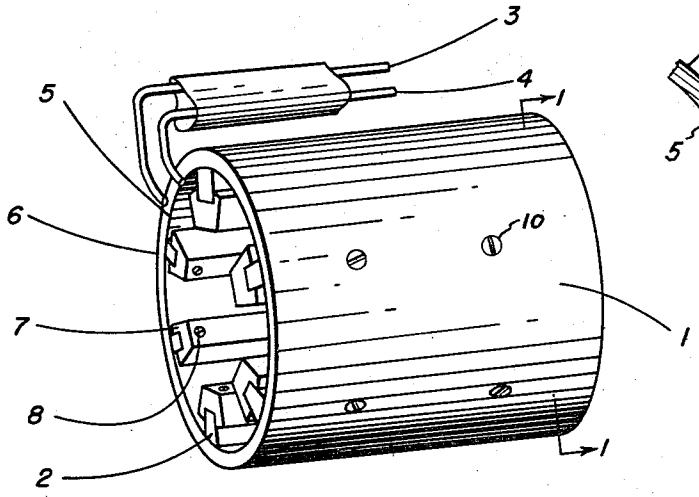


FIG. 2

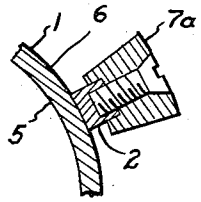


FIG. 4

INVENTOR.
HARRY SUSSMAN
BY George Sipkin
ATTORNEY

United States Patent Office 2,775,749
Patented Dec. 25, 1956

2,775,749

MASS-LOADED RING VIBRATOR

Harry Sussman, Waterford, Conn.

Application April 1, 1953, Serial No. 346,293

13 Claims. (Cl. 340—8)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of American for governmental purposes without the payment of any royalties thereon or therefor.

This invention concerns a mass-loaded ring vibrator. In particular the invention concerns a vibrator that can be used in the resonant range as a receiver or as a transmitter of airborne or underwater sound.

The resonant frequency of a ring vibrator is determined by the dimensions and the elastic properties of the ring. The fundamental resonant frequency is proportional to the ratio of the stiffness to the mass and, therefore, to its average diameter. Increasing the radial thickness of the ring increases its mass but also increases its stiffness in approximately the same ratio so that its fundamental radial resonant frequency changes very little. As a result of this situation, rings which are resonant in the lower portion of the audio-frequency range are very large in diameter.

In the prior art it is known that the resonant frequency of a magnetostrictive ring may be lowered by cutting a very large number of radial slots or tooth-shaped protuberances uniformly around the ring in such a manner that the mass of the ring is increased without any essential increase in its elasticity. By resort to the above expedient the mass of the ring is increased but the elasticity is not significantly changed.

The present invention marks an advance from the prior art by providing a mass-loaded ring having a relatively few radial protuberances that increase the mass and decrease the effective stiffness of the ring. The protuberances are preferably detachable from the ring. The protuberances are of a preselected size and weight to regulate the resonant frequency of the ring. In this manner a structure of given size can be made to resonate at a much lower frequency than the fundamental resonance of an equivalent simple ring. The resonant frequency can be changed by detaching one set of protuberances or by attaching a set of added weights.

In the vibrator of this invention the mass may be increased while the elasticity is decreased thereby achieving lower frequences for the same sized structure. Whereas the aforementioned prior art is limited to magnetostrictive laminations, the vibrator improvement of this invention is adaptable to magnetostrictive laminations, piezoelectric rings, and electrostrictive rings. In the prior art only a single resonant frequency is achieved by a given resonator, but in the vibrator of this invention the resonant frequency can be changed by a change in the number of and/or the size of the protuberances.

An object of this invention is to provide a mass-loaded ring vibrator.

Another object is to provide a vibrator ring and means which increase the mass and decrease the effective stiffness of the ring.

Another object is to provide a ring and means for varying the fundamental resonant frequency of the ring.

Another object is to provide a ring that can be made

of piezoelectric, electrostrictive, or magnetostrictive material and means for increasing the mass and decreasing the effective stiffness of the ring and for varying the fundamental resonant frequency of the ring.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a cross-sectional view taken along line 1—1 of Fig. 2 of a preferred embodiment of the invention including a ring piezoelectric or electrostrictive material.

Fig. 2 is a perspective view of the preferred embodiment shown in Fig. 1.

Fig. 3 is a fragmentary sectional view showing a modification of the invention including a ring of magnetostrictive material and an electrical coil therefor, and

Fig. 4 is a fragmentary sectional view of a modification of the invention shown in Fig. 1.

The active element shown in Fig. 1 is either a piezoelectric ring **1** or a polarized electrostrictive barium titanate ring **1**. Six narrow metal protuberances **2** are evenly spaced and detachably fastened by screws **10** or the like to the inner surface of ring **1**. Ring **1** is excited into resonant vibration by an alternating current of the proper frequency. This current is fed into terminals **3** and **4**, which are connected to an inner electrode **5** and an outer electrode **6**. Each of electrodes **5**, **6** is a layer of silver-conducting paint baked to the inner and outer surfaces of ring **1**. The resonant frequency of the mass-loaded ring is lower than that of ring **1** alone because of the added mass of the protuberances **2** and the lower effective stiffness of the mass-loaded ring **1** due to some bending vibration, which is a result of the small number of added discrete masses. The resonant frequency may be changed by sliding six additional keyed weights **7** onto the protuberances **2** and fastening these by means of screws **8**. For use under water, electrical insulation and protection against corrosion (not shown) are provided.

In Fig. 3 there is shown a modification of this invention differing from the form shown in Figs. 1 and 2 in that it includes a magnetostrictive ring **1***a* and a toroidal coil **11**.

In Fig. 4 there is shown a modification of this invention wherein the protuberances **2** and the weights **7** are disposed on the outside of ring **1**.

In this invention, a relatively small number of protuberances **2** that are uniformly spaced, are attached on the inside and/or outside of ring **1**. The protuberances **2** may be detachable, permanently fastened, or an integral part of the ring **1**. The ring **1** may be of magnetostrictive, piezoelectric, or polarized electrostrictive material such as barium titanate. In the case of the magnetostrictive ring **1***a* acting as a sound transmitter, an alternating current in toroidal winding **11** excites the structure into vibration. When the magnetostrictive structure is used as a sound receiver, a voltage is generated in the toroidal winding as a result of the resonant vibration produced in the structure by sound waves. For the piezoelectric and the electrostrictive materials, the curved inner and outer surfaces of the ring **1** are covered with electrodes **5**, **6** suitable for driving the structure as a generator or for collecting the generated electric charges when the unit acts as a sound receiver.

The embodiments described provide for changing the resonant frequency of the device by changing the attached weights **7**. If only a single resonant frequency is desired, this provision can be omitted. In that case, it is also possible to make the ring **1** and its protuberances **2** in one piece. The number of weights **7**, the method of attachment, and their location may be varied in several different ways.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A mass-loaded ring vibrator, said vibrator comprising a ring of transducing material adapted for reversibly converting energy which is quantitatively characterized by flux density into energy of mechanical vibration, and a small number of separate narrow radial protuberances detachably fastened to said ring.

2. The vibrator defined in claim 1 in which said material is piezoelectric material.

3. The vibrator defined in claim 1 in which said material is electrostrictive material.

4. The vibrator defined in claim 1 in which said material is magnetostrictive material.

5. The vibrator defined in claim 1 in which said protuberances are inside said ring.

6. The vibrator defined in claim 1 in which said protuberances are outside said ring.

7. The vibrator defined in claim 1 in which said protuberances are made of metal.

8. The vibrator defined in claim 1 in combination with additional weights fastened radially onto said protuberances.

9. A mass-loaded ring vibrator, said vibrator comprising a ring, said ring being made of piezoelectric material, and a pair of electrodes formed one on the inside and one on the outside of said ring, and a small number of separate narrow radial protuberances fastened to said ring.

10. The vibrator defined in claim 9 in which said electrodes are made of silver.

11. A mass-loaded ring vibrator, said vibrator comprising a ring, said ring being made of electrostrictive material, a pair of electrodes formed one on the inside and one on the outside of said ring, and a small number of separate narrow radial protuberances fastened to said ring.

12. The vibrator defined in claim 11 in which said electrodes are made of silver.

13. A mass-loaded ring vibrator, said vibrator comprising a ring, said ring being made of magnetostrictive material, a toroidal winding on said ring, and a small number of separate narrow radial protuberances fastened to said ring.

References Cited in the file of this patent

UNITED STATES PATENTS

1,882,398	Pierce	Oct. 11, 1932
2,521,136	Thuras	Sept. 5, 1950