Feb. 17, 1931. A. C. KELLER ET AL 1,792,497

VIBRATION DAMPING DEVICE

Filed May 14, 1927

FIG. 1.

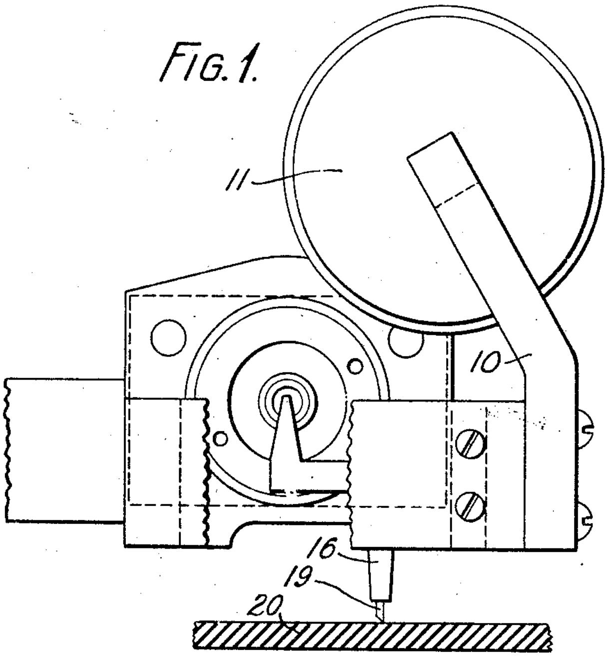


FIG. 2.

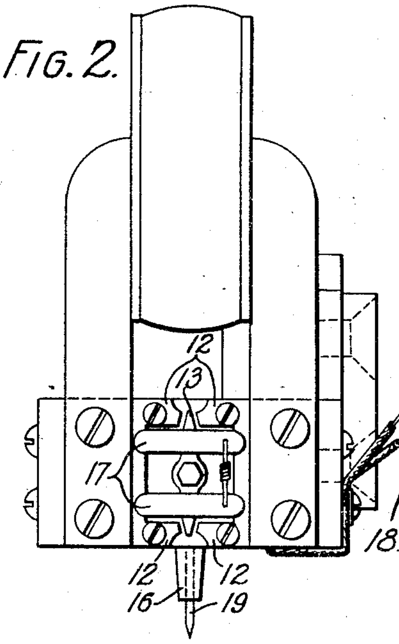


FIG. 3.

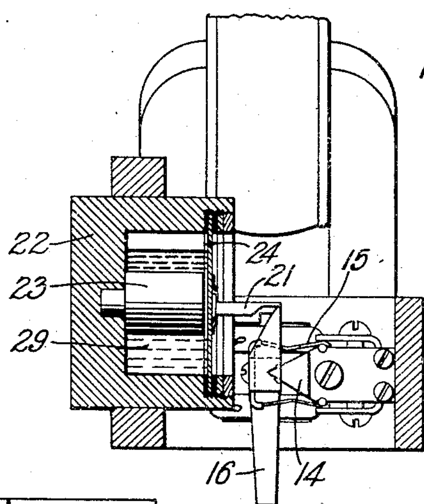


FIG. 5.

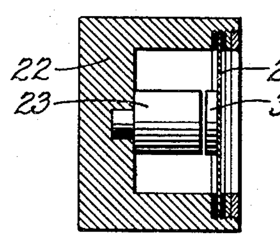
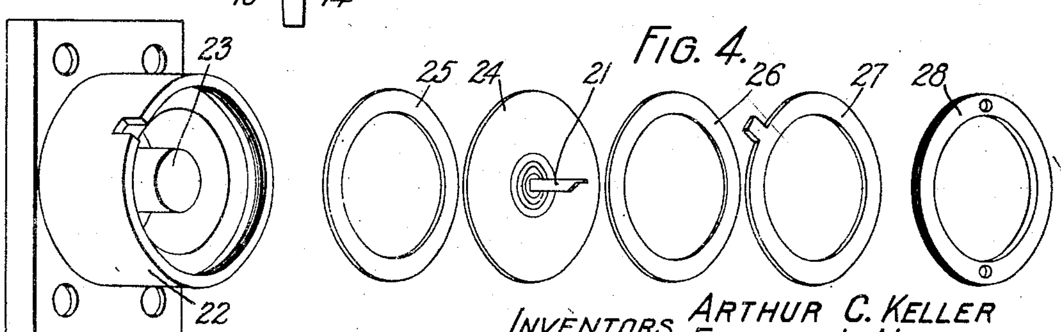


FIG. 4.



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UNITED STATES PATENT OFFICE

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VIBRATION-DAMPING DEVICE

Application filed May 14, 1927. Serial No. 191,527.

This invention relates to damping devices and more particularly to a device for damping mechanical vibrations, such for example as occur in electro-mechanical translating devices adapted to respond to all frequencies within the audible range.

The object of the invention is to provide a unitary damping means having a substantially straight line response characteristic over a wide band of frequencies regardless of normal temperature changes.

In accordance with the features of this invention, there is provided a structure comprising two relatively movable flat parallel surfaces located in a chamber filled or substantially filled with a viscous material which is displaced laterally of the flat surfaces in response to reciprocal movement between them.

The viscous material is one which is comparatively insensitive to normal temperature changes and the other materials of the unit are so chosen with respect to their temperature coefficients that they will compensate for any change in viscosity that may occur.

In the drawings in which the invention is illustrated as applied to an electromagnetic recorder or reproducer of sound waves:

Fig. 1 is a view in side elevation with parts broken away of an electromagnet system with the device of this invention applied thereto;

Fig. 2 is a view in front elevation of the parts shown in Fig. 1;

Fig. 3 is sectional view of the parts illustrated in Fig. 2;

Fig. 4 is an exploded view of the device with the various elements shown in perspective; and

Fig. 5 is a detailed cross-sectional view of a modified unit of this invention.

Referring particularly to Figs. 1 to 4 there is shown an electromagnetic phonograph recorder or reproducer having an electromagnet 10 energized by a winding 11. Secured to the magnet are pole pieces 12 between which is mounted an armature 13. The armature is provided with a notch and is pivoted on a knife edge 14 being held in place by a spring 15. Attached to the armature is a stylus holder 16. A pair of windings 17 are mounted coaxially with the armature and arranged to be connected to a suitable electrical circuit by means of the leads 18. The downward projecting end of the stylus holder 16 is provided with a socket in which is mounted a phonograph stylus 19 which engages the record 20. The opposite end of the stylus bar is connected to the damping device of this invention by means of the short metallic bar 21.

The damping device comprises a cylindrical chamber 22 rigidly mounted with respect to the magnet 10. In the center of the chamber there is mounted a post member 23, the face of which is in close space relation to the flexible metallic diaphragm 24. This diaphragm closes the opening of the chamber and is rigidly attached to the bar 21 so that it is moved by vibrations of the armature 13 and stylus bar 16. As shown in Fig. 4, washers 25, 26 and 27 and a clamping ring 28 are provided so that the diaphragm 24 may be mounted in the chamber opening in such a way as to completely seal the chamber. Before the chamber is closed it is filled with a viscous liquid 29, preferably a mixture of about 75% polymerized castor-oil and 25% nitro-benzol, which has a viscosity of the order of 2 dyne-seconds per square centimeter. The vibration of the diaphragm displaces the oil from between it and the post member 23. The result is that the diaphragm has a mechanical impedance to motion which is substantially constant and a substantially pure resistance over a wide range of frequencies.

In order to compensate for changes in the viscosity of the oil produced by changes in temperature, the center post 23 is constructed of a material with a comparatively high linear expansion coefficient and the chamber 22 is constructed of a material with a comparatively low linear expansion coefficient and the length of the post is made such that the changes in the length of the gap with temperature will be such as to compensate with the corresponding changes in the viscosity of the oil.

Fig. 5 shows a modification of the damping unit in which a metallic plate 30 is mounted on the inner surface of the diaphragm so that the surfaces forming the gap will always be in substantial parallel relation. For most purposes the arrangement shown in the other figures is satisfactory as the variation from a parallel relation will not be sufficient to materially affect the mechanical impedance characteristic.

In many systems the values of the mass and stiffness are known and from the required degree of damping the value of resistance required can be determined. It has been found that the mechanical resistance which will be added by the use of the unit of this invention is given by the expression:

$$R=\frac{3a^2\mu A}{2d^3}$$

in which a is the radius and A the area of the parallel surfaces (i. e., in the device shown of the post number), d the separation of the surfaces, and μ the viscosity of the viscous material. This expression is based on the assumption that the surfaces are circular and for other shapes a will be an effective value.

In order that the mechanical impedance of the unit be kept a substantially pure resistance, the following limitation is set on the choice of these dimensions:

$$d>\frac{2a}{0.7}\sqrt{\frac{6\pi\mu f}{E}}$$

E being the bulk modulus of the viscous material and f being the frequency which in the case of a band of frequencies is the upper limiting frequency. For values of d below this value a stiffness reaction will be introduced.

Also if the length of the gap is greater than that given by the expression

$$d=\sqrt{\frac{10\mu}{2\pi f\rho}}$$

ρ being the density of the viscosity material the mass reactance is at least comparable to the resistance.

What is claimed is:

1. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, viscous matter in said container, and a pair of spaced relatively movable members in said container adapted in their movement to move the viscous matter laterally between their faces, the container and one of the members being made of materials having such different coefficients of expansion as to compensate for changes in viscosity of the matter in the container.

2. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container for viscous matter, viscous matter in the container, and a pair of relatively movable flat-faced members of approximately equal areas mounted in spaced relation in said container, the viscous matter filling the chamber to an extent to cover the opposed faces but with sufficient clearance to provide free lateral movement of the viscous matter between the opposing faces.

3. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, a vibrating diaphragm forming a closure for said container, a flat-faced member carried by the diaphragm, a stationary member in said container having a flat face comparable in area to the area of the first mentioned flat-faced member and located in opposed spaced relation thereto, and viscous matter in the casing adapted for free lateral movement across the adjacent flat faces in response to movement of the vibrating member to control the character of the vibrating movement.

4. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, a flat-faced vibrating member in one end of the container, a stationary member in the container having a flat face comparable in area to the area of the vibrating member and located in opposed spaced relation to the vibrating member, and viscous matter in the container filling said container to an extent to cover the opposed faces but with sufficient clearance to permit free lateral movement of the viscous matter between said faces.

5. In an electro-mechanical translating device responsive to all freqeuncies within the audible range, a vibration damping means having a substantially constant mechanical impedance and a pure resistance over a wide range of frequencies and comprising a container opposing relatively reciprocal flat-faced members in the container, and viscous matter in the container moved laterally of the flat-faced members in their relative movement to produce the desired impedance and resistance in the movable parts.

6. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, a pair of opposing relative movable flat-faced members in the container, and viscous matter in the container moved laterally between the flat-faced members in their relative movement, the area and separation of the flat-faced members being predetermined and so related to a chosen viscosity of the matter that the movable part has a substantially pure resistance over a range corresponding to useful sound vibrations.

7. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, a pair of opposing

relatively reciprocal parallel flat-faced members of predetermined area mounted in the container in predetermined spaced relation, and viscous matter in the container moved laterally of said members by their relative reciprocation to produce a required damping.

8. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibration damping means comprising a container, a pair of parallel opposed relatively reciprocal flat-faced members in the container, and viscous matter in the container moved laterally of the flat-faced members by the reciprocation of one member to produce a resistance equal to

$$\frac{3a^2\mu A}{2d^3}$$

where a is the radius and A the area of the flat-faced members, d the separation of the surfaces and μ the viscosity of the viscous matter.

9. In an electro-mechanical translating device responsive to all frequencies within the audible range, a vibrational damping means comprising a container of material having a relatively low linear expansion coefficient, a flexible diaphragm closing one end of the container, a post in the container having one end in close spaced relation to the diaphragm and having a relatively high linear expansion coefficient, and viscous material in said container moved laterally between the adjacent faces of the diaphragm and post in the movement of the diaphragm.

In witness whereof, we hereunto subscribe our names this 12th day of May, A. D., 1927.

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