July 18, 1939. R. R. RIESZ 2,166,326

METHOD OF DAMPING VIBRATORY MEMBERS

Filed June 25, 1936

FIG. 1

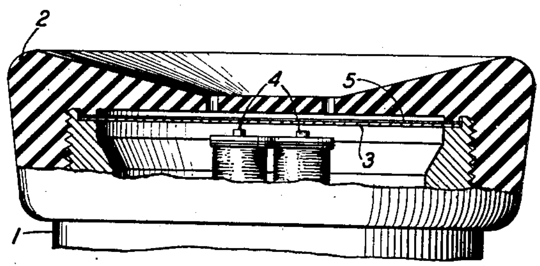


FIG. 2

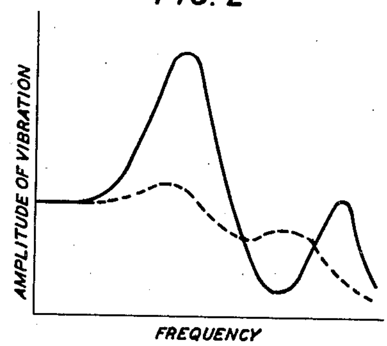


FIG. 3

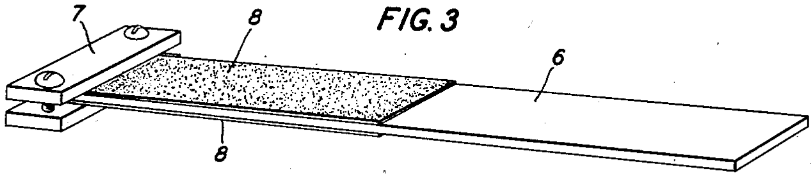


FIG. 4

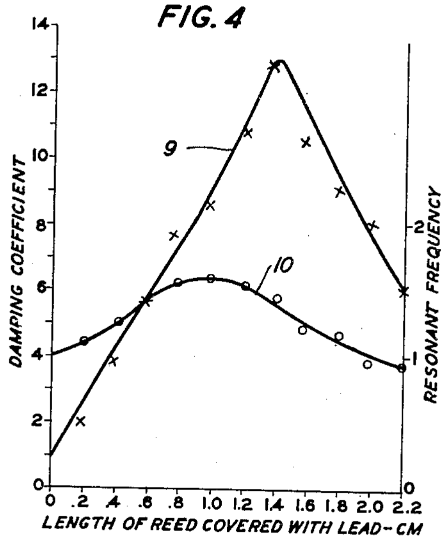
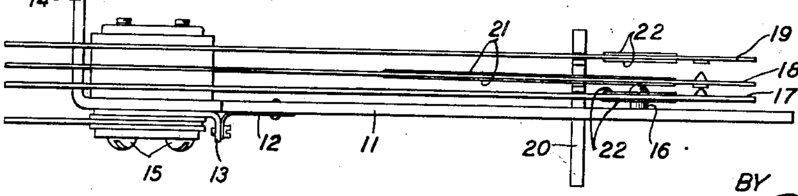


FIG. 5



INVENTOR
R. R. RIESZ
BY
P. C. Smith
ATTORNEY

Patented July 18, 1939

2,166,326

UNITED STATES PATENT OFFICE

2,166,326

METHOD OF DAMPING VIBRATORY MEMBERS

Robert R. Riesz, Mount Vernon, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 25, 1936, Serial No. 87,205

3 Claims. (Cl. 179—180)

This invention relates to a method of damping vibratory members and more particularly to a method of mechanically damping such members by means of a deposition of lead thereon.

The object of the present invention is to provide a means for controlling the damping of various vibratory members.

Another object of the invention is to provide a means for reducing troublesome noise radiating from various parts of moving machinery or other apparatus.

The applicant has found that by the use of lead a convenient method of introducing mechanical damping in vibrating reeds, diaphragms, springs and similar vibratory apparatus can be very readily accomplished.

When a metal is being elongated at acoustic frequencies, the applied force is opposed by two reactions, one, the elasticity of the body of metal, and the other, the viscosity or internal friction. These reactions are additive. Therefore, if in a given vibrating system regions of high elongation are covered with a thin coating of lead, due to the Young's modulus for lead, which is quite low, the potential energy of the system will be altered but little and the vibration curve will be very much the same as before, but due to the high coefficient of internal friction of lead, the rate of dissipation of energy will be greatly increased. Also, if the lead is coated on in regions of high potential energy but low kinetic energy the damping coefficient of the system will be greatly increased. The applicant has found that the most convenient method of applying a thin coating of lead to a vibratory member is by electroplating the coating thereon.

In accordance with the present invention the applicant has illustrated a few typical applications of his invention, but it is to be understood that the invention is not limited in its scope to such illustrated applications but is generally applicable to vibratory elements when mechanical damping is desirable.

It is believed that a clearer conception of the invention may be had by reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 shows a partial cross-sectional view of a telephone receiver to the diaphragm of which lead coating has been applied;

Fig. 2 is a diagram illustrating the effectiveness of the lead coating in damping out excessive vibration of the diaphragm of a telephone receiver;

Fig. 3 shows a vibratory reed with lead coatings applied thereto for the most efficient damping effect;

Fig. 4 is a diagram illustrating the damping effect obtained in connection with a reed of the character disclosed in Fig. 3; and

Fig. 5 shows the application of the invention to the springs of a relay.

Lead is unique among the metals in that its coefficient of internal friction is very high compared to other metals while its Young's modulus is quite low. This property is shown in the following table, in which several metals commonly used for vibratory members have been listed.

Metal	$\frac{E \text{ (lead)}}{E \text{ (metal)}}$	$\frac{\mu \text{ (lead)}}{\mu \text{ (metal)}}$	$\frac{\rho \text{ (lead)}}{\rho \text{ (metal)}}$
Steel	.07	75	1.45
Duralumin	.19	300	4.24
Brass	.14	50	1.35
Phosphor bronze	.12	60	1.43

The above table shows that lead is in a class different from other common metals not only with respect to its elastic constants but with respect to its density. Compared with common metals suitable for use in vibratory apparatus, lead may be described as a material of moderately high density, low Young's modulus and very high coefficient of internal friction.

These facts have suggested the use of lead as a convenient method of introducing mechanical damping in vibrating reeds, diaphragms, relay springs, strings and similar vibratory apparatus. When a metal is being elongated at acoustic frequencies, the internal friction is "in series" with Young's modulus. Therefore, if in a given vibrating system regions of high elongation are covered with a thin coating of lead, due to the low Young's modulus of lead, the potential energy of the system will be altered but little and the vibration curve will be much the same as before the coating was applied, but due to the high coefficient of internal friction of the lead coating the rate of dissipation of energy will be greatly increased. Also if the lead is coated on in regions of high potential energy but low kinetic energy the damping coefficient of the system will be greatly increased. It has been found that the most convenient method of applying a thin lead coating is by electroplating, as a better union with the element to which it is applied is obtained without injury to the temper of the element.

The effectiveness of lead as a damping medium may best be shown by the following examples. Reference will first be had to Fig. 1 which discloses a partial sectional view of a telephone receiver to the diaphragm of which a lead coating has been applied. The receiver shell is shown at 1, the upper end of which is threaded to receive the receiver cap 2. Clamped between the end of the shell and cap is a diaphragm 3 which is positioned just above the pole-pieces 4 of an electromagnet. The outer edge of the upper surface of the diaphragm is coated with a ring of lead or other material having high dissipation, low elastic constants and high density. Although a ring of lead has been disclosed as applied to only the upper face of the diaphragm, a ring could also be applied to the lower face. For the best results the ring of lead should have a width equal to approximately half of the radius of the diaphragm and a thickness equal to approximately half of the thickness of the diaphragm.

The response curves of telephone receivers usually have small pronounced peaks in the voice frequency range due to the resonance of the diaphragm. For example, there is a sharp peak in the curve at frequencies between 800 and 1000 cycles due to the first normal mode of vibration of the diaphragm and a smaller peak at frequencies between 2700 and 3000 cycles due to the second normal mode of vibration of the diaphragm. This is illustrated by the full line curve shown in Fig. 2. The high peak at the lower frequencies is undesirable since it makes the receiver too efficient in a narrow frequency range and the lower peak at the higher frequencies is of little use since it is too high in frequency to merge with the low frequency range of the receiver to extend the useful frequency band.

The application of the lead ring to the diaphragm as previously described damps the low frequency peak but leaves its frequency almost unchanged and moves the low frequency peak to a lower frequency so that it will merge with the low frequency response range and so increase the useful frequency range of the receiver. The response curve of the same receiver whose diaphragm is provided with a lead damping ring is illustrated by the dotted line in Fig. 2.

In Fig. 3 the application of a coating of lead to a reed 6, one end of which is clamped at 7 and the other end of which is free, is illustrated. The lead coating is indicated at 8 as applied to both faces of the reed. Mathematical calculations indicate that the damping effect of the lead coatings is a maximum for a given thickness of lead when the reed is coated for one-half of its length extending from the clamped end. This is due to the fact that when lead is applied near the clamped end a large amount of dissipation is introduced and very little mass is added, while if the lead is applied at the free end of the reed little dissipation is obtained but a large mass is added. Thus as greater and greater lengths of lead are applied beginning at the clamped end, the damping effect first rises, passes through a maximum and then decreases. The resonant frequency of the reed so treated changes in a similar manner, the frequency for the reed covered with lead being lower than that when there is no lead applied. For reeds coated with a certain length of lead, which length varies with the thickness of the coating, the resonant frequency is equal to that when no lead has been applied to the reed. This then furnishes a convenient method of controlling the damping of clamped free reeds without changing their resonant frequencies.

The curves shown in Fig. 4 illustrate the extent of damping and the effect on the resonant frequency, obtained experimentally with a steel reed when both faces of the reed are lead coated to various distances from the clamped end. The curve 9 of Fig. 4 is plotted from points having as their abscissa different .2 centimeter lengths of lead coating on a reed 2.2 centimeters long, .0028 inch thick and .044 inch wide, the lead coating on each face of the reed being .0031 inch thick and, as their ordinates the values of the coefficient of damping obtained. This curve indicates that the maximum damping was found when 1.4 centimeters of the length of the reed was thus coated. The curve 10 is plotted from points having as their abscissa different .2 centimeter lengths of lead coating and as their ordinates the values of resonant frequency obtained. By a comparison of these curves it will be apparent that when the damping is at its maximum value, the resonant frequency is also approximately at its maximum value. While the results obtained experimentally do not quantitatively agree with the theoretical expectations, due to the damping effect added by the clamp, they do agree qualitatively and indicate that the damping effect is at a maximum when the reed is coated to approximately one-half its length and that the resonant frequency of the reed is substantially unaffected.

In Fig. 5, the invention is illustrated as applied to the springs of a relay, the core and winding of the relay being omitted in order to clarify the disclosure. The armature 11 is secured by reed hinges 12 to the member 13 which with the spring pileup is clamped to the bracket 14 by the screws 15. The armature at its free end is provided with a stud 16 of insulating material which passes freely through an opening in the lower spring 17 into engagement with the middle spring 18. The lower and upper springs 17 and 19 are supported near their free ends in the usual manner in the proper position with respect to the center spring 18 by the outer spoolhead indicated at 20.

It has been found that there is a tendency for relay springs to vibrate when operated into or out of contact by the attraction or retraction of the relay armature resulting in a chattering of the spring contacts and thereby in false operation of circuits controlled thereover. This tendency to chatter may be effectively reduced or eliminated by coating the springs with lead as illustrated, the center or armature operated spring 18 being coated on both faces at 21 and the springs 19 and 17 with which it cooperates on the attraction and retraction respectively of the armature being coated as indicated at 22. Since the springs 17 and 19 while clamped at one end, are also supported near their free ends in the spoolhead, they are not free reeds of the type disclosed in Fig. 3 but are more nearly cantilevers and therefore the most effective damping of these springs is attained by coating the portions of the springs extending beyond their support in the spoolhead 20, the ends of the springs where the contacts are affixed being free from the coating. Also due to the engagement of the stud 16 with the armature spring 18, this spring does not function as a true reed and the most effective damping of this spring is attained by coating that portion of the spring which has the maximum potential energy, or approximately the outer half of the spring extending back from its contacts to its clamped end.

It will be apparent that the application of the lead coating to the springs of a relay to obtain the maximum damping effect will be dependent on the relay structure and the manner in which the springs are mounted.

While certain specific applications of the invention have been illustrated herein it is to be understood that the scope of the invention is not to be limited thereby, but that the invention is equally applicable for mechanically damping in any vibratory system or apparatus. Furthermore while lead has been stated herein as a substance having the requisite damping properties of low elasticity and high internal friction, the invention also embraces other substances having similar characteristics.

What is claimed is:

1. In combination, a rigid support, a spring member clamped at one portion thereof to said support, and means for mechanically damping said spring member comprising a thin coating of lead electroplated on the surface thereof between its clamped portion and the portion thereof having the maximum amplitude of vibration, that portion of said surface having the maximum amplitude of vibration being uncoated.

2. In combination, a rigid support, a spring member clamped at one portion thereof to said support, and means for mechanically damping said spring member comprising a coating of lead applied to both surfaces of said spring member between its clamped portion and the portion thereof having the maximum amplitude of vibration, that portion of said surface having the maximum amplitude of vibration being uncoated.

3. In combination, a rigid support, a reed spring clamped at one end to said support, and means for mechanically damping said spring comprising a coating of lead applied to both surfaces of said spring between its clamped and free ends, the free end of said spring being uncoated.

ROBERT R. RIESZ.