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J. A. MILLER
RECORDING APPARATUS

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2 Sheets-Sheet 2

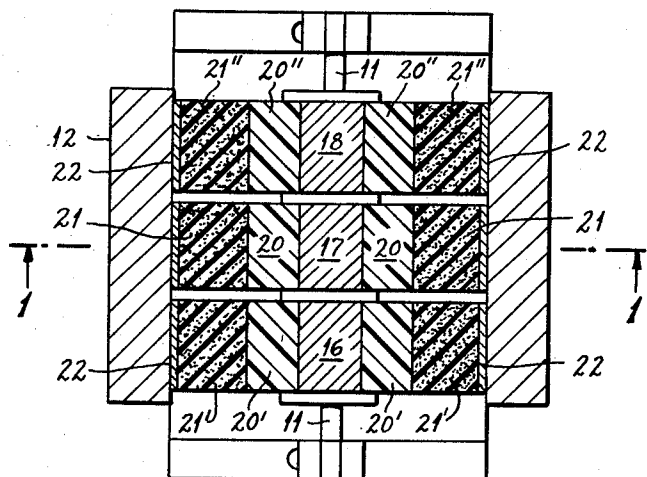


Fig. 3

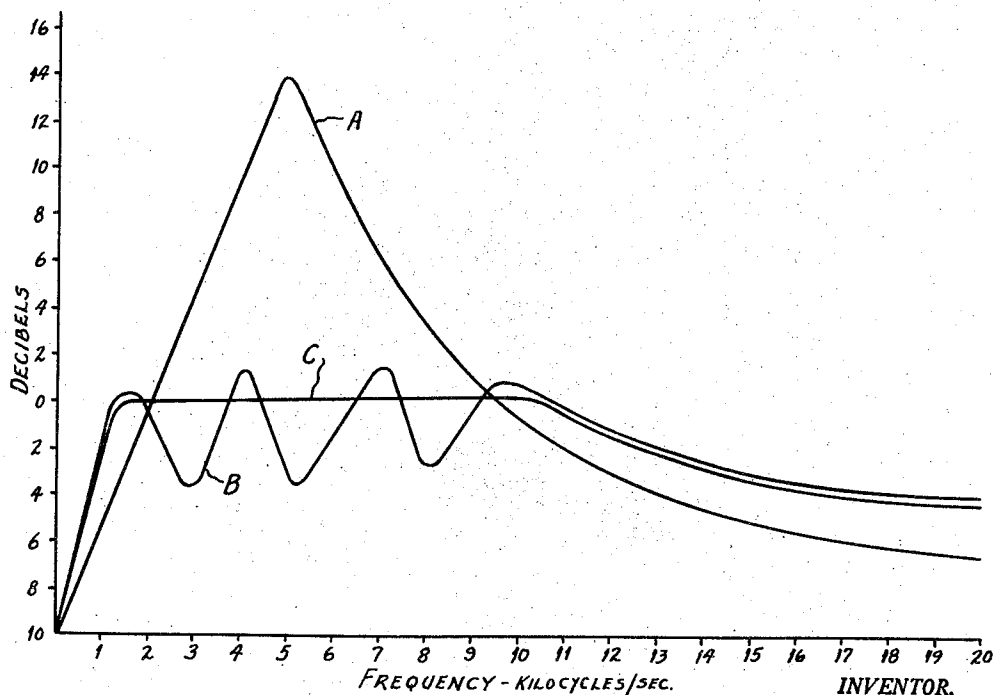


Fig. 4

INVENTOR.
JAMES A. MILLER

BY

Compton, Buntup, Ren & Stave
HIS ATTORNEYS

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RECORDING APPARATUS

James A. Miller, Darien, Conn.

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6 Claims. (Cl. 179—180)

This invention relates to apparatus for recording sound, and has particular reference to a means for actuating a cutter for recording sound vibrations on a phonograph record or the like, although the invention is not limited to that use.

Phonograph record cutters heretofore employed afforded limited fidelity of reproduction, largely because they are either over-damped or under-damped, so as to produce a distorted response to the sound vibrations which are desired to be reproduced. In my Patent No. 2,037,255 the response characteristics of a phonograph record cutter were improved by controlling the coupling between the parts of an electromagnetic armature carrying the cutter or stylus, so that the transfer of energy accorded with an harmonic relation between the resonant frequencies of the armature parts. This desirable result was obtained by damping the armature parts so that the natural periods of the parts do not undesirably interfere with vibration of the armature as a whole. The means suggested for effecting such selective damping was immersion of the armature in a damping liquid. The present invention is an improvement on the recording and reproducing apparatus disclosed in said patent, but effects the damping by tuning the armature at a plurality of different frequencies without reliance on the harmonics of any frequency.

In accordance with the present invention, an electromagnetic recording system is provided in which a suspended balanced armature structure having a primary resonance on the order of 4500 cycles or above is connected to a plurality of resonant band pass damping members which feed back energy to the armature in predetermined phase opposition and of such amplitude as to compensate for resonant and phase shift characteristics thereof.

In a preferred embodiment of the invention, an electromagnetic armature carrying a recording cutter is provided with three band pass damping sections comprising at least one and preferably three energy-absorbing units interposed between a relatively rigid base and three corresponding points on the armature vibrating at different predetermined frequencies.

It will be seen that the recording or reproducing apparatus of this invention provides controlled floating mass damping at a corresponding number of independent frequencies so as to afford a selective band pass damping mechanism having the effect of electrical feed-back but with mechanical means.

For a more complete understanding of the invention, reference may be had to the accompanying drawings, in which:

Figure 1 illustrates a vertical section through an electromagnetic translating apparatus embodying the invention, as seen along the line 1—1 of Fig. 3;

Fig. 2 is a semi-diagrammatic view illustrative of the invention;

Fig. 3 is a transverse section through the apparatus of Fig. 1, as seen along the line 3—3 thereof; and

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Fig. 4 is a group of resonance curves illustrative of the acoustic effects of the invention.

Referring to the drawings, numeral 10 designates a balanced armature type of cutter unit of conventional construction having substantial mass and supported by stiff torsion springs 11 in the field of a permanent magnet 12 and vibrating in response to the fluctuating currents traversing coils 13 to actuate the cutter stylus 14 for inscribing the record blank 15 in the usual way.

Damping of the cutter unit 10 is commonly effected by resilient damping means or an equivalent liquid damping arrangement of the nature shown in the afore-mentioned patent, so that resonance is obtained in the region of 5000 cycles per second as indicated by curve A in Fig. 4, which illustrates several resonance curves plotted with decibel response as ordinates and using constant velocity reference. The straight resistance or resilient kind of damping of the nature described, having a non-linear characteristic with displacement or frequency, produces intermodulation distortion and reduction of transient response.

If, in order to improve the results obtained by straight resistance damping, one or more different masses, such as three, are resiliently mounted on the cutter unit armature and their vibrations remain uncontrolled, their effect imposed on the vibration of the armature is illustrated by curve B of Fig. 4. This improved damping is obtained by resiliently mounting three different weights 16, 17 and 18, having masses M_1 , M_2 , M_3 , by respective reeds 16', 17' and 18' on cutter unit 10, having the mass M , in the manner shown in Fig. 2. The reeds 16', 17' and 18' are shown as of different lengths in Fig. 2 to indicate different response characteristics, so that each weight vibrates 180° out of phase with the cutter unit 10, thereby affording independent "negative" damping reactions thereon which are in the nature of "negative" mechanical feed-backs instead of the usual "positive" mechanical damping in phase with the vibration of the cutter unit 10. The out-of-phase frequency vibration of the weights 16, 17 and 18 may be otherwise obtained as is well understood.

Thus, weight 16 is tuned to have a resonance peak at about 1500 cycles per second to impose a negative mechanical feed-back on unit 10 up to about 3000 cycles per second, weight 17 is tuned to resonate at about 4000 cycles to provide a negative mechanical feed-back up to about 5000 cycles, while weight 18 similarly provides a negative mechanical feed-back at about 8000 cycles per second as indicated by curve B of Fig. 4.

Curve B accordingly illustrates the effect of selective but uncontrolled floating mass negative damping on unit 10. When the vibration of damping weights 16, 17 and 18 is controlled in accordance with the invention, the gross negative mechanical feed-back is such that the response of unit 10 becomes substantially constant or flat between the desired frequencies of 1000 to 10,000 cycles per second and curve C of Fig. 4 results.

This desirable effect is obtained by damping the vibrations of the weights 16, 17 and 18 by mechanical band pass damping members which are composed of two superimposed blocks of materials having different mechanical energy-absorbing characteristics. Thus, interposed in the plane of vibration of each weight between opposite sides of the same and a relatively fixed support is a block 20 of relatively high damping material and a block of relatively soft elastic or resilient material 21 as shown in Fig. 1. Conveniently, each soft block 21 may be seated in a socket 22 on the permanent magnet 12 and the hard block 20 cemented to the corresponding soft block 21 and in turn cemented to the corresponding surface of the weight 17.

Although numerous relatively hard and relatively soft

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materials may be selected for making blocks 20 and 21, I have found sponge rubber to be suitable for soft elastic blocks 21 and Viscoloid for relatively hard blocks 20. Other suitable soft elastic materials are felt, light coiled springs and the like, and Bakelite, wood and fiber and the like, as other relatively hard materials.

As shown in Fig. 3, such series-composite members 20, 21 are similarly interposed between weights 16 and 18 and designated 20', 21' and 20'', 21'', respectively, and perform the same controlled damping function for their respective floating damping weights 16 and 18 as do the series-composite members 20, 21 of weight 17.

In operation of the sound recording system of this invention, the cutting function of the apparatus is obtained by energizing the unit to actuate the stylus 14 relatively to the record blank 15 in the usual way, but with the enhanced fidelity obtained by the controlled mass damping mechanism. The damping mechanism afforded by resiliently-mounted weights 16, 17 and 18, each tuned to vibrate 180° out-of-phase with armature 10, together with the individual composite damping members 20', 21' and 20'', 21'', respectively, effectively reduces the amplitude of vibration of the armature 10 at any chosen point without introducing distortion and without reducing the transient response.

At low frequency the combined mass $M_1 + M_2 + M_3$ of weights 16, 17 and 18 is added to the mass M of the armature 10, thereby lowering the point of natural resonance. At high frequency, the combined compliance $S_1 + S_2 + S_3$ of reeds 16', 17' and 18' is added to the compliance of torsion spring 11 to thereby raise the response in the upper frequency region. The damping has no effect on low frequency vibration of armature 10 and becomes part of the cutter unit mass at low frequency.

Further regulation of the negative damping action of the series composite damping members may be effected by varying the thickness of the hard blocks 20, 20' or 20'' relatively to the thickness of the corresponding soft blocks 21, 21' or 21'', or by making them severally of different materials, or both.

The controlled floating mass negative damping mechanism thus provided by this invention affords selective band pass damping by negative mechanical feed-back and has similar effect as electrical feed-back. The same beneficial effects are obtained when a translating device of this invention is utilized as a reproducer of sound for phonograph records, or for other purposes.

Although a preferred embodiment of this invention has been illustrated and described herein, it is to be understood that the invention is not limited thereby, but is susceptible of changes in form and detail within the scope of the appended claims.

I claim:

1. In damping mechanism for an acoustic device having a vibratile member, the combination of a mass, a resilient connection between said mass and said member tuned to vibrate about 180° out-of-phase with relation to the vibration of said member at a predetermined frequency, and damping means comprising a fixed abutment, a relatively soft elastic element engaging said abutment and a relatively harder cushioning element engaging said mass for controlling the vibration thereof to reduce the amplitude of vibration of the member in the region of its natural resonant frequency.

2. In damping mechanism for an acoustic device having a vibratile member, the combination of a plurality of different masses mounted on said member and each

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tuned to vibrate about 180° out-of-phase with relation to the vibration of said member at different predetermined frequencies, and damping means comprising a fixed abutment, series-connected cushioning elements interposed between each said mass and said fixed abutment for reducing the amplitude of vibration of the member at its natural resonant frequency.

3. In damping mechanism for an acoustic device having a vibratile member, the combination of a plurality of different masses mounted on said member and each tuned to vibrate about 180° out-of-phase with relation to the vibration of said member at different predetermined frequencies, and damping means comprising a fixed abutment, a relatively soft cushioning element engaging said abutment and a relatively harder cushioning element engaging each said mass for reducing the amplitude of vibration of the member at its natural resonant frequency.

4. In damping mechanism for an acoustic device having a vibratile member mounted on a support, the combination of a plurality of different masses mounted on said member and each tuned to vibrate about 180° out-of-phase with relation to the vibration of said member and each having a different resonant frequency, and damping means comprising a relatively soft cushioning element and a relatively harder cushioning element on said support and engaging each said mass for reducing the amplitude of vibration of the member at its natural resonant frequency.

5. In damping mechanism for an acoustic device having a vibratile member, the combination of a plurality of masses, a resilient reed connecting each mass to said member, said reeds being tuned to different frequencies to cause the masses to vibrate about 180° out-of-phase with respect to the vibration of said member at their respective tuned frequencies, and damping means comprising a relatively soft cushioning element and a relatively harder cushioning element engaging opposite sides of said mass in the plane of vibration thereof for controlling its vibration to reduce the amplitude of vibration of the member in the region of its natural resonant frequency.

6. In damping mechanism for an acoustic device having a vibratile member mounted on a support, the combination of a mass, a resilient reed connecting said mass to said member and tuned to different frequencies to cause the mass to vibrate about 180° out-of-phase with relation to the vibration of said member at their respective tuned frequencies, and damping means comprising a relatively soft elastic element and a relatively harder cushioning element on said support and engaging opposite sides of said mass in the plane of vibration thereof for controlling its vibration to reduce the amplitude of vibration of the member in the region of its natural resonant frequency.

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