363,627

PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in or relating to Apparatus for the Interconversion of Electrical and Mechanical Energy such as Used in Sound Recording and Reproducing Apparatus

I, ALAN DOWER BLUMLEIN, of 57, Earl's Court Square, London, S.W.5, a British subject, do hereby declare the nature of this invention to be as follows:-

This invention relates to devices employed for the interconversion of electrical and mechanical energy, and is more particularly directed to devices of this character in which parts of the apparatus are set into vibration at varying frequencies, such as sound recording and reproducing devices.

In such apparatus it has been usual to introduce damping in the form of frictional or elastic forces imposed by a material connected with the moving system whereby resonance of the system when vibrating in the manner intended (which we will call its authorised mode), is suitably controlled. It is usually possible, of course, that the system is capable of vibration in other, unauthorised, modes, such, for example, as vibrations within the moving system itself due to inherent flexibility or to flexibility of the supports; but in general the damping material introduced to suppress resonance in the authorised mode also serves to damp vibrations in unauthorised modes. If, however, for damping vibrations in the authorised mode forces other than frictional or elastic forces are employed, such, for example, as electric or electro-magnetic force, it sometimes, and quite usually, happens that such forces are completely ineffective in suppressing resonance of vibration in authorised modes. Thus for example the whole rigid structure of the device may have a natural frequency, in the working range, at which on account of lack of damping in any form, it will resonate at must undesirably large amplitudes under quite small forces.

The object of the present invention is to introduce means whereby the difficulties of damping the various vibrations of such apparatus may be successfully overcome, and the invention consists in the method of modifying the frequency response of apparatus employed for the interconversion of electrical and mechanical energy in which means are employed to damp vibrations in unauthorised modes different from the damping means employed for vibrations in the authorised mode.

The invention further consists in means for carrying into effect the method specified in the next preceding paragraph, comprising apparatus for the interconversion of electrical and mechanical energy in which vibrations in the authorised mode are damped by electromagnetic means, while vibrations in unauthorised modes are modified by mechanical damping in the form of frictional or elastic forces for example.

The invention also consists in apparatus of the character referred to wherein vibrations in a unauthorised modes are damped by the insertion in the mountings and joints of the various members of the apparatus, of thin layers of suitable damping material such as cork or rubber which however preferably have no effect upon vibrations in the authorised mode, which are otherwise damped.

Further features of the invention will appear from the following description of one modification thereof as applied to apparatus in the form of a moving electric coil oscillating in an electromagnetic field, employed for the recording of sound; but it must be understood that the invention is not limited to such a device since it is applicable to all forms of apparatus employed for the interconversion of vibratory electrical and mechanical energy.

The apparatus considered in this description of one convenient manner of carrying the invention into effect comprises essentially a stylus shaft of stiff and rigid construction, rigidly mounted between knife edges, and adapted to be subjected to rotational movements which are damped by electromagnetic forces brought into play. If the moving system is an any way out of balance forces may introduced tending to bend the stylus shaft and set it into lateral vibrations. At most frequencies the strength of the shaft is sufficient to prevent such vibrations reaching any undesirable magnitude, but it will be appreciated that on account of its stiffness and its rigid mounting the shaft will have a very sharp and pronounced resonant frequency, and, since the electromagnetic damping affects only the rotational movements, at this frequency vibrations of the shaft will be completely undamped. Very small forces at this frequency may therefore be sufficient to cause undesirable lateral vibrations of extremely large amplitude. In a similar way small out-of-balance forces reform the stylus shaft, or from other parts of the moving system, may excite undesirable vibrations of appreciable amplitudes in associated parts of the assembly such as the rigid structure of the knife edge supports, for example, at the resonant frequencies of these parts. It will therefore be appreciated that there may be a number of frequencies at which resonant vibrations may be set up and that since these vibrations are undamped only very small forces are necessary to introduce them.

In order to prevent these undesirable oscillations occurring in the stylus shaft and framework in accordance with the invention I may introduce a very small amount of damping into these systems by interleaving very thin layers of cork or other suitable material between surface joints in the framework and/or also in stylus shaft assembly. In one type of such apparatus for example a stylus arm is attached to the stylus shaft by being clamped between a fork in the end of the latter. In this fork between the stylus shaft and the stylus arm may be inserted two pieces of cork which are clamped by screws passing through the fork, these screws not touching the stylus arm. Thus the stylus arm makes no metallic contact with the stylus shaft but is clamped between two layers of cork; these layers of cork may be of any suitable thickness but are usually of a small order such as .003 inches thick, but they serve to provide just that small degree of damping that is necessary to prevent unauthorised oscillation of the stylus shaft. Similarly, the knife edges may be clamped between steel plates with interleavings of thin cork sheet, the end plates having interleavings of cork between them and the pole pieces. These latter interleavings of cork serve to damp out oscillations in the main frame.

It is to be noted that the damping so introduced has no effect upon the rotational oscillation of the stylus shaft, but only serves to prevent the vibrations of the system is unauthorised modes.

The method of damping unauthorised modes of vibrations is applicable to any electromechanical device, but is usually only necessary in some cases where the damping provided to suppress the main resonance in the authorised mode is of such a form that it produces no damping in authorised modes of vibration. It is therefore particularly applicable to electromagnetically damped devices.

The invention is not limited only to cork interleavings; rubber or other suitable material may be used instead. An advantage of cork is that it may conveniently be obtained in thin sheets and that the introduction of these sheets does not allow sufficient relative movement of the connected parts to spoil the alignment etc. of the device.

A modified method of introducing damping for parts of the system liable to vibrate in unauthorised modes at their resonant frequencies is to combine with the member or members tending to bend, one or more additional strengthening members, the contacting surfaces being interleaved with cork or other suitable damping materials in the manner described. Thus two points liable to have unauthorised relative movement during vibration in the authorised mode, or two parts of the member likely to bend relative to one another may have clamped thereto an additional stiff member, washers of cork being interposed between the parts and the added member for damping relative oscillation.

It is to be understood that the invention is not limited to any particular details given in the above description, since it may be applied to any form of electromechanical conversion apparatus; and we may vary the different parts thereof, their material, disposition and relative association in accordance with various requirements to be fulfilled without departing from the scope of the invention in any way.

Dated this 12th day of September, 1930.

MARKS & CLERK.

COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for the Interconversion of Electrical and Mechanical Energy such as Used in Sound Recording and Reproducing Apparatus

I, ALAN DOWER BLUMLEIN, of 57, Earl's Court Square, London, S.W.5, a British subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

This invention relates to devices employed for the interconversion of electrical and mechanical energy, and is more particularly directed to devices of this character in which parts of the apparatus are set into vibration at varying frequencies, such as sound recording and reproducing devices.

In such apparatus it has been usual to introduce damping in the form of frictional or elastic forces imposed by a material connected with the moving system whereby resonance of the system when vibrating in the manner intended (which we will call its authorised mode), is suitably controlled. It is usually possible, of course, that the system is capable of vibration in other, unauthorised, modes, such, for example, as vibrations within the moving system itself due to inherent flexibility or to flexibility of the supports; but in general the damping material introduced to suppress resonance in the authorised mode also serves to damp vibrations in unauthorised modes. If, however, for damping vibrations in the authorised mode forces other than frictional or elastic forces are employed, such for example, as electric or electromagnetic forces, it sometimes, and quite usually, happens that such forces are completely ineffective in suppressing resonance of vibration in unauthorised modes. It must be understood that the present invention is concerned with the vibrations of the member or members which is or are normally intended to be in oscillation, and the scope of the invention does not include damping means, for example between the complete apparatus and its container or support, to prevent the whole device vibrating in a unitary manner. Thus in one prior propose it has been suggested to provide acoustic insulation between the whole electromagnetic system of a sound-recorder and its support, and not only is such an arrangement outside the scope of this invention but it moreover fails to discriminate between vibrations of the moving system in it authorised and unauthorised modes which, as will be seen below is a feature of the present invention. Nor does the present invention include constructions such as have previously been proposed wherein the resilient supports of the moving member are arranged, e.g. by strengthening more in some directions than others, to resist vibrations in directions other than that desired.

The object of the present invention is to introduce means whereby the difficulties of damping the various vibrations of such apparatus may be successfully overcome and the invention consist in apparatus for the interconversion of electrical and mechanical energy comprising a member adapted to oscillate in one mode, wherein resonance of the said member in its authorised mode is damped solely by electromagnetic means, and resonance in unauthorised modes, and/or resonance of associated parts tending to induce such oscillations, is damped by non-resilient elastic means.

The invention also consists in apparatus for the interconversion of electrical and mechanical energy comprising a pivoted electric coil, the resonant pivotal oscillations of which are damped electromagnetically, resonant vibrations in other modes, and/or resonant vibrations of associated parts of the apparatus (e.g. an arm carried by the coil shaft) tending to induce such undesired oscillations, being damped by non-resilient elastic means which do not directly affect the pivotal resonance of the coil.

Further features of the invention will appear from the following description of one modification thereof as applied to apparatus, in the form of a moving electric coil oscillating in an electromagnetic field, of the character described in Specifications Nos. 350,998 and 350,954 and employed for the recording of sound; but it must be understood that the invention is not limited to such a device since it is applicable to all forms of apparatus employed for the interconversion of vibratory electrical and mechanical energy, such as pick-ups, microphones, loudspeakers, oscillographs, etc.

The invention will be more readily understood from the following description of one modification thereof by reference to the accompanying drawings wherein:-

Figure 1 represents a side sectional elevation and

Figure 2 represents a front sectional elevation of a moving coil sound recording device embodying the invention.

The apparatus to be considered in the following description of one convenient manner of carrying the invention into effect is shown in Figures 1 and 2 and comprises essentially a stylus shaft *a* of stiff and rigid construction, mounted upon knife edges *b, b* and adapted to be subjected to rotational movements by an electrically conductive coil *c* mounted upon it. This coil is positioned between magnetic pole pieces *d, d* (Figure 2) which form the ends of an adjacent electromagnet (not shown). Within the coil is a core *e* forming part of a second magnetic circuit *f,* (Figure 1) upon which are wound exciting coils *g, g,* so that the moving coil *c* forms the secondary winding of a transformer of which the coils *g, g* are primary windings. Electrical impulses generated by the sound to be recorded, (e.g. at a microphone) are fed to coils *g, g* and induce corresponding impulses in the coil *c* which under the influence of the magnetic field between the pole pieces *d, d* thereupon oscillates about a vertical axis carrying with it the stylus shaft *a* to which it is attached and a stylus arm *h* attached to the bottom of the shaft *a*. the stylus arm *h* carries at its outer end a sapphire or like cutting tool *i* whereby a record may be cut in wax or similar material.

The circuits of the coils *g, g* are so arranged that any undesirably large oscillations of the coil *c* are damped by electromagnetic forces brought into play in the manner described in Patent Specification No. 350,998 referred to above. If the moving system is in any way out of balance, however, forces may be introduced tending to bend the stylus shaft and set it into lateral vibrations. At most frequencies the strength of the shaft is sufficient to prevent such vibrations reaching any undesirable magnitude but it will be appreciated that on account of its stiffness and its rigid mounting the shaft will have a very sharp and pronounced resonant frequency, and since the electromagnetic damping affects only rotational movements, at this frequency vibrations of the shaft will be completely undamped. Very small forces of this frequency may therefore be sufficient to cause undesirable lateral vibrations of extremely large amplitude. In a similar way small out-of-balance forces from the stylus shaft, or from other parts of the moving system, may excite undesirably vibrations of appreciable amplitudes in associated parts of the assembly such as the rigid structure of the knife edge supports, for example, at the resonant frequencies of these parts. It will therefore be appreciated that there may be a number of frequencies at which resonate vibrations may be set up and that since these vibrations are undamped only very small forces are necessary to introduce them.

In order to prevent these undesirable parasitic oscillations occurring in the stylus shaft and framework in accordance with the invention I may introduce a very small amount of damping into these systems by interleaving very thin layers of cork or other suitable material between surface joints in the framework and/or also in stylus shaft assembly. In the type of such apparatus shown for example the stylus arm *h* is attached to the stylus shaft *a* by being clamped between a fork *k* in the end of the latter. In this fork between the stylus shaft and the stylus arm may be inserted two pieces of cork 1, 1, (figure 2) which are clamped by screws passing through the fork, these screws not touching the stylus arm. Thus the stylus arm makes no metallic contact with the stylus shaft but is clamped between two layers of cork. These layers of cork may be of any suitable thickness but are usually of a small order such as .003 inch thick; but they serve to provide just that small degree of damping that is necessary to prevent unauthorised oscillation of the stylus shaft. Similarly, the knife edges maybe clamped between metal plates *l* with interleavings of thin cork sheet 2, 2 which serve not only to damp resonant vibrations of the knife edges but also to allow some slight resiliency therein whereby resonant vibrations of the coil in unauthorised modes are damped; and the end plates or blocks *m* may have

interleavings of cork 3, 3 between them and the pole pieces. The screws *o* holding the bocks *m* to the pole pieces may have between them and the blocks hard rubber bushings *n* which, while serving to clamp the blocks, have sufficient resiliency to allow the cork interleavings to be effective in damping. These last interleavings 3, 3, of cork and the bushings *n* serve not only to damp out oscillations in the main frame but also to insulate the blocks *m* from the pole pieces and thus prevent a short-circuited turn being formed by the frame round the exciting magnetic circuit. In the case of the knife edge supports and if desired in the case of the connection between the blocks *m* and the pole pieces the clamping screws pass through clearance holes in the supported member so that the only contact between the supported members and the supporting members if through the cork interleaving provided.

It is to be noted that the damping so introduced has no effect upon the rotational oscillation of the stylus shaft, but only serves to prevent the vibrations of the system in unauthorised modes, and further that since all the cork interleavings 1, 2 and 3 are so arranged that any relative movement of the members between which they are placed necessitates a shearing strain in the cork, any adjustment of tightness of the clamping screws in order to alter compression of the cork will not affect the relative position of the parts of the apparatus considered; for example the clearance between the moving coil and the pole pieces will not be affected by increasing the tightness of the knife edge clamping screws.

This method of clamping unauthorised modes of vibrations is applicable to any electromechanical device, but is usually only necessary in cases where the electromagnetic damping provided to suppress the main resonance in the authorised mode produces no damping in unauthorised modes of vibration.

The invention is not limited only to cork interleavings; rubber or other suitable material may be used instead. An advantage of cork is that it may conveniently be obtained in thin sheets and that the introduction of these sheets does not allow sufficient relative movement of the connected parts to spoil the alignment etc. of the device.

A modified method of introducing damping for part of the system liable to vibrate in unauthorised modes at their resonant frequencies is to combine with the member of members tending to bend, one or more additional strengthening members, the contacting surfaces being interleaved with cork or other suitable damping materials in the manner described. Thus two points liable to have unauthorised relative movement during vibration in the authorised mode, or two parts or the member likely to bend relative to one another may have clamped thereto an additional stiff member, washers of cork being interposed between the parts and the added member for damping relative oscillations.

It is to be understood that the invention is not limited to any particular details given in the above description, since it may be applied to any form of electromechanical conversation apparatus, and to any points in the apparatus other than or in addition to the particular places described, where such damping is desired. Further, I may vary the material, form, disposition and relative association of the damping interleavings and/or the parts of the apparatus in accordance with various requirements to be fulfilled without departing from the scope of the invention as defied in the appended claims in any way.

Having now particularly described and ascertain the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:-

1. Apparatus for interconversion of electrical and mechanical energy comprising a member adapted to oscillate in one mode, wherein resonance of the said member in its authorised mode is damped solely by electromagnetic means, and resonance in unauthorised modes, and/or resonance of associated parts tending to induce such oscillations, is damped by non-resilient elastic means.
2. Apparatus for the interconversion of electrical and mechanical energy comprising a pivoted electric coil, the resonant pivotal oscillations of which are damped electromagnetically, resonant vibrations in other modes, and/or resonant vibrations of associated parts to he apparatus (e.g. an arm carried by the coil shaft) tending to induce such undesired oscillations, being damped by non-resilient elastic means which do not directly affect the pivotal resonance of the coil.
3. Electromechanical interconversion apparatus as claimed in Claim 1 or 2 wherein interleaving or packing is provided adjacent to parts of the apparatus, e.g. frame members, pivotal knife edge supports etc., parasitic resonance of which it is desired to damp.
4. Electromechanical interconversion apparatus as claimed in claim 3 wherein the interleavings or packings are formed of cork, rubber or like material.
5. Electromechanical interconversion apparatus as claimed in Claim 3 or 4 wherein compression of the interleavings may be adjusted without affecting the clearances allowed between the main or operative members of the apparatus.
6. Electromechanical interconversion apparatus as claimed in any of Claims 2-5 wherein knife edges which carry the moving coil are mounted upon resilient damping supports whereby to damp resonate vibrations of the knife edges but to allow slight damped flexibility thereof in order to damp resonant vibrations of the moving coil in unauthorised mode.
7. Electromechanical interconversion apparatus as claimed in any of Claims 1-6 wherein interleavings of cork or like damping material are introduced between magnetic pole pieces (adjacent to the moving coil) and the frame blocks adjacent thereto which support other parts of the apparatus, e.g. the knife edge supporting plates.
8. Electromechanical interconversion apparatus wherein the moving system comprises two or more parts, the mechanical connection between which is effected through a damping elastic medium whereby to damp the resonance of said system in unauthorised modes.
9. Electromechanical interconversion apparatus as claimed in any of Claims 2-8 wherein the pivotal shaft of the moving coil carries with a fork at its free end a radially projecting arm.
10. Electromechanical interconversion apparatus as claimed in Claim 8 or 9 wherein damping interleavings of cork or like material are provided between the fork and the radial arm which it supports.
11. Electromechanical interconversion apparatus as claimed in any of Claims 1-10 wherein transmission of vibration between inter-damped supported and supporting members of the apparatus can take place only through the intervening damping medium, e.g. cork interleaving or the like.
12. Electromechanical interconversion apparatus as claimed in Claim 11 wherein clamping screws locking the supporting members, e.g. metal plates, against the interleaving packing and the supported member (e.g. knife edge) pass through clearance holes in, and do not contact with, the supported member.
13. Electromechanical interconversion apparatus comprising a member adapted to oscillate in one mode wherein oscillations of the said member in unauthorised modes, and/or oscillations of other parts or the apparatus tending to induce such unauthorised

oscillations (e.g. by flexure of the member or parts, or relative movement there between) are prevented by additional strengthening or stiffening members connected with the parts through the medium of a damping material (e.g. cork interleavings).

14. Electromechanical interconversion apparatus in which parasitic vibrations are damped by packings of cork or like elastic material substantially as described herein with reference to the accompanying drawings.
15. A sound recorder substantially as described herein with reference to the accompanying drawings.
16. Sound records whenever prepared by apparatus substantially as described herein with reference to the accompany drawings.

Dated this 30th day of May, 1931.

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