July 31, 1945. K. J. GERMESHAUSEN 2,380,514

VIBRATION-TRANSLATING DEVICE

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Fig. 1.

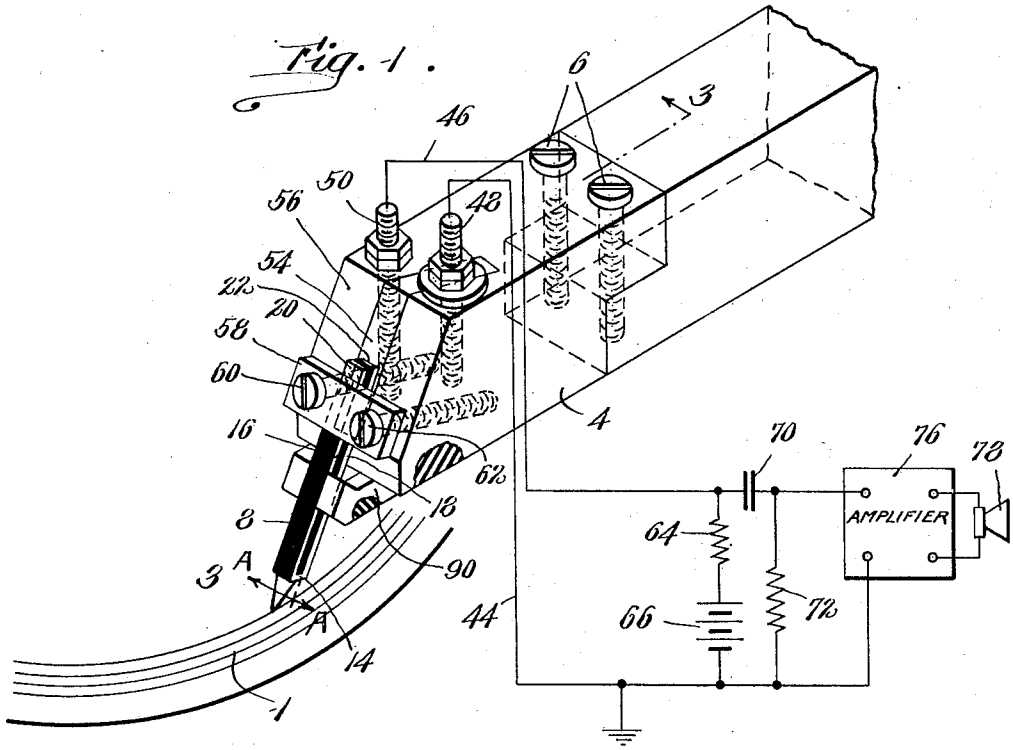


Fig. 2.

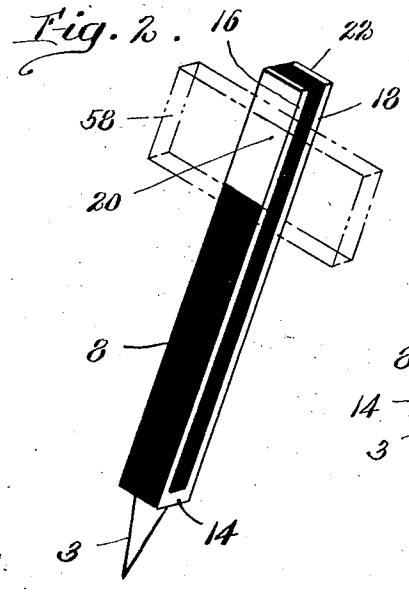
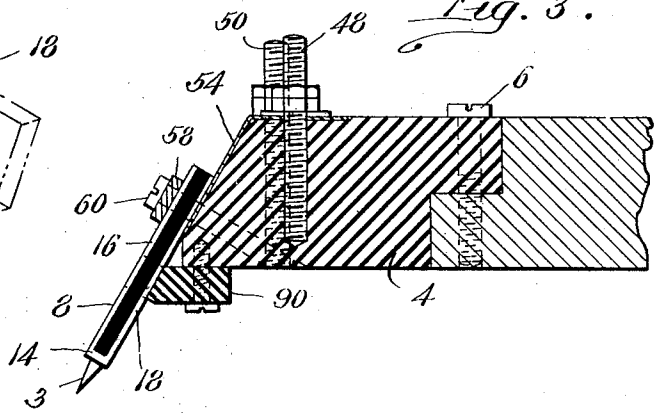


Fig. 3.



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Fig. 4.

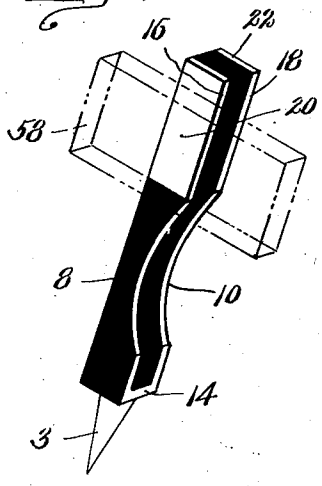


Fig. 5.

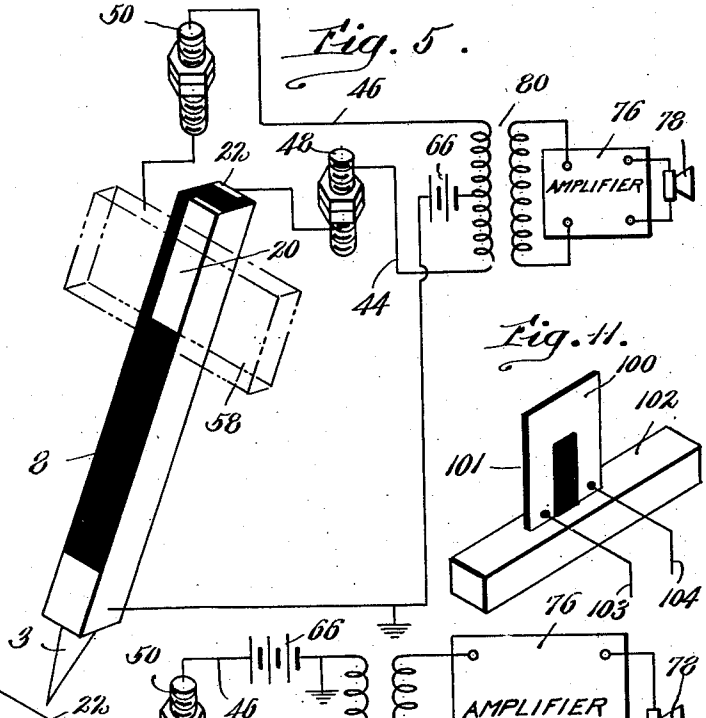


Fig. 11.

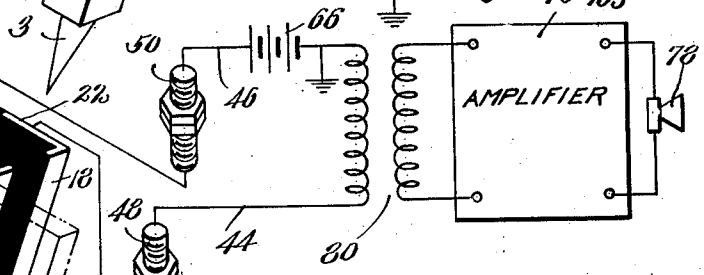


Fig. 6.

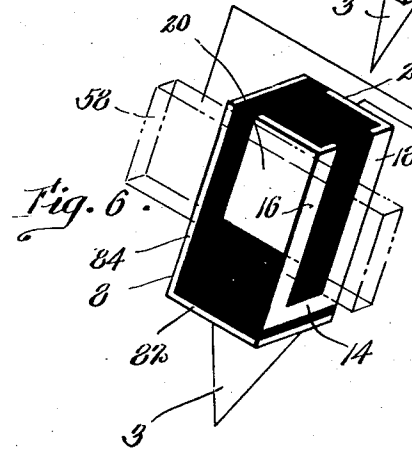


Fig. 8.

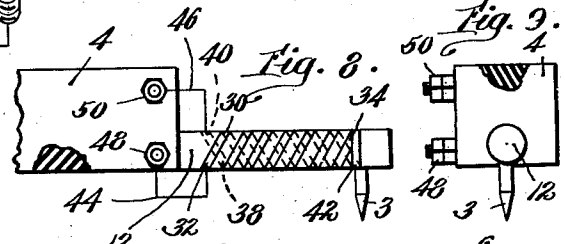


Fig. 9.

Fig. 7.

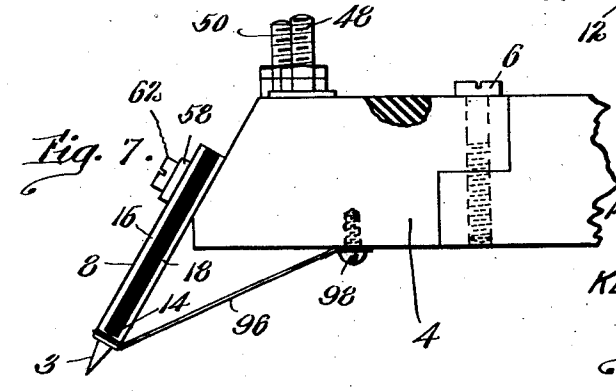
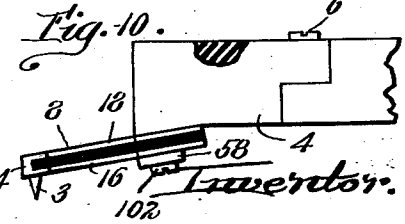


Fig. 10.



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UNITED STATES PATENT OFFICE

2,380,514

VIBRATION-TRANSLATING DEVICE

Kenneth Joseph Germeshausen, Cambridge, Mass.

Application June 12, 1940, Serial No. 340,156

10 Claims. (Cl. 179—100.41)

The present invention relates to electro-mechanical-conversion devices, and more particularly to vibration-translating devices, like phonograph pick-ups and microphones, for reproducing sound with wax, shellac, lacquer, metal, and similar phonograph-record materials.

An object of the present invention is to provide a new and improved phonograph reproducer that shall reproduce phonograph records with great fidelity and with very small wear on the material of which the records are constituted, even at high frequencies.

Other and further objects will be explained hereinafter, and will be particularly pointed out in the appended claims.

The invention will now be described in connection with the accompanying drawings, in which Fig. 1 is a fragmentary perspective illustrating the invention, as applied to a phonographic reproducer, one form of connections to a loud speaker being shown diagrammatically; Fig. 2 is a similar perspective, upon a larger scale, of the needle or stylus, showing also, in dotted lines, a plate normally in contact therewith when mounted on the reproducer or recorder supporting arm; Fig. 3 is a vertical section taken substantially upon the line 3—3 of Fig. 1, looking in the direction of the arrows; Fig. 4 is a perspective, similar to Fig. 2, of a modification; Figs. 5 and 6 are similar perspectives of modifications, diagrammatically showing also slightly different connections; Figs. 7 and 8 are side elevations of further modifications; Fig. 9 is an end elevation of the modification illustrated in Fig. 8; Fig. 10 is a side elevation of a further modification; and Fig. 11 illustrates the invention applied to use with microphones.

Referring to Figs. 1, 2 and 3, a stylus or needle 3, the lower end of which is adapted to be disposed in contact with the grooves in the phonograph record 1, is shown mounted rigidly upon a flexible insulating member 8. The member 8 may be rectangular in cross section and is in general somewhat longer than its thickness. Suitable dimensions for the member 8, as shown in Fig. 1, may be $\frac{1}{8}$ inch square in cross section, and $\frac{3}{4}$ inch long. The member 8 may be made of a suitable plastic, such as Celluloid, and should be of a material having a comparatively low modulus of elasticity.

The member 8 is rigidly clamped to an insulating support 4 which is, in turn, fastened to a suitable tone arm by means of screws 6, 6. The member 8 is shown provided with a conducting layer 14, 16 and 18 which is situated on the surface perpendicular to the direction of motion of the stylus 3 as produced by the modulation of the grooves of the record 1. The conducting layer is U-shaped, the U being shown extending longitudinally along the said surface. At the upper end of the member 8, the arms 16 and 18 of the U are shown connected to conducting surfaces 20 and 22. This facilitates connecting the conducting layer into the circuit.

The conducting layer 14 may be composed of graphite or it may be a very thin metallic layer. The conducting layer is in all cases, however, relatively thin compared to the thickness of the member 8 by which it is carried, in order that the characteristics of the system may be determined by the vibratory deflections of the flexible member 8. A preferred layer may be composed of finely divided carbon in a suitable binder, such as collodion or shellac. Other suitable coatings may be applied by means of colloidal suspensions of graphite in water or carbon tetrachloride. The coatings may be equally well applied in the manner used in the preparation of carbon resistors.

Movement of the stylus in the direction A—A, radially of the record, as produced by the record causes the member 8 to bend as a cantilever beam. The bending of the member 8 causes extension and compression of the conducting layer along with the outer fibers of the beam adjacent to the surface of the beam to which the conducting layer is secured. Extension and compression of the conducting layer causes a change in resistance of the layer and the change in resistance is proportional to the displacement of the stylus 3. When properly connected into a circuit, the changes in resistance may be used to produce a faithful electrical record of the motion of the stylus. Bending of the member 8 in the direction perpendicular to A—A does not produce a change in resistance since the average extension or compression of the conducting layer is zero.

To prevent resonance in the member 8, a damping element 90 is provided. This damping element may consist of rubber or a very soft plastic. The damping member is placed in contact with the moving element 8 and is in turn fastened to the insulating block 4. The damping element 90 absorbs unwanted vibrations of the moving element.

On the surface 56 of the insulating member 4 is a conducting metallic strip 54 which is connected to the binding post 48. The moving element 8 is held clamped to the conducting strip 54 at the same inclination as the surface 56 by a conducting plate 58, by means of screws 60 and 62 that extend through the plate 58 and into the insulating support 4, with the screw 60 in engagement with the binding post 50. The conducting layer 22 of the member 8 is thus held clamped in contact with conductor 54 and the

conducting layer 20 with the conducting plate 58.

Connections are thus established from the binding post 48 to the conducting strip 54 and to the conducting layer 22. The circuit continues down the arm 18 of the U-shaped resistance layer, and up the other arm 16, to the surface 20 which contacts the plate 58. From the plate 58, the connection continues by way of the screw 60 and to the binding post 50.

All that is necessary is to connect the binding posts 48 and 50 into the circuit. One such circuit is illustrated in Fig. 1, the conductors 44 and 46 being connected in circuit with a resistor 64 and a source of voltage, such as a battery 66. The resistor 64 may equally well be an inductance or a combination of resistance and inductance. This circuit is shown as capacitively coupled, by means of condenser 70 and resistor 72, to the input circuit of an amplifier 76 of any well-known form, and may include any desired number of stages, and the output circuit of which may be connected to a loud speaker 78. Instead of the resistance-capacitive coupling, transformer coupling may be employed as by means of the transformer 80 shown in Fig. 6. In both cases, the resistance of the graphite layer or layers is included in the circuit between the binding posts 48 and 50, and variations of this resistance resulting from the bending of the member 8 will be reproduced, in the loud speaker 78, as amplified sound variations.

The above methods of connecting the resistance layer into circuit are similar to those employed in the well-known case of the carbon microphone.

It should be understood that Fig. 1 merely shows one method of mounting the member 8 and of making connections to it. There are many possible ways that will occur to persons skilled in the art.

The resistance of the conducting layer 16, 14, 18 may be of any desired value. When used in circuits as shown in Fig. 1, it is desirable to have the resistance high, say 50,000 ohms, to secure maximum output. When used with transformer coupling, as in Fig. 6, it may be desirable to have the resistance low, as low as 500 to 1000 ohms.

Typical values for the circuit shown in Fig. 1 might be: the resistance of the moving element 50,000 ohms; that of the resistor 64,250,000 ohms; and the battery 66,300 volts. The voltage obtained from the battery 66 might equally well be obtained from the power supply for the amplifier.

The voltage obtained across the resistance layer of the member 8 is directly proportional to the movement of the stylus 3, and forms what is known as a "constant-amplitude pickup." With most commercial records, the low-frequency response would be excessive, and it is usually necessary to provide some compensation in the amplifier.

Fig. 4 shows a moving member 8 whose cross section is not uniform along its length. By providing a cut-away section 10, illustrated in Fig. 4, or by having a member of non-uniform cross section such as would be obtained by a tapered member 8, the effects of resonance are greatly minimized, and it is no longer necessary to employ a damping element, as in Fig. 1. It is desired to have the resonant frequency of the member 8 as low as possible, say 2000 cycles per second, since it then will be more flexible and will not require as much force to bend it.

In Fig. 7, there is shown a fine wire 96 extending from the stylus 3 to a screw 98 in the insulating support 4. This fine wire prevents the member 8 from bending in a direction parallel to the record grooves and thus prevents frequency modulation that would be caused by such bending.

As illustrated in Fig. 5, the resistance layers may be situated on opposite sides of the member 8. The pickup is thus rendered adaptable for push-pull operation, as is shown in the circuit of Fig. 5. This arrangement will eliminate any even harmonic distortion that may be present and is commonly used in the case of carbon microphones.

According to the modification in Fig. 6, the member 8 is much shorter and thicker than in Fig. 1. The amount of extension or compression of the resistance layers for a given stylus deflection is proportional to the length and the thickness of the member 8. A short thick member will have much greater extension and compression and hence greater output voltage. However, the arrangement shown in Fig. 6 will be much stiffer unless the modulus of elasticity of the member 8 is lower than that in Fig. 1. The output of the pickup in Fig. 6 is still further increased by confining all the extension and compression to the surface on which the resistance layer is situated. This is accomplished by a metallic layer 84, 82 which, because of its higher modulus of elasticity, prevents the deformation of the member 8 along those surfaces.

In Figs. 8 and 9, there is shown an arrangement where the flexible member is stressed in torsion, instead of bending. The resistance layers 30, 38 are helically coated around the flexible cylinder 12 from one end at 32 to the other at 34, and then it returns back to 40. The layers 30, 38 are arranged as a double thread, so that both are stretched or compressed by a given motion of the stylus 3. Connections are made at 32 and 40 by means of conductors 44 and 46 to the binding posts 50 and 48.

A preferred method of mounting the member 8 is shown in Fig. 10. The member 8 is similar to that shown in Fig. 4, but it is mounted horizontal with respect to the surface of the record, or very nearly so. The stylus 3 is fastened to the member 8 at the proper angle to contact the record grooves. The member 8 is fastened to the support 4 by means of the clamp 58 and the screw 102. Connections to the resistance layer 18, 16 may be made in any desired manner, or as shown in Fig. 1.

Arranging the member 8 in the position as shown in Fig. 10 prevents movement of the stylus 3 along the record groove and, further, it permits a degree of flexibility vertically. The latter is particularly desirable to reduce record wear and needle scratch, and to allow better tracking. Superior results are obtained with the mounting as shown in Fig. 10. Further, vertical flexibility prevents damage to the stylus 3 or to the record when the pickup is dropped or otherwise roughly engaged with the record.

The phonograph pickups as illustrated and described possess many advantages over present devices. They are very simple and inexpensive to construct and have long life. The low cost of the pickup element permits the use of a sapphire or semi-permanent stylus so that the need for changing needles is obviated.

Pickups built according to the description have excellent frequency response from zero to as high

as 20,000 cycles per second, and are free of distortion. The results obtained are markedly superior to the usual commercial device.

Of great importance is the extremely low mass of the moving parts and the great flexibility of the moving member. This allows a very low stylus pressure on the record, as little as one-third of an ounce, and also permits a very long record life. Commercial records may be played thousands of times with no appreciable wear.

In contrast to the use of loose carbon granules as in the carbon microphone, the resistance layer is permanent and does not deteriorate or become noisy with age.

In the microphone of Fig. 11, a thin flexible insulating member **100** is provided with a resistance layer **101**. The member **100** is supported by the clamping member **102**. Connections to the resistance layer are made by the conductors **103** and **104**. Sound waves striking the member **100** cause it to bend, thus changing the resistance of the layer **101**. These changes in resistance may be used to reproduce the sound waves striking the member **100**. A microphone of the above type has the advantage of permanence and simplicity over the usual type.

Further modifications will occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:

1. A vibration-translating device comprising a beam-like vibratory insulating element having a graphite conducting layer extending along one edge of a face of the element from one end of the element toward the opposite end, then across to another edge of the element, and then along the said other edge from the said opposite end to the said one end, the conducting layer being relatively thin compared to the thickness of the insulating element.

2. A vibration-translating device comprising a beam-like vibratory insulating element provided with a stylus and having a thin graphite conducting layer on a face disposed substantially perpendicular to the direction of vibration of the stylus, the element being reduced in thickness in the direction of vibration of the stylus.

3. A vibration-translating device consisting of a beam-like flexible member arranged to be deflected by the vibration, said member being provided on at least one surface with a thin resistance layer that will be stressed by the deflection of the member, and this member being of non-uniform cross section to prevent resonance effects.

4. A vibration-translating device adapted to be mounted on a tone arm and to have a stylus directly connected thereto, comprising a beam-like vibratory insulating element connected at one end to the tone arm and having on at least one surface thereof a thin graphite conducting layer, the stylus having one end adapted to ride in contact with a record and the other end connected directly to the other end of the vibratory insulating element.

5. Apparatus of the character described adapted to be mounted on a movable, substantially rigid member of considerable inertia, as a phonograph tone arm, for reproducing mechanically recorded sound, including: a small, beam-like translating element having one end thereof rigidly mounted on the member; a relatively thin coating on at least one surface of the element, flexure of the element affecting its electrical resistance; and record engaging means rigidly mounted on said element, whereby electrical variations are effected by vibrations transmitted directly and unmodified to the translating element.

6. Apparatus of the character described adapted to be mounted on a movable tone arm for translating mechanical variations in the grooves of a rotating record into corresponding electrical variations, and adapted to be vibrated by a short, rigid stylus, including: a very small, light, flexible beam-like element of non-conducting material having one end thereof rigidly mounted on the tone arm and adapted to have the other end closely approach the record when the arm is in operative relation thereto; and a very thin conductive but high resistance coating on at least one surface of said element, said coating being of material having its resistance varied by strain therein upon flexure of the element, said stylus being mounted directly and rigidly on said other end of the element and adapted to engage the rotating record, whereby electrical variations are effected by vibrations transmitted directly and unmodified to the translating element.

7. Apparatus for translating mechanical vibrations into corresponding electrical variations, including: a beam-like vibratory element fixedly mounted at one end, at least the surface of said element being of non-conducting material; and a thin coating of conducting material originating at the fixedly mounted end of the element, extending to the free end of the element, and returning in an unbroken circuit path to the fixedly mounted end, said coating being of material having its electrical resistance varied by strains therein.

8. Apparatus for translating mechanical vibrations into corresponding electrical variations, including: a beam-like vibratory element fixedly mounted at one end, at least one surface of said element being of non-conducting material and the cross section of the element being rectangular; and a thin coating of conducting but high resistance material on said surface of the element, originating at the fixedly mounted end of the element, extending to the free end of the element, and returning in an unbroken circuit path to the fixedly mounted end, said coating being of material having its electrical resistance varied by strains therein.

9. A vibration-translating device comprising a flexible beam arranged to be deflected about a longitudinal axis therewithin and provided on its opposite surfaces with layers of resistance material that are relatively thin compared to the thickness of the beam, the layers of resistance material being bonded to the respective surfaces so as to be oppositely stressed with the fibers of the beam adjacent to the said surfaces in response to the vibratory deflection of the beam.

10. A vibration-translating device comprising a vibratory flexible beam having a record reproducing stylus fixed on one end thereof and at least one surface of insulating material and having on said surface a high resistance, thin conducting layer, whereby the resistance of said layer is varied by flexure of said beam, the beam being of non-uniform cross-section.

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