Oct. 11, 1932. G. W. PIERCE ET AL 1,882,400

VIBRATORY DEVICE

Filed March 4, 1931

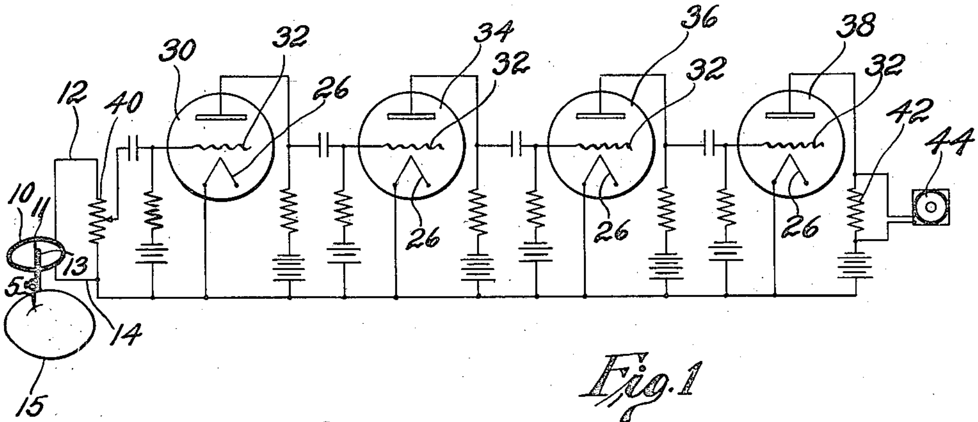

Fig. 1

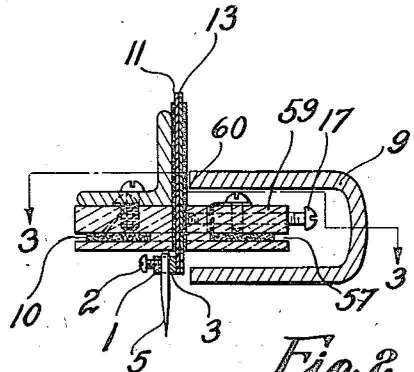

Fig. 2

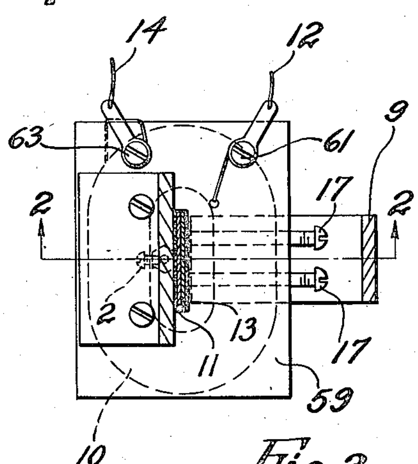

Fig. 3

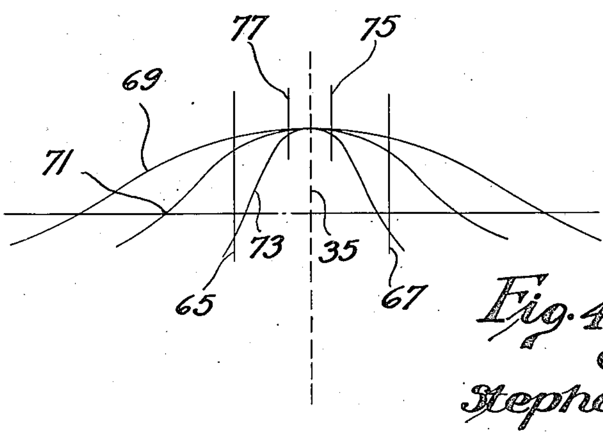

Fig. 4

Inventors
George W. Pierce
Stephen A. Buckingham
By David Rines
Attorney

Patented Oct. 11, 1932 1,882,400

UNITED STATES PATENT OFFICE

GEORGE WASHINGTON PIERCE, OF CAMBRIDGE, MASSACHUSETTS, AND STEPHEN ALVORD BUCKINGHAM, OF CHEVY CHASE, MARYLAND; SAID BUCKINGHAM ASSIGNOR TO SAID PIERCE

VIBRATORY DEVICE

Application filed March 4, 1931. Serial No. 519,970.

The present invention relates to magnetostrictive devices and, though having more general fields of usefulness, as hereinafter set forth, will be described more particularly in connection with phonographic reproducers and recorders. In the following specification and claims, the word "phonographic", or its equivalent, will be used in a broad sense to signify either a reproducer or a recorder. A chief object of the present invention is to provide a phonograph operable by magnetostrictive action. Other objects will be explained hereinafter, and will be particularly pointed out in the appended claims.

The invention will be explained in greater detail in connection with the accompanying drawing, in which Fig. 1 is a diagrammatic view of circuits and apparatus constructed and arranged according to a preferred embodiment of the present invention; Fig. 2 is a section of a portion of the apparatus illustrated in Fig. 1, the section being taken upon the line 2—2 of Fig. 3, looking in the direction of the arrows; Fig. 3 is a section taken upon the line 3—3 of Fig. 2, looking in the direction of the arrows; and Fig. 4 illustrates qualitative or ideal plots or curves for an aid to an understanding of the present invention.

A needle holder 1 is secured, in any desired manner, as by soldering at 3, to a magnetostrictive core, and holds a phonograph needle 5, which may be removed by means of a set screw 2. The core may be held in place in any approved manner as by means of clamping screws 17. The magnetostrictive core is positioned substantially in axial alinement within an inductive and resistive solenoid field coil 10, provided with conductors or leads 12 and 14, by means of which it is connected into circuit with a resistance 40. The resistance 40 is connected in the input circuit, between the filament 26 and the grid 32, of a vacuum tube 30. This tube may be of the 240 type and is coupled to a similar tube 34. Two further stages of amplification, represented by a tube 36, that may be of type 171, and a tube 38, that may be of type 250, are illustrated, the output circuit of the last-named tube having a resistor 42 to which a loud speaker 44 may be coupled. The various couplings, though illustrated as of the resistance-coupled type, may, of course, be of any desired form.

As is explained in Letters Patent No. 1,750,124, granted March 11, 1930, it is desirable to apply a steady magnetizing field to the core, in order to increase its magnetostrictive effect; and this result may be attained either by passing through the coil 10 a steady magnetizing current from a battery or other source of supply (not shown) or, preferably, by means of a permanent magnet 9.

The vibrations of the needle 5, running in the grooves of a phonograph disc 15, will be communicated to the magnetostrictive core and the resulting deformations or distortions, in turn, into variations in the electric current or voltage in the circuit, as will be understood from the description in the said Letters Patent. The amplified current will produce correspondingly amplified variations in the sound issuing from the loud speaker 44. The loud speaker will thus reproduce the sound that was originally recorded on the phonograph disc 15.

A magnetostrictive core such as is illustrated in the said Letters Patent may be used, but it is preferred, for improved results, to employ a composite or bimetallic core because of its greater sensitivity. The illustrated core is constituted of strips 11 and 13 of dissimilar materials integrally united along their adjoining surfaces throughout their length or at several isolated points in any desired way, as by welding, spot-welding, soldering, or pressing. At least one of these materials is magnetostrictive, and if both are, they should preferably have magnetostrictive properties of different degree or in the opposite sense. Nickel has very good magnetostrictive properties; phosphor bronze, none at all. Phosphor bronze, however, has very desirable springy qualities and, furthermore, lends itself readily to soldering to the nickel strip. Other metals than phosphor bronze may, however, be employed, among them copper.

The reasons for the greater sensitivity of the composite core will be understood from the following considerations. In a solid nickel core, for example, the magnetostrictive effect of expansion on one side of the centre would tend to become neutralized by the magnetostrictive effect of contraction on the other side of the center, and only the difference between the two effects would remain. This differential effect, probably produced by non-linearity or strains in the metal, or both, is eliminated by the bimetallic nature of the core.

The core should be of a length such that its natural frequency of mechanical vibration shall lie either above or below the range desired; though the response may be broad enough to be tolerable if the core is sufficiently damped. Within limits, the greater the thickness and the width of the core, the greater is its sensitivity. The core is shown in the drawing longer than is really needed, but the added length is of no functional consequence, the nodes of the core being positioned in the same place irrespective of its length.

In order to prevent leakage, the coil 10 is positioned as close as possible to the core, though not so close as to interfere with its vibrations. The spacing between the coil and the core, to prevent binding, should be as small as is mechanically feasible, thus reducing leakage as far as possible. The amount of the spacing necessary, therefore, is determined entirely by the dimensions of the device and the material used in its construction. In some cases, however, the coil may be wound directly on the core. The dimension of the coil may have any convenient values consistent with the frequency range that it is desired to reproduce.

A node of bending of the core is a node of distortion of the material of which it is made and hence a node of magneto-strictive effect. The magneto-strictive effects on the two sides of such a node are opposite and hence, when such a node lies within the coil, opposite effects will be produced in the parts of the coil on opposite sides of the node. If the core were homogeneous throughout its length and if the node lay at the exact center of an ideal coil, complete neutralization might occur; but in general if the coil is not ideal, or if the core is not homogeneous, or if the node is not at the center of the coil, the effect is only to reduce the response to the frequency of the core provided with a node so positioned. For greatest sensitivity the coil should be short enough to extend only from one node to the next, and should have its center at an anti-node of bending.

For different frequencies, the wave-length, and hence the distance between nodes, is different and the higher the frequency, the shorter is the wave-length. For uniform reproduction of a band of frequencies, therefore, the coil should preferably be short in comparison with the wave-length of the highest frequency desired. A coil of length equal to the distance between the lines 65 and 67 in Fig. 4 while reproducing fairly equally frequencies corresponding to the curves 69 and 71 would be decidedly deficient in its reproduction of frequencies corresponding to the curve 73, since a coil of such length would overlap two nodes. In the case of a coil having a length equal to the distance between the lines 75 and 77, on the other hand, which length is short compared to the shortest wave-length desired, the magnitude of the magnetostrictive effect will be nearly a maximum throughout the length of the coil, for all of the frequencies, and hence the reproduction is practically uniform. Such a short coil, however, will not give maximum sensitivity for any of the frequencies illustrated, but only for some one frequency, which will be higher than any frequency shown.

In general, no such nice even configuration as that shown will exist, but instead the antinodes will be scattered along the core so that no matter how short the coil, it would not meet the requirements of uniform reproduction. In order to have the antinodes positioned closely together, or substantially at a single point, resort should be had to some device, such as changing the location of the coil along the core, or constraining the core. According to the expedient adopted in Figs. 2 and 3, the core is clamped tightly at some point, as by means of the screws 17, thus constraining it to have an antinode of bending at that point for every frequency of its distortion. If clamping constrains one side, only one half of Fig. 4 will apply, the half either to the right or to the left of the line 35. The coil need only be short in comparison with a quarter wave-length in the case that only half of Fig. 4 applies. The coil should, preferably, be placed close to the clamp, in order to give good results. In Fig. 2, the coil 10 is located as close to the clamping screws 17 as is consistent with strong mechanical construction. The above description, in the case of clamping, has been stated in slightly idealized form, because in actual practice, where the clamp yields somewhat, the antinodes may not all occur exactly at the supposed point of clamping.

As shown, therefore, the coil 10 is preferably quite flat, using convenient dimensions of the core. The preferred length of the coil, being governed by the wave length of the lateral vibration of sound in the core, may be altered by changes in thickness or elastic properties of the materials composing the core.

Under certain conditions of clamping, it may happen that the whole of Fig. 4 applies, in which case the coil need only be small in comparison with a half wave-length and should preferably have its centre at the clamp.

The following dimensions have been found to produce very satisfactory results: a half-nickel, half-bronze, soldered core ⅜ inches long, ⅝ inches wide and 0.050 inches thick; and a coil 3/64 inches long having 2100 turns of No. 40 enamelled wire. The coil was wound around in a slot 57 in an insulating support 59 of length 2¼ inches, width 1⅝ inches and thickness 5/16 inches. The slot 57 was 3/64 inches long. The support 59 may be of bakelite-impregnated duck layers. The slot 60 through which the cores extended was ¾ inch long and ¼ inch wide. The ends of the coil were secured to terminals 61 and 63 to which the conductors 12 and 14 were respectively connected.

The invention yields quite a fruitful reproduction of the sound recorded on the record 15, and the quality is most satisfactory, both on loud and low reproduction, and at high and low frequencies.

The above description has proceeded upon the supposition that the invention is utilized as a reproducer. Obviously, however, the operation is reversible and the coil 10 may be used to drive the core for record-cutting purposes.

The device herein described is by no means limited to use as a phonographic reproducer or recorder in the customary sense of the word, but can be used for practically any purpose requiring the transformation of mechanical vibrations into electrical ones or electrical vibrations into mechanical ones. The vibrations need not be plural, for a single impulse will produce an effect. It might be used, for instance, for the measurement of speeds, of revolution, or of frequency of occurrence of any sort of mechanical impact. It would have the advantage over the ordinary tachometer that it could register at some place remote from the source, without the use of long and unwieldy cables.

For example, to measure linear speeds, the magnetostrictive core, 11, 13, might be attached to the moving member and the needle 5 might be caused to run in a properly designed track, such as a sine-wave track. Again, to measure the speed of a rotating shaft the needle should travel in a properly designed continuous path, which may be either concentric with the axis of the shaft and having irregularities, such as sine variations, or it might be eccentric and either smooth or otherwise suitably designed. The invention might also be used, for example, as a counter of impulses, such as may be produced by successively falling bodies, the bodies falling on the needle 5 or other extending portion of the core.

The invention is not, of course, limited to the modifications illustrated herein, and may be further modified and changed by persons skilled in the art without departing from its spirit and scope, as defined in the appended claims.

What is claimed is:

1. A phonographic device comprising a magnetostrictive core constituted of mechanically connected members having different magnetostrictive properties integrally secured together so as to vibrate as a unitary vibrator, and a phonograph needle connected with the core.

2. A phonographic device comprising a coil, a core adapted to be subjected to the electromagnetic field of the coil, the core being constituted of mechanically connected members having different magnetostrictive properties integrally secured together so as to vibrate as a unitary vibrator, a phonograph needle connected with the core, and a circuit in which the coil is connected.

3. A phonographic device comprising a composite core constituted of mechanically connected members one of which is magnetostrictive and the other of which is not magnetostictive and a phonograph needle connected with the core.

4. A phonographic device comprising a composite core constituted of mechanically connected members of which one is magnetostrictive and the other of which is not magnetostrictive but has a relatively high degree of elasticity and a phonograph needle connected with the core.

5. A phonographic device comprising a composite core constituted of mechanically connected nickel and phosphor-bronze strips, and a phonograph needle connected with the core.

6. A device of the class described comprising a magnetomechanical core and a coil surrounding the core, the length of the coil being small compared with a quarter wave-length of sound of the highest frequency which it is desired to reproduce.

7. A device of the class described comprising a magnetomechanical core and a coil surrounding the core, the length of the coil being small compared with a half wave length of sound of the highest frequency which it is desired to reproduce.

8. A phonographic device comprising a composite core constituted of mechanically connected members having different magnetostrictive properties secured to each other along their length, and a phonograph needle connected with the core.

9. A phonographic device comprising a composite core constituted of mechanically connected members one of which is magnetostrictive and the other of which is not magnetostrictive, the members being secured to each other along their length and a phonograph needle connected with the core.

10. A phonographic device comprising a composite core constituted of mechanically connected nickel and phosphor-bronze strips integrally secured together, and a phonograph needle connected with the core.

11. A device of the class described comprising a composite core constituted of mechanically connected members having different magnetostrictive properties integrally secured together and a coil surrounding the core, the length of the coil being small compared with a quarter wave-length of sound of the highest frequency which it is desired to reproduce.

12. A device of the class described comprising a composite core constituted of mechanically connected members having different magnetostrictive properties integrally secured together and a coil surrounding the core, the length of the coil being small compared with a half wave-length of sound of the highest frequency which it is desired to reproduce.

13. A phonographic device comprising a clamped magnetomechanical core constituted of mechanically connected members having different magnetostrictive properties integrally secured together so as to vibrate as a unitary vibrator, a coil surrounding the core and disposed very near to the clamped portion of the core, and a phonograph needle connected with the core.

14. A device of the class described comprising a clamped magnetomechanical core constituted of mechanically connected members having different magnetostrictive properties integrally secured together along their length, a coil surrounding the core and disposed very near to the clamped portion of the core, and a phonograph needle connected with the core.

In testimony whereof, we have hereunto subscribed our names this 24 day of February, 1931.

GEORGE W. PIERCE.
STEPHEN A. BUCKINGHAM.