

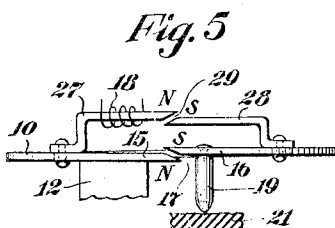
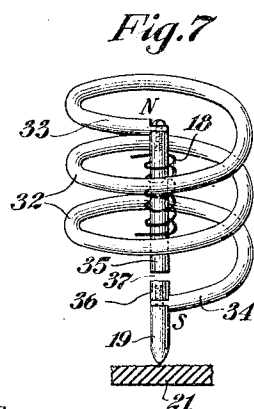
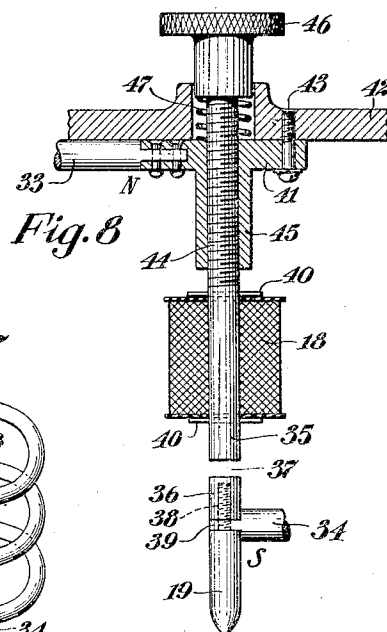
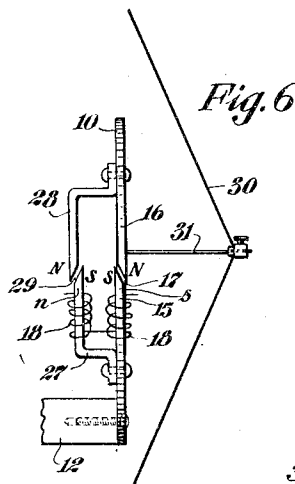
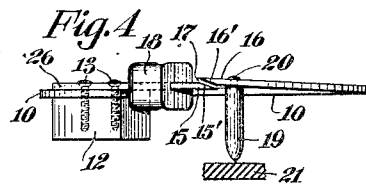
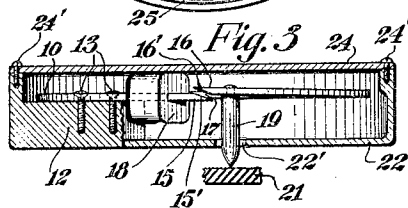
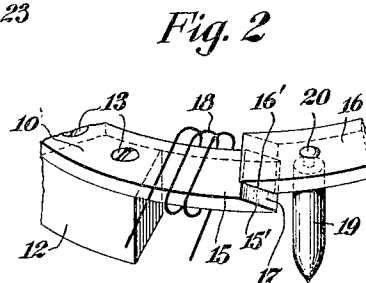
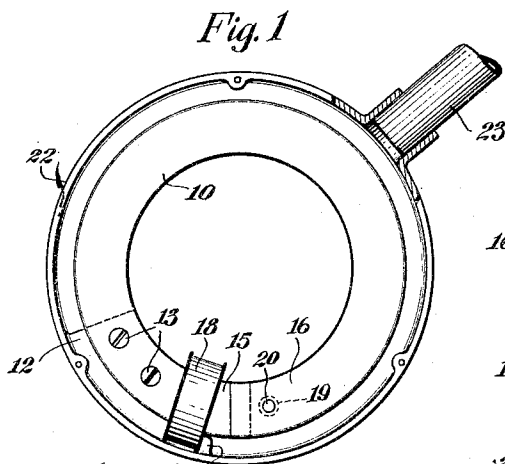
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1,792,554

ELECTROMAGNETIC INSTRUMENT

Filed April 4, 1928



INVENTOR

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ELECTROMAGNETIC INSTRUMENT

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This invention is for an electromagnetic instrument characterized by utter simplicity of structure and high sensitiveness in operation, and capable of functioning equally well as transmitter and receiver. The most important feature of my invention is an elastic spiral magnet having relatively movable polar ends to provide a variable airgap. One end of the magnet is rigidly supported, while the other end is resilient and free to vibrate. If the instrument is designed as a transmitter, an acoustically actuated member is connected to the free resilient end of the spiral magnet. A coil mounted on the magnet generates current impulses in accordance with the movements of the connected member, which may be an acoustic diaphragm, a phonograph stylus, and the like. As will be explained later, this new instrument is particularly useful as a pick-up for vertical-cut records of the finely grooved type in which the track runs to several hundred lines to the inch.

My invention is also adapted to operate as a receiver for converting electric impulses to mechanical vibration. As instances of such use I may mention driving units for cone speakers and recording tools for phonograph records. Whether my new instrument is constructed as a transmitter or as a receiver, there is a total absence of lost motion between the vibratory end of the spiral magnet and the connected member. In fact, the magnet is its own armature, so that the construction is one of unusual simplicity and compactness, coupled with a high degree of sensitivity.

The operation and advantages of my invention will be fully understood from a description of the accompanying drawings, in which—

Fig. 1 shows a plan of a phonograph pick-up embodying a simple form of elastic spiral magnet;

Fig. 2 is an enlarged perspective of a portion of the magnet shown in Fig. 1 to illustrate more clearly the overlapping pole pieces;

Fig. 3 is a side view of Fig. 1, partly in section;

Fig. 4 shows a construction in which the coil is mounted on a separate polar extension of the magnet;

Fig. 5 illustrates a pickup having a modified form of spiral magnet in which the ends carry each a polar extension to provide two airgaps in parallel;

Fig. 6 represents a driving unit for cone speakers embodying the spiral magnet of Fig. 5.

Fig. 7 is an isometric perspective of a pickup having a spiral magnet with several turns; and

Fig. 8 is an enlarged fragmentary view of Fig. 7 to show an adjustable mounting for one of the pole pieces.

Referring first to Figs. 1, 2 and 3, there is a permanent magnet 10 in the form of an elastic spiral of one turn mounted at or near one end on a fixed support 12 by screws 13 or otherwise. In the present instance, this magnet consists of a one-piece band or flat bar of resilient magnetic metal shaped into a spiral ring with overlapping polar ends 15 and 16. Steel alloys of silicon, tungsten and chromium are widely used for permanent magnets of good quality. The elastic spiral body of magnet 10 may be solid or composed of thin laminae suitably held together. In the broader aspect of my invention, the magnet 10 may be an electromagnet, especially in those cases where an unusually heavy magnet field is required.

The overlapping pole pieces or polar ends 15 and 16 of magnet 10 are preferably cut obliquely, as shown at 15' and 16', to provide an airgap 17 of increased cross-sectional area. That is to say, the area of this oblique airgap is considerably greater than the radial cross-sectional area of the flat spiral band that constitutes the magnet, whereby the efficiency and sensitivity of the instrument are increased. This will be clear to electrical experts without further explanation. The polar end 15 is rigid, while the polar end 16 is resilient and free to vibrate. A coil 18 is mounted on the fixed pole piece 15 or in any other operative position on the magnet. Since the device of Figs. 1, 2 and 3 was designed as an electric phonograph pickup for

vertical-cut records, a vertically movable stylus member 19 is attached to the vibratory polar end 16 in any practical way, as by a screw or rivet 20. In Fig. 3, the stylus member 19 is shown in playing contact with a vertical-cut disk record 21, of which the Edison type is probably the best known example.

The elastic spiral magnet 10 is enclosed in a non-magnetic casing 22 carried by an arm 23, which is mounted at its other end to swing horizontally and vertically over the record, so that the stylus member 19 can follow the helical groove on the record surface. As such mountings are well known in the art, I need not show or describe them. For vertical-cut records, the magnet 10 is supported substantially in horizontal position, and so the casing 22 is a flat cylindrical box, as shown in Fig. 3. The supporting block 12 is best formed as an integral projection of the casing, which may be cast or molded of aluminum, brass, bakelite, or any other suitable material. Aluminum is recommended on account of its lightness and strength. The casing 22 has a removable top 24 fastened by screws 24', so that the magnet 10 and all parts carried thereby can be inserted as a unit through the open top of the casing. The stylus member 19 extends through an opening 22' in the bottom of casing 22 near the front edge thereof.

The coil 18 is machine-wound and is slipped over the magnet by bending the resilient polar end 16 out of the way. This, of course, is done before the stylus member 19 is attached to the magnet. A simple way to hold coil 18 in place on the magnet is to provide the inner wall of casing 22 with an integral lug 25 spaced the width of the coil from the adjacent side of block 12. When the magnet 10 is inserted in the casing, the coil is retained between block 12 and lug 25 without the need of separate fastening means.

In the operation of the pickup above described, the vertical vibrations of stylus member 19 as it tracks a record are directly transmitted to the elastic free end 16 of the magnet, so that the airgap 17 is correspondingly varied to produce current impulses in coil 18. It goes without saying that this coil is connected in the input circuit of a suitable transmission system which amplifies the impulses in the coil to operate or control loud-speaker mechanism. As there are many such systems available in the radio art, and as they are furthermore well understood, I need say nothing more about the circuit connections of coil 18. The absence of all lost motion in actuating the vibratory portion of the elastic spiral magnet and the large airgap area formed by the oblique overlapping polar faces 15' and 16' make the instrument unusually sensitive to the minutest vibrations of stylus member 19. This pickup is therefore capable of efficiently reproducing from

the so-called long-playing records in which the groove has several hundred lines to the inch.

Another practical advantage of the elastic spiral magnet 10 lies in its inherent ability to adjust itself automatically to different frequencies and amplitudes. In other words, the length or section of the resilient magnet in motion at any instant depends on the impressed frequency and amplitude, the length of the vibrating section increasing as the frequencies decrease and the amplitudes increase. I do not say that there is a fixed mathematical ratio between those factors, because that is not necessary. It is sufficient to say that variable lengths of the spiral magnet 10 come into action according to the varying frequencies and amplitudes of vibration transmitted by the playing stylus member 19. The result is a reproduction with substantially uniform efficiency over the entire musical scale.

Obviously, the dimensions of magnet 10 must be so chosen as to impart the right degree of elasticity to the magnet for any particular design of instrument. This can only be determined by actual experiment, because so many factors must be taken into account that no fixed mathematical rule can be laid down. For example, the material of the magnet is an important factor in determining the diameter, width and thickness of the spiral band, which should have sufficient stiffness to support the weight of the pickup as a whole in playing position without causing an undue separation of the pole pieces 15 and 16. On the other hand, if the magnet is too stiff, the pole piece 16 will not respond efficiently to the movements of the stylus member. The right amount of stiffness or resiliency in the spiral magnet can be ascertained by the experimental skill of those who are familiar with this art. Figs. 1, 2 and 3 are not to be considered shop drawings laid out to accurate scale. On the contrary, those figures have been purposely exaggerated for clearness, the actual device being much smaller.

I would call attention to the uttermost simplicity of the electromagnetic instrument above described. There is in effect only one movable part: an elastic spiral magnet carrying an actuating member 19. There is no armature separate from the magnet, which operates as its own armature. When the pickup is in idle or rest position, the inherent resiliency of the spiral magnet holds the movable pole piece 16 slightly spaced from the fixed pole piece 15. When the stylus member is placed on a record, the weight of the pickup causes a small increase of airgap 17, depending on the resiliency of the magnet at the free polar end as well as on the effective weight or pressure at the stylus point. If the pickup should be accidentally dropped,

there would be a momentary rise of pole piece 16, but no damage would result. There is really nothing to get out of order, and if the stylus member has a permanent point requiring no replacement (like a diamond point for playing Edison records), the instrument will always be in playing condition without attention by the user. It should be noted that the stylus member 19 is near the front edge of casing 22, so that a person can easily see the stylus point when placing it on a record. The stylus member may obviously be replaced by any other form of acoustically actuated element, such as a diaphragm for transmitting sound, or other practical connection for imparting movement to pole piece 16.

The device of Figs. 1, 2 and 3 can equally well be used as a receiver by sending current impulses through coil 18 to cause vibration of the resilient pole piece 16. In that case, the part 19 might be an acoustic diaphragm for reproducing transmitted sound, or a recording tool for cutting a stylus track in a phonograph record, or any other member capable of performing a useful function. In the basic aspect of my invention it is immaterial to what service the vibrations of the elastic spiral magnet are applied.

The pickup of Fig. 4 differs from that of the preceding figures in having a separate pole piece 26 on which the coil 18 is mounted. The practical advantage of this modification is that a machine-wound coil can be mounted on the magnet without forcing the ends of the elastic spiral apart, as in Figs. 1-3. The polar extension 26 is preferably of higher magnetic permeability than the body of the magnet and is fixed in place by screws 13 (or otherwise) after the coil 18 has been slipped over it. If desired, the pole piece 26 may have slots through which the fastening members 13 pass in order to permit adjustment of the pole piece relatively to the other polar end of the magnet. In this way, the normal width of airgap 17 may be regulated. Otherwise, what has been said about Figs. 1-3 applies fully to Fig. 4 without the need of repetition.

In Fig. 5, the elastic spiral magnet 10 is provided with a pair of polar extensions 27 and 28 arranged to form an airgap 29 in parallel with airgap 17. The coil 18 is preferably mounted on polar extension 27, because the coil can be slipped in position before the extension is secured to the magnet. The airgaps 17 and 29 are in opposed relation, so that one is decreased when the other is increased. When the vibratory end of the magnet moves up (as viewed in Fig. 5), the lower airgap 17 is increased and the upper airgap 29 is simultaneously decreased, with the result that most of the field flux passes through coil 18. Conversely, when the polar ends 16 and 28 move down, the airgap 29 is increased

while the airgap 17 is decreased, so that most of the flux passes through the main pole pieces 15 and 16. It is thus evident that the vibrations of member 19 produce corresponding flux variations in coil 18, and these flux variations are in amplified ratio to the movements of the actuating member. That is so because the parallel flux paths 15-16 and 27-28 are cumulative in their effect on the coil. The polar extensions 27 and 28 are preferably of a material having greater magnetic permeability than the steel body of the magnet.

The construction of Fig. 5 may be utilized as a receiver to operate a loudspeaking diaphragm, as shown in Fig. 6, where a cone diaphragm 30 is connected by a rod or link 31 to the vibratory end 16 of the spiral magnet. In this instance it is better to use two coils 18 mounted on the stationary pole pieces 15 and 27. These coils are connected in series and are so wound as to produce opposing polarities. Thus, if at any moment the coil on pole piece 27 produces a north polarity at *n*, the coil on pole piece 15 produces a south polarity at *s*. Consequently, the magnetic attraction across airgap 29 is weakened and that across airgap 17 is strengthened, with the result that the diaphragm 30 is pulled toward the left (as viewed in Fig. 6). When the current impulses in coils 18 produce polarities that weaken the flux across airgap 17 and simultaneously strengthen the flux across airgap 29, the diaphragm is pushed toward the right. We therefore have positive actuation of the diaphragm in each direction, this being known as a push-pull operation. The variable talking flux of coils 18 does not pass through the complete body of the magnet, but has a path of its own through the main pole pieces 15 and 16 and the auxiliary polar extensions 27 and 28, whereby the efficiency and sensitiveness of the driving unit are increased.

Fig. 7 shows a magnet 32 in the form of an elastic spiral having a plurality of turns arranged vertically to operate as a phonograph pickup for vertical-cut records. The upper polar end 33 of the magnet is fixed, while the lower end 34 is free to vibrate. The spiral coils 32 are shaped from elastic steel wire capable of being permanently magnetized and having the required degree of resilience. A pole piece 35 is secured to the stationary end 33 of the magnet so as to extend through the spiral approximately in the direction of its axis. The lower end 34 of the magnet is preferably provided with a short pole piece 36 in axial alignment with the stationary pole piece 35 to provide a variable airgap 37. A simple way to attach the pole piece 36 is by means of a screwthreaded extension 38 on stylus member 19. The pole piece 36 is threaded to receive the extension 38, whereby the parts 19 and 36 are rigidly clamped on opposite sides of a flat tongue 39 in which the magnet end

34 terminates. The coil 18 is supported on pole pieces 35 in any practical way, as by cross-pins 40.

The enlarged view of Fig. 8 illustrates an adjustable mounting for pole piece 35 for regulating the normal width of airgap 37. The polar end 33 of spiral magnet 32 is attached to a magnetic plate 41, which is mounted in a non-magnetic casing 42. It is understood that this casing is operatively supported on a movable arm, as explained in connection with casing 22 of Figs. 1 and 3. Screws or bolts 43 hold the magnetic plate 41 to the underside of the top of casing 42. The pole piece 35 is a round iron core with a screwthreaded portion 44 rotatably mounted in a screwthreaded hub or extension 45 of plate 41. A finger piece 46 attached to the upper end of pole piece 35 (or otherwise connected thereto) permits axial adjustment of the pole piece from outside the casing. A tensioned coil spring 47 holds the pole piece 35 firmly in adjusted position. The screwthreaded mounting of pole piece 35 is so fine as to produce micrometer regulation of the normal airgap 37 for the best operation of the instrument.

There is no need to go into a detailed description of the operation of Figs. 7 and 8, for what was said about the elastic spiral magnet 10 of the other figures applies to the elastic spiral magnet 32. The several turns of spiral 32 make it more flexible than the single turn of spiral 10, in addition to providing a magnet of greater length, which is always an advantage. The actuating member 19 of Figs. 7 and 8 may be replaced by any other practical form of connection either to vibrate the resilient end 34 of the spiral magnet or to be vibrated by current impulses in coil 18. Although the turns of spiral 32 are shown as having the same diameter, it is evident that they may become smaller as they progress toward the lower end. In other words, the spiral turns 32 may outline a cylinder (as illustrated) or a cone.

As the terms "spiral" and "helical" are frequently used by mechanics and engineers in a confusing sense, I want to make it clear that in the description and claims I use the word "spiral" to designate a coiled figure or curve which advances in the direction of its axis, like wire or ribbon wound progressively around an imaginary cylinder or cone, and which may have one or more turns.

When I speak of an elastic spiral magnet in the claims, I use the expression in a broad sense to include magnets having one or more spiral turns. The particular embodiments which I have selected for illustration and description are not to be regarded as limitations of my invention, which may be carried out in other ways without departing from the scope of the appended claims.

I claim as my invention:

1. An electromagnetic device comprising an elastic spiral magnet having relatively movable polar ends to provide a variable airgap, a coil associated with said magnet, and an operative member connected to a movable polar end.

2. A device of the class described comprising a permanent magnet in the form of a spiral spring having its ends arranged to provide a variable airgap, a coil on said magnet, and an operative member connected to a movable portion of said spring.

3. A device of the class described comprising a permanent magnet in the form of an elastic spiral having overlapping polar ends to provide a variable airgap, a coil influenced by or producing variations in said airgap, and an operative member connected to a movable portion of said spiral.

4. A device of the class described comprising a permanent magnet having a one-piece body in the form of an elastic spiral, whereby the polar ends of said magnet are relatively movable to form a variable airgap, a coil associated with said magnet, and an operative member connected to a movable polar end.

5. A device of the class described comprising a permanent magnet comprising a flat elastic band or ribbon of steel in the form of a spiral, the polar ends of said spiral band overlapping to provide a variable airgap, a coil associated with said magnet, and an acoustic member connected to a movable portion of said spiral.

6. An electromagnetic instrument comprising a magnet having an elastic spiral body provided with relatively movable pole pieces arranged substantially in the axis of the spiral, and a coil in operative relation to said magnet.

7. An electromagnetic instrument comprising an elastic spiral magnet having relatively movable polar ends to provide a variable airgap, means for adjusting the normal distance between said polar ends, and a coil in operative relation to said magnet.

8. In an electromagnetic instrument adapted to transmit or receive vibratory movements, a permanent magnet in the form of an elastic spiral capable of vibration for at least a portion of its length, and a coil influenced by the vibrations of said magnet, said coil being also adapted to receive current impulses to cause vibration of said magnet.

9. A device of the class described having a permanent magnet comprising a flat elastic band or ribbon of steel in the form of a spiral, the polar ends of said spiral band being cut obliquely and overlapping to provide a variable airgap, the oblique polar faces having each a greater area than the radial cross-sectional area of the band, a coil associated with said magnet, and an operative member connected to a movable portion of said spiral.

10. An electric phonograph reproducer comprising a spring magnet adapted to vibrate at one end to vary the magnetic airgap, and a stylus member connected to said vibratory end.

vary the magnetic airgap, and a coil in operative relation to said magnet.

18. In an electromagnetic instrument, an electromagnet comprising a body portion in the form of an elastic vibratory spiral, means for rigidly supporting one end of said spiral, the other end of said spiral being resilient and free to vibrate, an operative member connected to the resilient vibratory end of said spiral, a pole piece extending axially from the rigid end of said spiral toward said vibratory end to provide a variable airgap, and a coil mounted on said pole piece.

19. In an electromagnetic instrument, an electromagnet comprising a body portion in the form of an elastic vibratory spiral, means for rigidly supporting one end of said spiral, the other end of said spiral being resilient and free to vibrate, an operative member connected to the resilient vibratory end of said spiral, a pole piece extending axially from the rigid end of said spiral toward said vibratory end to provide a variable airgap, a coil mounted on said pole piece, and means for adjusting said pole piece to regulate the normal width of said airgap.

20. In an electromagnetic instrument, a magnet structure comprising a magnet in the form of an elastic spiral rigidly supported near one end, the other end of the spiral being resilient and free to vibrate, a polar extension attached to each end of the magnet, the ends of said magnet overlapping to form a variable airgap and the free ends of said polar extensions also overlapping to form another variable airgap, the arrangement of these airgaps being such that when the free resilient end of the magnet is vibrated one of the airgaps is increased and the other airgap is simultaneously decreased, a coil mounted on said magnet structure to produce vibration of the resilient end of the magnet when current impulses pass through the coil or to generate current impulses by the vibrations of the resilient portion of said magnet structure, and an operative member connected to the vibratory portion of the magnet structure.

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11. In an electromagnetic instrument, a magnet in the form of an elastic spiral fixed at one end and movable at the other, whereby the polar ends of said magnet provide a variable airgap, a vibratory member mounted on the movable end of said magnet, and a coil in operative relation to said magnet.

12. An electromagnetic instrument comprising a permanent magnet having a spring strip or wire rigidly supported at one end and free to vibrate at the other end, said spring strip or wire being so shaped that the polar ends thereof provide a variable airgap, and an operative member connected to said vibratory end.

13. In an electromagnetic instrument, an elastic spiral magnet rigidly supported at one polar end, the other polar end being resilient and free to vibrate, whereby said polar ends form a variable airgap, a coil mounted on a stationary portion of said magnet, and an operative member connected to said movable polar end.

14. An electromagnetic instrument comprising a field magnet in the form of an elastic spiral having overlapping polar ends arranged to form a variable airgap, means for rigidly supporting one of said polar ends, an operative member connected to the other polar end which is resilient and free to vibrate, and a coil in operative relation to said magnet.

15. In an electromagnetic instrument, a spiral magnet having a resilient movable pole piece which forms a variable airgap with the other pole piece, a coil on said magnet to produce vibration of said movable pole piece in accordance with current impulses sent through the coil or to generate current impulses in accordance with the vibrations of said movable pole piece, and an operative member connected to said movable pole piece.

16. An electric phonograph reproducer comprising a spiral magnet rigidly supported at one polar end, the other polar end being resilient and free to vibrate, whereby said polar ends form a variable airgap, a stylus member connected to the vibratory resilient end of said magnet to vary said airgap, and a coil in operative relation to said magnet.

17. An electric phonograph reproducer for vertical-cut records comprising a permanent magnet in the form of an elastic spiral arranged with its axis substantially vertical, means for rigidly supporting one end of said spiral magnet, the other end of said elastic spiral being free to vibrate, a vertically movable stylus member connected to the movable end of said spiral for vibrating the same to

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