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A. A. THOMAS

1,778,048

ELECTROMAGNETIC TRANSMITTER AND RECEIVER

Filed Feb. 10, 1928

Fig. 1

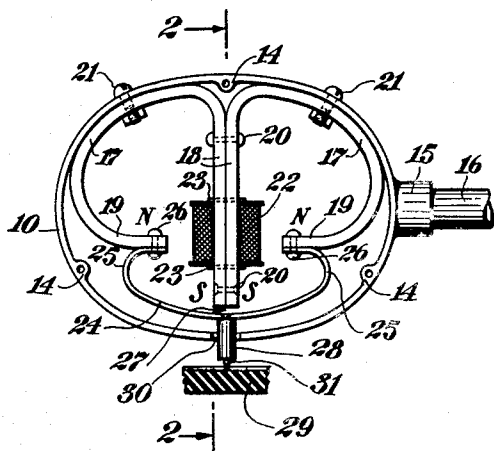


Fig. 2

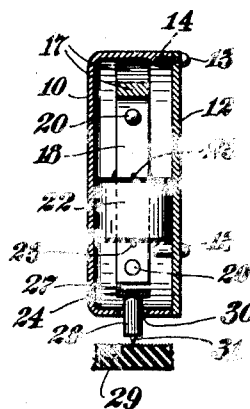


Fig. 3

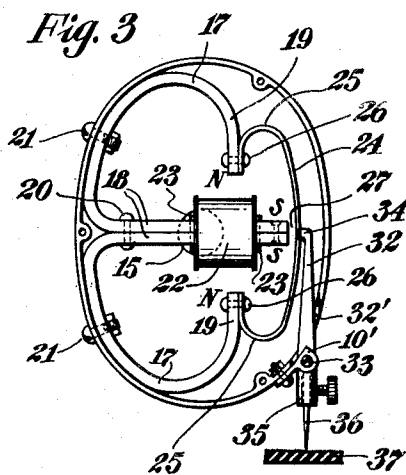


Fig. 4

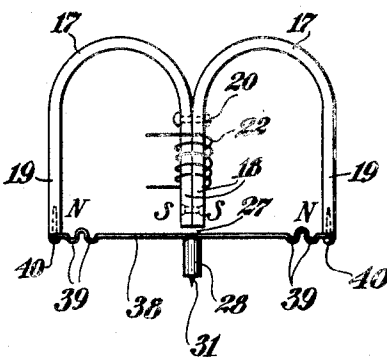
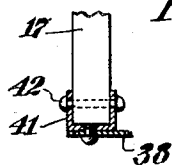


Fig. 5



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ELECTROMAGNETIC TRANSMITTER AND RECEIVER

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This invention is for an electromagnetic translating device of novel construction and improved operation for converting mechanical motion into electric impulses or causing electric impulses to produce mechanical motion. The uses of my invention are various, as for telephone receivers and transmitters, phonograph recording and reproducing instruments, and for other devices along similar lines. When my invention is constructed in the form of a phonograph pickup, it is particularly useful in playing finely grooved vertical-cut records, like those of the Edison type, although it is equally efficient on lateral-cut records.

The essential feature of my invention comprises a three-pole magnet and a spring armature secured at its ends to the two outer poles of the magnet. The middle portion of the armature is separated from the third or intermediate magnet pole by an airgap. An actuating member is connected to the center of the armature for vibrating the same and thereby varying the magnetic airgap to induce current impulses in a coil preferably mounted on the middle pole of the magnet. Conversely, current impulses in the coil produce vibrations of the armature and the connected member. This member, which may be an acoustic diaphragm, a recording tool, a reproducing stylus, and the like, can be mounted directly on the spring armature, so that the most delicate vibrations are directly transmitted from one to the other without the possibility of lost motion.

In a preferred form of my invention, the armature consists of a magnetic leaf spring bent into an open elliptic or oval shape with its ends extending toward each other and attached to the outer poles of the magnet. This produces an armature structure with a main central portion resiliently supported in tensioned condition between curved end portions. In another form of my invention, the armature is a magnetic ribbon connected at its ends to the outer poles of a three-pole magnet and so constructed as to be constantly tensioned or stretched, as by means of transverse corrugations. Both forms of armature are

exceedingly sensitive and capable of reproducing faithfully all movements of the connected member from the smallest to the greatest amplitude. For this reason my invention is highly efficient as a phonograph recording tool and as a pickup or reproducer, especially for the new type of record in which the spiral track runs to several hundred lines to the inch.

The operation and advantages of my invention will be fully understood from a detailed description of the accompanying drawings, which show several forms of electric phonograph pickups constructed in accordance with my invention. I want it clearly understood that I selected these particular embodiments merely by way of example and not as restrictions or limitations of my invention. In these drawings,

Fig. 1 shows an inside view of an electric pickup adapted for vertical-cut records of the Edison type, with the stylus member mounted directly on the elastic armature;

Fig. 2 is a cross-section on line 2-2 of Fig. 1, with the cover plate on the casing;

Fig. 3 illustrates a construction in which the stylus member is a pivoted needle arm connected at its inner end to the armature spring for playing lateral-cut records;

Fig. 4 shows diagrammatically a modification in which the vibratory armature consists of a tensioned magnetic band or ribbon stretched between the outer poles of a three-pole magnet; and

Fig. 5 is a fragmentary detail showing another way of attaching the armature band of Fig. 4 to the magnet pole.

Before proceeding with a detailed description of the several views, I wish to explain that the drawings have been made largely diagrammatic and the parts have been purposely exaggerated in their relative proportions so as to make the figures clear and easy to read. The actual device is considerably smaller than the illustrations, which are therefore not to be taken as shop drawings made to accurate scale.

Referring to Figs. 1 and 2, there is a casing 10 of non-magnetic material, such as brass, 100

aluminum, bakelite, and the like. For compactness and neatness of appearance, the casing may be in the form of a flat oval or ellipse, one side of which is closed by a removable cover 12. The body of the casing can be cast or molded in a single piece. Screws 13 or the like enter screwthreaded holes in bosses 14 for holding the cover 12 in place. A hub 15 projecting from one edge of the casing permits the same to be easily mounted on a supporting arm 16, which may be a small light tube supported at its rear end to allow movement of the reproducer over a record.

In casing 10 are mounted two permanent magnets 17, which are magnetically and mechanically connected to form a middle pole piece 18. If the polar ends 19 of the magnets are of north polarity, the pole piece 18 is of south polarity, as indicated in the drawings. Rivets 20, or other fastening means, hold the two magnets together as a single structure, which is secured to the casing by bolts 21, or in any other practical way. As seen in Figs. 1 and 3, the magnets 17 follow generally the elliptic or oval outline of the casing, so that a magnetic path of maximum length is obtained in a small space. A coil 22 is mounted on the middle pole piece 18 and held thereon by any suitable means, as cross-pins 23. The coil is machine-wound and easily slipped in place after the magnets are connected.

The two magnets 17 are shaped from a flat bar of good magnetic steel, such as chromium or silicon steel, and they may be either solid or laminated. Since the two magnets are identical in shape, only one pattern or shaping device is needed. In this way it is possible to make the magnets from a long flat bar which is bent at one end to form the curved portion 19 and then the straight portion 18 is cut off for the right length. The complete magnet structure is made by simply connecting two magnets back-to-back.

The outer pole pieces 19 of the three-polar magnet structure 17 are connected by a spring armature 24, which consists of a magnetic leaf spring bent into the shape of an open ellipse. That is to say, the leaf spring is bent inwardly at its ends, as shown at 25, so that the central or main portion of the armature is suspended under tension between the curved ends of the spring for vibratory movement in its own plane. Suitable fastening members, such as bolts or rivets 26, secure the armature to the polar ends 19 of the magnet. The armature is in good magnetic contact with the pole pieces 19, and constitutes in effect an elastic vibratory extension thereof. The spring armature 24 is so dimensioned as to have the proper amount of resiliency and sufficient cross-sectional area to carry the field flux without saturation.

In the broad aspect of my invention, any practical actuating member may be connected to the armature to vibrate the same in its own plane toward and from the central pole piece 18, from which the armature is always separated by a variable airgap 27. In Figs. 1 and 2 I have shown a stylus member 28 directly mounted on the armature spring 24 at or near the center thereof opposite the end of pole piece 18. The stylus member 28 extends through an opening 30 in the bottom of casing 10. In this instance I have assumed that the stylus member 28 is intended to play vertical-cut records of the Edison type, which are usually played with a diamond point permanently attached to a suitable holder. In Figs. 1 and 2 a cross-sectional fragment of a vertical-cut record is diagrammatically indicated at 29.

The operation of the instrument above described will be plain to those skilled in the art, but it might be well to summarize it in a few sentences: As the stylus member 28 moves up and down in accordance with the hill-and-dale variations of the record groove tracked by the stylus point 21, the elastic tensioned armature 24 vibrates in its own plane and varies the airgap 27. That is to say, when the stylus member 28 moves up, it pushes the armature closer to pole piece 18. The tension of armature 24 is such that it automatically springs away from pole piece 18 when the record groove permits. The flux variations thus produced in the field magnet system generate current impulses in the circuit of coil 22. Since the stylus member 28 is directly mounted on the armature spring 24, the stylus vibrations are transmitted to the armature without lost motion, so that the minutest movements of the stylus point are faithfully converted into current impulses in coil 22. The elliptic spring 24 responds correctly to all frequencies within audible range, because various lengths of the spring come into operation at different bands of frequencies. Thus, at high frequencies the central portion of the armature will vibrate. At low frequencies, the vibrating portion of the armature extends to the curved resilient ends 25, between which the central part of the armature is suspended. In other words, between the highest and lowest frequencies, different lengths or sections of armature spring 24 will respond instantly and faithfully.

I have not considered it necessary to show any circuit arrangement for coil 22, because amplifying circuits are well known in the electric phonograph and radio art. It is a simple matter to amplify the feeble current impulses in coil 22 by means of radio tubes for controlling or operating loudspeaker mechanism. This is so well understood that I need not say any more about it. In the broad view of my invention, the current im-

pulses in coil 22 may be utilized in any practical way.

The weight of the reproducer is such that when the stylus point 31 rests on a record, the center of armature 24 is separated from the end of pole piece 18 by a small airgap, which is shown at 27 in exaggerated width. The elastic armature has sufficient inherent stiffness to take up the load of the reproducer without hitting the end of pole piece 18.

It is not necessary that the stylus member 28 should be directly mounted on the armature spring 24. For instance, referring to Fig. 1, it is easy to see that the stylus member 28 can be mounted at one end of a pivoted arm or lever which is connected at its other end to the center of the armature. In that way, the vertical movements of the stylus member 28 can be transmitted through the pivoted lever to the armature in amplified ratio. This will be understood without the need of additional illustration.

Fig. 3 differs from Fig. 1 in that the stylus member 28 of Fig. 1 is replaced by a needle arm 32 pivoted to the casing 10 at 33 for playing lateral-cut records of the well-known Victor type. The needle arm 32 is connected at its inner end 34 to the center of armature spring 24, and the lower end 35 of the needle arm is in the form of a holder for needles 36. The fragment 37 is supposed to represent a lateral-cut record in substantially radial cross-section. The casing 10 is mounted on the supporting arm 16 so as to hold the needle arm 32 in proper playing position. A hole or slot 32' in casing 10 allows free movement of the needle arm. A simple way of mounting the needle arm on the casing is to provide the latter with a pair of ears 10' between which the pivot 33 is mounted. A pair of pointed screws mounted in the bearing lugs 10' are usually sufficient to form a pivot support with practically no lost motion.

It is evident from Fig. 3 that the vibrations of the needle arm 32 right and left pull and push the center of armature spring 24 away from and toward the face of pole piece 18. Otherwise, what has been said about the construction and operation of Fig. 1, applies fully to Fig. 3 without the need of repetition. It will be noticed in Fig. 3 that the movements of the needle point 36 are transmitted in slightly amplified ratio to the armature 24.

In the modification of Fig. 4, the armature 38 consists of a steel band or ribbon having transverse corrugations 39 and secured at its ends to the outer pole pieces 19 by magnetic pins or screws 40, or otherwise. The corrugations 39 hold the central portion of the armature band 38 in permanently stretched or tensioned condition, so that the armature will operate in substantially the same way as the elliptic spring 24 of Figs. 1 and 3. Otherwise, what has been said for Figs. 1 and 3 applies to Fig. 4, which will therefore be

fully understood without further description.

Fig. 5 shows another way of attaching the ends of armature 38 to the outer pole pieces of the magnet structure. In this instance, each end of the tensioned armature ribbon carries a magnetic bracket 41, which fits tightly over the end of the magnet pole and is held in place by the bolt or rivet 42. This establishes good magnetic contact between magnet and armature.

It is hardly necessary to add that the constructions above described are equally adapted to operate as receivers, since current impulses in coil 22 will produce corresponding vibrations of armature 24 or 38, and these armature vibrations may be utilized in any practical way, as, for example, operating a recording tool or an acoustic diaphragm, vibrating a mirror that controls a photoelectric element, etc. Being constantly under tension, the leaf springs 24 and 38 are self-damping and respond instantly and accurately whether the instrument acts as a transmitter or receiver. Should the armature spring accidentally be forced against the magnet pole 18, its own resiliency will cause it to recoil almost instantly, for the tension of the spring is stronger than the attractive force of the magnet at that point.

The three-pole magnet structure in this instrument need not be so heavy as the bipolar magnets in prior pickups using a pivoted armature, where there is always lost motion and where the low efficiency of the instrument requires an unusually heavy magnet. Those heavy pickups are also objectionable because they produce loud needle noises and tend to slow up the turntable. Attention is called to the fact that my three-polar magnet system provides a magnetic path of unusual length, thereby increasing the life of the magnetic field and the sensitivity of the instrument. The parts comprising my new instrument are few and cheaply made, are easily assembled and not liable to get out of order. The magnet and the parts carried thereby are inserted as a unit in the casing, where they are fully exposed for easy access by simply removing the cover 12. It is thus seen that I provide an electromagnetic transmitter and receiver of unusual simplicity and efficiency.

Although I have shown and described certain specific constructions by way of example, I want it understood that the illustrations in the drawings do not impose any restrictions or limitations as to details unless so specified in the claims that define my invention. Those claims which describe a phonograph reproducer are also intended to apply to a phonograph recording tool, since the same structure may be put to either use.

I claim as my invention:

1. An electromagnetic device free from an

acoustic diaphragm comprising a three-pole magnet structure in which the two outer poles are of like polarity, a non-acoustic vibratory armature magnetically connected to said outer poles and separated by a variable airgap from the middle pole of said magnet structure, said armature consisting of an elastic band rigidly supported at its ends so that its main or central section is held under tension, and a coil operatively associated with said magnet structure to cause vibration of said armature by electric impulses or to produce electric impulses by the vibrations of said armature.

2. An electromagnetic device free from an acoustic diaphragm comprising a three-pole magnet structure in which the two outer poles are of like polarity, a non-acoustic spring armature magnetically connected at its ends to said outer poles, said armature consisting of an elastic band rigidly supported at its ends so that its main or central portion is held under tension, the central portion of said armature being separated from the middle pole of said magnet structure by an airgap, an operating member connected to said armature at or near the middle thereof, and a coil arranged to produce electric impulses by the vibration of said armature or to actuate said armature in accordance with current impulses in the coil.

3. An electromagnetic device free from an acoustic diaphragm comprising a three-pole magnet structure in which the two outer poles are of like polarity, a non-acoustic spring armature magnetically connected at its ends to said outer poles, said armature consisting of an elastic band rigidly supported at its ends so that its main or central portion is held under tension, the central portion of said armature being separated from the middle pole of said magnet structure by an airgap, an operating member connected to said armature at or near the middle thereof, and a coil mounted on said middle pole.

4. An electromagnetic device free from an acoustic diaphragm comprising a three-pole magnet structure in which the two outer poles are of like polarity, an armature consisting of a flat spring bent inwardly at the ends which are secured to said outer poles, whereby the central portion of said armature is resiliently supported under tension by said curved ends for vibratory movement, the middle pole of said magnet structure being separated from the vibratory central portion of said spring armature by an airgap, an operating member connected to said armature at or near the middle thereof, and a coil arranged to produce electric impulses by the vibration of said armature or to actuate said armature in accordance with current impulses in the coil.

5. An electromagnetic device free from an acoustic diaphragm comprising a three-pole magnet structure in which the two outer poles

are of like polarity, an armature consisting of a flat spring in one piece bent inwardly at the ends which are secured to said outer poles, whereby the central portion of said armature is resiliently supported by said curved ends for vibratory movement, the middle pole of said magnet structure terminating out of line with the outer pole pieces and being separated from the vibratory central portion of said spring armature by an airgap, an operating member connected to said armature at or near the middle thereof, and a coil on said middle pole.

6. In an electromagnetic device free from an acoustic diaphragm, a magnet structure consisting of a pair of substantially U-shaped magnets having two like polar limbs connected together to form a middle or intermediate pole piece, the other polar limbs of said magnets constituting two outer pole pieces of like polarity, an elastic magnetic strip secured to said outer pole pieces and separated from said middle pole piece by an airgap, said elastic strip being held between its ends under tension and constituting a non-acoustic vibratory armature to vary said airgap, and a coil on said middle pole piece.

7. In an electromagnetic device free from an acoustic diaphragm, a magnet structure consisting of a pair of substantially U-shaped magnets having two like polar limbs connected together to form a middle or intermediate pole piece, the other polar limbs of said magnets constituting two other pole pieces of like polarity, an armature consisting of a flat spring in one piece bent inwardly at the ends which are secured to said outer poles, whereby the central portion of said armature is resiliently supported by said curved ends for vibratory movement, the middle pole of said magnet structure being separated from the vibratory central portion of said spring armature by an airgap, said magnets and armature lying in the same plane, and a coil in operative relation to said magnets and armature.

8. An electric phonograph reproducer comprising a three-pole magnet structure in which the two outer poles are of like polarity, a non-acoustic vibratory armature magnetically connected to said outer poles, said armature consisting of an elastic band rigidly supported at its ends so that its main or central portion is held under tension, the central portion of said armature being separated from the middle pole of said magnet structure by an airgap, a stylus member connected to said armature at or near the middle thereof, and a coil associated with said magnet structure for converting the vibrations of said stylus member into electric impulses.

9. An electric phonograph reproducer free from an acoustic diaphragm comprising a three-pole magnet in which the two outer poles are of like polarity, an armature con-

sisting of a flat spring in one piece bent inwardly at the ends which are secured to said outer poles, whereby the central portion of said armature is resiliently supported by said curved ends for vibratory movement, the middle pole of said magnet structure being separated from the vibratory central portion of said spring armature by an air-gap, a stylus member connected to said armature at or near the middle thereof, and a coil associated with said magnet structure for converting the vibrations of said stylus member into electric impulses.

thereby, so that the vibrations of said stylus member are directly transmitted to said elastic armature to vary said airgap, and a coil for converting the vibrations of said stylus member into electric impulses.

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10. In an electric phonograph reproducer
15 free from an acoustic diaphragm, a magnet
structure consisting of a pair of substan-
tially U-shaped magnets having two like
polar limbs connected together to form a
middle or intermediate pole piece, the other
20 polar limbs of said magnets constituting two
outer pole pieces of like polarity, an elastic
magnetic strip secured at its ends to said
outer pole pieces and supported thereby, said
elastic strip being separated from said mid-
25 dle pole piece by an airgap and constituting
a tensioned vibratory armature to vary said
airgap, a stylus member connected to said
armature strip for actuating the same, and
a coil for converting the movements of said
30 armature strip into electric impulses.

11. In an electric phonograph reproducer free from an acoustic diaphragm, a magnet structure consisting of a pair of substantially U-shaped magnets having two like polar limbs connected together to form a middle or intermediate pole piece, the other polar limbs of said magnets constituting two outer pole pieces of like polarity, an armature consisting of a flat spring in one piece bent inwardly at the ends which are secured to said outer poles, whereby the central portion of said armature is resiliently supported by said curved ends for vibratory movement, the middle pole of said magnet structure being separated from the vibratory central portion of said spring armature by an air-gap, a stylus member for actuating said armature, and a coil on said middle pole piece for converting the movements of said armature into current impulses.

12. An electric phonograph reproducer for playing vertical-cut records, comprising a magnet structure having two outer poles of like polarity and a middle pole of opposite polarity, an elastic armature magnetically connected to said outer poles and adapted to vibrate in a vertical plane, said armature consisting of a one-piece spring strip rigidly supported at its ends so that its main or central portion is held under tension, the central portion of said armature being separated from the middle pole of said magnet structure by an airgap, a vertically movable stylus member mounted on said armature at or near the middle thereof and supported