

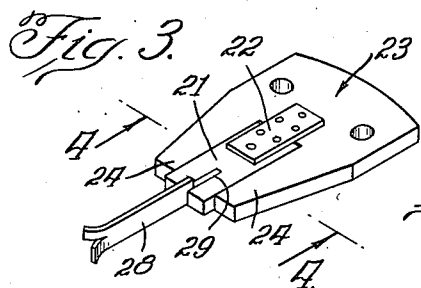
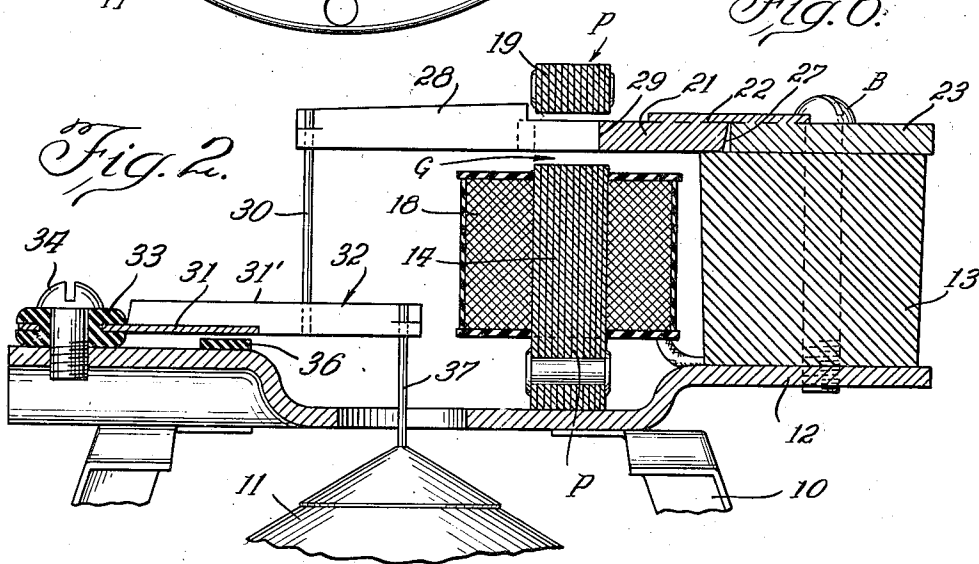
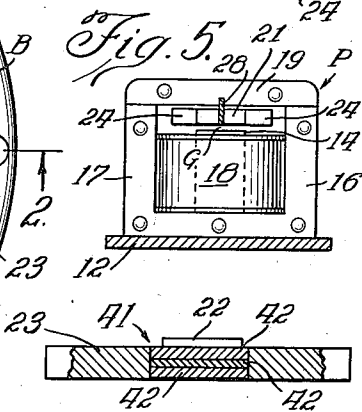
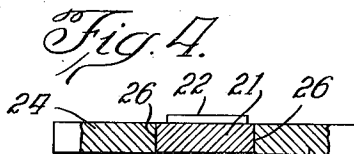
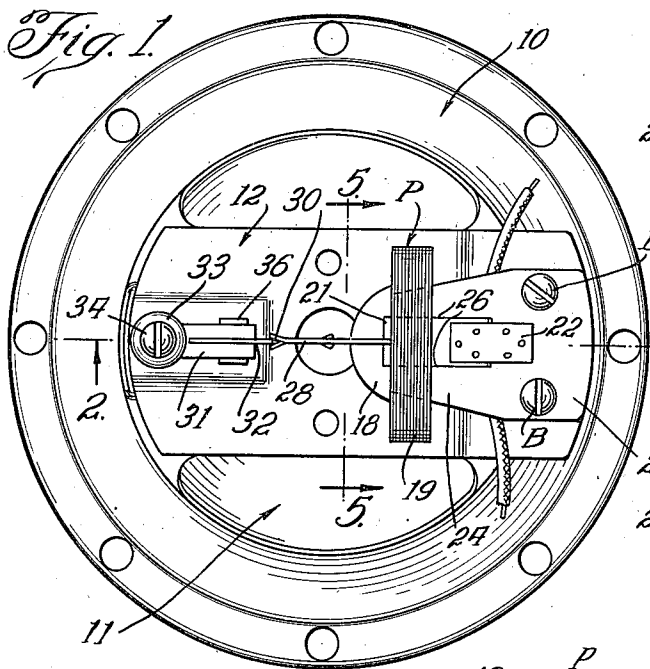
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J. P. QUAM

2,251,001

LOUD-SPEAKER AND DRIVING MOTOR THEREFOR

Filed Sept. 30, 1939



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UNITED STATES PATENT OFFICE

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LOUD-SPEAKER AND DRIVING MOTOR
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Application September 30, 1939, Serial No. 297,385

12 Claims. (Cl. 179-108)

This invention relates in general to vibratory motors, and more in particular to a vibratory motor for a loud speaker of the so-called magnetic type, and to such loud speaker. In this connection, this invention relates to the subject matter of my copending application, Serial No. 210,934 filed May 31, 1938.

An object of my invention is to provide an improved vibratory motor having various applications, but particularly adapted for use in a loud speaker of the so-called magnetic type.

Another object of my invention is to provide a magnetic type speaker with all of the known advantages over the dynamic type speakers as to low power requirements, low cost, and small light-weight construction, and which in addition provides a noticeable improvement in tone and fidelity of reproduction over dynamic type speakers of a relatively comparable cost.

A still further object of my invention is to provide an improved vibratory motor for a magnetic type speaker producing none of the objectionable metallic, harsh sounds which have characterized many of the prior speakers of this type.

One of the features of my vibratory motor invention is the provision of a relatively small vibratory armature which is bounded on three sides by the rigid magnet structure of the motor to provide a highly efficient magnetic flux path from the magnet to the armature and thereby cooperate in producing a high driving power output in such armature. The clearance between the armature and the magnet on the sides bounding the armature to permit vibratory movement of the armature relative to the magnet are so small that there is little or no flux loss therein. The efficiency of operation of the motor as a whole, and the driving power of the armature, are enhanced by extending a portion of such armature-bounding-magnet structure with the armature directly into the pulsating magnetic field of the pole-piece structure for the motor.

Another feature of my invention is the provision of rubber mounting structure for some of the driving portions of the motor which prevents undesirable metallic contacts by such portions upon operation thereof to in turn prevent distortion in the sound reproduction of the speaker, and prevent undesirable metallic sounds.

Other objects and features of my invention will be apparent from the following description, taken with the drawing, in which:

Fig. 1 is a plan view of a complete loud speaker embodying my invention. The speaker illus-

trated is identical in size with a typical commercial embodiment of the invention.

Fig. 2 is a fragmentary vertical sectional view taken along the line 2-2 of Fig. 1 and enlarged to double size over the structure of Fig. 1.

Fig. 3 is a detail view in perspective of the armature and directly associated structure of my vibratory motor.

Fig. 4 is a cross-sectional view along the line 4-4 of Fig. 3 illustrated in the same size as that structure in Fig. 2.

Fig. 5 is an elevational and sectional view approximately along the line 5-5 of Fig. 1.

Fig. 6 is a modification of the armature structure shown in the same manner and of the same size as the structure of Fig. 4.

In practicing my invention, I provide a vibratory motor including a frame plate of magnetic material for mounting directly on the diaphragm frame of a loud speaker. A permanent magnet is rigidly mounted at one end of the frame plate and a diaphragm driving element is mounted in rubber at the opposite end of the frame plate for connection with a diaphragm for the speaker. Driving elements are actuated by a vibratory armature hingedly supported on a magnet plate secured to the magnet. The magnet plate includes a notched portion extending laterally from the magnet and into the confines of a pole piece structure to lie adjacent the armature at the air gap in the pole piece. The pole piece structure is supported on the frame plate for the motor intermediate the magnet and the driving elements. A minute air gap is provided on each side of said armature, intermediate the adjacent notched portion of the magnet plate and such armature, and a resilient spring steel hinge is employed to support the armature on the magnet plate and center such armature in the notch. The armature and its associated magnet plate, the magnet itself, and the pole piece structure are all of such construction and so assembled as to provide a magnetic flux path, or circuit, of low reluctance, so that there is a minimum in flux losses, and maximum driving power is provided by the armature. A driving arm for the armature is pressed into a corresponding notch in the armature and extends longitudinally therefrom for connection with the rubber mounted driving element of the motor.

Referring now to the drawing, the loud speaker illustrated in Fig. 1 includes a stamped-out diaphragm frame 10 with a cone-shaped diaphragm 11 secured at its edges to said frame, and a vibratory motor rigidly secured to said

diaphragm frame at the back thereof. As can be seen more clearly in Fig. 2 the vibratory motor includes a stamped-out frame plate 12 welded to the diaphragm frame, and carrying thereon at one end a permanent magnet 13 secured by bolts B to the plate. The plate 12 is of magnetic material to provide a magnetic circuit from the magnet 13 to a laminated pole piece P which includes a plurality of E-shaped laminations, having a central leg 14 and integral outside legs 16 and 17. A coil 18 is mounted on the center leg 14 of the pole piece and is adapted to be connected with a radio receiver or the like. A laminated bridge 19 rests upon the outer legs 16 and 17 of the pole piece as shown in Fig. 5, and is soldered or otherwise secured thereto. The pole piece structure is more fully described in the above-mentioned depending application.

The diaphragm driving structure of the motor includes an armature 21 of high-grade silicon steel which is vibrated in accordance with the impulses of uni-directional pulsating current introduced into the coil 18 from a radio receiver or other energizing source. The armature is hingedly supported by a hinge member 22 of spring steel welded at one end to the armature and at the other end to a magnet plate 23 of magnetic material which is magnetically connected to the permanent magnet 13 and forms a part of the magnetic structure for the motor. The plate 23 is secured to the magnet 13 by means of the bolts B which likewise secure the magnet to the frame plate 12, and the entire assembly is therefore rigidly secured in position. The magnet 13 has likewise been welded to the frame 12, and the plate 23 welded to the magnet to provide a rapid, inexpensive assembly, and a very rigid structure. The plate 23 includes an integral U-shaped, or notched, extension comprising a pair of tongues 24 with an opening or notch 25 therebetween. The notch extends into the body portion of the plate 23 a distance such that the armature 21 at its hinged end or side extends over the permanent magnet 13 approximately $\frac{1}{8}$ th or $\frac{1}{4}$ th of an inch, or an amount which will not interfere in any way with the vibratory movement of the armature on the magnet. This overlapping provides an improved flux path between the permanent magnet and the armature to thereby increase the operating power of such armature. Similarly, the hinged end 27 of the armature abuts the corresponding end of the notch 26 in such a manner that the armature will not in any way be hampered in its vibratory movement by the plate 23. To insure the best operating conditions, the end 27 is machined at a slight angle so as to provide a triangular opening as shown in Fig. 2. Freedom of action is likewise improved by making the vertical thickness of the armature approximately .005 inch less than the corresponding thickness of the plate 23, and by mounting the armature with its top face in the same plane with the top face of the plate 23 to provide the bottom face of such armature raised above the plane of the bottom face of the plate 23 an amount equal to the difference in thickness. This is shown clearly in Figs. 2, 4 and 6.

Among the important factors to be considered with reference to a magnetic type loud speaker are the matters of low reluctance in the magnetic flux path throughout the magnetic circuit of the motor for such speaker, and particularly low reluctance and low inertia in the vibratory armature for the motor. Likewise, there must be

a high degree of resiliency between the armature structure and its corresponding mounting so that such armature will be sensitive to the fluctuating impulses in the coil 18, and hence in the pole piece which determine the vibratory movement of the armature. At the same time the armature itself is desirably extremely rigid so that there will be no distortion of movement therein, and similarly there must be no transverse or lateral movement or distortion of the armature out of its restricted vibratory path. Related to the factor of magnetic flux is the matter of flux loss due to air gaps in the magnetic circuit between various conducting elements of such circuit. With my invention such losses are reduced to a minimum by means including the configuration and arrangement of the armature 21 and the magnet plate 23 which are such that the armature is, in a manner, buried within the magnet plate 23 and hence in the permanent, or static, field of the magnet. The tongues 24 extend into the air gap G defined by the leg 14 of the pole piece and the bridge 19 thereof, while a clearance as small as .001 inch, in some commercial embodiments of the invention, separates each tongue from its corresponding side of the armature 21. Clearances as great as .004 inch have been employed but the minimum limit is more satisfactory from an operating and production standpoint. With the hinge 22 wide enough and rigid enough in a transverse direction so that there is no distortion out of the normal line of vibratory movement, such hinge welded to the armature 21 and to the plate 23 maintains the armature perfectly centered with reference to the notch in the plate 23 and relatively finite clearances on each side prevent rubbing between the tongues and armature. Bringing the permanent or static magnetic field into an adjacent position to the armature substantially over the entire length thereof provides a flux path over this portion of the motor such that it is possible to use a relatively small armature having low inertia by virtue of its size, and hence greater freedom and sensitiveness of movement. Furthermore, the small size of the armature makes it easier to provide such member in a material of low reluctance. The armature corresponds in width to the width of center leg 14 of the pole piece and is extremely sensitive to the slightest impulse in the pulsating magnetic field produced by the coil 18 at the pole piece. The pole piece structure as illustrated and described provides a powerful pulsating magnetic field for the armature, and the latter operates with marked efficiency in the gap G thereof.

The cone or diaphragm 11 is driven by means including a knife-edge driving arm 28 which is pressed into a corresponding notch 29 in the armature 21 and then soldered therein so as to provide a rigid permanent connection therewith. A driving rod 30 is appropriately secured at one end in the notched end of the arm 28 and secured at its other end to a combination step-up and tension lever 32. Such lever includes a bracing plate 31, and a knife-edge arm 31' extending substantially the length of the plate, and soldered or otherwise secured thereto, to provide an extremely rigid yet relatively light-weight unit. The lever 32 acts to enlarge the amplitude of vibration of the diaphragm 11 with reference to the corresponding amplitude of vibration of the armature 21 so that the latter can be operated in a relatively small gap G and still provide

the desired movement for satisfactory reproduction at the diaphragm.

It is understood of course that the armature 21 and consequently the diaphragm 11 and connecting structure operate at terrific speed, completing as many as 5000 cycles per second, and sometimes more than this, depending of course upon the range of voice frequencies over which the energizing source for the coil 18 is operating. At this tremendous speed and with the difficult operating conditions arising from a variation in amplitude of vibration, as well as speed of vibration, in prior speakers objectionable metallic noises have developed in the driving structure of such speakers. This difficulty is eliminated by mounting the lever 32 in a relatively soft rubber grommet 33, which in turn is secured to the frame plate 12 by a bolt or screw 34. The rubber of the grommet 33 is of such constituency as to enjoy a long life, and retain its resiliency throughout such life. Although it has normally been found unnecessary, further insurance against objectionable metallic noises is provided in a rubber pad 36 secured to the plate 12 beneath the body portion of the lever 32 at a point spaced from the grommet so as to prevent contact between the lever and such plate. Direct connection between the lever 32 and the diaphragm 11 is provided by a stylus 37 secured to each in the usual manner.

Inasmuch as the armature 21 itself is entirely rigid over the entire body, and all resiliency is centered in the hinge 22, the preferred construction of such armature is a one-piece member, which in one commercial embodiment is $\frac{1}{8}$ inch in vertical thickness. In the event that high-grade silicon steel of this thickness or any desired variation therefrom is not available so that a one-piece member can be provided, an armature of the desired thickness can be built up in a laminated structure as shown in Fig. 6, and indicated by the reference character 41. The illustrated modification shows the armature with three laminated plates 42 which are appropriately welded together into what is effectively an integral member. Previous to welding the laminations are machined and polished so that the maximum magnetic contact is obtained between adjacent laminations. The armature is secured to the plate 23 by a hinge 22 in the manner previously discussed. A driving arm 28 is pressed into a notch in the armature and secured therein in the same manner as previously described.

Although the invention has been described and illustrated in its preferred embodiments, it is understood that such invention is not limited thereto, but is limited only by the scope of the appended claims.

I claim:

1. In a loud speaker having metal frame means, and a diaphragm mounted on said frame means, a motor on said frame means for driving said diaphragm including in combination a permanent magnet providing a static magnetic field, an energizable pole piece providing a pulsating magnetic field, a magnet member of magnetizable material rigidly supported on said permanent magnet and magnetically common thereto having a portion extending into the pulsating magnetic field of the pole piece and with said portion being notched to receive an armature therein, a relatively small vibratory armature normally out of direct physical engagement with said magnet member but hingedly connected to said member, 75

positioned in said notch and extending into the pulsating field of the pole piece, with the armature being of such size and so arranged with reference to the extending portion of the magnet member that energization of the pole piece provides a powerful, sensitive diaphragm driving stroke in the armature, movable means for connecting said armature with said diaphragm, and a rubber means on said frame means mounting and supporting a portion of said connecting means, said rubber member separating said portion of said connecting means from said frame means to prevent undesirable metallic noises arising in the connecting means and between such connecting means and the frame means in spite of a powerful driving stroke for said armature.

2. A vibratory motor for a loud speaker including frame means, a permanent magnet on said frame means providing a static magnetic field, a pole piece on said frame means spaced from said magnet having energizable means thereon for providing a pulsating magnetic field, a magnetizable non-vibratory extension on said permanent magnet spaced from said frame means and projecting into a plane through said pole piece at right angles to said extension, with the latter extending the static magnetic field to said pole piece, a vibratory armature mounted on said extension within the static field and having a free end in the pulsating field to be acted upon thereby and hinge means at the other end thereof secured thereto and to said extension supporting said armature on said extension.

3. A vibratory motor including frame means, a magnet portion on said frame means providing a static magnetic field, a pole-piece portion on said frame means spaced from said magnet portion having an energizable coil thereon and providing a pulsating magnetic field, said magnet portion having a U-shaped extension therefor rigid over its entire length and projecting into a plane through the pole-piece portion which plane is substantially at right angles to said extension, and a vibratory armature hinged at one end to said magnet portion, projecting at the other end into said plane, and freely vibrating at such other end upon energization of said coil, hinge means secured to said magnet portion and to said armature at one end to support said armature and with said U-shaped magnet extension having a pair of legs and an opening therebetween for receiving the vibratory armature.

4. In a vibratory motor having a permanent magnet and a pole piece including a frame structure with an opening therein, the combination of a magnet plate of magnetizable material rigidly mounted upon the permanent magnet and extending therefrom into the opening in the pole piece, said magnet plate having an aperture therein for receiving a vibratory armature having a plurality of sides which is bounded upon at least two of said sides by the edges of said aperture, a vibratory armature operatively connected at one side with said magnet plate, positioned within the magnet plate aperture, and having a side opposite to said one side extending into the opening in the pole piece and being freely movable therein and hinge means secured to said armature and supported by said plate hingedly supporting said armature in said aperture.

5. In a vibratory motor for a loud speaker including a permanent magnet and an energizable pole piece having a central portion, the com-

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bination of a laminated armature with a top face and a bottom face and including a plurality of laminations with each two adjacent laminations in full face contact with one another, a magnetizable member having an opening extending therein from one end thereof and being supported at an opposite end on said magnet, a spring hinge irremovably secured to the top face of said armature and to said member in a position to mount said armature in said member opening, and with said member bounding said armature at said opening upon at least three sides of said armature.

6. In a vibratory motor including a permanent magnet and an energizable pole piece having a central portion, the combination of a permanent magnet having a top face thereon, a magnetizable member rigidly supported upon said permanent magnet at the top face thereof and having a notch extending from one end into said member to a point therein positioned above said top face of said magnet, and a vibratory armature hingedly connected at one end to said magnetizable member and positioned in said notch with said connected end overlapping a portion of the top face of said magnet, with said member substantially abutting said armature at said notch on at least two opposite sides of said armature, and with said armature and said member extending from said permanent magnet to a position substantially over the central portion of said pole piece.

7. In a vibratory motor including a permanent magnet portion and a non-permanent, but energizable magnet portion, the combination of a magnet plate having a mounting portion at one end rigidly supported on said permanent magnet and a U-shaped portion at the other end extending over said non-permanent but energizable magnet portion, and a vibratory armature hingedly connected to said plate and vibrating within the U-shaped portion thereof and hinge means secured to said armature and supported by said plate supporting said armature in said U-shaped portion.

8. In a loud speaker having metal frame means and a diaphragm mounted on said frame means, a motor on said frame means for driving said diaphragm including in combination a pair of pole piece portions spaced apart to provide an air gap therebetween, an armature vibrating in said air gap, a knife edge driving arm having a portion at one end secured within the armature and moving therewith, means operatively connected to said driving arm for operatively connecting said driving arm to said diaphragm including a step-up arm spaced from said driving arm, connecting means extending from one end of said driving arm to said step-up arm at a point intermediate the ends thereof, second connecting means connected to one end of said step-up arm and extending toward said diaphragm, a rubber member supporting said step-up arm at the other end thereof, and means securing said rubber member to said metal frame means.

9. In a loud speaker having frame means and a diaphragm mounted thereon, the means for driving said diaphragm including a pair of pole piece portions mounted on said frame means and spaced apart to provide an air gap there-

between, an armature vibrating in said air gap, a driving arm having one end secured within said armature and the other end extending outwardly therefrom, means operatively connected to said other end of said driving arm for operatively connecting said driving arm and said diaphragm including a substantially longitudinally extending member movable with said driving arm, a diaphragm stylus rigidly secured to said movable member at one end of said movable member, an apertured rubber member supporting said movable member at the other end thereof, and securing means extending through the aperture of said rubber member and into said frame means to secure said rubber member to said frame means and mount said movable member thereon.

10. In a vibratory motor having a permanent magnet and means providing a pulsating magnetic field, the combination of a permanent magnet extension comprising a mounting portion mounted on said permanent magnet and an integral portion projecting therefrom substantially into said pulsating magnetic field, a vibratory armature operatively connected with said permanent magnet, with said permanent magnet extension integral portion bounding said armature on at least one side, lying in the longitudinal plane of said armature and extending substantially the length thereof at said side but spaced therefrom in the same plane a distance substantially only enough to permit vibratory movement of the armature relative thereto and hinge means secured to said armature and to said magnet extension to support said armature for vibratory movement.

11. In a vibratory motor including a permanent magnet, a pole piece magnetically common thereto, and an energizable coil on said pole piece and with said pole piece having an air gap, the combination of a rigid magnetizable member supported at one end on said permanent magnet and extending at the other end to said pole piece and having an opening in said other end, a vibratory armature positioned in said opening and extending at one end into the air gap of said pole piece, and resilient metal means secured at one end to said magnetizable member and at the other end thereof to said vibratory armature to hingedly support said armature in said opening and normally maintain said armature substantially in the plane of said magnetizable member, with said armature and said coil being contemporaneously movable and energizable respectively.

12. In a loud speaker having metal frame means and a diaphragm mounted on said frame means, the means for driving said diaphragm including an armature, a driving arm rigidly secured on said armature, a diaphragm stylus, means connecting said driving arm and said stylus including a driving rod and a lever, with said driving rod substantially parallel to said stylus, and said lever extending substantially at right angles to said stylus and connected thereto, a rubber unit having a transverse opening therein receiving an end of said lever and supporting said lever in rubber at that end, and means operatively connected with said rubber unit for securing the rubber unit on the metal frame means.

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