March 8, 1949. S. F. LYBARGER 2,463,786

ELECTROMAGNETIC MECHANISM FOR BONE CONDUCTION RECEIVERS, ETC.

Filed Feb. 10, 1947 2 Sheets-Sheet 1

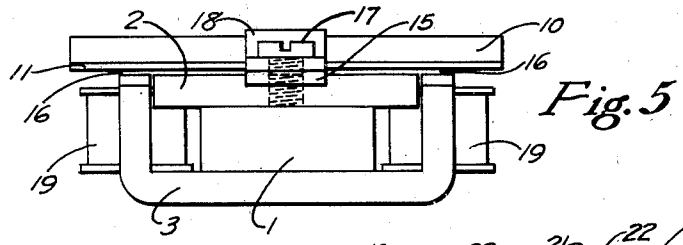



Fig. 5

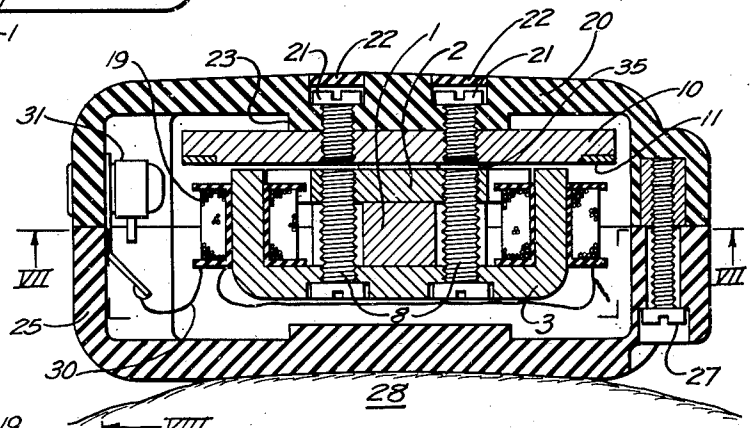



Fig. 1

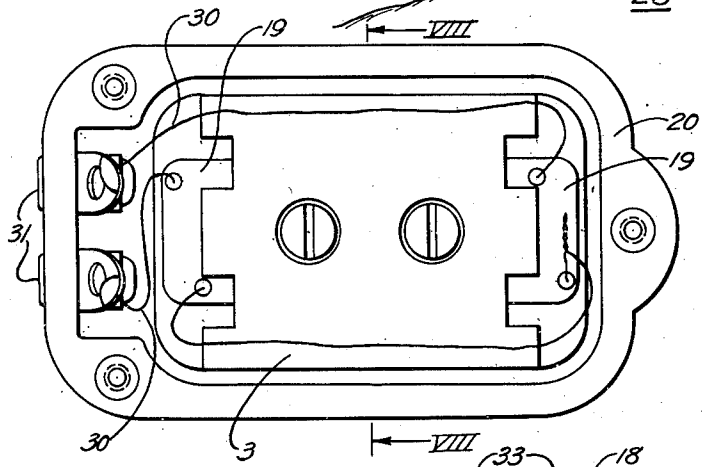



Fig. 7

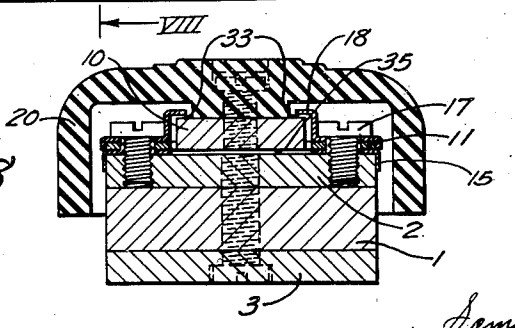



Fig. 8

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ELECTROMAGNETIC MECHANISM FOR BONE CONDUCTION RECEIVERS, ETC.

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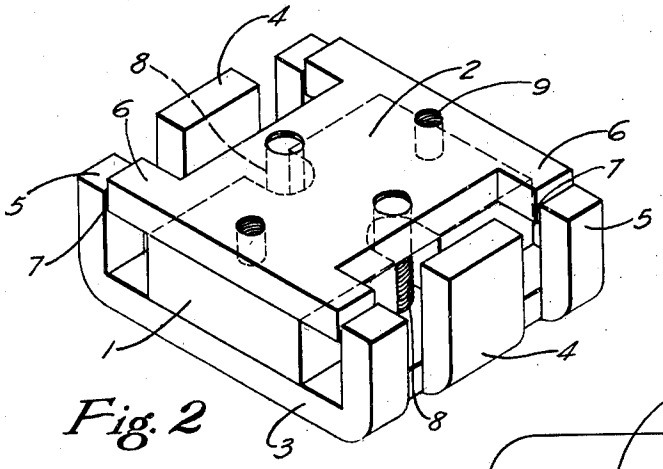



Fig. 2

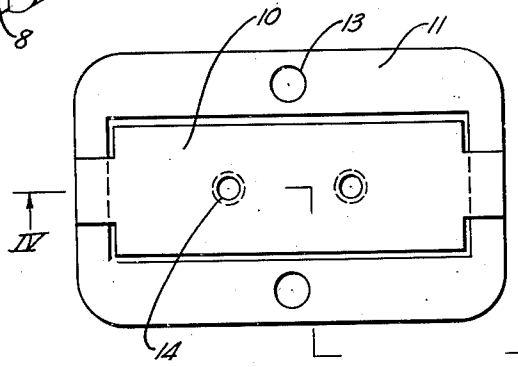



Fig. 3

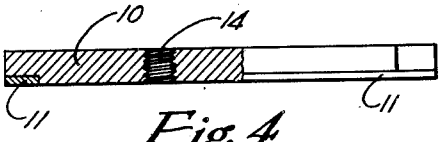



Fig. 4

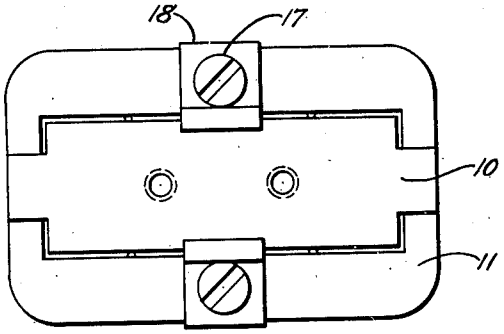



Fig. 6

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# UNITED STATES PATENT OFFICE

2,463,786

## ELECTROMAGNETIC MECHANISM FOR BONE CONDUCTION RECEIVERS, ETC.

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Application February 10, 1947, Serial No. 727,699

8 Claims. (Cl. 179—107)

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This invention relates to electromagnetic devices for converting electrical energy to vibrational or to sound energy. While it relates particularly to bone conduction receivers used with wearable hearing aids, the magnetic system is applicable to air receivers and other similar devices.

While bone receivers in the past have been reasonably satisfactory, they have a number of faults. They have not fully utilized the available small space to the best advantage. Because of the limited electrical power output available from vacuum tube hearing aids particularly, higher efficiency in the receiver has been highly desirable. Most bone receivers have had spring members made of soft annealed alloys or iron which do not have good mechanical spring properties. On those receivers using a more stable spring member, there has been no good way of parallelizing the armature with the pole faces. This invention overcomes many of these difficulties and provides a number of additional new features.

One of the features of this invention is that it effectively provides two complete magnetic systems in a space not appreciably larger than usually occupied by a single system.

Another feature is that only a single centrally located magnet is required for both systems.

Another feature is that a spring having good elastic properties is so used that its magnetic properties are not of material importance.

Another feature is that the construction and arrangement of the armature on which the magnetic pull is exerted is such that it can have excellent magnetic properties without its spring properties being of importance.

Another feature is that the one side of the spring and armature assembly can be ground to a single plane, thus assuring parallelism between the armature and the pole faces.

Another feature is that a second series of flux return paths for the alternating magnetic flux can be provided without added parts, thus increasing the efficiency by reducing the reluctance of the system for alternating flux.

Another feature is that limitation of the movement of the spring is provided without extra parts. This prevents excessive deflection when the unit is dropped or otherwise subjected to sharp impact.

The object of the invention is to provide a hearing aid receiver, especially a bone conduction receiver, constructed to attain some or all of the foregoing features, and which may be easily assembled and economically manufactured.

The invention is illustrated in the accompanying drawing, of which Fig. 1 is a longitudinal central sectional view to enlarged scale of a bone conduction receiver embodying the invention;

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Fig. 2 an isometric view of the magnet and pole piece assembly in the receiver shown in Fig. 1; Fig. 3 a plan view of the armature assembly; Fig. 4 a combined section and side view of the armature assembly taken on the line IV—IV, Fig. 3; Figs. 5 and 6 an elevation and plan view, respectively, of the armature assembly of Fig. 3 attached to the magnet and pole piece assembly shown in Fig. 2; Fig. 7 a bottom plan view of the mechanism within the casing, the plane of view being indicated by the line VII—VII, Fig. 1; and Fig. 8 a transverse sectional view taken on the line VIII—VIII, Fig. 7.

Referring first to Fig. 2 of the drawings, 1 is a permanent magnet which is preferably formed of a material having a high coercive force and high energy product, such, for example, as a suitable alloy of aluminum, nickel and cobalt. Such a magnet may have a length in the direction of magnetization of about ⅛ inch and a cross section of about two-tenths of a square inch. The top and bottom magnet 1 are ground flat and parallel. On its top there is a pole face member 2 made from a suitable magnetic material suitably heat treated, for example, a nickel-iron alloy. The bottom of the magnet is provided with a pole piece 3 that extends beyond the sides of the magnet a short distance and has a right angle turn at each end. The horizontal portion of the pole piece is a continuous plate that rests against the magnet, and is provided at each end with a central leg 4 and smaller side legs 5 that extend upwardly at right angles to the horizontal portion. The legs 4 at each end constitute the principal cores over which windings are placed. Legs 5 form alternating flux path returns which are separated from projections 6 on the pole face member 2 by a somewhat larger air gap 7 than is employed between the pole piece leg 4 and an armature shown in Fig. 3. The magnet and pole piece assembly is held together by screws 8 that go through counterbored holes in the bottom of pole piece 3, pass through slots provided in the sides of magnet 1, and thread into tapped holes in pole face member 2. Two additional tapped holes 9 are provided in the pole face member for mounting the armature assembly. After assembly, the entire top side of the pole face member 2 and the tips of pole pieces 4 are ground to a flat common surface.

As shown in Fig. 3, 10 is an armature, made from a highly permeable alloy. It is fairly thick and hence quite rigid relative to a spring 11 which is rectangular in exterior shape having a rectangular cut-out in its center which provides clearance from armature 10 except at its points of end attachment. The only points of contact between the spring 11 and armature 10 are at the ends of the armature.

Referring to Fig. 4, recesses are milled in the

bottom face of armature 10 to receive the ends of spring 11 and to make the lower faces of the armature and the spring flush. The attachment of the two members may be made by soldering, welding or riveting, soldering having been found to be suitable. Holes 13 are provided in spring 11 for mounting the spring to the pole face member 2. Tapped holes 14 are provided in the armature for mounting it to surrounding case 20. After fastening armature 10 to spring 11, the flush faces are ground so that they lie in a common plane.

The attachment of the armature assembly and the magnet assembly is illustrated in Figs. 5 and 6. Very thin sheet metal shims 15, of such a thickness that they will give the desired operating air gaps 16, are placed between the spring 11 and pole face member 2. These shims are provided with a central hole to receive shanks of assembly screw 17, and extend a sufficient distance on each side of screw 17 towards the ends of spring 11 to assure parallelism of the bottom face of the spring and the top surface of pole face member 2. Under the heads of screws 17 are placed clamps 18, which assure tight clamping of spring 11 against shims 15. These clamps are formed to prevent excessive excursions of the spring and armature away from the magnet and pole piece assembly, such as might be occasioned by dropping the unit. Coils 19, consisting of a suitable number of turns of fine insulated wire, the number of turns depending on the electrical impedance desired, are placed on pole piece legs 4. These coils may be connected either in series or in parallel, but must have their connections such that the phase of the alternating force produced at the ends of the armature is the same.

As shown in Fig. 1, armature 10 is attached to the top portion 20 of a molded plastic case by screws 21, the heads of which are concealed by plastic buttons 22. A projection 23 in the case portion 20 engages armature 10 only over a limited area near its center. While the armature acts essentially as a rigid member over the important frequency range of operation of the receiver unit, it may be lengthened or otherwise reduced in stiffness to give an additional resonance at the high frequency end of the range.

The top portion 20 of the case is fastened to a bottom portion 25 by screws 27 to form a completely closed case for the mechanism. Bottom portion 25 also rests against the head of a user, indicated at 28, and transmits vibrations from the top portion 20.

The complete magnet, coil and pole piece assembly is freely supported inside the case through the spring 11. Connections to coil 19 are made through flexible wire leads 30 to sockets 31 into which the external wires from a hearing aid amplifier are inserted.

The operation of limiting clamps 18 is clearly indicated in Fig. 8, which shows that the clamps overlap armature 10 a small amount. A small gap 33, which may be about .005 of an inch, prevents contact during normal vibration between the armature and the clamps. Excessive excursions, caused by inertial forces on the magnet assembly due to sudden shock, are prevented and no damage can result to the spring and armature assembly.

The mechanism within the case forms two complete magnetic operating systems, one through each of the two coils 19. In the operation of the receiver, a strong permanent magnetic flux is produced by permanent magnet 1. Substantially equal portions of the flux flows through each system. In addition to the normal flux leakage, the flux in each system divides into three paths. Most of it goes through center pole piece 4 and is modulated by the alternating voice currents in coils 19. A considerable portion of the flux goes through legs 5 and through air gaps 7 between projections 6 on pole face member 2 and legs 5 of pole piece 3. This portion of the permanent flux is not effective in producing vibromotive force, but it does impair the operation of the system because it is easily possible to supply this leakage flux by making the magnet a little larger than would otherwise be done. In fact, the larger vibratory mass resulting from increased magnet size is of benefit in increasing the low frequency response of the receiver. The increased magnet area also results in a lower reluctance to alternating flux through the magnet.



The alternating flux results from alternating voice or other current in coils 19. Its principal path is through pole piece 4, across operating air gaps 16 where the vibratory force is generated, through armature 10, across a very low reluctance air gap 35 between armature 10 and pole face member 2, through magnet 1 and back through pole piece 3 and legs 4. In addition, another return path is provided through legs 5 and air gaps 7, to further lower the reluctance of the magnetic path to alternating flux.

Since ample space is available for the permanent magnet, an additional benefit results from the leakage of permanent flux in gaps 7. In order to supply this leakage flux, the magnet must have a larger cross section than it would otherwise have. This makes the reluctance of the magnet to the alternating flux less than it would otherwise be.

Superimposing of an alternating flux on the permanent flux, by means of the currents in coils 19, gives rise to the efficient production of vibration forces at air gaps 16, and to a small extent at gap 35 between armature 10 and pole face member 2. A vibration of the floating magnet assembly relative to the armature results, and the reaction forces of this vibration are transmitted through the relatively rigid armature to the case and then to the head of a user.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention, and have illustrated and described what I now consider to be its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, my invention may be practiced by other forms than that specifically illustrated and described.

I claim:

1. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid armature having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of the pole face member, a leaf spring having a central opening for receiving the armature with the ends of the spring secured to said armature ends, the sides of the spring being spaced from the armature and attached centrally to the outer face of said pole face member, a pole piece attached to the other end of said magnet and having ends extending equal distances be-

yond opposite sides thereof, each end of said pole piece being provided with a leg, and an electro-magnetic winding surrounding each of said legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

2. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid armature extending parallel to said pole face member and having ends projecting equal distances beyond opposite sides thereof, a spring attached to the outer face of said pole face member and to said armature, a pole piece attached to the other side of said magnet and extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a central leg forming a core for an electro-magnetic winding and being provided with a pair of auxiliary legs positioned one at each side of said central leg, and an electro-magnetic winding between each said pair of auxiliary legs and surrounding each of said central legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

3. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid armature extending parallel to said pole face member and having ends projecting equal distances beyond opposite sides thereof, a spring attached to the outer face of said pole face member and to said armature, a pole piece attached to the other end of said magnet and extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a central leg forming a core for an electro-magnetic winding and being provided with a pair of auxiliary legs positioned one at each side of said central leg, and an electro-magnetic winding between each said pair of auxiliary legs and surrounding each of said central legs, the free ends of said central legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece, and the free ends of said auxiliary legs being spaced from the ends of said pole face member to form auxiliary air gaps for reducing the reluctance of the magnetic system to alternating flux.

4. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid flat armature having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of the pole face member, a flat spring having a central opening for receiving the armature with the ends of the spring secured to said armature ends, the sides of the spring being spaced from the armature and attached centrally to the outer face of said pole face member, the spring being materially thinner than said armature, the inner faces of said armature and spring being coplanar, a pole piece attached to the other end of said magnet and having ends extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a leg whose free end lies in the plane of the outer face of the pole face



member, and an electro-magnetic winding surrounding each of said legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

5. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid flat armature having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of the pole face member, a flat spring having a central opening for receiving the armature with the ends of the spring secured to said armature ends, the sides of the spring being spaced from the armature and attached centrally to the outer face of said pole face member, shims spacing the central portions of said sides of the spring from the pole face member, the spring being materially thinner than said armature, the inner faces of said armature and spring being coplanar, a pole piece attached to the other end of said magnet and having ends extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a leg whose free end lies in the plane of the outer face of the pole face member, and an electro-magnetic winding surrounding each of said legs, the spaces between the free ends of said legs and the inner face of said armature forming force-producing air gaps for effecting vibration of the armature relative to said pole piece.

6. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid flat armature having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of said pole face member, a flat spring having side portions thereof positioned at and spaced from each side of said armature, said spring being attached at its end portions to the ends of said armature and being attached intermediate of its end portions to said pole face member and spaced from it, a pole piece attached to the other end of said magnet and having ends extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a leg, and an electro-magnetic winding surrounding each of said legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

7. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid armature having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of said pole face member, a flat spring having a central opening for receiving the armature and medially attached at side portions thereof to the outer face of said pole face member and to said armature, shims positioned between adjacent faces of said spring and said pole face member, clamps attached to said spring directly opposite to said shims and having lugs extending over and spaced from said armature to limit movements of the armature away from

said pole face member, a pole piece attached to the other end of said magnet and having ends extending equal distances beyond opposite sides thereof, each end of said pole piece being provided with a leg, and an electro-magnetic winding surrounding each of said legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

8. Electro-magnetic mechanism for vibrating a vibration responsive member, comprising a permanent magnet, a pole face member attached to an end of said magnet, a substantially rigid armature adapted to be rigidly connected to an element to be driven by it and having its inner face extending parallel to and spaced from said pole face member, the armature having ends projecting equal distances beyond opposite sides of the pole face member, a leaf spring extending along the armature and connected to its ends, the rest of the spring being spaced from the armature and having side portions projecting laterally from



the sides of the armature, means connecting the centers of said side portions to the outer face of the pole face member in spaced relation thereto, a pole piece attached to the other end of said magnet and having ends extending equal distances beyond opposite sides of the magnet, each end of the pole piece being provided with a leg, and an electro-magnetic winding surrounding each of said legs, the free ends of said legs being spaced from the inner face of said armature to form force-producing air gaps for effecting vibration of the armature relative to said pole piece.

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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,062,372 | Nicholides | Dec. 1, 1936 |
| 2,127,468 | Greibach | Aug. 12, 1938 |
| 2,255,250 | Greibach | Sept. 9, 1941 |