March 9, 1937. J. McCRACKEN 2,073,561

SOUND REPRODUCING MEANS

Filed Aug. 16, 1934

Fig. 1.

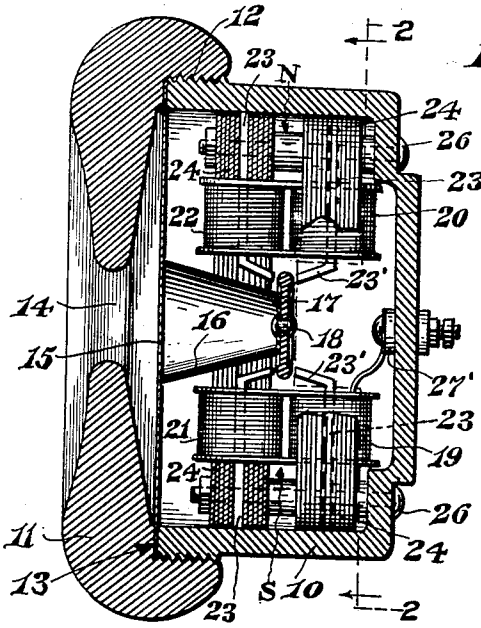


Fig. 3.

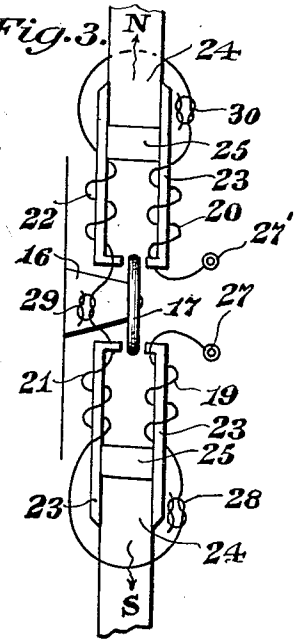


Fig. 2.

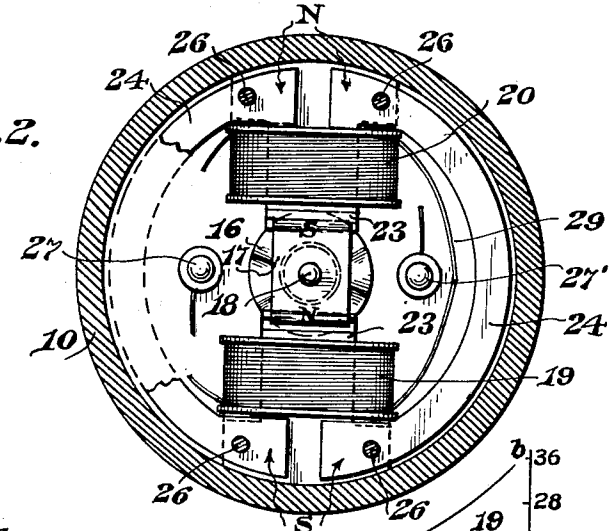
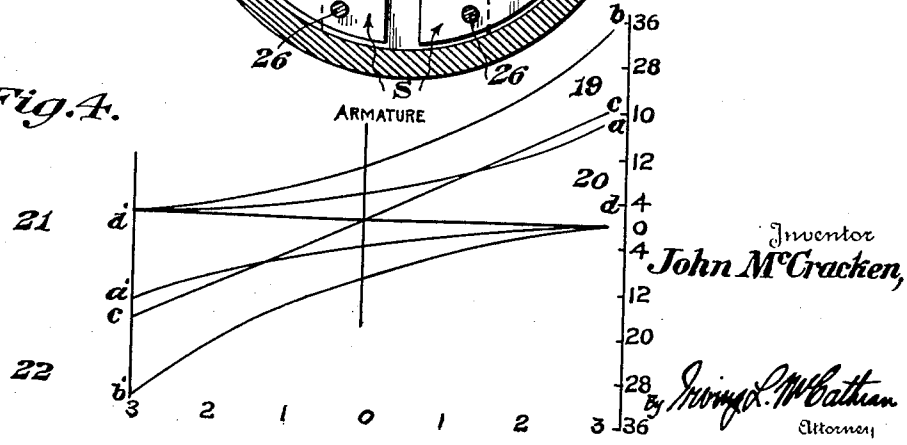


Fig. 4.



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Patented Mar. 9, 1937

2,073,561

UNITED STATES PATENT OFFICE

2,073,561

SOUND REPRODUCING MEANS

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Application August 16, 1934, Serial No. 740,175

3 Claims. (Cl. 179—119)

This invention appertains to an improvement in sound reproduction instrumentalities generally, and more particularly to a type thereof for use in telephony.

An object of the invention is to provide a means for sound reproduction from transmitted electrical signal current variations which has a mean constant efficiency over a wide range of sound frequencies.

Another object resides in the provision of a sound receiver which is simple and inexpensive in construction and manufacture, and highly efficient and practical in operation.

With these and other equally important objects and advantages in view, the invention resides in the certain new and useful combination, construction and arrangement of parts and circuits, as will be hereinafter more fully described, set forth in the appended claims, and illustrated in the accompanying drawing, in which:—

Figure 1 is a longitudinal section through an exemplified form of the receiver;

Figure 2 is a transverse section taken on the line 2—2 of Figure 1;

Figure 3 is a diagrammatical view of magnet winding circuit within the receiver; and

Figure 4 is a graph of the diaphragm flexation for all positions of the armature.

Referring to the drawing, wherein like characters of reference designate corresponding parts in the several views thereof, the embodiment of the invention, as is exemplified therein, is constituted in a casing 10 which is preferably of an insulating material, such as hard rubber or the like, and cylindrical in form and open at one end to have a sound emitting cover or ear-piece 11 detachably secured thereto, as by means of the screw threads 12.

Clamped between the edge of the open end of the casing 10 and an annular flattened portion 13 of the cover 11 is a diaphragm 15, the central area of which is opposed to an opening 14 formed in the center of the cover, for emitting sounds to be translated by vibrations of the diaphragm when it is subjected to magnetic influences, therethrough. The inner and outer faces of the wall of the cover 11 are preferably concaved, the inner face thereof inwardly of the annular flattened portion 13, to afford a proper clearance to the diaphragm 15 when vibrated, and the outer face to allow for a lateral spread of the emitted sound waves on a plane of appreciably greater area than that to which the sound waves are restricted in their passage through the opening 14.

Extending inwardly of the casing 10, from the center of the rear face of the diaphragm 15, is a support 16, to the inner end of which an armature 17 is fixedly secured, as at 18, in parallel relation to the diaphragm. This armature 17 is preferably in the form of a substantially rectangular plate which is permanently magnetized so as to retain a substantially constant magnetic value and polarity. The support 16 is formed of an insulating material, preferably vitreous in nature, and is hollow and substantially bell-shaped, the armature 17 being secured crosswise of its inner smaller end, somewhat as is best shown in Figure 1.

Mounted at diametrically opposite points within the casing 10 are inductive windings or coils 19, 20, 21, and 22, each coil being positioned about a soft iron core or pole-piece 23. The coils are arranged to function in pairs, the coil 19 with the coil 20 and the coil 21 with the coil 22, and the coil groups 19—21 and 20—22 at opposite sides of the casing 10 are disposed in line longitudinally of the casing in order to space the inwardly projecting ends of the pole-pieces 23 to either side of an adjacent edge portion of the armature 17 and, due to this spacing, the free ends of the pole-pieces 23 are preferably angled, as at 23', toward adjacent sides of the armature to form proper air gaps therebetween.

The outer ends of the pole-pieces 23 of each pair of the windings 19—20 and 21—22 are rigidly and magnetically joined by a permanent magnet 24, of substantially constant magnetic value and preferably of a usual laminated construction. As is best shown in Figure 3, each of the permanent magnets 24 is perferably supplemented by a soft iron part or lamination 25 at its inner side to bridge the complemental of the pairs of pole-pieces 23, in order to increase the effectiveness of the magnetic circuit between the latter. Each of the two magnet assemblies thus provided is substantially semi-circular in form to closely abut an adjacent portion of the peripheral wall of the casing 10 and is secured in place within the casing as by means of a pair of bolts or the like 26 passing through the end wall of the casing for engagement therewith.

A pair of binding posts 27—27' are mounted in the end wall of the casing 10 and these are electrically connected in circuit with the coils 19—20 and 21—22, as follows:—The binding post 27 to coil 19, the coil 19 through connection 28 to coil 21; the coil 21 through connection 29 to coil 22; the coil 22 through connection 30 to coil 20; and the latter coil directly to the binding post 27'.

In order to prevent the armature 17 from sticking to the pole-pieces 23', points 17', of a vitreous or other non-magnetic material, may be provided at opposite sides of the armature and in line with the pole-pieces to that end. Also to increase the inductive effect between adjacent coils 19—21 and 20—22, the opposed surfaces thereof will preferably be coated with shellac or the like.

As thus constituted, the receiver, in principle, involves a two-branched magnetic circuit, wherein the pair of coils 19—20 function to establish one branch, and the pair of coils 21—22 the other branch, so that the passage of an undulating signal current through the coils influences one branch in a manner to augment or increase its magnetic strength and thereby cause the armature 17 to move toward a corresponding set of the pole-pieces 23, and the other branch in a manner to decrease its magnetic strength thereby permitting the armature 17 to move away from the other set thereof. Thus, the armature 17 travels toward one set of pole-pieces 23 under the attraction of their increasing ratio of polarity over that of the opposite set and it is thereafter brought back to a position of stability by the reflex action of the diaphragm 15.

By employing a transformer (not shown), having a one to one ratio between its primary and secondary windings, in the external circuit of the receiver, the aforesaid undulating signal current will pass through the receiver in the form of an alternating current, so that flexing action of the diaphragm may be minimized, but, in any case, the tension of the latter on the armature 17 must be sufficient to prevent any contact of the armature with either set of the pole-pieces 23 by virtue of its nearer proximity to them in either direction of vibratory travel.

In operation, a transmitted signal current will enter the receiver at binding post 27 and pass to the binding post 27' by way of the connection 28, the coils 19 and 21, the connection 29, the coils 22 and 20, and the connection 30, during its positive half cycle of flow, so that the armature 17 is drawn toward one set of the pole-pieces 23. During a reversed directional current flow or negative half cycle, which will be from the binding post 27' to the binding post 27 through the several connections and coils, the armature 17 will move away from the first set of pole-pieces 23 and toward the other set thereof. This alternate direction of travel of the armature 17 will, of course, be transmitted to the diaphragm 15 through the support 16, as is well understood.

In the operation, the resultant magnetism set up by the reversals of signal current in the several coils, in effect, cuts up and down through the adjoining coils from one set of pole-pieces 23 to the other, and exerts its tractive power on the armature 17, first on one side, and then on the other. The pairs of coils 19—20 and 21—22 respectively in the two branches of the magnetic circuit are wound to almost as great a degree of resistance and inductance as the expected signal current can most efficiently overcome were either branch of the magnetic circuit to be employed alone. Thus, the power consumed by the magnetic back pressure on the first pair of coils is sufficient to energize the second pair of coils when they are arranged to relieve the pressure from the first set, or, in other words, the coils 19—20 and 21—22, being oppositely wound and connected in series as shown in Figure 3, alternately aid and oppose the magnetization of the pole-pieces of the coil pairs or sets, so that armature movement, and consequently movement of the diaphragm 15, is produced by a corresponding weakening and strengthening of the pole-pieces at opposite sides of the armature.

The pole-pieces 23 are to be ample in permeability and effectiveness to establish a comparatively powerful field of magnetism, the pairs of coils merely acting to shift the field from one branch of the magnetic circuit to the other and making it relatively effective four times in each signal current cycle; twice on each one-half cycle, minus to the armature's magnetic strength on one set of the pole-pieces and plus on the other set.

It is to be here noted that on an unbranched or single magnetic circuit, the undulating signal current's effectiveness is greatest at its point of greatest value, i. e., one-half undulation, on account of the armature nearness to the pole-pieces, and is least at the ending and beginning of successive undulations when the armature is at its greatest distance from the pole-pieces. This effective efficiency varies inversely as the square of the distance of the armature from the pole-pieces, causing corresponding variations in sound volume or distortion. It is therefore obvious from the armature travel to and fro, corresponding in distance to the sound pitches, duration or frequency, as well as to its magnitude or volume, that the lower octaves of sound, having the greater duration, and those of greater magnitude, will experience the greater distortion; and also that overtones, occurring during the various positions taken by the armature, will likewise be reproduced with varying volume. Hence, anything tending to give the armature more travel, such as lower octaves of sound, stronger signal, or less air resistance on the diaphragm will cause greater sound distortion.

In order to demonstrate the diaphragm action and the forces acting on the armature 17, reference is made to Figure 4 of the drawing. Here, the curve *c—c* representing by its co-ordinates the magnitude of elasticity or tensile strength of the diaphragm 15 for all positions of the armature is of sufficient magnitude to hold the latter in stabilized or centered position between the opposed set of pole-pieces, when there is no signal current flowing through the coils. Now under the influence of a signal current of low frequency, carrying low octaves of sound and of sufficient power to overcome the air resistance on the diaphragm 15 in unit time per cycle, the armature 17 will travel to and fro from one set of pole-pieces to the other. In practice, the air resistance on the diaphragm should be great enough to prevent so great a distance of travel. The curve *a, d'* represents by its co-ordinates the magnitude of the magnetic tractive power on the armature 17 by the pole-pieces of the coil pair 19—20 which are (figuratively) located on the right hand side of the figure and the distance of armature travel in that direction from its central position of stability represented by the axes *d, d'*, while the curve *a', d* represents by its co-ordinates the magnitude of magnetic tractive power on the armature by the pole-pieces of the coil pair 21—22 located (figuratively) at the left hand side of the figure and the armature's distance from the central position when the force is effective. The forces represented by these curves are oppositively disposed and completely neutralize each other at a point

indicated by the axes *d*, *d'* midway between the two sets of pole-pieces, and at which point the armature comes to rest when stabilized.

The resultant tractive power of the magnetism set up by the signal current flow through the coils and from one branch only of the magnetic circuit, when impressed upon the permanent magnetism of the involved parts, is shown by the curves *b*, *d'* and *b'*, *d* and each indicates that part of the power due to the positive and negative half cycles of signal current respectively, and the axes *d* and *d'* similarly indicate the decreased tractive power of the opposing magnetic branch. The points *b* and *b'*, of the curves *b*, *d'*, and *b'*, *d*, are indicative respectively of the increased powers of *a*, *d'* and *a'*, *d* and *d* and *d'* of their decreased zero powers. The magnetic force, represented by the line *c*, *c'*, is minus when the armature is nearer the attracting poles and plus when it is nearer the repelling poles. The forces *c*, *y* and *c'*, *y* occurring as they do at different times, one in each oppositive half cycle of the signal current, cannot exist together, hence the force represented by *c'*, *y* is effective, for instance, during the positive part of the signal and that represented by *c'*, *y* effective during the negative part.

Having described the invention, what is claimed as new is:

1. In a sound reproducer of the class described, a hollow casing open at one end, an ear piece detachably applied to the open end of the casing, a diaphragm clamped between the ear piece and walls of the casing at the open end thereof, an armature carried at the inner side of the diaphragm and located intermediate the depth thereof, pairs of magnets within the casing having their ends extending towards each other and overlying opposite ends of the armature, and pole-pieces extending from each end of each of the magnets at opposite sides thereof and disposed at opposite sides of a respective end of the armature with their free ends bent laterally to project toward the armature, magnet windings on each of said pole-pieces, the said windings being oppositely wound and in series with each other and with a source of signal current whereby to alternately aid and oppose the magnetization of the pole-pieces at opposite sides of the armature and cause the latter to have reversed directional movement relative to the pole-pieces corresponding to an increase and decrease in the strength of the magnetic fields in each half cycle of flow of the signal current through the magnet windings.

2. The receiver as set forth in claim 1 wherein a tubular driving element is projected inwardly of the casing from the rear center of the diaphragm and the armature is secured crosswise of the inner end of the element for the disposition of its opposite ends between complemental pairs of the pole-pieces.

3. The sound reproducer as set forth in claim 1 wherein a hollow conical driving element is projected inwardly of the casing from the rear center of the diaphragm and the armature is secured crosswise of the smaller end of the element for the disposition of its opposite ends between complemental pairs of the pole-pieces.

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