June 19, 1928. 1,674,539

C. R. ALBERTUS

LOUD SPEAKING TELEPHONE

Filed Aug. 20, 1927

Fig. 1

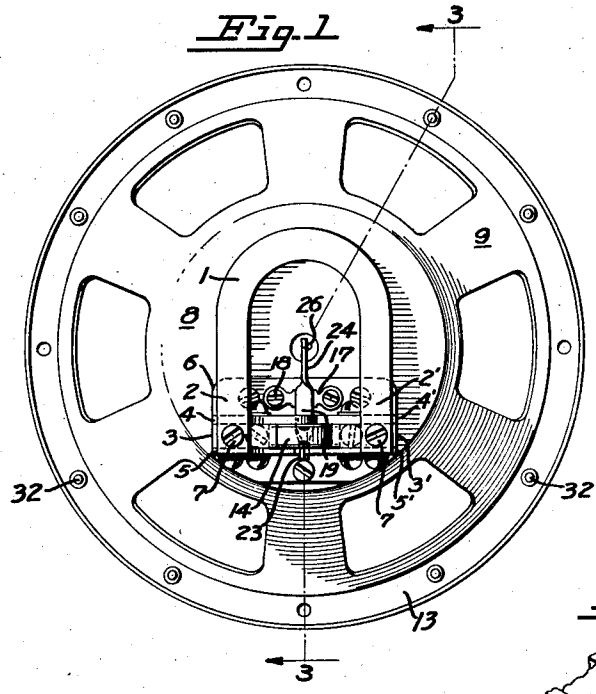



Fig. 3

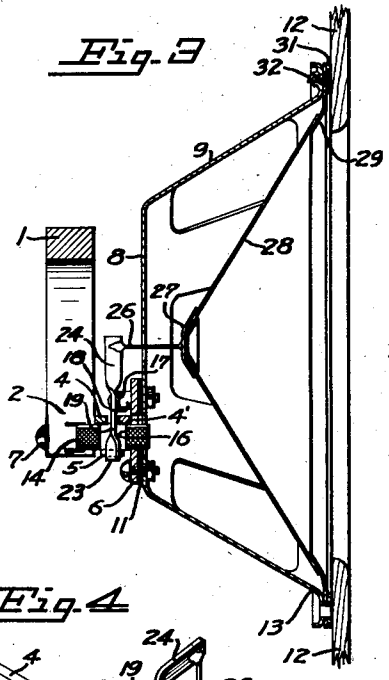



Fig. 4

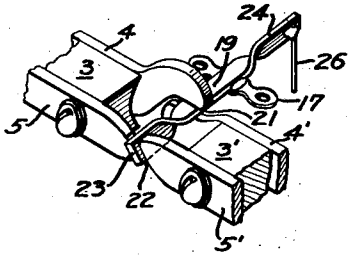



Fig. 2

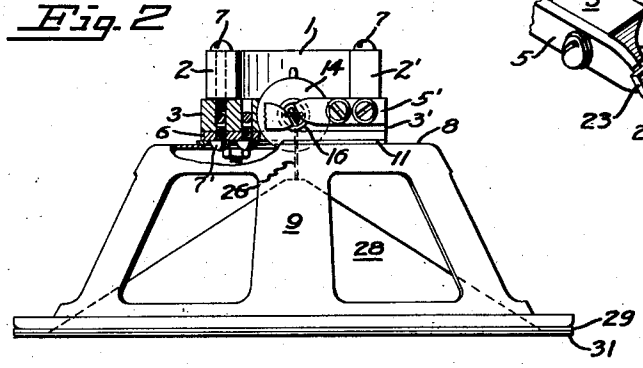
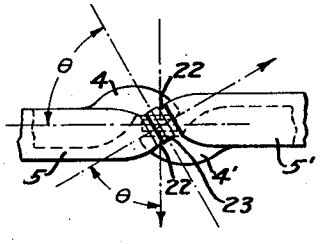



Fig. 5




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HIS ATTORNEY.

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# UNITED STATES PATENT OFFICE.

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## LOUD-SPEAKING TELEPHONE.

Application filed August 20, 1927. Serial No. 214,276.

My invention relates to mechanisms for driving telephone diaphragms and specifically to units of the balanced armature type.

An object of my invention is to provide a means whereby the space available for the coil winding can be used to greatest advantage.

A further object is to utilize a larger proportion of the flux from the permanent magnet than has hitherto been possible.

Another object is to produce a device in which a large amplitude of motion can be obtained without the use of cumbersome and inefficient levers or linkages, and one which is simple and cheap to produce.

Referring to the drawings:

Figure 1 is a plan view of an embodiment of my device as it is used to drive a conical diaphragm.

Figure 2 is an elevation of the same structure.

Figure 3 is a sectional view, the line 3—3 of Figure 1 indicating the plane of section.

Figure 4 is a detail of the pole piece and armature structure, with the coil removed for greater clarity.

Figure 5 is a diagrammatic view illustrating the angular relation of the air gaps.

Mechanisms of this general character consist of a permanent magnet and a pivoted armature held by spring action with its ends in the center of air gaps between pairs of pole pieces with which the magnet is provided.

Surrounding the armature is a coil which carries currents of the frequency of the sounds to be reproduced. These currents produce magnetic fluxes of the same frequency in the armature, and these fluxes cooperate with the flux from the permanent magnet to pull the armature from its central position in the air gaps against the action of the spring. A linkage connects the armature with a diaphragm, which communicates the vibrations to the air to produce sound.

In order that the mechanism may be most effective, it is desirable that the armature be short, so that its magnetic reluctance may have but little effect on the flux through it. This restricts the space allowable for the coil.

It is also desirable that both air gaps be of the same length, and that the movement of the armature through the gaps be the same, for if one be short and the other long, an unequal flux distribution will result, with a loss of efficiency which may, in extreme cases, amount to a practical short circuiting of the flux.

It is desirable, too, to have the angle through which the armature vibrates small, as a rectilinear movement of the diaphragm is what is wanted. On the other hand, long lever arms are to be avoided as such are susceptible to parasitic vibrations which seriously impair the quality of reproduction. It will be seen that my mechanism combines these desirable elements in a high degree.

The earliest units of this type pivoted the armature in the center. This necessitated dividing the coil in two to allow space for the pivoting structure. This resulted in waste of coil space, and a relatively wide angular motion of the armature.

The next advance was to pivot the armature outside of the coil, and by reversing the pole pieces, i. e., by placing the north pole pieces at one end of the coil above the armature and at the other end below it, with a similar reversal of the south pole pieces, an operative device was produced which used the available winding space more efficiently and decreased the arc through which the armature moved. With this structure, however, either one air gap must be materially longer than the other; or the percentage of the gap through which the armature moves must be materially different at the two ends; or else the pivot about which the armature rotates must be so far removed from the driving portion of the mechanism as to make the inter-related problems of rigidity, weight, and parasitic vibration difficult of solution.

In the broad conception of my invention I pivot the armature externally to the coil and dispose the air gaps at different angles to the plane of movement of the armature, so that I am enabled to overcome all the difficulties which I have enumerated as affecting this general type of structure.

In terms of greater detail, the present embodiment of my invention comprises a permanent magnet 1 conveniently of horseshoe type, and provided on one side adjacent the ends of its poles 2, 2′ with a pole structure consisting of the blocks 3, 3′; the rear pole pieces 4, 4′; and the front pole pieces 5, 5′.

This pole structure is secured to the poles of the magnet and to a brass base plate 6, by screws 7, 7'. The base plate is fixed on the outside face of the bottom wall 8 of the supporting housing or cage 9, a soft rubber pad 11 being interposed therebetween. The housing is mounted on the supporting structure 12 in which the complete unit is embodied, by any suitable means disposed about the rim 13.

The adjacent ends of the blocks 3, 3' are curved as best shown in Figure 4, to embrace the coil 14, suitably wound upon the hollow bobbin 16, held within the pole structure, and extending thru an aperture formed for the purpose in the wall 8 of the housing.

On the ligamentary spring 17, fixed at its ends to studs 18, extending from the plate 6 toward the magnet, is mounted the armature 19, extending from the vibrational axis thus established thru the bobbin and coil and lying within the air gaps 21 and 22 between the ends of the respective pairs of pole pieces.

It will be noted from an inspection of Figure 4 that the rear pole pieces 4, 4' are shaped to provide terminal surfaces defining the rear air gap 21 and that these surfaces lie in planes parallel to the vibrational axis of the spring 18, and at right angles to the plane of movement of the armature. The front pole pieces 5, 5' are also shaped to provide terminal surfaces defining the front air gap 22; and these surfaces lie in parallel planes forming an angle with the planes of the terminal surfaces of the rear pole pieces, and with the vibrational axis of the armature; and also with the plane of movement of the armature. The parts are arranged so that these air gaps are of equal length.

It will also be observed that the free end 23 of the armature is twisted so that the end has an angular relation to the main body of the armature equal to that between the two air gaps; or in other words, equal to the angular relation between the front air gap and the vibrational axis of the armature.

The armature is extended beyond the vibrational axis or fulcrum provided by the spring 17, to form a lever arm 24, adjacent the end of which a pin or stud 26 is fixed. The stud passes thru an aperture in the housing wall 8 and is fixed to the cap 27, mounted on the point of the conical diaphragm 28, lying within the housing and secured at its periphery to the annular leather flange 29, the outer edge of which is caught between the housing rim and an annular clamp ring 31 secured to the rim by screws 32.

In operation the magnetic flux provided by the permanent magnet divides, a portion passing through the rear pole piece 4, and down through the air gap 21 to the pole piece 4'. The remainder passes through the front pole piece 5 and up through the gap 22 to the pole piece 5'. The length of the air gaps being substantially the same, the field strengths of the two are equal. It will be noted, however, that while the path of the magnetic flux in the rear gap 21 is in the direction of the plane of movement of the armature, the path of the magnetic flux in the front gap 22 is at an angle $\theta$ with this plane of movement. It will also be noted that the same angular value obtains between the two air gaps, and between the body and twisted end of the armature, each portion of which thus lies normal to the path of flux in its associated air gap.

When a current flows in the coil 14, it induces a flux in the armature with opposite poles at opposite ends of the coil. The flux from these poles co-operates with the flux from the pole pieces 4, 4' and 5, 5', and since this flux also is in opposite directions at opposite ends of the coil, the total effect is to urge the armature in one direction, which will be assumed to be down.

The armature now is not in the center of the gap, and since the reluctance of the armature is so low as compared with that of air as to be negligible, the larger portion of the flux from the magnet will pass through the pole piece 5, and the armature to the pole piece 4'. When the current in the coil is reversed the armature moves upwardly, and the larger part of the permanent flux now flows from pole piece 4, through the armature to pole piece 5'.

The distance from the vibrational axis of the armature to the rear pole piece may be assumed to have a value of $a$, and to the front pole piece a value of $b$. If the armature moves through an angle $\phi$ it will shorten the distance between armature and rear pole piece by air amount equal to $a \sin \phi$. The front end of the armature will move a distance equal to $b \sin \phi$; but since the front gap is at an angle $\theta$ to the direction of motion, the change in distance between pole piece and armature will be $b \sin \phi \cos \theta$. If the angle $\theta$ is so chosen that $\cos \theta$ is equal to $\frac{a}{b}$ the two gaps will change by the same amount, and maximum effectiveness and minimum distortion in reproduction will result.

A further effect of inclining the air gap to the plane of armature motion may, under some circumstances, be highly desirable. In order to radiate a large volume of sound from a small diaphragm it is necessary that it vibrate through a large amplitude. To obtain this amplitude step-up leverage systems have previously been employed, but it is difficult to design such systems with the

necessary rigidity. By suitably inclining both air gaps to the plane of armature motion in accordance with the principles above explained, the amplitude of armature motion may be increased so as to produce a result identical with that following the use of a longer lever arm.

I claim:

1. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap.

2. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, and an armature mounted for movement in said air gaps.

3. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, and an armature mounted for movement in said air gaps in a plane angular to the path of the magnetic flux in at least one of the air gaps.

4. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap and an armature mounted for movement in said air gaps in a plane angular to the path of the magnetic flux in one of the air gaps and parallel to the path of the magnetic flux in the other air gap.

5. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, and an armature pivotally mounted for movement in said air gaps.

6. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, and an armature mounted for movement in said air gaps about an axis at one side thereof.

7. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, and an armature mounted for movement in said air gaps about an axis at one side thereof and parallel to the nearest air gap; the proportions conforming to the following formulæ:

$a$=distance between axis and nearest air gap;

$b$=distance between axis and farthest air gap;

$\Theta$=angle between path of magnetic flux in the farthest air gap and the plane of armature movement, and so chosen that

$$\cos \Theta = \frac{a}{b}.$$

8. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, an armature mounted for movement in said air gaps, and a coil adapted to be energized disposed about said armature.

9. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, an armature mounted for movement in said air gaps, and a coil adapted to be energized disposed about said armature between the pairs of pole pieces.

10. In a sound reproducer, a permanent magnet provided with pole pieces disposed in spaced pairs and to provide an equal air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, an armature mounted for movement in said air gaps about an axis at one side thereof, a coil adapted to be energized disposed about said armature between the pairs of pole pieces, a diaphragm, and means connecting the armature to the diaphragm.

11. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap and the air gaps being substantially the same length.

12. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap and the air gaps being substantially the same length, and an armature mounted for movement in said air gaps about an axis to one side thereof.

13. A magnet provided with pole pieces disposed in pairs to provide an air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap and the air gaps being substantially the same length, and an armature mounted for movement in said air gaps about an axis to one side thereof, the proportions being such that the movement of the armature in both air gaps is relatively the same.

14. In a sound reproducer, a permanent magnet provided with pole pieces disposed in spaced pairs and to provide an equal air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, an armature mounted for movement in said air gaps about

an axis at one side thereof, a coil adapted to be energized disposed about said armature between the pairs of pole pieces, a diaphragm, and a lever arm fixed on the armature and operatively connected to said diaphragm.

15. In a sound reproducer, a permanent magnet provided with pole pieces disposed in spaced pairs and to provide an equal air gap between each pair, the path of the magnetic flux in one air gap being at an angle to that in the other air gap, an armature arranged in said air gaps, a mounting for said armature at one side of the pole pieces for resiliently holding it in the center of the air gaps, a coil adapted to be energized disposed about said armature between the pole pieces, a diaphragm, and means connecting the armature to the diaphragm.

In testimony whereof, I have hereunto set my hand.

CARL R. ALBERTUS.