

July 15, 1941.

E. E. MOTT

2,249,161

ELECTROACOUSTIC DEVICE

Filed May 19, 1939

2 Sheets-Sheet 1

FIG. 1

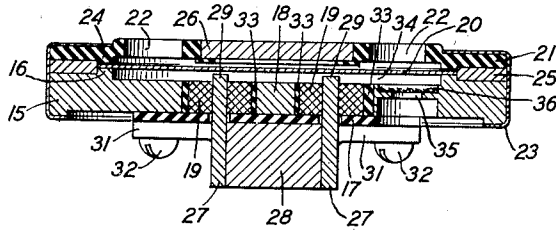


FIG. 2

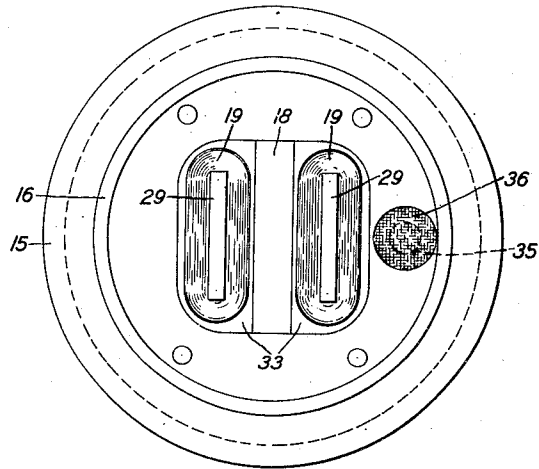


FIG. 3

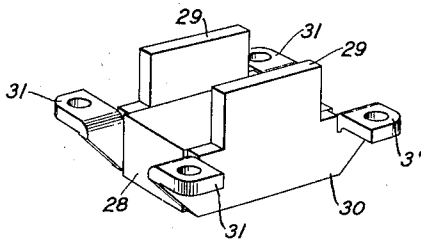


FIG. 4

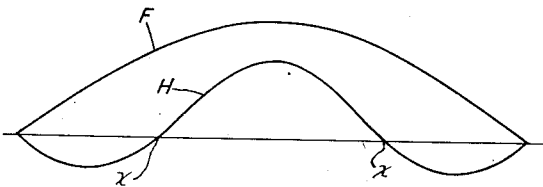


FIG. 5

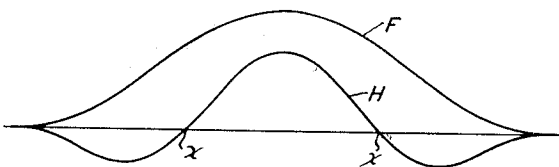
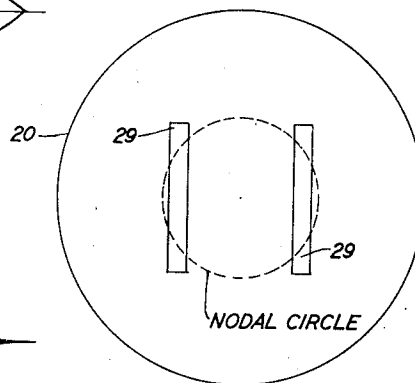


FIG. 6



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FIG. 7

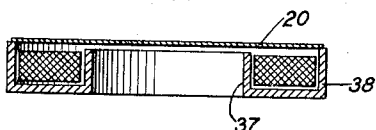


FIG. 8

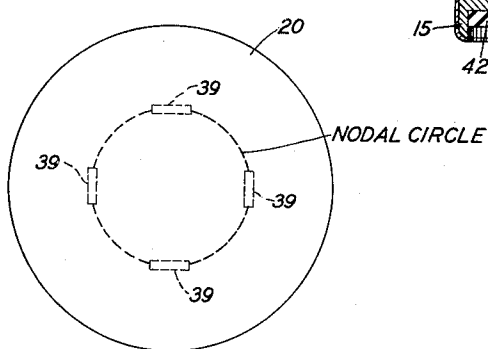


FIG. 9

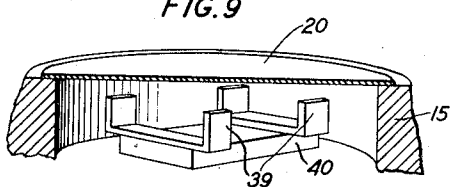


FIG. 10

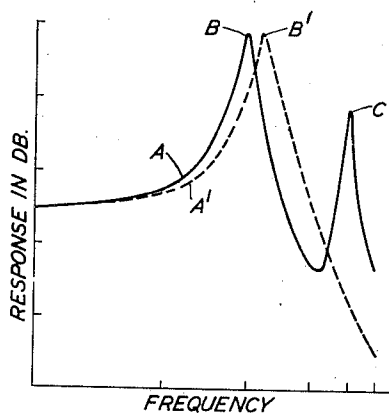


FIG. 11

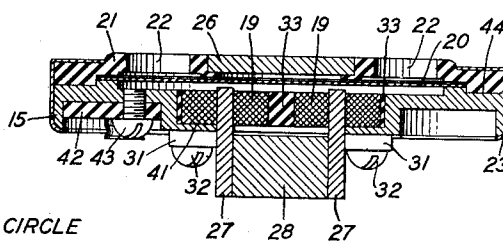
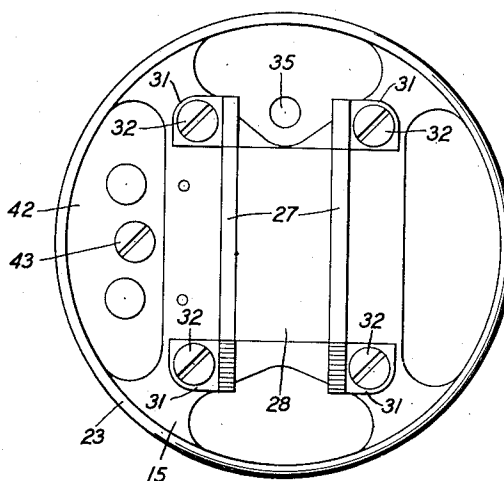


FIG. 12



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ELECTROACOUSTIC DEVICE

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Application May 19, 1939, Serial No. 274,484

12 Claims. (Cl. 179—114)

This invention relates to electroacoustic devices and more particularly to telephone receivers having a magnetic vibratile element or diaphragm.

One object of this invention is to reduce the number of component parts of an electroacoustic device and thereby to simplify the structure, reduce its size and weight, and facilitate the manufacture thereof.

Another object of this invention is to improve the efficiency of electroacoustic devices and more particularly to increase the efficiency of the magnetic system of telephone receivers.

A further object of this invention is to improve the vibrating characteristics of a magnetic diaphragm in telephone receivers and, more specifically, to substantially eliminate vibration of such a diaphragm in other than its fundamental mode.

In one illustrative embodiment of this invention, a telephone receiver comprises a magnetic diaphragm, which may be clamped or unclamped at its periphery, a support therefor, and actuating means, including pole-pieces and a magnet, for the diaphragm.

In accordance with one feature of this invention, the magnetic system comprises a pair of pole-pieces having parallel arms and also extensions or lugs affixed to one face of the support, and a single bar magnet having a high ratio of coercive force to remanence mounted between the parallel arms of the pole-pieces and affixed thereto.

In accordance with another feature of this invention, the pole-pieces are so dimensioned and related that the driving forces are applied to the diaphragm at the first nodal circle thereof whereby the diaphragm vibrates substantially only in its fundamental mode and distortion through harmonics is prevented.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a side view in section of a telephone receiver illustrative of one embodiment of this invention;

Fig. 2 is a top view of the receiver shown in Fig. 1 with the cover member and diaphragm removed;

Fig. 3 is a perspective view of the pole-piece and magnet structure embodied in the telephone receiver shown in Figs. 1 and 2;

Fig. 4 is a diagram illustrating the bending

curve of a diaphragm freely supported at its periphery, as in the receiver shown in Fig. 1;

Fig. 5 is a diagram illustrating the bending curve of a similar diaphragm clamped at its periphery;

Fig. 6 is a diagrammatic view illustrating the relation of the pole-pieces with respect to the first nodal circle of a diaphragm, as in the telephone receiver illustrated in Fig. 1;

Fig. 7 is a side view in section of another receiver wherein the diaphragm is driven at its first nodal circle;

Figs. 8 and 9 are top and perspective views, respectively, illustrating another form of magnetic structure which may be employed to drive a diaphragm at its first nodal circle;

Fig. 10 is a graph showing comparative response characteristics for similar diaphragms driven at points at and removed from its first nodal circle;

Fig. 11 is a side view in section of a telephone receiver illustrative of another embodiment of this invention; and

Fig. 12 is a bottom view of the receiver shown in Fig. 11.

Referring now to the drawings, the telephone receiver shown in Figs. 1 and 2 comprises a centrally apertured foundation frame or support 16, such as a disc, of non-magnetic material, such as an aluminum or zinc alloy, having on one face thereof an annular ridge or seat 16. Affixed to the frame 15 and extending over the central aperture therein is a plate 17 of non-magnetic material, such as phenol fibre, having a pair of parallel elongated slots therein. A cross-piece 18, which may be integral with the frame or made separately and fitted in the central aperture therein, extends across the central aperture in the frame and forms therewith and the plate 17 a pair of pockets in which the signal coils 19 are positioned.

Seated upon the annular ridge 16 is a diaphragm 20 which may be a circular disc of magnetic material. A cover member 21, having apertures 22 allowing egress of sound waves, overlies the diaphragm 20 and is clamped to the frame 16 by an annular crimped band 23. The cover member 21 is provided with an annular ridge 24 slightly spaced from the periphery of the diaphragm, as through the intermediary of an annular spacer 25 between the cover member 21 and the frame 15, so that the diaphragm is held in position solely by magnetic attraction. Alternatively, the diaphragm may be clamped at its periphery between the ridges 16 and 24.

The cover member 21 may have mounted in its central portion an auxiliary permanent magnet 26, as described fully in the application Serial No. 274,485, filed May 19, 1939, of Louis A. Morrison.

The electromagnetic structure for actuating the diaphragm 20 includes a pair of pole-pieces, designated generally as 27, and a single bar permanent magnet 28 magnetized to have poles of opposite polarity at the ends of its shorter axis. As shown clearly in Fig. 3, each of the pole-pieces 27 includes a T-shaped portion having an up-right arm 29 and a lateral arm 30, and mounting flanges or lugs 31. The permanent magnet 28 is disposed between the arms 30 and affixed thereto as by soldering. As shown clearly in Fig. 1, the pole-pieces 27 are affixed to the frame 15, as by screws 32 extending through the flanges or lugs 31 and threaded into the frame, with the T-shaped portions thereof parallel and the arms 29 passing through the slots in the plate 17.

It has been determined that the relative dimensions of a magnet requisite for producing a desired flux are determinable from the equation

$$\frac{l_s}{A_s} = \frac{B_r l_a}{H_c A_a}$$

where

l_s = length of magnet

A_s = section area of magnet which links the useful flux, (about half the total section area)

B_r = remanence

H_c = coercive force

l_a = length of air-gap, and

A_a = area of air-gap.

The magnet 28 is of an alloy of 53 per cent iron, 20 per cent nickel, 10 per cent aluminum, 12 per cent cobalt, and 5 per cent copper. A magnet of this composition, it has been found, has a very high coercive force in proportion to the remanence and enables the use of a very short bar magnet. For example, in the receiver shown in Fig. 1, a magnet of a length of $\frac{3}{8}$ inch and section of $\frac{1}{4}$ inch by $\frac{3}{4}$ inch may be used satisfactorily. In a similar structure including a magnet of cobalt steel, two magnets $1\frac{1}{4}$ inches long by $\frac{1}{4}$ inch square would be necessary to produce a comparable flux. The decrease in the magnet length thus results in a short magnetic path and reduces leakage, for example, by as much as a factor of 2 to 1.

It will be noted that in the structure described above, the coils 19 are relatively wide and rectangular in form and located entirely between the opposite faces of the frame 15. This results in a very thin and lightweight structure which is especially suitable for use in headsets such as used, for example, by telephone operators.

The spaces between the coils and the frame 15 and cross-member 18 may be sealed with thermoplastic material 33 whereby a shallow chamber 34 below the diaphragm 20 is formed. This chamber may be completely closed except for a restricted aperture 35 having a sheet of acoustic resistance material 36, such as silk, extending thereacross. The elements of the acoustic network thus formed may be designed in accordance with the invention disclosed in the application Serial No. 93,792, filed August 1, 1936, of Louis A. Morrison and Edward E. Mott to obtain a uniform response characteristic throughout a wide frequency range.

In receivers of the general type disclosed, it has been found that the motion of the dia-

phragm is characterized by two predominant modes of vibration, namely, a piston-like mode, termed the fundamental, and a harmonic in which the central and outer portions of the diaphragm vibrate in opposite phase. The bending curves of a diaphragm, such as the diaphragm 20, unclamped at its periphery are illustrated in Fig. 4, where curve F illustrates the bending for the fundamental mode and curve H illustrates the bending for the harmonic mode. Fig. 5 shows similar bending curves for a similar diaphragm clamped at its periphery.

The effect of the harmonic mode of vibration is to introduce a resonance peak in the response of the receiver. Thus, as illustrated by the curve A in Fig. 10, the fundamental mode of vibration produces a peak B in the response and the harmonic resonance for example produces a second peak C. The peak B may be suppressed by damping, as described in the aforementioned application of Louis A. Morrison and Edward E. Mott; the peak C, however, cannot be suppressed by acoustic damping because of the rotating character of the resonance.

In the case of a diaphragm unclamped at its periphery, it has been determined that the harmonic resonance produces a peak C at 6.7 times the fundamental frequency. For a clamped diaphragm, the harmonic resonance occurs at a frequency 3.9 times the fundamental.

It will be noted from Figs. 4 and 5 that the harmonic mode produces a nodal area passing through points X at which there is no motion. If a driving force were applied to the diaphragm at this area, no motion would occur at any point along the diaphragm on the curve H because of the principle of reciprocity. In other words, resonance due to any harmonic mode of vibration may be suppressed by driving the diaphragm at the nodal circle corresponding to this particular mode. In a telephone receiver, it has been found satisfactory to drive the diaphragm at its first nodal circle, the resonance frequencies for higher harmonics lying outside of the range of frequencies it is usually desired to transmit.

It has been determined that for a diaphragm, such as the diaphragm 20, unclamped at its periphery, the first nodal circle has an average diameter 44.5 per cent of the seating diameter and that for a diaphragm clamped at its periphery, the average diameter of the first nodal circle is 37.9 per cent of the clamping diameter.

In a bipolar receiver of the construction shown in Fig. 1, suppression of the resonance due to the harmonic corresponding to the first nodal circle may be effected by spacing the arms 29 of the pole-pieces so that, as shown in Fig. 6, the pole faces lie on the nodal circle and are approximately bisected by it. In this case, as indicated by the curve A' in Fig. 10, the fundamental peak B is shifted slightly to B' and the peak C is entirely eliminated.

Various other forms of magnetic structures may be employed to effect application of the driving forces to the diaphragm at the nodal circle. For example, as shown in Fig. 7, the magnet structure may include concentric annular pole-pieces 37 and 38, the inner pole-piece 37 having a diameter equal to the average diameter of the nodal circle of the diaphragm 20. In the form shown in Figs. 8 and 9, the pole-pieces 39 may be U-shaped, mounted at opposite ends of a bar magnet 40 and spaced so that the pole faces thereof lie opposite equally spaced areas of the nodal circle. In the forms shown

in Figs. 6, 8 and 9, the pole-pieces may be arcuate and of the same curvature as the nodal circle to provide greater conformity between the pole faces and the nodal circle.

In the receiver illustrated in Figs. 11 and 12, which is generally similar to that shown in Figs. 1 to 3 and described heretofore, the frame 15 is provided with an inwardly extending flange 41 upon which the coils 19 are seated and into which the pole-piece mounting screws 32 are threaded. A suitable terminal block 42 of insulating material is positioned in a recess or cavity in the frame 15 and is secured to the frame 15 by a screw 43. The spaces between the coils 19 and the frame may be sealed by thermoplastic material 33. The cover member 21 is provided with a peripheral shoulder 44 which spaces the cover from the diaphragm 20, the diaphragm being held in position solely by magnetic attraction. Alternatively, the diaphragm may be clamped at its periphery.

Although specific embodiments of the invention have been shown and described, it will be understood, of course, that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A telephone receiver comprising a substantially flat foundation member having an annular seating surface on one face thereof and having also a central aperture, a magnetic diaphragm mounted on said seating surface, and actuating means for said diaphragm including a pair of substantially parallel T-shaped pole-pieces the legs of which extend through said central aperture and terminate in proximity to said diaphragm and the arms of which extend along the opposite face of said foundation member, said pole-pieces having lugs seated upon and secured to said opposite face, signal coils on said legs and a single bar permanent magnet extending between and secured to said arms of said pole-pieces.

2. A telephone receiver in accordance with claim 1 wherein said magnet is a rectangular bar having its shorter dimension normal to said arms and is of an alloy of 53 per cent iron, 10 per cent aluminum, 20 per cent nickel, 12 per cent cobalt, and 5 per cent copper.

3. A telephone receiver comprising a substantially flat support having a seating surface on one face thereof and having also a central aperture, a diaphragm seated on said surface, and means for actuating said diaphragm including a pair of pole-pieces affixed to the opposite face of said support and having pole tip portions extending through said aperture and other portions extending beyond said opposite face, a bar permanent magnet between and secured to said other portions and signal coils encompassing said pole tip portions and positioned entirely within said aperture.

4. A telephone receiver comprising a disc frame having an aperture therein and an annular seat on one face thereof, a diaphragm seated on said seat, pole-pieces having arms extending

through said aperture and terminating adjacent said diaphragm, signal coils encompassing said arms and located entirely within said aperture, and filler means sealing the spaces between said coils and said frame whereby a shallow acoustic chamber is formed between said diaphragm and said frame, said chamber being completely closed except for a restricted opening through said frame.

5. A telephone receiver comprising a substantially flat frame having a central aperture, an inwardly extending flange adjacent one face and a seating surface on the opposite face, a diaphragm seated on said surface, a magnetic structure including pole-pieces extending through said aperture and terminating adjacent said diaphragm, and signal coils seated upon said flange and encompassing said pole-pieces.

6. A telephone receiver in accordance with claim 5 wherein said pole-pieces have parallel portions extending outwardly beyond said one surface of said frame and comprising a bar permanent magnet secured between said portions.

7. A telephone receiver comprising a disc magnetic diaphragm, and means for actuating said diaphragm comprising a pole-piece having its pole-face in juxtaposition to the first nodal circle of said diaphragm.

8. A telephone receiver comprising a magnetic disc diaphragm, and means for actuating said diaphragm including a plurality of pole-pieces terminating in juxtaposition to one surface of said diaphragm at areas substantially coincident with the first nodal circle of said diaphragm.

9. A telephone receiver comprising a magnetic disc diaphragm, and means for actuating said diaphragm including a pair of parallel pole-pieces terminating adjacent the first nodal circle of said diaphragm and having their pole-faces substantially bisected by said circle.

10. A telephone receiver comprising a magnetic disc diaphragm freely supported at its periphery, and means for applying driving forces to said diaphragm at areas thereof on and immediately adjacent a circle having a diameter of substantially 44.5 per cent the diameter of said diaphragm.

11. A telephone receiver comprising a magnetic disc diaphragm clamped at its periphery, and means for applying driving forces to said diaphragm at areas thereof on and immediately adjacent a circle having a diameter of substantially 37.9 per cent of the diameter of said diaphragm.

12. A telephone receiver comprising a substantially flat frame having a seating surface on one face thereof, a magnetic disc diaphragm seated on said surface, and means for applying driving forces to said diaphragm along the first nodal circle thereof including a pair of pole-pieces having parallel arms projecting through said frame and terminating adjacent said diaphragm and having also mounting lugs seated upon the opposite surface of said frame, and a bar magnet secured between said arms.

EDWARD E. MOTT.