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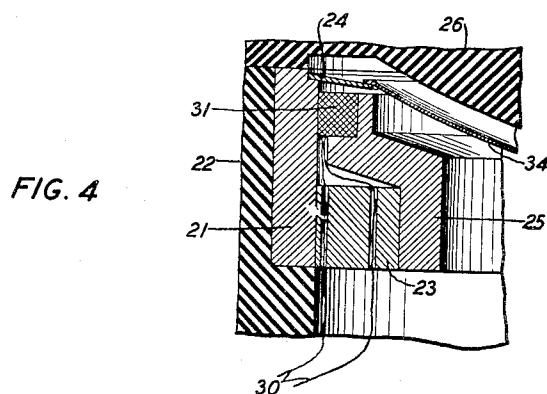
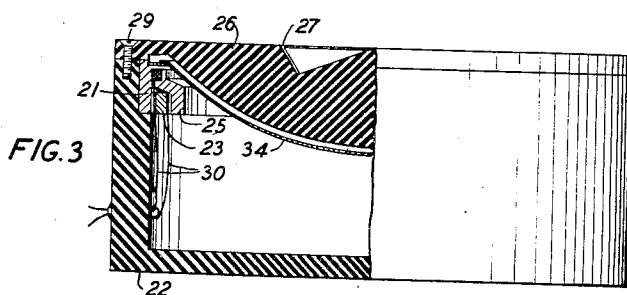
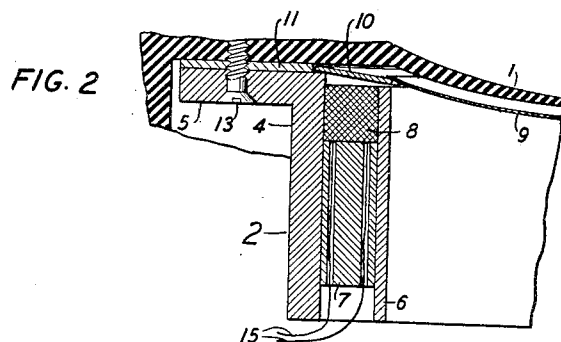
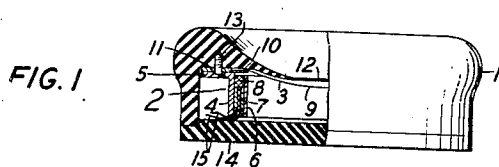
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2,171,733

ACOUSTIC DEVICE

Filed Oct. 6, 1937

2 Sheets-Sheet 1



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FIG. 5

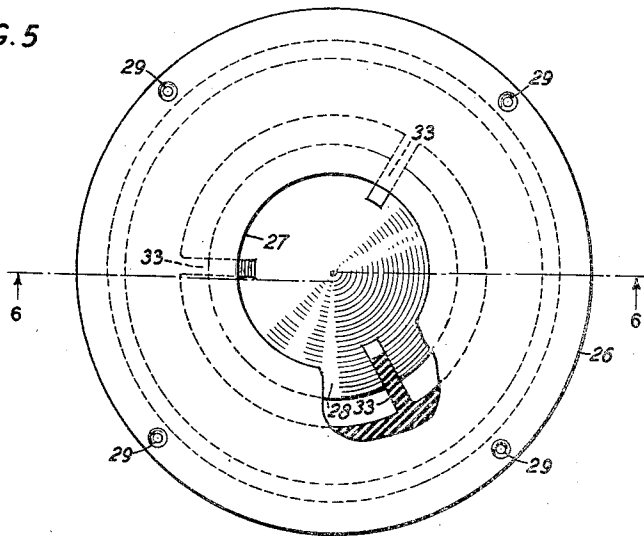


FIG. 6

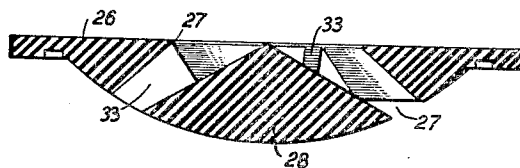
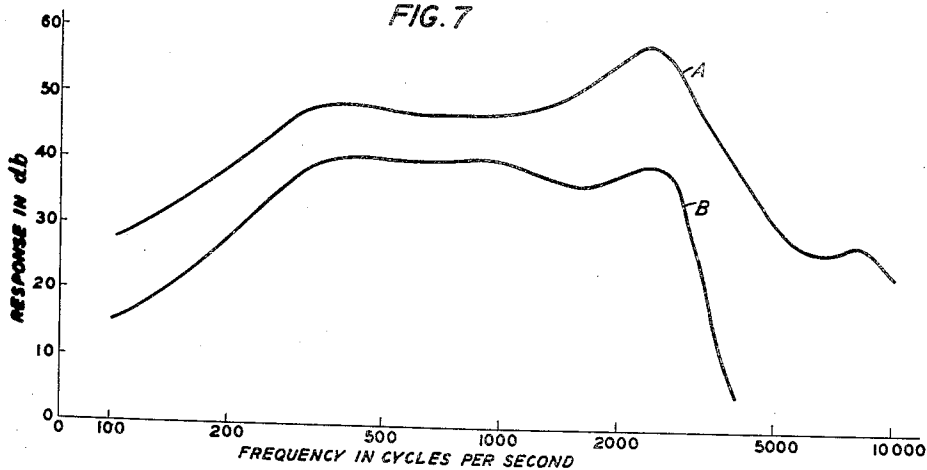


FIG. 7



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ACOUSTIC DEVICE

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Application October 6, 1937, Serial No. 167,546

12 Claims. (Cl. 179—115)

This invention relates to acoustic devices and more particularly to sound receivers and transmitters.

Reference is made to the application Serial No. 95,537 filed August 12, 1936, of Edward E. Mott wherein a related invention is disclosed.

One object of this invention is to improve the efficiency and fidelity of translation of acoustic devices, such as receivers and transmitters utilized in telephone systems and the like.

Another object of this invention is to simplify the structure, and thereby to facilitate the fabrication and reduce the cost, of telephone receivers and transmitters.

A feature of this invention is a composite diaphragm having an outer armature section of magnetic material and an inner very thin but stiff section of non-magnetic material.

A further feature of this invention is a device in which an annular magnetic structure cooperates with the composite diaphragm and particularly the armature section to produce a receiver having a very good response characteristic and relatively high efficiency.

Other and further objects and features will appear in the following description taken in connection with the accompanying drawings in which:

Fig. 1 is an elevation of a receiver illustrative of one embodiment of this invention, some parts being shown in section;

Fig. 2 is an enlarged fragmentary section of the receiver illustrated in Fig. 1 showing details of the armature and magnetic structure;

Fig. 3 is an elevation of a transmitter constructed in accordance with this invention, some parts being shown in section;

Fig. 4 is an enlarged fragmentary section of the transmitter illustrated in Fig. 3 showing details of the diaphragm and magnetic structure;

Fig. 5 is a plan view of the transmitter cover;

Fig. 6 is a section taken along line 6—6 of Fig. 5; and

Fig. 7 is a chart showing response characteristics of a receiver constructed in accordance with this invention and of a receiver of known design.

Referring now to the drawings, the receiver shown in Figs. 1 and 2 comprises a housing 1, an annular magnetic structure 2, and a composite diaphragm 3. The magnetic structure comprises an outer pole-piece in the form of a ring 4 having an integral flange 5. The inner pole-piece may be a ring 6 which has an axial length slightly less than that of the ring 4 for a purpose to be later described. These parts may be of soft iron

or the like. A ring 7 of suitable magnetic alloy constitutes a permanent magnet section of the magnetic structure. The rings 4, 6 and 7 are of such radial dimensions that when assembled concentrically with ring 7 between the pole-piece rings 4 and 6 they form an annular magnetic structure. The rings 4 and 6 when assembled preferably have one set of faces in a common plane. The axial length of the permanent magnet 7 is sufficiently less than that of the pole-pieces 4 and 6 to provide a space or channel in which an annular actuating coil 8 is mounted. The rings 4, 6 and 7 are secured together by suitable means, such as cement or the like.

The diaphragm 3 comprises an inner dome-shaped portion 9, preferably of non-magnetic material such as duralumin or a similar alloy about 1 mil thick and sufficiently rigid to vibrate bodily. The portion 9 is suitably secured, as by cementing, to a ring 10 of magnetic material, preferably permalloy, of the order of 10 mils thick, which acts as an armature for driving the portion 9 as a piston. The external diameter of ring 10 is slightly greater than the internal diameter of the outer pole-piece 4 to allow seating of the armature on this pole-piece, the armature being held against this pole-piece by magnetic attraction. A spacer member or washer 11, which may be of magnetic material such as soft iron, slightly thicker than the armature 10, is secured to the flange 5 to form a shoulder which prevents lateral movement of the diaphragm. The additional thickness of the member 11 also allows the diaphragm and magnetic assembly to be secured in the casing 1 without exerting any clamping action on the diaphragm. The member 11 may be separate from the flange 5 or integral therewith and may be provided with a groove forming a seat for the armature 10.

As previously mentioned, the axial length of the inner pole-piece 6 is less than that of the outer one 4. Because of this an air-gap is defined between the face of pole-piece 6 and the inner portion of the ring armature 10.

The permanent magnet 7 is radially magnetized so that the path of its flux is around the coil 8. The force due to this portion of the magnetic circuit holds the armature firmly on the outer pole-piece and deflects it towards the inner pole-piece.

The parts of the magnetic system are so proportioned that the force of the unidirectional portion of the magnetic field for a very small air-gap between the armature 10 and pole-piece 6 is balanced by the resistance to deflection of

the ring armature. The restoring force of the ring armature increases rapidly with deflection. For each successive increment of deflection there is added an increment of restoring force greater than the preceding one. In the construction disclosed, an increased deflection results in a decrease in the air-gap.

Since decreasing the air-gap of the magnetic circuit increases the magnetic force there is an increase of magnetic force for an increase of deflection. However, this rate of increase is less than that of the restoring force in the armature. Consequently, at some particular amplitude of deflection an equilibrium of these forces is reached. As noted above, this occurs at a very small air-gap, which results in a high magnetic efficiency. This small air-gap is possible because any further decrease in air-gap caused by increased deflection is opposed by a greater restoring force. Sticking of the armature to the pole-piece 6 is thus prevented. Moreover, this stable condition at the very short air-gap allows for greater efficiency of the alternating or voice current portion of the field, produced by the flow of signal or audio frequency currents in the coil 8.

This may be explained in another way by stating that the incremental elasticity of the armature 10 should be slightly greater than the negative incremental elasticity of the magnetic field at the equilibrium position of the armature. The resultant elasticity of the diaphragm in its operation position will then be considerably lower than the elasticity of the armature alone. This condition can be attained by selecting dimensions for the ring armature which when substituted in the restoring force equation

$$F = \frac{E\delta t^3}{(1-\sigma^2)a^2M} \left(\frac{1\delta^2}{2t^2} + 1 \right)$$

where

σ =Poisson's ratio

F =force

E =Modulus of elasticity

δ =deflection

a =outer radius of ring

b =inner radius of ring

t =thickness of ring

$$M = \frac{6}{\pi \log_e \alpha} \left(\frac{\alpha-1}{\alpha} \right)^2$$

$\alpha = a/b$

will give a force-deflection curve which, at the equilibrium position of the diaphragm, crosses at a small angle the negative force-deflection curve of the magnetic field given by the relation

$$F = -\frac{B^2 A}{8\pi}$$

where

A =area of the inner pole-piece

B =flux density at various separations

F =force

The inner portion 9 of the diaphragm, being very thin and of considerable area, has a low effective mass. Furthermore, due to the stiffness of the domed section 9 and the edge application of the driving force, the effective portion of the diaphragm vibrates as a whole and does not "break up" at higher frequencies.

The portion of the housing 1 adjacent the dome-shaped diaphragm portion 9 conforms rather closely thereto leaving a small space between the diaphragm and the housing. The housing is provided with an opening 12 for the egress of sound waves.

The unit is held in the casing 1 by fastening means such as screws 13 which pass through openings in the flange 5 and engage with the housing. A cover plate 14 closes the open end of the housing 1 at the back or bottom.

Suitable connections 15 are provided for connecting the coil 8 in a telephone or similar system.

It has been found desirable to keep the radial width of the armature ring 10 small with respect to the total diameter of the diaphragm. A factor of about 1 to 10 has given good results.

In a specific receiver which has given a good response characteristic, the diaphragm was of about 1.5 inch over-all diameter with an armature about 10 mils thick and .125 inch in radial width. The magnetic system included a permanent magnet .20 inch by .08 inch in cross-section and a coil of 155 turns of No. 37 wire. These dimensions should be taken as illustrative of relative proportions that have been found to give a good receiver. Variations may be made without departing from the principles involved. The shorter the air-gap at which balance occurs between the restoring force of the armature and the unidirectional field force, the better the receiver.

The response of a receiver such as that described above is shown graphically in Fig. 7 along with the response curve for a conventional bipolar receiver, both measured on an artificial ear. Curve A is that of a ring armature receiver constructed in accordance with this invention, and curve B of a bipolar receiver. The response of the bipolar receiver as shown on curve B is considered to be rather good. By comparison, therefore, it is clear that devices constructed in accordance with this invention have a highly satisfactory response characteristic.

The invention may be utilized also in a high quality transmitter as shown in Figs. 3, 4, 5 and 6. The construction of the diaphragm and magnetic portion is similar to the corresponding elements of the receiver. The outer ring pole-piece 21 is fitted into a groove in the casing 22. The radial width of the permanent magnet 23 is greater than that of the armature ring 24. This necessitates a somewhat Z-shaped cross-section for the annular inner pole-piece 25 so that its pole-face may be opposite the inner portion of the armature ring 24. The domed piston portion is designated as 34. The ratio of armature width to the total diameter of the diaphragm is about 1 to 20. The diaphragm may be of the order of 3.5 inches in diameter.

In order to maintain proper acoustic relations with this relatively large diaphragm the cover 26 is provided with a restricted annular passageway 27. This passageway is formed by a frusto-conical opening in the cover proper and a conical member 28 mounted in the center thereof by means of a plurality of spaced supports 33. The inner surfaces of the cover 26 and of the conical member 28 are curved to conform to the dome shape of the central portion of the diaphragm and are located relatively closely thereto.

By providing an annular opening of this type the distances traveled by sound waves impinging on all portions of the diaphragm are substantially equal and interference due to phase difference is avoided.

The cover member 26 is attached to the casing 22 by suitable fastening means such as screws 29.

Leads 30 are attached to the coil 31 and extend through a suitable opening in the case 22, the

current in the coil being modulated in accordance with variations in the reluctance of the magnetic circuit produced by vibrations of the diaphragm.

- 5 In the case of either a receiver or a transmitter having the ring armature construction described above, the importance of the spring action peculiar to the ring construction should not be overlooked. Because of this action it is possible to
10 design a device for a very small air-gap, for example of the order of 3 to 6 mils, with resulting high efficiency.

The ring portion 10 functions both as an armature and as a restoring spring. Thus an efficient
15 device is obtained with a small number of simple parts.

Permalloy, referred to heretofore, may be defined as an alloy containing nickel to the extent of 30 per cent or more, balance chiefly iron, and
20 having the characteristic property of high initial permeability.

What is claimed is:

1. An acoustic transmitter device comprising an annular magnetic structure having two concentric ring pole-pieces, the outer of which is
25 of greater axial extent than the inner, and a diaphragm means having a thin, domed, central sound responsive portion of non-magnetic material and a thicker marginal armature portion of
30 magnetic material joined thereto, the junction of these portions being opposite the inner pole-piece and the outer portion of the armature resting on the outer pole-piece and held there by magnetic attraction.

2. An electro-acoustic device comprising an annular magnetic structure having concentric ring pole-pieces the faces of which lie in different
35 planes, and a diaphragm means comprising a marginal ring armature portion of magnetic material and an inner non-magnetic, very thin, stiffened portion, the armature portion having its outer part resting on the outer pole-face and its inner part flexed towards but out of contact with the inner pole-face to define an air-gap,
40 said armature being held in position by magnetic attraction.

3. A telephone receiver comprising an annular magnetic structure having two concentric ring pole-pieces, and a diaphragm comprising a ring
50 armature of magnetic material resting on the outer pole-piece and spaced from the inner pole-piece to provide an air-gap and a very thin dome-shaped inner portion attached to the armature, the diaphragm being held in position by magnetic
55 attraction.

4. An electro-acoustic device comprising a vibratile member having a ring-shaped marginal portion of magnetic material of the order of 10
60 mils thickness and a dome-shaped central portion of duralumin of about 1 mil in thickness, said portions being suitably secured together at their juncture, and a magnetic structure having two concentric pole-pieces, the outer pole-piece having a shoulder for seating the outer edge of
65 the vibratile member and the inner pole-piece cooperating with the inner margin of the magnetic ring to define an air-gap, said vibratile member being held in place by magnetic force.

5. An electro-acoustic device comprising a
70 composite diaphragm which includes a very thin but stiff piston portion to the outer margin of which is attached a flat ring of magnetic material having a radial width of one-tenth or less of the diameter of the piston portion, and a magnetic structure for cooperation with the dia-

phragm comprising a radially magnetized permanent ring magnet and a voice current coil included between two concentric ring pole-pieces, the face of the outer pole-piece acting as a seat
5 for the outer edge of the magnetic ring and that of the inner pole-piece cooperating with the inner margin of said ring to define an air-gap, the magnet ring being held to the outer pole-face and flexed toward the inner by the force of the field of the permanent magnet.

6. An electro-acoustic device comprising a
10 composite diaphragm having a marginal, flat ring armature portion of magnetic material and an inner dome-shaped portion, and a magnetic structure having means for setting up a uni-
15 directional and an alternating field and including two concentric ring pole-pieces, the outer of which is provided with a seat for supporting the outer edge of the flat ring armature, the inner margin of said armature being opposite
20 the inner pole-piece and cooperating therewith to define an air-gap, said dome-shaped portion being of very thin non-magnetic material and attached at its outer periphery to the inner margin of the armature and extending into the space
25 defined by the inner pole-piece, said armature having about ten times the thickness of the thin non-magnetic material and being of a radial width one-tenth or less than the diameter of the dome-shaped member.

7. An electro-acoustic transmitter comprising a casing in which is mounted an annular magnetic structure comprising two concentric ring pole-pieces between which are located a radially
35 magnetized permanent magnet ring with a voice current coil, a composite diaphragm having a marginal, flat, ring armature portion of magnetic material having its outer edge resting on the outer pole-piece and its inner margin spaced from
40 the inner pole-piece to define an air-gap, and a central dome-shaped portion of very thin non-magnetic material, the dome-shaped portion extending into the space defined by the inner pole-piece, and a cover for the casing, the inner surface of which is curved to conform to the curvature of the dome-shaped diaphragm portion and
45 having an annular opening therein for passage of sound to the diaphragm.

8. An acoustic device comprising a magnetic structure including spaced pole-pieces, and a
50 diaphragm including a magnetic driving section and a non-magnetic driven section, said magnetic driving section, having a portion seated upon one of said pole-pieces and held thereon solely by magnetic attraction and another portion
55 adjacent the other of said pole-pieces.

9. An acoustic device comprising a diaphragm having an inner non-magnetic portion and an outer marginal portion of magnetic material, rigid supporting means at the periphery of said
60 outer portion, and means at the inner boundary of said outer portion and on one side only of said diaphragm for actuating said diaphragm by flexure of said outer portion.

10. A telephone receiver comprising a diaphragm having a central concave portion, and a
65 magnetic structure including a substantially annular pole-piece having a pole-face opposite the diaphragm at the boundary of said concave portion, said concave portion projecting into the space defined by the pole-piece.

11. A telephone receiver comprising a diaphragm having an annular planar portion of magnetic material and a concave central portion, and a magnetic structure including an annular
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pole-piece having a pole-face spaced from the inner peripheral portion of the diaphragm annular portion, the concave portion of said diaphragm projecting into the space defined by the pole-piece.

5 12. An acoustic device comprising a diaphragm having a central rigid portion of non-magnetic

material and a rim portion of magnetic material, rigid means for supporting said diaphragm at the periphery of said rim portion, and means for applying a driving force to parts of said rim portion removed from the periphery thereof.

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