June 13, 1939. E. E. MOTT 2,162,270

ACOUSTIC DEVICE

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FIG. 1

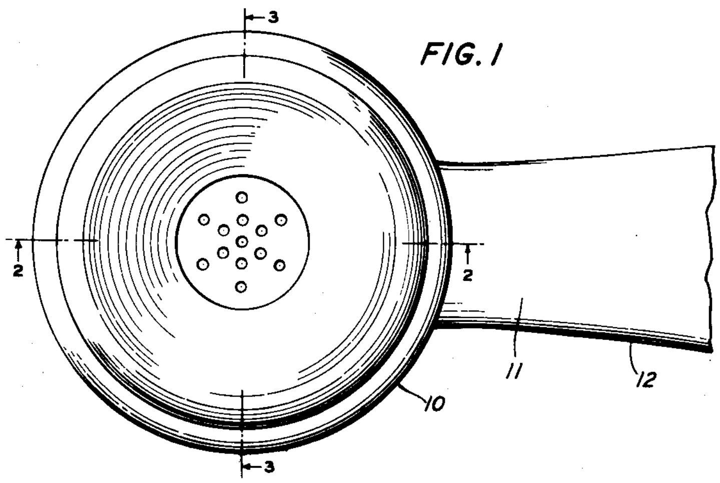


FIG. 2

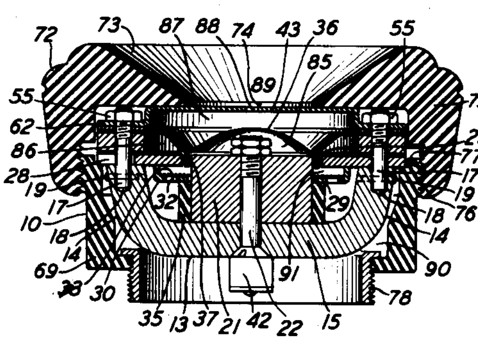


FIG. 3

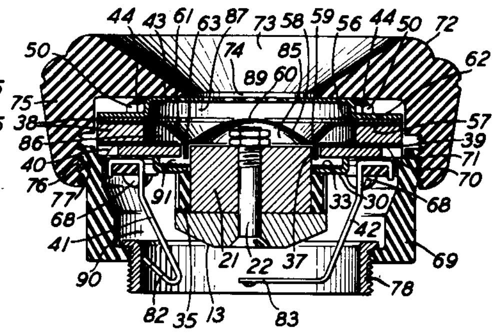
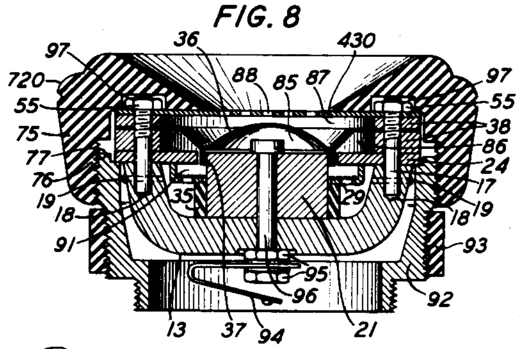


FIG. 8



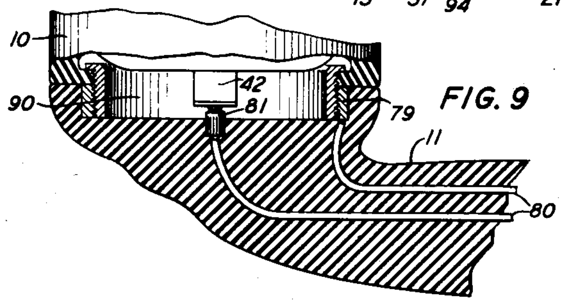


FIG. 9

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FIG. 7

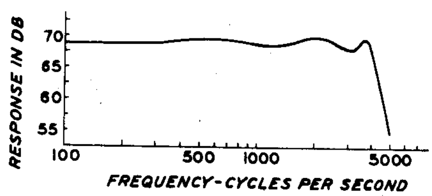


FIG. 6

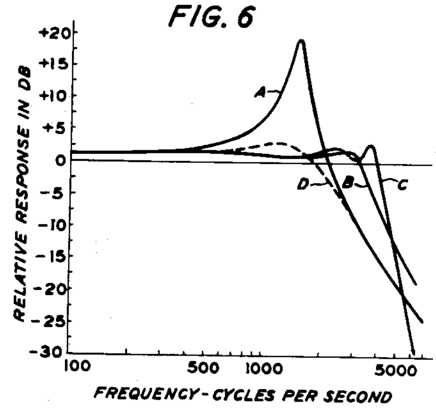


FIG. 5

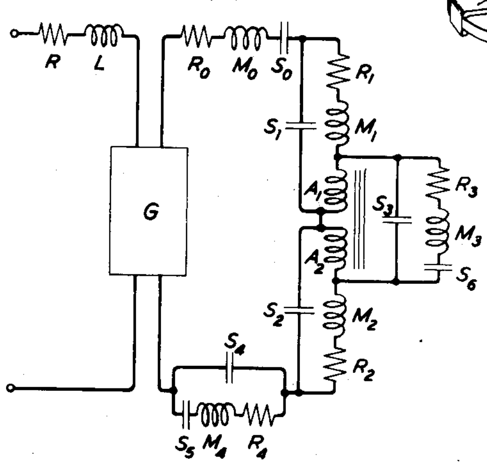
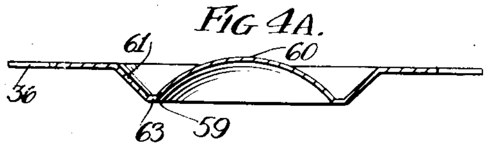


FIG 4A.



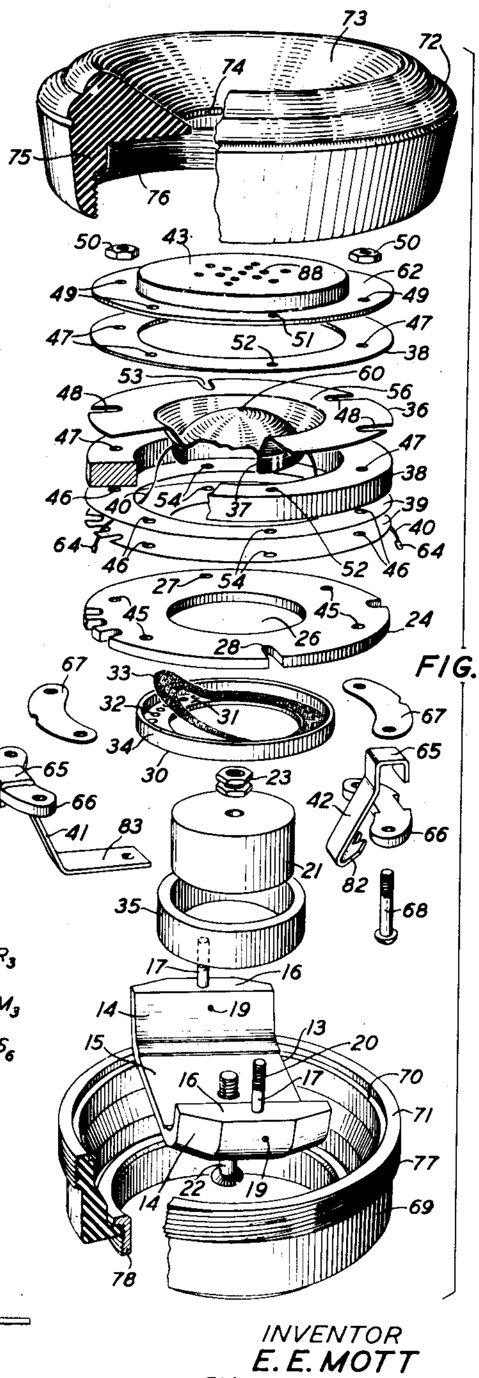


FIG. 4

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UNITED STATES PATENT OFFICE

2,162,270

ACOUSTIC DEVICE

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Application February 6, 1934, Serial No. 709,935

2 Claims. (Cl. 179—115.5)

This invention relates to acoustic devices and, more particularly, to electro-dynamic telephone devices.

An object of this invention is to improve the quality of sound reproduction in acoustic devices of the electro-dynamic type.

A further object is to simplify and cheapen the structure of such devices without impairing the quality of sound wave reproduction thereby.

A feature of the invention comprises a diaphragm that enables the obtaining of a large radiating area with a minimum of mass.

Another feature comprises a damping arrangement for an acoustic device in which the damping member is securely held in position solely by means of a resilient member engaging portions of the magnet structure of the device.

A further feature of this invention comprises a magnet structure in which a plate pole member is provided with openings adapted to receive pin or stud members on a magnet, to insure proper relative positioning of the plate pole and the magnet, one opening being a slot extending inwardly from the plate periphery.

This invention is embodied preferably in a telephone receiver comprising a straight magnet in the form of a bar having bent end portions from each of which a pin member extends. A plate pole member, preferably annular, is supported on the magnet. It contains an aperture to receive one pin member, and a slot extending inwardly from the plate periphery to receive the other pin member, the slot preferably being at the other end of the diameter on which the aperture is located. A central pole, preferably cylindrical, is secured to the central portion of the bar magnet and extends into the central opening of the plate pole, forming an annular air gap with the plate pole. An acoustic damping arrangement is supported under the magnet air gap. It comprises an L-sectioned ring of non-magnetic material whose horizontal portion contains a plurality of spaced openings over which an annulus of silk is secured. The ring member extends between the plate pole and the central pole fitting loosely about the latter. To seal the space between the central pole and the ring member and to maintain the latter in position, a sleeve member of resilient material, such as rubber, is inserted between the ring and the bar magnet and surrounds the central pole. Supported by the plate pole and preferably secured thereto so as to form with it an assembly attachable to and removable from the magnet as a unit, are a diaphragm, a coil attached to the diaphragm and adapted to be positioned in the air gap, a pair of annular members between which the peripheral portion of the diaphragm is clamped, and a protecting plate or grid forming a chamber with the diaphragm. The diaphragm, preferably, is in a single piece and of uniform thickness, and comprises an annular, flexible, planar outer portion; a central dome-shaped portion, whose base portion is in a plane parallel to and on one side of the annulus and whose uppermost portion is in a plane parallel to and on the other side of the annulus; and an intermediate frusto-conical portion, which portion is at an angle of 20° to 60°, preferably 45°, with the annular portion. The moving coil is attached to the diaphragm at the junction of the central and intermediate portions.

A more complete understanding of this invention will be obtained from the detailed description which follows, read with reference to the appended drawings, wherein:

Fig. 1 is a plan view of a fragment of a hand telephone set showing the receiver end thereof;

Fig. 2 is a sectional view of the receiver of the hand telephone of Fig. 1 along the line **2—2** thereof, removed from the handle of the set and embodying this invention;

Fig. 3 is a sectional view of the receiver of the telephone set of Fig. 1 along the line **3—3** thereof and removed from the handle of the set;

Fig. 4 is an exploded, perspective view of the receiver of Figs. 1 to 3;

Fig. 4A is a sectional view to an enlarged scale of the diaphragm embodied in the device of Figs. 1 to 4;

Fig. 5 is an electric circuit analogy of the acoustical elements involved in the operation of the device of Figs. 1 to 4;

Fig. 6 illustrates how the receiver response may be modified in different portions of the frequency range translated;

Fig. 7 is a typical response characteristic for a receiver embodying this invention;

Fig. 8 shows another embodiment of this invention; and

Fig. 9 is a sectional view of a fragment of a hand telephone set showing how a receiver embodying this invention may be secured to the handle thereof and connected in an electric circuit.

The acoustic device of Figs. 1 to 4, comprises a telephone receiver **10**, preferably of the type adapted to be mounted on and secured to one end of a handle portion **11** of a hand telephone set **12**, a fragment only of which is shown. The receiver comprises, preferably, a bar magnet 13, for instance, of cobalt steel and approximately rectangular in cross section, having its end portions 14 bent at an angle to its intermediate straight portion 15 and terminating in planar surfaces 16 from each of which extends a pin or stud member 17. One end of each stud member is held in a drilling 18 in the magnet by a pin 19, and the other end is preferably threaded, as at 20. A central pole 21, preferably cylindrical, is secured to the midportion of the straight portion of the magnet, for instance by the fastening member or bolt 22 and double nut 23, and extends in the same direction as the magnet end portions to a point above the plane of the surfaces 16. A plate pole 24, preferably annular and of magnetic iron, is supported by the magnet on the surfaces 16 and defines an annular air gap 25 with the central pole. The plate pole is provided near its peripheral portion and on opposite sides of its central aperture 26 with an opening or hole 27 and a slot 28 to receive the stud members. The slot preferably extends inwardly from the plate pole periphery and is on the same diameter as the hole or aperture 27.

Heretofore, the plate pole has been centrally located with reference to the center pole by the use of a pair of pin members extending from the magnet and engaging corresponding holes in the plate pole. These holes necessarily had to be located with great accuracy and their location was made difficult by warpage of the cobalt steel magnet during heat treatment thereof. Furthermore, to facilitate drilling of the holes to receive the pin members soft iron inserts had to be provided in the magnet.

The use of a plate pole with the slot described permits interchangeability of magnets and their corresponding plate poles, avoids the necessity of accurate location of the opening and the stud members with which they engage, allows for warpage of the magnet during heat treatment, and obviates the need for soft iron plugs in the magnet for accurately mounting these stud members.

An acoustic damping arrangement 29 is supported under the air gap and comprises an L-shaped plate or ring member 30 of non-magnetic material, for instance, of brass, whose horizontal or planar portion 31 contains a plurality of preferably equally spaced, circular drillings or holes 32, over which an annulus 33 of cloth, preferably silk, is secured along its edges by a suitable adhesive. The ring member 30 extends between the plate pole and the center pole, fitting loosely about the latter, and has its vertical or annular flange portion 34 engaging the underside of the plate pole. To seal the space between the central pole and the ring and to maintain the latter in position, a sleeve member 35, preferably cylindrical, of resilient material, preferably a long life rubber, is inserted between the undersurface of the planar portion of the ring and the portion 15 of the magnet and snugly surrounds the center pole.

Supported by the plate pole and preferably secured thereto so as to form with it an assembly attachable to and removable from the magnet as a unit, are a diaphragm 36; a coil 37 attached to the diaphragm and adapted to be positioned in the air gap 25; a pair of frame, clamping members or space rings 38 between which the peripheral portion of the diaphragm is mounted; a pair of insulating washers 39, for instance of paper, between which the coil leads or endings 40 are brought out to be terminated at spring terminals 41, 42 carried on the under surface of the plate pole; and a protecting plate or grid 43. This assembly is held together as a unit by suitable fastening means, for instance, by bolts 44 which extend through the aligned apertures 45, 46, 47, 48 and 49, in the plate pole, insulating washers, clamping or spacer rings, diaphragm, and protecting grid, respectively, and nuts 50. The assembly is secured to the magnet structure by the stud members 17, which extend through the aligned apertures 51, 52, 53 and 54, of the grid, spacer rings, diaphragm, and insulating washers, respectively, and the aperture 27 and the slot 28 in the plate pole, the threaded ends of the stud members being engaged by nuts 55.

The diaphragm 36, preferably, is in a single piece of uniform thickness, for instance, approximately .001″, and of a lightweight, high strength material, for instance, an aluminum alloy, such as duralumin. It comprises an annular, flexible, planar outer portion 56, the peripheral margin 57 of which is secured between the members 38; a central, dome-shaped, stiffened portion 58, whose base portion 59 is in a plane parallel to and on one side of the peripheral annulus and whose uppermost portion 60 is in a plane parallel to and on the other side of the peripheral annulus; and an intermediate, rigid, frusto-conical portion 61 the base portion 59 being joined to the intermediate portion 61 by a flat annular portion 63. This diaphragm has a large radiating area in proportion to its effective mass, and enables the enclosing of a comparatively large volume of air between its under or inner surface and the plate pole. The angle of a cone-shaped portion of the diaphragm with the plane of clamping or of the annular portion 56, is preferably 45°, although any angle between 20° and 60° appears to give good results. The diaphragm is clamped in a plane considerably above that of the top of the moving coil 37, the annular portion 56 of the diaphragm being spaced from the plate pole by the lower and thicker one of the rings 38 and from the marginal portion 62 of the grid 43 by the upper and thinner one of the rings 38.

The coil 37 is fastened to the diaphragm at the flat annular portion 63 connecting the dome-shaped and frusto-conical shaped portions, and comprises an edgewound, oxidized aluminum ribbon, successive turns of which are held together by a thin layer of adhesive. The use of an oxidized aluminum ribbon enables the obtaining of a space factor of as high as 93%. Before being wound into a coil, the ribbon is treated in an electrolytic bath employing a chromate solution charged by an electrode to a potential of about 50 volts with respect to the ribbon, to form a thin layer of aluminum oxide of high dielectric strength on the ribbon. The coil leads 40 are brought out between the paper washers 39 and are soldered at their ends, which are reinforced by U-shaped sleeves 64, to hook ends 65 of the spring terminals 41, 42. These terminals are carried by kidney shaped strips 66 of insulation, spaced from the plate pole by similarly shaped strips 67 of insulation, the strips 66 and 67 being secured to the plate pole by suitable fastening means, for instance, screws 68, only two of which are shown.

The receiver structure described is mounted within a case comprising a hollow, substantially annular member 69, preferably of insulating material, the plate pole resting on a ledge 70 in the rim 71 thereof; a receiver earpiece or cap member 72 having a substantially frusto-conically flaring surface 73 adapted to be placed against the user's ear, a central opening 74, and a peripheral flange 75 interiorly threaded at 76 for engagement with the exteriorly threaded portion 77 of the member 69, to clamp the plate pole against the ledge 70; and an exteriorly threaded, metallic member or coupling ring 78, adapted to threadedly engage the interiorly threaded metallic ring insert 79 in the receiver end of the handle portion 11.

The receiver conductors 80, preferably, are embedded in the handle 11, which may be of insulating material, in accordance with the teachings of W. C. Kiesel Patent 1,425,977, issued August 15, 1922, and are secured at one end to the ring 79 and the molded-in terminal stud member 81. One of the conductors is connected with the coil 37 through the coupling members 78, 79 and the terminal 41, which, at its reversely bent end 82, engages the member 78, and the other of the conductors through the member 81 and the horizontal end portion 83 of the terminal 42 which are in engagement when the receiver is mounted on the handle 11.

Fig. 5 is a circuit analogy of the acoustical elements involved in the operation of the receiver described hereinabove. R is the resistance and L is the inductance of the receiver electrical circuit, G is the gyrostatic mutual. R_0, M_0 and S_0 are effective resistance, mass, and stiffness, respectively, of the diaphragm 36. S_1 is the acoustic stiffness of the chamber 85 between the center pole and the central portion of the diaphragm, and R_1 and M_1 are the acoustic resistance and mass, respectively, of the passage defined by the coil 37 with the center pole; while S_2 is the acoustic stiffness of the chamber 86 between the portions 56 and 61 of the diaphragm and the plate pole, and R_2 and M_2 are the acoustic resistance and mass, respectively, of the passage defined by the coil 37 with the plate pole. S_3 is the acoustic stiffness of the chamber 91 between the member 30 and the plate pole, R_3 the acoustic resistance of the silk cloth annulus 33, and M_3 the acoustic mass provided by the holes 32. S_4 is the acoustic stiffness of the chamber 87 between the outer surface of the diaphragm and the grid 43, and R_4 and M_4 are the acoustic resistance and mass, respectively, of the perforations 88 in the grid 43. S_5 is the acoustic stiffness of the chamber 89 in the earpiece above the grid 43, and S_6 is the acoustic stiffness of the chamber 90 provided by the receiver case when mounted on the handle 11. The windings of the ideal transformer are determined by the area A_1 of that portion of the diaphragm constituting a defining wall for the chamber 85, and the area A_2 of that portion of the diaphragm constituting a defining wall for the chamber 86. The proportions of the various air chambers, the dimensions of the holes in the cap grid and damping plate, and the values of the acoustic resistances, are adjusted, preferably, such that when the receiver is in operation, a substantially uniform response in the ear chamber over a frequency range between 300 and 4500 cycles per second is produced.

In Fig. 6, A represents the response characteristic of the diaphragm of a receiver constructed in accordance with this invention, B illustrates the effect of the chambers and passages on the plate pole side of the diaphragm, and C indicates the effect of providing, in addition, the chamber and cap grid on the other or front side of the diaphragm. D shows the effect of damping only on the diaphragm.

Fig. 7 shows a typical overall response characteristic of a typical telephone receiver constructed in accordance with this disclosure, indicating that the response is substantially uniform in the frequency range of importance for telephone communication.

Fig. 8 shows a modification of the receiver described above, like parts of each, however, being given similar identifying numerals. The receiver of this figure comprises a one-piece shell 92 of a lightweight, metallic material, for instance, aluminum, externally threaded so as to be engaged by an earpiece 720 and a lock ring 93, and to be threadedly secured to the handle 11 of the hand telephone set 12. The case, being metallic, forms a part of the electrical circuit of the receiver, and a single contact spring 94, only, insulatively supported between nuts 95 on the center pole securing member 96, is employed. The coil leads (not shown) are brought out in any suitable manner so that one is electrically connected to the metallic shell and the other is electrically connected to the contact spring 94. The grid 430, containing perforations 88, is planar and the clamping nuts 55 fit into suitably shaped recesses 97 in the receiver earpiece.

Although this invention has been disclosed with reference to certain specific embodiments, it is to be understood that departures therefrom may be made without passing beyond the scope of this invention, which is to be considered as limited by the appended claims only.

What is claimed is:

1. An acoustic device comprising a diaphragm, a coil attached to said diaphragm, a magnet structure defining an air-gap in which said coil is positioned, said structure comprising a magnet, a center pole extending from said magnet toward said diaphragm and a plate pole encompassing said center pole and forming said air-gap therewith, a cup-like member under said air-gap, having openings in the bottom thereof including a central opening through which the center pole projects and having its rim in contact with the plate pole, and resilient means abutting said magnet and said member for holding said rim in engagement with said plate pole.

2. An acoustic device comprising a magnet structure including a U-shaped magnet, a cylindrical pole extending from the central portion of said magnet and a pole plate seated on the ends of said magnet and defining an air-gap with said cylindrical pole, a diaphragm, a coil attached to the diaphragm and disposed in said air-gap, means under said air-gap for controlling the vibratory characteristics of said diaphragm, said means comprising an L-sectioned, annular member containing apertures in its horizontal portion covered by acoustic damping material, the vertical portion being at the outer periphery of the horizontal portion and engaging with the plate pole, and a soft rubber sleeve fitted on said cylindrical pole and having its ends abutting said annular member and said magnet.

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