June 27, 1933. L. W. GILES 1,915,358

ELECTRODYNAMIC DEVICE

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FIG. 1

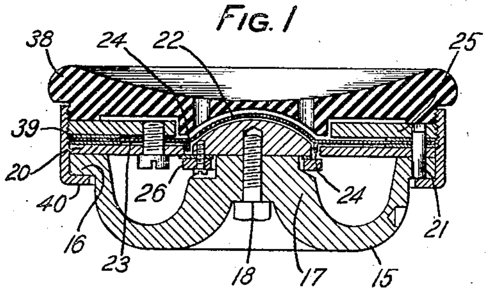


FIG. 2

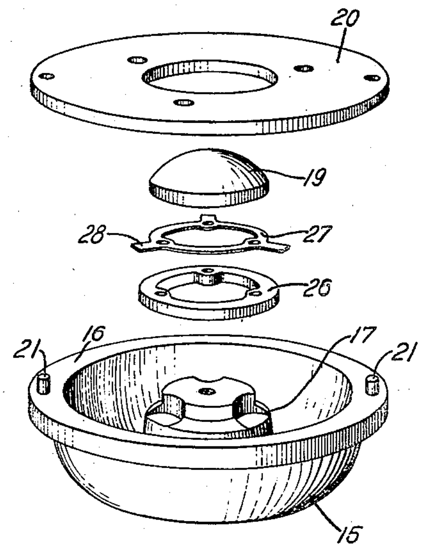


FIG. 3

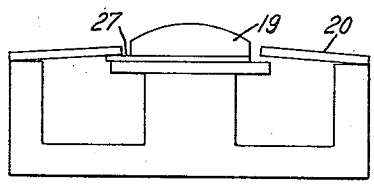


FIG. 4

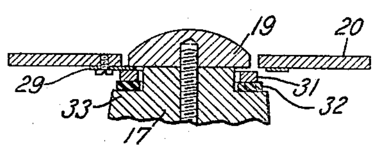


FIG. 5

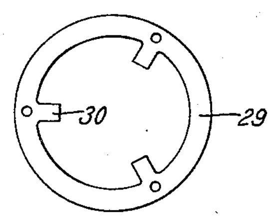


FIG. 7

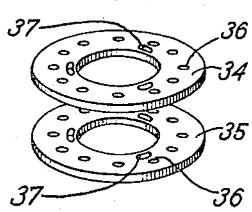


FIG. 6

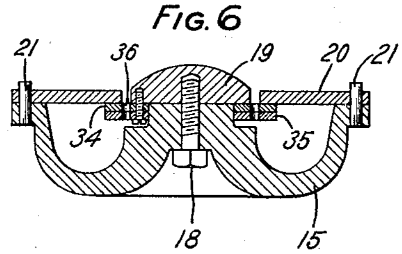
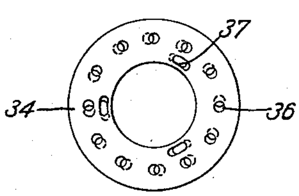


FIG. 8



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ELECTRODYNAMIC DEVICE

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FIG. 9

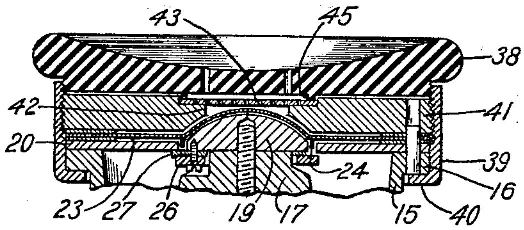


FIG. 10

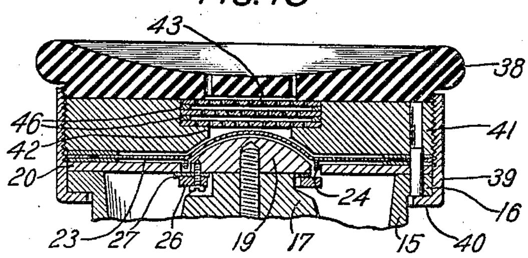


FIG. 10-A

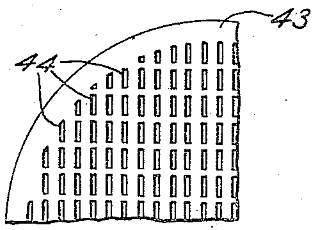
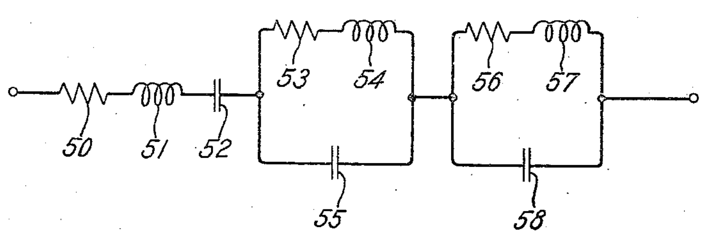


FIG. 11

FIG. 12



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Patented June 27, 1933 **1,915,358**

UNITED STATES PATENT OFFICE

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ELECTRODYNAMIC DEVICE

Application filed April 11, 1930, Serial No. 443,491. Renewed November 11, 1932.

This invention relates to electrodynamic devices and particularly to such devices for use in transmitting and receiving sound waves.

An object of the invention is to improve the quality and transmission characteristics of telephone transmitters and receivers over substantially the whole audible range.

In accordance with this invention, the electrodynamic device comprises a magnet structure having coaxial pole pieces separated by an annular gap and a piston-type diaphragm carrying a movable coil. The diaphragm is attached to the magnetic structure so as to vibrate when variable currents pass through the movable coil and change the constant magnetic flux in the annular gap in which the coil is suspended. The diaphragm is controlled in its movement by providing a chamber under the diaphragm and utilizing the mass, elasticity and viscosity of the air to efficiently damp the mechanical motion of the diaphragm. This chamber is provided by substantially closing the annular gap, at the side of the pole pieces opposite the diaphragm and coil, with a damping plate which is supported wholly by the inner pole piece.

In one embodiment of the invention, the damping plate is maintained in proper relation with the pole pieces by a thin spacing member having extensions which bridge the gap between the pole pieces and insure a definite restricted path for the passage of air from the chamber. This arrangement insures close calculation of the area of the restricted slot through which the air from the damping chamber must pass, so that the proper acoustic impedance of the air in the chamber when associated with the impedance of the diaphragm produces a resultant impedance which is inversely proportional with frequency. The spacing member not only insures the proper amount of resistance in the chamber to damp out resonance, but also introduces a mass reactance caused by the movement of air in the slots which can be proportioned to resonate with the stiffness of the air chamber, formed by the diaphragm and the slot, at a frequency other than the resonant frequency of the diaphragm.

A feature of the invention relates to the positive contact of the outer annular pole piece with the spacing member to maintain a constant separation between the outer pole piece and the damping plate whereby the area of the restricted slot remains fixed regardless of atmospheric changes. This arrangement consists in attaching the spacing member to the face of the center pole of the magnet structure so that the plane of the center pole is raised a distance equal to the thickness of the spacing member above the plane of the outer pole of the magnet structure. The damping plate is also attached with the spacing member to the center pole piece which is attached to the center pole of the magnet. The annular pole piece is seated on the magnet coaxial with the center pole piece and rigidly fixed. Due to the slight difference in the planes of the outer and inner contact edges of the annular pole piece, the inner edge exerts a constant pressure against the spacing member so that the area of the restricted slots formed by the cut-out portions of the spacing member between the outer pole piece and the damping plate is definitely fixed.

In another embodiment of the invention, the damping plate forms the restricted passageway for the air in the diaphragm chamber and means is provided for varying the area of the restricted path. This arrangement consists of bi-lateral damping members in the form of two interposed rings having a plurality of apertures of small area therein. These rings are attached to the central pole piece and extend across the annular gap between the two pole pieces of the magnet structure so as to completely close the gap. In order to form the restricted passageways for introducing the proper impedance of the air in the chamber under the diaphragm, one of the two rings is rotated sufficiently to misalign the cooperating apertures in the two rings. After these rings are adjusted to insure the proper restricted openings leading to the air chamber under the diaphragm they are rigidly fixed so that the area of the restricted path is maintained constant. This arrangement provides an accurate adjustment of the impedance introduced into the system and provides means whereby this impedance can be individually regulated for each device.

Another feature of the invention relates to providing acoustic chambers on opposite sides of the vibrating diaphragm to equalize the damping effect and improve the quality of the device over a large range of speech and music frequencies. This arrangement consists in forming the restricted resistance paths in the chamber under the diaphragm as previously described and supplementing this arrangement with a hollow chamber on the opposite side of the diaphragm either formed in the cap or separated from the cap and inserting a plate or screen having numerous perforations therein in the chamber between the diaphragm and the cap. This feature of the invention may also be accomplished by providing multiple screens, adjacent screens having apertures or slots of varying area, to form successive paths through which the sound vibrations must pass. This arrangement introduces progressive filter action on the sound vibrations caused by the vibrating diaphragm, and, due to the varying values of air resistance of the screens and the capacities of the chambers of the mechanical filter system, the acoustic impedance on one side of the diaphragm supplements the acoustic conditions on the other side of the diaphragm so that the quality and transmission characteristics of the device are appreciably improved over the audible frequency range.

These and other features of the invention will be more fully understood from the following detailed description in connection with the acompanying drawings.

Fig. 1 is a cross-sectional view of an electrodynamic device made in accordance with this invention showing the arrangement of parts for introducing the necessary acoustic impedance into the damping chamber.

Fig. 2 is an exploded view in perspective of the magnet structure showing the detail elements and their relation to each other.

Fig. 3 is an exaggerated outline view of a magnet structure made in accordance with this invention to illustrate the pressure contact of the annular pole piece with the spacing member.

Fig. 4 is a partial cross-section of another embodiment of the invention in which the spacing member is carried by the annular pole piece.

Fig. 5 is a plan view showing the configuration of the spacing member shown in Fig. 4.

Fig. 6 illustrates in cross-section a different aspect of the invention in which the damping plate is provided with staggered holes to form the restricted paths for the air chamber without employing a separate spacing member.

Fig. 7 shows in perspective the two part damping plate shown in Fig. 6.

Fig. 8 is a plan view of the two part damping plate of Figs. 6 and 7 illustrating the adjustable arrangement of the restricted paths extending through the plate.

Fig. 9 is a cross-sectional view of a modified form of the invention illustrating an arrangement for applying damping to opposite sides of the diaphragm.

Fig. 10 shows in cross-section a further modification of Fig. 9 in which successive damping members are located on one side of the diaphragm to form a progressive filter.

Fig. 10—A is an enlarged plan view of a quarter section of the damping member shown in cross-section in Figs. 9 and 10.

Fig. 11 illustrates in cross-section the detail structure of a diaphragm shown in Figs. 9 and 10 and,

Fig. 12 is a diagram of electrical equivalents representing acoustical impedances of the arrangements disclosed in this invention.

Referring particularly to Figs. 1 and 2, the acoustic device of this invention comprises a mushroom-shaped casing or shell 15 having an annular outwardly extending flange 16 on the rim of the shell and a central or inner integral pole 17 having its face in the same plane as the top surface of the annular flange 16. The shell or casing is preferably formed of magnetizable material, such as cobalt steel or an alloy thereof, and is of the permanent magnet type so that the central pole and the annular rim form the ends of the magnet structure. The central pole is drilled to receive a bolt 18, which secures a dome-shaped circular inner pole piece 19 to the central pole, and a flat annular plate or outer pole piece 20 is mounted on the shell 15 to form a narrow annular gap between the edge of the inner pole piece 19 and the inner edge of the annular plate pole piece 20. The annular gap between these pole pieces is obtained by positioning the annular pole piece on the magnet structure and inserting a cylindrical gauge between the edges of the inner and outer pole pieces. The annular pole piece 20 and the flange 16 are drilled near the edge thereof at diametrically opposite points and pins 21 are inserted in the flange 16. After the gauge is removed, the annular pole piece may be removed to complete the assembly of the device which will now be described.

A thin light diaphragm is attached to one side of the annular pole piece 20 and comprises a central dome-shaped portion 22 and an annular flat portion 23. This diaphragm is preferably made of light material, such as aluminum or aluminum alloy, and is mounted on the annular pole piece 20 with paper spacing rings between the diaphragm and the annular pole piece 20. The dome-shaped portion 22 of the diaphragm operates as a piston and is provided with an annular coil 24 attached to the diaphragm at the juncture of the dome-shaped portion 22 and the flat annular portion 23. When the diaphragm is mounted in the structure as shown in Fig. 1 the coil is coaxially suspended in the annular gap between the edges of the inner pole piece 19 and the annular or outer pole piece 20 and a thin film of air separates the dome-shaped portion from the similarly shaped inner pole piece 19. An annular clamping plate 25 is mounted on the annular portion 23 of the diaphragm so that only a narrow annular area of the diaphragm is uncontrolled in its movement when the diaphragm is vibrated.

It is, of course, well known that a metallic diaphragm when vibrated has a natural period of vibration well within the speech range, and when speech vibrations are imparted to the air at the natural frequency of the diaphragm, distortion takes place and the speech is necessarily impaired. This is due to the uncontrolled mechanical motion of the diaphragm at the natural period of vibration. To overcome this difficulty and to raise the natural period of a diaphragm such as described beyond the range of importance in speech, the chamber under the diaphragm is closed by a damping plate or ring 26, preferably of brass or other non-magnetic material which fits over the cut-out portions of central pole 17 and is attached to the inner pole piece 19 by screws. The damping plate 26 which presents a solid surface across the annular gap between the pole pieces will not allow the passage of air from the chamber under the diaphragm and if holes are formed in the damping plate parallel to the annular gap, these holes or openings will not offer sufficient resistance to the air in the chamber to substantially raise the period of vibration of the diaphragm.

In accordance with this invention, the air in the chamber under the diaphragm is led out through restricted slots between the annular pole piece 20 and the damping plate 26 so that the air must travel radially at right angles after leaving the annular gap under the diaphragm. These slots are provided by a metallic spacing member or thin shim 27, preferably of nickel or an alloy metal, which is fastened to the inner pole piece 19 between the pole piece and the damping plate 26. This shim is provided with a plurality of radial extensions 28 which extend across the gap between the pole pieces and definitely fix the thickness of the slots through which the air must pass from the chamber under the diaphragm. The area of the slots introduces a mass reactance due to the action of the air forcing its way through the slots and this mass can be proportioned to resonate with the stiffness of the air chamber at a different frequency than the frequency of the diaphragm. The thin slots between the pole piece and the damping plate also introduce the necessary amount of resistance to the air leaving the diaphragm chamber so that the resonant frequencies of the combined system are damped out and the characteristic curve is flattened over a larger range of frequencies. The assembly of the damping ring and spacing member on the central pole piece provides a compact arrangement of the parts and insures a definite space relation between the annular pole piece and the damping plate to form the narrow slots for the passage of air from the acoustic chamber under the diaphragm.

Fig. 3 shows an arrangement of a magnet in which the spacing member 27 is formed from a solid disc with the extensions 28 projecting across the gap between the pole pieces. The object of making the center portion of the spacing member solid is to raise the plane of the central pole a sufficient distance so that when the annular pole piece 20 is attached to the magnet structure, the inner edge will bear down on the extensions 28 and insure a constant spacing of the annular pole piece with respect to the damping plate. This spacing will not be affected by atmospheric changes which may cause the inner edge of the outer pole piece to be displaced, thereby varying the area of the slots between the outer pole piece and the damping plate. Of course, the arrangement shown in Fig. 3 is exaggerated to show the relation of the various parts, although in actual practice the thickness of the shim or spacing member is small and the actual relationship of the parts is hardly noticeable.

Fig. 4 shows another embodiment of the invention in which constant pressure is exerted on the spacing member to maintain a definite area in the slots through which the air must pass from the chamber under the diaphragm. In this arrangement the inner pole piece 19 is directly attached to the central pole of the magnet, and the spacing member 29, more clearly shown in Fig. 5, is attached to the annular pole piece 20 and the inwardly extending ribs 30 bridge the gap between the pole pieces 19 and 20. The damping ring 31 seats on a resilient ring 32, such as rubber, which is located on the flanged portion 33 of the central pole of the magnet. In this arrangement the resilient ring member exerts sufficient pressure on the damping ring and spacing member 29 to maintain the definite areas of the slots between the pole pieces and the damping plate.

While the previously described damping arrangements for the air chamber under the diaphragm utilize a thin shim or spacing member to provide restricted slots for the passage of air from the diaphragm chamber, the same effect may be accomplished in accordance with this invention as shown in Figs. 6, 7 and 8. The damping plate is formed of two similar apertured rings 34 and 35, which are supported by the inner pole piece 19 and are provided with a plurality of circular openings 36 which are in alignment in the two rings. One or both rings may be provided with elongated slots 37 for fastening the rings to the pole piece 19 of the magnet structure. In this arrangement, the values of the mechanical resistance offered by the openings in the two rings may be adjusted to suit individual purposes by misaligning the apertures 36, as shown in Fig. 8, to form restricted air passages of definite area through which the air from the diaphragm chamber must pass. The large bearing surface of the annular pole piece 20 on the two-part damping ring, shown in Fig. 6, prevents any air escaping between these surfaces so that the only path through which the air can pass is through the misaligned openings in the rings 34 and 35.

Referring again to Fig. 1, after the damping ring 26 and spacing member 27 are attached to the inner pole piece 19 and fastened to the magnet structure by the bolt 18 and the diaphragm and coil are concentrically located in the annular gap of the magnet structure with the clamping plate 25 securely attached to the annular pole piece 20 to cover the greater portion of the periphery of the diaphragm, a perforated cap or ear piece 38 is placed on the clamping plate 25 and is formed on its lower surface to provide a restricted area or chamber above the diaphragm. The annular pole piece 20 and the related parts associated with magnet 15 are securely clamped thereto by a metallic sleeve member 39 having an inwardly projecting flange 40 which engages the lower surface of the flange 16 on the magnet 15. The sleeve 39 is provided with internal threads to engage the threaded portions of the clamping plate 25 and the cap 38 as shown on Fig. 1.

The structures heretofore described are concerned with the attainment of accurate, reproducible values of mass, stiffness and viscosity for affecting the mechanical motion of the diaphragm on one side thereof to improve the response characteristics of the device over the audible frequency range in order to obtain a true and natural reproduction of speech. The same results are obtained with a higher degree in the structures shown in Figs. 9 and 10 except that in these figures the device is disclosed as applying acoustical resonant systems to both sides of the diaphragm in order to increase the range of frequencies reproducible by the device.

As shown in Fig. 9 the clamping plate 41 is positioned above the diaphragm and has a configuration different from the clamping plate shown in Fig. 1 in that the inner edge is provided with a circular flange or seat 42 closely adjacent to the diaphragm portion 22. A disc or plate 43 having a plurality of elongated thin slots 44 is located on the flange 42 directly above the dome-shaped portion 22 of the diaphragm. The cap 38 seated on the clamping plate 41 has a downwardly projecting portion 45 which securely holds the disc 43 on the seat 42 of the clamping plate 41. A ring or sleeve 39 similar to Fig. 1 securely fastens all the elements to the magnet structure. In this arrangement the slotted disc 43 above the diaphragm accomplishes the same purpose as the damping plate and restricted slot under the diaphragm and, therefore, supplements the damping action underneath the diaphragm by controlling the mechanical motion of the diaphragm in both directions of vibration. This construction serves to smooth out the response characteristic of the diaphragm over a larger range of speech and music frequencies.

In Fig. 10 the seat 42 on the clamping plate 41 is made deeper so that a plurality of discs such as 43 may be located in the aperture to form successive damping members and in effect act as an acoustic filter for the air above the diaphragm. In this arrangement a spacing ring 46 is located between two adjacent discs to form an air chamber to affect the stiffness of the filter system. While in this figure, the slots in the discs are shown in alignment and of the same size in all the discs, it is, of course, understood that these slots may be staggered in relation or the slots in successive discs may be of different widths to vary the values of resistance of the filter system. Other types of openings in the disc may be used to accomplish the same purpose. The type of disc shown in Figs. 9 and 10 is shown in enlarged section in Fig. 10—A to illustrate the relative length and width of the slots and the relation thereof to the size of the disc. The slots 44 may be punched in a metallic plate as shown in this figure, but due to the difficulty of securing slots of very thin width by the punching operation the slotted disc is electroplated to fill up the edges of the slots and thereby produce slots of sufficient restricted area which have been found to answer the purpose of this invention.

Fig. 11 shows a preferred type of a two piece diaphragm of relatively light mass in which the dome shaped portion 22 is formed of .9 mils thickness of aluminum and the portion 23 is formed of 2.1 mils of similar material and in which the center portion 22 is fastened at its rim portion 47 to the inner rim of the annular portion 23 by cement, solder, welding or other suitable means. This type of diaphragm is relatively light in weight and since the dome-shaped portion 22 vibrates as a piston and the greatest part of the annular portion 23 is clamped rigidly between the clamping plate 25 and the annular pole piece 20 of the acoustic device, it will be seen that only a relatively small annulus of the diaphragm vibrates with a free period. However, it has been found that even this small area offers difficulties in the reproduction of speech and music over the whole frequency range and therefore the damping and additional resonant effects introduced in the device in accordance with this invention serve to control the mechanical motion of the diaphragm when vibrated.

While the device of this invention may contain all of the features enumerated, it is understood that the invention is not limited to such a combination, since, under certain conditions, the operating characteristics of the device may be sufficiently improved by employing one or more of the various features.

An acoustical impedance diagram showing the arrangements of the parts of the system from an acoustic wave transmission viewpoint in a form analogous to electrical impedance diagrams of electrical transmission systems is shown in Fig. 12. It is well known that the mechanical terms of mass, stiffness and friction or viscosity are the equivalent of electrical terms of inductance capacity and resistance, respectively, when considered in the analogous acoustic filter arrangement here to be described. The first section of the diagram represents friction or resistance 50, mass of inductance 51 and stiffness or capacity 52 in series relation of the diaphragm and coil mounted in the air gap between the poles of a magnet structure such as shown in Fig. 1. The diaphragm when set in vibration by speech currents traversing the movable coil in the air gap will contribute its own period of vibration and, therefore, cause distortion within the range of the speech frequencies due to its natural period. In order to overcome this distortion and to increase the range of frequencies to which the device responds, an acoustic system is added. The second portion of the diagram represent the values of resistance 53, mass 54 and stiffness 55 of this acoustic system and shows the parallel paths that the air under the diaphragm is subjected to by the damping plate and restricted slot which substantially closes the annular gap in which the coil is located. This introduces a resonance in addition to the resonance of the diaphragm which is different in frequency from that of the diaphragm. Sufficient resistance to damp out the resonances of the combined diaphragm and acoustic systems is obtained by use of the damping plate in which the air must force its way out through the restricted slots between the damping plate and the annular pole piece. The third portion of the diagram illustrates the supplemental resonant and damping effect on the opposite side of the diaphragm as shown in Fig. 9 in which resistance 56, mass 57 and stiffness 58 are the values represented by the chamber above the diaphragm and the restricted slots in the disc 43 through which the air must pass. In this way the mechanical motion of the diaphragm is controlled over substantially the whole speech and music range so that the response characteristic is uniform and substantially free from distortion, thereby improving the reproducible response of the diaphragm over the important speech frequency range.

While the features of this invention have been disclosed in various specific structures it is of course understood that various modifications may be made in the details of construction without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber under said diaphragm, and a damping ring supported solely by said inner pole piece and substantially closing the annular gap in which the coil is located.

2. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular polepiece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber under said diaphragm, a damping ring supported solely by said inner pole-piece, and a thin metallic spacing member interposed between one of said pole pieces and said damping ring.

3. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber under said diaphragm, a damping ring supported solely by said inner pole piece, and means in contact with at least one of said pole pieces and damping plate to form restricted slots between adjacent edges of said annular pole piece and damping plate.

4. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap

forming an acoustic air chamber, a damping ring supported solely by said inner pole piece, and a spacing member interposed between said pole pieces and damping ring, said spacing member having a plurality of extensions bridging the gap between said pole pieces.

5. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, a damping plate carried by said inner pole piece and extending across the end of the gap, and a spacing member separating said damping plate from said annular pole piece to provide a restricted gap at right angles to said annular gap.

6. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole-pieces and gap forming an acoustic air chamber, a non-magnetic damping member supported by said inner pole piece, and a spacing member having a plurality of radial extensions separating said damping plate from said annular pole piece.

7. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, a damping member supported by said inner pole piece, and means interposed between the pole pieces and damping member forming restricted radial openings whereby the mass reactance of the air in the openings is proportioned to resonate with the stiffness of the air chamber at a frequency other than the resonant frequency of the diaphragm.

8. An electrodynamic device comprising a magnet having an axial pole and an outer pole, the faces of said poles being in the same plane, a circular pole piece supported on said axial pole, a ring damping plate attached to said pole piece, an annular pole piece in contact with said outer pole and concentrically spaced about said circular pole piece, and spacing means interposed between said axial pole and circular pole piece to raise the plane of the inner edge of said annular pole piece, whereby pressure is exerted by said annular pole piece on said spacing member.

9. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, a perforated ring member bridging the gap between said pole pieces, and means for varying the area of the perforations in said member.

10. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, a perforated ring member bridging the gap between said pole-pieces, and adjustable means in face to face relation with said member for varying the area of the perforations therein.

11. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, and a pair of superimposed perforated members bridging the gap between said pole pieces, one of said members being rotatable for misaligning the perforations in said members.

12. An electrodynamic device comprising a shell magnet having an inner pole piece, an annular pole piece on said shell forming an annular gap with said inner pole piece, a diaphragm carried by said annular pole piece and having a coil located in the annular gap, said diaphragm, magnet, pole pieces and gap forming an acoustic air chamber, a pair of ring members extending across the gap between said pole pieces having aligned openings therethrough communicating with the annular gap, one of said members having elongated slots to permit rotation of said member, and means supporting said ring members from said inner pole piece.

13. An electrodynamic device comprising a casing having coaxial pole pieces forming an air-gap therebetween, a diaphragm supported in relation to said pole pieces and having a coil suspended in the air-gap, an air damping member extending across said air-gap on one side of said diaphragm, a plate on said diaphragm having an inner circular flange, and a plurality of superimposed perforated disc members seated on said flange.

14. An electrodynamic device comprising a casing having coaxial pole pieces forming an air-gap therebetween, a diaphragm supported in relation to said pole pieces and having a coil suspended in the air-gap, an air damping member extending across said air-gap on one side of said diaphragm, a

plate on said diaphragm having an inner circular flange, and a plurality of superimposed perforated disc members seated on said flange, successive discs having definite diameter perforations.

15. An electrodynamic device comprising a casing having coaxial pole-pieces forming an air-gap therebetween, a diaphragm supported in relation to said pole pieces and having a coil suspended in the air-gap, an air damping member extending across said air-gap on one side of said diaphragm, a plate on said diaphragm having an inner circular flange, a series of disc members seated on said flange having a plurality of slots therein, and means forming air chambers between adjacent disc members.

16. An electrodynamic device comprising a casing having coaxial pole pieces forming an air-gap therebetween, a diaphragm supported in relation to said pole pieces and having a coil suspended in the air-gap, an air damping member extending across said air-gap on one side of said diaphragm, a plate on said diaphragm having an inner circular flange, a plurality of superimposed perforated disc members seated on said flange, and a perforated closure member maintaining said disc members in position.

17. An electrodynamic device comprising a casing having coaxial pole pieces forming an air-gap therebetween, a diaphragm supported in relation to said pole pieces and having a coil suspended in the air-gap, an air damping member extending across said air-gap on one side of said diaphragm, a plate on said diaphragm having an inner circular flange, a plurality of superimposed perforated disc members seated on said flange, a perforated closure member superimposed on said discs, and a sleeve member clamping said closure member and one of said pole pieces to said casing.

18. An electrodynamic device comprising a shell magnet having a circumferential flange and a central pole, a dome-shaped pole piece attached to said central pole, an annular pole piece in engagement with said circumferential flange, and concentric with said dome-shaped pole piece to form an annular gap therebetween, a diaphragm having central and outer portions following the contour of said pole pieces, a coil attached to the periphery of said central portion and adapted to vibrate in said annular gap, a damping member attached to said central pole piece and surrounding said central pole, said damping member extending beyond the inner edge of said annular pole piece and a thin metallic spacing member having cut-out portions between said annular pole piece and said damping member, to maintain a restricted opening between the inner edge of said annular pole piece and said damping member.

19. An acoustic device comprising a diaphragm, and means providing an acoustic network on each surface of the diaphragm to control the vibratory characteristics thereof, said networks including acoustic stiffness, mass and resitance elements, said means comprising a member defining a sound passage on one side of the diaphragm, a perforated plate member extending across said passage, and means spaced from the other side of the diaphragm to form an air chamber having a substantially annular restricted outlet.

In witness whereof, I hereunto subscribe my name this 10th day of April, 1930.

LEONARD W. GILES.