April 17, 1934. A. L. THURAS 1,954,966

SOUND TRANSLATING DEVICE

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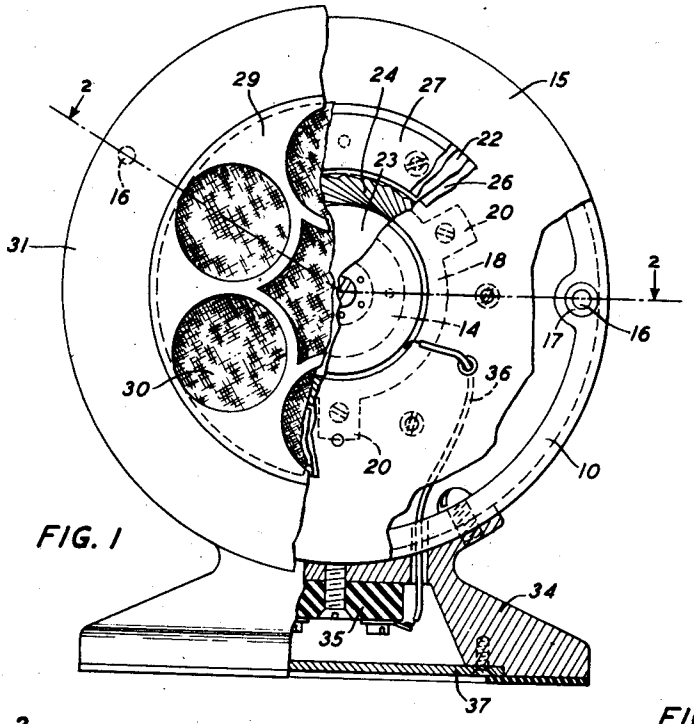

FIG. 1

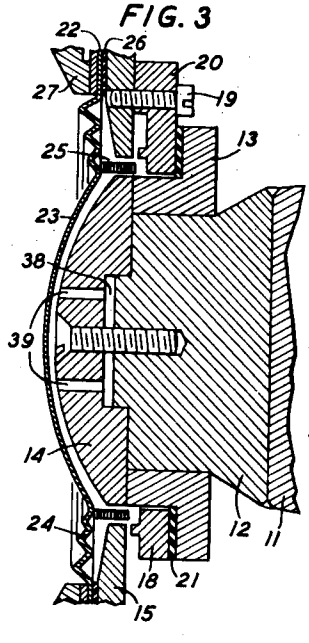

FIG. 3

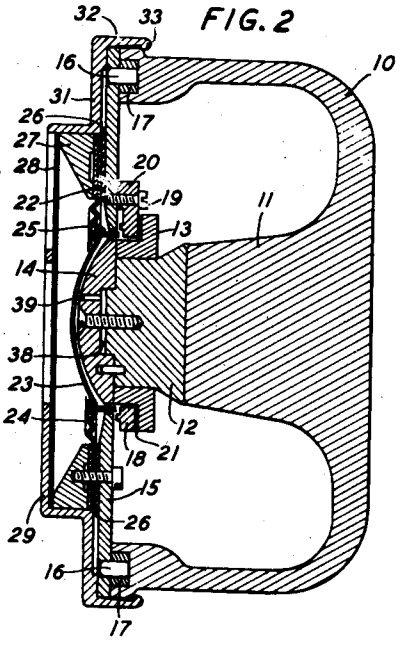

FIG. 2

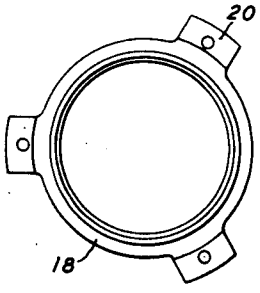

FIG. 3-A

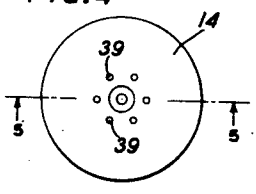

FIG. 4

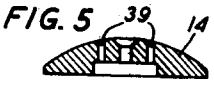

FIG. 5

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FIG. 6

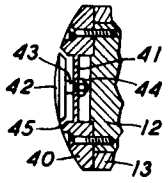


FIG. 7

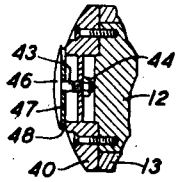


FIG. 8

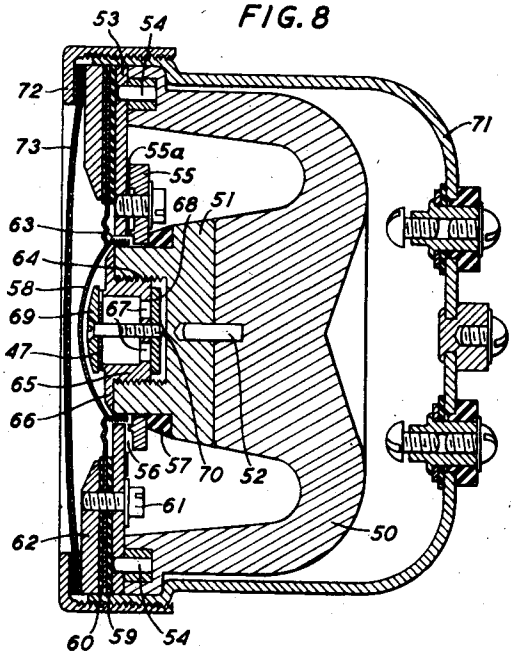
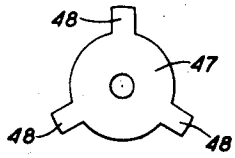


FIG. 9



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UNITED STATES PATENT OFFICE

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SOUND TRANSLATING DEVICE

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Application January 31, 1931, Serial No. 512,578

20 Claims. (Cl. 179—115.5)

This invention relates to sound translating devices and more particularly to such devices of the electrodynamic type for transmitting or receiving sound waves.

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

In accordance with this invention, an electrodynamic device comprises a magnet structure having coaxial pole pieces separated by an annular gap and supporting a piston type diaphragm carrying a movable coil which is centered in the annular gap. The coil is adapted to vibrate with the diaphragm to 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.

An auxiliary damping element is formed in the end of the inner pole piece to cooperate with the main damping element to provide a substantially flat operating characteristic over the important audible frequency range for a device employed in transmitting or receiving sound waves.

In one embodiment of the invention, the main damping element is attached to the annular pole piece and forms therewith a restricted radial passageway entering the annular gap between the pole pieces. A sealing ring carried by the central pole piece closes the gap between the central pole piece and the damping plate to restrict the passage of air from the annular gap to the radial passageway between the damping plate and the annular pole piece. The auxiliary damping element consists of a recessed central pole piece fitted with a closure member having small apertures to constitute an acoustic compensator having the desired values of stiffness, mass, and resistance which imposes an added stiffness on the diaphragm over the low frequency range, then acts substantially as a resistance over the frequency range where the diaphragm and chamber under the diaphragm produces distortion and at high frequencies acts as a mass reactance so that the movement of air in the chamber is toward the restricted radial opening in the damping plate.

A further feature of the invention relates to varying the constants of the auxiliary damping element or compensator by providing a unit which may be removable and adjustable to insure the correct values of mass, stiffness and resistance to alter the operating characteristics of the device in which it functions.

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

Fig. 1 is a front elevation of an electrodynamic device made in accordance with this invention with portions cut away to show the superposed elements and a portion of the base shown in cross-section to show the connection of the leads from the movable coil to the stationary terminals.

Fig. 2 is a cross-sectional view of Fig. 1 on the line 2, 2 showing the assembly of the various elements entering into the structure of the device and the relationship of the main and auxiliary damping elements in accordance with this invention.

Fig. 3 is an enlarged detailed view shown in cross-section of a partial assembly of Fig. 2 to show the cooperating damping chambers under the diaphragm.

Fig. 3—A is a plan view of the damping plate shown in Figs. 2, 3 and 8.

Fig. 4 is an enlarged plan view of the central pole piece which forms the auxiliary damping element.

Fig. 5 is a cross-sectional view of Fig. 4 on the line 5, 5.

Fig. 6 shows in cross-section, a modification of the invention in which the central pole piece is provided with an annular restricted passageway entering the auxiliary damping chamber.

Fig. 7 illustrates in cross-section, another modification of the invention in which the restricted passageway is provided by a thin spacing member.

Fig. 8 illustrates in cross-section a modified structure of the electrodynamic device shown in Fig. 2 in which the auxiliary damping element is removable and adjustable; and

Fig. 9 shows the form of spacer disclosed in the auxiliary damping element of Figs. 7 and 8.

Referring now to Figs. 1 and 2, an electrodynamic transmitter is shown comprising a mushroom-shaped casing having a magnet shell 10 preferably of cobalt steel and an integral central pole 11 to which is attached a circular extension 12. An annular flanged ring 13, of non-magnetic material, such as phosphor bronze, is fitted over the circular boundary of the extension 12 and seats against the lower tapered surface of the extension 12. A dome-shaped central pole

piece 14 is secured to the extension 12 and securely fastens the annular ring 13 to the extension. An annular plate or pole piece 15 is coaxially positioned on the magnet shell 10 with respect to the central pole piece 14 by pins 16 held in soft metal inserts 17, the annular pole piece 15 and central pole piece 14 forming therebetween an annular gap.

An annular damping plate or ring 18 of non-magnetic material, such as brass or aluminum, a plan view of which is shown in Fig. 3—A, is attached to one side of the annular pole piece 15 within the casing at three spaced positions where the attaching screw 19 extends through an outwardly extending portion 20 of the damping plate. This plate is provided with an undercut surface having an annular ridge which forms a restricted annular passageway between the surface of the annular pole piece 15 and the damping plate 18. A sealing washer 21 of pliable material, such as paper, is located between the surfaces of the damping plate 18 and the flanged non-magnetic ring 13, to seal the gap between the inner edges of the damping ring 18 and the flanged ring 13 so that any movement of air in the chamber between the pole pieces must pass out through the restricted opening between the annular pole piece 15 and the top of the damping plate 18 as shown clearly in Fig. 3. The flanged ring 13 is preferably made of non-magnetic material to overcome any loss of magnetic flux in the annular gap between the adjacent edges of the pole pieces of the magnet structure.

A diaphragm assembly is attached to the opposite side of the annular pole piece 15 and consists of a diaphragm proper having a flat outer portion 22, a central dished substantially rigid or piston portion 23 following the contour of the central pole piece 14 and an intermediate corrugated or flexible portion 24. A movable coil 25 is attached to the diaphragm assembly intermediate the flexible portion 24 and the dished rigid portion 23 and is adapted to move freely in the annular gap between the edges of the annular pole piece 15 and the central pole piece 14 to change or modify the constant magnetic flux in the annular gap between the pole pieces. The annular coil 25 may consist of a plurality of turns of ribbon conductor wound edgewise with adjacent turns insulated from each other by a coating of insulating varnish.

The diaphragm assembly is spaced from the pole pieces by a number of paper washers 26, to provide an air space between the diaphragm and the pole pieces which serves as a cushion for the movement of the diaphragm. The diaphragm assembly is secured to the annular pole piece 15 by screws threaded into a ring member 27 provided with a surface converging toward the diaphragm. A wire screen cloth 28 is located over the opening of the ring 27 and is held in place by a cover member having a central portion 29 provided with symmetrical cut-out portions 30 to allow the passage of sound to the diaphragm surface, an annular flanged portion 31 extending to the periphery of the magnet shell and an overhanging flange portion or rim portion 32 which is forced over a shoulder of the shell as shown at 33. A base mounting 34 is attached to the periphery of the shell as shown in Fig. 1 and provided with a stationary terminal block 35 to which the leads 36, only one being shown, from the movable coil in the gap are attached. The bottom of the base is closed by a plate member 37.

In electrodynamic devices of the movable coil type having a diaphragm of such mass and stiffness as to operate as a piston when vibrating, the mechanical movement of the diaphragm and coil causes distortion over a certain portion of the speech frequency range, due to the natural frequency of the diaphragm being within this portion of the frequency range. This is observed by the shape of the characteristic curve which has a decided slope at the higher frequencies. By utilizing the mass, stiffness and resistance of a volume of air confined in a chamber on one side of the diaphragm, the air being permitted to leave the chamber through a restricted passageway, it is possible to control the mechanical motion of the diaphragm and thereby reduce the distortion of the moving system over substantially the whole frequency range. This is accomplished by the main damping plate or ring 18 which introduces the necessary amount of mass, stiffness and resistance by the movement of the air in the chamber under the diaphragm to overcome the distortion of the diaphragm.

The acoustic chamber formed under the diaphragm by the damping plate 18 adds stiffness to the diaphragm and therefore raises the frequency of the diaphragm to a higher value. Due to the restricted passageway leading from the large air space within the shell magnet to the chamber under the diaphragm air is drawn through the passageway when the diaphragm is moved away from the pole pieces and likewise is forced out through the passageway when the diaphragm moves toward the magnetic structure. By properly proportioning the area of the passageway, it is possible to introduce an acoustic impedance to the air entering and leaving the chamber under the diaphragm whereby the mechanical motion of the diaphragm is controlled over substantially the whole operating range, which is approximately from 60 cycles to 10,000 cycles. For certain acoustic devices such as electromagnetic and electrostatic receivers and carbon microphones, this impedance should vary inversely as the frequency. In a translating device, such as a transmitter, as herein disclosed, this acoustic impedance should be constant with frequency over substantially the whole frequency range.

However, it has been found that the mass of the diaphragm and stiffness of the air in the chamber under the diaphragm, cause some distortion of the characteristic in the portion of the frequency range between 2,000 and 6,000 cycles where the curve slopes slightly, then rises above the desired flat characteristic. This condition is caused by the acoustic impedance imposed on the diaphragm being too high for the mass of the diaphragm.

In accordance with this invention, the mass reactance of the diaphragm is neutralized over the range of frequencies in which distortion occurs by introducing an auxiliary damping means or acoustic compensator under the diaphragm which cooperates with the main damping means to smooth out the characteristic curve of the device within a portion of the frequency range. This is accomplished in one form, as shown in Fig. 2, in which the central pole piece 14 is centrally recessed to form a hollow chamber 38 between the pole piece 14 and the central pole extension 12. Communication with this chamber is secured by a plurality of small apertures 39 extending from the curved surface of the pole

piece 14 to the chamber 38. These apertures may be arranged in a circle around the center of the pole piece, as shown in Fig. 4, and proportioned to introduce the necessary amount of resistance to the air forced through the apertures by the motion of the diaphragm. The apertures 39 also form a communicating passageway between the chamber 38 in the central pole piece and the chamber under the diaphragm which leads out through the restricted passageway in the main damping element 18.

In operation, the acoustic compensating means merely adds stiffness to the diaphragm over the low frequency range up to 2,000 cycles, then operates substantially as a resistance in a region about 5,000 cycles in which the diaphragm mass distorts the characteristic and at higher frequencies acts as a mass reactance. Since the main damping element offers a constant resistance over substantially the whole frequency range, it will be seen that the increased resistance of the compensating means neutralizes the mass reactance of the diaphragm to smooth out the slope and rise in the characteristic curve of the device so that the operating efficiency of the diaphragm is substantially a flat characteristic over the whole frequency range.

Fig. 6 shows a modified structure of the acoustic compensating means in which a central pole piece 40 is provided with a large central aperture having a bridge member 41 extending across the aperture within the hollow chamber. The aperture is covered by a dome-shaped closure member 42 having a central stem 43 which extends through the bridge member 41 and is attached thereto by a nut 44. The closure member 42 is provided with a tapered edge 45 to correspond with the machined surface of the aperture and suitable spacers may be positioned between the surfaces of the closure member 42 and the pole piece 40, to insure an accurate centering of the closure member 42 whereupon it is rigidly fastened in place by the nut 44. The spacers may be removed after securing the closure member in position and the annular restricted opening or passageway formed between the surfaces of the closure member 42 and the pole piece 40 insures the necessary amount of resistance coupled to the stiffness and mass of the air in the acoustic chamber within the pole piece.

In Fig. 7 another modification of the acoustic compensating means is shown in which a closure member 46 is made of larger diameter than the aperture in the central pole piece 40 and a spacing disc 47 having projections 48 is interposed between the adjacent surfaces of the closure member 46 and the pole piece 40. In this construction the projections 48 of the spacing member 47 insure an accurate space relation between the pole piece 40 and the closure member 46 and likewise insure equal and constant spacing between the pole piece 40 and the closure member 46 whereby restricted slots are formed between the adjacent projections 48 on the spacing member 47.

Since individual diaphragm assemblies have different characteristics, it is extremely desirable that provision be made to associate individual auxiliary damping elements or acoustic compensating members with the magnet structure without requiring numerous separate elements. At the same time, it is desirable to employ an element or member which may be adjustable and removable and also capable of being measured prior to insertion in the electrodynamic device. In accordance with this invention this structure is disclosed in Fig. 8 in which the device comprises a magnet shell 50 having a central pole piece 51 attached thereto and centered by a pin 52. An annular pole piece 53 is coaxially centered around the pole piece 51 and supported on the magnet structure by pins 54, the central pole piece 51 and the annular pole piece 53 forming an annular gap therebetween. An annular damping plate or ring 55, similar to the ring 18 disclosed in Figs. 1 and 2, is attached to the lower surface of the annular pole piece 53 and forms a plurality of restricted slots 56 between the damping plate and the annular pole piece 53 due to a spacing washer 55*a* being interposed between the extensions of ring 55 and the annular pole piece 53. The damping plate lies against a soft rubber ring 57 held on the central pole piece 51 which seals the gap between the inner surface of the damping plate and the surface of the pole piece 51 so that the air from the chamber under the diaphragm must travel out through the restricted slots 56 between the damping plate and the annular pole piece. A diaphragm assembly 58 is held between spacing washers 59 and 60 and attached to the annular pole piece 53 by screws 61, extending through an annular retaining ring 62 placed on top of the diaphragm assembly. An annular movable coil 63 is attached to the diaphragm and moves freely in the annular gap between the surfaces of the annular pole piece and central pole piece 51.

The central pole piece 51 is provided with a hollow recess which is threaded as shown at 64. The threaded cavity of the central pole piece 51 provides for the ready insertion of the damping element or acoustic compensator member which consists of a cup-shaped member 65 provided with a flange 66, the cup-shaped member being threaded to enter the threaded portion of the cavity and the flange 66 lying against the top of the pole piece 51. The cup-shaped member 65 is provided with a plurality of holes 67 in the bottom thereof which are closed by a removable plate 68. Across the open end of the cup-shaped member 65 is positioned a dome-shaped closure member 69 which is spaced from the edge of the cup-shaped member 65 by a spacing washer 47, the whole assembly being secured together by a screw 70.

Prior to inserting the auxiliary damping element in the magnet structure, the damping element is assembled without the plate 68 so that the element may be measured with respect to the values of air stiffness and mass of the hollow cavity in the cup-shaped member and the air resistance value of the restricted slots between the closure member 68 and the wall of the cup-shaped member 65. When the proper values are ascertained the closure 68 is secured to the bottom of the damping element and the damping element may be inserted in the central pole piece 51. The magnet assembly is enclosed in a metallic casing 71 and is secured therein by an annular flanged ring 72 which is threaded to the casing 71. The flanged ring also secures a perforated screen 73 across the diaphragm surface to prevent the entrance of dust and to protect the diaphragm from injury.

While the invention has been disclosed in various modifications as applied to an electrodynamic device, it is, of course, understood that the auxiliary damping or acoustic compensating means may be associated with a main damping element in other devices, and, therefore, the invention is

only to be limited within the scope of the appended claims.

What is claimed is:

1. A sound translating device comprising a magnet structure and a diaphragm, damping means associated with said magnet structure for damping the mechanical motion of said diaphragm over substantially the whole operating range, and an acoustic compensating means adjacent said diaphragm for influencing said diaphragm within a portion of said range.

2. A sound translating device comprising a magnet structure and diaphragm, damping means associated with said magnet structure for damping the mechanical motion of said diaphragm over substantially the whole operating range, and an acoustic compensating means adjacent said diaphragm, said means having the resistance, stiffness and mass reactance of such values as to change the acoustic impedance imposed on the diaphragm at any desired portion of the frequency range above 1,000 cycles.

3. A sound translating device comprising a magnet having a central pole piece, a pole piece surrounding said central pole piece and forming an air gap therebetween, a diaphragm in operative relation with respect to said pole pieces, a coil attached to said diaphragm and located in said gap, main damping means associated with said magnet structure for damping the mechanical motion of said diaphragm over substantially the whole operating range, and compensating damping means adjacent said diaphragm for controlling the motion of said diaphragm within a portion of said range.

4. A sound translating device comprising a magnet having a central pole piece, an outer pole piece surrounding said central pole piece and forming an air gap therebetween, a diaphragm attached to said outer pole piece, a coil carried by said diaphragm and located centrally in the gap between said pole pieces, a damping plate attached to said outer pole piece under said diaphragm to control the mechanical motion of said diaphragm over substantially the whole audible frequency range, and compensating damping means formed in said central piece to control said diaphragm within a portion of said audible range.

5. A sound translating device comprising a magnet having a central pole piece, an annular pole piece on said magnet forming an annular gap with said central pole piece, a diaphragm supported on one side of said annular pole piece, an annular coil attached to said diaphragm and movable in said gap, and a plurality of damping means located on one side of said diaphragm adjacent said coil, one of said means being central and cylindrical and the other being annular and surrounding said central means.

6. A sound translating device comprising a magnet having a central pole piece, an outer pole piece on said magnet forming an air gap with said central pole piece, a diaphragm supported on one side of said outer pole piece, a coil attached to said diaphragm and movable in said gap, and a plurality of coaxial damping means associated with said magnet pole pieces and located on one side of said diaphragm.

7. A sound translating device comprising a magnet having a central pole piece, an outer pole piece on said magnet forming an air gap with said central pole piece, a diaphragm supported on said outer pole piece, a coil attached to said diaphragm and movable in said gap, and a plurality of damping means on one side of said diaphragm having restricted peripheral openings transverse to said gap, said openings being in parallel planes.

8. A sound translating device comprising a magnet having a central pole piece, an outer pole piece on said magnet forming an air gap with said central pole piece, a diaphragm supported on said outer pole piece, a coil attached to said diaphragm and movable in said gap, and a plurality of damping means on one side of said diaphragm, one of said means being supported within said central pole piece and the other being supported by said outer pole piece.

9. A sound translating device comprising a magnet having a central pole piece provided with a recessed chamber, an outer pole piece on said magnet forming an air gap with said central pole piece, a diaphragm supported on said outer pole piece, a coil attached to said diaphragm and movable in said gap, and a plurality of damping means on one side of said diaphragm, one of said means being adjustable and removably positioned in the chamber of said central pole piece and the other surrounding said central pole piece.

10. A sound translating device comprising a magnet having a central pole piece, an outer pole piece on said magnet forming an air gap with said central pole piece, a diaphragm having a dish-shaped portion supported on said outer pole piece, a coil attached to said diaphragm and movable in said gap, and a plurality of damping means on one side of said diaphragm, one of said means forming a restricted path adjacent said outer pole piece and another of said means forming a chamber and a restricted path adjacent the dish-shaped portion of the diaphragm.

11. An electrodynamic device comprising a diaphragm and a magnetic structure, one side of said diaphragm and walls of said magnetic structure forming a chamber, and means forming a plurality of substantially annular openings for the ingress and egress of air into said chamber.

12. An electrodynamic device comprising a magnet structure, a diaphragm having a portion sufficiently rigid to vibrate as a whole and a flexible portion, a coil attached to said diaphragm and suspended in an air gap between the poles of said magnet structure, damping means within said magnet structure adjacent said diaphragm at its flexible portion and coil, and auxiliary damping means close to said diaphragm at its rigid portion, said coil being positioned substantially in a line between said auxiliary damping means and said first damping means.

13. An electrodynamic device comprising a magnet structure having a recessed central pole piece, an outer pole piece engaging said magnet structure and forming an air gap with said central pole piece, a diaphragm, a coil, a damping plate surrounding said central pole piece and substantially closing said gap, and a removable damping means within said recessed central pole piece.

14. An electrodynamic device comprising a magnet structure having a recessed central pole piece, an outer pole piece engaging said magnet structure and forming an air gap with said central pole piece, a diaphragm associated with said pole pieces, a coil attached to said diaphragm and located within said gap between said pole pieces, a stationary damping plate surrounding said central pole piece and substantially enclosing said

gap, and an adjustable damping member within said recessed central pole piece.

15. An electrodynamic device comprising a magnet structure having a recessed central pole piece, an annular pole piece engaging said magnet structure and forming an annular gap with said central pole piece, a diaphragm mounted on one side of said annular pole piece, a coil attached to said diaphragm and located in said annular gap, a stationary damping plate attached to the opposite side of said annular pole piece and forming a chamber under said diaphragm, said damping plate having restricted radial openings communicating with said chamber, and a closure member fitted over the open end of said recessed central pole piece and having peripheral slots communicating with said recessed pole piece and the chamber under said diaphragm.

16. In a constant impedance device, a magnet structure having pole pieces forming an air gap therebetween, a diaphragm associated with said pole pieces having a portion sufficiently rigid to vibrate as a whole, a coil attached to said diaphragm and suspended in said gap, a damping member attached to one of said pole pieces to form an air chamber in the rear of said diaphragm, said damping member offering a constant resistance over substantially the whole audible frequency range, and an auxilary acoustic compensator member close to the central portion of said diaphragm, said member presenting substantially a resistance over a portion of said frequency range to neutralize the mass reactance of said diaphragm.

17. In a constant impedance device, a magnet structure having pole pieces forming an air gap therebetween, a diaphragm supported on one side of said pole pieces, said diaphragm having a portion sufficiently rigid to vibrate as a whole, a coil attached to said diaphragm and suspended in said gap, a damping member supported on one of said pole pieces opposite said diaphragm and forming a chamber under said diaphragm having a constant resistance over a frequency range from 60 to 10,000 cycles, and an acoustic compensator close to the central portion of said diaphragm, said compensator acting substantially as a resistance within a range in the neighborhood of 6,000 cycles.

18. An electrodynamic device comprising a shell magnet having a central pole, a hollow pole piece attached to said central pole, an annular pole piece surrounding said hollow pole piece, but spaced therefrom to form an annular gap between said pole pieces, a diaphragm attached to one surface of said annular pole piece and having a dome-shaped portion located over said hollow pole piece, an annular coil attached to said diaphragm and movable in the gap between said pole pieces, said pole pieces and diaphragm forming walls of an air chamber, an annular damping plate attached to said annular pole piece having radial peripheral openings communicating said shell magnet with said chamber, sealing means closing the opening between said damping plate and said central pole, and an auxiliary damping plate closing said hollow pole piece having openings forming restricted passageways between said chamber and hollow pole piece.

19. An electrodynamic device comprising a magnet shell having a central pole, a flanged ring on said central pole, an annular pole piece on said magnet, a central pole piece attached to said central pole and forming an annular gap with said annular pole piece while maintaining said flanged ring on said central pole, a diaphragm carried by said annular pole piece, a coil on said diaphragm located in said annular gap, a damping plate attached to said annular pole piece substantially closing said annular gap, said damping plate forming restricted radial slots between said plate and annular pole piece, and sealing means interposed between said damping plate and flanged ring.

20. An acoustic device comprising a magnet having a pair of poles forming an annular air gap, a diaphragm, a coil secured to said diaphragm for movement in said gap, and means including one of said poles and said diaphragm forming an air chamber on one side of said diaphragm, said one pole having an air cavity therein and having bores connecting said air chamber and said air cavity.

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