

March 1, 1932.

A. L. THURAS

1,847,702

SOUND TRANSLATING DEVICE

Filed May 2, 1931

3 Sheets-Sheet 1

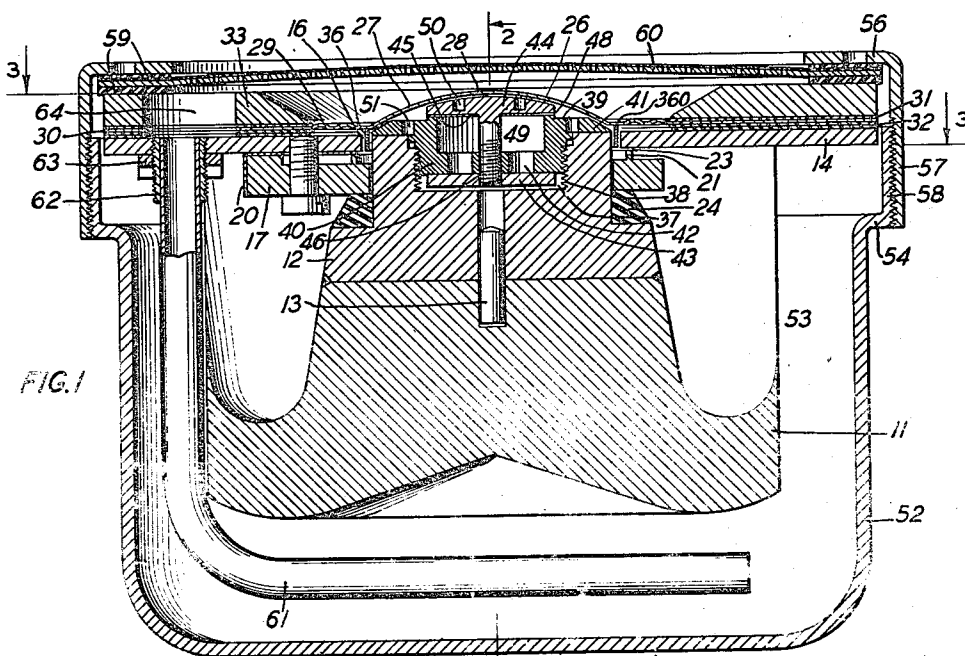


FIG. 1

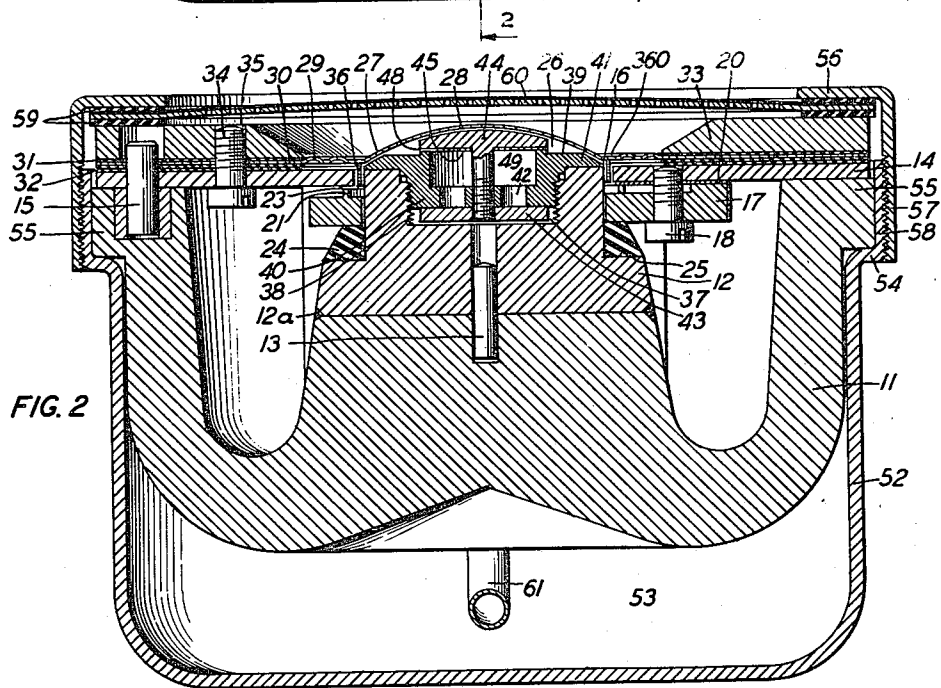


FIG. 2

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FIG. 3

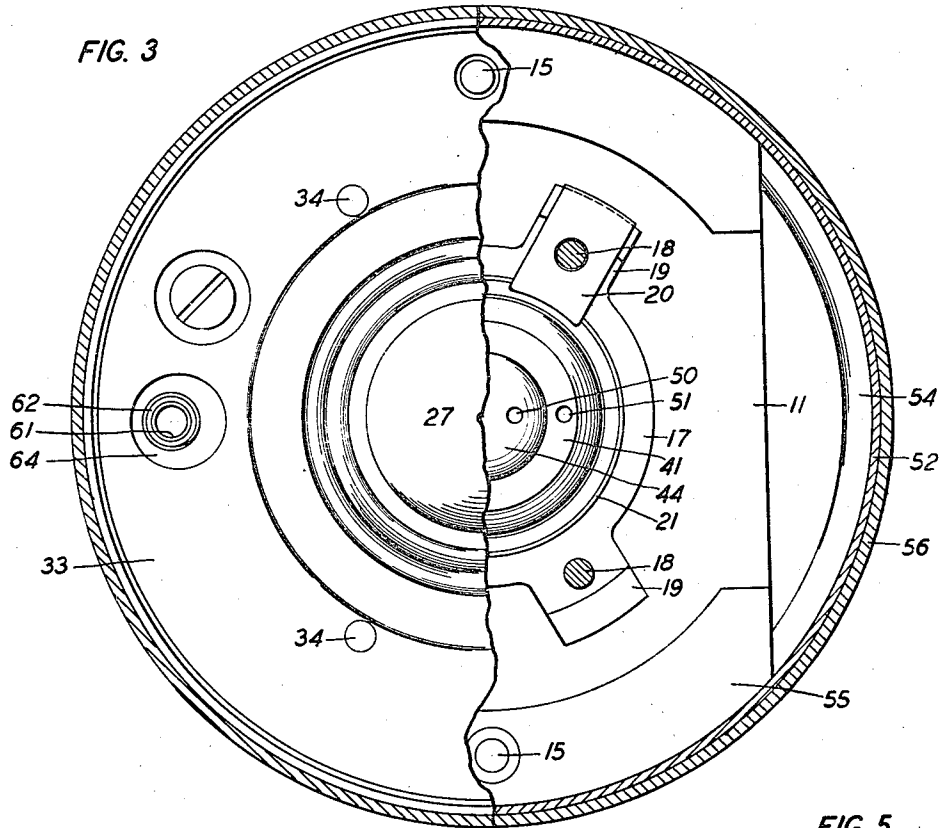


FIG. 4

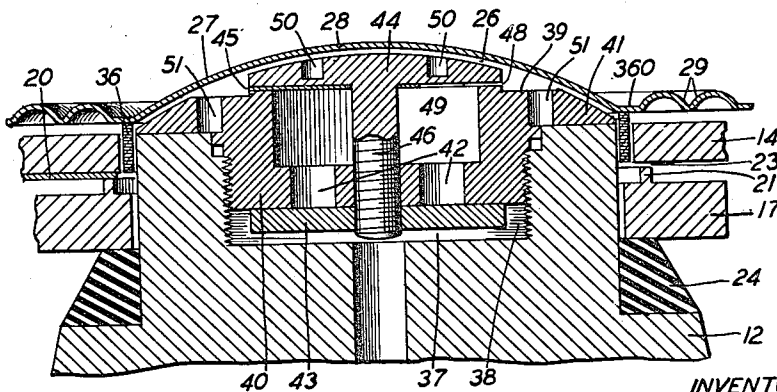
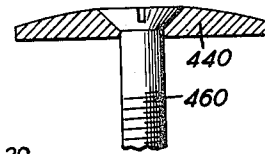


FIG. 5



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FIG. 6

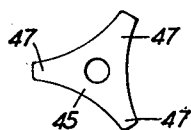


FIG. 7

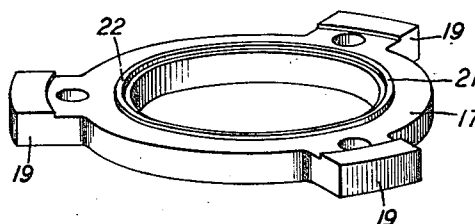


FIG. 8

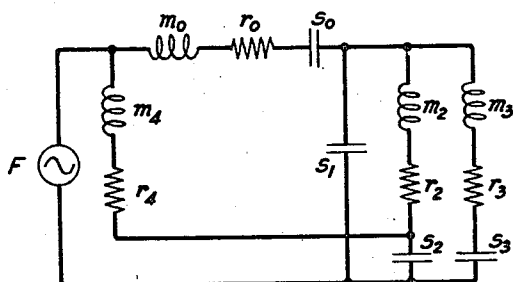


FIG. 9

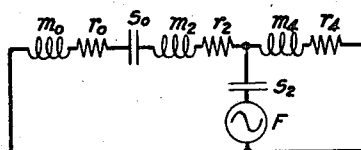
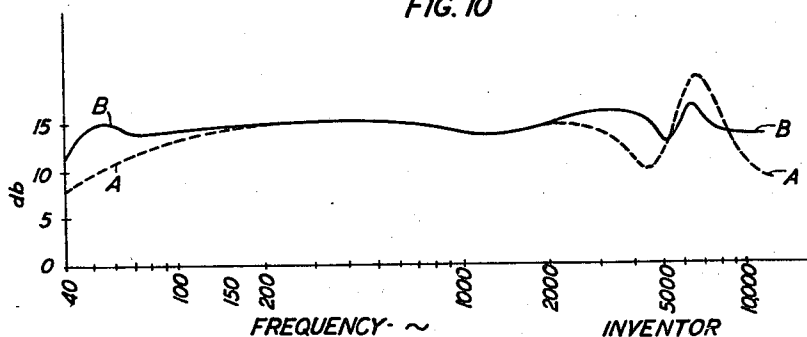


FIG. 10



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SOUND TRANSLATING DEVICE

Application filed May 2, 1931. Serial No. 534,655.

This invention relates to sound translating devices and more particularly to a sound translating device of the electrodynamic type.

An object of this invention is to improve the quality and transmission characteristics of a telephone transmitter over substantially the entire frequency range.

Another object of this invention is to cause a sound translating member to vibrate with substantially constant velocity for all frequencies of sound waves it is desired to have translated by it.

A feature of this invention resides in a sound translating device having a plurality of means associated with its sound translating member, each of which means controls the movements of such member, over a portion of the frequency range to be translated, one of such means controlling the movement of the member over substantially the entire frequency range to be translated, another of such means controlling the movement of the member over a band of frequencies within the frequency range to be translated, and another of said means controlling the movement of the member over the lowermost portion of the frequency range to be translated.

Another feature of this invention resides in a sound translating device in which a plurality of air chambers is associated with one surface of its sound translating member, the chambers being connected with each other through a plurality of restricted paths, one of the chambers having means extending thereinto, connecting it with the atmosphere outside of or on the exterior of said device.

Another feature of this invention resides in a sound translating device in which a plurality of air chambers is associated with one surface of its sound translating member, the chambers being connected with one another through a plurality of restricted paths, each of the chambers defining an acoustic stiffness element and each of said restricted paths an acoustic mass and an acoustic re-

sistance element, one of the chambers having means extending thereinto connecting it with the atmosphere outside of the device, this means defining an acoustic resistance and an acoustic mass element, all these elements acting to cause the sound translating member to respond more uniformly for all frequencies of sound waves it is desired to translate.

In accordance with this invention, an electrodynamic device comprises a magnet structure having coaxial pole pieces separated to provide a magnetic air gap and supporting a piston type diaphragm carrying a current conducting coil centered and movable in the air gap. This coil is adapted to move with the diaphragm to change the constant magnetic flux in the gap in which the coil is positioned. The diaphragm is controlled in its movement over substantially the entire frequency range by providing a chamber under the diaphragm and utilizing the mass, elasticity, and viscosity of the air therein to efficiently damp the mechanical motion of the diaphragm. This air chamber is provided by substantially closing the air gap at the side of the pole pieces opposite the diaphragm and coil with a damping plate.

An additional diaphragm movement controlling means is formed in one pole piece to cooperate with the first diaphragm movement controlling means acting particularly and substantially over a band only of frequencies within the audible frequency range translated by the device.

The device is provided preferably with an air chamber behind the damping plate communicating with the chamber under the diaphragm through a restricted path formed by the plate. This chamber has means extending into it, connecting it with the atmosphere outside of the device, preferably in the vicinity of the diaphragm, which means acts as another diaphragm movement controlling means influencing particularly the diaphragm movement in the region of the lowest

frequencies to be translated by the device.

A more complete understanding of this invention will be obtained from the detailed description which follows taken in conjunction with the appended drawings, wherein:

Fig. 1 is an elevational sectional view of an electro-dynamic device embodying the features of this invention;

Fig. 2 is an elevational sectional view of the device of Fig. 1 along the line 2—2;

Fig. 3 is a plan view of the device of Fig. 1 along the line 3—3;

Fig. 4 shows a fragment in enlarged sectional detail of the device of Fig. 1;

Fig. 5 shows in enlarged section an alternative construction of the closure member on the center pole piece;

Fig. 6 shows in detail the spacing washer or shim member utilized in the device of Fig. 1 to space the closure member from the upper surface of the center pole piece;

Fig. 7 shows in perspective the damping plate utilized in the device of Fig. 1 to provide a restricted passage or path under the air gap thereof;

Fig. 8 is an electrical circuit analogue of the mechanical and acoustical vibratory element in the device of Fig. 1;

Fig. 9 is an electrical circuit analogue of the mechanical and acoustical vibratory elements in the device of Fig. 1 which are effective to influence the low frequency response of the device; and

Fig. 10 illustrates the characteristic response of an electrodynamic device prior to incorporating the features of this invention and after such incorporation.

There is disclosed in Figs. 1 to 7 an electrodynamic sound transmitting device which comprises a magnet structure 11, for instance of cobalt steel, having a central pole piece 12, for instance of magnetic iron, attached thereto, as by welding at 12a, and centered by a pin 13. An annular pole piece 14, for instance of magnetic iron, is coaxially centered around the pole piece 12 and supported on the magnet by pins 15, the central pole piece 12 and the annular pole piece 14 forming an annular air gap 16 therebetween. An annular damping plate or ring member 17 is attached to the lower or under surface of the annular pole piece 14 by bolts 18 extending through the extensions 19 and spaced therefrom by the spacing washers or shims 20 interposed between the extensions 19 and the under surface of the annular pole piece. The ring 17 is provided with an annular, rectangular sectioned, raised portion or ridge 21 which, when the ring is secured in position, has its upper flat surface 22 in spaced relation to the annular pole piece to form restricted passages or paths 23. The plate or ring 17 lies against a ring or annulus 24 of a resilient material, such as soft rubber, supported on the shoulder 25 of the

pole piece 12. This rubber ring fills the gap between the inner surface of the damping plate and the surface of the pole piece 12 so that the air from the chamber 26 under the diaphragm 27 must travel out through the restricted paths 23. The diaphragm 27 is, preferably, of a light-weight high strength material, such as aluminum, or an aluminum alloy, such as duralumin, and comprises a central rigid portion 28, a concentrically corrugated flexible portion 29, and a stationary rim portion 30 clamped between spacing washers 31 and 32, of phenol fabric material and condenser paper, and the pole piece 14 and the face plate 33 by a plurality of fastening screws 34 extending through the pole piece 14 and threading into the tapped apertures 35 in the face plate. An annular current conducting coil 36 is attached to the diaphragm preferably at the junction 360 between the flexible and central rigid portions of the diaphragm and is positioned in and adapted for movement in the gap 16.

The pole piece 12 is provided with a hollow recess or cavity 37 which has a threaded wall portion 38. This threaded cavity provides for the ready insertion of an assembly 39 consisting of a cup-shaped member 40 provided with a flange 41, the member 40 being threaded to engage the threaded wall portion 38 and the flange 41 resting against the top of the pole piece 12. The cup member has a plurality of holes or openings 42 in the bottom thereof which are closed by a removable plate 43. Across the open end of the cup member is positioned a dome shaped closure member 44 which is spaced from the edge of the cup member by a spacing washer or shim 45, for instance of brass, the whole assembly being secured together by the threaded shank portion 46 which is formed integrally, preferably, with the closure member 44. The shim 45 is of such shape that its extensions 47 only are located between the closure member and the top of the cup member, the shim portions intermediate the extensions curving inwardly to provide a plurality of arcuately shaped restricted paths or passages 48 leading into the chamber 49 in the cup member 40. Although advantageous from an assembly viewpoint to have the closure member 44 and the securing portion 46 integral, the closure member may consist of a circular dome shaped member 440 having a countersunk central opening to receive a fastening screw 460 which performs the function served by the portion 46. The closure member 44 is provided with a plurality of drillings 50 therein to receive a spanner wrench whereby the closure member may be secured tightly in position. The flange portion 41 of the cup member 40 is provided with drillings 51 for a similar purpose.

It is apparent that the upper surfaces of the flange portion 41 and closure portion 4

of the assembly 39 form a small air chamber 26 with the under or rear surface of the diaphragm and that this chamber between the diaphragm and the walls of the magnet poles connects with the chamber 49 through a restricted path 48 and with the fluid under the annular pole piece through a restricted path 23.

The magnet structure is enclosed by a housing or casing 52 providing a substantially large air chamber 53 with which the chamber 26 is in communication through a restricted path 23. The casing 52 is provided with a shoulder portion 54 upon which the flanged portions 55 of the magnet structure rest, and which structure is secured within the casing by an annular, flanged clamping member 56 whose internally threaded portion 57 engages the externally threaded portion 58 of the casing. The member 56 also secures between the annular peripheral washers 59 of insulating material a perforated metal guard or screen 60 across the front of the diaphragm to exclude dust and to protect the diaphragm against injury.

The chamber 53 is connected, preferably, with the atmosphere outside of the electrodynamic device by a tube or conduit 61. Although shown as a bent tube, it is to be understood that it may be given any desired shape or curvature. The tube 61 is secured at one extremity to the annular pole piece 14 having a threaded bushing 62 to which it is fastened, as by brazing, and which threads into a tapped drilling in the pole piece 14. A lock nut 63 maintains the tube securely against movement. The face plate 33 and the clamping washers 31 and 32 are provided with axially aligned openings 64 leading to the tube 61 whereby the latter is open to sound waves which are impressed upon the front or exposed surface of the diaphragm and provides a path for a portion thereof, preferably the lower frequencies, into the chamber 53, and, therefore, to the substantially enclosed other, or rear, surface of the diaphragm. It is not necessary, but it is preferable, to have the end or extremity of the tube connecting with the atmosphere outside the device adjacent the peripheral portion of the diaphragm and it may, if desired, extend out, for instance, through the side wall of the casing 52.

In electrodynamic devices of the movable coil type having a diaphragm of such stiffness and mass so as to operate as a piston when vibrating, the mechanical movement of the diaphragm and coil causes distortion over a certain portion of the audible frequency range because of the natural frequency of the diaphragm being within this portion of the frequency range. In the device herein disclosed, the effective mass, mechanical resistance and stiffness of the diaphragm and coil may be designated m_0 , r_0 and s_0 , respectively.

This distortion is to be observed in the shape of the characteristic curve which is irregular over the greater portion of the frequency range and 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 path or passage, 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 utilizing the air gap 16 and the damping plate 17 to introduce the necessary amount of acoustic mass and acoustic resistance and by utilizing the chamber 26 to introduce the necessary amount of acoustic stiffness in an acoustic circuit to overcome the distortion of the diaphragm. For purposes of ready identification these acoustic mass, resistance and stiffness elements are designated m_2 , r_2 , and s_1 , respectively.

The chamber 26, in adding stiffness to the diaphragm system, raises the resonant frequency thereof to a higher value. Because of the restricted path or passage 23, leading from the large air space or chamber 53 within the casing 52 to the chamber 26, air is drawn through such passages when the diaphragm is moved away from the pole pieces and is forced through such passage when the diaphragm moves toward the magnet structure. By properly proportioning the area of the passage, it is possible to introduce such an acoustic impedance to the air flow between the diaphragm and casing chambers whereby the diaphragm movement, in response to sound waves to be translated, is controlled over substantially the entire operating range of the electrodynamic device. 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 entire frequency range. The response of an electrodynamic transmitter when the damping ring 17 only is associated therewith, is indicated by curve A of Fig. 10.

It has been found, as indicated by curve A, that the mass of the diaphragm and the stiffness of the air in the chamber thereunder, cause some distortion in the characteristic of the device in the portion of the frequency range between approximately 2000 and 6000 cycles per second, the curve sloping slightly and then rising fairly sharply above the desired flat characteristic.

To correct for this condition, the mass reactance of the diaphragm is neutralized over the range of frequencies in which distortion occurs by introducing the assembly 39 in the

center pole piece, this assembly providing an auxiliary acoustic circuit, mesh, or impedance, acting as an additional diaphragm movement controlling means. This auxiliary acoustic circuit provides the chamber 49 containing air having a predetermined acoustic stiffness s_3 and the restricted paths 48 having predetermined acoustic resistance r_3 and acoustic mass m_3 . In operation, this acoustic element adds stiffness to the diaphragm over the low frequency range up to approximately 2000 cycles, then operates substantially as a resistance in a region about 5000 cycles per second in which the diaphragm mass distorts the characteristic and at higher frequencies acts substantially as a mass reactance.

It will be noted from curve B, Fig. 10, that this added acoustic impedance on the rear surface of the diaphragm flattens out the characteristic in the region where it was formerly greatly distorted and produces a closer approach to the ideal condition of uniform response of the diaphragm for all frequencies impressed thereon.

Although the use of an additional diaphragm movement controlling means makes the response of the device more uniform in the upper frequency range, the response of the device at the lower frequencies remains the same, dropping off below approximately 150-200 cycles per second because of the stiffness reactance s_0 of the diaphragm and that (s_2) of the cavity 53. The effect of the latter could be reduced by increasing the size of the cavity, but there is a limit to which the stiffness of the diaphragm can be decreased without sacrificing stability and mechanical ruggedness. The response at the low frequencies can, however, be materially improved and a rugged diaphragm structure obtained by the expedient of connecting the chamber 53 with the atmosphere external or outside of the device by the tube or conduit 61. When sound waves are generated on the front or exposed surface or side of the diaphragm and to be translated thereby, a pressure is developed within the casing 52 and on the substantially enclosed or rear surface or side of the diaphragm of such magnitude and phase as to increase the effective pressure on the diaphragm at the low frequencies to increase the response of the device. The improvement in the response of the device of this invention using a tube providing an acoustic mass m_4 and an acoustic resistance r_4 over a device in which the hitherto described diaphragm movement controlling means only were utilized, is shown by curve B, Fig. 10, in its low frequency portion. It will be understood, of course, that the low frequency cut-off will be determined by the proportions of the tube 61 and may be lower or higher than that of the particular device whose characteristics are disclosed in the curves of Fig. 10. The tube 61 is be-

lieved to act partially as an acoustic filter of the low pass type and also as a means to enable a phase shifting of the frequencies passed by it in order that, in acting on the enclosed surface of the diaphragm, the effective pressure on the diaphragm is increased. It is apparent from the nature of curve B that the electrodynamic device of this invention includes a sound translating member which responds with substantially equal velocity per unit pressure for all frequencies of sound waves it is desired to translate.

An electrical circuit analogue of the mechanical and acoustical elements of the device of this invention is shown in Fig. 8. Fig. 9 is an electrical circuit analogue of those acoustical and mechanical elements of the device which are factors in the uniform response thereof to the lower audible frequencies only.

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

What is claimed is:

1. A sound translating device comprising a diaphragm, magnetic translating means associated with said diaphragm, a chamber on one side of said diaphragm, a plurality of other chambers on the same side of said diaphragm, means connecting each of said other chambers with said first chamber through a restricted path, and means extending into one of said other chambers connecting it with the atmosphere adjacent the other side of said diaphragm.

2. A sound translating device comprising a diaphragm, one surface of which is directly exposed to sound waves and the other surface of which is substantially enclosed, means defining a plurality of air chambers on the enclosed side of said diaphragm, said chambers being connected with one another through restricted passages, and means extending into one of said chambers connecting it with the atmosphere outside the device.

3. A sound translating device comprising a diaphragm, a chamber on one side of said diaphragm, a plurality of other chambers on the same side of said diaphragm, each of said other chambers being connected to said first chamber through a restricted path, and tubular means extending into one of said other chambers connecting it with the atmosphere adjacent the other surface of the diaphragm.

4. A sound translating device comprising a diaphragm, electromagnetic means associated with said diaphragm, a plurality of acoustic means associated with said diaphragm, each controlling movement of said diaphragm in different bands of the audible

frequency range, one of said means controlling the diaphragm movement over the entire frequency range to be translated, another of said means controlling the diaphragm movement over an intermediate portion of said range, and another of said means controlling the diaphragm movement over the lowermost portion of the frequency range.

5 5. A sound translating device comprising a diaphragm, electromagnetic means associated with said diaphragm, a plurality of acoustic means associated with said diaphragm, each controlling movement of said diaphragm in different bands of the audible frequency range, one of said means controlling the diaphragm movement over substantially the entire frequency range to be translated, another of said means controlling the diaphragm movement over an intermediate portion of said range, and another of said means controlling the diaphragm movement over the lowermost portion of the frequency range, said last means providing an acoustic path enabling sound waves to be translated by each surface of the diaphragm.

6. A sound translating device comprising a diaphragm one surface of which is directly exposed to sound waves, means substantially enclosing the other surface of the diaphragm and defining a plurality of air chambers and associated restricted air paths thereadjacent, one of said chambers and paths acting to damp the mechanical motion of the diaphragm over substantially the whole operating range thereof, another of said chambers and paths influencing the diaphragm within a portion only of the entire range, and means extending into another of said chambers connecting it with the atmosphere outside said chamber, said means influencing the diaphragm in the lower portion of the frequency range only.

7. A transmitter comprising a diaphragm, magnetic translating means operatively associated with said diaphragm comprising a coil attached to said diaphragm and a magnet structure forming a magnetic air gap in which said coil is positioned, said magnet structure having a center pole piece whose upper portion is adjacent one surface of said diaphragm and forms a small air chamber therewith, said center pole having an air chamber therein, means providing a larger air chamber, the chamber adjacent one surface of the diaphragm and said larger air chamber being connected through a restricted path, and means extending into said larger chamber connecting it with the atmosphere outside that chamber.

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

and out of said chamber, means enclosing said magnetic structure to provide a second chamber, said chamber communicating with said first chamber through one of said openings, and means extending into said second chamber connecting it with the atmosphere adjacent the other side of said diaphragm.

9. 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, 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, a casing for said magnet structure forming a chamber behind said annular damping means, and a tubular member extending through said annular pole piece into the casing chamber, said member allowing low frequency sound waves to pass into said chamber.

10. An electrodynamic device comprising a diaphragm, a coil attached thereto, a magnetic structure comprising spaced pole pieces forming a magnetic air gap in which said coil is movable, one side of said diaphragm and the walls of said magnetic structure forming a chamber, a casing for said transmitter providing an air chamber, means positioned under said air gap and providing a restricted path connecting said chambers, a chamber in one of said pole pieces, means providing a restricted path connecting it with the chamber between the diaphragm and the walls of the magnetic structure, and means extending into the chamber formed by the casing, said means being hollow and open at each end and connecting said casing chamber with the atmosphere adjacent the other side of said diaphragm.

11. A transmitter comprising a diaphragm, a current conducting coil secured thereto, a magnet structure providing a magnetic air gap in which said coil is movable, said magnet structure having a center pole member and a surrounding annular pole member, an enclosure for said magnet structure forming an air chamber, said diaphragm spaced from said center pole to form a small air chamber, said center pole containing an air chamber, and means carried by said center pole forming a restricted path to connect said chambers, means positioned under the magnetic air gap forming a restricted path between the air chamber formed by the diaphragm and the air chamber provided by the enclosure, and a tubular member extending into the chamber formed by the enclosure connecting it with the atmosphere outside

said enclosure adjacent the front surface of the diaphragm.

12. A sound translating device comprising a sound translating member, means associated with said member to cause it to vibrate with substantially constant velocity for all frequencies of sound waves translated by it, said means providing at least three air chambers on one side of said diaphragm, said air chambers being connected together by restricted paths, and means connecting one of said chambers with the atmosphere adjacent the other side of said diaphragm.

13. An electrodynamic transmitter comprising a diaphragm, an air chamber on the back side of the diaphragm for controlling movement of the diaphragm, a second and a third chamber on the back side of the diaphragm one of which is larger than the other connected by restricted passageways with said first mentioned air chamber and means for allowing for the passage of a limited amount of air from the front side of the diaphragm to said larger air chamber.

14. A sound translating device comprising a diaphragm, a plurality of damping means associated therewith, each controlling movement of said diaphragm in different bands of the audible frequency range, and means for effectively increasing the movement of the diaphragm in response to the lowest frequencies it is desired to translate.

15. A sound translating device comprising a diaphragm, a plurality of damping means associated therewith, one of said means controlling movement of the diaphragm over substantially the entire frequency range, another of said means controlling movement of said diaphragm over a band of frequencies in said range, and means for effectively increasing the movement of the diaphragm in response to the lowest frequencies it is desired to translate.

16. An acoustic device comprising a sound translating member and means to cause said member to respond with substantially constant velocity to all frequencies of sound waves it is desired to translate, said means comprising a plurality of damping means, one of which controls movement of the sound translating member over substantially the entire frequency range, and another of which controls the movement of said member over a band of frequencies within said range, and means for effectively increasing the movement of said member in response to the lowest frequencies to be translated.

17. A sound translating device comprising a diaphragm, and a plurality of means associated therewith and each controlling movement of said diaphragm in different bands of the audible frequency range, one of said means comprising an acoustic mass, stiffness, and resistance, proportioned to effectively control the movement of the diaphragm over

the entire frequency range, another of said means comprising an acoustic stiffness, mass, and resistance, proportioned to effectively control the movement of the diaphragm over a band of frequencies within said range, and another of said means comprising an acoustic mass and stiffness, proportioned to effectively increase the movement of the diaphragm at the lowest frequencies it is desired to translate.

18. A sound translating device comprising a diaphragm, a coil attached thereto, a magnetic structure providing a magnetic air gap in which said coil is movable, said structure and one side of said diaphragm forming a shallow chamber, said structure containing a cavity communicating with said shallow chamber through a restricted passage, said cavity and passage proportioned to provide acoustic stiffness, mass, and resistance to control the movement of the diaphragm over a band of frequencies within the frequency range to be translated, an enclosure for the magnet structure providing an air chamber, means under the air gap providing a restricted path between such air chamber and the shallow chamber, the shallow chamber, air gap, and restricted path proportioned to provide acoustic mass, stiffness, and resistance to control the movement of the diaphragm substantially over the entire frequency range, and means extending into the air chamber connecting it with the atmosphere outside the device proportioned to provide such acoustic mass and resistance that the movement of the diaphragm in response to the lowest frequencies to be translated are increased.

19. An electrodynamic device comprising a magnet structure providing a magnetic air gap, a diaphragm having a portion sufficiently rigid to vibrate as a whole, a coil attached to said diaphragm and movable in said air gap, diaphragm movement controlling means within said magnet structure adjacent the rigid portion of said diaphragm, additional diaphragm movement controlling means under said air gap, means forming an air chamber under said last means, and diaphragm movement controlling means extending into said chamber and connecting it with the atmosphere outside of the device.

20. An electrodynamic device comprising a magnet structure providing a magnetic air gap, a diaphragm having a portion sufficiently rigid to vibrate as a whole, a coil attached to said diaphragm and movable in said air gap, diaphragm movement controlling means within said magnet structure adjacent the rigid portion of said diaphragm, said means controlling the movement of said diaphragm over a band of frequencies within the frequency range to be translated, additional diaphragm movement controlling means under said air gap, said means controlling the movement of said diaphragm

over substantially the entire frequency range to be translated, means forming an air chamber under said last means, and diaphragm movement controlling means extending into
5 said chamber and connecting it with the atmosphere outside of the device to increase the movement of the diaphragm in response to the lowest frequencies of the frequency range to be translated.

10 In witness whereof, I hereunto subscribe my name this 29th day of April, 1931.

ALBERT L. THURAS.

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