Sept. 4, 1951 E. E. MOTT 2,566,849

ELECTROACOUSTIC TRANSDUCER

Filed Oct. 19, 1946

FIG. 1

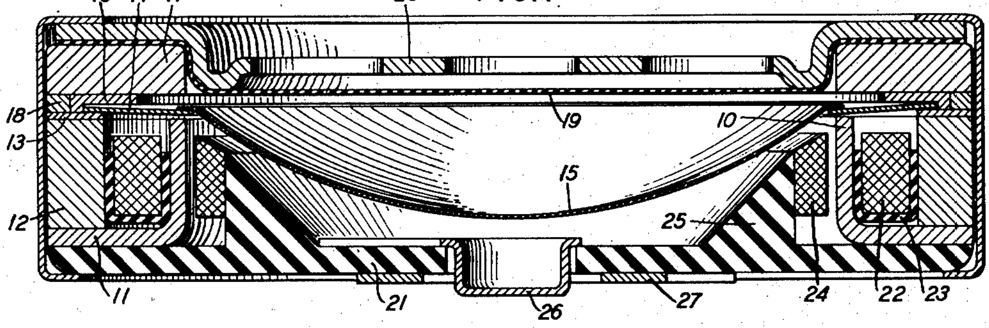


FIG. 2

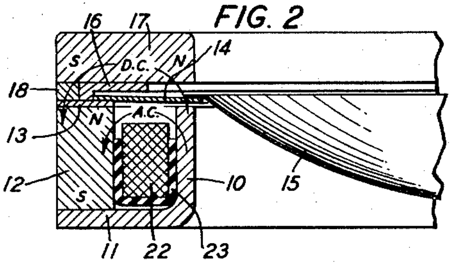


FIG. 5

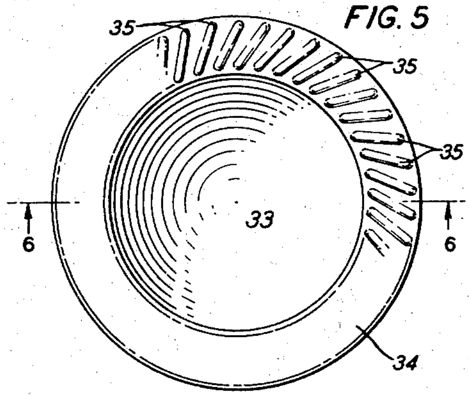


FIG. 4

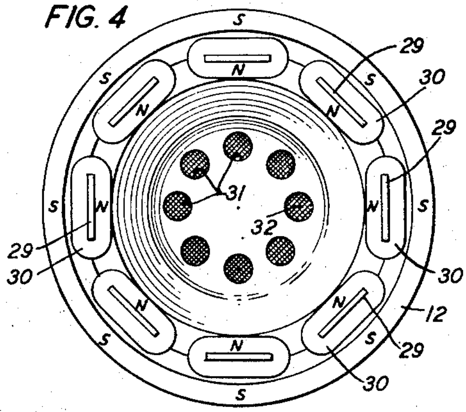


FIG. 6

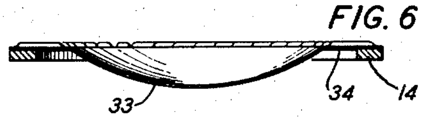


FIG. 7

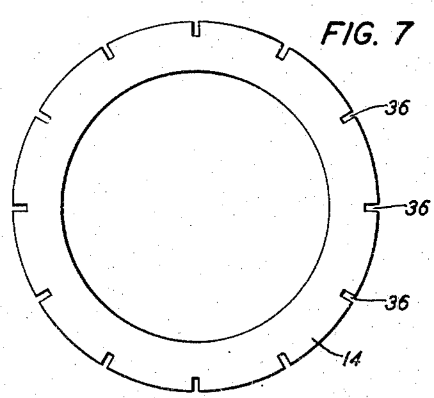
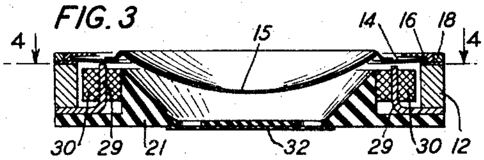


FIG. 3



INVENTOR
E. E. MOTT
BY
ATTORNEY

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ELECTROACOUSTIC TRANSDUCER

Edward E. Mott, Upper Montclair, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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3 Claims. (Cl. 179—120)

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This invention relates to electroacoustic transducer and more particularly to such transducers of the ring armature type such as disclosed in Patent 2,249,160, granted July 15, 1941 to Edward E. Mott.

One object of this invention is to simplify the construction of electroacoustic transducers of the ring armature type and, thus, to facilitate the manufacture of such devices in quantity and at relatively low cost.

Another object of this invention is to improve the performance of such transducers.

Electroacoustic transducers of the ring armature type comprise, in general, an annular magnetic system including a ring armature to which a lightweight diaphragm member is coupled. The magnetic system includes also a permanent magnet which advantageously, in order to reduce the weight and size of the transducer and to provide the large polarizing flux requisite for efficient and high power translation of signals, is made of a high magnetic strength alloy, such as "Alnico." Such alloys are extremely hard and difficult to machine.

The performance of a ring armature type electroacoustic transducer is dependent very largely upon the air-gap between the armature and the pole-piece in juxtaposition thereto. In order to realize high efficiency operation for any unit, this air-gap must be small and accurately meet preassigned dimensions; in order that similar devices may have the same operating characteristics, it is necessary that this air-gap be essentially the same in the several devices.

In accordance with one feature of this invention, the requisite small and accurate air-gap in any transducer and the substantial identity of the air-gaps in a multiplicity of transducers are attained facilely and with minimum working of the magnet. More specifically, in accordance with one feature of this invention, the inner pole-piece is provided with a flange remote from the pole tip thereof, and the magnet is seated upon the flange and serves as the outer pole-piece. One end face of the magnet is made accurately coplanar with the pole tip of the inner pole-piece and the armature is seated upon a spacer in turn seated upon the end face of the magnet. The air-gap between the armature and inner pole-piece is fixed by the thickness of the spacer. Thus, the air-gap of desired length is realized by mere association of the armature, spacer and pole-piece magnet assembly.

As disclosed in the Mott patent above-identified, improved performance may be realized by providing an auxiliary magnet opposite the armature and the pole faces of the main magnetic structure. In accordance with another feature of this invention, a low reluctance path is provided between the auxiliary magnet and the main magnetic structure whereby the magnetic efficiency of the transducer is increased.

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The response level of the transducer is dependent to a large extent upon the vibrational parameters of the diaphragm. In accordance with a further feature of this invention, a low mass, bodily vibratile diaphragm member having low internal losses and substantially unaffected by ambient temperature variations or humidity is realized. More specifically, in accordance with this further feature of the invention, this diaphragm member is formed of a synthetic plastic fibre cloth impregnated with a phenolic condensation product.

In accordance with still another feature of this invention, an auxiliary signal coil coupled to the alternating current flux path of the magnetic system is provided in series with the main signal coil, thereby to increase the linkage to the signal flux and effect an increased force factor for the transducer.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing which:

Fig. 1 is a cross-sectional view of an electroacoustic transducer illustrative of one embodiment of this invention;

Fig. 2 is a fragmentary sectional view of a portion of the transducer illustrated in Fig. 1 showing the paths for the biasing or polarizing, and signal fluxes in the magnetic system;

Fig. 3 is a view in cross-section of a transducer illustrative of another embodiment of this invention;

Fig. 4 is a plan view taken along plane 4—4 of Fig. 3;

Fig. 5 is a plan view of one form of diaphragm and armature assembly which may be employed in a modification of the transducers illustrated in Figs. 1 and 3;

Fig. 6 is a sectional view taken along plane 6—6 of Fig. 5; and

Fig. 7 is a plan view of a modification of the armature included in the transducers illustrated in Figs. 1 and 3.

Referring now to the drawing, the transducer illustrated in Figs. 1 and 2, which may be utilized either for translating sound into electrical signals or vice versa, comprises a frame or body defined in part by a pole-piece having a circular cylindrical portion 10 and an annular flange 11 extending normal to the portion 10, and in part by a circular, cylindrical, longitudinally polarized permanent magnet 12. The pole-piece 10, 11, in a particularly advantageous construction, is of a high permeability nickel-iron alloy known commercially as "Permalloy." The magnet is of a high strength magnetic alloy known commercially as "Alnico," is seated upon the flange 11 and soldered thereto, and, as illustrated in Fig. 1, the free end face thereof is coplanar with the end face of the pole-piece portion 10.

Seated upon the end face noted of the permanent magnet 12 is a thin, magnetic, for example "Permalloy," annular spacer 13, upon which in turn a unitary armature-diaphragm assembly is supported. This assembly comprises an annular magnetic armature 14, for example, of "Permalloy," coaxial with the frame or body, the outer marginal portion of the armature resting upon the spacer 13 and the inner marginal portion thereof overlying the pole-piece portion 10. Secured to the inner marginal portion of the armature 14, as by a suitable cement, is a non-magnetic, dished diaphragm member 15.

In a particularly advantageous construction, the diaphragm member 15 is formed, e. g. molded, of a synthetic fibre cloth of polyacryl-nitrile impregnated with a phenolic condensation product, advantageously with a phenolic formaldehyde impregnating varnish. Such diaphragm is characterized by very low mass and high modulus of elasticity, retains its form, vibrates bodily throughout a wide range of frequencies and is non-hygroscopic and substantially unaffected by ambient temperature variations.

Seated upon the spacer 13 and overlying a portion of the armature 14 is a non-magnetic spacer 16 of L-shaped section against which an annular magnetic member 17, coaxial with the armature 14 and extending laterally from the magnet 12 over the pole-piece portion 10, rests. An annular magnetic member 18, for example of "Permalloy," is fitted between the spacer 13 and magnetic member 17 and about the spacer 16.

The spacer member 16, it will be noted, is spaced from the armature 14 so that the latter is held upon the spacer 13 solely by magnetic attraction. Consequently, restraint upon vibration of the armature is minimized and highly efficient operation and large amplitude diaphragm motion are realized. The spacer 16 extends over a substantial portion of the armature and, thus, serves to prevent dislodgment thereof. Additionally, it serves to prevent sticking of the armature to the auxiliary magnet or magnetic member 17.

A moisture-proof membrane 19 overlies the diaphragm 15 and is held in place by a protective grill 20. Particularly advantageous materials for the membrane 19 are polymers composed in whole or in part of vinylidine chloride, vinyl chloride and/or vinyl acetate, which have a low modulus of elasticity, a low moisture diffusion rate and a low moisture absorption characteristic. The grill 20, together with the magnetic members 17 and 18, spacers 13 and 16, frame or body 10, 11, 12 and an insulating plate 21 are securely held together by a metallic band the edge portions of which are crimped over the grill 20 and plate 21 as shown in Fig. 1.

Disposed between the magnet 12 and pole-piece portion 10 is an annular signal coil 22 which is partly encased in an insulating sleeve 23 cemented to the magnet and pole-piece portion. A second or auxiliary annular signal coil 24, connected in series with the coil 22, is mounted upon a cylindrical member 25 integral wtih the plate 21. The two coils are connected to terminals 26 and 27 upon the plate 21 by suitable conductors, not shown. The two coils, arranged as shown and connected in series, provide an efficient and high linkage to the signal flux in the magnetic system and, thus, result in the attainment of a high force factor.

The magnetic member 17 may be of "Alnico" and magnetized radially so that, as illustrated in Fig. 2, the south pole thereof is opposite the north pole of the magnet 12 and its north pole is opposite the pole tip (south polarity) of the pole-piece portion 10. Thus, the direct current flux path of the magnetic system comprises the magnet 12 and pole-piece 10, 11 in series with two branches, one through the armature 14 and the other through the magnetic member 17 in parallel. The predominantly major portion of the alternating current or signal flux traverses the series path comprising the armature 14, magnet 12 and pole-piece 10, 11. The auxiliary magnet 17 is of less strength than the main magnet 12 so that a partial unbalance of the magnetic system obtains.

The magnetic member 18 provides a low reluctance connection between the magnet 12 and the magnetic member 17 and, as has been determined, substantially increases the efficiency of the device for any given air-gap in the magnetic circuit. In one illustrative and specific case, an increase in efficiency of the order of 3 decibels has been realized by the use of the magnetic member 18.

In an alternative construction, the magnetic member 17 is not separately polarized and serves as a magnetic shunt for the armature 14 to prevent saturation of the latter by the direct current flux. In one such construction, this member 17 may be of "Permalloy."

The performance of a transducer of the type herein disclosed is dependent to a large measure upon the air-gap between the armature 14 and the pole tip of the pole-piece portion 10. This being so, it is apparent that in quantity manufacture of devices for use in a given system having specified requirements, it is important that the air-gaps of all the devices be essentially the same and, additionally, from an economic standpoint, that such essential identity be realized facilely. The construction illustrated in Fig. 1 and heretofore described is especially advantageous from the standpoint of attainment of these desiderata. In the fabrication of the device, after the magnet 12 and pole-piece 10, 11 are joined, the upper faces (in Fig. 1) of the magnet and pole-piece 10 are lapped or ground simultaneously so that the two are accurately coplanar. The upper face of the magnet, therefore, provides a reference surface for fixing the air-gap between the armature 14 and the pole face of the pole-piece portion 10. Hence, the air-gap length is fixed automatically and accurately by the thickness of the annular spacer 13. The latter may be made of any desired thickness easily, accurately and at low cost. The spacer 16 and magnetic member 18 similarly may be made accurately of any specified thickness so that the length of the air-gap between the armature 14 and magnetic member 17 is accurately fixed at a desired value upon assembly of the device. Thus, the several parts of the device may be taken from stock and assembled facilely to produce in quantity transducers having essentially the same operating characteristics.

In a modification, illustrated in Figs. 3 and 4, a plurality of individual, equally spaced pole-pieces **29** may be employed in place of the single pole-piece **10, 11** in the transducer illustrated in Fig. 1. Each pole-piece has thereon a signal coil **30**; the several coils may be connected in series aiding or in parallel. Also, as shown in Figs. 3 and 4, the plate **21** may be provided with apertures **31** having acoustic resistance material **32** extending thereacross. These apertures, together with the chamber between diaphragm **15** and plate **21**, constitute an acoustic network comprising mass, stiffness and resistance, which functions to reduce the response peak due to the diaphragm resonance and to enhance the response throughout a band of frequencies, whereby a substantially uniform response over a wide frequency range is obtained. It will be understood that such a network may be incorporated also in devices of the construction illustrated in Fig. 1.

The response of a transducer of the type illustrated, operating either as a receiver or a transmitter, is directly dependent upon the amplitude of the diaphragm vibrations. Enhanced vibration may be obtained by employing a diaphragm-armature assembly of the construction illustrated in Figs. 5 and 6. As shown in these figures, the diaphragm comprises a central dished portion **33** and an integral, annular peripheral portion **34** provided with stiffening flutes or ribs **35**. The armature is affixed to the diaphragm portion **34** and, as shown in Fig. 6, is of less width than this portion. The diaphragm-armature assembly may be mounted upon the spacer **13** in the same manner as the assemblies illustrated in Figs. 1 and 3. The diaphragm portion **34**, it will be noted, constitutes a lever whereby the amplitude of displacement of the diaphragm portion **33** in response to vibration of the armature is increased.

The response of a transducer is dependent also upon the stiffness of the armature **14**. Magnetic considerations restrict the thinness of armature that can be employed to best advantage. However, the radial width of the armature can be varied substantially without substantial degradation of the operating efficiency, thereby to adjust the armature stiffness to a desired value and fix the resonant frequency of the vibrating system.

Changes in armature stiffness by varying the radial width of the armature are accompanied, for a given armature thickness, by changes in the armature mass. For a given armature thickness and width, the armature stiffness may be reduced substantially by providing the armature with radial slots **36** as illustrated in Fig. 7.

Although specific embodiments of the invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electroacoustic transducer comprising an annular magnetic armature, a pole-piece having a cylindrical portion coaxial with said armature and terminating at one end in a pole face in juxtaposition to the inner edge portion of said armature, said pole-piece having also an annular flange extending outwardly from the other end of said cylindrical portion and normal thereto, a cylindrical, axially magnetized magnet seated at one end upon said flange, encompassing said cylindrical portion and coaxial therewith, the other end of said magnet being coplanar with said pole face, a magnetic spacer seated upon the other end of said magnet, said armature having its peripheral portion seated upon said spacer and being held thereon solely by magnetic attraction, an annular magnetic member overlying said armature and having its inner and outer marginal portions opposite said pole face and said other end of said magnet respectively, and an annular low reluctance member spacing said magnetic member from said spacer.

2. An electroacoustic transducer in accordance with claim 1 comprising an annular non-magnetic member seated upon said spacer and having a flange portion extending between said armature and said magnetic member and spaced from said armature.

3. An electroacoustic transducer comprising a magnetic circuit including a permanent magnet and having coaxial, inner and outer annular pole faces, an annular magnetic spacer seated upon the outer pole face, an annular magnetic armature seated adjacent its periphery upon said spacer and having its inner edge portion in juxtaposition to the inner pole face, a non-magnetic spacer seated upon said first spacer, an annular magnetic member overlying said armature and seated upon said second spacer, and an annular magnetic member interposed between said first magnetic member and said outer pole face.

EDWARD E. MOTT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,331,469	Kraft	Feb. 17, 1920
1,439,785	Andrew	Dec. 26, 1922
1,455,745	Egerton	May 15, 1923
1,708,943	Goodrum	Apr. 16, 1929
1,800,573	Skala	Apr. 14, 1931
1,830,160	French	Nov. 3, 1931
2,003,908	Smith	June 4, 1935
2,044,608	Harford	June 16, 1936
2,077,425	Lieber	Apr. 20, 1937
2,141,595	Cornwell	Dec. 27, 1938
2,170,571	Mott	Aug. 22, 1939
2,249,160	Mott	July 15, 1941
2,360,796	Roberton	Oct. 17, 1944
2,395,166	Collins	Feb. 19, 1946
2,404,727	Houtz	July 23, 1946