

Oct. 23, 1962

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3,060,282

ELECTROACOUSTIC TRANSDUCER

Filed July 26, 1957

2 Sheets-Sheet 1

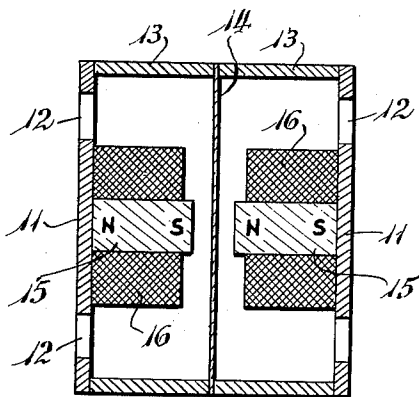


Fig. 1.

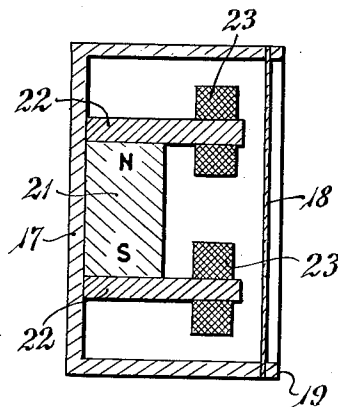


Fig. 2.

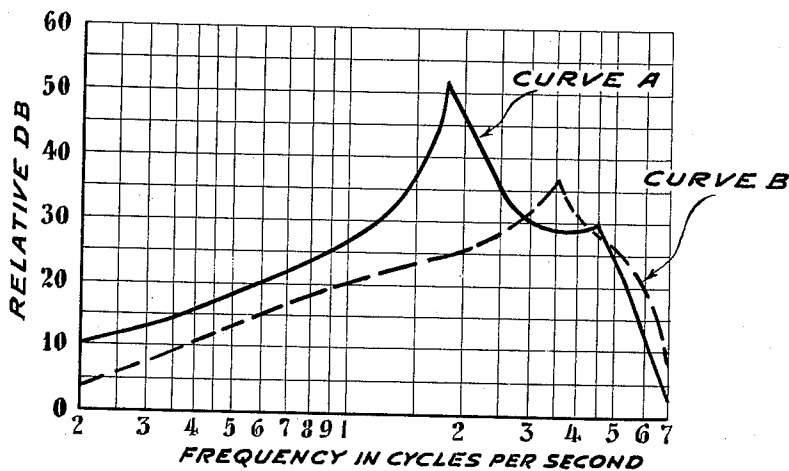


Fig. 6.

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2 Sheets-Sheet 2

Fig. 3.

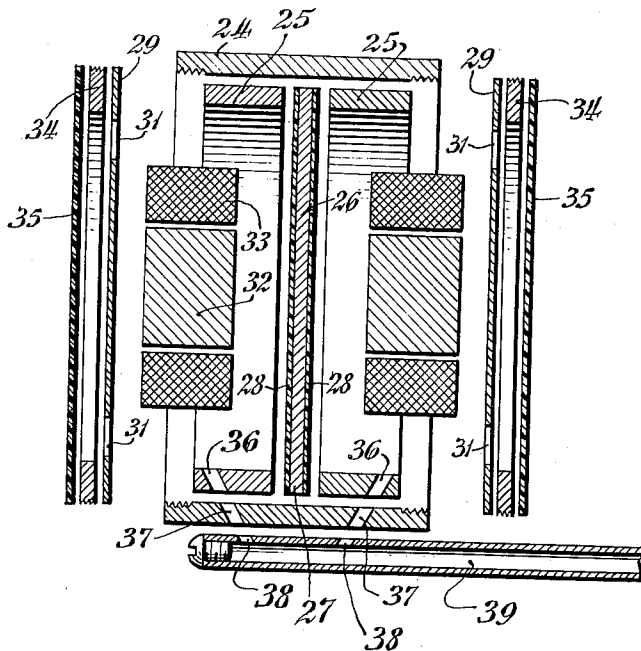


Fig. 4.

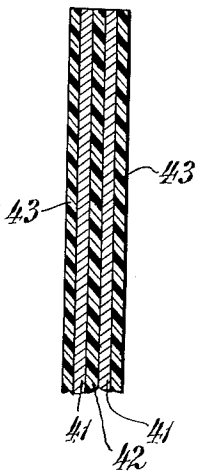
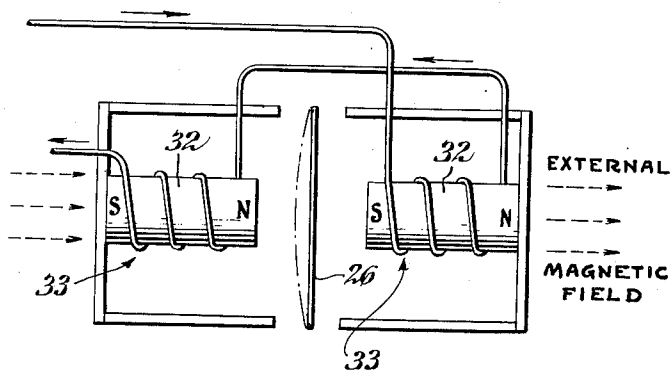


Fig. 5.



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ELECTROACOUSTIC TRANSDUCER

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Filed July 26, 1957, Ser. No. 674,351

5 Claims. (Cl. 179-115)

The present invention relates to electromagnetic acoustical transducers, and more particularly to an improved magnetic diaphragm therefor.

Electromagnetic acoustical transducers generally employ a vibratile diaphragm of soft magnetic iron, which may be of the order of a few thousandths of an inch thick. The diaphragm is usually supported or clamped about its periphery so as to be spaced in proper relation to magnetic flux carrying members. Changes in the space relation of the diaphragm to these members changes the distribution of the magnetic flux carried in the magnetic circuit. Thus, in a reproducer, a change of magnetic flux in the magnetic structure will produce a movement of the diaphragm, and in a microphone the sound waves impinging on the diaphragm cause it to move, thereby changing the magnetic flux density and generating an electromotive force in an electric coil.

In the construction of electromagnetic acoustical transducers, a number of problems are encountered. Because the vibratile diaphragm has a low value of mechanical resistance, it vibrates and resonates as a relatively high Q device. This produces an excessively high electrical output of a microphone at or near the resonant frequency of the diaphragm. Attempts to counteract this effect by acoustic damping material interposed between the diaphragm and the source of sound will lower the Q of the device, but this relationship varies with the ambient air pressure. Thus, where a microphone is to be used at high altitudes acoustic damping becomes ineffective. Stable mechanical damping, other than the dash pot type, is difficult to obtain.

Another difficulty encountered in the construction of electromagnetic acoustical transducers of this type is encountered in the support of the diaphragm at its peripheral edge. Proper support requires that the diaphragm be clamped evenly around its periphery to avoid undue stresses and strains which might cause the diaphragm to vibrate with spurious resonances and undesired effects. While a precision mechanical fit in the supporting surfaces around the periphery of the diaphragm may serve the purpose, the expense involved is usually prohibitive for any quantity production. Attempts to employ gaskets have been unsatisfactory because of changes due to aging and temperature variations.

In the construction of transducers of this type, it is quite advantageous to magnetize the structure after complete assembly. Such operation requires saturating the magnetic structure with magnetic flux to obtain the desired magnetization of the permanent magnet. During this operation mechanical forces are exerted on the diaphragm which far exceed any forces apt to be encountered during normal operation of the device. Not infrequently in such magnetization operation the diaphragm is displaced to such an extent that it touches and adheres to the pole or pole pieces of the device and subsequently is practically inoperative. Any attempt to remedy this condition usually results in a change in the normal stiffness of the diaphragm so that its restoring force is not sufficient to prevent subsequent sticking to the pole pieces when extremely high intensity sound is encountered.

In transducers of this type, it is also necessary to protect the soft iron diaphragm from oxidation or rusting. At extremely high sound levels, the diaphragm is apt to

strike the pole piece which produces a high level noise which is detrimental to intelligent sound transmission.

In accordance with the present invention, the foregoing difficulties encountered are obviated by an improved magnetic diaphragm which is covered on both sides with a polyester film of exceptional physical characteristics. This film protects the diaphragm against oxidation and rusting and reduces the detrimental noise effects encountered where high sound levels cause the diaphragm to strike the pole pieces. The film covering on the diaphragm also produces a desired damping so as to change the resonant frequency of the diaphragm and minimize the magnitude thereof. During the magnetization operation the polyester resinous film prevents the diaphragm from sticking to the pole pieces. At the same time, the film covering the diaphragm on both sides acts in a manner similar to a gasket in the peripheral clamping surfaces so that the diaphragm is more evenly supported without introducing unusual stresses and strains into the diaphragm.

It, therefore, is an object of the present invention to provide in an electromagnetic acoustical transducer an arrangement which will minimize the effects of the natural resonance of the diaphragm irrespective of ambient atmospheric pressure.

Another object of the invention is to provide for the even supporting of the peripheral portion of a diaphragm.

Still another object of the invention is to provide a transducer with means to prevent a transducer diaphragm from sticking to the magnetic pole pieces while the structure is magnetized and also when in use in encountering high level sound intensities.

A further object of the invention is to simultaneously prevent oxidation and rusting of a ferrous diaphragm.

A still further object of the invention is to provide a means for minimizing the effect of the diaphragm striking magnetic pole pieces thereby to reduce the noise generated.

A still further object of the invention is to provide an improved transducer structure for minimizing the effects of stray magnetic fields on the transducer.

Other and further objects of the invention subsequently will become apparent by reference to the following description taken in conjunction with the accompanying drawings, wherein:

FIGURES 1 and 2 are diagrammatic representations of electromagnetic acoustical transducers, to which the present invention has been applied;

FIGURE 3 is an exploded view of a transducer incorporating the features of the present invention;

FIGURE 4 is a partial cross-sectional view through a modified type of diaphragm constructed in accordance with the present invention;

FIGURE 5 is a diagrammatic representation of the coil structure employed in transducers of the types shown to minimize the effects of external magnetic fields; and

FIGURE 6 is a curve showing the improved response obtained by the application of the present invention.

Referring to FIGURE 1 there is diagrammatically shown a transducer which will serve as a microphone. This comprises a housing having two similar end pieces 11 each provided with a plurality of apertures 12 so that sound may enter into the cavities within the structure. Similar cylindrical housing members 13 are interposed between the ends 11 and a ferrous diaphragm 14. Within the two chambers formed by the diaphragm 14 are two similar magnetic structures each comprising a permanent magnet 15 surrounded by a winding or coil 16.

Where a diaphragm with the housing forms a single cavity, the structure is similar to that shown in FIGURE 2. Therein a non-magnetic housing 17 supports a diaphragm 18 retained in position by a suitable clamping

ring 19. Within the housing 17 is a permanent magnet 21 having pole piece extensions 22 surrounded by windings 23. In accordance with the present invention, the diaphragms 14 and 18 of FIGURES 1 and 2 preferably is coated on both sides with a polyester resinous film, such as Du Pont Mylar.

A preferred transducer particularly suited for high altitude microphone service is shown in the exploded view of FIGURE 3. This structure comprises a cylindrical casing 24 having therein two spacing rings 25 which are arranged to engage the clamp the peripheral edge portions of a diaphragm 26. The diaphragm 26 has a central ferrous sheet metal portion 27 coated on opposite sides by a polyester resinous film 28 which preferably is baked on the sheet metal portion 27. The spacing rings 25 are of soft iron and serve as a part of a magnetic circuit which is completed by an end piece 29 having suitable sound apertures 31 therein. Each end piece 29 abuts a permanent magnet member 32 which is surrounded by an electromagnetic coil 33. The end piece 29 is engaged by a threaded clamping ring 34, to which is applied a flexible membrane covering 35 to exclude moisture from the structure. In order that the chambers formed within the housing 24 by the diaphragm 26 may be suitably vented to atmospheric pressure, the rings 25 are each provided with openings 36 which align with openings 37 in the housing 24, which in turn are aligned with openings 38 in a conduit 39. The conduit 39 may pass in the instance of a facial mask to the exterior of the mask to vent the structure to atmospheric pressure.

It has been mentioned that the diaphragm 26, which is of the order of 0.005 inch thick, is covered with a film of polyester resin which may be of the order of .0025 inch thick. The normal gap between the magnetic member 32 and the diaphragm 26 is of the order of .007 inch. The normal amplitude of motion of the diaphragm is approximately .003 inch with a maximum travel of the diaphragm in one direction of .0045 inch.

Where it is desired to increase still further the stiffness of the diaphragm, a modified diaphragm structure may be employed as illustrated in the partial cross-sectional view of FIGURE 4. Therein two thinner sheets of ferrous material 41 are cemented to a film 42 of polyester material such as the Du Pont Mylar. The outer surfaces of the two cemented together ferrous diaphragm members 41 are covered by Mylar films 43. While the polyester film produces the damping effect, there also may be some loss in the response sensitivity, but this is believed to be offset by some of the other features gained by the use of the polyester film. The film operates in a manner similar to a gasket at the clamping surfaces to distribute the clamping pressure evenly and thus avoid an expensive construction and eliminate undue detrimental strains in the metallic diaphragm. The elimination of such strains, therefore, insures an improved response characteristic.

In the winding of the coils 33 of FIGURE 3, the coils are wound in the manner diagrammatically shown in FIGURE 5. It will be noted that the magnetic structures 32 are so magnetized that the north poles are in the same direction relative to the south poles of the structures. The connections of the coils 33 are such that a displacement of the diaphragm 26 from the solid line to the dash-dot line representation will generate in the coils 33 a potential tending to cause a flow of current as indicated by the arrows. Those skilled in the art will readily appreciate that an external magnetic field, such as that represented by the dotted line arrows, will generate voltages in the coils 33 which are in opposition to each other, and hence no detrimental voltages or currents will appear in the circuit to which the transducer is connected due to the external magnetic field.

The improvement resulting from the application of the polyester film to opposite sides of the ferrous metal dia-

phragm is illustrated in the comparison of the curves shown in FIGURE 6 wherein curve A is the response characteristic of a typical diaphragm which does not have the polyester film, whereas curve B is the same diaphragm coated with a film in accordance with the teaching of the present invention.

Accordingly, the present invention overcomes many of the detrimental effects and problems heretofore encountered in prior structures. From the representations of the preferred embodiments as shown in FIGURES 3 and 5, it becomes apparent that it is possible to magnetize the structure after assembly and still prevent the diaphragm 26 from remaining stuck to one of the magnetic pole pieces. This eliminates the difficulty encountered in prior constructions where a subsequent forcing of the diaphragm from the pole piece produced a change in the magnetic field and often resulted in a change in the normal stiffness of the diaphragm. Without magnetic saturation between the magnetic members in an ideal magnetic circuit, the magnetic force of attraction of a diaphragm is proportional to the square of the flux density. The flux density is approximately proportional to the length of the air gap between the magnetic members for operation over a restricted portion of the demagnetization curve. In a typical practical magnetic circuit the resulting force of attraction, while far from being a perfect square law function with respect to separation, is greater than a linear relation. The restoring force of the diaphragm, due to its mechanical stiffness, is approximately proportional to the magnitude of the displacement of the diaphragm. It thus may be seen that a condition can exist such that as the diaphragm is displaced up to a certain point, it will return to its normal position when the displacing force is removed. If the diaphragm should pass a critical point, the diaphragm will continue to move toward the pole piece until it rests upon it. The application of the film is such, however, that this latter condition is obviated.

While for the purpose of illustrating and describing the invention particular embodiments have been shown in the drawings, it is to be understood that the invention is not to be limited thereby since such variations and modifications are contemplated as may be commensurate with the spirit and scope of the appended claims.

I claim as my invention:

1. An electromagnetic acoustical transducer comprising a hollow cylindrical housing, a circular diaphragm of ferromagnetic material disposed within the housing and provided with a coating of polyester resin on the surfaces thereof, said diaphragm having a diameter approximately equal to the inner diameter of the housing, a cylindrical sleeve of ferromagnetic material disposed within the housing on each side of the diaphragm and abutting the diaphragm, an end plate of ferromagnetic material having a plurality of apertures disposed abutting the side of each of the sleeves opposite the diaphragm, a magnet mounted on each of the end plates and extending toward the diaphragm, and a coil disposed about each of the magnets.

2. An electromagnetic acoustical transducer comprising the elements of claim 1 wherein the magnets have cylindrical shapes and the central axes of the magnets are disposed upon a common axis normal to the diaphragm, and the coils disposed about the magnet are provided with the same number of turns and connected in series opposition.

3. An electromagnetic acoustical transducer comprising the elements of claim 1 wherein the diaphragm comprises two spaced sheets of ferromagnetic material, a sheet of polyester resin disposed between and abutting the sheets of ferromagnetic material, and a coating of polyester resin disposed on the surfaces of the ferromagnetic sheets opposite the sheet of polyester resin.

4. An electromagnetic acoustical transducer compris-

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ing a hollow cylindrical housing having threads extending therein on the inner surface thereof from each end, a circular diaphragm of ferromagnetic material disposed within the housing and provided with a coating of polyester resin on the surfaces thereof, said diaphragm having a diameter approximately equal the inner diameter of the housing, a cylindrical sleeve of ferromagnetic material disposed within the housing on each side of the diaphragm and abutting the diaphragm, an end plate of ferromagnetic material having a plurality of apertures disposed abutting the side of each of the sleeves opposite the diaphragm, a magnet mounted to each of the end plates and extending toward the diaphragm, a coil disposed about each magnet, a threaded ring engaging the threads on each end of the housing and securing the end plates between the ring and the confronting sleeve, and a moisture barrier sealed to the side of the ring opposite the end plates.

5. An electromagnetic acoustical transducer comprising the elements of claim 4 wherein the diaphragm comprises two spaced sheets of ferromagnetic material, a sheet of polyester resin disposed between and abutting the sheets of ferromagnetic material, and a coating of polyester resin disposed on the surfaces of the ferromagnetic sheets opposite the sheet of polyester resin.

6

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