

Feb. 2, 1960

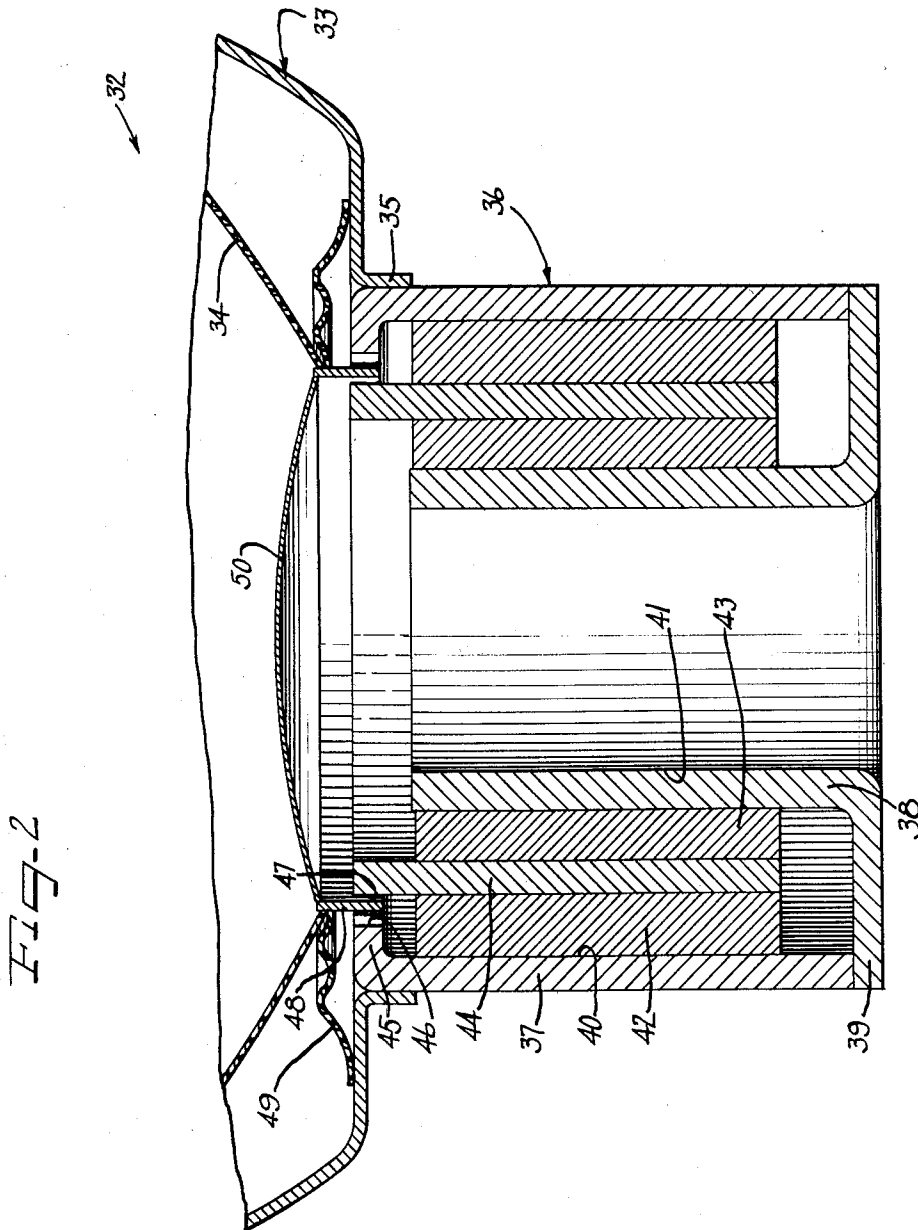
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2,923,783

ELECTRO-ACOUSTICAL TRANSDUCER

Filed June 17, 1957

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2,923,783

ELECTRO-ACOUSTICAL TRANSDUCER

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Application June 17, 1957, Serial No. 665,918

9 Claims. (Cl. 179—115.5)

This invention relates to an electro-acoustical transducer and more particularly to a transducer having a voice coil movable in an annular air gap of a permanent magnet structure in which the magnet structure is so constructed as to be compact, economically manufacturable and efficient in operation.

This application is a continuation-in-part of my co-pending application entitled, "Speaker," filed November 6, 1956, Serial No. 620,606, in which I disclose an improved type of diaphragm and an improved arrangement in which the diaphragm is connected at its periphery to the voice coil. In the parent application I also disclose magnet structures which efficiently utilize a ferrite material which is low in cost and has a high energy relative to mass, but which has a low saturation flux density. In particular, I disclose arrangements in which the magnets can have a short length in the direction of magnetization while having a relatively large area transverse to the direction of magnetization, which area is large compared to the cross-sectional area of the air gap.

In one arrangement, as disclosed in said application, the magnet structure comprises a pair of annular pole pieces defining the annular air gap with a magnet of ferrite material between the pole pieces, the magnet being radially magnetized. In another arrangement as disclosed in said application, the magnets are axially magnetized with axially spaced annular pole pieces. Both of these structures make it possible to have a short length in the direction of magnetization with a relatively large area transverse to the direction of magnetization, with the area being large compared to the cross-sectional area of the air gap.

The instant application is directed to structures such as above described and is further directed to arrangements in which the weight of the magnets can be increased to obtain greater efficiency and power-handling capabilities, without greatly increasing the overall size of the transducer. In particular, the magnet structure may comprise a first pole piece of generally U-shaped cross-sectional configuration having a pair of surfaces in spaced facing relation with a pair of permanent magnets disposed within the first pole piece and with a second pole piece disposed between the magnets, the pole pieces being arranged to define spaced facing concentric surfaces to form the air gap receiving the voice coil. Thus it is possible to use an additional magnet without greatly increasing the overall size of the unit. This feature may be incorporated either in the arrangement in which the magnets are axially magnetized, or in the arrangement in which the magnets are radially magnetized, as will be described in detail hereinafter.

It will be appreciated from the foregoing that the primary object of this invention is to provide an electro-acoustical transducer in which the magnet structure is so constructed as to be compact, economically manufacturable and efficient in operation.

This invention contemplates other and more specific objects, features and advantages which will become more

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fully apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate preferred embodiments and in which:

Figure 1 is a cross-sectional view through a speaker constructed according to the principles of this invention;

Figure 2 is a cross-sectional view through a modified form of speaker constructed according to the principles of this invention.

Reference numeral 10 generally designates one preferred form of speaker constructed according to the principles of this invention. The speaker 10 comprises a frame 11 having an annular rim portion 12 from which the peripheral edge portion of a cone or diaphragm 13 is flexibly supported. The frame 11 has an apertured generally conical portion 14 which converges from the rim 12 to an annular plate portion 15 on which a magnet structure 16 is supported.

The magnet structure 16 comprises a circular plate 17 which is secured to the portion 15 of the frame 11 and has a central circular opening 18. The second plate 19 has an integral peripheral flange portion 20 engaged with the periphery of the plate 17, and the plates 17 and 19 together define a first pole piece of generally U-shaped cross-section having surfaces 21 and 22 in spaced facing relation, the surface 21 being the inner surface of the plate 17 and the surface 22 being the inner surface of the plate 19. It will be appreciated that the plates 17 and 19 may be integral, but, for purposes of economy in production and simplicity of assembly, they are preferably made separate and then secured together.

A pair of permanent magnets 23 and 24 are disposed within the pole piece defined by the plates 17 and 19, with the magnets 23 and 24 magnetized in an axial direction and with like poles engaged with the surfaces 21 and 22. Thus, for example, the north pole (N_1) of the magnet 23 may be engaged with the surface 21, and the north pole (N_2) of the magnet 24 engaged with the surface 22. Disposed between the magnets 23 and 24 is a second pole piece defined by a plate 25 which has the south poles S_1 and S_2 of magnets 23 and 24 engaging the opposite sides thereof and has an integral sleeve portion 26 projecting axially from the central portion thereof into the opening 18. The dot and dash lines indicate the magnetic flux paths.

The internal surface of the opening 18 and the external surface of the sleeve portion 26 are concentric and in evenly spaced relation to define an annular air gap in which the flux produced by the magnets 23 and 24 is concentrated. A voice coil form 27 is connected to the central portion of the diaphragm 13 and is movable in the air gap. The illustrated voice coil comprises a round wire 28 wound on the form 27, which is of paper or other insulating material and cylindrical in form. In the alternative, the wire could be of square cross-section of a ribbon shape which might be wound either on a tubular form or might be cemented in a manner to be self-supporting. A cap 30 may be secured to the voice coil. To insure centering of the voice coil in the air gap, a centering disc 31 may be secured between the voice coil and the inner surface of the plate 17.

It has been found that this construction permits optimum use of a ferrite material for the magnets in that the magnets can have a short length in the direction of magnetization and a relatively large area transverse to the direction of magnetization, with the area transverse to the direction of magnetization being large in comparison to the cross-sectional area of the air gap. At the same time, the construction is compact and the magnet structure does not greatly increase the overall dimensions of the speaker.

It should be noted that in some cases in which effi-

ciency and power-handling capabilities are not primary considerations, it is not necessary to use both magnets, and the magnet 24 and the plate 19 may be eliminated if desired. On the other hand, for increased efficiency, additional magnets may be employed, using the same basic type of construction. For example, an additional magnet may be disposed against the outer face of the member 19 and an additional pole piece member may be disposed against the outer face of the additional magnet, with the additional pole piece being provided with a central sleeve portion connected to the central portion of the pole piece 25. It may also be noted that the magnets may, if desired, be divided into segments and need not form a complete annulus although such an arrangement is preferred to make ultimate use of space.

The pole pieces can be relatively thin material but should have a high saturation flux density as compared to the saturation flux density of the magnets, in order to obtain a high flux density in the air gap.

Referring now to Figure 2, reference numeral 32 generally designates another preferred form of speaker constructed according to the principles of this invention. The speaker 32 comprises a frame member 33 which is similar to the frame 11 in the speaker of Figure 1 and is arranged to support the periphery of a conical diaphragm 34. The frame 33 has an outwardly projecting annular flange portion 35 which is secured to a magnet structure generally designated by reference numeral 36. The magnet structure 36 comprises an outer sleeve 37 secured within the flange 35 and an inner sleeve 38 in concentric relation to the sleeve 37, the inner sleeve 38 having a radially outwardly projecting annular flange portion 39 engaged at its periphery with the outer end of the sleeve 37.

The sleeves 37 and 38 together define a first pole piece of generally U-shaped cross-sectional configuration having surfaces 40 and 41 in spaced facing relation, the surface 40 being the inner surface of the sleeve 37 and the surface 41 being the outer surface of the sleeve 38.

A pair of magnets 42 and 43 are disposed within the pole piece defined by sleeves 37 and 38, both magnets being of sleeve-like configuration and being radially magnetized, with like poles being engaged with the surfaces 40 and 41. Thus, the north pole of the magnet 42 may be engaged with the surface 40, with the north pole of the magnet 43 engaged with the surface 41.

Disposed between the magnets 42 and 43 is a sleeve 44 which defines a second pole piece. The pole piece 44 is thus engaged with like poles of the magnets 42 and 43. For example, if the north poles of the magnets 42 and 43 are respectively engaged with the surfaces 40 and 41, the south poles of the magnets will be engaged with the inner and outer surfaces of the pole piece 44.

The sleeve 37 at its inner end has a radially inwardly projecting flange portion 45 having a cylindrical surface 46 in facing concentric relation to a cylindrical surface portion 47 of the pole piece 44 to define an annular air gap.

A voice coil 48 is connected to the diaphragm for movement in the air gap and a centering disc 49 may also be provided. A cap 50 is secured to the voice coil 48.

It will be appreciated that the arrangement of Figure 2 allows optimum use of ferrite magnet materials for the same reasons as discussed above in connection with the speaker of Figure 1. The construction of Figure 2 requires a larger voice coil diameter to obtain the same effective size of magnet but this is of considerable advantage as discussed in my above-identified copending application in that for a given weight of magnet, the field structure can have a very short axial length or, conversely the field structure can be very heavy for a given axial length. In addition, the voice coil can have a large area compared to the volume thereof, to increase heat dissipation and the power-handling capabilities of the speaker. Of course, the voice coil diameter may be made quite large in the embodiment of Figure 1. It

should be further noted that with a large voice coil diameter, a high impedance voice coil can be readily wound, without requiring the use of extremely fine wire and without requiring the use of a large number of layers. For example, with a voice coil having an eight inch diameter, and a one-fourth inch axial length it is possible to obtain a 500 ohm impedance with only two layers of No. 37 or No. 38 wire. Such a voice coil can be connected directly to a transistor output stage, without using the conventional output transformer.

It should be noted that the opening defined by the inner sleeve 38 provides a passage for sound waves from the surface of the cap 50 to the space behind the speaker, which is of considerable advantage acoustically. The same thing is true in the arrangement of Figure 1, in which an opening is defined by the inner surface of the sleeve portion 26.

In cases in which the efficiency and power-handling capabilities are not of primary importance, both magnets need not be used. For example, the magnet 43 and the inner sleeve member 38 may be removed, if desired. Likewise, additional magnets may be added if desired. For example, an additional magnet may be engaged with the inner surface of the sleeve 38 and an additional sleeve-like pole piece may be engaged with the inner surface of the added magnet, and the added pole piece may be provided with a radially outwardly projecting flange at its inner end engaged at its periphery with the pole piece 44.

It should be noted that the term "ferrite" is intended to include all magnetic materials having a large coercive force but a low saturation flux density, in which maximum efficiency is obtained by having a short length in the direction of magnetization and a large area transverse to the direction of magnetization. Such ferrite materials apparently have magnet elements which are effectively spaced or separated transversely, thus accounting for the low saturation flux density and the high coercive force. In some cases the magnet elements may be atoms of a crystal type structure while in other cases, the magnet elements may be particles in a matrix of plastic or the like.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a permanent magnet ring of ferrite material having a low saturation flux density, and a pair of ring shaped pole pieces concentric with the magnet ring having faces engaged with the poles of said magnet and having a pair of facing concentric surfaces defining an annular air gap receiving said voice coil, the ring shaped pole pieces also defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap, the areas of said faces being large in comparison to the cross-sectional area of said air gap.

2. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a permanent magnet ring, and a pair of ring shaped pole pieces in concentric relation to said magnet ring having faces engaged with the poles of said magnet and having a pair of facing concentric surfaces defining an annular air gap receiving said voice coil, the ring shaped pole pieces also defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap, the areas of said faces being large in comparison to the cross-sectional area of said air gap, with said magnet having a short length in the direction of magnetization compared to the area thereof transverse to the direction of magnetization.

3. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a first ring shaped

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pole piece of generally U-shaped cross-sectional configuration on both sides of the open center having a pair of surfaces in spaced facing relation, a pair of ring shaped permanent magnets disposed in concentric relationship to and within said first pole piece and having like poles engaged with said surfaces, and a second ring shaped pole piece disposed in concentric relationship to and between said magnets with its opposite surfaces in engagement with the other poles of said magnets, said pole pieces having spaced facing concentric surfaces defining an annular air gap receiving said voice coil, the ring shaped pole pieces defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap.

4. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a first ring shaped pole piece of generally U-shaped cross-sectional configuration on both sides of the open center having a pair of surfaces in spaced facing relation, a pair of ring shaped permanent magnets disposed in concentric relationship to and within said first pole piece and having like poles engaged with said surfaces, and a second ring shaped pole piece disposed in concentric relationship to and between said magnets with its opposite surfaces in engagement with the other poles of said magnets, said pole pieces having spaced facing concentric surfaces defining an annular air gap receiving said voice coil, the ring shaped pole pieces defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap, the areas of said poles being large in comparison to the cross-sectional area of said air gap.

5. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a pair of ring shaped pole pieces of annular configurations having facing concentric surfaces refining an annular air gap receiving said voice coil, and a permanent magnet ring concentric with and disposed between said pole pieces, the ring shaped pole pieces defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap.

6. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a pair of ring shaped pole pieces of annular configurations having facing concentric surfaces defining an annular air gap receiving said voice coil, and a permanent magnet ring concentric with and disposed between said pole pieces, the ring shaped pole pieces defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap, said magnet being radially magnetized with said pole pieces being respectively engaged with radially inner and outer surfaces thereof.

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7. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a pair of ring shaped pole pieces of annular configurations having facing concentric surfaces defining an annular air gap receiving said voice coil, and a permanent magnet ring concentric with and disposed between said pole pieces, the ring shaped pole pieces defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap, said magnet being axially magnetized with said pole pieces being respectively engaged with axially opposite faces thereof.

8. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a first annular pole piece of generally U-shaped cross-sectional configuration having a pair of radially extending surfaces in spaced facing relation, a pair of annular permanent magnets disposed within said first pole piece and having like poles engaged with said surfaces, said magnets being axially magnetized, and a second pole piece disposed between said magnets with its opposite surfaces in engagement with the other poles of said magnets, said pole pieces having spaced facing concentric surfaces defining an annular air gap receiving said voice coil, the annular pole pieces also defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap.

9. In an electro-acoustical transducer, a diaphragm, a voice coil connected to said diaphragm, a first annular pole piece of generally U-shaped cross-sectional configuration having a pair of generally concentric cylindrical surfaces in spaced facing relation, a pair of annular radially magnetized permanent magnets disposed within said first pole piece and having like poles engaged with said surfaces, and a second annular pole piece disposed between said magnets with its opposite surfaces in engagement with the other poles of said magnets, said pole pieces having spaced facing concentric surfaces defining an annular air gap receiving said voice coil, the annular pole pieces also defining a central opening in the back of the structure open to the back of the diaphragm and concentrically arranged with respect to and communicating with said air gap.

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