MAGNETIC FIELD ASSEMBLY FOR ELECTROMECHANICAL TRANSDUCERS

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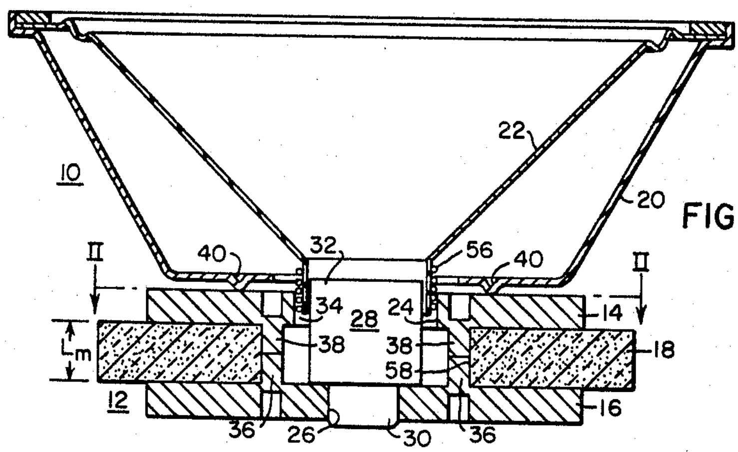

FIG. 1.

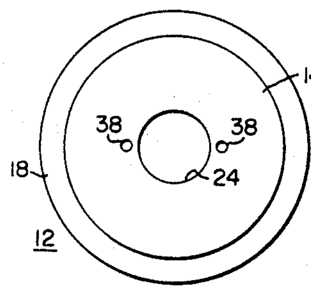

FIG. 2A.

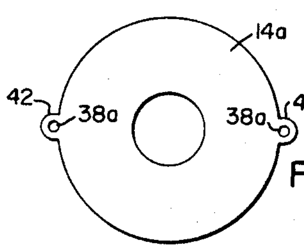

FIG. 2B.

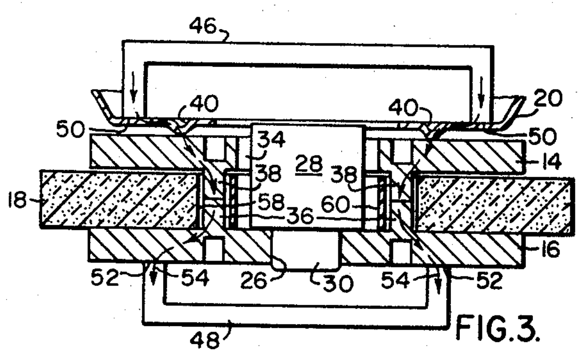

FIG. 3.

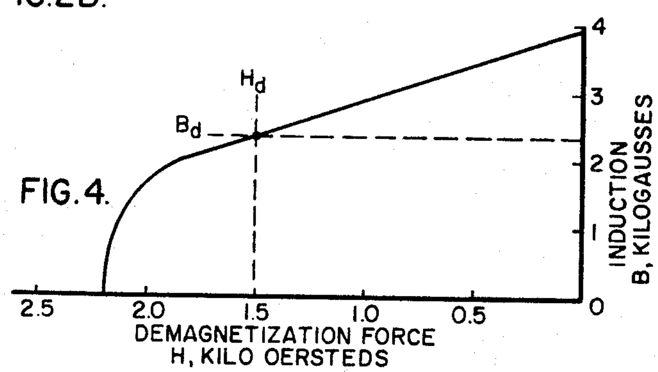

FIG. 4.

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MAGNETIC FIELD ASSEMBLY FOR ELECTRO-MECHANICAL TRANSDUCERS

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ABSTRACT OF THE DISCLOSURE

This invention relates to magnetic assemblies for loudspeakers including front and back pole plates, and a ferrite magnet disposed therebetween. More specifically, this invention is directed toward the means of securing the ferrite magnet between the front and back pole plates and in one illustrative embodiment, includes projections extending from each of the pole plates which are welded together.

This invention relates to magnetic field assemblies for electromechanical transducers such as a loudspeakers, and more particularly to magnetic field structures employing ceramic or ferrite magnets and to means for securing the elements of such assemblies together.

The use of ferrite or ceramic magnets has been found to have several advantages over other magnets, such as those made from the Alnico alloys, that are customarily used in loudspeakers. First, the use of ferrite magnets has been found to be less costly epsecially where the larger, high powered sizes of magnets arc needed. Secondly, ceramic magnets made of such materials as strontium or barium ferrite typically have high values of demagnetizing force which allows the use of much shorter lengths of this material than is normal for other typical loudspeaker magnetic materials. However, greater cross-sectional areas of the magnet are required due to the comparatively low values of the simultaneous magnetic induction associated with these ceramic materials. As a result, the ceramic ferrite magnets are typically of a shorter axial length and the loudspeakers in which they are incorporated may be designed to have a significantly shallower depth.

In order to take advantage of the properties of the ferrite magnets, "ring" type magnetic assembly includes an annularly shaped ceramic magnet disposed between a back pole plate and a front pole plate having an opening therein. Further, a center pole piece extends from the back pole plate through the opening of the ceramic magnet to form a circular air gap between the inner periphery of the opening of the upper pole plate and the center pole piece.

However, difficulty has been encountered in firmly securing together the front and back pole plates to the ferrite magnet. One method of holding this assembly together is to place an epoxy adhesive between the faces of the ceramic magnet and the corresponding faces of the front and back pole plates, but this process has been found to be very expensive due to the excessive fixturing and curing times required, the cost of the adhesive, and the necessary steps of preparatory cleaning. Further, it is difficult, if not impossible, to reclaim the magnets from these assemblies after they have been secured with such adhesives. Another known method of securing the magnetic pole plates together is to use fastening means such as screws or rivets. The screws or rivets are of themselves relatively expensive to manufacture, and in addition these fasteners require the expensive steps of punching (or drilling) and tapping the holes in the pole plates, and additional assembly operations. A still further method requires the use of a ferrule which is inserted about the center pole piece and has protrusions which may be disposed in slots machined within the pole faces and secured thereto by bending.

It is therefore an object of this invention to provide a new and improved magnetic assembly for ferrite magnets which is easily and inexpensively assembled.

It is a still further object of this invention to provide a new and improved magnetic assembly for ferrite magnets which may be assembled without additional fastening means in a single step as by welding.

It is a still further object of this invention to provide a new and improved magnetic assembly for ferrite magnets wherein the ferrite magnet may be easily aligned with the remaining elements of the assembly.

Briefly, the present invention accomplishes the above mentioned objects by providing a magnetic assembly for an electro-mechanical transducer such as a loudspeaker which includes front and back pole plates, an annular ferrite magnet disposed between the front and back pole plates, and a central pole piece magnetically associated with the back pole plate and extending into an aperture within the front pole plate to form, a circular air gap between the central pole piece and the front pole plate. More particularly, the front and back pole plates are secured together by means which include one or more projections which are formed as by punching in the front and/or back pole plates and extend collectively a distance approximately equal to the thickness of the ferrite magnet. The front and back pole plates are so disposed with respect to each other and the protrusions are aligned with the protrusions of the other plate so that they may be easily welded together. Further, the projections may be disposed adjacent the aperture within the front pole plate and the pole piece so as to provide means for aligning the annularly shaped ferrite magnet which may be disposed about these projections.

These and other objects and advantages of the present invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIGURE 1 is a sectioned view of an electro-mechanical transducer including a magnetic assembly in accordance with the teachings of this invention;

FIG. 2A is a plan view taken along the line II—II of FIG. 1 of the magnetic assembly as shown in FIG. 1;

FIG. 2B is a plan view of an alternative embodiment of the magnetic assembly which may be incorporated in the electro-mechanical transducer of FIG. 1;

FIG. 3 is an elevational view showing the elements of the magnetic assembly in accordance with this invention, a basket member and the placement of electrodes during a welding operation, which in accordance with the teachings of this invention may be accomplished in a single step; and

FIG. 4 shows in graph form the demagnetization curve of the magnet to be incorporated within the magnetic assembly of FIG. 1.

Referring now to the drawings and more particularly to FIG. 1, an electro-mechanical transducer such as a loudspeaker **10** is shown having a magnetic assembly **12** and a basket member **20** secured thereto for supporting a diaphragm **22**. The magnetic assembly **12** includes a front pole plate **14** and a back pole plate **16** between which there is disposed a ceramic, ferrite magnet **18**. Typically, the back and front pole plates **16** and **14** are made of a suitable flux conducting material such as a low carbon steel in order to improve their permeability, although other types of ferrous material could be used. The back pole plate **16** is formed with a central, circular opening **26** to securely receive as by force fit a center pole piece **28**. The center pole piece **28** has a neck portion **30** which extends into and is so dimensioned so as to be secured within the aperture **26**, and an enlarged portion **32** which extends from the surface of the back pole plate **16** into a circular aperture **24** centrally disposed within the front pole plate **14**. Illustratively, the center pole piece **28** is of a circular configuration and has a diameter slightly smaller than the diameter of the aperture **24**. Further, the aperture **24** is disposed concentrically about the center pole piece to form an annularly shaped air gap **34** therebetween in which a voice coil **56** to be hereinafter described can be inserted.

Magnetic flux is provided by the ferrite magnet **18** which is disposed centrally within an opening **58** of the front pole plate **14**. The magnet **18** is formed substantially in the same shape as the front and back pole plates **14** and **16** which can be rectangular, circular or any other desired shape. In accordance with the teachings of this invention, the magnetic assembly **12** and the means for securing the elements of this assembly are designed to incorporate a ferrite magnet therein. More specifically, the ceramic, ferrite magnets may be made of suitable materials such as barium ferrite ($BaO\cdot 6Fe_2O_3$), strontium ferrite ($SrO\cdot 6Fe_2O_3$) and lead ferrite ($PbO\cdot 6Fe_2O_3$). In one illustrative application of this invention, a strontium ferrite as manufactured under the name Westro-Alpha (a trademark of the Westinghouse Electric Corporation) could be the material of which the magnet **18** is made. A demagnetization curve for a typical sample of the magnetic material Westro-Alpha is presented in FIG. 4 to which reference will be made in explaining the advantages of these ferrite, ceramic materials.

In order to determine the dimensions of the magnet **18**, a value of the demagnetizing force H_d is selected upon a demagnetization curve such as shown in FIG. 4. Typically, it is desired to select such values of the demagnetizing force H_d to be of a maximum value while excluding that portion of the curve in which variances may occur due to temperature changes. Illustratively, an operating point for the value of the demagnetizing force H_d of approximately 1500 oersteds may be selected upon the demagnetization curve of FIG. 4. The axial length (shown in FIG. 1 as L_m) of the magnet **18** may be determined from the following expression:

$$L_m=\frac{H_g L_g R}{H_d}$$

Where L_g=the length of the air gap (i.e. the distance between the pole plate **14** and the center pole piece **28**), H_g is the magnetic field intensity within the air gap, and R is a reluctance factor and typically has a value of between 1.1 and 1.3. Further, the cross-sectional area required of the magnet **18** may be determined from the expression:

$$A_m=\frac{H_g A_g K}{B_d}$$

where K equals a leakage factor, B_d is the simultaneous induction value at H_d on the demagnetization curve (see FIG. 4), and A_g is the area of the air gap. Thus, where the length of the air gap length L_g is determined to be about .050 inch, the reluctance factor is selected to be approximately 1.2, and the necessary magnetic field H_g in the air gap is selected to be approximately 10,000 oersteds, the axial length of the magnet L_m is illustratively determined to be .40 inch. The cross-sectional area of the magnet **18** may be determined for the illustrative case in which the leakage factor K is determined to be approximately 2, the area of the air gap is approximately .785 square inch where the aperture **24** is one inch in diameter, the thickness of the front plate **14** is .25 inch, and the simultaneous induction value B_d is determined from the curve shown in FIG. 4 to be 2.4 kilogausses; thus the value of the cross-sectional area of the magnet **18** may be calculated to be 6.5 square inches. Thus, from this illustrative example, it may be seen that high values of the demagnetizing force

H_d of ferrite magnets make possible magnets with substantially shorter lengths than is normal for other dimensions of commonly used permanent magnet materials. In comparison, commonly used metallic permanent magnet materials such as Alnico V have a useful value of H_d of about 550 oersteds and a value of B_d of about 10 kilogausses. Similarly, as may be seen from FIG. 4, the values of the simultaneous induction B_d for ferrite materials are lower and thus greater areas of the cross-section of the magnet are required. As a result of these dimensional requirements, it is desirable to incorporate ferrite magnets into assemblies providing pole pieces which take advantage of the short axial length of the magnet and which additionally provide means for directing the flux from substantial cross-sectional areas across the air gap.

Such a design is shown in FIG. 1 where the magnet **18** has an axial length L_m which is relatively small in comparison with its cross-sectional dimensions. Likewise, the cross-sectional area of the magnet **18** is relatively large and is effectively used as by the front and back pole plates **14** and **16** which are disposed on either side to direct the flux therefrom. Specifically, the magnetic circuit directs the flux from the magnet **18** in the following manner: a first leg of the magnetic circuit is formed by the back pole plate **16** which directs the flux from the magnet **18** therethrough and into the center pole piece **28**. The flux is thereby directed across the air gap **24** into the front pole plate **14** to be returned to the magnet **18**. In this manner, the particular properties of the ferrite, ceramic magnets may be effectively utilized.

In accordance with the teachings of this invention, the elements of the magnetic assembly **12** may be secured together to position a ferrite magnet in the following manner. The front pole plate **14** is formed with one or more projections **38** therein as by punching which proves to be an inexpensive operation. In a like manner, projections **36** may be formed in the back pole plate **16**. As is shown in FIG. 1, the projections **36** and **38** are formed in those portions respectively of the plates **16** and **14** that are adjacent to the apertures **26** and **24** respectively. Further, the projections **36** and **38** are so disposed that they are substantially aligned with each other. In addition, the projections **36** and **38** are so placed upon the pole plates **14** and **16** that the magnet **18** may be accurately and quickly aligned with respect to the openings within the front and back pole plates **14** and **16**. More specifically, the spacings of the projections **36** and **38** from the centers of the back plates **14** and **16** are so determined, that the magnet **18** may be slipped over either the projections **38** or **36** and be positioned concentrically with respect to the openings **24** and **58**. Further, the thickness of the front and back plates **14** and **16** is so selected to provide projections **36** and **38** with the appropriate dimensions. The combined dimensions of the projections **36** and **38** are selected to be slightly in excess of the axial length L_m of the magnet **18**. In an illustrative embodiment, each of the projections **36** and **38** is determined to be in slightly excess of one half of the axial length L_m of the magnet **18**. Thus, when the projections **36** and **38** are welded together as will be explained in greater detail later, the protrusions **36** and **38** upon cooling will shrink so that their combined dimensions will be slightly less than the axial dimension L_m thereby providing a tight fit of the magnet **18** between the pole plates **14** and **16**.

If the magnetic field assembly **12** is to be used as in a loudspeaker, as illustrated in FIG. 1, the basket member **20** may be mounted upon the front pole piece **14**. The conically shaped diaphragm **22** is mounted upon the basket member **20** in a manner well known in the art and includes the voice coil **56** composed of windings of wire which are disposed upon the diaphragm **22**. Further, the voice coil **56** is disposed within the air gap **34** between the enlarged portion **32** of the center pole piece **28** and the inner periphery of the aperture **24** of the front pole piece **14**. In order to secure the basket member **20** to the front pole piece **14**, a plurality of projections **40** may be formed by punching within the basket member **20**. The projections **40** are offset from the axis of the basket member **20** so that the basket member **20** may be aligned with the front plate **14**, and the projections **40** will abut a portion of the front pole plate **14** adjacent the depressions associated with the projections **38**.

Referring now to FIGS. 1 and 2A, it is desirable for the diameter of the magnet **18** to exceed the cross-sectional dimension of the front and back pole plates **14** and **16**. In order to save the material used to make these plates, the peripheral edge of the magnet **18** should extend beyond the front and back pole plates **14** and **16** as shown particularly in FIG. 2A. By so disposing the magnet **18**, the magnetic flux leakage between the front pole plate and the back pole plate may be reduced thereby providing a more efficient magnetic circuit and effecting a saving in the material of which the pole plates are made.

Referring now to FIG. 2B, an alternative method of securing the front and back pole plates is shown. Specifically, a front pole plate **14***a* may be secured to the back pole plate (not shown) by means which include a pair of ears **42** which extend from either side of the front pole plate **14***a* and have impressed therein a projection **38***a*. It may be understood that the bottom pole plate will have an aligned pair of ears and projections to coincide with those of the front pole plate **14***a*. In a manner to be described, the projections may then be welded together to thereby secure the front and back pole plates. It may be understood that a magnet is disposed between the pole plates and that the projections **38***a* extend beyond the periphery of the of the magnet.

Referring now to FIG. 3, there is shown an illustrative method of welding the front and back pole plates **14** and **16** respectively to each other. First, the central pole piece **28** is assembled with the back pole plate **16** as by press fitting the portion **30** within the aperture **26** of the plate **16**. Next, the opening **58** within the magnet **18** is disposed about either of the sets of projections **36** or **38** to thereby align the magnet **18** with respect to the pole plates. The other pole plate is brought into position so that the projections **38** and **36** of each of the pole plates are aligned with each other. Next, the basket member **20** is mounted upon the front pole plate **14** so that the projections **40** closely abut the surface of the pole plate near the depressions associated with the projections **38**. Then, a pair of electrodes **46** and **48** having respective contact points **50** and **52** are brought into position so that the contact points **50** closely abut a portion of the basket member **20** close to the projections **40** and so that the contact points **52** closely abut the depressions associated with the projections **36** of the back pole plate **16**. Finally, voltage is then applied between the electrodes **46** and **48** to thereby provide a current flow generally indicated by the numeral **54** through the front pole plate **14** and its projection **38**, the back pole plate **16** and its projections **36**, and the basket member **20** and its associated projections **40**.

Further, a shielding member or means **60** may be assembled about the pole piece **28** and between the pole plates to prevent the small particles resulting from the welding of the projections **36** and **38** from being attracted into the air gap **34** to thereby effect the performance of the loudspeaker. More specifically the shielding member **60** may be of a cylindrical configuration and made of a suitable insulating material such as reinforced paper or other fibrous material.

Further, it is noted that the ferrite material of which the magnet **18** is made has a very high resistivity and thereby the current flow is primarily restricted to a path through the projections **38** and **36**. On the other hand, other typical magnetic materials such as Alnico are highly conductive and such a material would short the current thereby preventing the use of such a welding technique. In particular, typical ceramic magnetic materials such as the strontium ferrite marketed under the trademark Westro-Alpha has a resistivity in the order of 10^8 ohms per cubic centimeter. Thus, the magnetic assembly **12** is capable of being assembled and secured together in a single step involving the welding of the front and back pole plates together.

As mentioned above, the magnetic path of the flux is directed through the bottom pole plate **16**, the center pole piece **28**, across the air gap **34** and back to the magnet **18** through the top pole plate **14**. As shown in FIG. 1, there would be a tendency for the projetcions **36** and **38** to short the magnetic path across the magnet **18**. However, the area of contact between the projections **36** and **38** should not exceed about 2.0% of the entire cross-sectional area presented between the pole plates and the magnet **18**. This small shunting area readily saturates and with such a small percentage of the magnetic flux being shunted across the magnet **18**, the magnetic sub-assembly **12** does provide an efficient magnetic circuit to direct flux across the air gap and the voice coil. Further, the contact area should be large enough so that a strong weld is effected between the projections **36** and **38**.

Thus, there has been shown an improved magnetic assembly for electro-mechanical transducers and in particular for loudspeakers which provides an improved means of securing the parts of the assembly together. The structure of the magnetic assembly is particularly adapted to use with the ferrite magnetic materials which due to their inherent magnetic characteristics are adapted to a design in which the axial dimensions of the magnet is shallow in comparison with the cross-sectional area exposed to the magnetic assembly. Thus, the means for securing the magnetic structure of this invention effectively secures a pair of pole plates in an inexpensive manner as by welding without substantially impairing the magnetic characteristics of this assembly.

Since numerous changes may be made in the above apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A magnetic field structure for an electromechanical transducer comprising first and second spaced magnetic plates, at least one of said first and second flux conducting plates having projection means extending therefrom, ferrite magnetic means disposed between and in a flux transferring relationship with said first and second flux conducting plates, said first and second flux conducting plates being secured together as by said projection means, said projection means being welded to the opposite flux conducting plate from which said projection means extends.

2. A magnetic field structure as claimed in claim **1**, wherein said ferrite magnetic means is associated with said first and second flux conducting plates to provide an area of flux transfer, said projection means presenting a contact area to said opposite flux conducting plate which does not exceed about 2.0% of said area of flux transfer.

3. A magnetic field structure as claimed in claim **1**, wherein said flux conducting plate has an opening therein; and a magnetic pole piece is associated with said second flux conducting plate so that magnetic flux may be transferred therebetween, and extends into said opening in a spaced relation with said opening to provide an air gap.

4. A magnetic field structure as claimed in claim **3**, wherein said ferrite magnetic means has an opening therethrough, said pole piece extending through said opening of said ferrite magnetic means, said projection means being disposed through said opening of said ferrite magnetic means to align said ferrite magnetic means with respect to said first and second flux conducting plates.

5. A magnetic field structure as claimed in claim **1**, wherein the peripheral edge of said ferrite magnetic means extends beyond the peripheral edges of said first and second flux conducting plates to thereby reduce the flux leakage between said first and second flux conducting plates.

6. A magnetic field structure as claimed in claim **1**, wherein said projection means include first and second projection members extending respectively from said first and second flux conducting plates, said first and second projection members having a combined first dimension, said ferrite magnetic means having a width of a second dimension, said first dimension being less than said second dimension so that when said first and second projection members are welded together that said ferrite magnetic means is firmly secured between said first and second pole plates.

7. A magnetic field structure as claimed in claim **3**, further including a shielding means disposed between said projection means and said air gap to prevent particles resulting from the welding of said projection means from being drawn to said air gap.

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