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[54] LOUDSPEAKER VOICE COILS

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[52] **U.S. Cl.** .....**179/115.5 VC,** 336/223

[51] **Int. Cl.** **H04r 9/04**

[58] **Field of Search**.....179/115.5 R, 115.5 DV, 115.5 VC; 336/223

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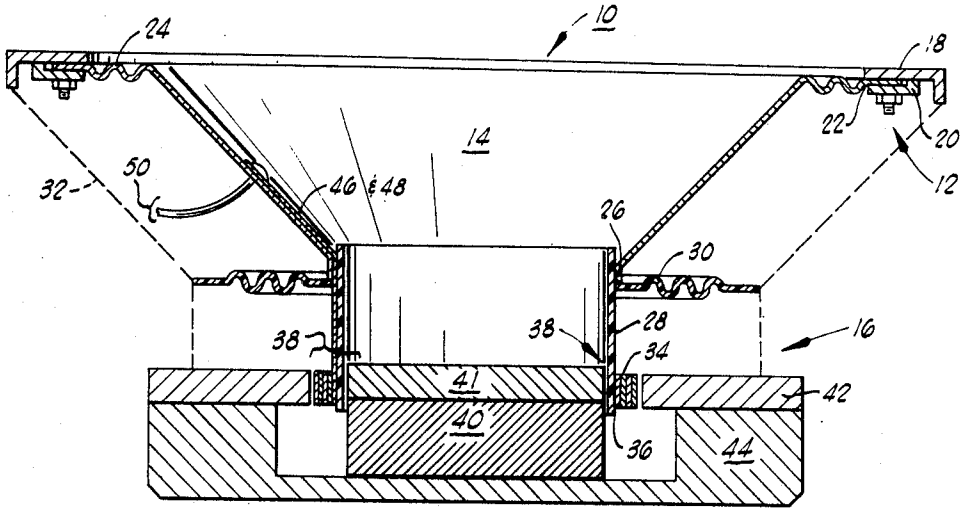
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[57] **ABSTRACT**

An improvement in the method and manner of constructing a loud speaker voice coil, such improvement consisting of utilizing conductive metal foil as the wound element for supported positioning and reciprocal movement within an associated magnetic air gap; such a metallic foil coil may consist of one or more turns of either superimposed or alternately off-set foil windings.

2 Claims, 5 Drawing Figures



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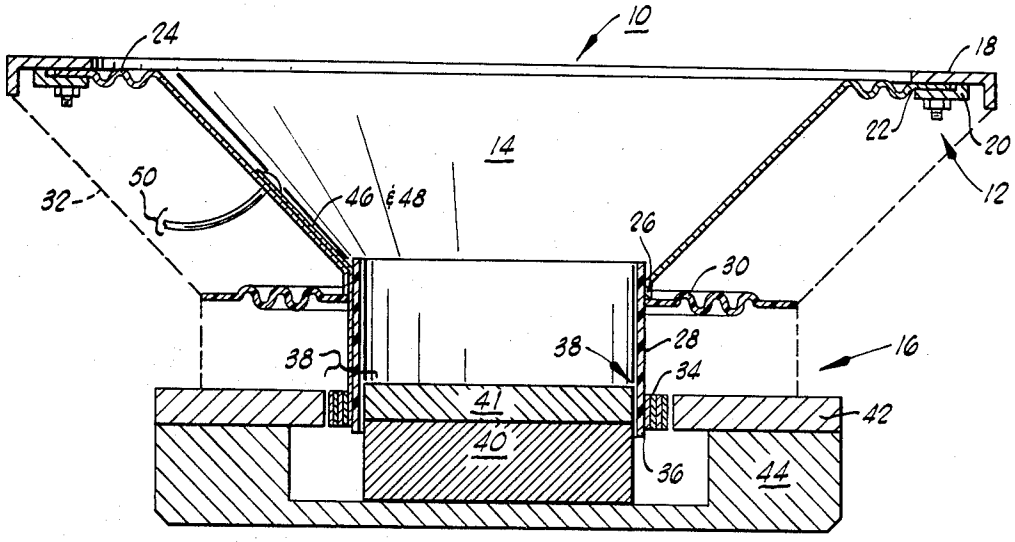


FIG. 1

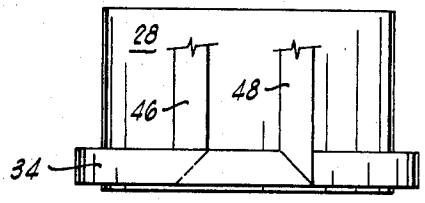


FIG. 2

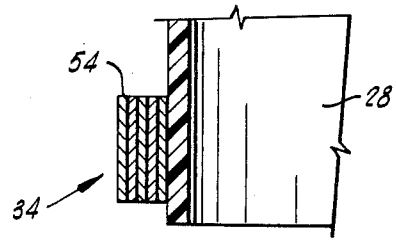


FIG. 3

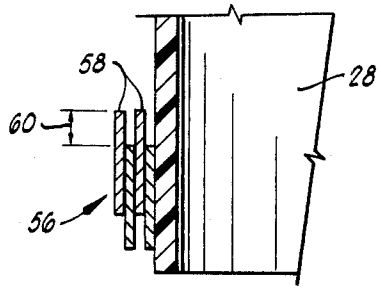


FIG. 4

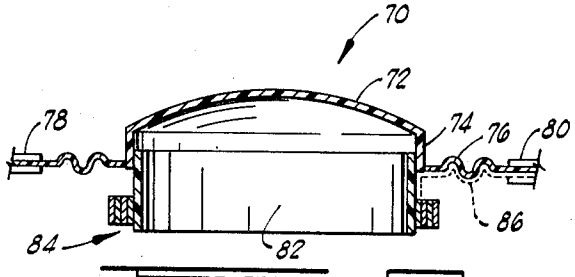


FIG. 5

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LOUDSPEAKER VOICE COILS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to the art of audible sound reproduction and, more particularly, but not by way of limitation, it relates to improved voice coil apparatus for use in loudspeaker assemblies.

2. Description of the Prior Art

The prior art includes no teaching as to a similar type of voice coil structure as formed by wound metallic foil. The use of foil has been known in constructing certain transformer and radio frequency coil structures, and particularly in such applications wherein the inherent characteristics and structural capabilities of foil lend themselves to particular applications. There are no known teachings heretofore which extend in any way into the sound reproduction art.

SUMMARY OF THE INVENTION

The present invention contemplates an improved transducer drive coil wherein the drive coil assembly is constructed of one or more windings of a metallic foil of selected thickness and width. The wound foil coil may be varied in any of foil thickness, foil width, type and configuration of foil overlap per winding, etc., to vary accordingly the inductance characteristics of the coil for particular applications.

Therefore, it is an object of the present invention to provide an improved acoustic energy transducer drive coil which offers the advantages of increased strength, simplicity, heat-dissipation capability, and high volume-efficiency.

It is also an object of the invention to provide a transducer drive coil having higher power handling capability per unit size of structure.

It is still further an object of the present invention to provide a loudspeaker voice coil of high efficiency which can be constructed with decreased thickness and volume as compared to prior art forms of voice coil.

Finally, it is an object of the present invention to provide a loudspeaker or microphone voice coil which is inherently stronger than like units formed with prior construction techniques and materials, and which foil voice coil exhibits increased exposure surface while allowing less dead space within the magnetic gap volume.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawing which illustrates the invention.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical section through a loudspeaker structure which utilizes a voice coil constructed in accordance with the present invention;

FIG. 2 is a side elevation of a coil former and voice coil constructed in accordance with the invention;

FIG. 3 is a partial vertical section showing one form of coil former and voice coil relationship;

FIG. 4 is a partial vertical section showing an alternative form of coil former and voice coil configuration; and

FIG. 5 is a vertical section through a typical form of dome diaphragm utilizing a foil coil constructed in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

While the teachings of the invention are applicable to any of various types of electromagnetic transducing assembly, the description proceeds relative to an exemplary application in an acoustic energy generating device. Thus, referring now to FIG. 1, a conventional form of loudspeaker assembly **10** consists of a frame element **12** supporting a diaphragm **14** and driver assembly **16**. The frame element **12** consists of an outer ring frame **18** and such as a clamping ring **20** suitably fastened therebeneath to receive and hold an outer peripheral edge **22** of diaphragm **14**. Diaphragm **14** is of the usual construction having such as molded concentric ridges **24** adjacent the outer supporting point or peripheral edge **22**.

An inner circumferal edge **26** of diaphragm **14** is formed as a cylindrical sleeve and secured as by bonding with suitable epoxy or the like to the outside of one end of a coil former **28**, i.e., usually a cylindrical tube section formed of phenolic plastic or the like and secured to diaphragm **14** in axial alignment therewith. Centering of the diaphragm **14** and coil former **28** is effected in usual manner by a resilient spider **30** which is suitable bonded at the point of juncture of diaphragm **14** and coil former **28** to extend radially outward for circumferal affixure to the speaker frame, shown schematically as dash-line **32**. Thus, the frame portion **32** provides secure structure from the outer frame ring **18** rearward to support and align the various operating elements of the loudspeaker **10**, this structure being well-known and conventional in design.

The magnet assembly **16** is rigidly supported by frame portion **32** so that it is maintained in magnetically interactive relationship with coil former **28** and voice coil **34**. The voice coil **34** is comprised of one or more turns of a selected foil material as wound circuitously around the lower end **36** of coil former **28** to be moveably supported within a symmetrically shaped air gap **38** as formed by magnet assembly **16**. The voice coil **34** may be wound from any of selected metallic foil materials; however, operation has been achieved to excellent advantage using aluminum foil of thickness 0.001 inch. Any of various metal foils or alloy foils may be used. The thickness too is a matter of choice depending upon the type of speaker performance and the characteristics to be stressed.

The magnetic assembly **16** is of conventional design having a cylindrical magnet **40** and a center pole portion **41**, and an annular ring portion **42** is secured by a brace portion **44** to maintain the proper circular air gap **38**. The type and configuration of magnetic assembly **16** may also be varied so long as a sufficient size of air gap **38** is provided to receive the voice coil **34**.

FIG. **2** illustrates the manner in which voice coil **34** is connected to respective take-down leads **46** and **48**, shown in FIG. **1** as connected through diaphragm **14** to signal supply leads **50**. As can be noted in FIG. **2**, the wound foil voice coil enables a further advantage of utilizing folded extensions of the coil foil as the take-down leads **46** and **48**. This is proven to be a superior method of take-down lead construction due to the fact that the foil is extremely thin and can be folded at right angles and led out of the coil configuration without the need for a special tolerance in the magnetic structure.

Thus, a speaker with a foil coil need not suffer an efficiency loss due to the necessity to provide a clearance for the take-down lead as has been a chronic problem in conventional loudspeaker designs of single layer coil construction. Each of the take-down leads **46** and **48** is made by folding a simple 90° bend in the foil ends so that the ends (leads **46** and **48**) extend along the coil former **28** for suitable connection to the external energizing voltage input. Such energizing voltage may be applied by any of various well-known connection methods; however, as shown in FIG. **1**, connection may be by suitable solder joint or other affixure through the diaphragm **14** to voltage supply leads **50**.

The foil coil winding may be arranged in any of various cross-sectional configurations. Thus, as shown in FIG. **3**, the foil coil **34** is wound about the lower end of coil former **28** which each successive foil overlay placed in exact superposition over prior wrapped layers. The coil **34** may consist of as many overlays **54** as are needed in establishing the requisite inductive characteristics; and also, the choice of foil width, thickness, metal type, etc. are subject to similar selection and adjustment.

FIG. **4** illustrates an alternative form of foil coil **56** which is wound with alternate foil overlays **58** off-set by a pre-determined distance denoted by arrows **60**, such configuration enabling much increased external exposure surface to each individual foil overlay **58**. Thus, in certain applications where dead space may not be critical, and heat dissipation may become a primary consideration, the cross-sectional configuration such as that of foil coil **56** may be desirable. It should be understood that various cross-sectional configurations and foil overlay patterns different from those shown may find use in certain special applications. It is also contemplated that it may be advantageous to vary the foil thickness or width along its length to further alter the concentration of inductive material about the coil.

In operation, the speaker assembly **10** functions in generally the same manner utilizing foil coil **34** as does the conventional speaker assembly utilizing a wound wire coil. The only differences in operation are in the improvements of certain physical characteristics as enabled by the foil coil. Thus, the foil voice coil has served to overcome some persistent problems in speaker manufacture such as coil concentricity. This is an especial problem with construction of the larger voice coil sizes, and coils formed in accordance with the foil coil method have proven to be much more resistant to warping than are conventional wire wound coils. In the usual practice, the curing of a very thin epoxy bonding agent in and around the combination of many layers of thin foil forms a monolithic block which is inherently stronger than conventional voice coil structures. Another common failing of conventional voice coils is the loosening of the end turns of the coil in response to certain stress movements, which loosening quickly weakens and lessens dependability of the coil structure. In the case of the foil coil there are no end turns to loosen as the entire surface of each foil layer is firmly bonded or attached to the next foil layer above (as well as below) with the result that the entire coil package is extremely sturdy and exhibiting a high affinity for coil concentricity.

The method of foil coil construction also has an increased advantage in simplicity. Thus, a coil winding machine needs no complex traverse mechanism, no gears, no cams, etc. The coil is easily positioned accurately on the coil former, and thereafter it is easily inspected and handled in further assembly. In construction, the designer has the advantage of knowing the precise measurement of the axial length of the coil since this is the width of the foil itself. There are so many variables in normal wire coil construction practice that it has been usual to design the speaker to operate with a rather large tolerance in the axial length of the voice coil. This practice then contributes to a wasting or a failure to utilize all or an appreciable majority of the available magnetic flux across the associated air gap.

FIG. **5** illustrates a foil coil as constructed in accordance with the invention and utilized in a high-powered compression driver horn application. Thus, FIG. **5** illustrates a dome diaphragm **70**, as is commonly utilized in a driver unit of a horn assembly. The dome diaphragm **70** consists of a dome portion **72** and cylindrical side wall **74** which is formed integrally with a radially extending spider portion **76** to be suitably retained in annular clamping assemblies **78** and **80**, as is well-known. A coil former **82** of cylindrical form is axially aligned with the cylindrical side wall **74** of diaphragm **70** and securely affixed thereto by suitable bonding, e.g., by epoxy cement or the like. A foil coil **84** is then wound around the lower end of coil former **82**, such foil coil **84** being suitably bonded in the manner as previously set forth. The take-down leads from foil coil **84** may be led out in any of various ways; however, it may prove advantageous in many applications to lead the foil strip take-down leads **86** (shown in dash-lines) outward along the under side of spider portion **76** of dome diaphragm **70**. Such practice will result in no unnecessary drag or unbalancing of the spider element to hamper operation of the driver assembly. It is also foreseen that some applications will allow elimination of the coil former member altogether.

The foregoing describes a novel voice coil which has many inherent advantages. The invention is superior to all other types of voice coil construction in its ability to dissipate heat. Thus, a multi-layer foil voice coil may be made such that each turn has two edges exposed for heat dissipation. The fact that there are no trapped turns, as are found in conventional square or round wire coils, also allows the coil to heat evenly with no hot spots. This enables the voice coil to make maximum use of the available magnetic flux within the air gap of the magnet assembly, there being no dead air space. The ability to increase the cross-sectional area of the conductor within the flux gap serves to increase the volume-efficiency of the voice coil. That is, the efficiency of a loud speaker varies as the square of the magnetic flux density times the square of the length of wire within the air gap. Since the length of wire with a given cross-sectional area and a given resistance is fixed, and the magnetic flux density increases with reduction of the magnetic gap volume, the volume-efficiency of the coil will be the controlling factor in the efficiency of a speaker with a given magnet structure.

The use of the foil coil and advanced insulation and bonding measures of an extremely thin coating con-

tribute to the lessening of the dead space in the center of the magnetic gap and therefore, this effects an increase in the volume-efficiency of the coil. Such increase enables the best use of the magnetic flux available in the given magnetic gap thereby to convert more of the electrical energy to acoustic energy than would be possible with a conventional speaker utilizing a wire wound voice coil. This, in turn, will result in less of the electrical energy being converted to heat, and the combination of the features brings into being the possibility of construction of loud speakers with higher efficiency and higher power-handling capability than any yet designed.

It should be understood too that the employ of single and multi-layer foil coil energizing units is by no means limited to loudspeaker assemblies. Various other forms of electromagnetic transducer, such as the numerous types of microphone and many accelerometer devices including high-powered shake table transducers, should gain functional advantage with utilization of the foil coil teachings.

Changes may be made in the combination and arrangement of elements as heretofore set forth in the specification and shown in the drawing; it being understood that changes may be made in the embodiments disclosed without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. In an electromagnetic transducer assembly of the type having a frame member supporting a diaphragm in contact with the surrounding air, and a magnet assembly secured in place by said frame member to define an air gap having magnetic flux present thereacross, the coil structure comprising:

coil former means securely affixed to said diaphragm and disposed to be supported within said air gap;

coil means formed from metallic foil wound in circuitous form, said coil means being wound upon said coil former means within said air gap with each alternate winding of said metallic foil in an off-set relationship relative to a mid-position within said air gap;

means providing insulation between any one part of said metallic foil and another part of said metallic foil; and

conduction means providing electrical connection to each one of the opposite ends of said metallic foil.

2. A transducer assembly as set forth in claim 1 wherein said strip of metallic foil is formed into a coil with successive windings displaced from superposition by predetermined amounts which vary the inductive characteristics in pre-set manner.

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