Feb. 16, 1960 W. R. KOCH 2,925,541
VOICE COIL STRUCTURE
Filed March 1, 1955

Fig. 1.

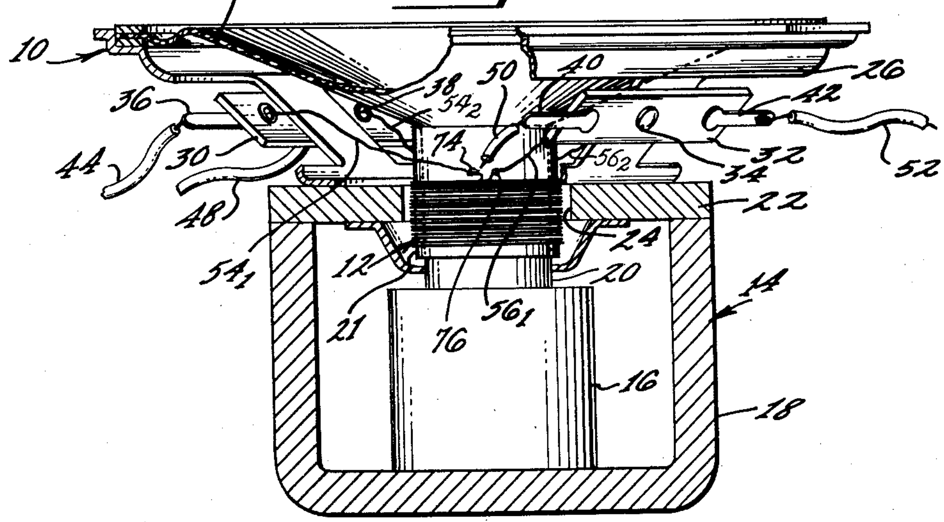


Fig. 2.

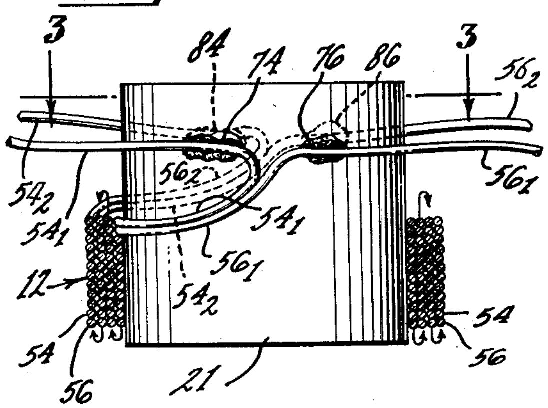
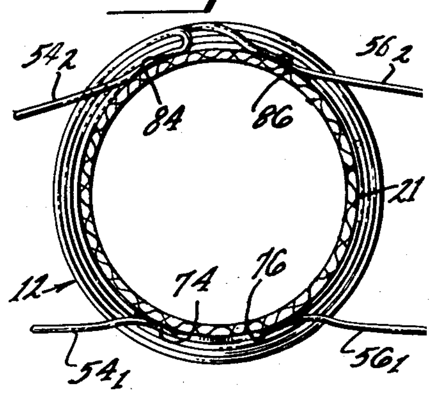


Fig. 3.



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VOICE COIL STRUCTURE

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Application March 1, 1955, Serial No. 491,253

3 Claims. (Cl. 317—158)

This invention relates to a loudspeaker voice coil structure, and more particularly to a loudspeaker voice coil structure suitable for use with driving circuits having symmetrical properties.

Certain loudspeaker voice coil driving circuits have balanced or symmetrical properties. A driving circuit utilizing transistors, for example, may have critically balanced characteristics. Transistors of the junction type have symmetrical properties. One type of symmetrical property is the complementarp characteristic of n-p-n and p-n-p transistors. A loudspeaker voice coil may be driven in push-pull operation from transistor amplifier circuits exhibiting these symmetrical properties. An example of a symmetrical circuit for driving a loudspeaker voice coil may be found in the June 1953 issue of the Proceedings of the I.R.E., Fig. 6, page 719, in an article by G. C. Sziklai entitled "Symmetrical Properties of Transistors and Their Applications."

For these symmetrical circuits to operate successfully, associated components must be balanced. This requires a voice coil winding which is electrically balanced to a high degree. Existing multiple-winding voice coils are wound in separate layers. These windings are unequal in length which may cause their resistance and mass to be accordingly unequal.

An object of this invention is to provide a loudspeaker voice coil which is electrically and mechanically balanced.

Another object is to provide a multiple-winding loudspeaker voice coil which is suitable for driving circuits having symmetrical properties.

A further object is to provide a multiple-winding loudspeaker voice coil which is suitable for push-pull operation by a symmetrical circuit which includes transistors.

In accordance with this invention a multiple-winding loudspeaker voice coil is wound in bifilar form. A pair of strands of electrically conductive wire of equal length and equal resistance are wound side by side or in juxtaposition to form a layer of a voice coil structure. Any given number of layers may be formed in this bifilar manner. The ends of the strands leading into and away from the voice coil structure may be symmetrically disposed about the axis of the voice coil structure to form a structure of balanced mass.

The novel features of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawing in which:

Fig. 1 is a view in elevation and partially in cross section of a loudspeaker including a voice coil embodying this invention in one form;

Fig. 2 is an enlarged view in elevation and partially in cross section of a portion of the embodiment shown in Fig. 1; and

Fig. 3 is a cross-sectional view taken through Fig. 2 along the line 3—3 looking in the direction of the arrows.

In Fig. 1 is shown a loudspeaker **10** incorporating a bifilar voice coil **12**. The loudspeaker **10** includes a magnetic structure **14**. This magnetic structure **14** includes

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a cylindrical permanent magnet **16**. The magnet **16** is made of a permanent magnet material, alnico for example. The permanent magnet **16** is joined to the inner base of a U-shaped yoke **18** of ferromagnetic material, sofe iron for example. A cylindrical extension **20** of permanent magnet **16** extends within the voice coil form **21** which is made of paper, for example. A pole piece **22** also of ferromagnetic material, soft iron for example, lies across the ends of the U-shaped yoke **18**. The pole piece **22** includes a central circular aperture **24** which cooperates with the permanent magnet extension **20** to form an annular air gap for the voice coil.

A frame member **26** is joined to the outer surface of pole piece **22** to provide support for the loudspeaker cone **28**. The frame may be conveniently made of press-formed sheet steel, for example. Terminal boards **30** and **32** are joined to convenient portions of frame **26**. These terminal boards are made of insulating material, fiber composition for example. The terminal boards **30** and **32** are secured to the frame **26** by steel rivets **34**. Solder-type terminal lugs **36** and **38** are provided on the terminal board **30** to provide means for connection to voice coil leads, and solder-type lugs **40** and **42** are provided on the terminal board **32** to provide means of connection to other voice coil leads. Extension leads **44** and **48** of insulated wire are respectively soldered to lugs **36** and **38** on terminal board **30**. Extension leads **50** and **52**, also of insulated wire, are respectively soldered to lugs **40** and **42** of the terminal board **32**. These leads provide means for connecting the voice coil to the output circuit of its driving means.

The voice coil is of bifilar construction. It is formed from a pair of strands **54** and **56** of electrically conductive wire. This wire may be, for example, No. 40 copper wire which is enamel insulated. These strands are continuously wound in a helical manner about a coil form **21**. The starting portions of the voice coil winding are respectively designated as leads $\mathbf{54_1}$ and $\mathbf{56_1}$. The finishing portions of the voice coil winding are respectively designated as leads $\mathbf{54_2}$ and $\mathbf{56_2}$. Leads $\mathbf{54_1}$ and $\mathbf{54_2}$ are respectively soldered to lugs **36** and **38** of terminal board **30** and coil ends $\mathbf{56_2}$ and $\mathbf{56_1}$ are respectively soldered to lugs **42** and **40** of terminal board **32**. Terminal boards **30** and **32** provide means for connecting the windings in center-tapped fashion or other forms of connection.

In Fig. 2 an enlarged view of the bifilar voice coil is shown. Coil form **21** is shown with a four layer bifilar voice coil **12** wound upon it. Strands or wires **54** and **56** are equal in length so that they have equal resistance. This balanced resistance property is required to provide the symmetrical characteristics required by transistor operated driving circuits. The wire is carefully chosen so that its resistive properties are uniform to aid in matching the impedance of one coil winding with the other. The portions of wires **54** and **56** which start the first layer in the multilayer voice coil are designated as leads $\mathbf{54_1}$ and $\mathbf{56_1}$. These ends are brought together and are respectively cemented to the paper form at points designated as **74** and **76**. Wires **54** and **56** are wound side by side, or in juxtaposition, in a helix about the voice coil form to form the bottom or innermost layer of the voice coil. Since this illustrative voice coil is a four layer winding, wires **54** and **56** are wound back over the first layer also in continuous side by side relationship to form the second, third and fourth layers of the voice coil. The wires emerge or leave the outer layer of the voice coil structure and are there designated as leads $\mathbf{54_2}$ and $\mathbf{56_2}$. Leads $\mathbf{54_2}$ and $\mathbf{56_2}$ are respectively carried in side by side relationship to points designated as **84** and **86**, respectively, where they are cemented to the coil form.

In Fig. 3, the symmetrical or balanced physical disposition of the coil leads is illustrated. Leads $\mathbf{54_1}$ and $\mathbf{56_1}$

are shown respectively cemented to points 74 and 76 on the coil form, and leads 54_2 and 56_2 are shown respectively cemented to points 84 and 86 on the voice coil form.

This bifilar voice coil structure is both electrically and mechanically balanced. It is electrically balanced because the wires making up the voice coil are equal in length and uniform in resistivity. This provides a multi-winding voice coil in which each winding is equal in resistance. The leads into the coil and away from the coil are symmetrically positioned about the axis of the voice coil. This provides a voice coil of balanced mass. The leads are maintained in side by side relationship throughout the voice coil structure. This enhances the mutual coupling between the coil windings. This balanced mass and high mutual coupling provides a coil which operates relatively free of distortion.

What is claimed is:

1. A loud speaker voice coil comprising a cylindrical coil form, a pair of strands of electrically conductive wire of equal length, both of said strands being helically wound in one direction around said form to provide a layer of single turns disposed longitudinally of said form, both of said strands being helically wound in the opposite direction along said form to provide another layer of single turns disposed longitudinally of said form and in juxtaposition with said first layer, the starting and finishing ends of said coils being disposed adjactnt to each other, the electrical resistance of said strands being subtantially equal, and means for securing the starting ends of said strands at a pair of spaced positions on the surface of said coil form, means for securing the finishing ends of said strands at another pair of spaced positions on said coil form diametrically opposite said first mentioned positions whereby said ends are symmetrically disposed to provide a voice coil structure whose mass is balanced.

2. A loud speaker voice coil comprisig a coil form, a pair of strands of electrically conductive material wound in continuous side by side relationship in an even number of layers on the surface of said coil form, both of said strands in said pair being equally distant from said surface, the length of said strands being equal, said strands having the same resistivity, and mean for securing the starting ends of said strands at a pair of spaced positions on said surface of said coil form, said positions being at substantially the same distance from one of the ends of said form, and means for securing the finishing ends of said strands at another pair of spaced positions on said coil form surface diametrically opposite the first mentioned positions, said other pair of positions being at substantially the same distance from said one end of said form whereby said ends are symmetrically disposed about said coil form to cause said voice coil to have balanced mass characteristics.

3. A bifilar loud speaker voice coil winding on a coil form comprising a pair of strands of electrically conductive wire of substantially equal lengths, said strands having a substantially equal resistance and being helically wound side by side to form an even number of coaxial cylindrical layers of turns and means for securing the starting ends of said strands at a pair of spaced positions on the surface of said coil form, and means for securing the finishing ends of said strands at another pair of spaced positions on said coil form surfact diametrically opposite said first mentioned positions, said first named positions being at substantially the same distance from one of the ends of said form, said other pair of positions being at substantially said same distance from said one end of said form whereby said ends are symmetrically disposed to each other to form a structure of balance mass.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,925,541 February 16, 1960

Winfield R. Koch

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 5, for "sofe" read -- soft --; column 4, line 22, for "surfact" read -- surface --.

Signed and sealed this 11th day of October 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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