An improvement in an electro-acoustic converter having a magnetic circuit with an air gap therein, the improvement including an air gap formed of a magnetic material laminated with a conductive layer having a comparatively higher magnetic resistance in the magnetic circuit, thereby increasing a magnetic resistance against a magnetic flux caused by a voice coil and acting the conductive layer as shorting rings to decrease the inductance of the voice coil, and thus eliminating the reproduction distortion caused by the magnetic non-linearity of the magnetic circuit.

5 Claims, 6 Drawing Figures
MAGNETIC CIRCUIT FOR AN ELECTRO-AcouSTIC CONVERTER

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to a magnetic circuit for an electro-acoustic converter such as a speaker or a microphone.

2. Description of the Prior Art
Normal magnetic material has a magnetic hysteresis loop characteristic and the relation of magnetizing force and magnetic flux density is non-linear. Therefore, when magnetic flux of a voice coil passes through a center pole and a plate near an air gap, the magnetic reaction in the voice coil results in a distorted output signal from the electro-acoustic converter such as a speaker or a microphone.

Accordingly, various methods of eliminating the distortion have been attempted, such as methods of covering a center pole (a) with a copper cap (b) as shown in FIG. 1a, putting in a copper ring (c) as shown in FIG. 1b, or making a depression on an upper surface of a center pole (a) and plating a depression with copper (d) as shown in FIG. 1c. The above-mentioned methods shown in FIGS. 1a and 1b, however, do not only require a higher level of manufacturing technique than a conventional normal magnetic circuit for making the air gap a predetermined size, but also results in decreasing the magnetic flux density within the air gap due to the substantial increase in the air gap width. When using copper ring (c), the copper ring disturbs the magnetic flux distribution in the air gap thus disturbing the output signal. In the last case shown in FIG. 1c, it is difficult to uniformly plate with sufficient thickness.

SUMMARY OF THE INVENTION

The present invention has taken notice of the aforementioned problems and eliminates the distortion caused by the magnetic circuit. The primary object of the present invention is to provide a magnetic circuit for an electro-acoustic converting device characterized in that a portion or all of the magnetic circuit elements defining an air gap have magnetically anisotropic characteristics, thereby increasing the magnetic resistance against magnetic flux caused by the voice coil and eliminating the reproduction distortion caused by the magnetic non-linearity of the magnetic circuit.

Another object of the present invention is to provide a magnetic circuit for an electro-acoustic converter which includes an air gap defined by magnetic parts of magnetic material laminated with a conductive layer so as to have the magnetically anisotropic character whereby the reproduction distortion caused by the inductance of the voice coil is sharply reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1a–1c are vertical sections of conventional magnetic circuit portions for an electro-acoustic converter.

FIGS. 2 and 3 are vertical sections of embodiments of a magnetic circuit in accordance with the present invention.

FIG. 4 is an enlarged fragmentary sectional view schematically illustrating directions of magnetic flux of a voice coil.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Explaining the present invention in accordance with the drawings, 1 is a yoke, 2 is a center pole fixed in the center of the yoke, 3 is a ring-shaped magnet, 4 is a plate fixed on the magnet, 5 is a voice coil cylinder, and 6 is a voice coil.

In the present embodiment as shown in FIGS. 2 and 3, the upper outside portion of the pole 2 and the inside portion of the plate 4 are respectively constructed with magnetic parts 7 and 8 which alternately laminate a sheet of magnetically anisotropic material or normal magnetic material 9, and a conductive layer 10 having comparatively higher magnetic resistance so as to have characteristics of magnetic anisotropy. The easy magnetizing axis and a hard magnetizing axis of the parts 7 and 8 are consequently directed at right angles and parallel to the voice coil 6, respectively.

Therefore, the magnetic flux out of the magnet 3 returns to the same magnet 3 by way of the plate 4, the easy magnetizing axis of the magnetically anisotropic part 8, the air gap, the easy magnetizing axis of the magnetically anisotropic part 7, the center pole 5 and the yoke 1. The magnetic flux for driving the speaker passes the air gap through the same path as in the conventional magnetic circuit. The total magnetic resistance of the magnetic circuit is slightly increased as compared to a conventional magnetic circuit, because the magnetic flux for driving the voice coil passes through the easy magnetizing axis of the magnetically anisotropic parts 7 and 8.

Magnetic flux caused by the voice coil 6 follows the path shown by dotted lines in FIG. 4, that is, the magnetic flux complete closed loops which pass along both hard magnetizing axes of the magnetically anisotropic parts 7 and 8. However, the magnetic flux passing the magnetically anisotropic parts is limited because of the high magnetic resistance and the magnetic saturation brought about by the small magnetic flux. Consequently, the reproduction distortion due to the magnetic non-linearity of the magnetic circuit elements decreases greatly because of the weak mutual relation of the magnetic flux of the voice coil 6 and the magnetic circuit parts. Further, since the resistance of the two directional silicon steel is higher than normal iron, the silicon steel is useful for decreasing eddy current power loss caused by the magnetic flux of the voice coil in the magnetic circuit elements. Further, the conductive layers 10 not only act as magnetic resistance members, but also act as short rings, and thus the reproduction distortion decreases because of the weak mutual relation of the inductance of the voice coil 6 and the surrounding magnetic material.

As described above, the magnetic circuit of the present invention is composed of laminated magnetic parts which increase the magnetic resistance against the magnetic flux caused by a voice coil. The sheets of the magnetically anisotropic material are oriented such that the direction of the easy magnetizing axis is the same as the direction of the magnetic flux for driving the speaker or the microphone within the air gap. Consequently, reproduction distortion is sharply reduced. Since the conductive layers are between the sheets of the magnetic material, the conductive layers function as shorting rings, the inductance of the voice coil is di-
minished and thus the reproduction distortion is further reduced.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In a magnetic circuit for an electro-acoustic converter having a magnetic circuit means with an air gap therein, the improvement comprising:
   wherein at least a portion of said magnetic circuit means includes magnetically anisotropic parts composed of a magnetic material laminated with a conductive layer means.

2. In a magnetic circuit of claim 1 wherein said magnetic material is a magnetically anisotropic material.

3. In an electro-acoustic converter comprising:
   a. a center pole;
   b. voice coil means surrounding said center pole;
   c. magnetic means surrounding said center pole and said voice coil means; and
   d. plate means fixed to said magnetic means; the improvement comprising
   e. wherein at least a portion of said center pole comprises a magnetic material laminated with conductive layer means; and
   f. wherein at least a portion of said plate means comprises a magnetic material laminated with conductive layer means.

4. The apparatus of claim 3 wherein said center pole and said plate means each are constructed with magnetically anisotropic material laminated with said conductive layer.

5. The apparatus of claim 4 wherein said at least a portion of said plate means is all of said plate means.