(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 467 016 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
08.10.1997 Bulletin 1997/41

(51) Int Cl.[6]: **H04R 9/02**

(21) Application number: **91104052.5**

(22) Date of filing: **15.03.1991**

(54) **Magnetic circuit for a speaker**

Magnetische Schaltung für Lautsprecher

Circuit magnétique pour haut-parleur

(84) Designated Contracting States:
DE FR GB

(30) Priority: **20.07.1990 JP 193277/90**
19.10.1990 JP 280773/90

(43) Date of publication of application:
22.01.1992 Bulletin 1992/04

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- **PATENT ABSTRACTS OF JAPAN vol. 11, no. 237 (E-528)4 August 1987 & JP-A-62 048 246**

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EP 0 467 016 B1

Description

The present invention relates to a magnetic circuit for a speaker used in an audio system.

Fig. 20 shows a widely used cone speaker. The speaker comprises a yoke 51 having a yoke base 53 and a cylindrical pole 52 formed on the yoke base 53, an annular top plate 54, and a magnet 55 disposed between the yoke base 53 and the top plate 54. A voice coil 56 is supported by a damper 60 and disposed in a magnetic gap G between the pole 52 and the top plate 54 so as to be movable in the direction shown by arrows a and b. A frame 57 is secured to the plate 54, and a diaphragm 59 is provided between an edge 58 of the frame 57 and the voice coil 56. Reference numeral 61 designates a terminal and 62 is a lead.

Referring to Fig. 21, the magnetic circuit is formed by the yoke 51, magnet 55 and plate 54, each of which has a rectangular cross section. Consequently, the necessary magnetic efficiency of magnetic flux ϕD in the gap G is reduced by leakages of magnetic fluxes ϕA, ϕB and ϕC.

Furthermore, no effective measure is taken to prevent any leakage of magnetic flux. Although the periphery of the magnet 55 serves as a magnetic guard against the magnetic flux ϕA, upper and lower corners of the magnet have a small guarding effect.

Japanese Utility Model Publication 46-8272 discloses a magnetic circuit for a speaker intended to prevent the reduction of the magnetic efficiency.

Fig. 22 shows the magnetic circuit disclosed in the publication. The yoke base 53 has a tapered underside 64 which serves to reduce the leakage of the magnetic flux ϕA and ϕB. However, the tapered yoke base 64 has only a small effect to increase the magnetic efficiency at the gap G.

The United States Patent US-A-4 386 332 discloses a similar magnetic circuit for a dynamic speaker. The circuit comprises an annularly-shaped magnet having the back plate of a yoke coupled to a first surface of the magnet. The yoke has a center pole extending from a central portion of the back plate passing through a hole in the annular magnet. The magnet circuit further comprises an annular top plate coupled to a second surface of the magnet, where an air gap is provided between the top plate and the center pole.

An object of the present invention is to provide a magnetic circuit for a speaker which may increase its magnetic efficiency, thereby improving tone quality of the speaker.

Another object of the present invention is to provide a magnetic circuit which is light in weight and may be manufactured at low cost.

According to the present invention, there is provided a magnetic circuit as defined in claim 1.

In an embodiment of the invention, the magnet has a periphery having an outwardly curved sectional shape.

The magnet, yoke base and top plate may all have peripheries having outwardly curved sectional shapes respectively.

In another embodiment, at least one of the yoke base and the top plate has the inwardly curved periphery.

The magnet according to another embodiment may have a periphery having a sectional shape combining straight lines.

Other objects and advantages of this invention will become understood from the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a sectional view showing a magnetic circuit according to an embodiment of the present invention;
Fig. 2 is a sectional view of a second embodiment;
Figs. 3 is a sectional view showing a third embodiment;
Fig. 4 is an illustration showing lines of the magnetic force generated in the first embodiment;
Fig. 5 is an illustration showing lines of the magnetic force generated in the conventional magnetic circuit;
Figs. 6, 7a and 7b are sectional views showing modifications of the sectional shape;
Fig. 8 is a sectional view of a fourth embodiment;
Fig. 9 is a sectional view showing a modification of the fourth embodiment;
Fig. 10 is a sectional view for explaining effects of tapered portions;
Fig. 11 is an illustration showing lines of the magnetic force generated in the magnetic circuit of Fig. 9;
Fig. 12 is a table for comparing performance and weight of the magnetic circuit of Fig. 9 with conventional magnetic circuits;
Fig. 13 to 19 are sectional views showing fifth to eleventh embodiments of the present invention;
Fig. 20 is a sectional view showing a conventional cone speaker;
Figs. 21 and 22 are sectional views showing sectional shapes of magnetic circuits in prior arts.

Referring to Fig. 1, the magnetic circuit according to the present invention comprises a yoke 1 having a yoke base 2 and a cylindrical pole 3 having an aperture 3a, an annular magnet 4 mounted cn the yoke base 2, and an annular top plate 5. The magnet 4 is secured to the yoke base 2 with adhesive, and the top plate 5 is also secured to the magnet with adhesive. The magnetic circuit has a compressed spherical periphery. Namely, the yoke base 2 has a convex periphery 2a and the top plate 5 also has a convex periphery 5a, and the periphery 4a of the magnet 4 has an outwardly curved sectional shape.

In the magnetic circuit shown is Fig. 2, a solid pole 6 is formed on the yoke base 2. The yoke base 2 of the third embodiment shown in Fig. 3 has an annular recess 7 on the inside wall thereof, for allowing large axial movement of the voice coil, which is designed to be used for the woofer. A pole piece 8 is mounted on the pole 3.

Referring to Fig. 4 showing lines of magnetic force generated in the magnetic circuit of Fig. 1, most of magnetic lines gl of force generated from the north pole of the magnet 4 enter in the plate 5 and are led to the gap G as magnetic flux g2. Magnetic flux g3 in the gap G is induced in the pole 3 and the yoke base 2 as magnetic flux g4 and led to the south pole of the magnet 4.

Since the periphery of the magnet has an outwardly curved sectional shape, the magnetic flux gl in the magnet 4 is led to the plate 5 along the periphery. Consequently, magnetic flux density is high in the gap G as indicated by the equal magnetic flux density contours L1~L4. On the other hand, leakages ϕ1 and ϕ2 of magnetic flux outside the magnet 4, plate 5 and yoke 2 are low in density.

To the contrary, the conventional magnetic circuit has a low magnetic flux density in the gap G and a large leakage ϕ1 and ϕ2 of magnetic flux as shown in Fig. 5.

In a magnetic circuit according to the first embodiment having a magnet radius of 65 mm, a maximum magnetic flux density in the gap G is 1,312 tesla. In the conventional magnetic circuit of Fig. 21 having the same magnetic radius as the first embodiment, a maximum magnetic flux density in the gap G is 1,309 tesla, because of a large amount of the leakage ϕA and the leakage ϕC of the magnetic flux from the plate 54 to the pole 52.

In addition, the weight of the magnetic circuit of the present invention is reduced by 20 % of the weight of the conventional magnetic circuit, since edges of the yoke base 2, magnet 4 and plate 5 are rounded. Accordingly, expensive magnetic material is reduced in quantity to lower the manufacturing cost thereof. Furthermore, the magnetic flux density in the magnet 4 is more equalized, so that reduction of magnetization at low temperature is prevented.

Although each of the peripheries of the magnetic circuits of Figs. 1 to 3 has a continuously curved sectional shape, a discontinuous periphery may be employed as shown in Figs. 6, 7a and 7b.

Each of the magnetic circuit of Figs. 1 to 3 is a solid of revolution about a center line ℓ. However, another magnetic circuit having a square shape or ellipse shape in plan view may be used in embodying the present invention, too.

Referring to Fig. 8 showing the fourth embodiment, the periphery of a yoke base 17 of yoke 15 has a tapered surface 17a, and a top plate 18 has a tapered surface 18a. A solid pole 16 is formed on the yoke 15. Each of the tapered surfaces 17a and 18a is inwardly curved.

Since the outer periphery of the tapered surface 17a (18a), which has a circular shape in section, has a small thickness, leakage ϕB from the circular periphery can be prevented or reduced to a very small amount.

Fig. 9 shows a most preferable tapered surface. The periphery of each of the yoke base 17 and the top plate has no circular sectional shape. Namely, the inwardly curved surface converges on the surface of a magnet 19.

The magnetic flux and dimension of the magnetic circuit of Fig. 9 will be described with reference to Fig. 10. In the figure, X1 designates the outer radius of the magnet 19, X2 represents the inner radius, X3 the radius of the pole 16. Thickness t of the yoke base 17 at which inner magnetic flux density Bi becomes constant will be obtained as described hereinafter. Here it is assumed that all of the magnetic flux in the magnet 19 flows in the yoke 15, hence there is no leakages ϕA and ϕB.

1. When $X2 \leqq X \leqq X1$, magnetic flux between X and X1 is

$$\phi m(X)=\pi(X1^2-X^2)Bm.$$

Magnetic flux in the tapered portion of the yoke base 17 is

$$\phi i(X)=2\pi \cdot X \cdot t \cdot Bi\ .$$

Since $\phi m=\phi i$,

$$\pi(X1^2-X^2)Bm=2\pi \cdot X \cdot t \cdot Bi\ .$$

Therefore

$$t(X)=(X1^2-X^2)Bm/(2X \cdot Bi).$$

When $X3 \leqq X \leqq X2$, magnetic flux between X and X1 is

$$\phi m(X)=\pi(X1^2-X2^2)Bm\ .$$

Magnetic flux in the tapered portion of the yoke base 17 is

$$\phi i(X)=2\pi \cdot X \cdot t \cdot Bi\ .$$

Therefore

$$t(X)=(X1^2-X2^2)Bm/(2X \cdot Bi)\ .$$

When X=X1,

$$dt(X)/dX=Bm/(2Bi) \cdot (-x1^2/X^2-1)$$

$$dt(X)/dt(X=X1)=-Bm/Bi\ .$$

These are the conditions which define the dimensions of the yoke base.

The following is the analysis of these conditions.

When $X2 \leqq X \leqq X1$,

$$t(X)=(c1/X)-c2\cdot X$$

(c1 and c2 are constants).

Consequently, the tapered portion of the yoke base becomes an inwardly curved sectional shape.

When $X3 \leqq X \leqq X2$,

$$t(X)=c3/X\ .$$

(c3 is a constant)

Therefore, in this case also, the tapered portion becomes inwardly curved.

The above values are obtained on the assumption that the leakage of the magnetic flux ϕA does not exist. Actually a part of the flux does not pass through the pole 16 because of the leakage ϕA. Therefore, the value of the increasing rate of the thickness t is smaller than the above equations. However, the conditions for forming an inwardly curved sectional shape do not change. This is confirmed by numerical calculation, for example by the finite element method.

The above theory is also applied to the tapered portion of the plate 18.

Fig. 11 shows a distribution of the magnetic flux in the magnetic circuit of Fig. 9. The same references as in Fig. 4 are used.From the figure, it will be understood that a high density of magnetic flux is obtained in the gap G.

Fig. 12 shows magnetic flux densities and weight of prior arts 1 and 2 and the present invention. In the table, Bg represents the averaged magnetic flux density in the gap G, ϕg is the magnetic flux in the gap, and ϕm is a total magnetic flux in the magnet. It will be seen that the magnetic flux density of the present invention is higher than in the prior arts 1 and 2 and the magnetic circuit of the present invention is lighter than the prior arts in weight.

The magnetic circuit of Fig. 13 has a recess 16a in the underside of the pole 16 in order to reduce the weight thereof.

In the sixth embodiment shown in Fig. 14, an additional recess 16b is formed in the upperside of the pole 16 so as to further reduce the weight. Since each of the recesses 16a and 16b has a curved inner surface, leakage of magnetic flux therefrom can be reduced.

The magnetic circuit of Fig. 15 has a perforation 16c in the pole 16.

The magnet 19 of the magnetic circuit shown in Fig. 16 has an outwardly curved sectional shape similar to the first embodiment of Fig. 1.

Figs. 17 to 19 show various sectional shapes of the magnet circuit, wherein the magnet can have a periphery shaped as adjoining straight lines so as to project outwardly, for example a periphery of trapezoidal sectional shape.

While the presently preferred embodiments of the present invention have been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as defined in the claims.

Claims

1. A magnetic circuit for a speaker having a yoke base (2; 17), a cylindrical pole piece (3; 16) formed on the yoke base (2; 17), an annular magnet (4; 19) mounted on the yoke base (2; 17) and an annular top plate (5; 18) mounted on the magnet (4; 19) so as to form a gap G between the inside wall of the top plate (4; 19) and the opposed outer wall of the cylindrical pole piece (3; 16);
characterized in that a longitudinal cross-section containing the center line (*1*) of at least one of the yoke base (2; 17), the magnet (4; 19) and the top plate (5; 18) has a curved periphery (2a, 4a, 5a, 11a, 11b, 11c, 17a, 18a, 19a).

2. The magnetic circuit according to claim 1, wherein the curved periphery (2a, 4a, 5a) is outwardly curved.

3. The magnetic circuit according to claim 1, wherein the curved periphery (17a, 18a) is at least partially inwardly curved.

4. The magnetic circuit according to claim 2, wherein the cross-section of the magnet (4) has an outwardly curved periphery (4a).

5. The magnetic circuit according to claim 2, wherein the cross-section of the magnet (4) and one of the yoke base (2) and top plate (5) have outwardly curved peripheries (4a, 2a, 5a).

6. The magnetic circuit according to claim 2, wherein the cross-section of the magnet (4), the yoke base (2) and the top plate (5) have outwardly curved peripheries (4a, 2a, 5a).

7. The magnetic circuit according to claim 3, wherein the cross-section of at least one of the yoke base (17) and the top plate (18) has the at least partially inwardly curved periphery (17a, 18a).

8. The magnetic circuit according to claim 7, wherein the cross-section of one of the yoke base (17) and the top plate (18) has a circular periphery at its outer portion adjacent to the magnet.

9. The magnetic circuit according to claim 7, wherein the inwardly curved periphery (17a, 18a) converges to a surface of the magnet (19).

10. The magnetic circuit according to claim 7, wherein the cross-section of the magnet (19) has an outwardly curved periphery.

11. The magnetic circuit according to claim 7, wherein the cross-section of the magnet (19) has a periphery shaped as adjoining straight lines so as to project outwardly.

Patentansprüche

1. Magnetkreis für einen Lautsprecher, der folgendes aufweist:

   - eine Jochbasis (2; 17),
   - einen zylindrischen Polschuh (3; 16), der an der Jochbasis (2; 17) ausgebildet ist,
   - einen ringförmigen Magneten (4; 19), der an der Jochbasis (2; 17) angebracht ist, und
   - eine ringförmige obere Platte (5; 18), die an dem Magneten (4; 19) angebracht ist,

   wobei diese Teile einen Spalt G zwischen der inneren Wand der oberen Platte (4; 19) und der gegenüberliegenden äußeren Wand des zylindrischen Polschuhs (3; 16) bilden;
   dadurch gekennzeichnet,
   daß ein Längs-Querschnitt, der die Mittellinie (1) von wenigstens einem von der Jochbasis (2; 17), dem Magneten (4; 19) und der oberen Platte (5; 18) enthält, eine gekrümmte Peripherie (2a, 4a, 5a, 11a, 11b, 11c, 17a, 18a, 19a) hat.

2. Magnetkreis nach Anspruch 1,
   wobei die gekrümmte Peripherie (2a, 4a, 5a) nach außen gekrümmt ist.

3. Magnetkreis nach Anspruch 1,
   wobei die gekrümmte Peripherie (17a, 18a) wenigstens teilweise nach innen gekrümmt ist.

4. Magnetkreis nach Anspruch 2,
   wobei der Querschnitt des Magneten (4) eine nach außen gekrümmte Peripherie (4a) hat.

5. Magnetkreis nach Anspruch 2,
   wobei die Querschnitte von dem Magneten (4) und einer von der Jochbasis (2) oder der oberen Platte (5) nach außen gekrümmte Peripherien (4a, 2a, 5a) haben.

6. Magnetkreis nach Anspruch 2,
   wobei die Querschnitte des Magneten (4), der Jochbasis (2) und der oberen Platte (5) nach außen gekrümmte Peripherien (4a, 2a, 5a) haben.

7. Magnetkreis nach Anspruch 3,
   wobei der Querschnitt von wenigstens einer von der Jochbasis (17) und der oberen Platte (18) eine wenigstens teilweise nach innen gekrümmte Peripherie (17a, 18a) hat.

8. Magnetkreis nach Anspruch 7,
   wobei der Querschnitt von wenigstens einer von der Jochbasis (17) oder der oberen Platte (18) in seinem äußeren, an den Magneten angrenzenden Bereich eine kreisförmige Peripherie hat.

9. Magnetkreis nach Anspruch 7,
   wobei die nach innen gekrümmte Peripherie (17a, 18a) zu einer Oberfläche des Magneten (19) konvergiert.

10. Magnetkreis nach Anspruch 7,
    wobei der Querschnitt des Magneten (19) eine nach außen gekrümmte Peripherie hat.

11. Magnetkreis nach Anspruch 7,
    wobei der Querschnitt des Magneten (19) eine Peripherie hat, die in ihrer Form von aneinander angrenzenden Geraden gebildet wird, derart, daß diese nach außen vorstehen.

Revendications

1. Circuit magnétique pour un haut-parleur ayant une base de culasse (2 ; 17), une pièce polaire cylindrique (3 ; 16) formée sur la base de culasse (2 ; 17), un aimant annulaire (4 ; 19) monté sur la base de culasse (2 ; 17) et une plaque sommitale annulaire (5 ; 18) montée sur l'aimant (4 ; 19) de façon à former un intervalle G entre la paroi intérieure de la plaque sommitale (4 ; 19) et la paroi extérieure opposée de la pièce polaire cylindrique (3 ; 16) ;
   caractérisé en ce qu'une section transversale longitudinale contenant la ligne centrale (1) d'au moins l'un de la base de culasse (2 ; 17), de l'aimant (4 ; 19) et de la plaque sommitale (5 ; 18) a une périphérie incurvée (2a, 4a, 5a, 11a, 11b, 11c, 17a, 18a, 19a).

2. Circuit magnétique selon la revendication 1, dans lequel la périphérie incurvée (2a, 4a, 5a) est incurvée vers l'extérieur.

3. Circuit magnétique selon la revendication 1, dans lequel la périphérie incurvée (17a, 18a) est au moins partiellement incurvée vers l'intérieur.

4. Circuit magnétique selon la revendication 2, dans lequel la section transversale de l'aimant (4) a une périphérie incurvée vers l'extérieur (4a).

5. Circuit magnétique selon la revendication 2, dans lequel la section transversale de l'aimant (4) et de l'une de la base de culasse (2) et de la plaque sommitale (5) ont des périphéries incurvées vers l'extérieur (4a, 2a, 5a).

6. Circuit magnétique selon la revendication 2, dans lequel les sections transversales de l'aimant (4), de la base de culasse (2) et de la plaque sommitale (5) ont des périphéries incurvées vers l'extérieur (4a, 2a, 5a).

7. Circuit magnétique selon la revendication 3, dans lequel la section transversale d'au moins l'une de la base de culasse (17) et de la plaque sommitale (18) a une périphérie incurvée au moins partiellement vers l'intérieur (17a, 18a).

8. Circuit magnétique selon la revendication 7, dans lequel la section transversale de l'une de la base de culasse (17) et de la plaque sommitale (18) a une périphérie circulaire au niveau de sa portion extérieure adjacente à l'aimant.

9. Circuit magnétique selon la revendication 7, dans lequel la périphérie incurvée vers l'intérieur (17a, 18a) converge vers une surface de l'aimant (19).

10. Circuit magnétique selon la revendication 7, dans lequel la section transversale de l'aimant (19) a une périphérie incurvée vers l'extérieur.

11. Circuit magnétique selon la revendication 7, dans lequel la section transversale de l'aimant (19) a une périphérie formée par des lignes droites se rejoignant de façon à se projeter vers l'extérieur.

FIG. 1

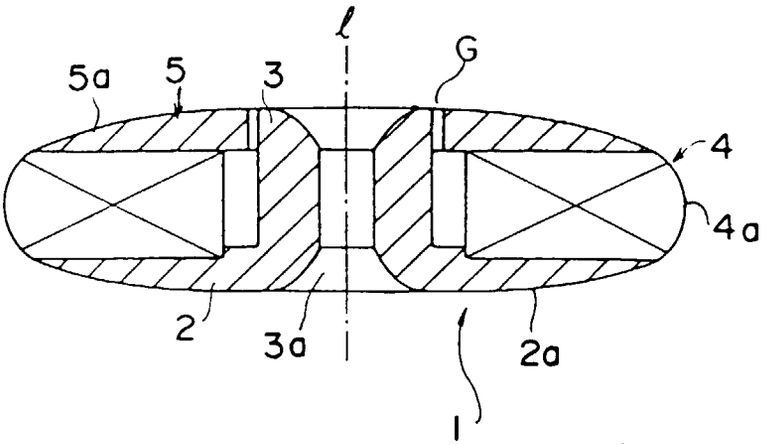


FIG. 2

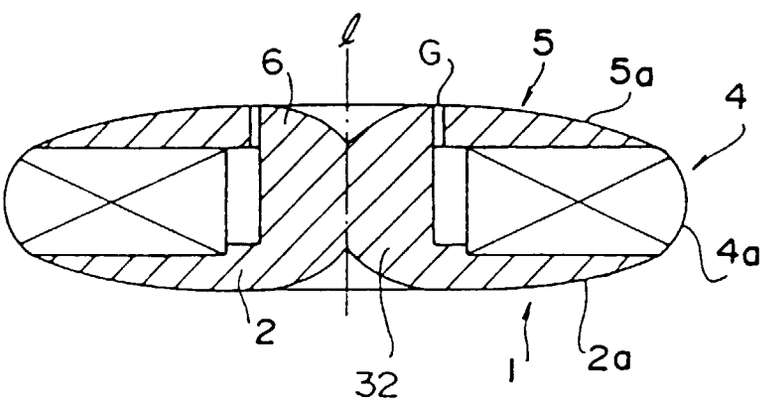


FIG. 3

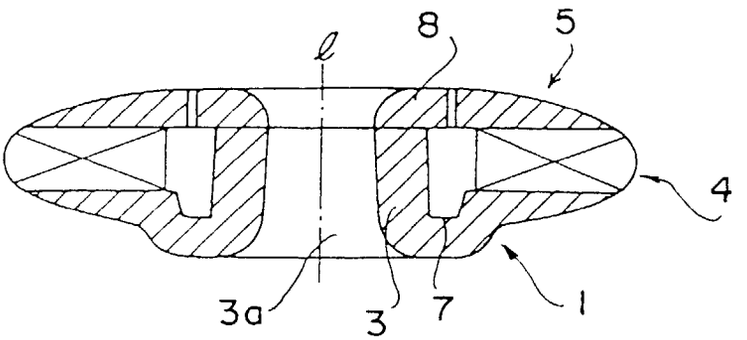


FIG. 4

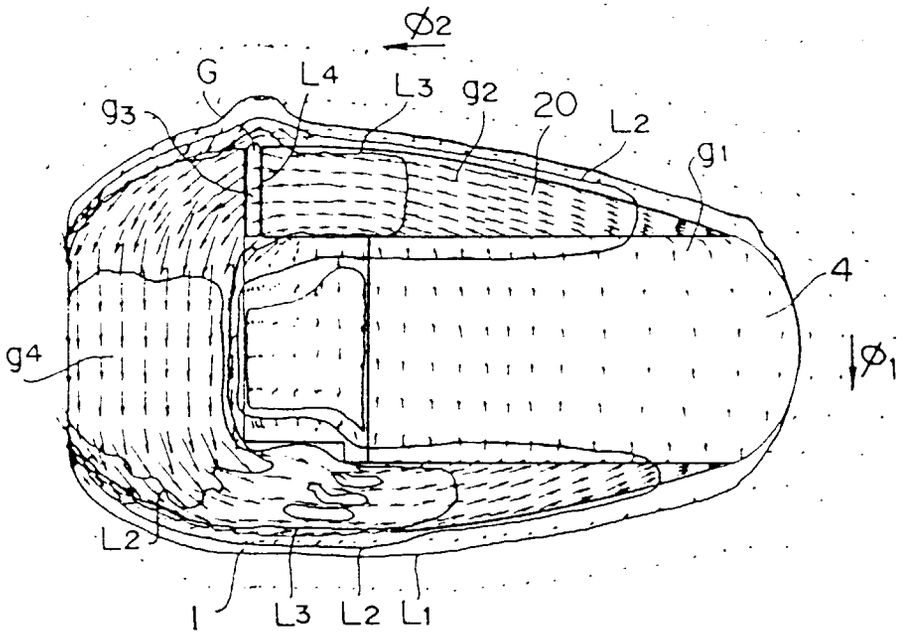


FIG. 5

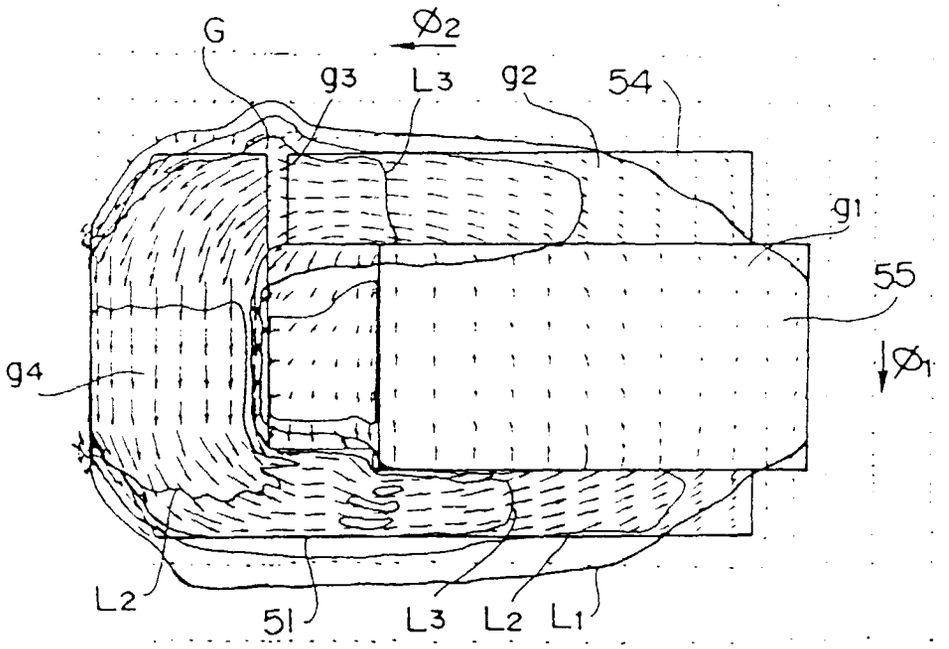


FIG. 6

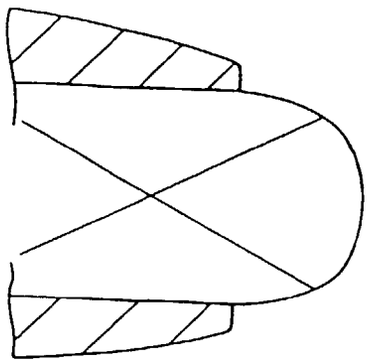


FIG. 7a

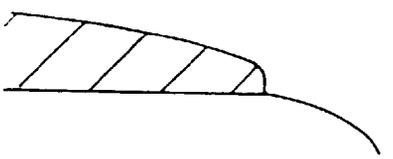


FIG. 7b

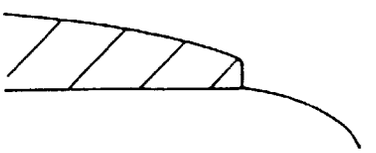


FIG. 8

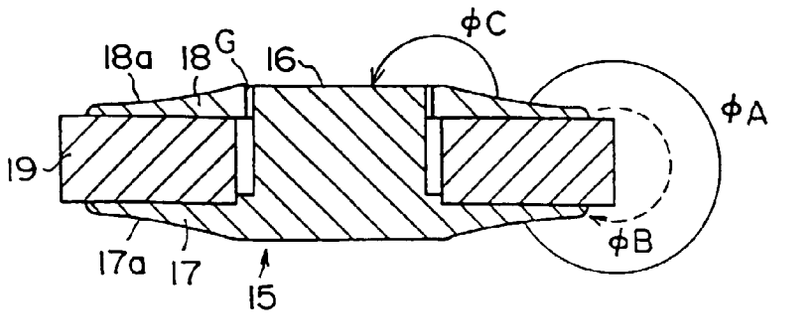


FIG. 9

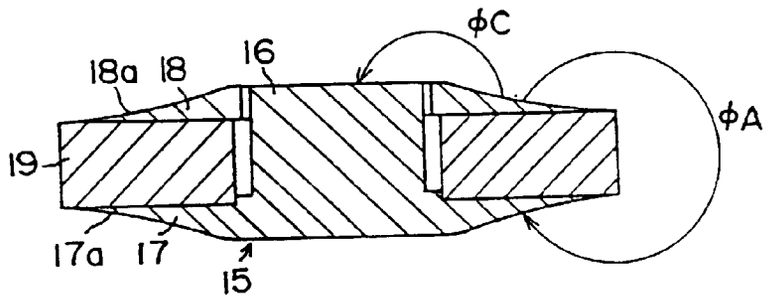


FIG. 10

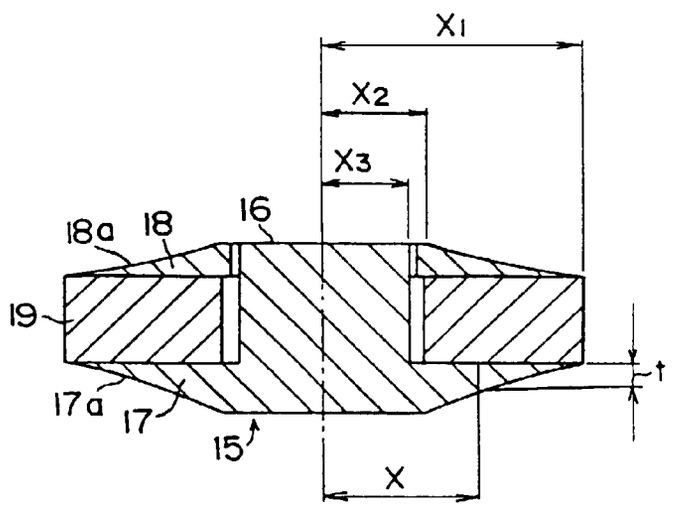


FIG. 11

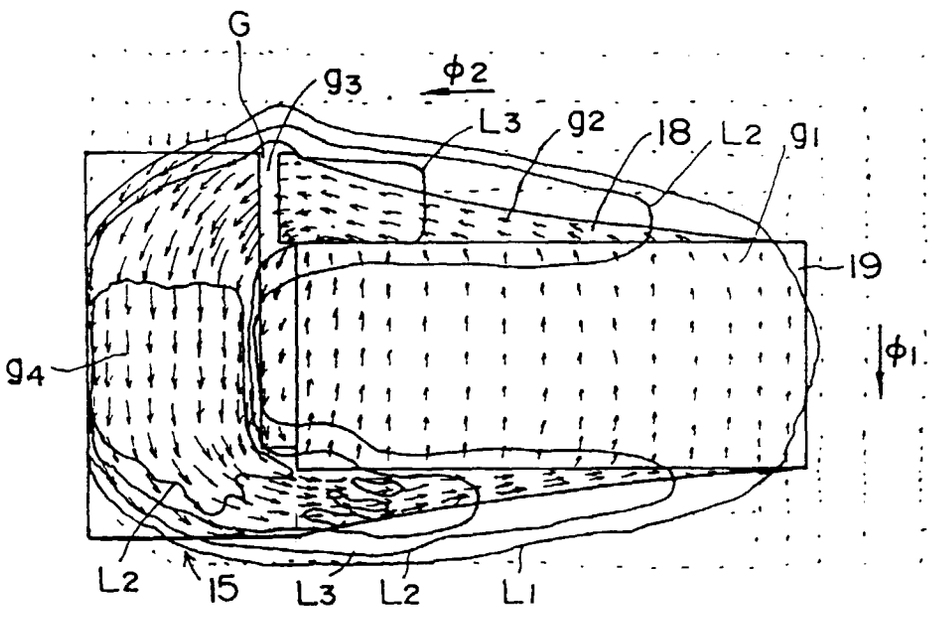


FIG. 12

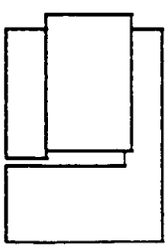
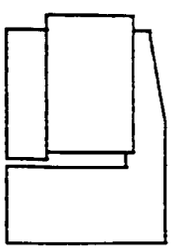
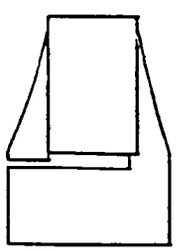
		Bg(T)	φg/φm (%)	YOKE WEIGHT (g)	PLATE WEIGHT (g)	MAGNET WEIGHT (g)	TOTAL WEIGHT (g)
PRIOR ART 1		1. 226	41. 57	124. 2	77. 0	138. 2	339. 4
PRIOR ART 2		1. 236	42. 08	105. 7	77. 0	138. 2	320. 9
PRESENT INVENTION		1. 244	44. 82	78. 9	31. 7	132. 0	242. 6

FIG. 13

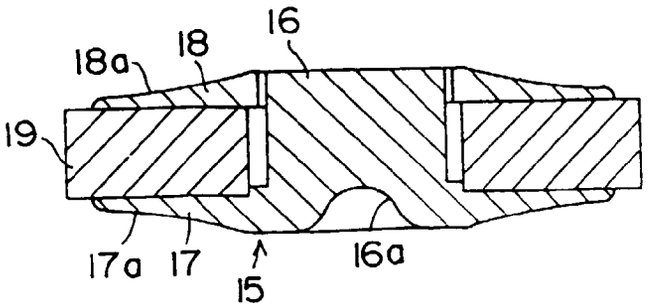


FIG. 14

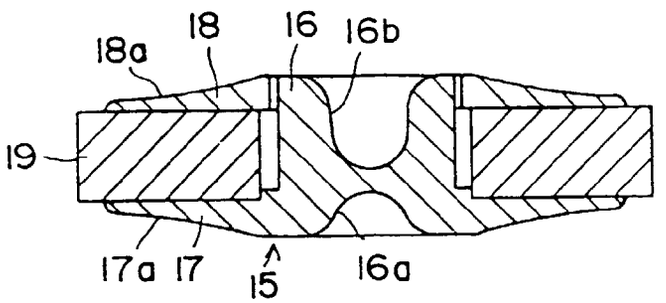


FIG. 15

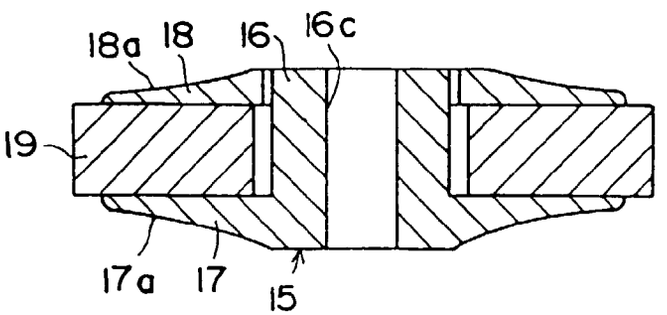


FIG. 16

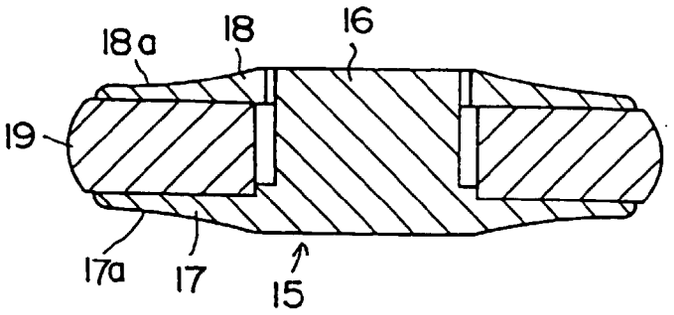


FIG. 17

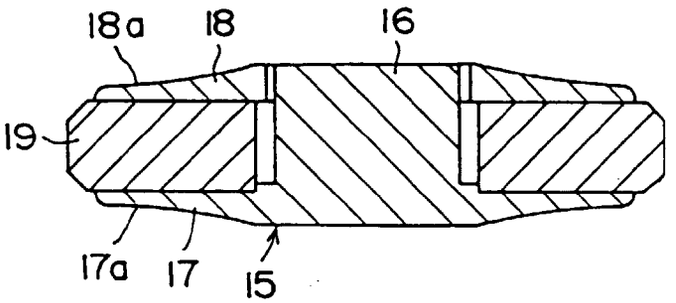


FIG. 18

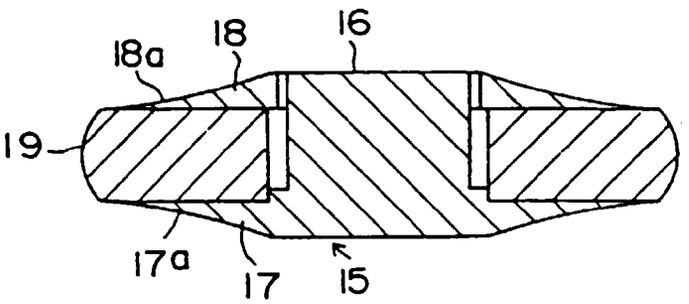


FIG. 19

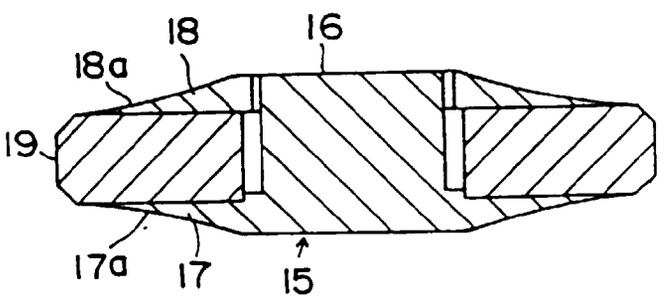


FIG. 20

PRIOR ART

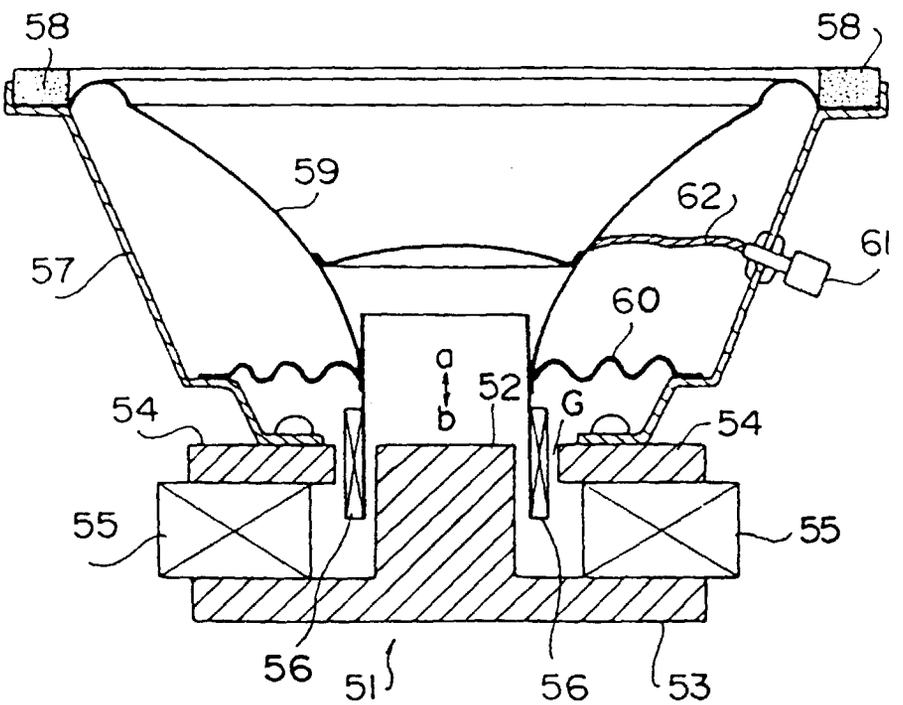


FIG. 21

PRIOR ART

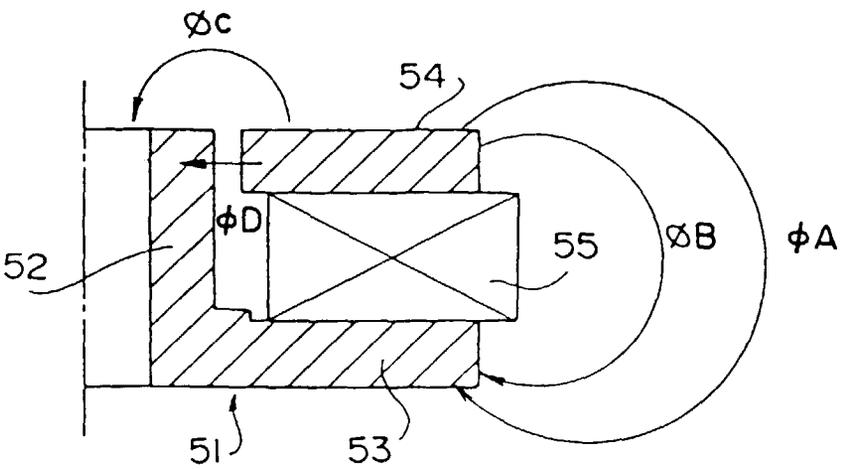


FIG. 22

PRIOR ART

