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Kohara et al.

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[54] **LOUDSPEAKER**

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[73] Assignee: **Foster Electric Co., Ltd.,** Tokyo, Japan

[21] Appl. No.: **68,180**

[22] Filed: **May 28, 1993**

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[5] **H04R 25/00**
[52] **U.S. Cl.** **381/199**; 381/194; 381/196; 381/193
[58] **Field of Search** 381/195, 199, 201, 202, 381/194, 196, 193

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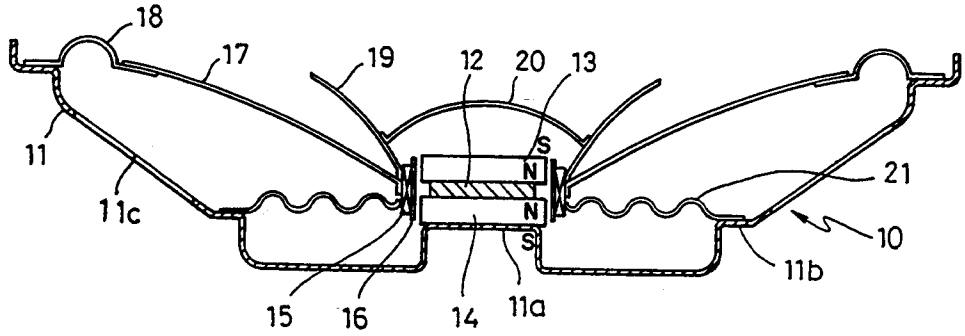
Primary Examiner—Curtis Kuntz
Assistant Examiner—Sinh Tran
Attorney, Agent, or Firm—Leydig, Voit & Mayer

[57] **ABSTRACT**

A loudspeaker has two magnets disposed directly with respect to voice coils for generating a repulsion magnetic field at the voice coils, without interposition of yoke but with mutually repulsing magnetic polarities of the magnets, and a diaphragm directly coupled at inner peripheral edge substantially to the center of outer periphery of the voice coils. Driving force is transmitted highly efficiently from the voice coils to the diaphragm, and the loudspeaker can be sufficiently minimized in the thickness and weight.

1 Claim, 3 Drawing Sheets



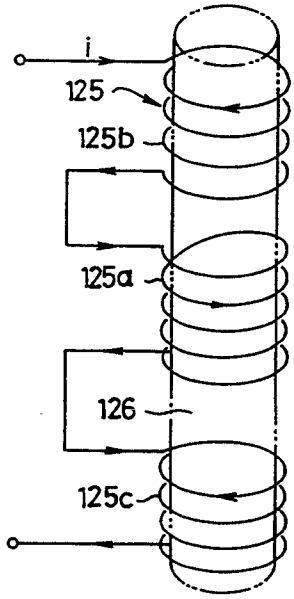


FIG. 1

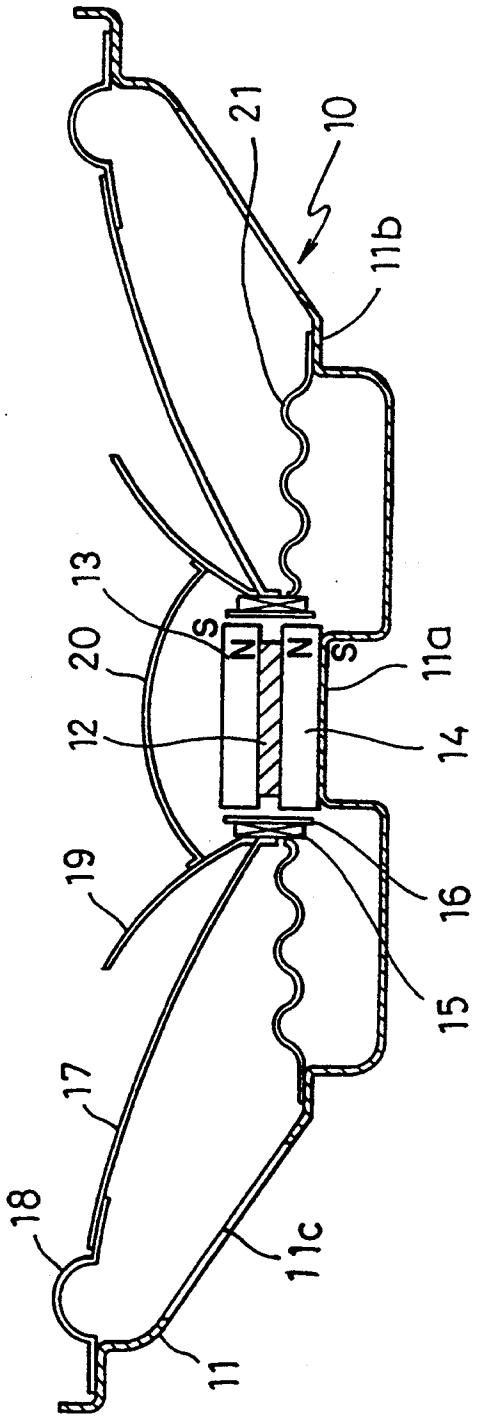
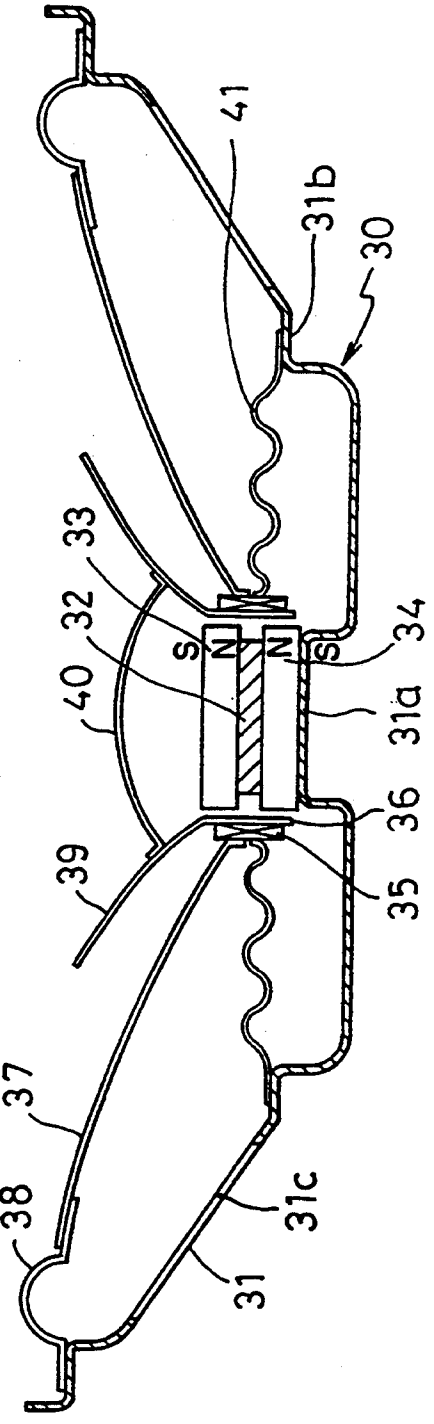

21
10
11b
13
S
N
N
S
20
11a
12
14
19
16
15
17
18
11c
11

FIG. 2


41
31b
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S
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34
40
31a
36
39
35
37
38
31c
31

FIG. 3

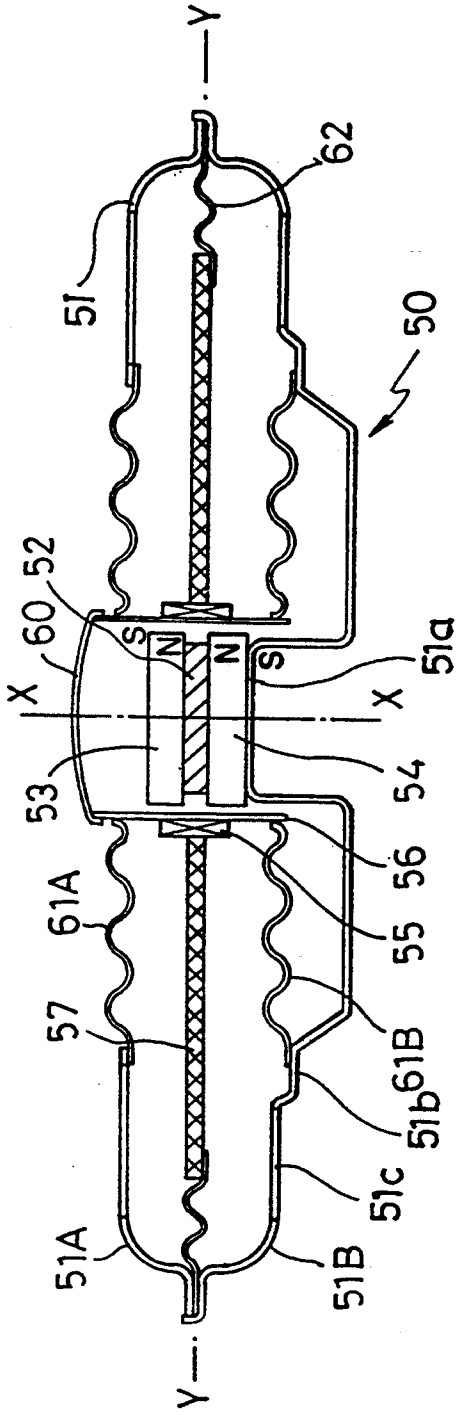
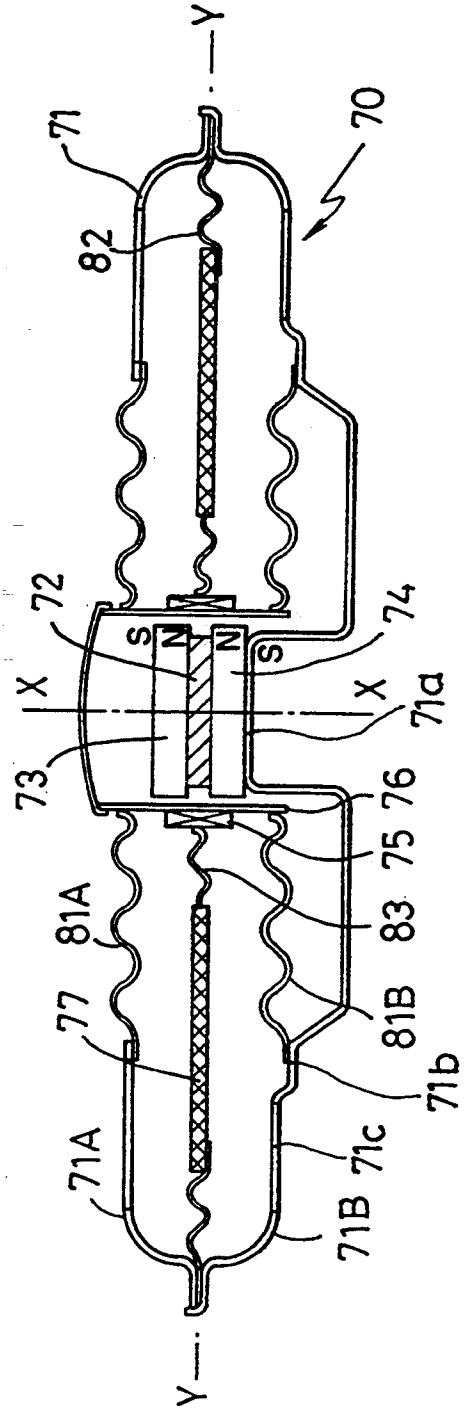

Y
62
51
50
52
60
S
N
N
S
51a
X
X
53
54
56
55
61A
57
61B
51b
51c
51A
51B
Y

FIG. 4


Y
71
70
82
72
S
N
N
S
74
X
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71a
73
76
75
83
81A
77
81B
71b
71A
71c
71B
Y

FIG. 5

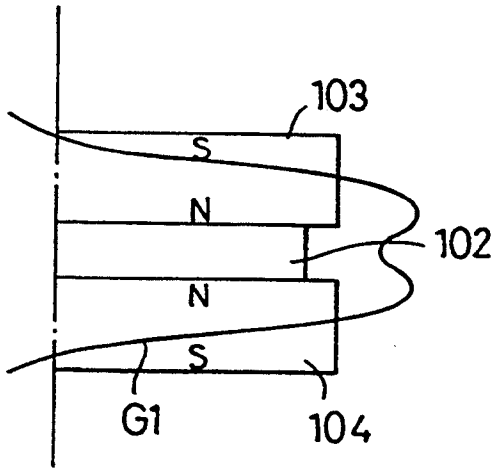


FIG. 6

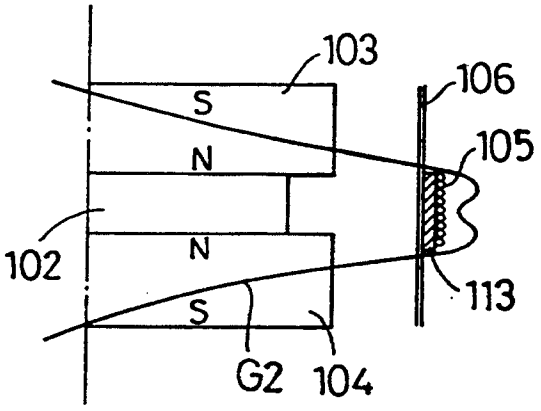


FIG. 7

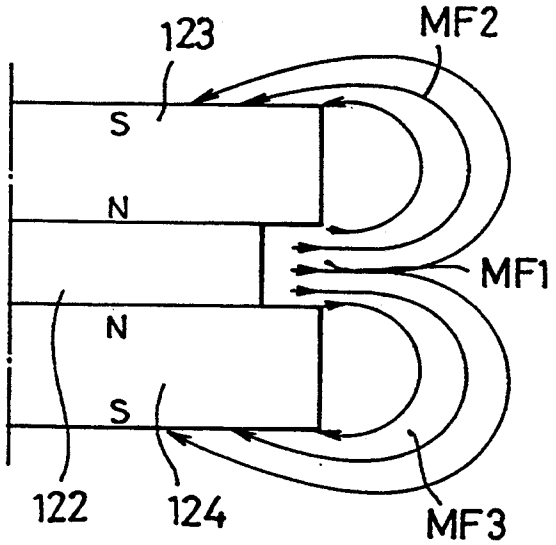
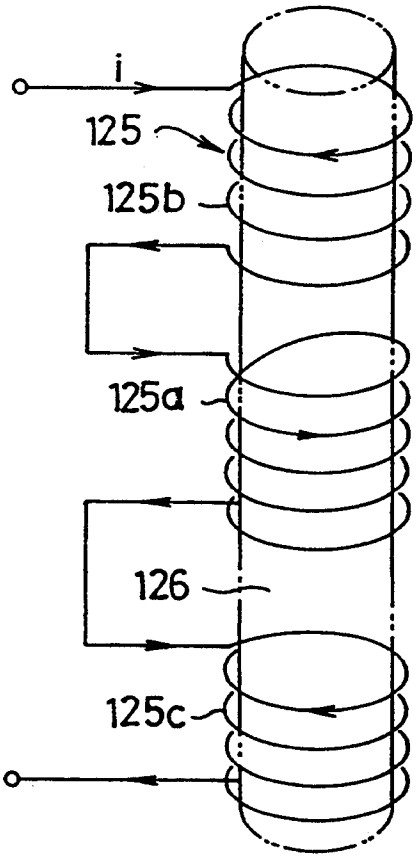


FIG. 8



LOUDSPEAKER

BACKGROUND OF THE INVENTION

This invention relates to loudspeakers and, more particularly, to a loudspeaker made to be thin and light with a repulsion magnetic field utilized.

DESCRIPTION OF RELATED ART

For known loudspeaker of the kind referred to, there may be enumerated ones described in Japanese Patent Publication No. 40-25922 by S. Morita, Japanese Utility Model Publication No. 2-30957 by U. Kawano, and so on, in which known loudspeakers a spacer is employed in combination with thin disk-shaped or ring-shaped permanent magnets disposed on both surfaces of the spacer to oppose their surfaces of the same polarity, so that the entire arrangement can be minimized in the thickness and weight. Further, a report titled "An Ultralight Loudspeaker With Repulsion Magnetic Field Applied" by H. Kumakura et al in JAS Conference '92 Appointed Theses, published by Nippon K. K. Kenwood, discloses a technical matter realizing the light weight loudspeaker by means of the repulsion magnetic field utilized.

In the loudspeaker of the kind referred to, generally, it has been demanded that the thinness and lightness are promoted after achieving high and sufficient improvements in the transmission efficiency of the driving force from the voice coils to the diaphragm and in the reproduced tone quality. At the foregoing known technical level, however, there has been shown no technique contributive enough for improving the driving force transmission efficiency from the voice coils to the diaphragm but only an arrangement in which the voice coils themselves or the voice coils and the diaphragm are mutually coupled through a transmission member interposed between them, so as to be the cause of a problem rendering transmission loss rather remarkable. Further, a supporting structure for the voice coils so far employed has been in the form of a so-called rolling mechanism, in which the voice coils cannot be supported at their center point, and generally the structure has involved a problem in highly improving the tone quality. For the field system with respect to the diaphragm, further, there has been employed an aspect still employing an outer yoke, i.e., a ring yoke, and this has been a restriction imposed on the thickness minimization.

SUMMARY OF THE INVENTION

Accordingly, a primary object of the present invention is to provide a loudspeaker which is capable of remarkably improving the transmission efficiency of the driving force from the voice coils to the diaphragm, effectively removing any influence of the known rolling mechanism for the voice coils, with any outer yoke made omittable while highly improving the tone quality, and sufficiently achieving the minimization in the thickness and weight.

According to the present invention, this primary object can be realized by means of a loudspeaker in which a pair of permanent magnets are disposed to mutually repulse in the magnetic polarity for forming a repulsion magnetic field in the center of a frame, voice coils wound on a coil bobbin are disposed within this repulsion magnetic field, and the voice coils are supported with respect to the frame by a supporting means

wherein the pair of magnets are disposed directly with respect to the voice coils for generating the repulsion magnetic field in a yoke-less manner, and a diaphragm is directly coupled at inner peripheral edge substantially to the center of outer periphery of the voice coils.

With the above yoke-less arrangement, the loudspeaker of the present invention can be sufficiently contributive to the minimization in the thickness and weight, while the direct coupling of the voice coils to the diaphragm can remarkably reduce any drive-force transmission loss to remarkably improve the transmission efficiency, and the supporting of the voice coils at the center of the outer periphery thereof can restrain any influence of the rolling mechanism.

Other objects and advantages of the present invention shall be made clear as the description of the invention advances with reference to preferred embodiments shown in accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertically sectioned view of the loudspeaker in an embodiment according to the present invention;

FIG. **2** shows in a vertically sectioned view another embodiment of the loudspeaker according to the present invention;

FIGS. **3** and **4** also show in vertically sectioned views further embodiments of the loudspeaker according to the present invention;

FIG. **5** is an explanatory view for the operation of magnetic circuit in the respective embodiments of FIGS. **1** to **4**;

FIG. **6** is an explanatory view for a further embodiment of the present invention;

FIG. **7** is an explanatory view for the magnetic field in the respective embodiments in FIGS. **1** through **4**; and

FIG. **8** is an explanatory view for still another embodiment of the present invention.

While the present invention should be described with reference to the respective embodiments shown in the accompanying drawings, it should be appreciated that the intention is not to limit the present invention only to these embodiments shown but rather to include all alterations, modifications and equivalent arrangements possible within the scope of appended claims.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, there is shown an embodiment of the loudspeaker according to the present invention, in which a loudspeaker **10** comprises a generally dish-shaped frame **11** having in the central part a support mound **11***a* bulged from a bottom flat part, a support step **11***b* made substantially at an intermediate position of peripheral side part, and sound holes **11***c* made in the peripheral side part around the support step **11***b*, which part being slightly sloped towards the axis of the central support mound **11***a*, and two permanent magnets **13** and **14** are stacked on the top of the mound **11***a* with a spacer **12** interposed between them.

The magnetic **13** and **14** are formed in a disk shape and respectively magnetized to have opposite polarities in thickness direction, and are opposed to each other at mutually repulsing sides of the same polarity, e.g., N-pole sides, as spaced by the spacer **12** preferably of the same disk shape, so that a repulsion magnetic field can

be provided without any yoke interposed between the magnets. While in this case the spacer **12** should preferably be prepared by such magnetic material as SS41 or the like, it is also possible to prepare the spacer with a non-magnetic material, and, when the magnets **13** and **14** are to be held in position by any other arrangement, the spacer may be replaced just by an air gap. On the other hand, the two magnets **13** and **14** should preferably be prepared by such anisotropic sintered magnet as a neodymium magnet.

Voice coils **15** are disposed within the frame **11** so as to surround the stacked magnets **13** and **14**, as wound on a coil bobbin **16** axially vibratable closely about outer pheripheral edge of the disk-shaped magnets **13** and **14**, that is, to be disposed within the repulsion magnetic field generated by the two magnets **13** and **14**. To the center of outer periphery of the voice coils **15** on the bobbin **16**, a cone-shaped disphragm **17** is directly coupled at its inner peripheral edge defining a central opening, while the diaphragm **17** is secured at its outer peripheral edge through an edge damper **18** to the frame **11** at its portion adjacent to a top outer periphery of the frame **11**. A sub-cone **19** is also directly coupled at its inner peripheral edge to the voice coils **15** at its part adjacent to the inner peripheral edge of the diaphragm **17**, and a dust-preventing center cap **20** is fitted to the center of the sub-cone **19** so as to cover the magnets **13** and **14**.

Further, a supporting damper **21** is secured at its inner peripheral edge to the central part on the outer periphery of the coil bobbin **16**, and at its outer peripheral edge to the support step **11***b*.

Now, in the loudspeaker **10**, as shown in FIG. **1**, the voice coils **15** are disposed directly within the repulsion magnetic field generated by the two magnets **13** and **14** as shown in FIG. **1**, without any yoke interposed, and the arrangement can be contributive to the minimization in the thickness and weight. Further, the direct coupling of the cone-shaped diaphragm **17** to the voice coils **15** is effective to reatrain any transmission loss of the drive force from the voice coils **15** to the diaphragm **17** to be the minimum, and the vibration of the diaphragm **17** can be made to faithfully rise in response to input signals to the voice coils. Further, since the support point of the voice coils **15** by the damper **21** is positioned substantially in the center of the voice coils **15**, any influence of the rolling mechanism can be removed, and generally speaking the tone quality can be improved at a high degree.

In another embodiment shown in FIG. **2**, the sub-cone **39** is provided integral with the coil bobbin **36**, in which event the vibration of the coil bobbin **36** on which the voice coils **35** are directly transmitted to the sub-cone **39**, and the function of this sub-cone **39** can be further improved.

In the embodiment of FIG. **2**, substantially the same constituents as those in the embodiment of FIG. **1** are denoted by the same reference numbers as those given in FIG. **1** but with "20" added, and other constituents and functions than described are the same as those in the embodiment of FIG. **1**.

In the foregoing embodiments of FIGS. **1** and **2**, it is possible to improve low frequency range characteristics, by interposing a mechanical filter (not shown) between the voice coils **15** or **35** and the diaphragm **17** or **37**.

Referring next to FIG. **3**, there is shown a further embodiment of the loudspeaker according to the present invention, in which loudspeaker **50** the frame **51** comprises two frame halves **51A** and **51B**, a lower positioned one **51B** of which is formed generally in a flat dish shape, while an upper positioned one **51A** to be fitted to the lower half **51B** is so provided that its outer peripheral part is disposed preferably to be substantially in a plane symmetry with an outer peripheral part of the lower positioned half **51B** with respect to a horizontal plane including a line Y perpendicular to the axial line X of the loudspeaker **50**. The coil bobbin **56** on which the voice coils **55** are wound is formed to be elongated in the direction of the axial line X, and the voice coils **55** are wound in central part of the outer periphery of the bobbin **56**, and upper and lower dampers **61A** and **61B** are secured at their inner peripheral edges respectively to each of both ends of the coil bobbin **56** in the axial line X.

To the center of the outer periphery of the voice coils **55**, an inner peripheral edge of the diaphragm **57** of, for example, a flat and honeycomb structure is directly secured, the flat diaphragm **57** is expanded on the plane including the horizontal line Y, and the outer peripheral edge of the diaphragm **57** is secured through an edge damper **62** held between both holding edges at outer peripheries of the upper and lower frame halves **51A** and **51B**, while the upper and lower dampers **61A** and **61B** are secured at their outer peripheral edges respectively to the inner peripheral edge of the upper frame half **51A** and to the support step **51***b* of the lower frame half **51B**. Further, the frame halves **51A** and **51B** include the sound holes **51***c* made in areas adjacent to the outer periphery.

In the present embodiment, in contrast to the foregoing embodiment of FIG. **1** or **2** employing the cone shaped diaphragm **17**, the two magnets **53** and **54**, upper and lower dampers **61A** and **61B** and outer peripheral parts of the frame halves **51A** and **51B** are disposed substantially in the plane symmetry with respect to the flat diaphragm **57**. Thus, in the present embodiment, the diaphragm **57** is directly coupled to the operational center point of the voice coils **55** and supporting system of the voice coils **55** and diaphragm **57** is made to be the plane symmetry with respect to the plane including the line Y, so that the influence of the rolling mechanism can be removed in a more excellent manner.

In the embodiment of FIG. **3**, substantially equivalent constituents to those in the embodiment of FIG. **1** are denoted by the same reference numbers as those used in FIG. **1** but with "40" added, and other constituents and functions than those referred to above are the same as those in the embodiment of FIG. **1**.

As shown next in FIG. **4** in contrast to the embodiment of FIG. **3**, the flat diaphragm **77** is coupled at the inner peripheral edge through a mechanical filter **83** to the center of the voice coils **75**, so that the low frequency zone characteristics can be made excellent. In this embodiment of FIG. **4**, too, the equivalent constituents to those in the embodiment of FIG. **1** or **3** are denoted by the same reference numbers as those used in FIG. **1** or **3** but with "60" or "20" added, and other constituents and functions are the same as those in FIG. **1** or **3**.

While in the foregoing embodiments the repulsion magnetic field has been disclosed to be generated by the disposition of the two disk-shaped magnets opposed at their repulsive pole surfaces of the same polarity with the spacer interposed between them, this magnetic circuit generating the repulsion magnetic field involves

such magnetic flux distribution as represented by a curve G1 shown in FIG. 5 with respect to the magnetic circuit, where a leakage of flux cannot be said less, and it is intended to more improve the degree of concentration of the flux, preferably, so as to elevate the utilizing efficiency of the magnets.

Accordingly, in a further embodiment of the present invention shown in FIG. 6, the voice coils **105** are wound on a short cylindrical magnetic sleeve **113** fixedly mounted to the central part on the outer periphery of the coil bobbin **106**, whereby the magnetic flux distribution in the magnetic circuit for generating the repulsion magnetic field will be as represented by a curve G2, in which the flux concentration is elevated specifically in the flux adjacent the magnetic sleeve **113**, and the utilizing efficiency of the magnetic force of the two magnets **103** and **104** can be elevated. In this case, the same operation can be achieved by forming the voice coils themselves or the coil bobbin with a magnetic material.

In the foregoing embodiments of FIGS. **1** to **4**, the repulsion magnetic field generated by the magnetic circuit of the two magnets **123** and **124** with the spacer **122** disposed between them will be as shown in FIG. **7**, in which a magnetic field portion MF1 generated radially outward between both of the two magnets **123** and **124** will be of a higher intensity than that of other magnetic field portion MF2 or MF3 divided from the portion MF1 towards outer exposed pole surface of the magnet **123** or **124** radially inward. When the voice coils are wound for adaption to the radially inward magnetic field portions MF2 and MF3, a drive force by means of the radially outward magnetic field portion MF1 is not sufficiently generated in the voice coils, and it is desired to utilize effectively this magnetic field portion MF1.

In another embodiment of the present invention shown in FIG. **8**, therefore, the voice coils **125** wound on the coil bobbin **126** comprise three portions, that is, a coil portion **125***b* corresponding to the magnetic field portion MF2 of the one magnet **124**, an intermediate coil portion **125***a* corresponding to the magnetic field portion MF1 between the two magnets **123** and **124**, and a coil portion **125***c* corresponding to the magnetic field portion MF3 of the other magnet **124**, and the respective coil portions **125***a* to **125***c* are made different in their winding direction for obtaining high drive forces with the respectively corresponding magnetic field portions MF1 to MF3, so that a clockwise drive force will be generated in the coil portions **125***b* and **125***c* as viewed in top plan view, for example, while an anticlockwise drive force will be generated in the coil portion **125***a* between the coil portions **125***b* and **125***c*.

With this arrangement, as will be readily appreciated, the reverse directional magnetic field portion between the two magnets **123** and **124** can be effectively utilized, and a high drive force can be obtained even if the thickness and weight are intended to be remarkably minimized.

According to the present invention, various design modification can be made within the scope of appended claims. While, for example, the magnets have been described as being formed in the disk shape, the one formed in a ring shape will allow substantially the same function to be attained.

What is claimed is:

1. A loudspeaker comprising a frame, a pair of magnets disposed in the center of said frame to be mutually repulsive in the magnetic polarity for forming a repulsion magnetic field in a yoke-less manner, a coil bobbin disposed closely about an outer periphery of said pair of magnets to be within said repulsion magnetic field, voice coils would on an outer periphery of said coil bobbin, means for supporting said voice coils with respect to said frame, and a diaphragm coupled directly at an inner peripheral edge substantially to the center of the outer periphery of said voice coils within the repulsion magnetic filed, wherein said voice coils comprise three coil portions, first and second portions of which correspond respectively to divided magnetic field portions of said pair of magnets and a third portion of which corresponds to a magnetic field portion between the pair of magnets, said third coil portion corresponding to the magnetic field portion between the magnets being would in a direction reverse to that of said first and second coil portions.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,371,806
DATED : December 6, 1994
INVENTOR(S) : Kohara et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 6, Line 30, change "would" to --wound--;

Line 42, change "would" to --wound--.

Signed and Sealed this

Twenty-eight Day of March, 1995

Attest:

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*